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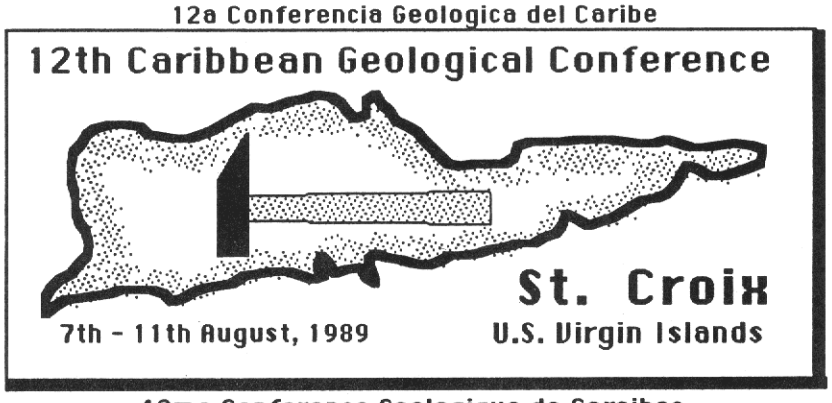

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EOCENE STRATIGRAPHICAL STUDIES, MARACAIBO BASIN, NORTHWESTERN VENEZUELA

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ABSTRACT

Benthic foraminiferal analysis were carried out in samples (cuttings, cores) of eight wells and one outcropping section from the Maracaibo Basin, northwestern Venezuela.

The wells located across the basin, from the west to southeast, are in the La Paz, Concepción, Sibucara, Cabimas and Ceuta oil fields; the outcropping Eocene section is near the Misoa Anticline, east of the Mene Grande oil field.

The early Eocene-late middle Eocene sequence includes the siliciclastic Trujillo, Misoa and Paují formations, and the siliciclastic-carbonatic Santa Rita and Jarillal formations.

Five paleobathymetric foraminiferal assemblages, were distinguished: 1) Lower alluvial Trochammina sp. assemblage typifies the Misoa Formation to the west. 2) Deltaic Trochammina - Haplophragmoides assemblages characterizes the Misoa Formation in the entire studied area. 3) A nearshore Quinqueloculina - Agglutinated Foraminifera assemblage recorded at the base and at the top of the Misoa Formation, in the central and eastern parts of the studied area. 4) Inner-Mid neritic Bolivina umbonifera assemblage recognized at the base of the Paují Formation and at the top of the Trujillo Formation. 5) Outer neritic/Upper bathial Sigmoilopsis schlumbergeri - Textularia saggitula assemblage recognized in the Paují and Jarillal formations and locally (to the midwest of the area) in the Misoa and Trujillo formations.

Paleobathymetric changes such as shallowing upward sequences (between the Trujillo and Misoa formations), deepening-upward sequences between the Misoa and Paují formations), and the main changes within the Misoa Formation are related to sediment supply and to eustatic changes of the sea level. However, local changes can be related to paleotopography and possibly to sinsedimentary faulting.

Known reservoirs in the Misoa Formation and at the top of the Trujillo Formation are sand bodies deposited in nearshore and deltaic environments; therefore, faunal assemblage distribution can be used to predict facies changes and consequently reservoir limits.

INTRODUCTION

This paper is a continuation of the studies on the micropaleontology of the Eocene Sediments from the Maracaibo basin.

The objective and scope is to compare the vertical and horizontal lithological-paleontological changes of the early Eocene - late middle Eocene sequence, characterized by the siliciclastic Trujillo, Misoa and Paují formations and the siliciclastic-carbonatic Santa Rita and Jarillal formations.

Eight wells and one outcropping section with good faunal and floral control were selected to provide a stratigraphical correlation across the basin, from west to southeast La Paz, Concepción, Sibucara, Cabimas, Mene Grande and Ceuta oil fields, (Fig. 1). The biostratigraphy of the wells was studied previously by Barbeito et al., 1985; Pittelli, 1985 and Pittelli and Molina 1989.

Sampling: The samples for this study were collected at the wells, micropaleontological analysis were carried out in cuttings, cores and side wall samples. The Trujillo, Misoa and Paují formations were sampled in 1980 by the author at the El Venado near Mene Grande area. The samples were washed through 80 u and 230 u sieves, the residue was split out in three fractions through 40, 180 and 300 sieve, and was handpicked for foraminifera, ostracodes and associated fauna.

STRATIGRAPHY

General Outline

The sequence in the Maracaibo Basin, western Venezuela, is illustrated in (Fig. 2). The stratigraphic column is one of the most interesting ones in Venezuela due to the variety of lithological types that it contains. Four major unconformities are present during the Triassic, Jurassic, Paleocene and the late middle Eocene.

Eocene

Trujillo Formation

Lithology: The Trujillo Formation is predominantely shaly, with laminated dark gray shales and black claystones. The sandstones are of different types: fine to coarse grained, poorly sorted, well cemented; gray, fine grained sandstones, calcareous, interbedded with shaly layers.

