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THE GULF OF MÉXICO BASIN SOUTH OF THE BORDER, *the* PETROLEUM PROVINCE OF THE 21ST CENTURY[1]

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ABSTRACT

The mexican part of the Gulf of México basin proper (MGOM) extends onshore into several oil and/or gas producing basins: **Burgos**, **Tampico - Misantla**, **Veracruz** and **Sureste;** the latter includes the: **Salina del Istmo**, **Comalcalco - Chiapas - Tabasco, Macuspana, Sonda de Campeche** and **Litoral de Tabasco** provinces. To the east, the MGOM includes the non-producing **Plataforma de Yucatán**. The deep water Gulf of México has been subdivided into eight provinces: **Franja Distensiva**, **Delta del Río Bravo**, **Franja de Sal Alóctona**, **Cinturón Plegado de Perdido**, **Cordilleras Mexicanas**, **Cañon de Veracruz**, **Salina del Golfo Profundo** y **Planicie Abisal**. The general petroleum characteristics of each one of these provinces are described.

INTRODUCTION

The mexican portion of the Gulf of México is limited, to the north by the maritime U.S. – México border, to the west and south by the states of Tamaulipas, Veracruz, and Tabasco, and to the east by the states of Campeche and Yucatán, and the maritime Cuba – México border (fig. 1). Geologically, the mexican part of the Gulf of México basin proper (MGOM) extends onshore (fig. 2) into several oil and/or gas producing basins: **Burgos** to the northwest, **Tampico - Misantla** to the west, and **Veracruz** and **Sureste** to the south; the latter includes three Tertiary provinces formed within the Mesozoic basin: **Salina del Istmo**, **Comalcalco** (which includes the Mesozoic province of **Chiapas – Tabasco**) and **Macuspana** and two offshore Mesozoic provinces: **Sonda de Campeche** and **Litoral de Tabasco**. To the east, the MGOM includes the **Plataforma de Yucatán**, limited by the Caribean. The deep water Gulf of México may be subdivided into eight provinces: **Franja Distensiva**, **Delta del Río Bravo**, **Franja de Sal Alóctona**, **Cinturón Plegado de Perdido**, **Cordilleras Mexicanas**, **Cañon de Veracruz**, **Salina del Golfo Profundo** y **Planicie Abisal**.

In the next few pages we describe, in a succint form, the petroleum geology of the these basins and of the deep water MGOM (>200m depth), with the certainty that a large percentage of the oil and gas that will be produced in the 21st century will come from reserves yet to be found in this megaprovince.

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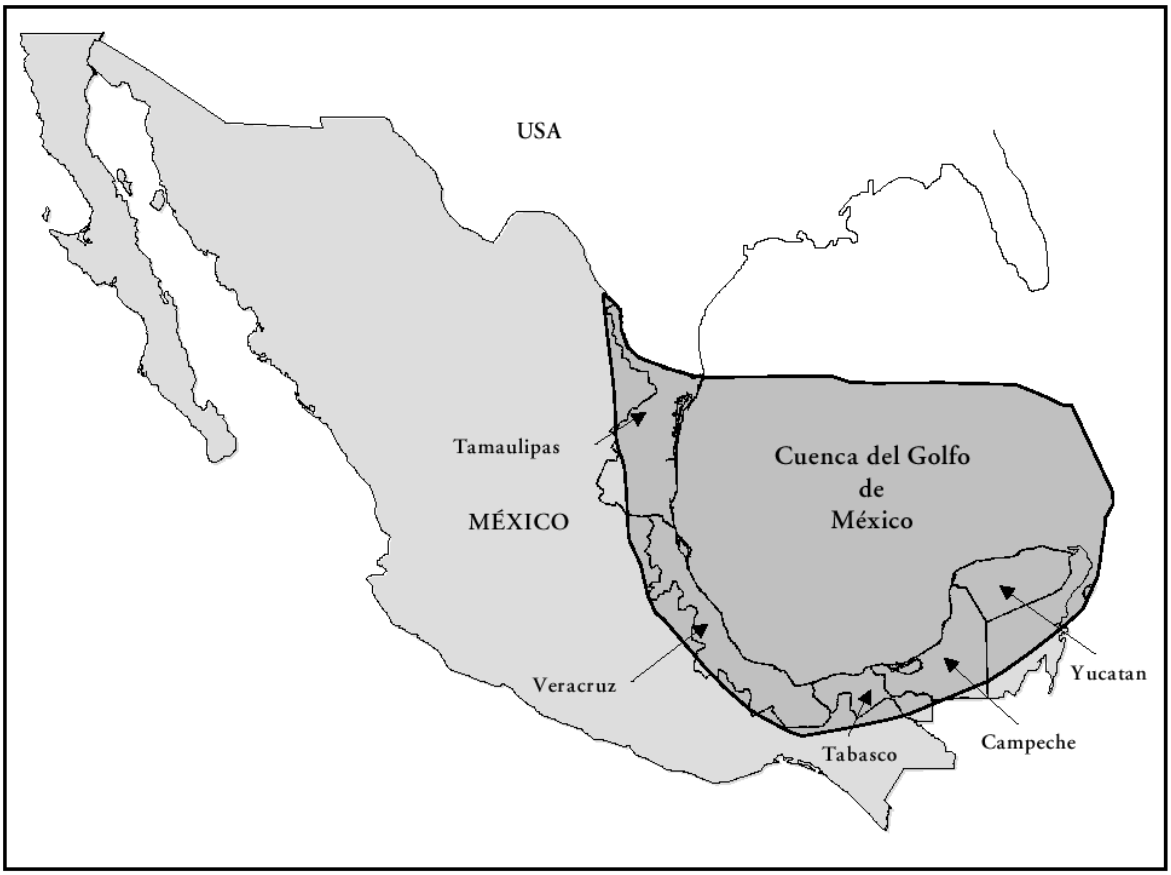


Figure 1. The Mexican portion of the Gulf of México.

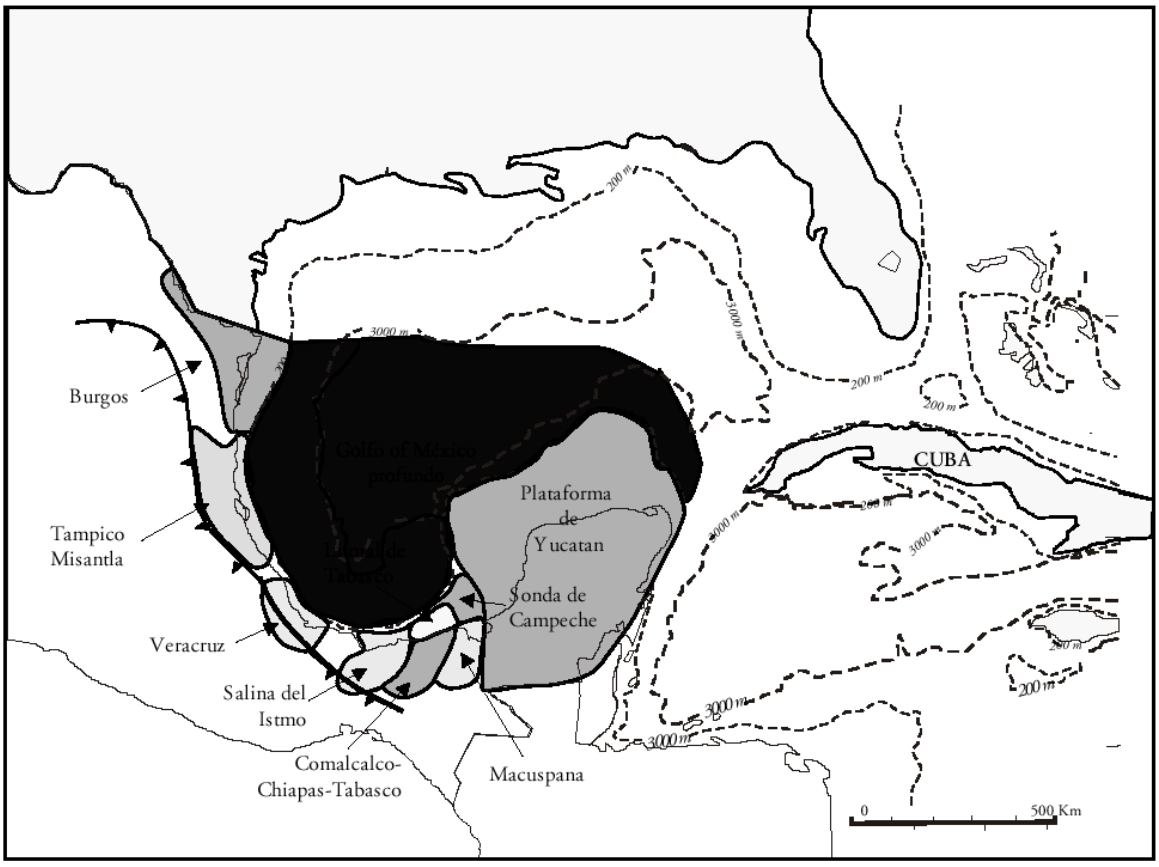


Figure 2. Provinces of the Mexican portion of the Gulf of México basin proper (MGOM).

PETROLEUM GEOLOGY OF THE MEXICAN SECTOR OF THE GULF OF MÉXICO BASIN PROPER

Cuenca de Burgos

Covering some 50,000 km^2 (fig. 3), it´s the northwestern most extension into México of the MGOM, and is a continuation to the south of the Rio Grande embayment of South Texas. It consists of a thick (>10 km) wedge of Paleocene to Miocene siliciclastics deposited in a passive margin under extensional conditions. Most plays are continuous with those of the U.S. side. Production, mainly of non associated dry and wet gas, started in 1945, and since then 185 fields have been discovered, out of which 84 are still active today. Since 1994, through the extensive application of petroleum geosciences, new concepts, and technology, the main fields have been rejuvenated; from a minimum output of 183 mmcfd in late 1993 (after having reached 620 mmcfd in 1970) to over 1,035 mmcfd being extracted at the end of 1999 (fig. 4). Cummulative output is 6,268 bcf and total reserves are 7,352 bcf.

The rejuvenation 15 year plan for the basin, currently under progress, calls for 3D seismic acquisition of 9,850 km^2, the drilling of 186 exploratory wells, the incorporation of 6,750 bcf (P50) of new gas reserves, and the drilling of over 1500 development wells, thus increasing average output to 1,200 mmcfd by 2001, and 1,400 mmcfd by 2004.

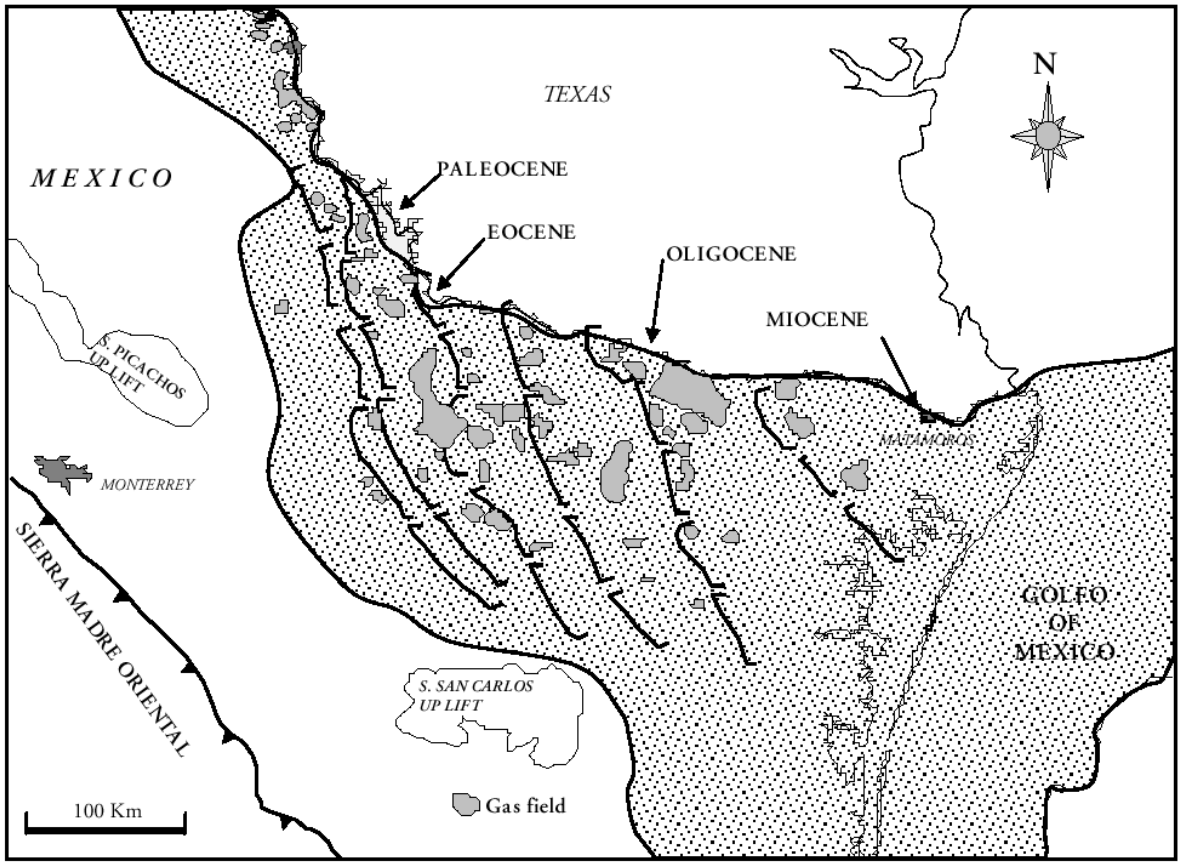


Figure 3. Cuenca de Burgos.

