PUBLICACIÓN DEL
ANUARIO MEXICANO DE DERECHO INTERNACIONAL

WESTERN POLYGON PROJECT*

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C O N T E N T S

I. OBJECTIVE

Define the geological characteristics of the Western polygon to evaluate its potential oil resources.

II. BACKGROUND

On the occasion of the negotiation and execution of the treaty on maritime limits between Mexico and the United States of America in 1978, the American Association of Petroleum Geologists (AAPG), proposed in 1979 a modification to the mari-

* This work is the result of the research conducted for the negotiation of the Treaty on the Delimitation of the Continental Shelf in the Western Region of the Gulf of Mexico beyond 200 nautical miles.

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time delimitation agreement between both countries, which suggested a change in the limits for the treaty talks of 1978, due to the oil potential they supposed for this portion of the Gulf of Mexico basin (see Figure 1 on the next page).

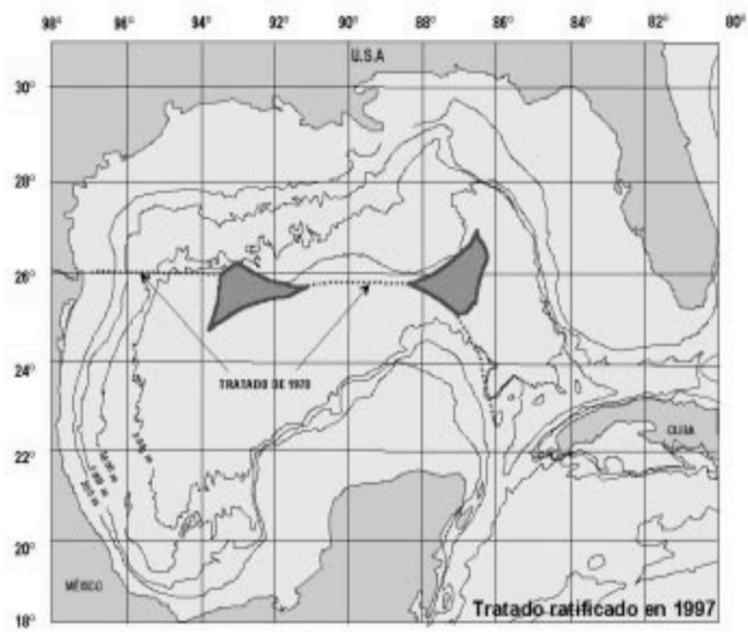


Fig. 1

According to this proposal, a large part of the areas of the Abyssal Plain, bounded by the 3,000-meter isobath, a portion of the Perdido Fold Belt, the Sigsbee Mounds, a part of the Sigsbee Escarpment, and part of the continental shelf would be in international waters, and therefore they would have to negotiate with Mexico.

As a result of this proposal, the USA Senate deferred the execution of the Maritime Boundary Treaty between Mexico and the United States of America and two years later, in 1981, the Department of the Interior of United States of America made through the Geological Service of this same country a regional study to assess the oil potential in the areas proposed by AAPG. This study was called "The Region of the Maritime Border in the Center of the Gulf of Mexico".

The region evaluated in that study was divided into six areas based on its geological characteristics (see Figure 2 on the next page):