Thickness: This unit is absent in la Paz oil field (Well 1). In La Concepción oil field is 190 meters thick (Well 2), and becomes thicker toward the northeast of the studied area to 684 meters (Sibucara oil field and Tablazo Bay, Wells 3, 4 and 5). In the Cabimas oil field it has not been penetrated (Well 6) and is absent toward the southeast of the studied area, Wells 8 and 9, (Fig. 3). Around the outcropping section this unit is present but not included in this study.

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FIG.1 LOCATION OF THE STUDIED AREA

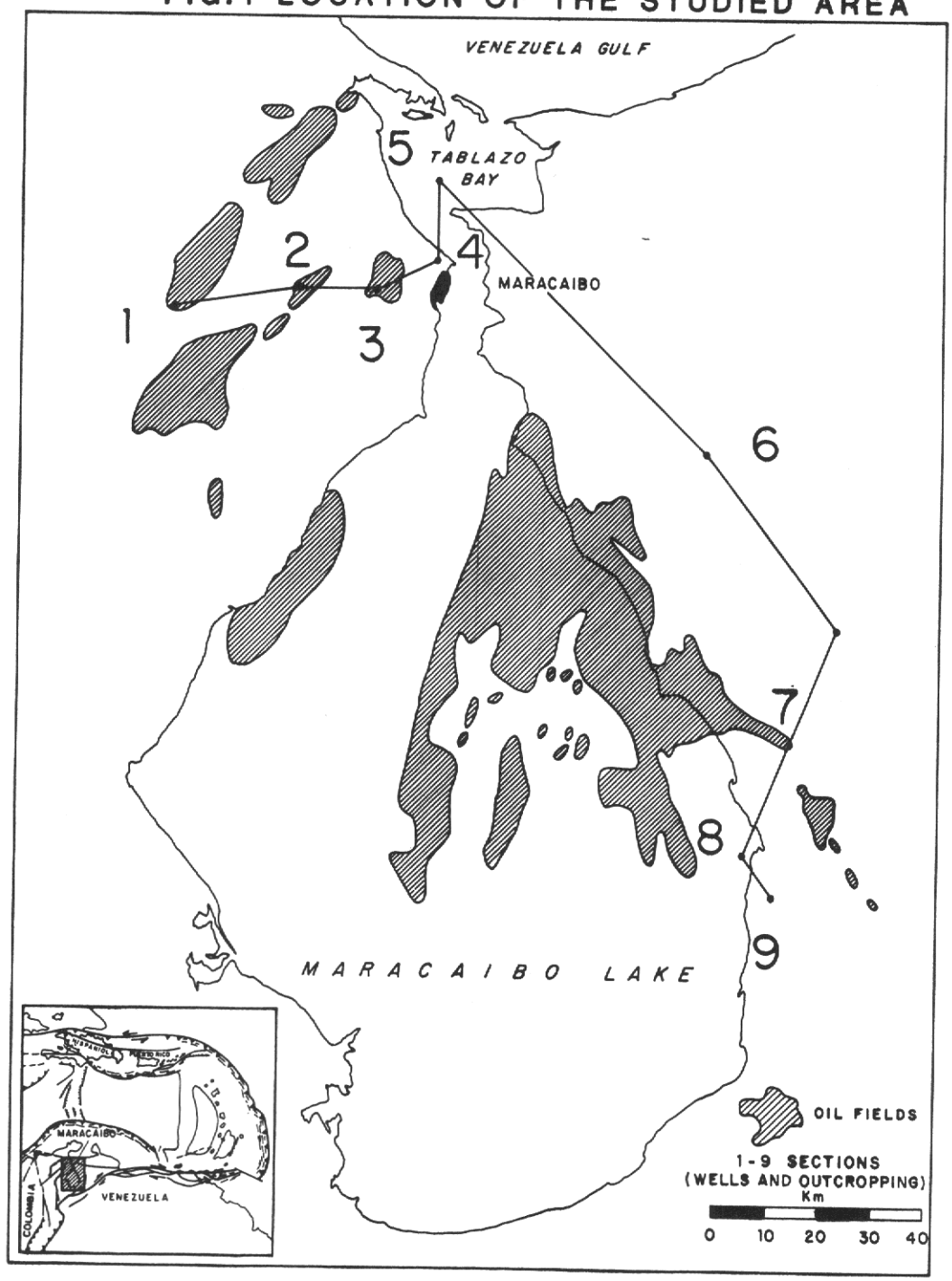
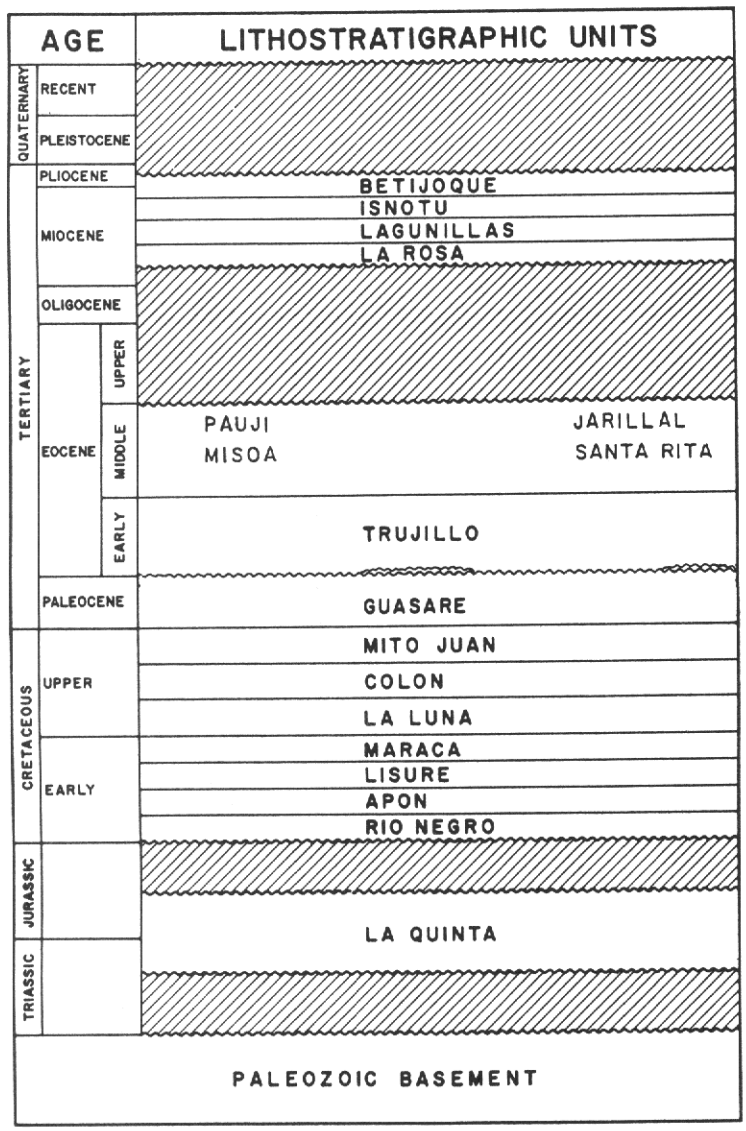


