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MIOCENE TURBIDITES IN THE CARAPITA FORMATION OF EASTERN VENEZUELA

by

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A B S T R A C T

The Carapita Formation consists primarily of deep marine shales deposited along the axis of the Eastern Venezuela Geosyncline in Oligo-Miocene time. The formation forms a gigantic wedge, with thicknesses of 15,000 to 20,000 feet in the northeast but thinning transitionally to zero in the west and south, where it merges into formations of shallow and non-marine origin (Naricual, Capiricual, Quiamare, Oficina and others). The full time-interval represented by the thickest developments corresponds to the planktonic zones from Globigerina ciperensis up to the base of Globorotalia menardii, but the zone most widely represented is that of Globigerinatella insueta.

Locally, in the upper part of the Carapita Formation, sands are encountered which are interpreted as turbidites. They are lenticular and completely surrounded by shales rich in foraminifera indicative of very deep water. Their content of mineral matter and reworked fossils indicates derivation from the Cretaceous and Lower Tertiary formations now exposed to the north. In this paper the turbidite sands are defined as the Cachipo Member of the Carapita Formation.

Detailed studies have shown that the stratigraphic level of the Cachipo sands near the basin axis corresponds with an unconformity farther north, along which the upper Carapita (G. fohsi Zone) rests on truncated lower Carapita (G. insueta Zone or older) or on pre-Carapita formations. It is deduced that the slumping of the turbidite sands into the basin was triggered by an abrupt uplift of the northern portion of the geosyncline, a phase of the southward advance of its mobile rim.

The Cachipo sands are clearly analogous to the Herrera sands of Trinidad, but are far less important as oil reservoirs. Commercial production has been obtained from them in the northeast extension of the Jusepín field, but elsewhere the oil encountered has been insufficient to warrant exploitation.

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INTRODUCTION

The area concerned in this paper is the northeastern flank of the Eastern Venezuela Basin, and especially the sector occupied by the Santa Bárbara-Jusepín oilfields (see map, Fig. 1). Oil production here is almost entirely from the La Pica and Las Piedras formations of mid-Miocene to Pliocene age. Deeper production is very limited, primarily because of lack of reservoir beds in the thousands of feet of uniform impermeable shales which underlie the producing formations over most of the specified area. These shales belong to the Carapita Formation of Oligo-Miocene age, which forms a gigantic wedge with thicknesses of 15,000 to 20,000 feet in the oilfields sector. The shales thin transitionally to zero to the south and west, where the deep-marine Carapita Formation merges laterally into formations of shallow and non-marine origin (Oficina, Naricual, Capiricual, Quiamare and others). In terms of basinal history, the Carapita shales represent the deep axial province of the basin during an interval inclusive of the zones of Globigerina ciperensis (upper part) to Globorotalia menardii (basal part).

Locally, however, sandstones have been encountered in the upper part of the Carapita Formation, and in the Northeast Extension of the Jusepín oilfield they have provided substantial amounts of oil. These sands are lenticular, interbedded with deep marine shales, and they exhibit textural and compositional features which identify them as turbidites. In the literature they have received casual mention*, but have never been formally named or described. This omission seems unfortunate, as the sandstones provide an important key to the geologic history of the basin, have a certain economic importance, and are undeniably a specially developed part of the Carapita Formation, hence qualify for designation as a formally named member.

In the following pages the interval inclusive of the turbidite sands is designated the Cachipo Member of the Carapita Formation. A type section is nominated and described, and supplemented by description of other reference sections. The paleontology of the member is discussed in reference to both its age and environment of deposition. Finally the regional correlation and paleogeographic significance of the Cachipo Member are discussed.

THE CACHIPO MEMBER OF THE CARAPITA FORMATION

(a) Selection of name

The two principal developments of turbidite sandstones in the Carapita Formation are in the Jusepín oilfield and in the concessions formerly known as the Cachipo Block. This block, lying immediately south of the Quiriquire oilfield, derived its name from the nearby village of Cachipo, which is the site of a small airport. (See map, Fig. 1).

* Mencher et al., 1951, p. 55; 1953, p. 743, 744; Petzall, 1956, p. 114 (Engl.), p. 141 (Span.); Young et al., 1956, p. 102, 103; Lamb and De Sisto, 1963, p. 274, 275; Soc. Ven. Ing. Pet., 1963, p. 175, 178.