1. Abyssal plain
2. Bank of the Rio Grande
3. Perdido Fold Belt

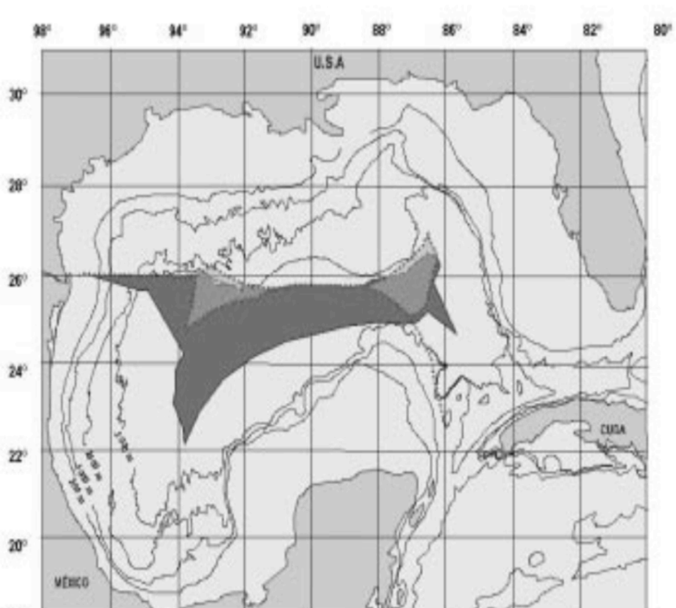
4. Sigsbee escarpment
5. Sigsbee mounds
6. Campeche escarpment

These areas are in water depths that vary from 30 m to 3,750 m, with more than 75% of the total surface under water depths that exceed 3,000 m.

It should be noted that the six areas evaluated in said study, as illustrated in Figure 2, constitute only a portion of the geological provinces to which they are referred.

The results of such a study were published by AAPG in 1983, where it is indicated that the volumes of hydrocarbons in situ are estimated based on a geological analysis and a probabilistic methodology.

The estimated potential as mean values in said study is presented in Figure 2. Regarding these estimates, it is pertinent to note that oil and gas volumes in situ refer to all oil that there may be in the porous spaces of the accumulating rocks, without considering what fraction can or could be produced (reserves) and without considering economic or technological limitations. As a reference of this in situ estimate, the United States Geological Survey quotes that in this country approximately 32% of the oil in situ can be produced, while 80% of the gas in situ can be recovered.



···· Tratado de 1978

Propuesta de American Association of Petroleum Geologist (A.A.P.G.) 1979

Fig. 2

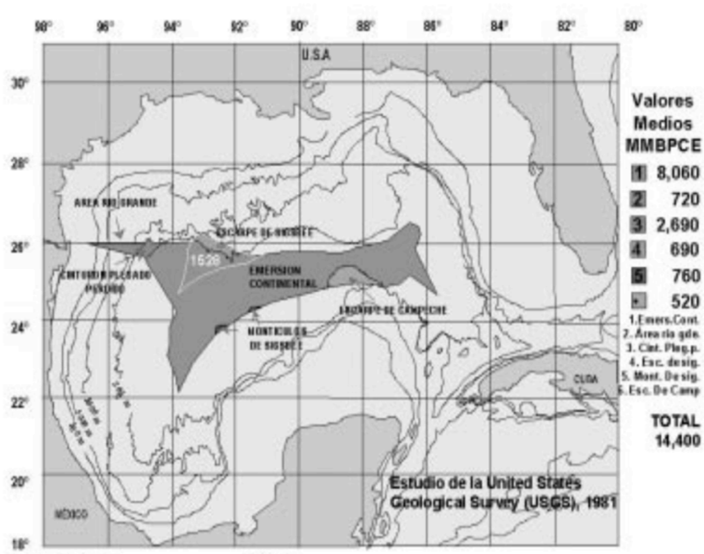
After that study, the USA Senate kept interrupted the execution of the treaty of 1978, and it was not until November 1997 that the treaty was ratified, so the limits remained as they had originally been agreed upon (see Figure 3 on the next page), the negotiation of the areas that are known as "Western Polygon" and "Eastern Polygon" was still pending.

In 1998, Mexico and the United States of America began talks to establish the boundaries between both countries in the Western Polygon. For this purpose, Petróleos Mexicanos was entrusted with carrying out a study of the oil potential of the area, and in this work the results obtained are shown.

III. GENERAL ASPECTS

The Western Polygon is located in the central part of the Gulf of Mexico between parallels 2630 and 2430N and meridians 9045 and 9400W and it has an area of 16,700 km, corresponding mostly to the Abyssal Plain (87%) and a small portion to the Sigsbee Escarpment (13%) and it is located in water depths that vary from 2,100 m to 3,700 m (see Figure 4 below p. 93).