FIG.2 GENERALIZED STRATIGRAPHY



Paleontology and Age: This unit is highly fossiliferous in the middle part of the sequence; throughout its lower and upper parts the faunal contents decrease. The most important genera are represented by Sigmoilopsis schlumbergeri; abundant Plectofrondicularia sp., differents species poor preserved of Ammodiscus spp., Tritaxia spp., Gaudryina spp., Textularia sp., Bathysiphon eocenicus, Haplophragmoides canariensiformis, and Cyclammina cancellata are also present. Toward the upper part the faunal content is poorer and is represented by a Bolivina-Siphonina umbonifera assemblage, associated with some Gyroidina soldanii, and Eocene planktonic foraminifera (badly preserved).

In this unit the palinoflora assemblage is very poor, only some species of Rugotricolporites felix and Echitriporites trianguliformis are present (Barbeito et al.,1985 and Muller J. et al., 1987). The age is early Eocene, based on the presence of the planktonics foraminifera: Hastigerina bolivariana, Pseudohastigerina. aff. wilcoxensis, Acarinina aff. broedermanni, A. pentacamerata and Morozovella edgari, Planktonic zone Morozovella edgari-Acarinina pentacamerata, sensu Toumarkine and Luterbacher, 1985 and P6 - P9, Berggren and van Couvering 1974 (fide Toumarkine and Luterbacher op. cit.).

Misoa Formation

Lithology: Mainly sandy sediments typifie this formation, which consists of light gray to brownish gray, medium to coarse-grained, consolidated sandstones. In the whole formation are subordinate amounts of fine to medium, gray and dark gray, carbonaceous, micaceous, laminated and cross-laminated sandstones. Interbedded with the sandstones are gray to dark gray shales.
Thickness: In La Paz oil field, Well 1, the Misoa Formation is 851 meters thick. Within the La Concepción and Sibucara oil fields, Wells 2, 3, and 4, thicknesses more than 2400 meters have been encountered. Toward the northeast and southeast the thicknesses of the Misoa Formation ranges between 1102 and 860 meters. In the outcropping section, only 760 meters were measured. In Well 9, this formation is thinner, the average thickness is about 320 meters (Fig. 3).
Paleontology and age: In the western part of the studied area the abundant genera Trochammina typifies the Misoa Formation. In the whole area the faunal assemblages are Trochammina spp., Ammobaculites sp. and Haplophragmoides spp. Local changes toward the central and the eastern parts of the studied area, are represented by diversity of fauna such as badly preserved Trochammina, Haplophragmoides, Recurvoides, Quinqueloculina, ostracods and some gastropods. A few planktonics foraminifera were recorded in the Tablazo area: Acarinina gr soldadoensis and Globigerinatheka sp. The palinoflora contents is characterized by the presence of Echitriporites trianguliformis, Retitricolporites guianensis, Bombacacidites soleaformis and Retitricolpites magnus (Barbeito et al., 1985 and Muller J. et al.,1987). The age determination based on palinoflora contents and planktonics foraminifera is late early Eocene to middle Eocene.