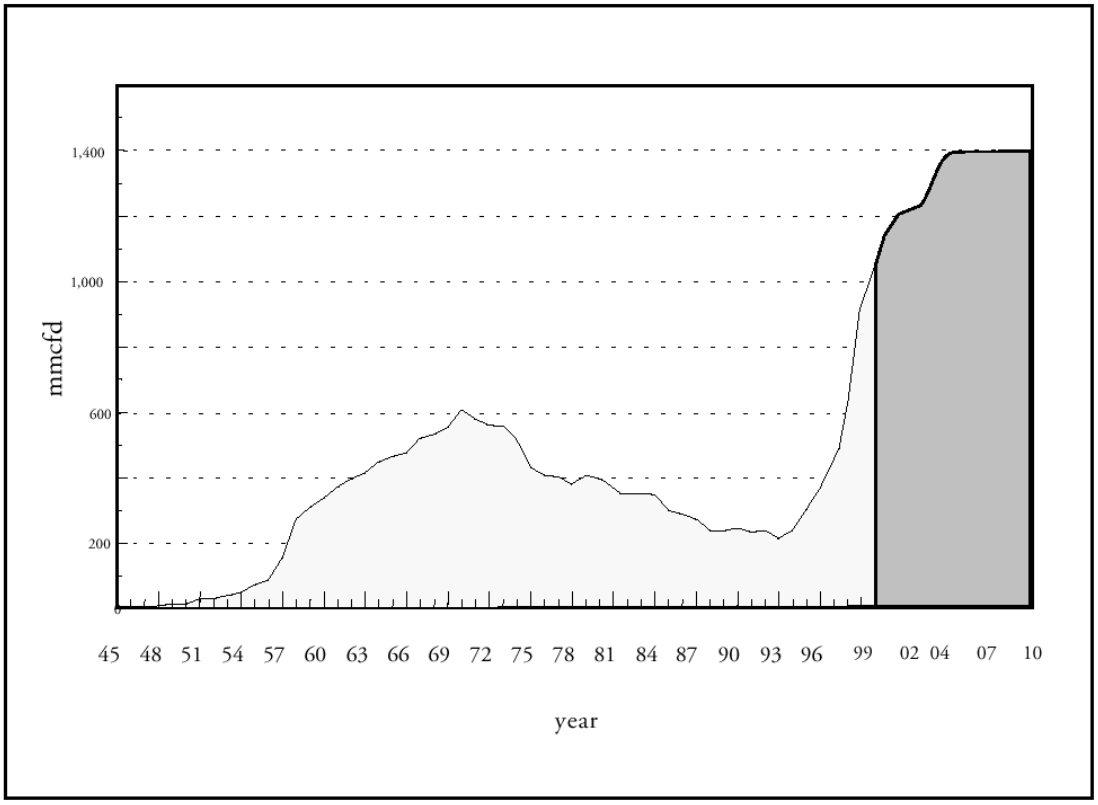


Figure 4. Production profile of the Cuenca de Burgos.

Cuenca de Tampico-Misantla

This basin, which covers some 25,000 km^2 (fig. 5), has been producing mostly heavy oil since 1904 when the renowned mexican geologist Ezequiel Ordóñez discovered, through the application of exploration concepts, the first oil province in México: the Ebano-Panuco district, which has produced over a billion barrels from fractured Late Cretaceous basinal carbonates. The basin also produces from Late Kimmeridgian oolitic carbonates and Early Cretaceous chalks, which in the Tamaulipas-Constituciones, San Andrés and Arenque fields (the latter offshore), have produced 257, 443 and 152 mmboe respectively. In the southern part of the basin production was established in 1908 in what is known as the "Golden Lane", which after the discovery of its southern and offshore extensions has produced over 3,500 mmboe from mid Cretaceous reef facies that surround an atoll developed on the Tuxpan platform (fig. 6). Rimming the fields of the Golden Lane is a second fairway that produces from facies developed as talus debris flows coming from the platform. The Poza Rica field, with a cumulative production of 1,725 mmboe, is the main field in this play.

The basin is presently producing in the order of 90,000 bod, after having reached a maximum of 600,000 bod in 1921. Remnant reserves are 1,727 mmboe, excluding those in the Paleocañón de Chicontepec, described in the next paragraph. Through the use of 3D seismic, many new opportunities have been identified within the traditional producing plays, which have characteristics similar to the producing ones, mostly in the offshore part of the basin, but since the expected product from them is medium to heavy oil, they have been put on hold, waiting for better prices for these products.

The Paleocañón de Chicontepec, spreading 3,000 km^2 on the western side of the Golden Lane (fig.7), developed as a foredeep filled with late Paleocene to early Eocene deep water siliciclastics. The OOIP and OGIP within these rocks are 139,000 mmbo and 49 tcf of gas, with total reserves of 12,324 mmb of oil, 1669 mmb of plant liquids and 28 tcf of dry gas. Plans are being drawn to develop these resources after the year 2000, beguining with the northern sector, rich in light oil. New drilling technology together with 3D seismic and new geoscience concepts such as sequence stratigraphy, have allowed these formerly submarginal resources (only 141 mmboe of cumulative production) to have rates of return attractive enough to warrant their development.

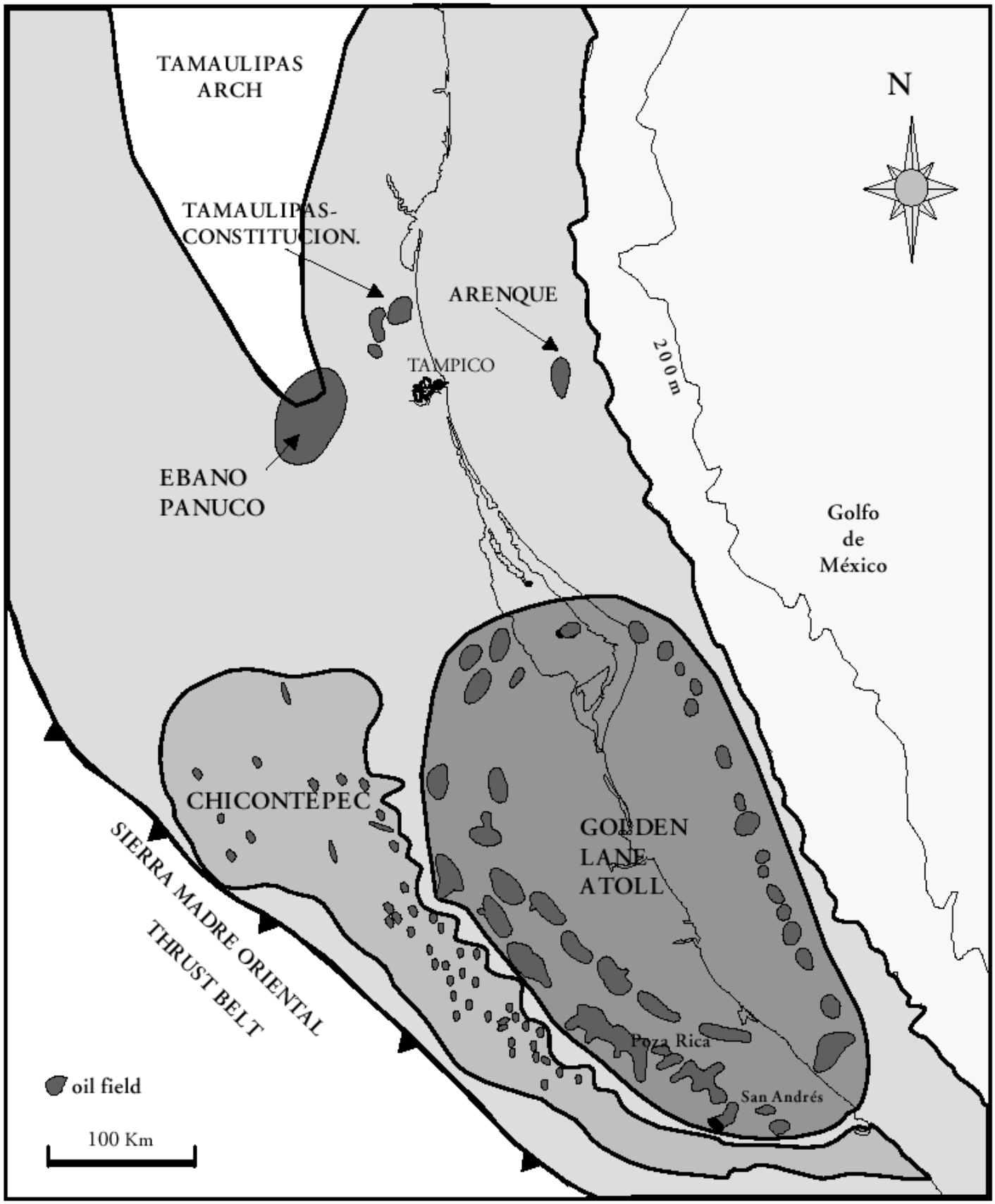


Figure 5. Cuenca de Tampico-Misantla.

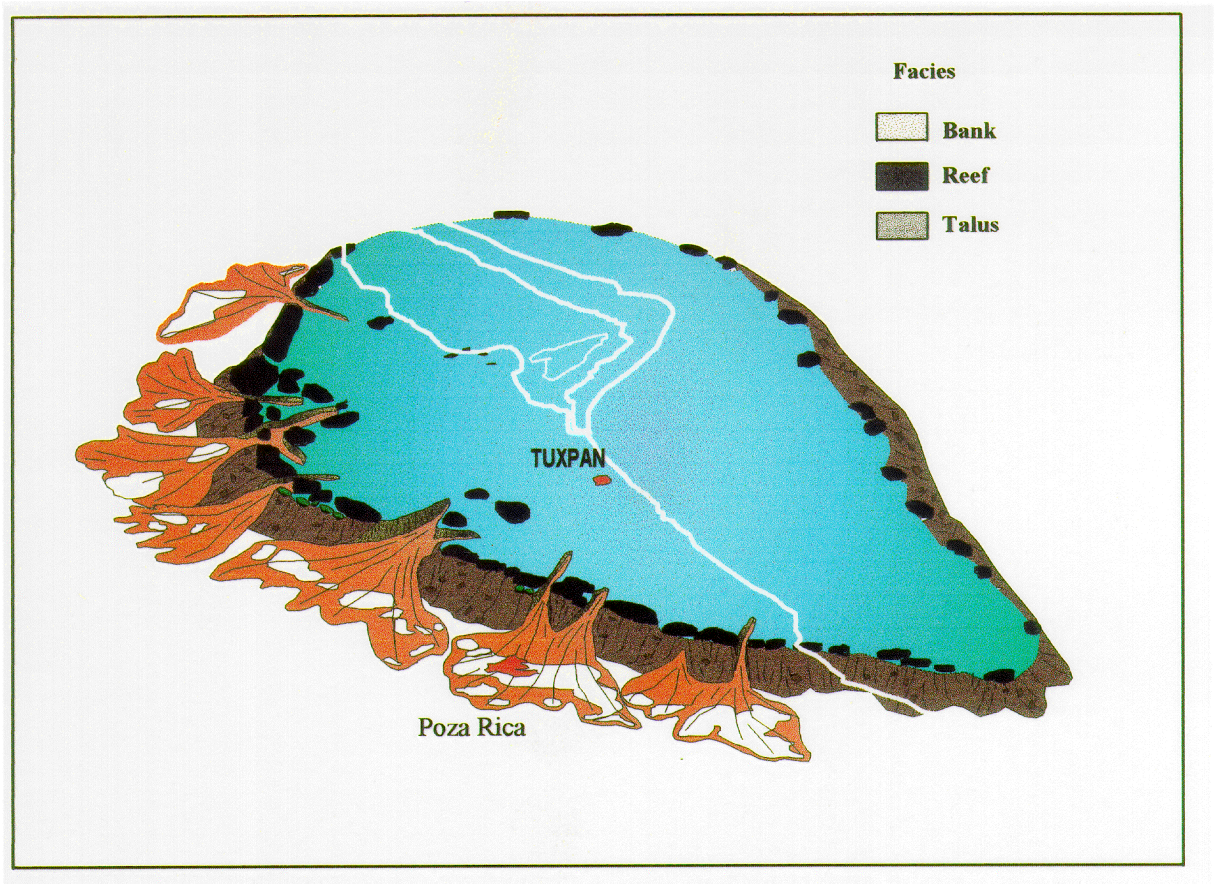


Figure 6. Main plays of the Golden Lane, southern Cuenca de Tampico-Misantla.