In order to have a good image of the geological characteristics of the subsoil, it is necessary to have the good quality seismic information of reflection. The procedure used in this case was to use the most advanced technology and the results were of high quality.



5000 pcg = 1 BPCE

Fig. 3

"Región de la Frontera Marítima en el centro del Golfo de México"

In the area of the Western Polygon, there are 2,300 linear km of two-dimensional seismic information; 980 km obtained from the Company Tensor Geophysical Services (TGS), which is engaged in doing acquisition of seismic data worldwide; complemented with part of a regional seismic work carried out by Pemex, Exploracion y Reproducción, in the September-November quarter of 1998 (see Figure 5 below p. 94), which consisted in the survey of 3,000 linear km, of which a grid of 18 seismic lines, totaling 1,300 linear km covers the entire polygon, with an average spacing between lines of 20 km and a recording length of 12 seconds. The latter is equivalent to recording depths in the subsoil of more than 14,000 meters below sea level (mbsl).

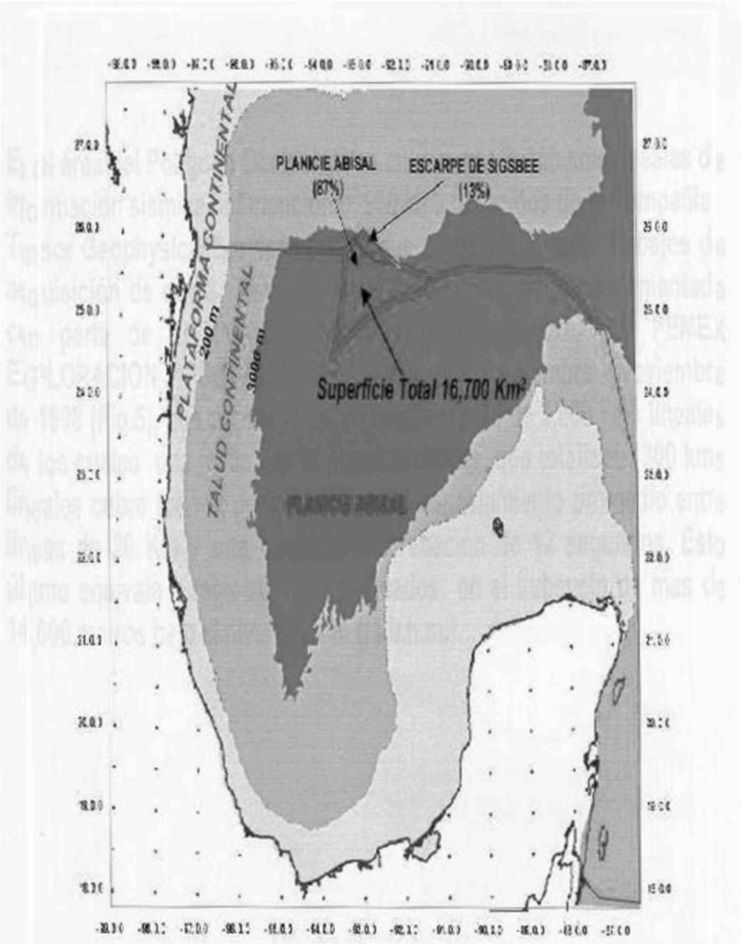


Fig. 4

IV. REGIONAL GEOLOGICAL FRAME

The area is characterized by two predominant features (see Figure 6 on the next page):

- The Sigsbee Escarpment that is a prominent physiographic feature that extends west-east in the northern portion of the polygon and the Abyssal Plain that occupies the rest of the area.
- The escarpment was formed by the ascent and subsequent lateral advance during several tens of kilometers towards the south, of a great saline mass of the Jurassic age. In this movement, it intruded to sediments of the Mesozoic, Tertiary and Quaternary ages.
- The Abyssal Plain is found in water depths greater than 3,000 m and is characterized by a sedimentary sequence of more than 10,000 meters thick, essentially flat, without important structural deformations. The 6,000 m at the top correspond to sediments sandy-clayey from the Tertiary age and more than 4,000 m at the bottom to calcareous-clayey sediments from the Mesozoic age.