Santa Rita Formation

Lithology: The Santa Rita Formation consists of coarse-grained conglomerates, with clasts averaging 5 cm in diameter, confined to the lower portion of the formation, calcareous sandstones, calcareous dark gray shales and marls with subordinate lepidocyclinids-red algal limestones (Fig. 3).
Thickness: This formation is only present in Well 6, where the thickness is 458 meters.
Paleontology and age: Textularia saggitula, badly preserved agglutinated foraminifera, abundant Lepidocyclinida pustulosa, Helicolepidina sp., Nummulites (Paleonummulites) trinitatensis, Melobesioid algae and molluskan debris are all present. The age of the Santa Rita Formation is middle Eocene based on fossils contents.

Paují Formation

Lithology: The Paují Formation contains dark gray silty laminated shales, black claystones, consolidated thin layers of gray, fine-grained sandstones and thin beds of silstone. The sandstones and silstones beds become thicker toward the base of the Paují Formation.
Thickness: The Paují Formation is present only in the southeast part of the studied area (Well 9), where the thickness is 258 meters.
Paleontology and age: Abundant benthonic and planktonic foraminifera such as: Bolivina spp., Textularia saggitula, Truncorotaloides rohri, Turborotalia cerroazulensis cerroazulensis, Globigerina eocaena and Globigerinatheka index are present. The age determination based on planktonic foraminifera is late middle Eocene; planktonic zone Truncorotaloides rohri, sensu Toumarkine and Luterbacher, 1985; and P14, sensu Berggren and van Couvering 1974 (fi and Luterbacher op. cit.).

Jarillal Formation

Lithology: The characteristic lithology of this formation is dark gray to black shales, ocassionally silty and calcareous; light gray consolidated, fine grained, well sorted sandstones and sandy gray limestones.
Thickness: This formation is only present in Well 6 with 1366 meters (Fig. 3).
Paleontology and age: The fossils content is very similar to the Paují Formation, the main difference is the presence of some Nummulites at some calcareous levels near the top of the Jarillal Formation. The age determination is late middle Eocene based on fossil control. Planktonic zone Truncorotaloides rohri, Toumarkine and Luterbacher, 1985 and P-14, sensu Berggren and van Couvering, 1974 (fide Toumarkine and Luterbacher, 1985).

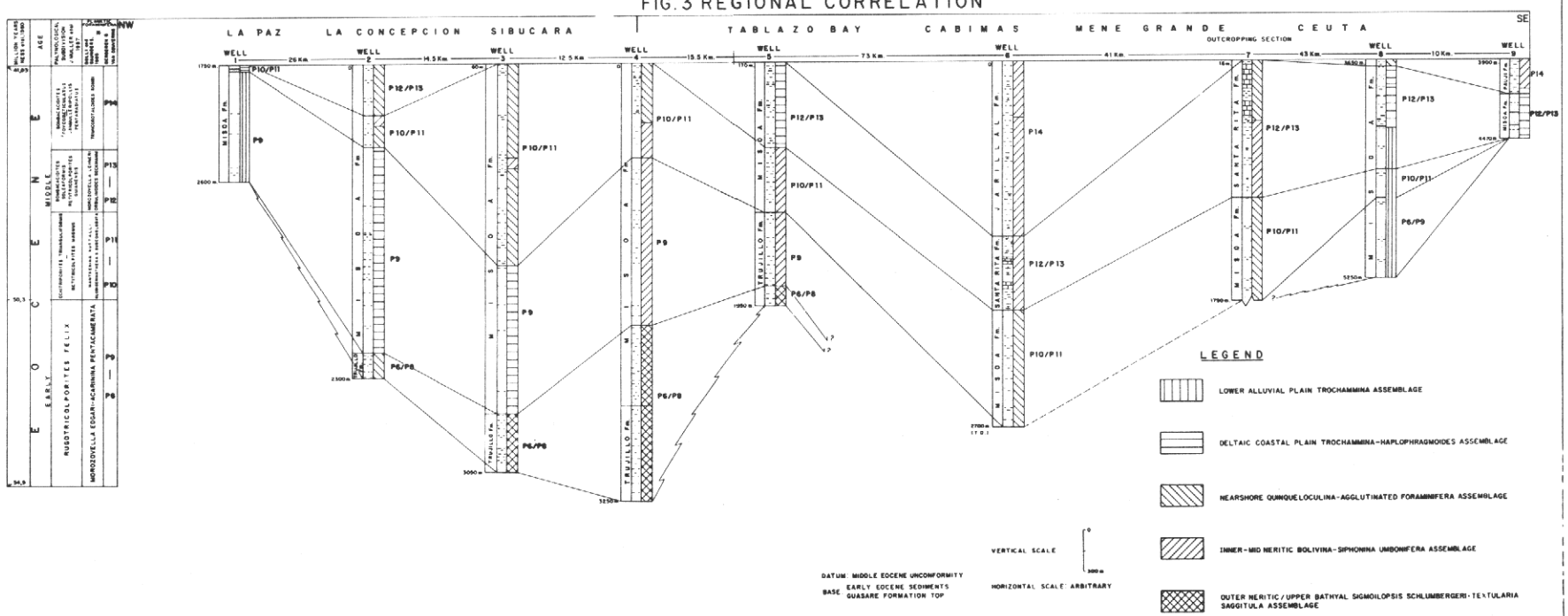
BIOFACIES

According to their foraminiferal contents, five major assemblages were recognized.