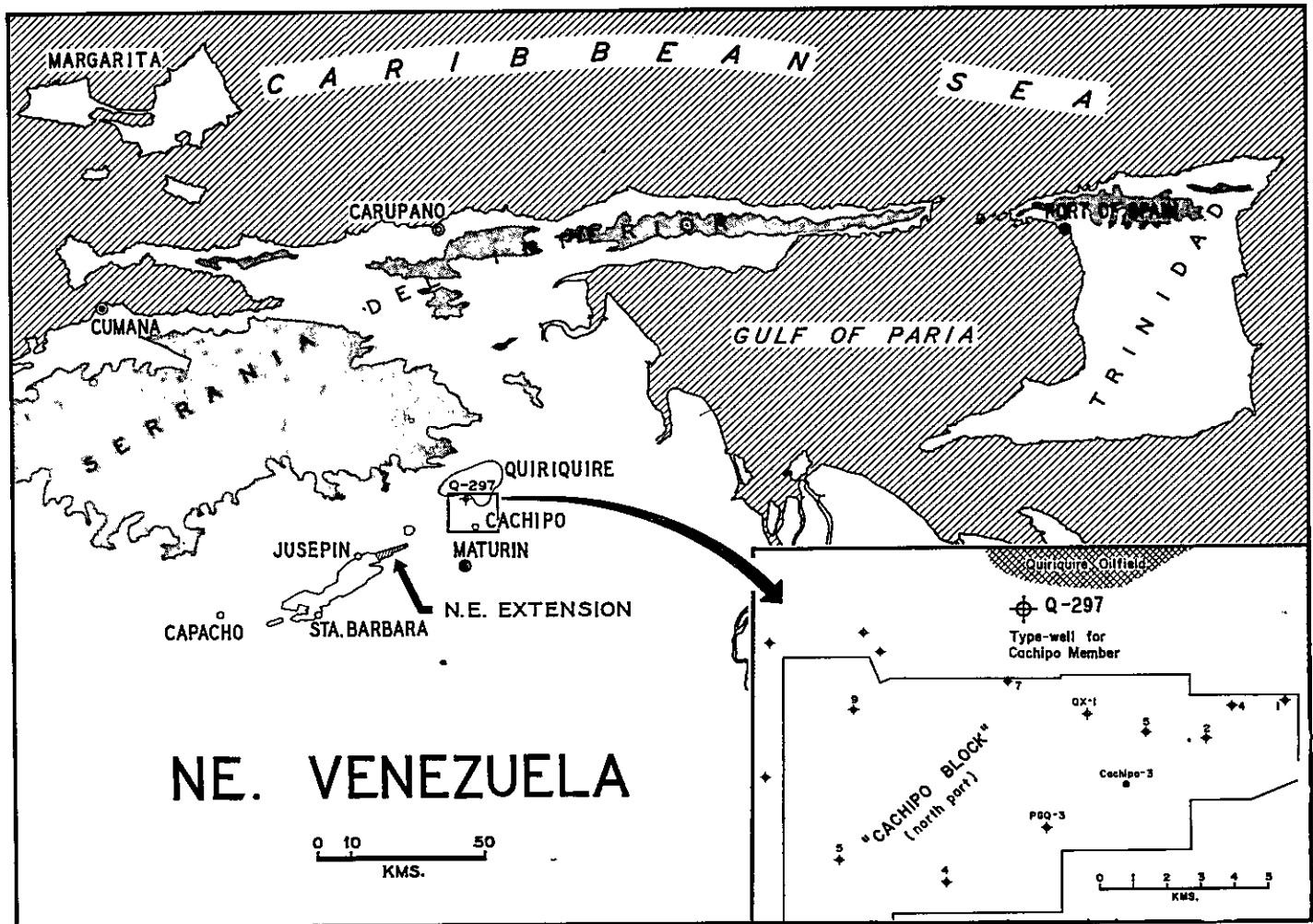


FIG. 1

Jusepín might appear the better name to apply to the sandstones, because of the commercial oil production obtained from them there. However, the name Jusepín is indelibly linked with production from the younger La Pica Formation. In informal usage a numbered sequence of "Jusepín" (or "J-") sands is applied to subdivision of the La Pica reservoirs : see De Sisto, 1962. Consequently application of the name Jusepín to a member of the Carapita Formation would be a source of confusion.

The name Cachipo, in contrast, has never appeared in the geologic literature, neither in reference to stratigraphy nor to oilfield operations. The turbidite sands are strongly developed in the Cachipo Block, and it is considered appropriate to introduce the name Cachipo Member for the sands under consideration. It may be noted that A. Salvador first used the term in this sense in 1958, in a private report of the Creole Petroleum Corporation.

A point to be observed here is that the Cachipo sands are lenticular and discontinuous. The American Code of Stratigraphic Nomenclature does not specifically provide for applying a single name in such a case. Nevertheless, this procedure is recommended because:

- 1) The lenticular turbidites have such close genetic relationship that a single embracive term is requisite for making regional reference to these beds. If each lens and lenticle were named separately, no such inclusive name would exist;

and

- 2) in analogous cases the use of a single name has proved entirely satisfactory. The Herrera and Retrench members of the Cipero Formation in Trinidad are obvious examples. Individual beds and groups of beds within each member are designated by local names and code-numbers for reservoir purposes, while the principal name remains valid for regional stratigraphic purposes. In Venezuela the Tinajitas Member of the Caratas Formation, as re-defined by Salvador (1964), provides a further example.

(b) Type Locality

The type area for the Cachipo Member is the former Cachipo Block of concessions. In 1957-58 the Creole Petroleum Corporation drilled nine exploratory wells in evaluation of this block, namely Cachipo-2, -3, -4, -5; PGQ-3, -4, -5, -7, -9. These were supplementary to the older wells QX-1 and Cachipo-1 within the Block, and to numerous wells around its periphery. As will be demonstrated, the sample descriptions and electric logs of these wells give a clear picture of the nature of the Cachipo sands.

However, it is preferable that the type well for any subsurface unit be extensively cored, and this is not true of any well within the Cachipo Block. Therefore the selected well is Q-297, which penetrated the entire Cachipo Member and was adequately cored. It lies just north of the Block, at N.220,793; E.201,337 meters on the Maturín coordinate grid (origin N.200,000; E.200,000 in the center of Plaza Bolívar at Maturín). The type section is designated as the interval from 5635 to 8075 feet in this well.

(c) Lithology of type section

The electric log of the type well, Q-297, is reproduced on Figure 2. In gross terms there are two main developments of sands and sandstones, an upper one at 5635-6595' and a lower one at 7190-8075'. The Carapita beds above, between and below these sandy intervals are almost entirely dark gray calcareous shales, with only minor laminae and stringers of sand.

In more detail, the core descriptions of the Cachipo Member of the type section read as follows:

i) upper group of sands (5635-6595')

Conglomerate, consisting of angular to subangular pebbles of black limestone in a medium-grained calcareous, sandstone matrix. Cobbles, well rounded, consisting of black limestone, hard, gray quartzitic sandstone and dark gray sandstone. Sandstone, dark gray, fine to medium grained, massive, poorly consolidated and argillaceous. Shale, dark gray to black, medium hard, slickensided, locally sandy, calcareous, containing a microfauna.

ii) intermediate shales (6595-7190')

Predominantly shale, dark gray to black, slickensided, slightly sandy, calcareous and fossiliferous. Sandstone, dark gray, fine grained, generally massive but contains local thin partings of black sandy shale.

iii) lower group of sands (7190-8075')

Sand, dark gray, silty, well sorted, very fine grained. Sandstone, salt-and-pepper gray; medium grained, very hard, calcareous. Pebbles, sub-angular, stream worn; loose, consisting of black, hard, dense limestone. Sandstone, brown to gray, well compacted but friable, generally medium grained but poorly sorted. Shale, dark gray to black, slickensided, slightly sandy, medium hard, calcareous, very fossiliferous.

