Salt Deposits of the Isthmas of Tehuantepec

by
Manuel Castillon[1]
J. P. Larios[2]
Mexico City, Mexico

INTRODUCTION

The salt basin of the Isthmus of Tehuantepec is 290 kilometers long and 70 kilometers wide. It occupies all the coastal plain extending from southern Veracruz through northern Tabasco, and possibly continues toward the east as far as the Península of Yucatán.

It is known that, since 1902, when this area began to be formally explored, 1500 oil and 2000 sulphur wells have been drilled. Almost all are located within the western half of the basin.

Permian (?) sediments up to Upper Miocene have been identified in it, and through stratigraphic correlations, a tentative Triassic-Jurassic age has been assigned to the salt.

Due to the enormous size of the salt structures (real masses covering areas as wide as 2,000 square kilometers) stratigraphic measures and other correlations, it is supposed that the evaporites of the basin attain a thickness of about 3,000 meters.

It is also believed that the upper parts of the salt structures have ascended more or less 3000 meters, and that these structures were originally formed by folding in Upper Jurassic time, to be finally constituted as dome structures by differences in pressure caused by the great thicknesses of Oligocene and Lower Miocene sediments.

The scanty number of perforations that have crossed important sections of salt, makes it almost impossible to determine the physical properties, lithologic characteristics and mineral content of the product. In reference to this, recent perforations made to evaluate the economic possibilities of the salt have obtained interesting results.

Location of the area

The different geological studies made in the north part of the Isthmus of Tehuantepec, Mexico, formerly initiated by the oil companies that were operating in the region and later systematically continued by Petroleos Mexicanos, have gradually brought about a more complete modification in the known limits of what, since 1902, has been known as the salt basin of the Isthmus.

Although considerable exploratory work has been made in the last 60 years, it has been impossible, so far, to get a complete delimitation of the basin (Figure 1). Its western limits, providing that some explored structures are not salt domes, are delimited approximately by the area crossed by the Tehuantepec Railroad, from Medias Aguas to Coatzacoalcos. Its southern limits are formed by the lower slopes of the Sierra Madre del Sur. Both the eastern and northern limits appear yet uncertain, but it extends to the east to the Medellin dome in the State of Tabasco and, to the north, it dips into the continental platform of the Gulf of Mexico.

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[1]Author -- Comisión de fomento Minero, Coatzacoalcos.

[2]Delivered Paper -- Consejo de Recursos Naturales no Renovables, Mexico City.