Trochammina Assemblage

Characteristics: This biofacies has been defined because of the abundance of the agglutinated foraminifera Trochammina spp. These species have

FIG. 3 REGIONAL CORRELATION



slightly compressed tests, with outlines rounded to ovate, periphery broadly rounded; walls are thin a and very fine grained. The diameter of th test is 0.40-0.70 mm; all the specimens are badly preserved. The others agglutinants have a relative representation of about 30% and include the genera Ammobaculites and Miliammina, also badly preserved.

Depositional environment: The Trochammina Assemblage, according to Barbeito et al, 1985 is typical of lower alluvial plain palaeoenvironment (brackish water).

Geographical distribution: This biofacies is predominantly developed in the western part of the studied area, La Paz oil field, but it appears also to be present in Well 8, southeast of the area (Fig. 3).

Stratigraphic position: In La Paz area, the biofacies occurs within the Misoa Formation in the whole sequence, and in Well 8 is confined to the middle and lower portion of the Misoa Formation.

Trochammina - Haplophragmoides Assemblage

Characteristics: The most abundant species are the agglutinated foraminifera Trochammina spp. and Haplophragmoides spp. The Trochammina are very similar to the first assemblage, the genera Haplophragmoides have a planispirally test, enrolled and evolute; wall finely agglutinated and thin, not alveolar and compressed. The specimens are poorly preserved. Others components of the assemblage, about 20% are agglutinants specimens, which are badly preserved, and difficult to identify.

Depositional environment: According to Barbeito et al, 1985, the assemblage is typical of deltaic coastal plain environments, marsh deposits, brackish water.

Geographical distribution: This biofacies has been recorded in the western part of the area, in La Paz (Well 1) and Concepción oil field (Wells 2 and 3), and in the southeast (Wells 8 and 9). In the center part of the area it is absent (Fig 3).

Stratigraphic position: The biofacies occurs in the upper-most portion of the Misoa Formation toward the west of the area. Toward the southeast, the assemblage have been recorded in the upper portion of the Misoa Formation (Well 8) and in the lower portion of the Misoa Formation (Well 9).

Quinqueloculina - Agglutinated Foraminifera Assemblage

Characteristics: This assemblage is made up basically of diversified agglutinated Foraminifera such as abundant Haplophragmoides spp., Eggerella bradyi, Recurvoides sp., and others arenaceous specimens badly preserved and difficult to identify. The Haplophragmoides specimens are different from those of the Trochammina-Haplophragmoides assemblage. The more conspicuos characteristics of those taxa are: test planispirally enrolled; wall coarsely arenaceous and granular, alveolar. Other components of the assemblage are calcareous foraminifera: small-sized Quinqueloculina sp. and a few species of piritized Bolivina sp.

Depositional environment: This assemblage reflects an increase in marine influence; shallow water, nearshore deposits.

Geographical distribution: The assemblage is more conspicuos in the central and southeast part of the studied area.

Stratigraphic position: Absent in La Paz (Well 1) and in the El Tablazo area (Well 5), this assemblage has been recorded in the upper portion of the Wells 2 and 3 and in the upper most portion of Well 4, (Misoa Formation). Toward the southeast the assemblage has been recorded in the lower portion of Well 6 (only Misoa Formation); upper and lower portion of the outcropping section (Santa Rita and Misoa formations); upper most portion of Well 8 and lower portion of Well 9 (Paují Formation).

Bolivina - Siphonina umbonifera Assemblage

Characteristics:. It is marked almost exclusively by large-sized calcareous foraminifera. Most conspicuos in this assemblage are: Siphonina umbonifera and different species of Bolivina, while the populations of several others are common Lenticulina sp., Gyroidina soldanii, and rare G. neosoldanii. Also present are the large-sized (up to 2 mm) Textularia saggitula, many broken Textularia spp., planktonic foraminifera, and ostracods, pteropods and fish teeth.

Depositional environment: This biofacies represents an interval of open marine fauna, which clearly differs from the mentioned biofacies described before. This assemblage is typical of Inner to mid neritic deposits.

Geographical distribution: It is distributed in the whole area, except in Well 1 and in the southeast Wells 8 and 9 (Fig 3).

Stratigraphic position: This biofacies have been recorded in the upper portion of Wells 2 and 3, probably as a respond to a large marine incursion (Fig. 3). In the central and southeast of the studied area, the assemblage was recognized in the upper and middle portion of the sequences at the base of the Paují Formation, top of the Trujillo Formation and Santa Rita Formation, and within the Jarillal Formation.

Sigmoilopsis schlumbergeri - Textularia saggitula Assemblage

Characteristics: This biofacies is defined by the abundance of open marine fauna. The faunas, are extraordinarily rich and diversified. In its most typical development, the assemblage includes: 60% of large-sized and coarsely arenaceous foraminifera (up to 3 mm), with abundant Sigmoilopsis schlumbergeri and Textularia saggitula; other agglutinants are Eggerella bradyi, Ammodiscus sp., Gaudryina sp., Cyclammina cancellata, and Tritaxia sp. 30% of the assemblage is represented by large-sized calcareous foraminifera Plectofrondicularia sp, Lenticulina sp., Gyroidina soldanii and by thick wall spinose Globigerinids, badly preserved.