Dips in the Cachipo Member in Q-297 are low, averaging 20°, hence the well-thickness (2440 feet) is close to the true stratigraphic thickness, which is estimated to be 2290 feet.

(d) Distribution

The type-section falls within an extensive development of the Cachipo Member, in which upper and lower sands are separated by a thick shale body. A representative north-south cross section is presented on Figure 3. The sandstones tend to shale out southwards.

For a few kilometers west of the Cachipo area wells drilled through the same stratigraphic interval have encountered only Carapita shales, with no sands or only trivial developments. However, when the Northeast Jusepin area is reached, a second strong development of lenticular sands is encountered. A representative north-south cross section of this sector is presented on Figure 4. On the basis

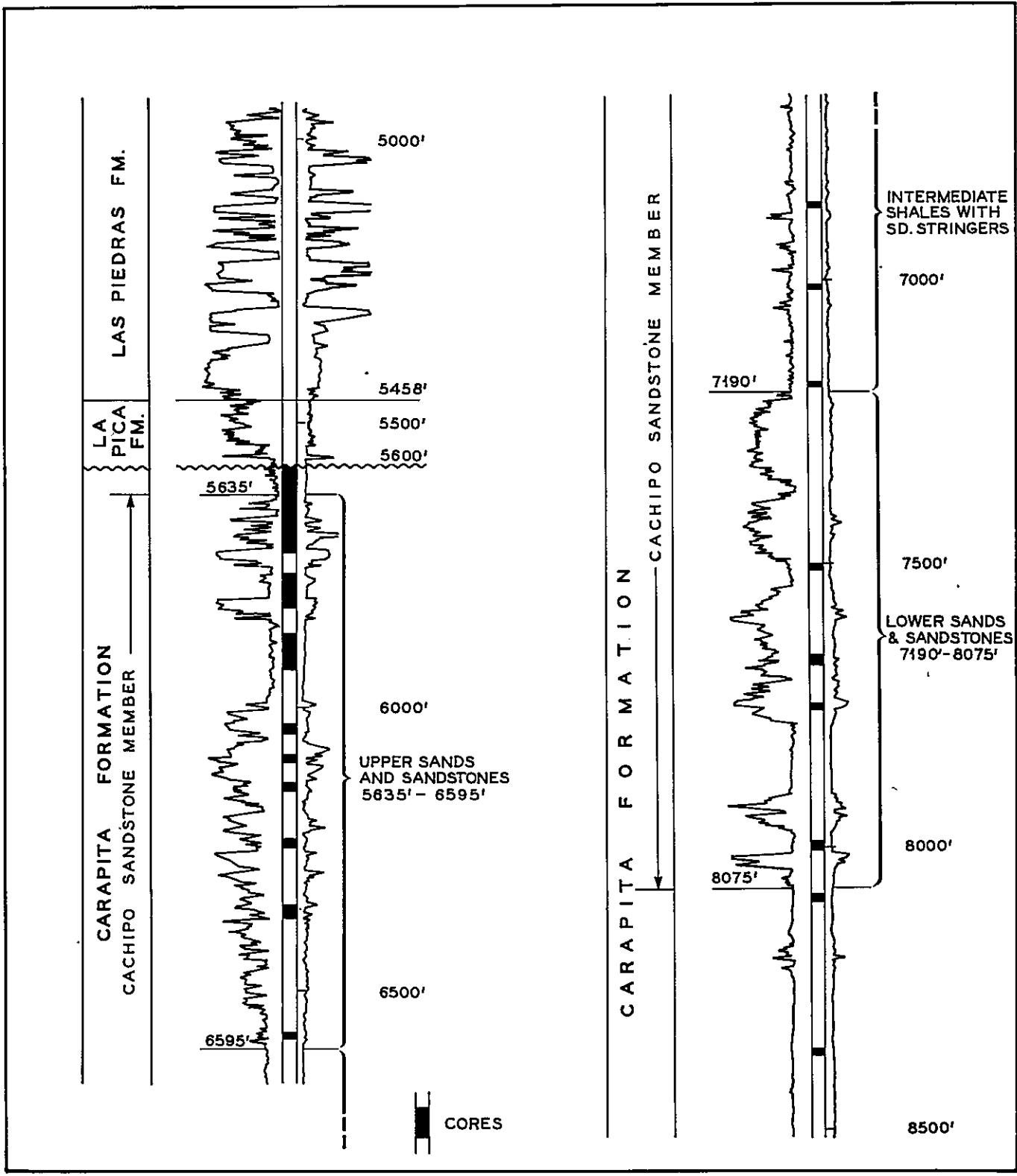


FIG. 2 ELECTRIC LOG OF THE TYPE WELL Q-297

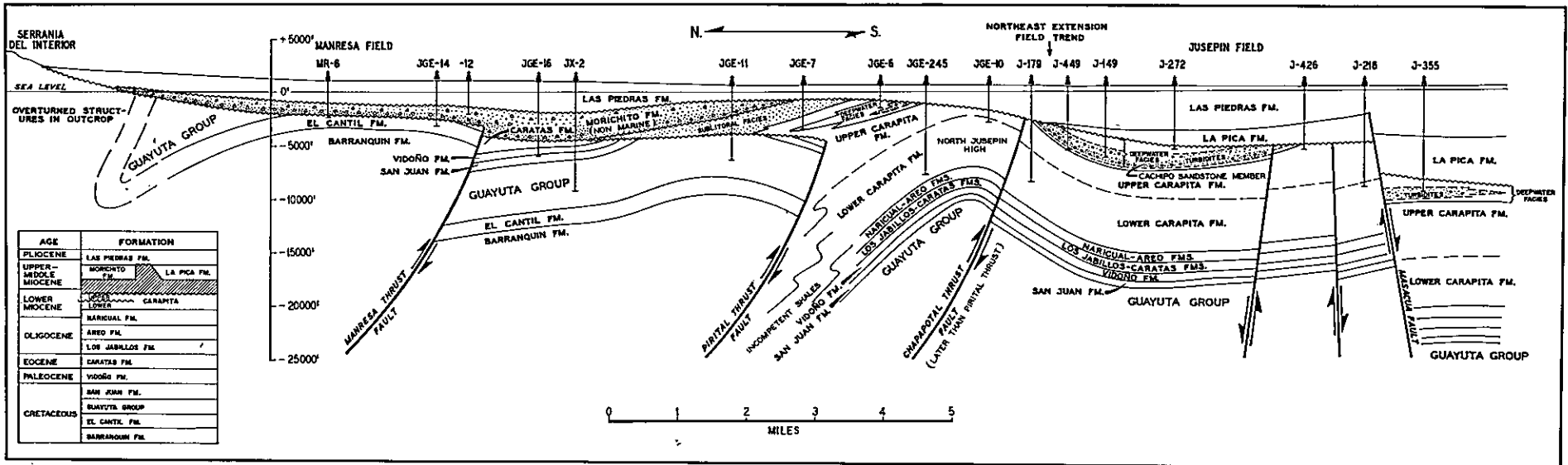


FIG. 4-NORTH-SOUTH CROSS SECTION THROUGH JUSEPIN SECTOR SHOWING THE STRATIGRAPHIC POSITION AND ATTITUDE OF THE TURBIDITE SEQUENCE (CACHIPO SANDSTONES) WITHIN THE CARAPITA FORMATION

of foraminiferal correlations these sands are correlated with the lower group of sands at Cachipo. A shaling-out to the south is again apparent.

Elsewhere in northern Monagas, to as far west as the Capacho area, occasional stray sands are encountered in the upper Carapita Formation, but no other developments are known comparable in magnitude to those at Cachipo and Jusepín. Although promising signs of petroleum have frequently been recorded in these sands, the combination of lenticularity and low permeability has rendered them sub-commercial. The sole exception is in the Northeast Jusepín Extension, where a favorable structure counteracts the unfavorable reservoir characteristics. In the twenty years following its discovery in 1944 this pool produced 25-million barrels of oil with an average gravity of 29° API.

Both at Cachipo and Jusepín the Cachipo Member is truncated below the unconformable cover of La Pica-Las Piedras beds. The known developments are remnants of formerly more extensive turbidites.