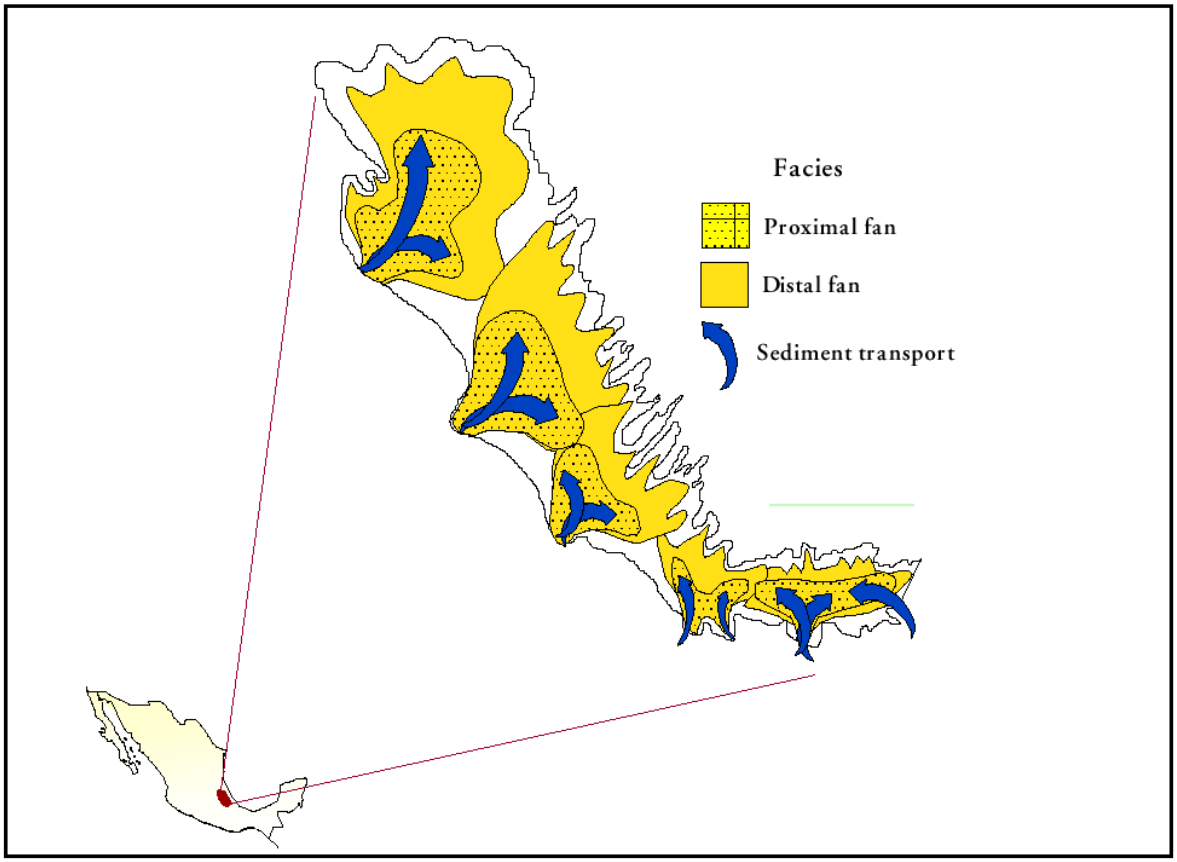


Figure 7. The Paleocañón de Chicontepec.

In the foothills of the Sierra Madre Oriental folded thrustbelt that bounds the Tampico-Misantla basin to the west, and thus the MGOM; a new province is presently being tested that may have a significant impact in the 21st century. This province continues to the south into the Veracruz basin, where it already produces oil and wet sour gas (fig. 8). Using reprocessed old 2D seismic, several attractive shallow structures have been identified, that from old tests and geochemical modelling are expected to be gas prone. Since gas demand in México is expected to rapidly increase in the industrial and electric generation sectors due to environmental concerns and economic growth, non associated gas exploration is being actively favored over other type of hydrocarbons.

Cuenca de Veracruz

This basin has an area of 18,000 km^2. Production started in 1956, since then 15 fields have been discovered in two diferent habitats (figs. 8 and 9):

- The Cordoba platform, the buried leading edge of the Sierra Madre Oriental thrusted foldbelt, consists of mid to Late Cretaceous limestones that produce medium to heavy oil and wet sour gas, from 11 fields which have accumulated 72 mmb of oil and 682 bcf of gas.

- The Tertiary trough, a depocenter filled with syntectonic conglomerates, sands and shales deposited as a result of the Sierra Madre uplift, and deformed by neovolcanic emplacement, has accumulated 136 bcf of dry sweet gas from four fields. These sediments extend offshore, to the continental shelf, where only three wildcats were drilled more than twenty five years ago.

Although total remnant reserves are only slightly over one tcf, through the reprocessing of old vintage 2D seismic, the acquisition of new 2D and 3D, and the application of new paradigms, such as testing low contrast, low resistivity sands; an important number of new opportunities has been identified in both habitats, which has encouraged the integration of ambitious plans to actively explore the gas prone plays of the basin. Particularly attractive are the offshore leads and prospects in the portfolio (fig. 10). The plans call for the aquisition of more than 2,000 km^2 of 3D seismic and 4,500 km of 2D onshore, and the drilling, both on and offshore, of more than 40 exploratory wells, with the expectation of bringing production up to 400 mmcfd by the year 2005, from the 174 mmcfd being produced today.

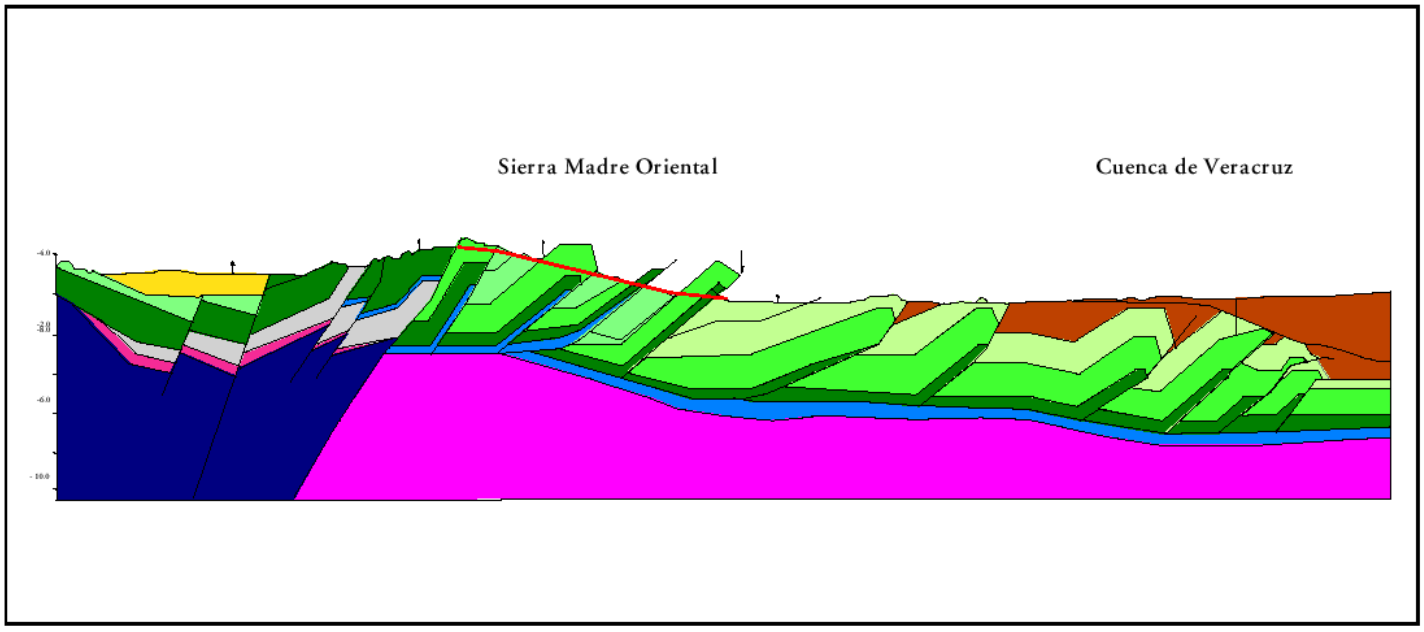


Figure 8. Section through the Sierra Madre Oriental folded thrust belt, producer in the Cuenca de Veracruz.

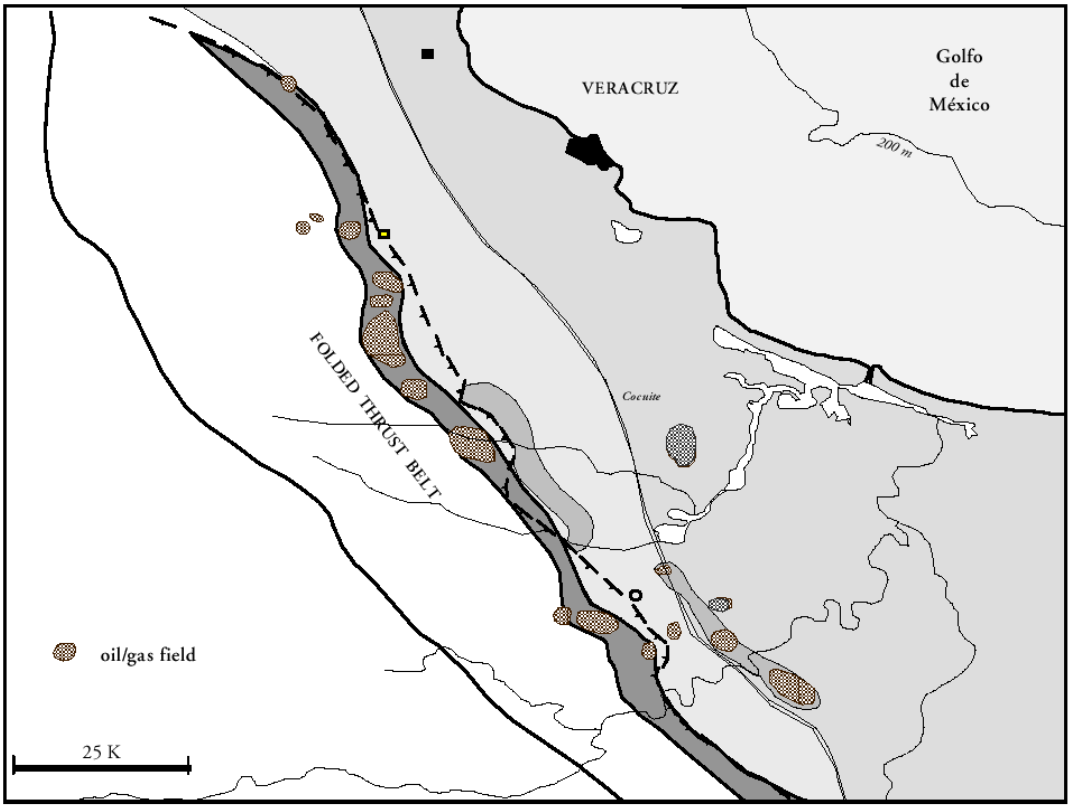


Figure 9. Cuenca de Veracruz.