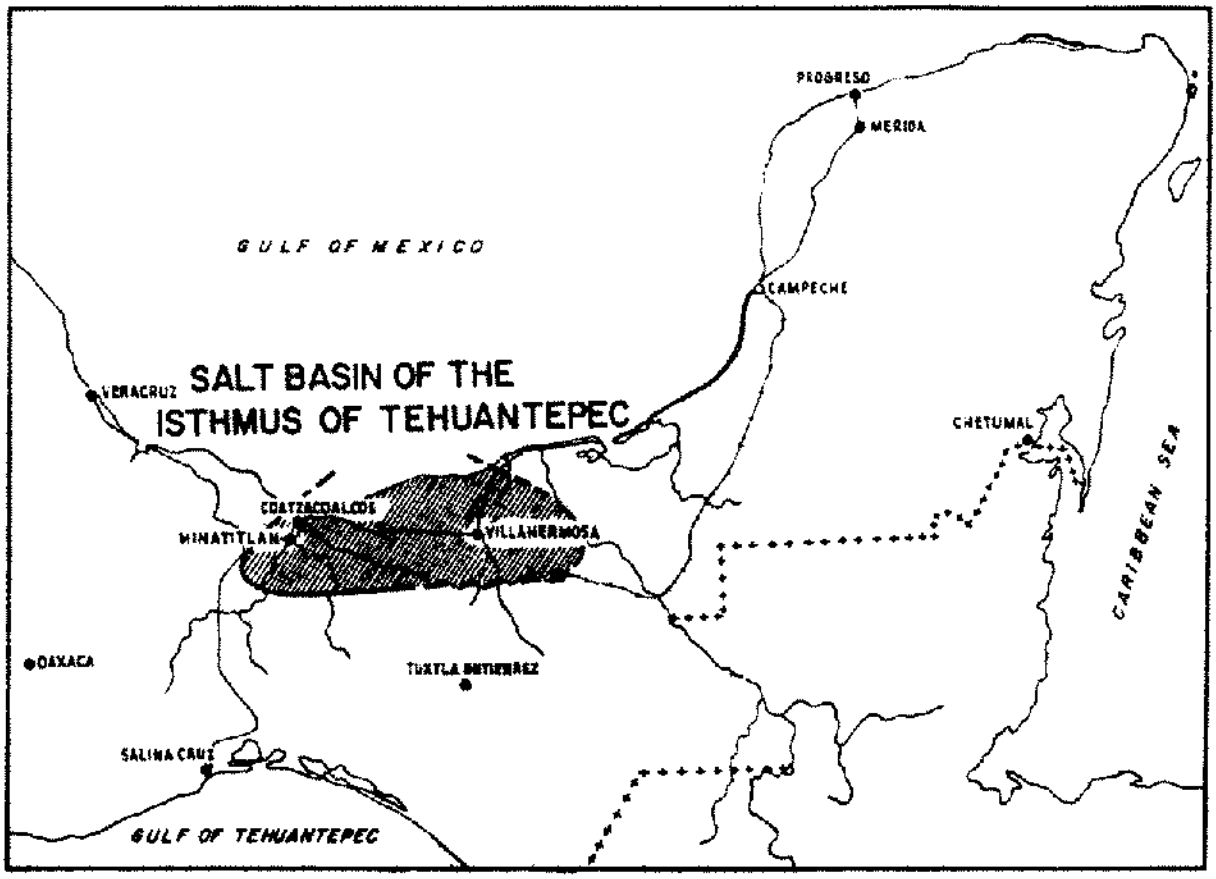


Figure 1.

In general terms, and not taking into account the abnormalities that its borders undoubtedly have, the salt basin extends 290 kilometers from east to west and 70 kilometers from north to south.

Objectives and Methods of the Investigation

Up to 1944, practically all the geological studies carried out in that zone had as their object the search for oil or gas. On April 28, 1944, the first well looking for sulphur was initiated in the dome of San Cristobal. The sulphur had been located in the past by the oil companies exploring the area, explorations that culminated in the discovery of oil for the first time in the Isthmus of Tehuantepec. Only in recent years has the Federal Government, through the Council of Non-Renewable Mineral Resources, started an exploration entirely devoted to salt.

Surface Geology

Practically all the north portion of the Isthmus of Tehuantepec, that is, the part that embraces the watersheds or slopes toward the Gulf of Mexico, has been explored by surface geological methods. Quite a few pits and trenches have afforded valuable data, mainly in the coastal portions. Though, in our opinion, only in the western part of the basin, geological surface methods define, in a very remarkable way, not only the existence, but the extension and orientation of the salt structures. The knowledge of the western portion will be very helpful therefore as a valuable index for later studies by geophysical methods and well perforation.

Refraction Seismology

With the purpose of knowing the particular morphology of each salt structure, quite a number of refraction lines have been spread out over the center of the basin. Variable results have been obtained, mainly due to the inaccuracy of the apparatus used before 1943. For this reason, the form of the flanks and, above all, the relations one structure may bear with another immediately below is generally unknown.

In 1957, work was done southeast of Minatitlán with excellent results, though unfortunately all the exploration was made to define the upper portion of a great salt mass without having obtained data to define its flanks.

Some work has been done by the fans method, though in this case the results have been not at all satisfactory, due to the enormous size of the salt masses.

Reflection Seismology

In 1948, Petróleos Mexicanos started intensive exploratory work by the seismic reflection method, shooting in intermediate zones among salt structures already known, but with the purpose of working out in detail the structure of the domes. In this way, it has been possible to detect salt reflexes from depths up to 5000 meters, delimiting clearly the flanks in some of the domes.

Wells

Within the salt basin of the Isthmus, around 1500 wells have been drilled looking for oil or gas. About 1,950 soundings for sulphur purposes have been made. Of these, exclusively bored in the western third of the basin, 415 soundings have reached the salt, penetrating it only a few meters, just to verify its existence for control purposes.

The wells that were bored in the search for sulphur afforded little information in regard to the salt itself, as none were bored for this purpose nor attained sufficient depth to give valuable data, about the characteristics of the salt bodies, except in the higher portions of them.

Some deep oil wells, especially in the more productive structures, have allowed the definition of the saline morphology with enough accuracy. In the Zanapa dome (Figure 2) a well drilled in the top of the structure found salt at a depth of 100 meters. Two wells bored in the flanks, 2800 and 2500 meters deep respectively, were later used to register by refraction, through a geophone, the profile of the salt, as indicated in the figure. It must be noticed that the characteristics of this dome are completely different from the ones shown by the other salt structures of the basin.

Acknowledgments

The present work has been prepared by the Comisión de Fomento Minero and written by Manuel Castillón, Director of the Coatzacoalcos Branch.