(e) Supplementary reference sections

(i) Cachipo area

The general features described in the type section (Q-297) hold good for other wells in the Cachipo area. The thickness in Q-297 (2440 feet) is the maximum recorded.

The sands are generally salt-and-pepper, gray and black, unconsolidated to cemented, calcareous, sub-angular, ranging in grain size from conglomeratic to silt, and are characterized by graded bedding. The shales are generally dark gray, bedded, medium hard, calcareous, silty, slickensided, and carry a prolific microfaunal assemblage. Rapid changes from shale to silt to conglomerate often occur within a few inches and none of the sand beds exceeds 15 feet in thickness.

(ii) Jusepín area

Because of established production, drilling has been closely spaced at Jusepín and numerous cores have been taken to assist in reservoir studies.

Well-to-well correlation of electric logs in the productive area reveals the high lenticularity of the sand reservoirs in the Cachipo Member. Figure 5 illustrates the gross correlation of four wells over an east-west distance of only two kilometers, and erratic shaling-out of the main sand bodies is clearly apparent. Furthermore these main bodies are themselves made up of many discrete lenticles separated by shales.

Examination of cores shows that the sand/shale alternation apparent on electric logs is a reflection of the graded bedding considered typical of turbidites. The usual upward sequence in cores is coarse sand passing gradationally up into silt and on into shale; abruptly the shale gives place to coarse sands and the sequence is repeated again, in some cases several times in one core. Figure 6 is a sketch of a representative cored sequence of this type. The thickness of individual sand-silt-shale packets ranges from 6 inches to 15 feet. The coarse-textured basal beds in each packet frequently contain twisted clasts of shale, which contains foraminifera of shallower type than the interbedded shales of the Cachipo Member. These are interpreted as fragments of semi-consolidated mud ripped off the sea-floor by turbidity currents moving into the basin.