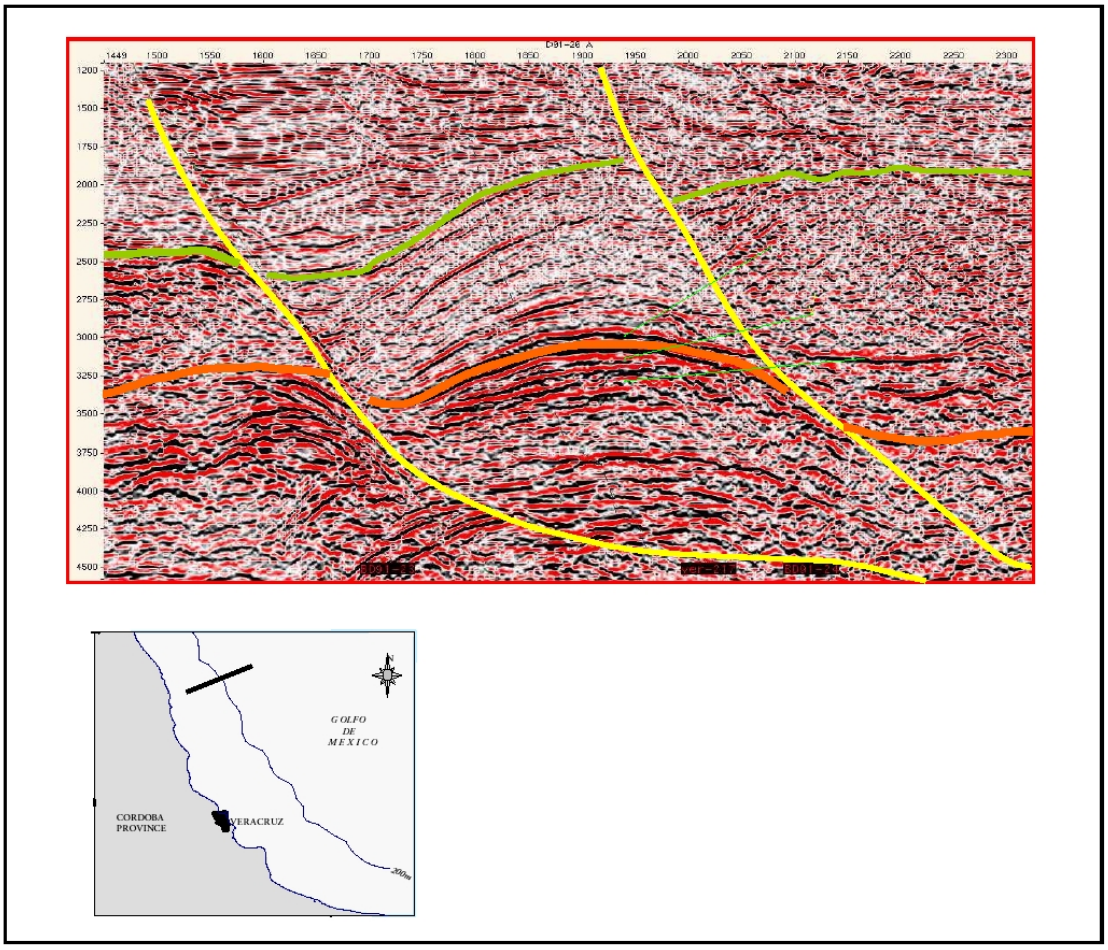


Figure 10. Illustration of conditions offshore Veracruz.

Cuencas del Sureste

These basins, with an extension of 60,000 km^2 (fig.11), have been the main producing area of México since the mid seventies, when the Mesozoic onshore light oil province, commonly known as Chiapas-Tabasco, was discovered. The extremely prolific offshore province known as the Campeche Sound, producer of heavy oil in its northeastern sector, was identified in the late seventies. Since then 7,808 mmb of oil and 21.75 tcf of gas have been produced onshore and 12,212 mmb of oil and 7.55 tcf of gas offshore. Reserves onshore are in the order of 6,047 mmb of oil and 19.6 tcf of gas while offshore they are 21,292 mmb of oil and 14.08 tcf of gas. The southern provinces of these basins are Tertiary depocenters: Salina del Istmo, Comacalco and Macuspana, mostly onshore, being the middle one coincident with the Mesozoic Chiapas-Tabasco light oil province. To the north, the Sureste basins have two distinct Mesozoic offshore provinces: the northeastern, heavy oil, Campeche Sound; and the southwestern Litoral de Tabasco, producer of extralight oil, condensate and gas.

Salina del Istmo

Hydrocarbons have been extracted from the Sureste basins since the early 1900´s, when production was established from shallow Tertiary siliciclastics deposited within the Salina del Istmo, Comalcalco, and Macuspana depocenters. The Salina del Istmo in the western part, with an area of around 20,000 km^2, about half of them offshore (fig.12), as its name implies, is a salt intruded siliciclastic pile that produces light to medium oil from plays that overlay, abut against, or underlay salt of Jurassic origin. Fifty two fields, have been discovered, twenty eight of them still producing in the order of 44 mbod and 54 mmcfd of gas, all except one, from the Tertiary. There are six fields that have produced over 100 mmbo, being Cinco Presidentes the most important one with 285 mmbo and 401 bcfg.

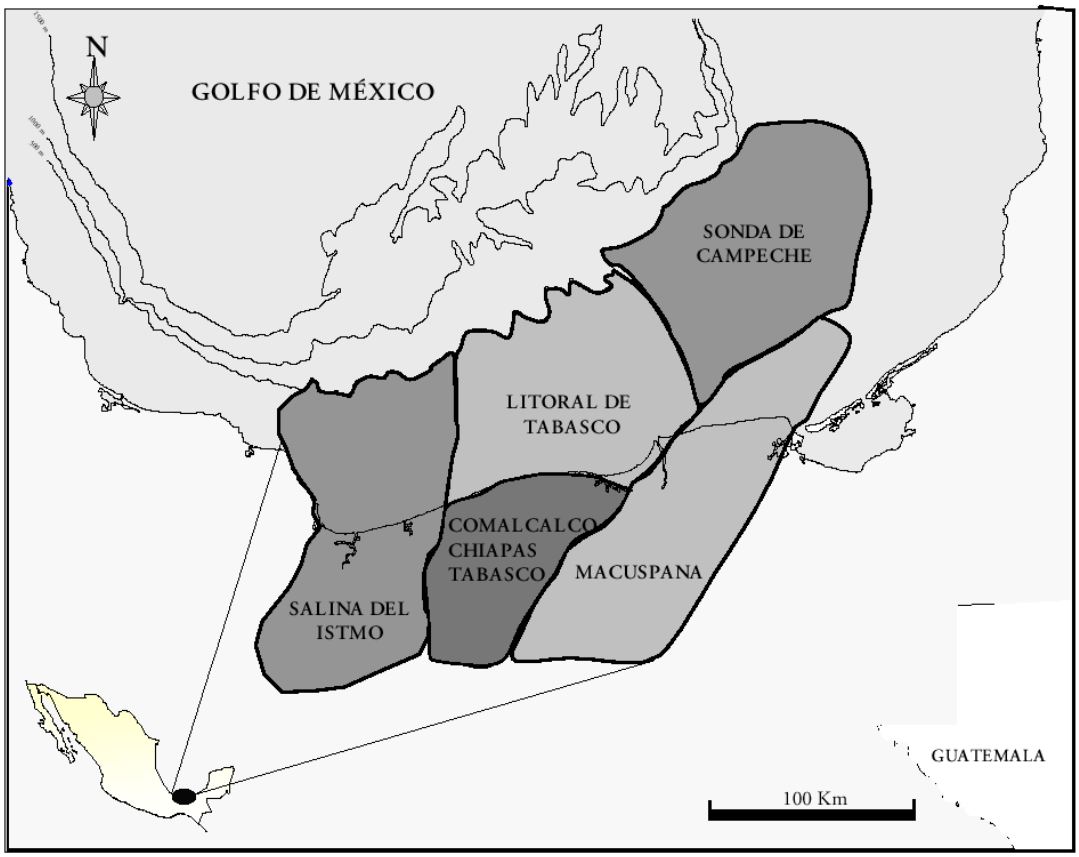


Figure 11. Cuencas del Sureste which include Salina del Istmo, Comalcalco and Chiapas-Tabasco, Macuspana, Sonda de Campeche and Litoral de Tabasco.

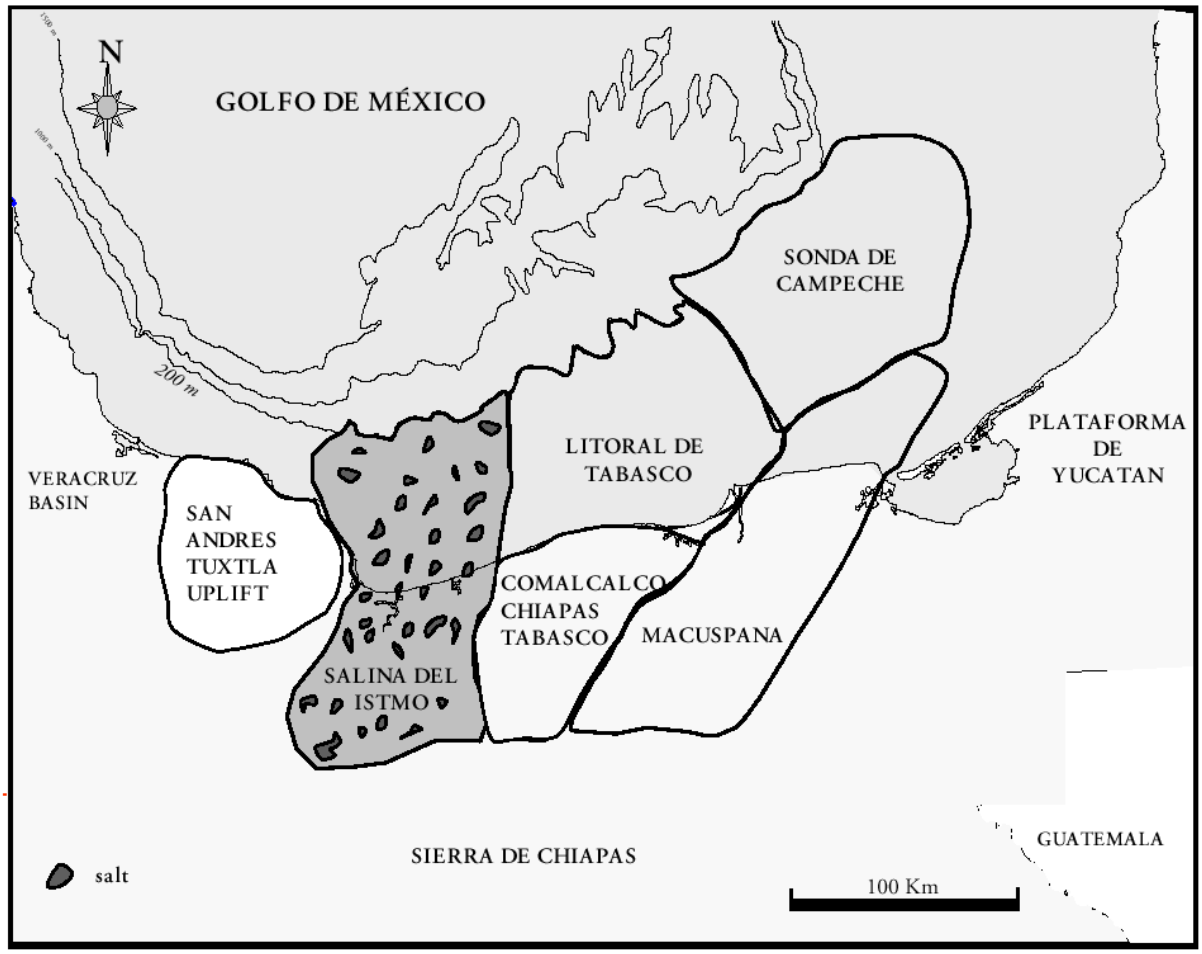


Figure 12. Salina del Istmo province.

Within this Tertiary province of the Sureste basins, through the application of 3D seismic and recently developed concepts of salt emplacement, withdrawal and associated deformation, a large number of new exploration opportunities have been identified, particularly in the offshore extension, which has had very little light oil production. The application of new imaging exploration technology will allow the identification of Tertiary subsalt opportunities, and is expected to aid in the quest for the continuation of production from the Mesozoic, which in this area could have characteristics similar to the ones it has in the neighboring Chiapas-Tabasco area.