V. GEOLOGICAL COLUMN

The sedimentary column of the Western Polygon area varies from the Jurassic age to the Recent age and it is made up of five sedimentary sequences that are below an igneous basement (see Figure 7 below p 97).

This column is the result of the geological evolution of the Basin of the Gulf of Mexico and it is characterized by deep-sea sediments.

In accordance with the regional seismic-stratigraphic correlation performed in this study, the sedimentary sequences correspond to the units known as:

- Challenger, from the Middle Jurassic-Middle Cretaceous age, made up of clayey limestone.
- Campeche, from the Late Cretaceous-Paleocene age, which is subdivided in two segments: a lower segment of the Upper Cretaceous age formed by a clay-calcareous sequence, which marks the end of the presence of carbonated sedimentation; and an upper segment from the Paleocene age formed by sandstones and turbidite lutites that determine the beginning of the presence of siliciclastic sedimentation.
- Mixed Mexican ridges from the Pliocene age, formed by lutites and turbiditic sands, which in the northern portion of the polygon are intruded by salt masses from the Middle Jurassic age.

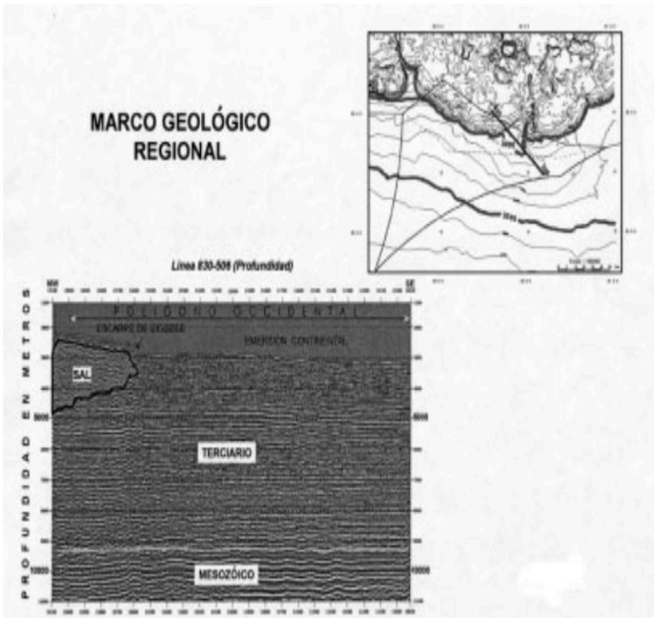

MARCO GEOLÓGICO
REGIONAL
PROFUNDIDAD EN METROS
POLIGONO OCCIDENTAL
EMERSION CONTINENTAL
SAL
TERCIARIO
MESOZÓICO

Fig. 6

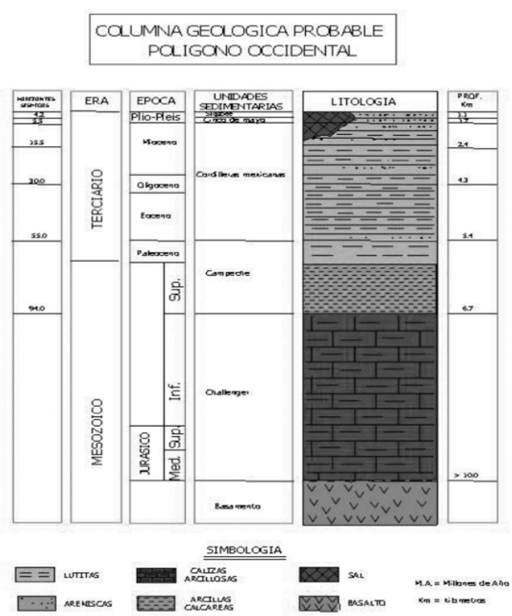

COLUMNA GEOLOGICA PROBABLE
POLIGONO OCCIDENTAL
ERA
EPOCA
UNIDADES SEDIMENTARIAS
LITOLOGIA
TERCIARIO
MESOZOICO
Plio-Pleis
Oligoceno
Eoceno
Paleoceno
Sup.
Inf.
JURASICO
Sup.
Med.
Cordilleras mexicanas
Campeche
Challenger
Basamento
SIMBOLOGIA
LUTITAS
ARENISCAS
CALIZAS ARCILLOSAS
ARCILLAS CALCAREAS
SAL
BASALTO

Fig. 7

- Sigsbee from the Pliocene Pleistocene age, formed by sequences of lutites and turbiditic sands, which, like Cinco de Mayo, are intruded by salt masses.

VI. INTERPRETATION