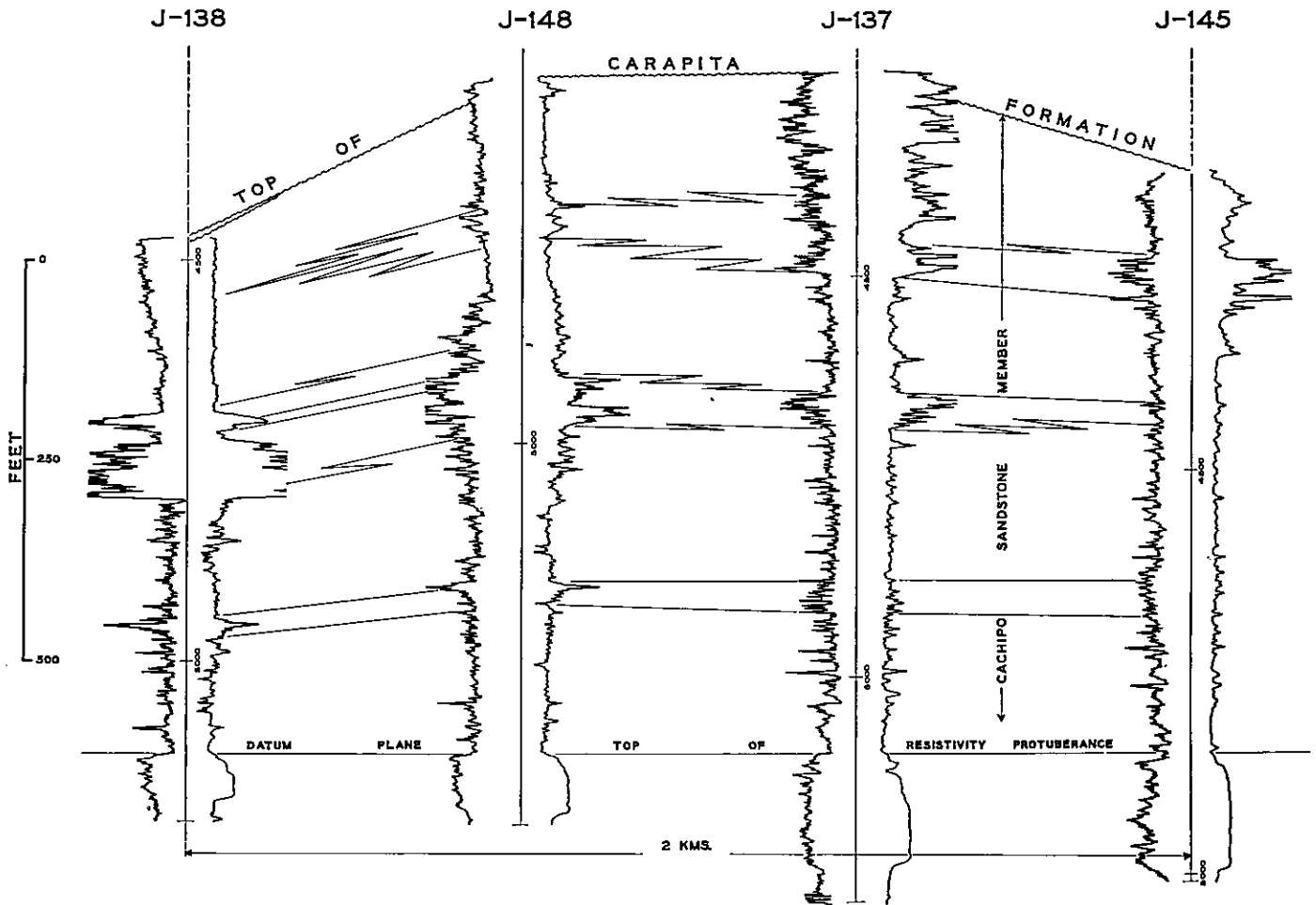


FIG.5 - EAST - WEST CROSS SECTION SHOWING LENTICULARITY OF SANDSTONES

WELL J-458 CORE N° 32

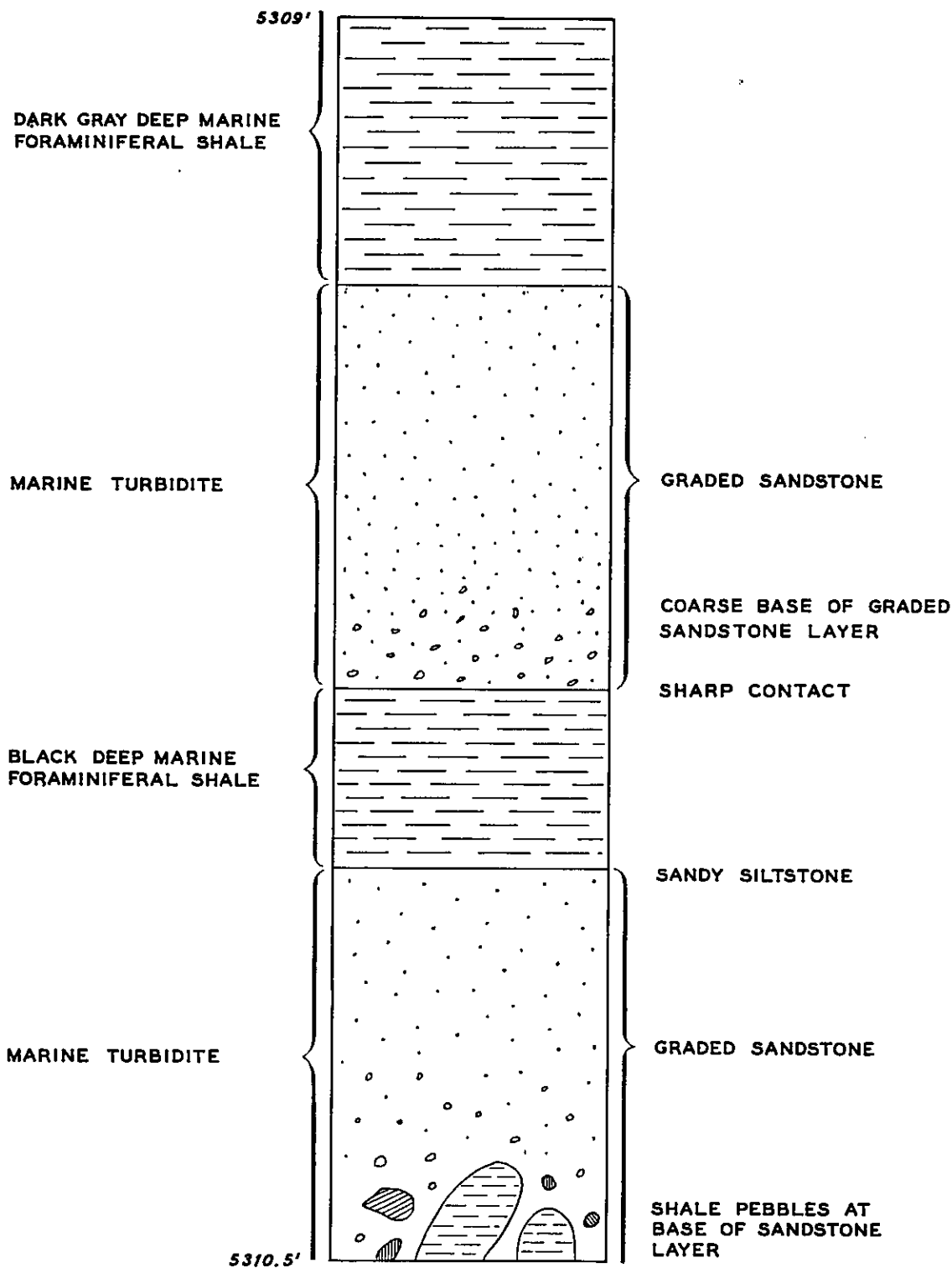


Fig.6 - LITHOLOGIC CHARACTERISTICS OF CACHIPO TURBIDITES

The term "coarse sands" is used loosely above, and actually the basal part of each packet of beds ranges from sand grade to cobble and even boulder conglomerate. The megascopic rock fragments are readily matched against formations of Cretaceous to Eocene age exposed in the present-day mountains to the north. The sands are typically gray to black with a "salt-and-pepper" texture, bedded, unconsolidated to cemented, calcareous, and subangular. Figure 7 is a sketch of a pebbly sand in a typical core (Well J-458, 5188-5208'), with some of the constituents identified.

The shales at the top of each packet of beds are generally dark gray, bedded, medium hard, calcareous, silty but not sandy, and slickensided. They contain plentiful foraminifera.

The stratigraphic thickness of the Cachipo Member at Jusepin is around 800 feet, which matches the lower group of sands at Cachipo. In some wells a considerably greater thickness is apparent, but this is a reflection of the steeply-dipping structure.

(f) Paleontology

No significant megafossils are recorded from the Cachipo Member. Microfossils of several groups are present, but only the foraminifera have been studied in detail.

(i) Age

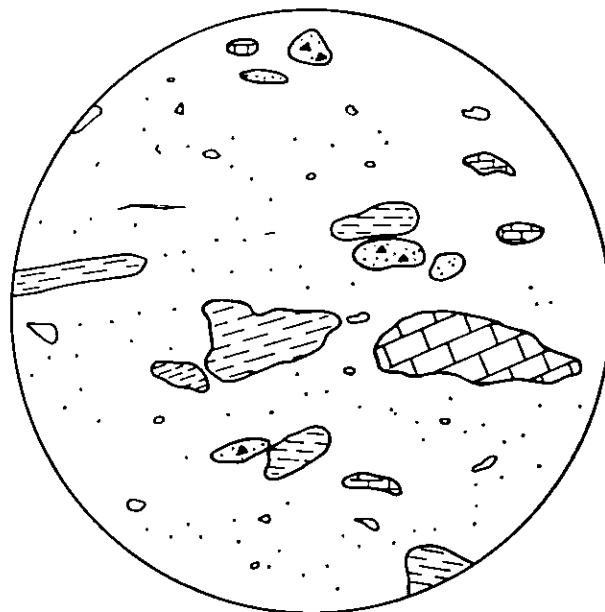
The age of the Cachipo Member is determined from the presence of planktonic foraminifera of zonal significance. In Trinidad and elsewhere they are confined, as a group, to the Zone of Globorotalia fohsi fohsi, which most modern authors place in the upper Lower Miocene (mid-Burdigalian). Confirmation is given by identification of the zones of G. fohsi barisanensis and G. fohsi lobata/robusta in the Carapita Formation below and above the level at which the Cachipo turbidites are developed.