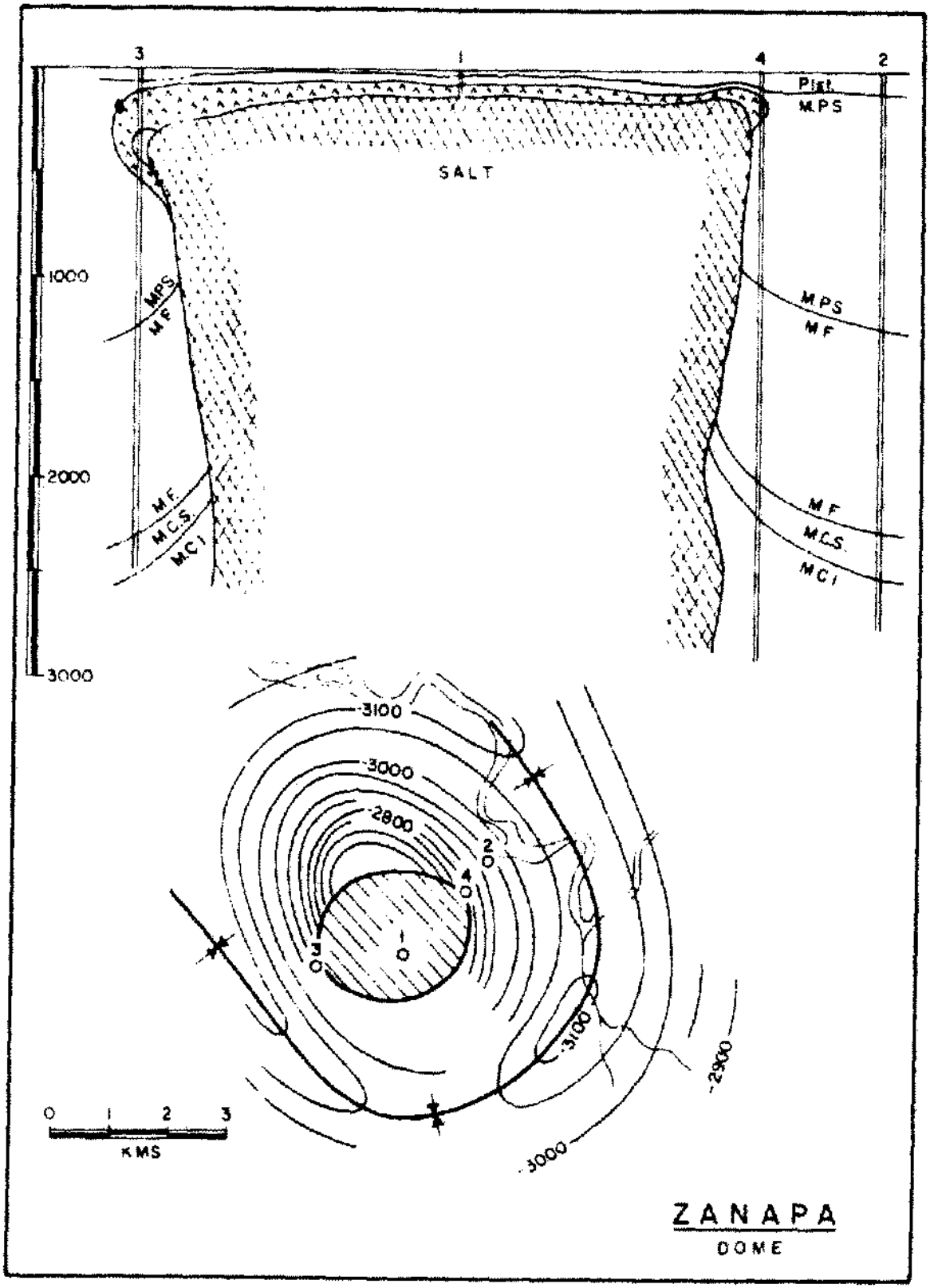
The author has counted on, with complete information from the sulphur companies working in the region, valuable data and advice from Roberto Gutiérrez Gil and Enrique Sansores of the Exploration Superintendency of Petróleos Mexicanos and with the collaboration of Rubén Pavón of the Comisión de Fomento Minero.

A great part of the generalized concepts on the geology of the basin is based in the work of Hugo Contreras, who devoted his life to the study of the zone.

GEOGRAPHY

Physiography

The salt basin of the Isthmus of Tehuantepec is entirely located in the coastal plain of the Gulf of Mexico. Only isolated hills not higher than 150 meters above sea level constitute the relief features on the plain. In the western part of the basin, the main topographic feactures are La Encantada and Manatí hills. The Coatzacoalcos River, with its important tributary, the Uspanapa River, as well as the Tonala River, is the dividing line between the states of Veracruz and Tabasco. With the great Grijalva River, they form the most important pluvial currents in the region. These streams flow from south to north to discharge in the Gulf of Mexico. The vegetation being of the tropical type, the area has a relative humidity of more than 80% and an annual rainfall of about 2,000 millimeters. In general, excepting the cuts that can be seen at the sides of roads, railroad tracks and streams, rock outcrops are scarce and decrease considerably to the east, where the zone gets very low and marshy.


3
1
4
2
Plst.
M.P.S
SALT
1000
2000
3000
MPS
MF
MF
MCS.
MCI
MPS
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MF
MCS.
MCI
3100
3000
2800
2900
3000
0 1 2 3
KMS
ZANAPA
DOME

Figure 2.

STRATIGRAPHY

Identified sediments within the basin embrace from Permian (?) up to Upper Miocene (Figure 3). Resting discordantly above the latter appear great thicknesses of gravels and coarse sand with no fossils at all. Pleistocene (?) and post-Pleistocenic deposits are designated as Alluvium or Recent in this report.

Permian (?)