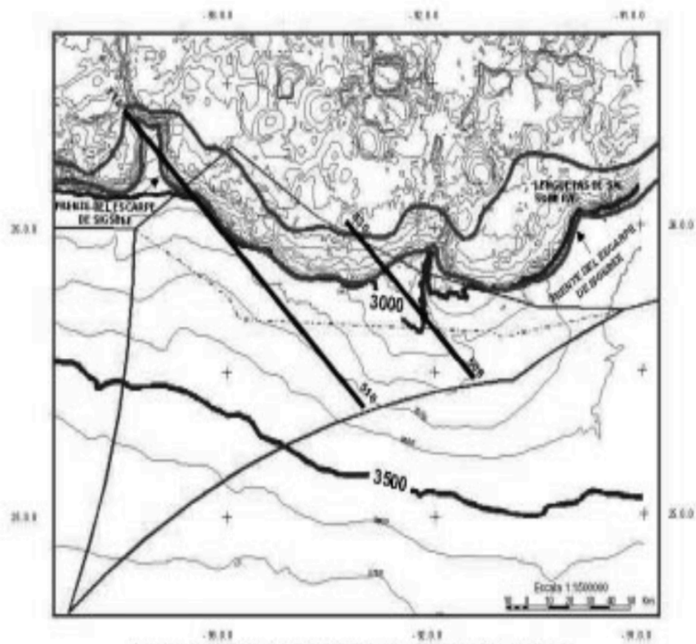
In order to clarify the idea that below the saline mass of the Sigsbee Escarpment there are different geological oil conditions in comparison to the rest of the polygon, which made people think of the idea that in that region there are large structures capable of storing huge quantities of hydrocarbons, seismology was used as the largest of the subsoil conditions.

For the elaboration of this study, all the lines were interpreted and the most representative were selected to be included in this document, that objectively show the geological characteristics of the Western Polygon area (see Figure 8 on the next page). These lines are presented in time and in depth to compare the effect that causes the presence of salt in the reflections below it. Likewise, the maps configured in depth of the Challenger Unit and the High Mexican Mountain Ridge Unit to show the structural geological behavior of a regional nature and its oil implications are included.

VII. LINES IN TIME

In a regional manner, seven seismic horizons that correspond to the limits of sedimentary units were interpreted.

These horizons show two important features, one of them is the presence of relatively horizontal seismic reflectors with good continuity associated with the Abyssal Plain and the other important feature is related to the presence of large salt masses near the sea bottom, under which the image quality of the reflectors and their position are strongly influenced by the relief of the sea bottom and by the saline bodies themselves. This influence is due to the fact that high-speed transmission of seismic waves in salt causes that the reflectors below, give the appearance that there are geological structures. However, the analysis of the characteristics of the seismic reflectors in both sectors allowed identifying and correlating said events.