Significant planktonic species recorded from the Cachipo Member include:

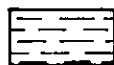
Globorotalia fohsi fohsi Cushman & Ellis
Globorotalia mayeri Cushman & Ellis
Globorotalia scitula (Brady)
Globigerinoides ruber (d'Orbigny)
Globigerinoides cf. bisphericus Todd
Orbulina suturalis Bronnimann
Biorbulina bilobata (d'Orbigny)
Globoquadrina venezuelana (Hedberg)
Sphaeroidinella seminulina (Schwager)

(ii) Biofacies

The foraminiferal assemblage of the Cachipo Member is to some extent heterogeneous. One element is an admixture of Cretaceous and Paleocene forms which complement the identification of rock fragments in the conglomeratic beds. A second element consists of large bleached arenaceous and abraded calcareous forms known at lower levels in the Carapita Formation and believed to be reworked. Thirdly there are fresh-looking specimens of calcareous species, such as Eponides coryelli and Planorbulinella trinitatensis, which live in shallow waters and are



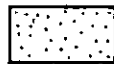
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INCH



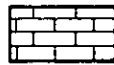
CARAPITA FM.



CARATAS FM.



SAN JUAN FM.



GUAYUTA GP.

Fig.7- SKETCH OF A PEBBLY SAND IN A TYPICAL CORE

a discordant element in these deep-water beds. They are assumed to have been displaced from their basin-margin environment by the scouring action of turbidity currents. Finally, the bulk of the fauna is a rich, highly diversified benthonic assemblage, plentifully present in the shaly intervals between the coarse-textured turbidites. In recent faunas many of the species are only recorded from great depths, in some cases not less than 6000 feet (Phleger et al., 1953; Bandy, 1953, and other authors). It is therefore concluded that the Cachipo Member was deposited in an abyssal environment, into which terrigenous and shallow marine material was carried by turbidity currents.