Chiapas-Tabasco and Comalcalco

The Mesozoic Chiapas-Tabasco, discovered in 1972 and developed in the mid 1970´s, and the Tertiary Comalcalco provinces, with an area of around 15,700 km^2, correspond to the central part of the onshore Sureste basin (fig.13). The offshore extension is the Litoral de Tabasco area and part of the Campeche Sound. Production comes from 57 fields (out of 75 discovered) most of them in the deep, Late Jurassic to mid Cretaceous carbonates that were deformed by salt movement and Tertiary transpression. Eleven of these fields have accumulated over a 100 mmb of oil, being the most important the Bermudez complex with 2,225 mmb and 2,894 mmcf of gas and Jujo-Tecominoacán with 810 mmbo and 1,049 mmcfg. This region will continue providing important volumes of light to medium gravity oil and associated gas during the 21st century, particularly through the application of production optimization and the identification of exploration opportunities.

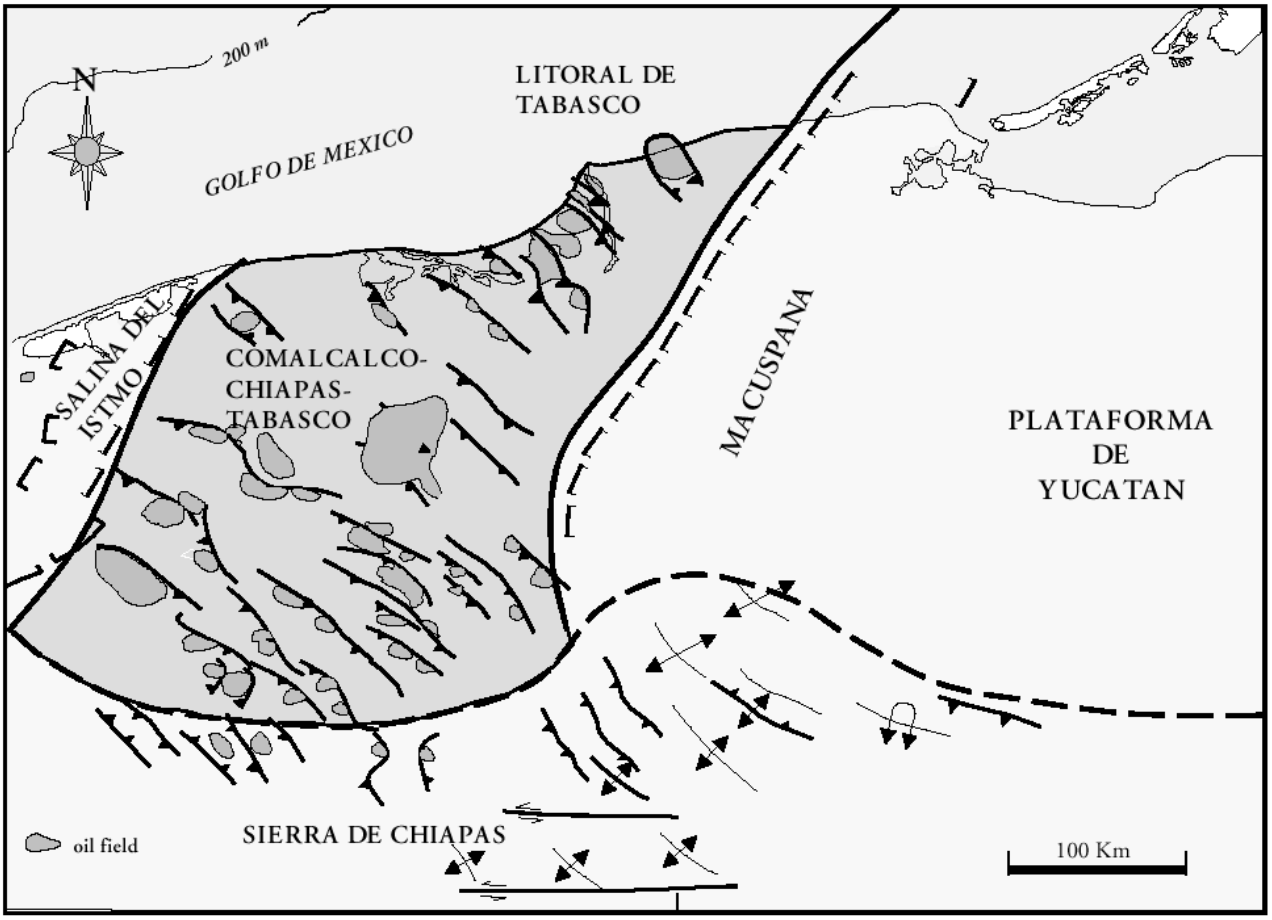


Figure 13. Comalcalco and Chiapas-Tabasco province.

Macuspana

The Macuspana Tertiary province in the east (fig.14), with around 10,000 km^2, roughly a quarter of them offshore, is a producer since the late 1950´s, of shallow (< 3000 m) non associated, sweet gas. As in the case of many of the previously described basins, the application of new technologies, and concepts, has permited the identification of a large number of new gas exploration opportunities, that through the application of an ambitious investment program that calls for the acquisition of 3,145 km^2 of 3D seismic, the drilling of a 100 exploration and over 210 development wells, and the construction of new facilities, will allow the rejuvenation of the basin by bringing production up to 800 mmcfd by the year 2004, from the present output of 170 mmcfd from 13 fields (out of 36 discovered). Previous maximum production for Macuspana was 720 mmcfd reached in 1975.

Unlike the reservoir rocks of Burgos and Veracruz, the fluvio-deltaic and shelf sandstones in Macuspana tend to be of better quality, due to the fact that they are younger (Miocene to Pliocene), cleaner and less compacted. Traps are both stratigrahic and structural, the latter being mostly rollover anticlines associated to extensional deformation. Although no production has been established in the offshore extension, very attractive structures have been identified, that will start being tested in the next couple of years.

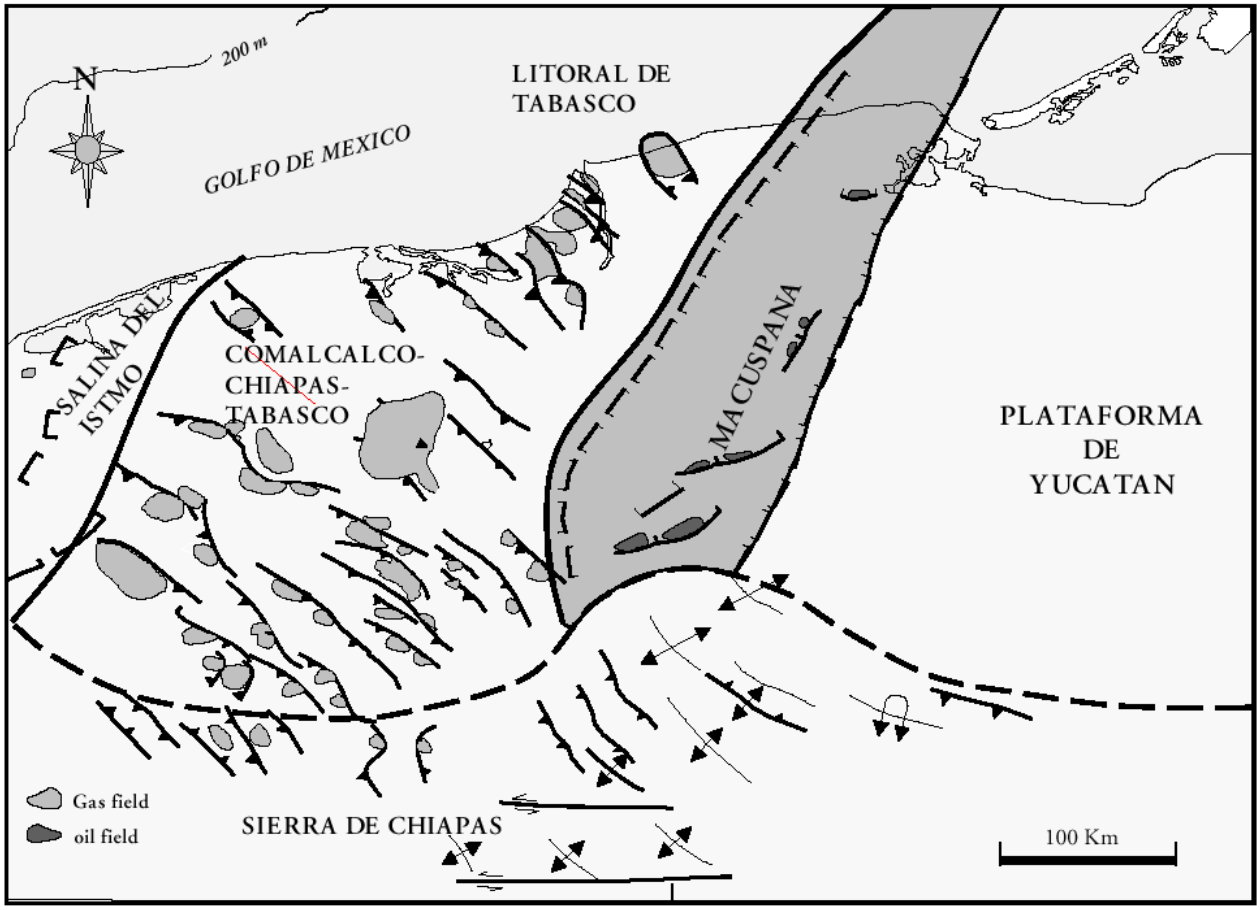


Figure 14. Macuspana province.

Sonda de Campeche

The Sonda de Campeche (Fig.15) was discovered in 1976 in waters less than 100 meters deep, since then 14 fields (10 producing) have been discovered, having medium to heavy oil. Most reservoirs were emplaced in Late Cretaceous to early Paleocene talus breccias, and Late Jurassic oolitic sediments, and only two in Oxfordian quartz sandstone dunes. The producing area, with just 326 km^2, is by far México´s most prolific, the Cantarell supergiant, with 11,936 mmbo and 5.17 tcfg of remnant reserves, produces, just by itself, 50% of the three million barrels of the nation´s daily output, and with the most ambitious project of the mexican oil industry, the field is being optimized through additional drilling, facilities, and in early 2000, the injection of one bcfd of nitrogen to maintain the reservoir pressure, these will allow the extraction of 2 mmbod. In early 1999, the exploration of a repeated section below this field confirmed a new, totally independent reservoir with lighter oil (28° vs. 24° API in the upthrown block) of proved plus probable reserves in the order of 1,400 mmbo, not yet officialy registered. The Ku-Maloob-Zaap complex with 1,304 mmbo and 680 bcfg accumulated and a daily production of 285 mbod is the second most important field in the area.

Although there has been little exploration focused on the Tertiary, the revision of the extensive 3D seismic obtained in the area, has allowed the identification of several leads and prospects within the siliciclastic younger section, that will be tested in a near future.

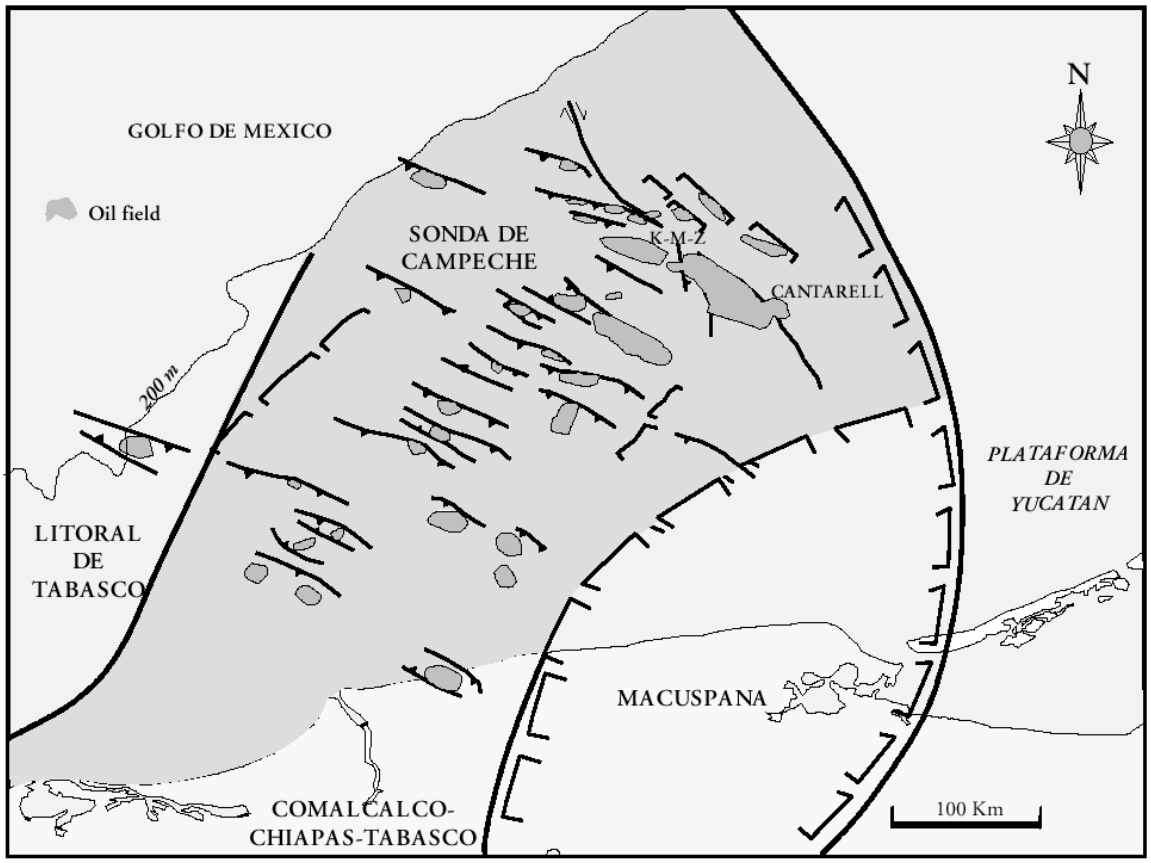


Figure 15. Sonda de Campeche province.