In the southern margin and already within the Sierra Madre exist metamorphic rocks constituted mainly of very distorted micaceous schist interstratified with carbonaceous limestone bodies with unidentified fossils. Due to its similarity with the Middle Permian of southeastern Chiapas, these rocks have been assigned tentatively to the Permian. They have a thickness of 800 to 900 meters. No relationship has been found between them and the salt domes.

Triassic-Jurassic

Above the metamorphics are 600 meters of red conglomerates, coarse grain sandstones to conglomeratic, and purplish slates, known altogether as Red Beds or Todos Santos formation. Several of the studied sections in this formation show very similar lithologic characteristics. The unit is easily identified in the frontal part of the Sierra, from an area lying directly to the south of Cordoba outside of the basin, down to the border of Guatemala, which is also outside of the basin. Apparently the sediments are concordant with the underlying schists and limestones and are covered by Upper Jurassic and Lower Cretaceous limestones and calcareous lutites.

The Red Beds are intimately related with the salt deposits, as they have been found in Medellin well No. 1, and in two or three wells, crossing great thicknesses of salt, in the Ixhuatlán field. Considerable thicknesses of these deposits are intimately related with the salt, sticking up as isolated hills in La Encantada, Manatí and Almagres. It is believed they have been pushed up by the salt core when constituting the dome structure. At Cerro Pelón, not yet considered within the basin, the Red Beds appear also to be connected with the salt intrusion.

Jurassic-Lower Cretaceous -- Chinameca limestone

As in the before-mentioned Cerro Pelón structure (upstream on the Río Playas) in the Chinameca limestone there appears scant amonite fauna with some determinable specimens. Chinameca sediments are supposed to have been carried up to its actual position during the raising of the salt.

Middle Cretaceous -- Sierra Madre limestone

Middle Cretaceous limestone (Valanginian to Turonian) do not appear within the salt basin. At favorable sites, it has been proved that the Upper Cretaceous rests above the Chinameca limestone (the Pedregal salt dome).

South of the basin, the thickness of the Sierra Madre limestone varies between 1,500 and 2,000 meters, although, to the southeast, it only attains a thickness of 200 or 300 meters.

Upper Cretaceous -- (Turonian to Maestrichtian)

More than 800 meters of Upper Cretaceous sediments appear at the front of the Sierra, or on the margin of the salt basin. It consists mainly of lutites and interstratified sandstones, showing a generalized scarcity of macrofauna. It has been found within the basin, immediately above the salt, though always rather thin in thickness and sometimes with a microfauna accompanied by Eocene and Oligocene species.

Within the salt have also been found lutites bearing Tertiary fauna, though in such cases those lutites are supposed to be lenses carried up by the salt in its upward movement.

Paleocene

Concordant Paleocene sediments, resting on the Upper Cretaceous, are found in all the front of the Sierra. They consist of lutites with sandstone bodies.

STRATIGRAPHIC COLUMN IN THE BASIN OF THE ISTHMUS OF TEHUANTEPEC

ERA	PERIOD	EPOCH	GEOLOGICAL DESCRIPTION
TERTIARY	Pleistocene		It consists of fine grained clastics grading up to gravels in size. In some areas there are lenses of gross grained sands, mixed with clays and gravels.
	Pliocene		North of the Isthmus it is represented by sandstones, sands and gray to bluish green clays with rests of lignitic plants, and by a conglomerate constituted of igneous-intrusive rock pebbles in a sandy matrix
	MIOCENO	UPPER	Cedral Formation -- It consists of sands, clays and conglomerates. In some areas it is subdivided in two parts; an upper part formed by clays with bluish sands, and a lower part formed by sands and gravels poorly interestratified. Agueguexite Formation -- Upper part: lignitic clays, grayish blue. Middle part: -- Sandstones, compact, fine to medium grained, brown to bluish gray. Occasionally interestratified with clays and sands. Lower part: -- Fossiliferous sandstones, poorly consolidated, brown colored; very sandy clays, well laminated, and yellowish sands with bands of very arenaceous clays. Total thickness fluctuates between 400 and 500 meters. It is very common in the north part of the basin.
		MIDDLE	Paraje Solo Formation -- Upper part: Sandstones, gross to fine grained, gray and brown in color, interestratified with clay, bluish gray. Lower part: -- Sandstones, compact, gross grained, gray and brownish gray, interestratified with clays and lignitic material. It outcrops at Paraje Solo, Acalapan, Moloacan, Tonalá, Ixhuatlán and other localities. Thickness: 600 meters. Filisola Formation -- Upper part: It is formed by arenaceous clays, red, or redish brown when weathered. Thickness: 400 meters. Middle part: -- Sands, cuarciferous, angular, fine to medium grained, white and light gray in color. Occasionally shows a brownish tint due to iron oxide impurities. Lower part: -- Lutites, gray to brown colored, and sandstones, poorly cemented. Average thickness: 400 meters.
		LOWER	Concepción Formation -- Upper part: Lutites, arenaceous, grayish blue in color, poorly estratified and well consolidated. Localities: Soconusco, Achotal, Romero Rubio y Acalyucan. Thickness: 100-200 meters. Lower part: -- Lutites, well consolidated, poorly estratified, gray, light blue and dark blue. Thickness: 300 meters. Encanto Formation -- It is formed by alternated series of fine grained sandstone and arenaceous lutites. Its color is bluish gray or yellowish gray. Thickness: 500 to 800 meters.
	OLIGOCENE		Depósito Formation -- Lutites, arenaceous, gray to greenish gray, occasionally blue, intercalated with layers of volcanic ash, from 0.30 m to 5.0 meters in thickness. Nanchital Conglomerate -- Very local distribution. La Laja Formation -- Lutites, gray, slightly sandy, well estratified and with some sandstone an volcanic ash intercalations.
	EOCENE		Nanchital lutites -- Lutites, hard, well estratified, gray blue and dark tints. In some places, alternate with calcite and sandstone beds. In some areas (Uzpanapa and Chalchijapa) they rest on the Uzpanapa conglomerate which is formed by rounded pebbles of igneous rock and sandstone.
MESOZOIC	CRETACEOUS	UPPER	Mendez Formation -- It is formed by marls, gray to gray brown, with intercalations of clayish sandstones, fine grained, and also gray to gray brown in color. Its thickness varies between 600 and 900 meters, and it outcrops at the S and SE margins of the basin.
		MIDDLE	Caliza Sierra Madre -- It is formed by gray and white limestone, gross bedded but alternating with thinner beds. It is not found within the limits of the basin.
		LOWER	Local discordance
	JURASSIC	Portlandian Kimmeridgian	Chinameca limestone
		Oxfordian Divesia	Red Beds
	TRIASSIC		Salty Formation