FIG.4 EARLY EOCENE: ZONE P9

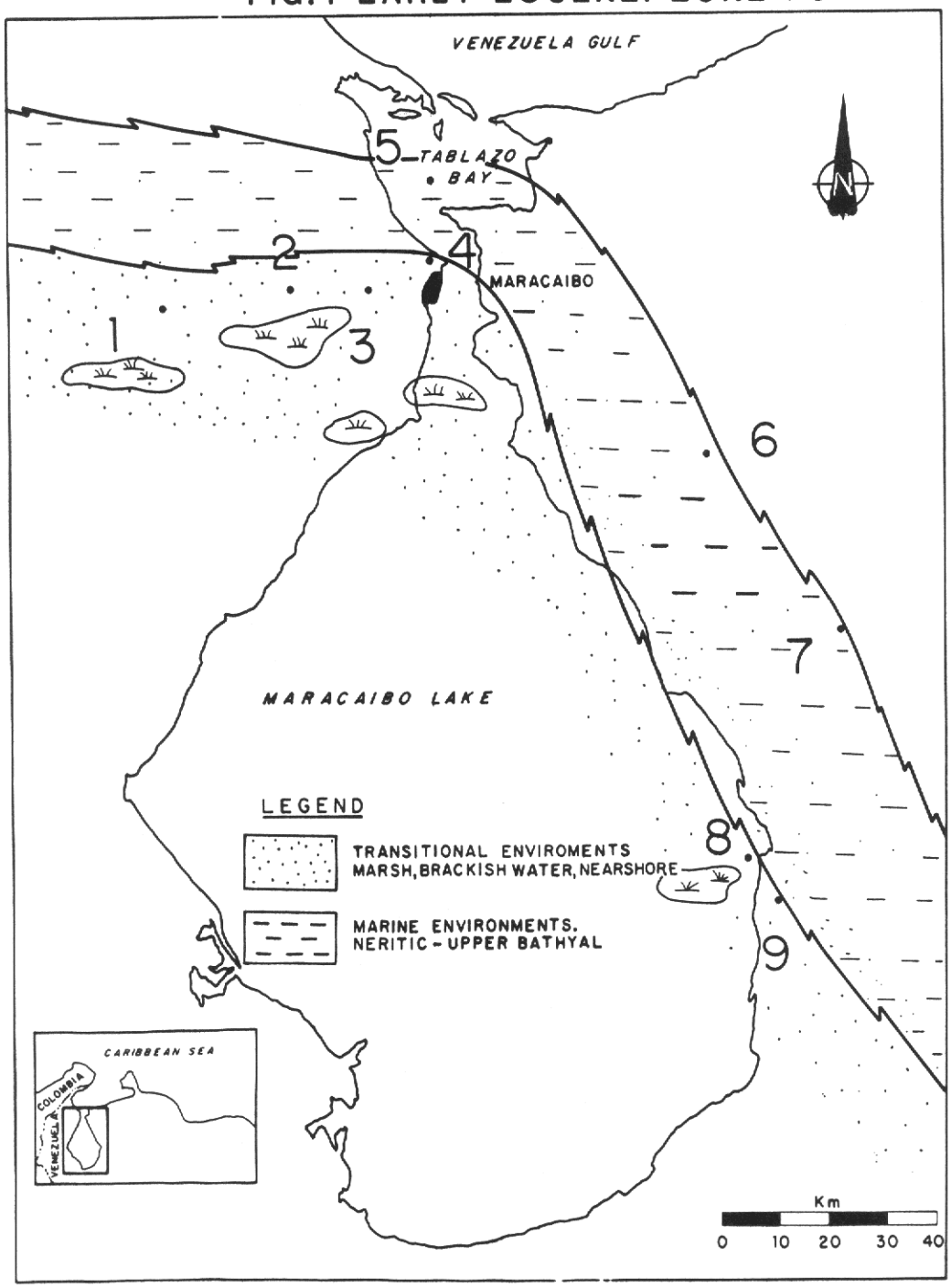


FIG.5 MIDDLE EOCENE: ZONE P10-P11