Litoral de Tabasco

The Litoral de Tabasco provinces (covering around 10,000 km^2) was discovered in 1979 (fig.16). It produces in its eastern part, on the order of 715 mbd of light oil and 1,000 mmcfd of associated gas, from 10 fields, of 28 discovered. The reservoirs are Cretaceous to Paleocene breccias and Jurassic shelf facies on the east, and mostly basinal, Jurassic to Cretaceous carbonates on the west; all deformed by compressional and salt tectonics. The main field is Abkatún with 1,968 mmbo and 1,601 bcfg of cumulative production, followed by Pol, Chuc and Caan with 788, 453, and 391 mmbo and 723, 489, and 686 mmcfg, respectively.

The western part of the area, rich in gas and condensates, will start being developed in the year 2,000, through a program that will increase gas production by another 1,000 mmcfg by the year 2008. This area has almost total 3D seismic coverage, which has allowed to identify a very large number of exploration opportunities, both within the Mesozoic and the Tertiary, that will provide a large portfolio for the 21st century.

Plataforma de Yucatán

The Yucatán platform is a very stable shelf developed in the Cretaceous, and thus lacks the highly productive source rocks of the Late Jurassic. Although a petroleum system sourced on Early Cretaceous supratidal facies has been documented to the south, in the Sierra de Chiapas and Guatemala, it hasn´t been confirmed to exist in Yucatán, thus it doesn´t seem that large quantities of oil will come from this region in the 21st century.

Cuenca del Golfo de México profundo

The mexican sector of the Gulf of México basin under waters deeper than 200 m, spans over around 500,000 km^2 (fig.17). Within the area only one well has been drilled, and based on around 28,000 km of recently acquired 2D, 8 potential petroleum provinces have been identified (fig.18). The definition of these tracts is based mostly on their tectonic characteristics:

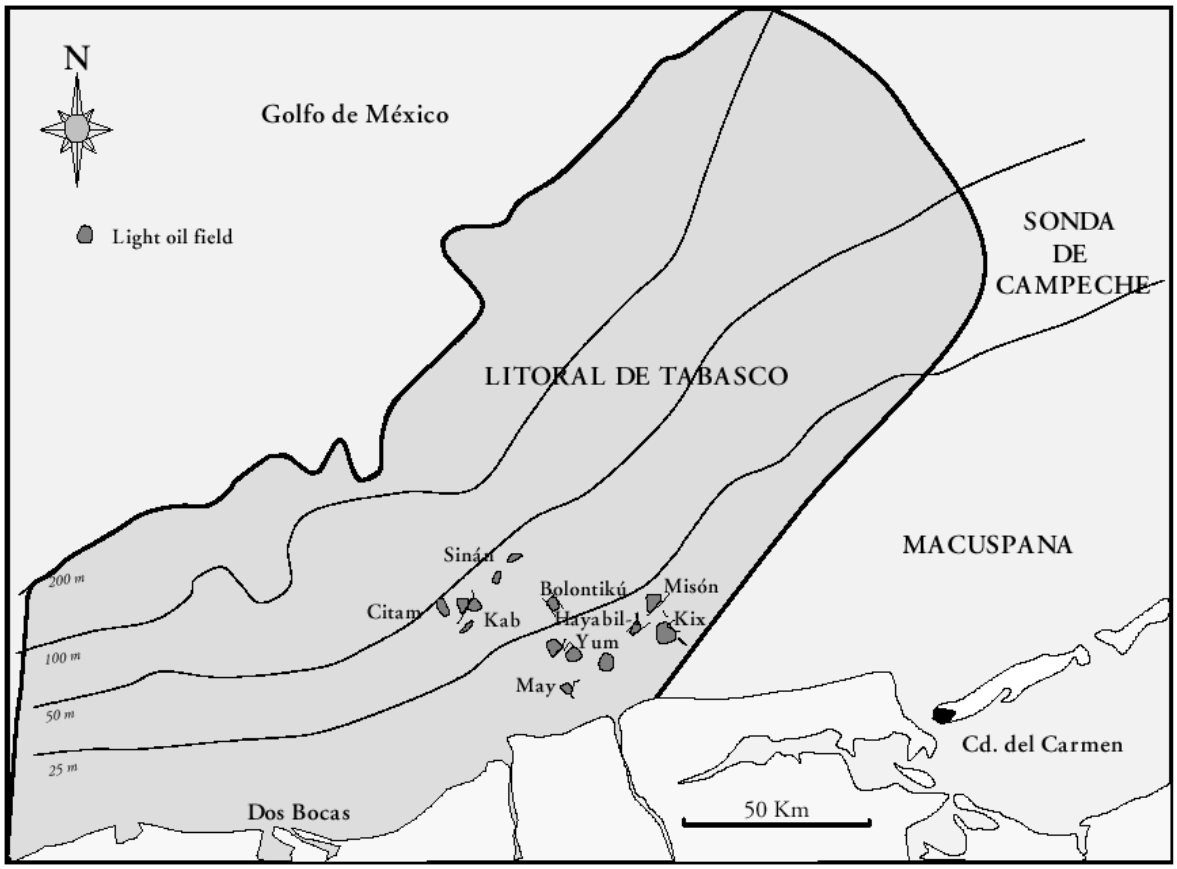


Figure 16. Litoral de Tabasco province.

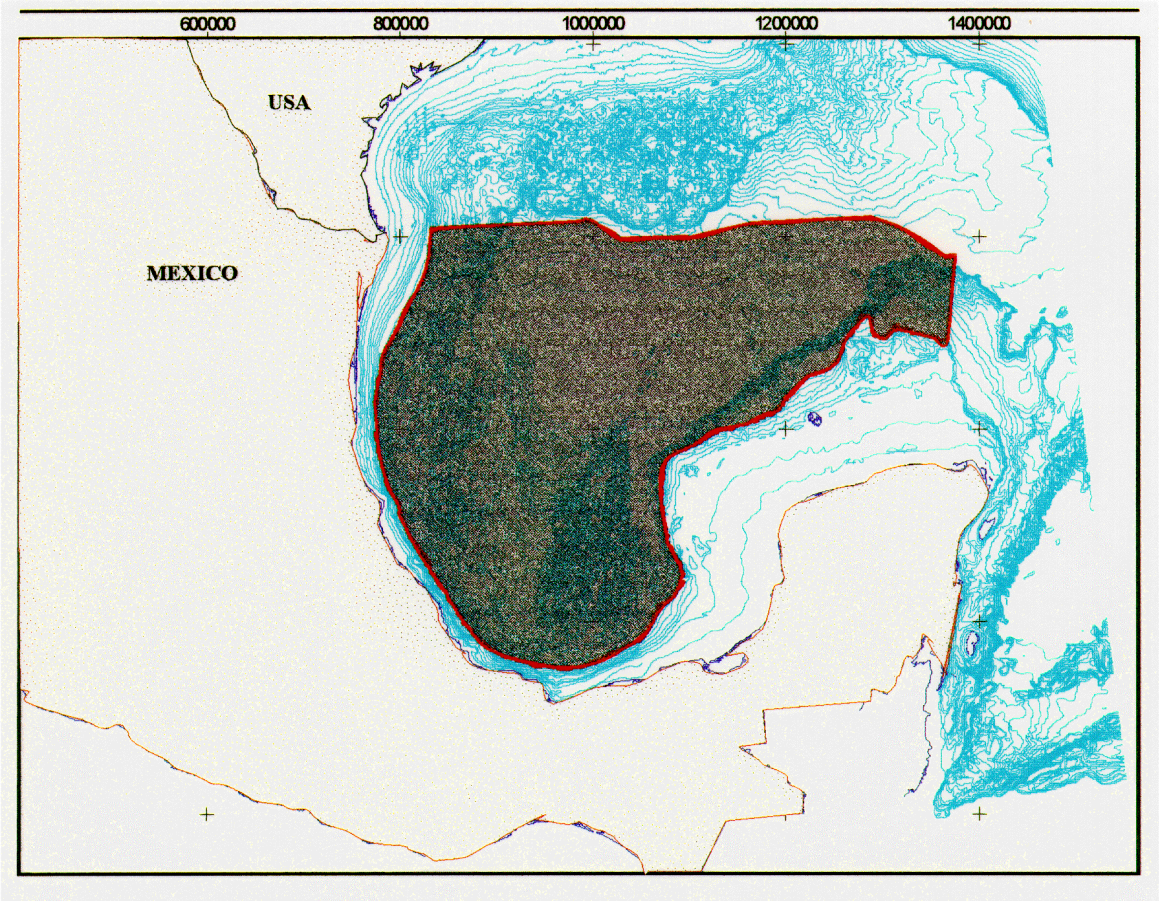
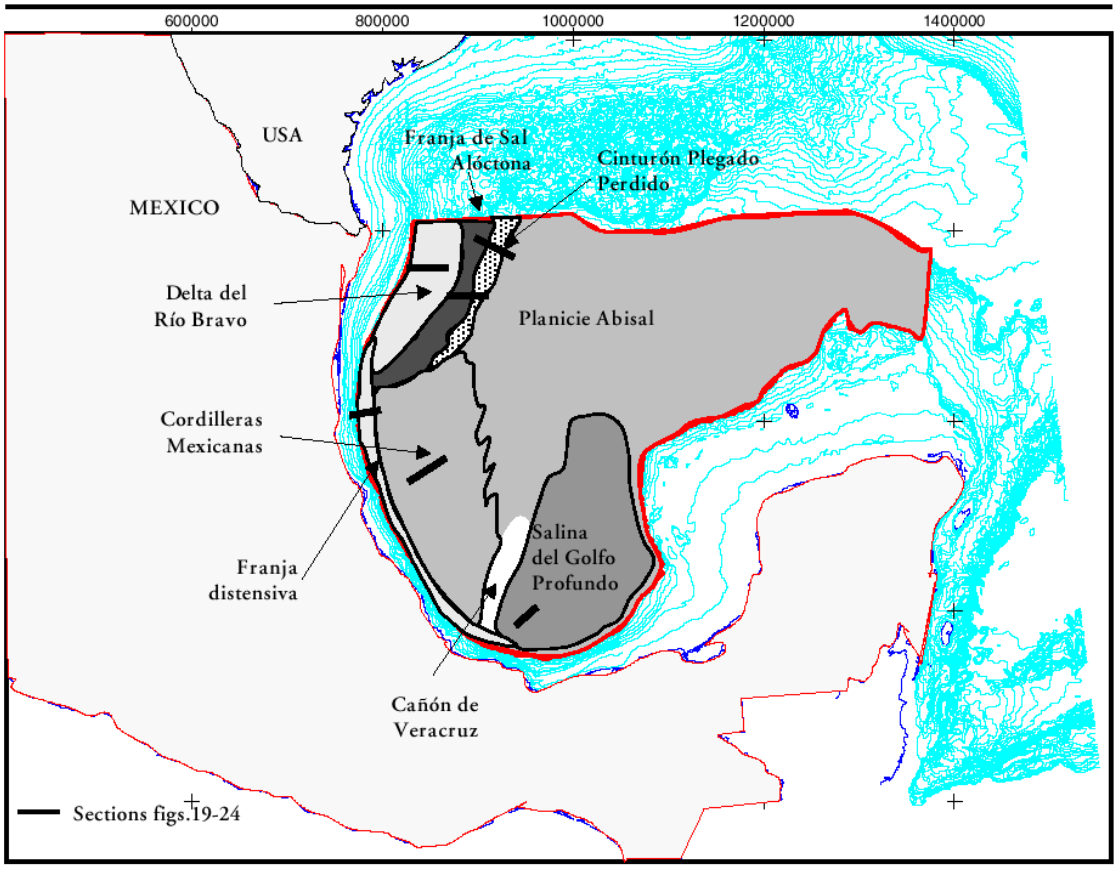


Figure 17. Cuenca del Golfo de Mexico profundo.