Species significant in reaching this conclusion include:

Bulimina alazanensis Cushman
Gyroidina soldanii (d'Orbigny)
Planulina wuellerstorfi (Schwager)
Uvigerina mantaensis Cushman & Edwards
Uvigerina rustica Cushman & Edwards
Nonion pompilioides (Fichtel & Moll)
Globobulimina pacifica Cushman
Globobulimina affinis (d'Orbigny)
Sphaeroidina bulloides d'Orbigny
Pullenia duplicata Stainforth
Bulimina ex gr. inflata Seguenza
Hoplundina elegans (d'Orbigny)
Cassidulina subglobosa Brady
Pyrgo mirrhina (Schwager)
Nodosaria longiscata d'Orbigny
Eponides umbonatus (Reuss)

(g) Mode of deposition

The combination of lithologic character (graded bedding, shale clasts, conglomeratic layers) and paleontologic features (deep marine fauna with allochthonous contemporary shallow marine and older reworked elements) identifies the Cachipo Member as a mass of turbidites. The presence of fragments and reworked microfossils from known Cretaceous to Eocene, and probably Lower Miocene, formations is suggestive of an abrupt uplift of the north flank of the basin. (Ample paleogeographic reasons exist for postulating the north, not the south flank). An unstable condition must be visualized, under which the uplifted rocks suffered rapid erosion. The eroded material accumulated along the lip of the steep north flank, from where it slumped periodically and was carried toward the basin axis by a succession of turbidity flows. In the focal areas of Cachipo and Jusepin the individual flows coalesced into thick turbidite fans.

These conclusions appear reasonable, though based primarily on the lithology and paleontology of the Cachipo Member. Ample substantiation is forthcoming when the member is considered in terms of basinal history, as will be shown below.

(h) Correlation

In the chronologic sense the Cachipo Member is directly correlative with, and laterally transitional into, basinal shales of the Carapita Formation. It must be assumed that uneven topography of the north flank of the basin caused concentration of turbidites in certain low areas.

To the east the Carapita Formation extends under the Gulf of Paria and merges into the Brassó and Cipero formations of Trinidad. The Herrera and Retrench members of the Cipero Formation are lenticular turbidites, including important oil sands, formed in exactly the same manner as the Cachipo Member and at closely similar zonal levels: see Kugler, 1953, p. 49.

In the genetic sense, formations ranging from Upper Cretaceous to mid-Miocene age show depositional features which reflect spasmodic uplifts of the north flank of the Eastern Venezuela Basin, and in this sense are homologous with the Cachipo Member. They include the flysch and wildflysch developments seen in Venezuela in the Garrapata (Cenozoic) and Guárico (Paleocene) formations, in Trinidad in the Chaudiere (Paleocene), Nariva (Basal Miocene) and Río Claro-Karamat (Middle Miocene) formations, as well as the aforementioned Herrera and Retrench members. Related to them are the non-marine "orogenic conglomerates" exemplified by the Guanape and El Pilar members of the Quimare Formation (Lower Miocene) and the Morichito Formation (Middle Miocene)*.

STATUS OF THE CACHIPO MEMBER IN BASINAL HISTORY*

The Eastern Venezuela Basin (or Geosyncline) is conveniently divided into three sectors, namely the Guárico, Maturín and Trinidad sub-basins. Although intimately interlinked, they differ appreciably in details of geologic history and stratigraphic sequence.

The area referred to in this paper lies north of the present axis of the Maturín Sub-basin. The most distinctive feature of this sector, relative to the Guárico and Trinidad sub-basins to west and east respectively, is that up until Lower Miocene time there is no evidence of existence of a north flank. Figure 8 shows a reconstructed north-south section through the Jusepin area corresponding in time to the upper part of the Zone of Globigerinatella insueta. The pre-Carapita formations thicken gently and develop deeper marine character in a northward direction. They represent build-up of sediments on a very stable shelf. Sedimentation was continuous from early Cretaceous to early Miocene time, with no unconformities, and the only signs of crustal movement are southward shifts of the deeper facies (Guayuta, Vidoño) indicative of gentle epeirogenic downwarping of the shelf. The topmost units (Caratas, Los Jabillos, Areo and Naricual formations) are of shallow to non-marine origin and represent an almost static regressive phase.

The sharp change from marginal marine facies (coal-bearing Naricual sandstones) to deep marine Carapita shales is the first sign of any abrupt change of basinal configuration. Also for the first time, foraminiferal biofacies in these lower Carapita shales reveal deepening from north to south. Towards the top of the interval (Zone of G. insueta) an overall shallowing of environment is apparent, and an approximate shoreline can be inferred. The basin has acquired a north flank.

Figure 9 shows a reconstruction of the same sector as it existed only a short time later (Zone of Globorotalia fohsi fohsi). The difference is remarkable. The older formations have been lifted and folded by tremendous upthrusts

* For an accepted correlation of the units mentioned, see the stratigraphic chart first published in 1963 (Soc. Ven. Ing. Pet., p. 188-189), later reproduced in Asoc. Ven. Geol. Min. Pet., Boletín Informativo, vol. 6, no. 11 (1963), vol. 7, no. 5 (1964).