LINEAS SISMICAS EN TIEMPO Y EN PROFUNDIDAD
Fig. 8

VIII. IN-DEPTH LINES

With the purpose of obtaining an image of the subsoil in which the seismic effects caused by the presence of salt, and the relief of the marine bottom are eliminated, the seismic information was processed to obtain in-depth lines. The processing consisted of eliminating the effect of the speed of the body of salt that is between 1000 and 2000 m thick, which caused a rise of the reflectors in time. For this, the seismic velocities corresponding to each type of rock were used.

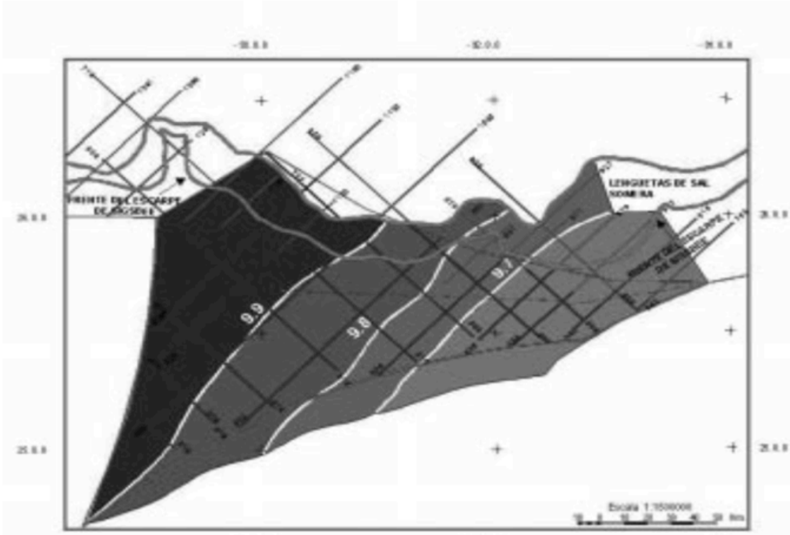
The result is the disappearance of the false subsaline structures and it implies that the structural conditions of the rocks of the Abyssal Plain extend below the Sigsbee Escarpment in the northern part of the Western Polygon. And, therefore, it is concluded that the entire area of the polygon has geological uniformity and has the same characteristics of the Abyssal Plain.

IX. DEPTH CONFIGURATION MAPS OF THE CHALLENGER UNITS AND THE MEXICAN MOUNTAIN RIDGE

The maps configured in depth were generated from the interpretation of the seismic in-depth lines available.

1. Challenger Unit Map

On this map (see Figure 9 on the next page), a structural behavior without deformations is observed; this shows a gentle upward trend from the northwest part to the southeastern part of the area, with a variation of depths from 10,000 mbsl to 9,700 mbsl.



MAPA DE CONFIGURACION EN PROFUNDIDAD (KILOMETROS)
HORIZONTE CHALLENGER (94 m.a.)
INTERVALO A C/100 METROS
Fig. 9

Considering these depths, the absence of structures, the water depth of more than 3,000 m and the probable high-degree of compaction of the Mesozoic clay-calcareous rocks, these are of little oil interest.

2. High Mexican Mountain Ridges Unit Map

Here, it is possible to observe that the structural behavior is maintained relatively flat, with a gentle downward trend that goes from the northwest portion to the southeast portion, with a variation in depth from 3,800 to 4,600 m. Such conditions involve absence of large structural traps capable of containing hydrocarbons and that in the case of existing traps, these would be strategic.

X. PETROLEUM GEOLOGY

In the Gulf of Mexico Basin, it has been shown that there are four geological horizons generators of hydrocarbons located in: the Jurassic, the Cretaceous, the Eocene and the Miocene. These four horizons were identified within the area of the Western Polygon at depths, which vary between 4,000 and 8,000 m under the sea bottom.

At the Tertiary level, the geological evolution of the basin makes it possible to assume that up to five sandy-clayey sedimentary units with characteristics to constitute hydrocarbon storage rocks at depths that vary between 800 and 3500 m under the sea bottom could be found.

These possible storage rocks would form probable stratigraphical traps where the possible seals would be interstratified clay rocks.