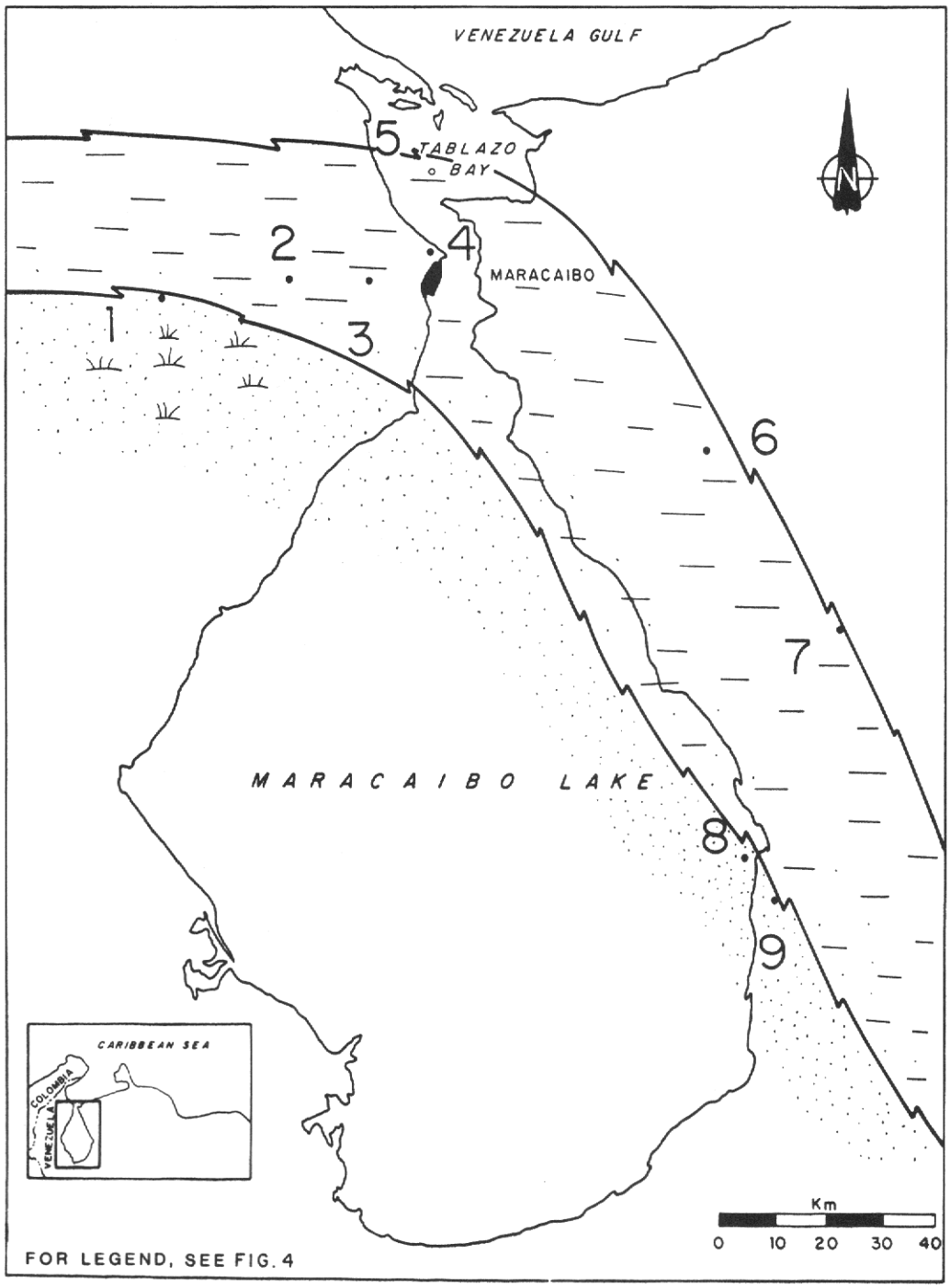
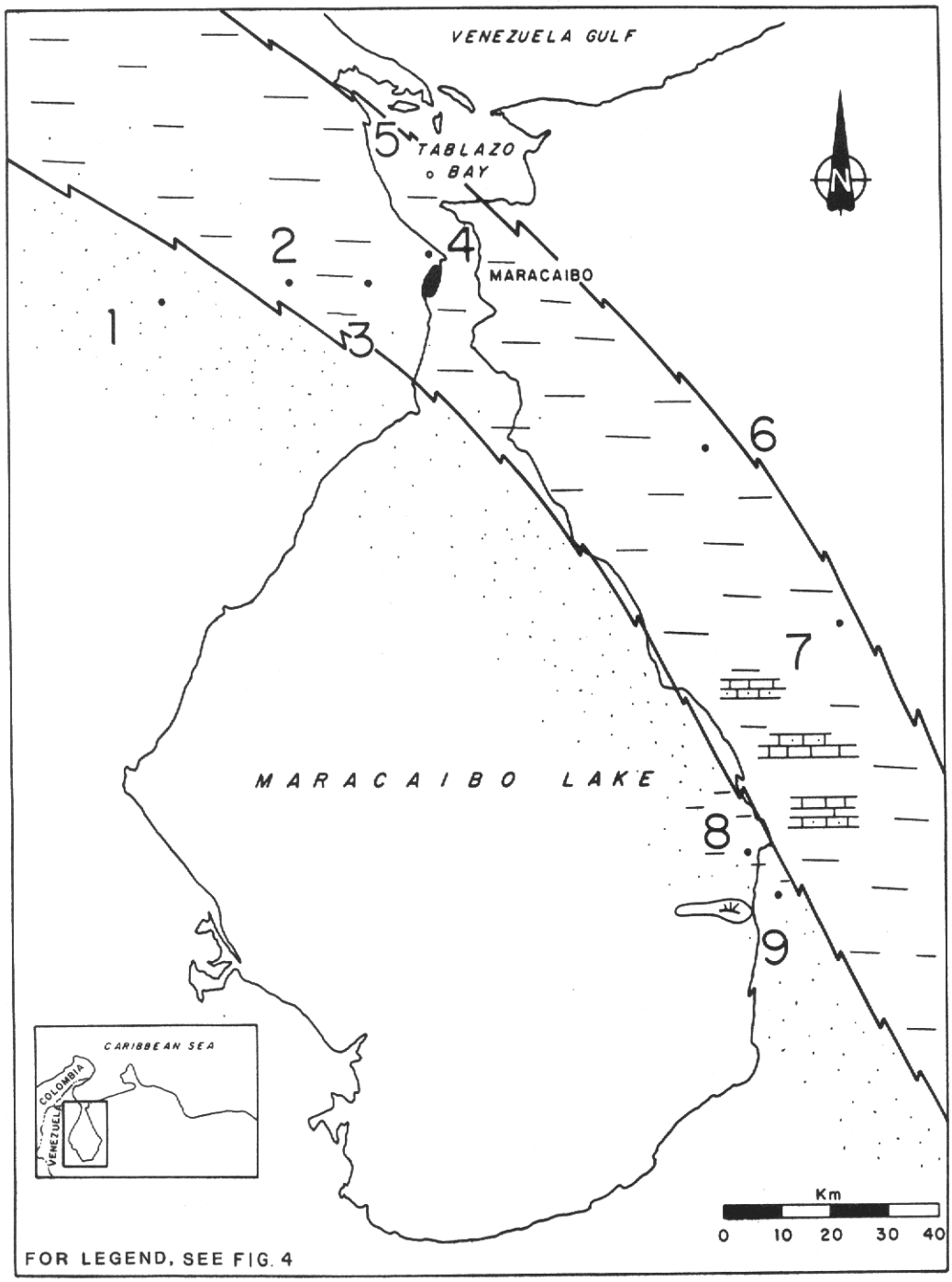