Figure 3.

Paleocene sediments attain an approximate thickness of 600 meters, though they are considerably thicker in the southeastern end. Age determination has been based on the study of its foraminifera.

Eocene

It also crops out in all the front of the Sierra and consists mainly in lutites and generally well cemented calcareous sandstones. It varies in thickness, averaging 400 meters. Very scarce Eocene sediments have been found resting directly above the salt. Its characteristic microfauna are easily subdivided in the front of the Sierra.

Oligocene

Oligocene sediments are found in all the salt basin, with thicknesses of more than 2000 meters in the western portion up to about 5000 meters eastward of the Pedregal river. They consist mainly of lutites, although the basal Eocene in the front of the Sierra is formed by the Nanchital conglomerate. They are from 300 to 400 meters in thickness. Oligocene has been subdivided in the La Laya and Depósito Sediments. They both have, throughout all their thickness, a more or less abundant microfauna. This statement also includes the conglomerate.

In the western portion of the basin, Oligocene plays an important role in the search for salt structures. These can be easily identified at the surface wherever a window of Oligocene appears surrounded by Miocene sediments.

Miocene

In the zone, Miocene has been studied in most detail, because within its sediments productive sand of oil and gas are found.

It has been subdivided in the following sequence, from bottom to top: Encanto formation at the base, Lower and Upper Concepcion, Filisola, Paraje Solo and Central. A part of the latter, showing up only in the north portion of the basin, consists of marine strata and is named the Aquequexquite Formation. All the Miocene represents a marine regression, with the exception of a small transgression represented by the Aquequexquite.

The Miocene column consists of lutites and marine sandstones generally deposited at shallow depths. At Paraje Solo There are lignites, silstones and carbonaceous clays deposited in "albuferas" or lagoons.

The thickness of Miocene sediments varies considerably. East to west, it increases from 300 to 400 meters, and up to 5000 meters in the vicinity of the Ogarrio field, a good oil producing area in the zone.

Stratigraphy of the salt

The previous facts allow a deduction for the age of the salt as pre-Chinameca limestone (pre-Kimmeridgian). The fact that Red Beds have been found interstratified and in intimate relation with the salt, indicates, without a doubt, the contemporaneous age of both units. However, as we do not know the exact age of the Red Beds, the exact determination of the age of the salt has been an insolvable problem. It has been ajudged, tentatively, as Triassic-Jurassic.

Considering the amplitude of the basin, and in spite of the numerous wells drilled in it, very little data has been obtained in regard to its geological characteristics. As previously indicated, the strictly economic character of the basin exploration and, above all, the pursued objectives, are both responsible for the small percentages of soundings crossing salt thicknesses, deep enough to afford reliable data on the salt lithology and its petrographic and mineralogic characteristics. A good number of drillings have touched the salt and gone through it a few meters. These wells have been drilled those few meters more just to check the presence of the salt. Information afforded by these wells, in regard to the salt, is practically of no value, because on top of the salt cores, petrographic characteristics are generally quite altered.

Only the Tuzandepetl 5, drilling 2,589 meters of salt (without crossing it); a well at La Soledad that went through 980 meters of salt; and one or two located in another part of the basin,

afforded adequate information. A certain number of wells have crossed thicknesses of salt within the order of 100 meters.