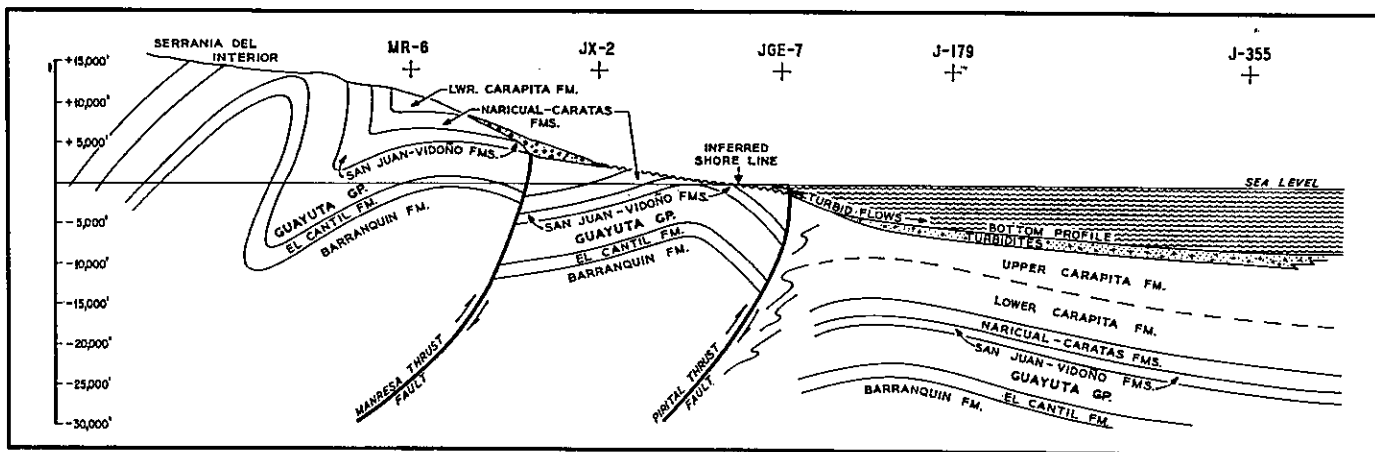


FIG. 9 - PALEOGEOLOGIC RECONSTRUCTION SHOWING THE NORTH FLANK OF THE MATORIN SUB-BASIN DURING UPPER CARAPITA TIME (ZONE OF G. FOHSI FOHSI) FOLLOWING THE SERRANIA UPLIFT, THRUSTING, AND EROSION.

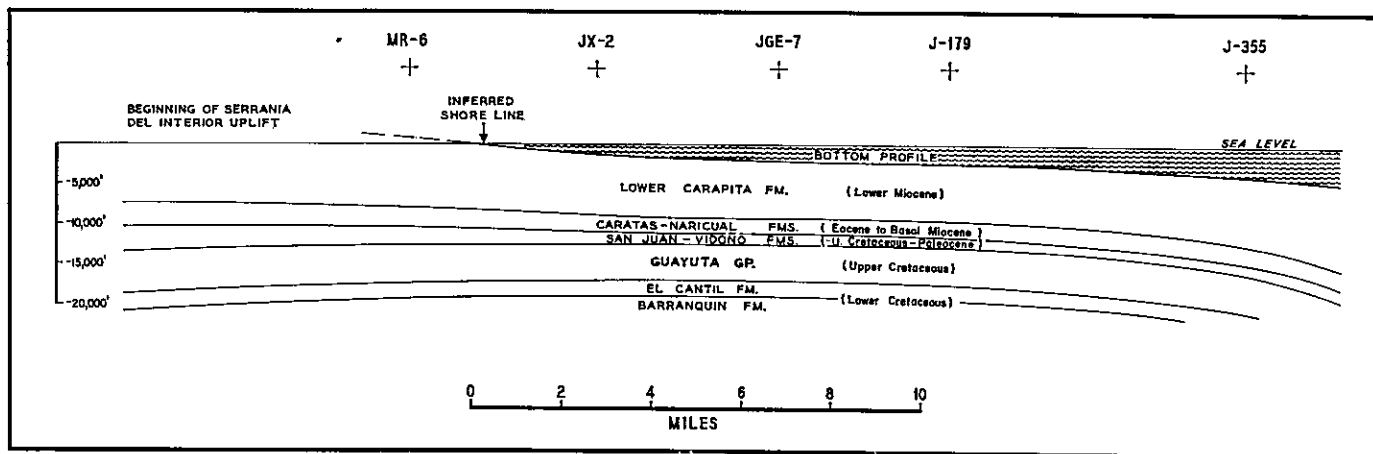


FIG. 8 - PALEOGEOLOGIC RECONSTRUCTION SHOWING THE NORTH FLANK OF THE MATORIN SUB-BASIN DURING LATE LOWER CARAPITA TIME (ZONE OF G. INSUETA).

in the north, forming the nucleus of the Serranía del Interior as it exists today. The older rocks are being vigorously eroded, forming fanglomerates around the basin margin, and these are slumping southwards to settle on the basin floor as turbidites of the Cachipo Member.

Slightly later the sea again transgressed northwards, and beds of the upper Carapita Formation can be found resting on truncated lower Carapita and older formations to the north of the Pirital Thrust Fault (see wells JGE-7, -11 on Fig. 4). Thus, as is logical, the basinal turbidites (Cachipo Member) correspond to a strong erosional hiatus in the formations preserved around the margin of the basin.

The reconstructions offered here (Figs. 8,9) are based on an interlocking grid of subsurface cross sections, supplemented by isopach and lithofacies maps of the pre-Carapita formations exposed in the Serranía del Interior to the north. Figure 9 is primarily derived from the present-day section shown on Figure 4 by eliminating the structures which have deformed the upper Carapita beds.

In the Guárico sector, especially, and in Trinidad the growth of the north flank of the Eastern Venezuela Basin can be traced back into pre-Miocene and even pre-Tertiary time. The mode of growth was spasmodic, in the form of violent orogenic uplifts separated by lengthy quiescent periods. The tendency was for each uplift to incorporate a new portion of the basin, so that its axis migrated spasmodically southward. Evidence for specific phases in the growth of the mobile rim, prior to the Cachipo-Herrera episode, is as follows:

Upper Cretaceous (Coniacian)	Garrapata Fm.,	turbidites and wildflysch, volcanic extrusions
Paleocene	Guárico Fm., Chaudiere Fm.,	flysch and wildflysch in basin, peripheral unconformity; flysch and wildflysch
Upper Eocene	Peñas Blancas Fm., San Fernando Fm.,	peripheral unconformity; peripheral unconformity, slumped blocks
Basal Miocene	Nariya Fm., Carapita Fm.,	flysch and wildflysch; local intraformational unconformity

The orogenic episode responsible for accumulation of the Cachipo and Herrera turbidites thus takes its place in a sequence of like events. One more was to follow in post-Carapita/pre-La Pica time (see Fig. 4), after which deformation of the basin by compressive forces came to an end.

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