Structurally, the Tertiary interval is affected by faults that could give rise to small stratigraphic-structural traps.

XI. EVALUATION OF POTENTIAL OIL RESOURCES

The evaluation of the oil possibilities of an area requires to analyze and define the components of the oil system, which are:

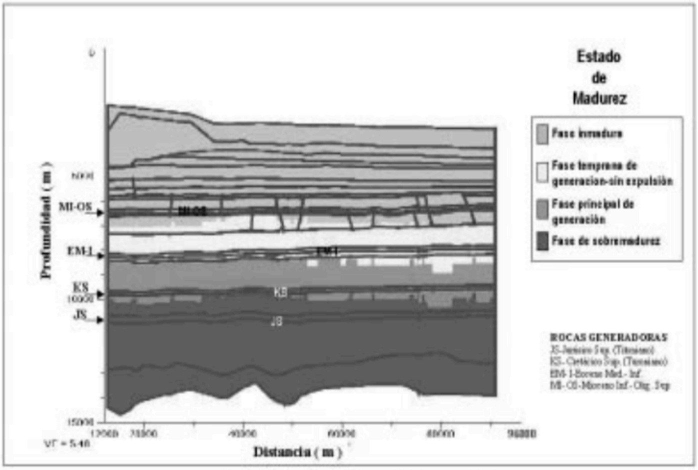
- Presence of hydrocarbon generating rocks.
- Presence of porous and permeable storage rocks.
- Presence of traps and seal rocks.
- Migration and synchronization of all the components.

XII. MASS BALANCE METHOD

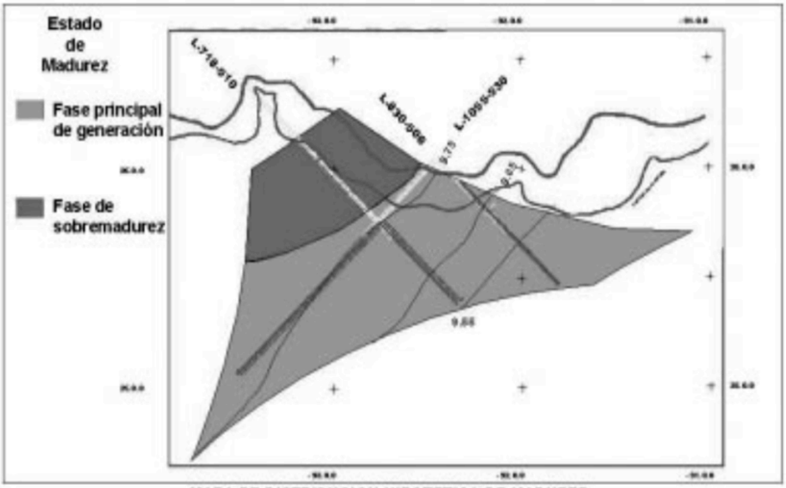
For the estimation of potential oil resources in the Western Polygon, the mass balance method was used. This method is based on the reconstruction of the transformation process of organic matter of hydrocarbons; due to the thermal evolution of the basin, supported by the "BasinMod" software for the two-dimensional geological-geochemical modeling process of the generation-migration of hydrocarbons, applied to three regional seismic lines in depth.

As a result, it could be established that the current thermal state of the Jurassic rocks, potentially generative, is overmature and its hydrocarbon generation potential has been exhausted. Finally, the Eocene rocks are in an initial stage of maturity without expulsion, and those of the Oligocene-Miocene are immature, as observed in the example shown for the case of the 830-506 seismic line (see Figure 10 on the next page). In accordance with the abovementioned, it is stated that it is the rocks of the Upper Cretaceous that have probably generated significant volumes of hydrocarbons in most of the area, which is deduced by looking at the maturity distribution map for this stratigraphic interval (see Figure 11 on the next page).