Based on that information, we can describe the evaporite deposits in the salt basin of the Isthmus as halite layers, in general with more than 5% of insoluble residues, with considerable variations, in purity, vertical and lateral. The halite layers are frequently interstratified with gray, black and red layers, probably of the Todos Santos Formation. Some sedimentary anhydrite beds, as well as thin arenaceous lenses, also exist. The thickness of the lutites within the salt become quite considerable, up to 300 meters at times. In medellin and Ixhuatlán, sandstones and red conglomerate cores were cut within the salt. The Salinas sulphur deposit, located in a small apophysis (1000 meters long) and inside of a big salt structure more than 10 kilometers of extension, presents an interesting and so far, unfortunately unsolved case (Figure 4). The cap rock here consists of about 200 meters of a limestone-anydrites-lutites mixture under which 300 meters of lutites appear, and no well has reached the salt so far.

As far as it can be considered as a local accident within a big structure with normal cap-rock characteristics, we think that the only explanation for the considerable thicknesses of lutite found there has to be based on the assumption that the lutite was already deposited within the salt when the formation of the cap-rock occurred.

In short, it can be said that the study of evaporites in the salt basin of the Isthmus practically has not been done yet. The little data we can count on so far shows a halite sequence with frequent shale intercalations of different thicknesses, as yet unknown.

STRUCTURAL GEOLOGY

Jaltipan -- Pedregal Area

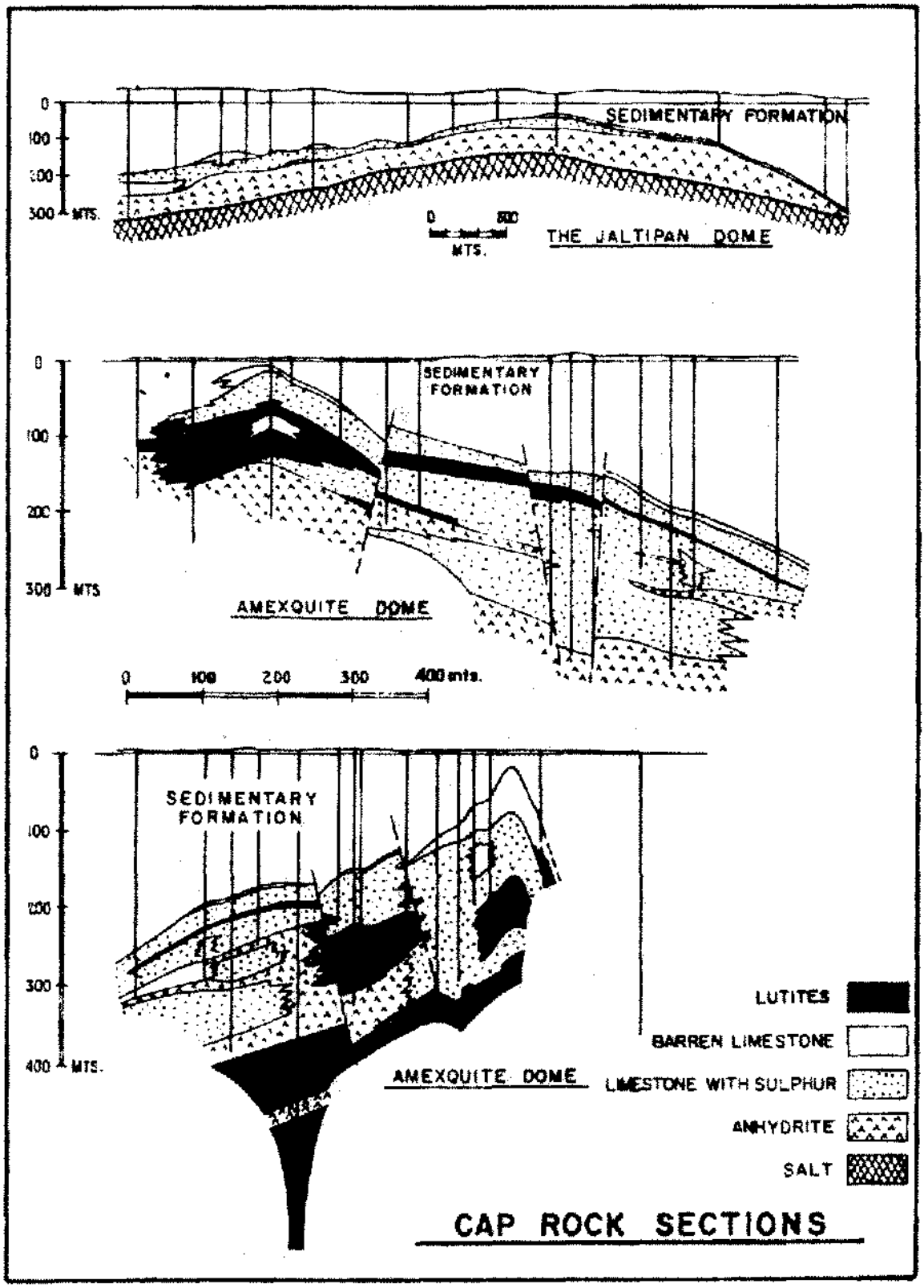
According to the recent petroleum discoveries in the basin, together with the geophysical explorations continuously made by Petróleos Mexicanos, it is now possible to give new opinions in relation to the morphology and structure of the salt cores (Figure 5).