Figur e 18. Pr ovinces of the Cuenca del Golfo de México pr ofundo.

Franja Distensiva

An extensional domain characterized by listric down to the basin faulting, forms a fairway that paralels the continental shelf under waters less than 200 m deep, infringing upon it in some areas, along the western margin of the MGOM, in front of the Burgos, Tampico-Misantla and Veracruz basins. The faults glide within the Tertiary siliciclastic section forming large rollover structures many of them expanded by syndepositional growth (fig.19). The structures identified so far tend to be quite large and from geochemical modeling and sampling of a few wells, and of the sea bottom bed, the expected hydrocarbons are gas and/or very light oils. Reservoir rocks include deltaic, shelf and talus sandstones, the latter assumed to be deep water turbiditic deposits.

Delta del Río Bravo

A Miocene to Pliocene depocenter, with an area of around 15,000 km^2 has been identified in front of the delta del Río Bravo del Norte (fig.20), this feature originated as salt was evacuated towards the east, creating structures associated to salt displacement. Expected hydrocarbons, from extrapolation of Burgos and the Padre Island area, are mostly gas. Reservoir rocks are distal deltaic and shelf sands provided by the ancient Río Bravo.

Franja de Sal Alóctona

This area, in the northwestern sector of the deep water MGOM basin, between water depths of 1000 m to 3000 m, is dominated by salt sheets, canopies, and diapirs, evacuated from the west (fig. 21). The area appears to be very atractive for gas prospection. Spaning over 25,000 km^2, it´s expected to be primarily gas prone. Reservoir rocks are assumed to be deep water turbidites.

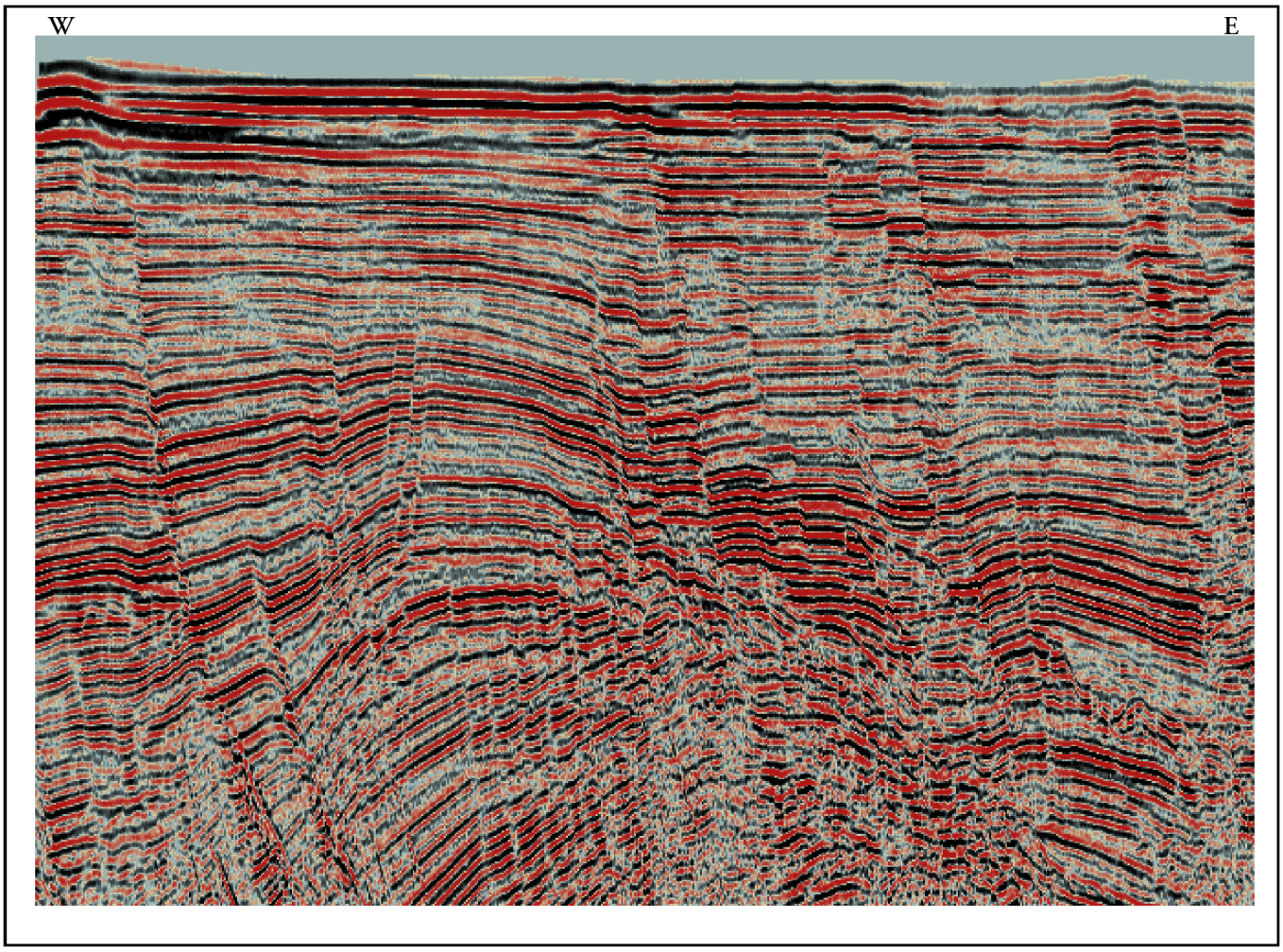


Figure 19. Seismic section showing the structural style in the Franja Distensiva province.

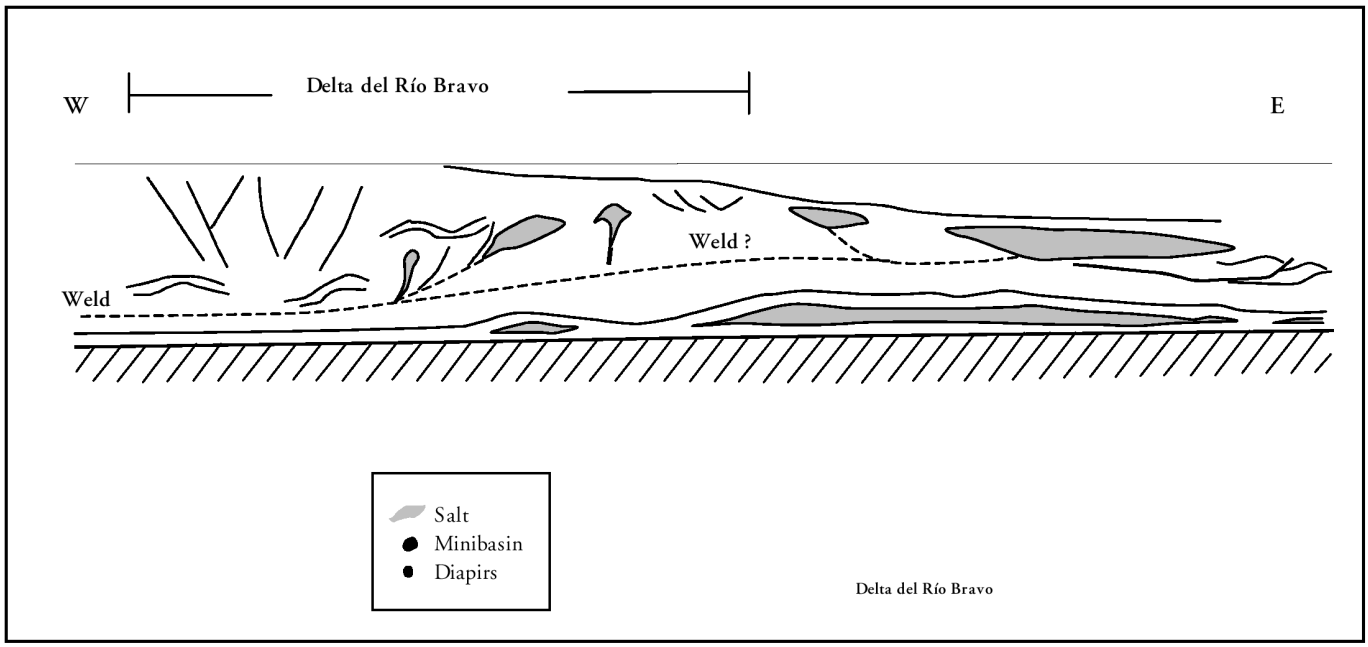


Figure 20. Section through the Delta del Río Bravo province.

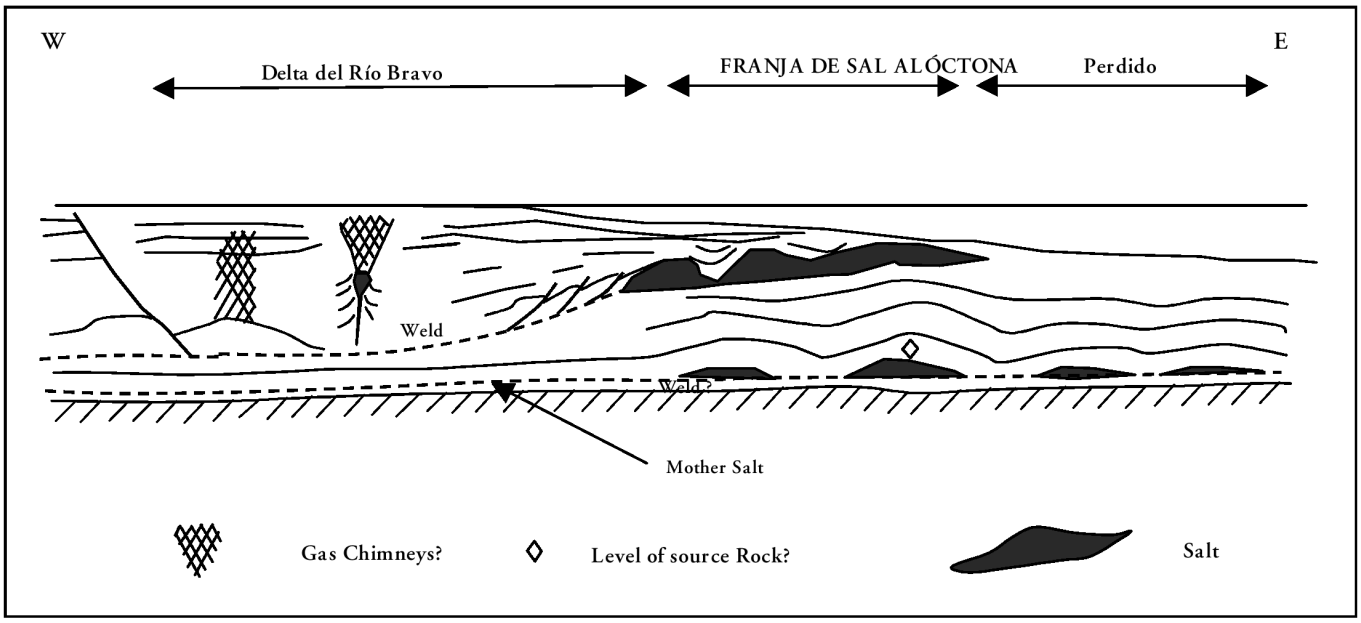


Figure 21. Section through the Franja de Sal Alóctona province.

Cinturón Plegado de Perdido

Downdip from the Displaced Salt alignment is a folded and thrusted belt originated by salt emplacement and gravity detachment at the top of the Jurassic salt, that involves the Mesozoic section. Structures appear to be cored by salt and are elongated, very large (>40 km) and tight (fig.22). This belt underlies water depths between 2,000 m and 3,500 m. Recently an industry consortia tested a structure within the belt, in the Alaminos Canyon area that, according to some sources, was successful. Expected hydrocarbons are mostly oil and reservoir rocks are supposed to be, within the Mesozoic, fractured deep water carbonates, and in the Tertiary, siliciclastic turbidites.

Cordilleras Mexicanas

Downdip from the Franja Distensiva, in front of southern Burgos, Tampico-Misantla and Veracruz, is the wide, compressionaly deformed belt, known as Cordilleras Mexicanas. It extends over 500 km, covering around 70,000 km^2, in water depths of 1,000 m to 3,000 m. Formed as a result of accommodation of the extensional deformation updip, the displacement along a Tertiary gliding plane acts as a sole fault that results in very long (some more than 40 km), narrow anticlines (fig 23). The structures appear to be confined to the Tertiary section. The expected hydrocarbons are light to medium gravity oils. Reservoir rocks are postulated to be deep water turbiditic sandstones.