Using representative parameters of the already known areas of the Basin of the Gulf of Mexico, in terms of the content of organic matter and its transformation percentage, it has been calculated that the hypothetical volume of liquid hydrocarbons expelled in the Western Polygon could be 20,226 mmbls and the hypothetical volume of gas expelled could be 10,067 mmm3. Therefore, the amount of hydrocarbons expelled reaches a total of 20,300 mmbpce. However, the international experience has shown that the maximum migration efficiency, i.e. when the traps are immediately above the active generating rocks, does not exceed 30%. Therefore, in the optimal case, the maximum estimated potential resources would be 6,090 mmbpce.



MODELO HIPOTETICO DE MADUREZ ACTUAL
LINEA SISMICA 830-506
Fig.10



MAPA DE DISTRIBUCION HIPOTETICA DE MADUREZ
ROCA GENERADORA DEL CRETACICO SUPERIOR (TURONIANO)
Fig. 11

On the other hand, in the event that possible accumulating rocks are not close and hydrocarbon migration routes are scarce, a minimum migration efficiency that internationally has a value of 5% would be applied, thus the potential resource would be of 1015 mmbpce. Based on the above, it was estimated that the average volume of the potential resource is 2,500 mmbpce.

XIII. TRANSBOUNDARY DEPOSITS

Due to the geologic uniformity that exists in the area of the polygon, the estimated volume could be distributed in transboundary deposits, as exemplified by the theoretical model of Figure 12 found on the next page.

Transboundary deposits are common in certain parts of the world, as in the North Sea, where Norway shares oil fields with the United Kingdom (see Figure 13 on the page following the next page).

XIV. CONCLUSIONS

As a result of this study, the following conclusions can be postulated:

1. The thickness of the sedimentary column that is uniformly distributed in the Western Polygon is greater than 10,000 m. The upper 6,000 are made up of Tertiary clay-sandy rocks and Mesozoic limestone-clayey rocks.
2. Within the sedimentary sequence, the existence of four rock intervals with hydrocarbon generating potential and five intervals with potentially accumulating rocks is stated.
3. Structurally the area of the Western Polygon is characterized by being essentially flat, not deformed, and therefore without important geological structures. This includes the area below the Sigsbee Escarpment, where the lack of structures that could lead to large hydrocarbon deposits is verified.
4. Between 5000 and 7500 mbnm, small traps of small dimensions associated with normal faults that could contain hydrocarbons are observed throughout the area of the polygon.
5. The results of the hydrocarbon estimation or quantity of hydrocarbons available to be accumulated in the area of the Western Polygon based on the mass balance method, indicate a potential average resource of 2,500 mmbpce.
6. If the results of the western polygon's oil potential are compared with those of other border areas of the Gulf of Mexico, the low potential of the Western Polygon is evident.

7. Considering that the geological-oil characteristics are uniform throughout the area of the polygon and that the possible deposits of hydrocarbons would be of a stratigraphic type, associated with the sedimentation patterns of the Tertiary age, it is necessary to consider the very high probability of the existence of transboundary deposits.

Fig. 12

EJEMPLOS DE YACIMIENTOS TRANSFRONTERIZOS
EN EL MAR DEL NORTE

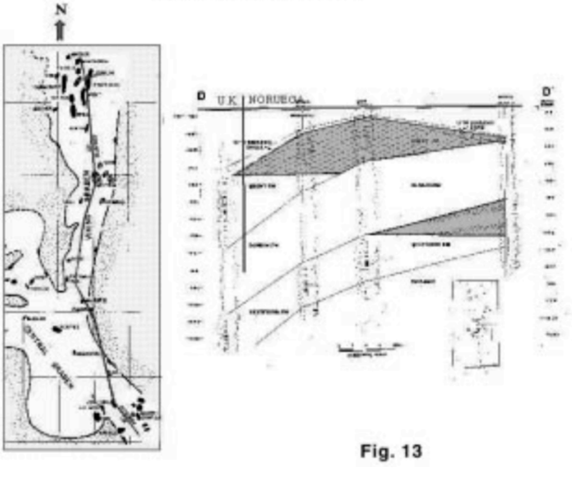


Fig. 13