FIG.6 MIDDLE EOCENE: P12-P13



Depositional environment: This assemblage is typical of outer neritic to upper bathyal deposits.

Geographical distribution: It is found in La Concepción, Sibucara and Tablazo area Wells 2, 3, 4 and 5 (Fig. 3).

Stratigraphic position: The assemblage is typical of the Trujillo Formation. It is absent in all the other formations but toward the southeast is present in the lowermost portion of the Misoa Formation. (Fig. 3).

DISCUSSION OF RESULTS

Time vs variation of assemblages

Most of the biofacies discussed here in, are based exclusively on the presence of mostly shallow, brackish-water assemblages of species with no time-stratigraphic significance; because they are environmentally controlled, notably variations in age at different sites within the basin could occur. Exceptions are the faunal marine assemblages, which appear to represent reasonably reliable chronostratigraphic in situ units. Based on the sparse planktonic foraminifera data and palinological biostratigraphy (Barbeito et al, 1985), I correlated the evolution in time of the defined biofacies. According to that scheme, I conclude that the oldest (Zone P9-P10) and shallowest sediments are in the NW, La Paz area (Fig 3).

Paleogeographic map:

In order to clarify the distribution of the several sediment types, I constructed three paleogeographic maps, based on palynological studies (Muller J. et al., 1987) and micropaleontological studies (Pittelli R., 1980, 1985, Barbeito P.J. et al, 1985 and Pittelli R. and Molina A., 1989) they are as follows.

Early Eocene Zone P 9 (Fig. 4): Locally swamp deposits and deltaic sediments are present in La Paz and Concepción oil field and toward the southeast (Wells 8 and 9). The water depth increases gradually to the northeast up to bathyal water depth. A valid exploration target may lie in deltaic sandstones. Sands are apparently absent in the Tablazo and Mene Grande area (Wells 5, 6, and 7).

Middle Eocene Zone P 10 - P 11 (Fig 5): Represents a marine invasion up to Concepción and Sibucara oil fields, with deepest conditions persistently in Tablazo and Mene Grande area. In Wells 1, 8 and 9 deltaic environments are still developed, therefore this is the best area for exploration target; Misoa Formation, Trochammina Assemblage and Trochammina-Haplophragmoides Assemblage.

Middle Eocene Zone P 12 - P 13 (Fig. 6): Stable conditions took place, the marine environment persisted to the north of Wells 1, 8 and 9. Some carbonate sediments are developed in the southeast of the studied area. The most important sands for exploration target are localized in Wells 8 and 9; Misoa Formation, Trochammina-Haplophragmoides Assemblage and Quinqueloculina-Agglutinated Foraminifera Assemblage.

CONCLUSIONS

Five biofacies recognized in the area permitted to determine shallowing-upward sequences between the Trujillo and Misoa formations, and deepening-upward sequences between the Misoa and Paují formations (Fig. 3).

The oldest and shallower sediments are in the La Paz oil field, toward the northwest of the studied area.

Main changes recognized within the Misoa Formation, probably are related to the sediment supply and eustatic changes.

The sediment supply tendency was southwest-northeast.

Relating the biofacies changes to the sedimentary environments and to sands distribution, we can predict facies changes and consequently sandy reservoir limits.

Acknowledgments

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