The basin has always been considered as containing two different types of salt structures: to the west, big masses of salt with independent culminations, and to the east, individual and isolated domes, similar to those located in the American Coastal Gulf Plain.

We have no basis to support or refute this idea, because very little is known about the salt cores in the eastern half of the basin, but through the experience gained mainly in the western third, we suppose that similar morphologic conditions must exist there. The new available data confirms this idea.

In such conditions, we think we can express the following statements:

1. The basin extends for 290 kilometers from east to west, and is 60 kilometers wide in its western end. This width increases toward the east to over 100 kilometers at the Medellin dome, the most eastern dome discovered to date.
2. The knowledge acquired, so far, is limited to the most western 140 kilometers, where about 70 "domes" exist. Only three have been tested in the remaining 150 kilometers.
3. A regional synclinal structure striking east-west marks the southern margin of the western third in the basin. Foldings appearing south of the syncline have the same orientation as the front of the Sierra Madre, with a tendency to be east-west in the western part and northwest-south-east toward the east, as is the orientation of the Sierra itself.
4. It is evident that the salt culminations in the uplifted structures are closer to the surface in the southern margin of the basin, adjacent to the anticline in the front of the Sierra Madre, and that considerable sinking exists toward the Gulf of Mexico and to the east.
5. This difference is clearly delimited, in the best known part of the basin (the western half), by an imaginary northwest-southeast line, passing immediately to the north of the town of Minatitlán and being prolonged as far as to the north of the Laguna Nueva and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SEDIMENTARY FORMATION
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THE JALTIPAN DOME
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AMEXQUITE DOME
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400 MTS.
SEDIMENTARY FORMATION
AMEXQUITE DOME
LUTITES
BARREN LIMESTONE
LIMESTONE WITH SULPHUR
ANHYDRITE
SALT
CAP ROCK SECTIONS

Figure 4.