Cañón de Veracruz

The Cañón de Veracruz is a physiographic feature, a submarine canyon, formed by the termination of the Cordilleras Mexicanas to the west and the Cuenca Salina del Golfo Profundo to the east. At present time, it appears to have little petroleum potential.

Salina del Golfo Profundo

This province, with an area of around 50,000 km^2, is the downdip extension of the Salina del Istmo. Within the area, both the Mesozoic and the Tertiary sections are affected by salt displacement as diapirs, sheets, and canopies that have created a large number of exploration opportunities (fig.24). Based on results of a recent well drilled within the basin, the expected hydrocarbons are heavy to medium gravity oils although in the older, deeper rocks, there could be lighter products.

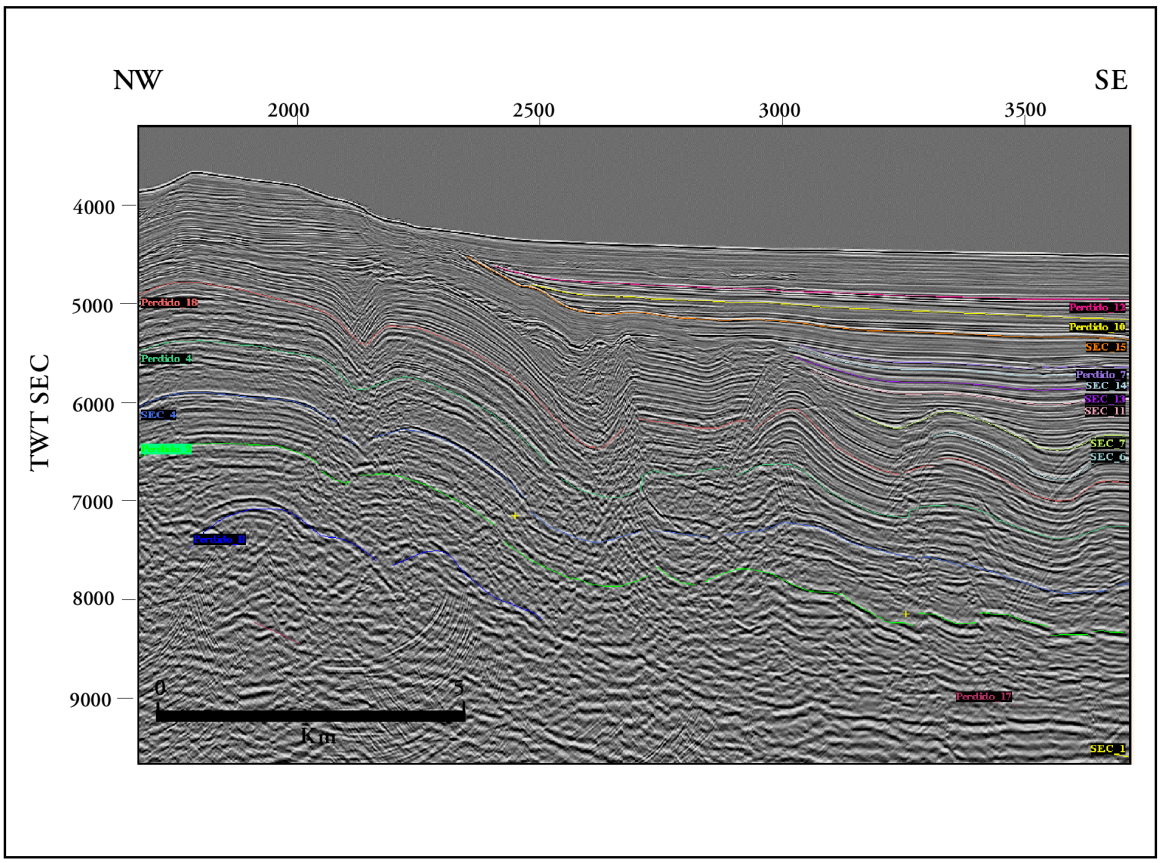


Figure 22. Seismic section through the Cinturón Plegado de Perdido province.

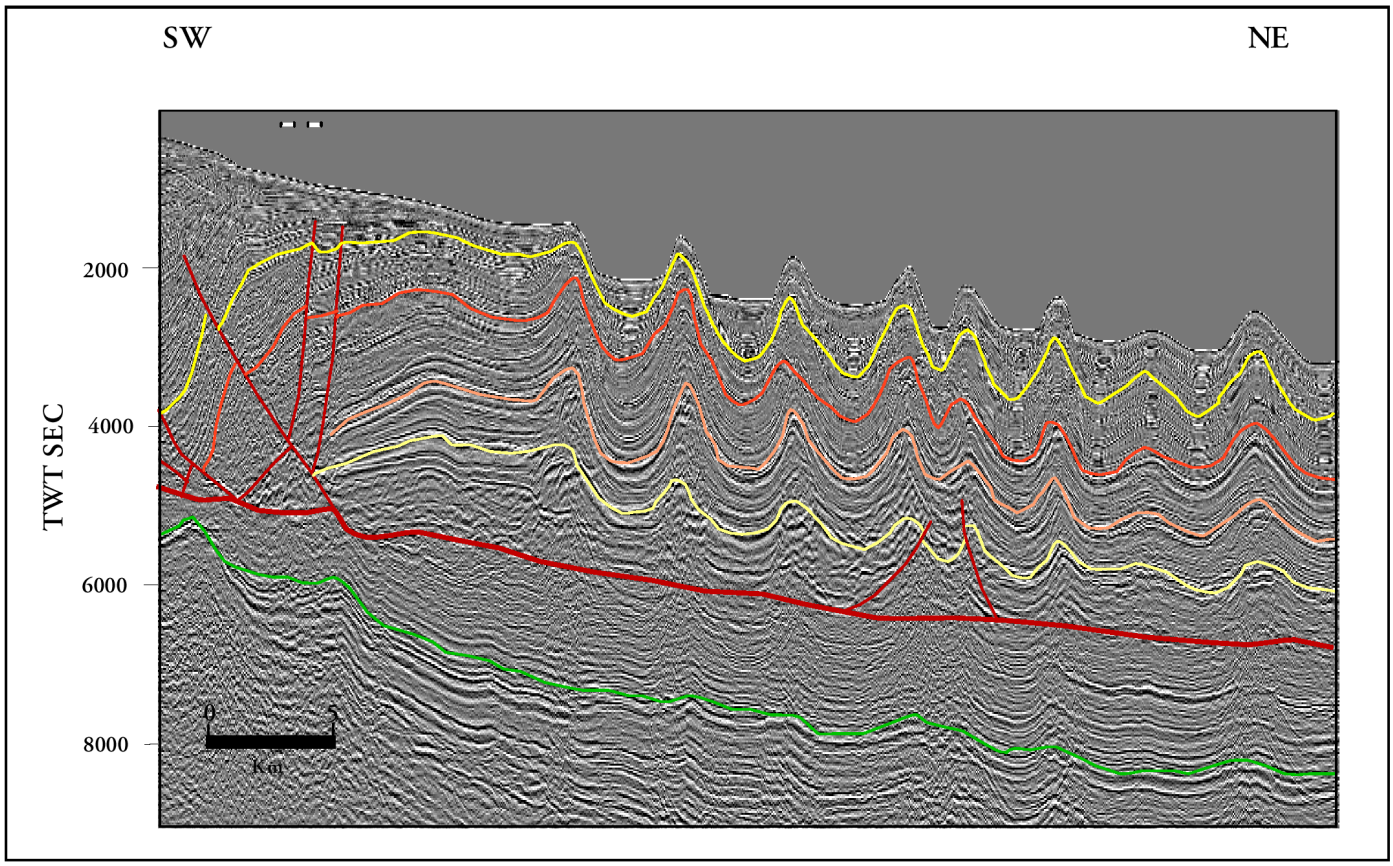


Figure 23. Seismic section through the Cordilleras Mexicanas province.

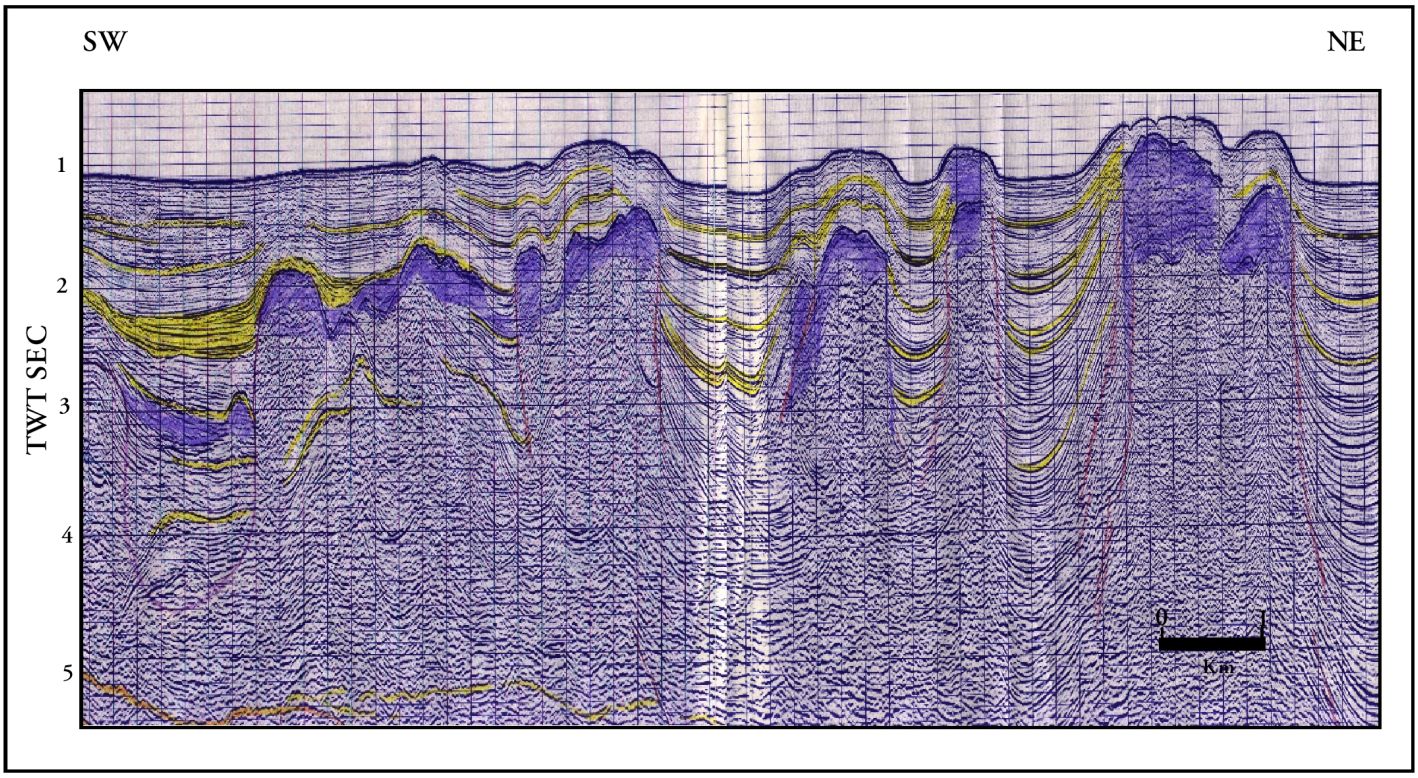


Figure 24. Seismic section through the Salina del Golfo profundo province.

Planicie Abisal

The central abyssal part of the basin, with water depths of more than 3,000 m, spans over 103,600 km^2. The area has little structural relief and thus its oil potential would appear to be limited, unless stratigraphic trapping is proved to exist.

CONCLUSIONS

The Mexican side of the Gulf of México basin proper has been producing oil and gas since the beginning of the 20th century. All of these hydrocarbons have been extracted from the onshore and shallow offshore parts of the basin (<200 m water depth), and so it would appear that most of the future production will come from the deep water. The truth is that, through the application of vigorous investments, technology, new concepts and methodology, the traditional, and not so traditional provinces of the basin (such as Chicontepec, the shallow offshore areas outside Campeche and others) will carry the burden of most of the production in the early part of the next century. It is also true that the deep water provinces of the basin hold a potential that, although not tested yet, appears to be quite large, and that the technology to explore and produce in large water depths is already available; these factors indicate that the MGOM could very well be *the* petroleum province of the 21st century.

REFERENCES

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