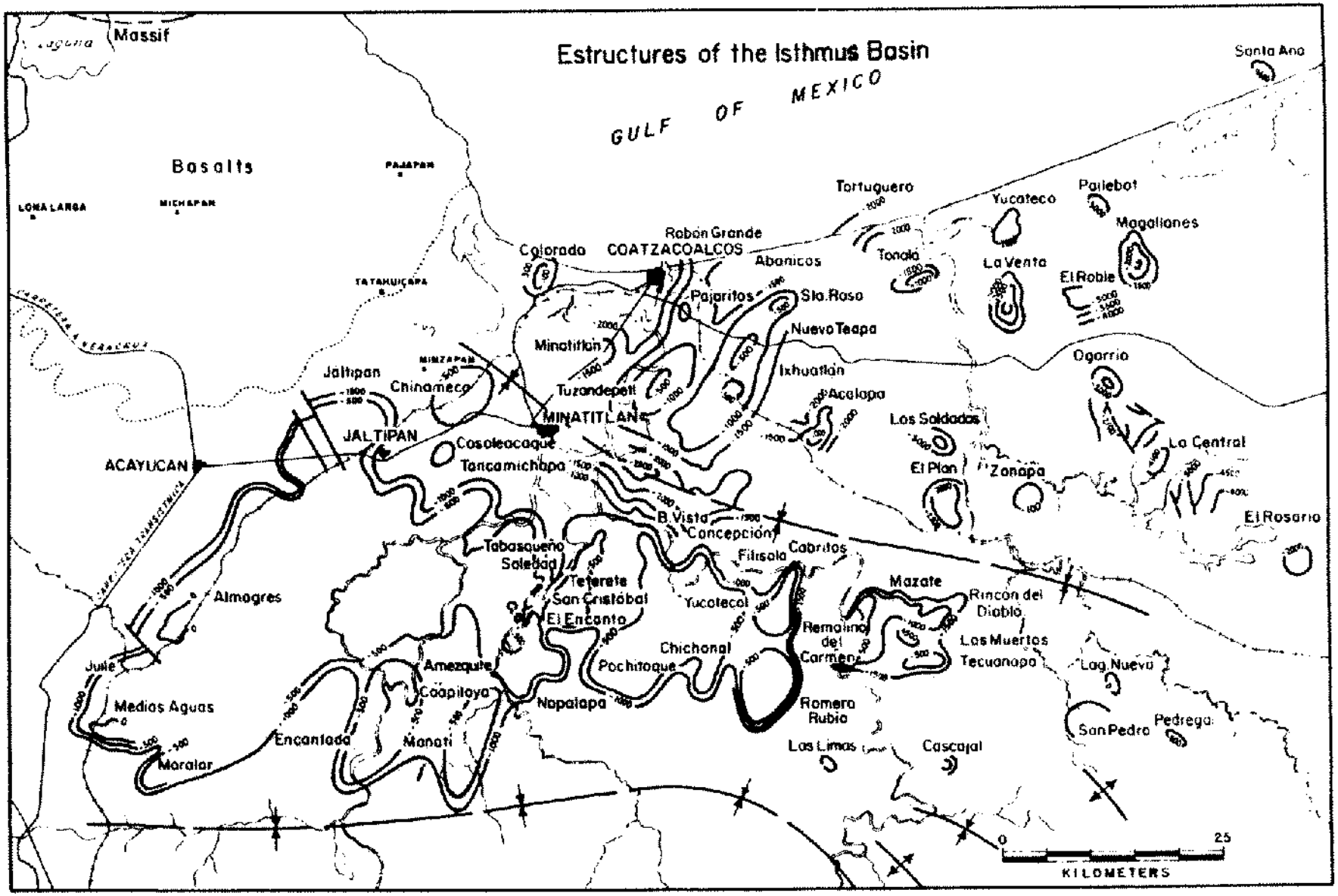

Estructures of the Isthmus Basin
GULF OF MEXICO
Laguna
Massif
Basalts
LOMA LARGA
MICHAPAN
PAJAPAN
TATAHUICAPA
CARRETERA A VERACRUZ
CARRETERA TRANSISTMICA
Santa Ana
Tortuguero
Yucateco
Pailebot
Magallanes
Roban Grande
Colorado
COATZACOALCOS
Abanicos
Tonalá
La Venta
El Roble
Pajaritos
Sta. Rosa
Nuevo Teapa
Minatitlán
Ixhuatlán
Ogarrio
Jaltipan
Chinameca
MINZAPAN
Tuzandepetl
Acalapa
Los Soldados
MINATITLAN
JALTIPAN
ACAYUCAN
Cosoleacaque
Tancamichapa
El Plan
Zonapa
La Central
B. Vista
Concepción
El Rosario
Tabasqueño
Soledad
Filisola
Cabritos
Almagres
Tetetete
San Cristóbal
Yucatecol
Mazate
Rincon del Diablo
El Encanto
Remolino del Carmen
Las Muertos
Tecuanapa
Chichonal
Pochitoque
Lag. Nuevo
Julie
Amezquite
Coapiloya
Napalapa
Medias Aguas
Romero Rubia
San Pedro
Pedrega
Encantada
Manati
Las Limas
Cascajal
Moralar
0
25
KILOMETERS

Figure 5.

Pedregal domes. South of the line, salt culminations are 100 or 150 meters below the sea level. Between this line and the Gulf of Mexico, the upper portions of the salt bodies are over 1000 meters deep, exception made for the uplifted Rabón Grande-Moloacán structure, which culminates at a depth of 500 meters, and for the Zanapa dome, the only typical dome known in all the basin. The latter is absolutely identical to the ones existing in the North American Gulf Coast.

In our opinion there exists sufficient structural evidence to suppose (and that is the way we are interpreting it), that this line of separation marks the axis of a regional syncline with an orientation definitely parallel to the foldings in the front of the Sierra Madre.

This fact, of great geological significance, shows that the formation of the uplifted salt structures originated with the foldings in the geosyncline, to a much bigger degree than is generally believed. The orientation of the great salt Jaltipan-Romero Rubio mass, offers evidence in this regard. Very little is known about the depth of the salt in the intermediate parts among the diverse salt structures; it is believed, however, that these have been pushed up 2,500 to 3,000 meters in relation to the original position of the mother bed of salt.

If a closure of this magnitude were considered for the basin structures, then a difference could be established between the Jaltipan-Pedregal area and an area south of a supposed Chinameca Laguna Nueva syncline (Figure 6).

1. A great uplifted salt structure would occupy all the southwestern portion of the basin and would extend from Jaltipan to Medias Aguas with an eastward prolongation to Cabritos and Romero Rubio. It would cover an extension of about 2000 square kilometers (approximately 500,000 acres).

   In this great uprising does exist several independent culminations, characterized by being at only 100 or 150 meters below sea level, with closures of only 400 meters, approximately. So far, only the following culminations can be differentiated:

   a. A great uplifted structure going from Jaltipan to Medias Aguas that extends eastward as far as the Coachapa river, and with an extension of 1,300 square kilometers (approximately 320,000 acres). It probably comprises ten isolated structures (with minor closures) that cannot be defined yet; exception made of the Jaltipan, Texistepec, Almagres, Juile, Medias Aguas, Moralar, Tancamichapan, Soledad, Amexquite and Nopalapa structures having a closure of scarcely 150 meters.

   b. The great uplifted salt Tabasqueño-San Cristobal structure immediately to the east of the Coachapa river; 11 kilometers long and 3 kilometers wide.

   c. The Buenavista-Chichonal structure of about 20 x 15 kilometers.

   d. The Cabritos structure, 8 x 3 kilometers.

   e. The Romero Rubio structure, 10 x 5 kilometers.

2. The uplifted salt Remolino del Carmen-Tecuanapa structure immediately to the east of the Tabasqueño-San Cristobal, 12 kilometers long and 10 kilometers wide, and with a known closure of 1500 meters.

   This structure comprises the following isolated structures with closures of 600 meters:

   a. Remolino del Carmen.

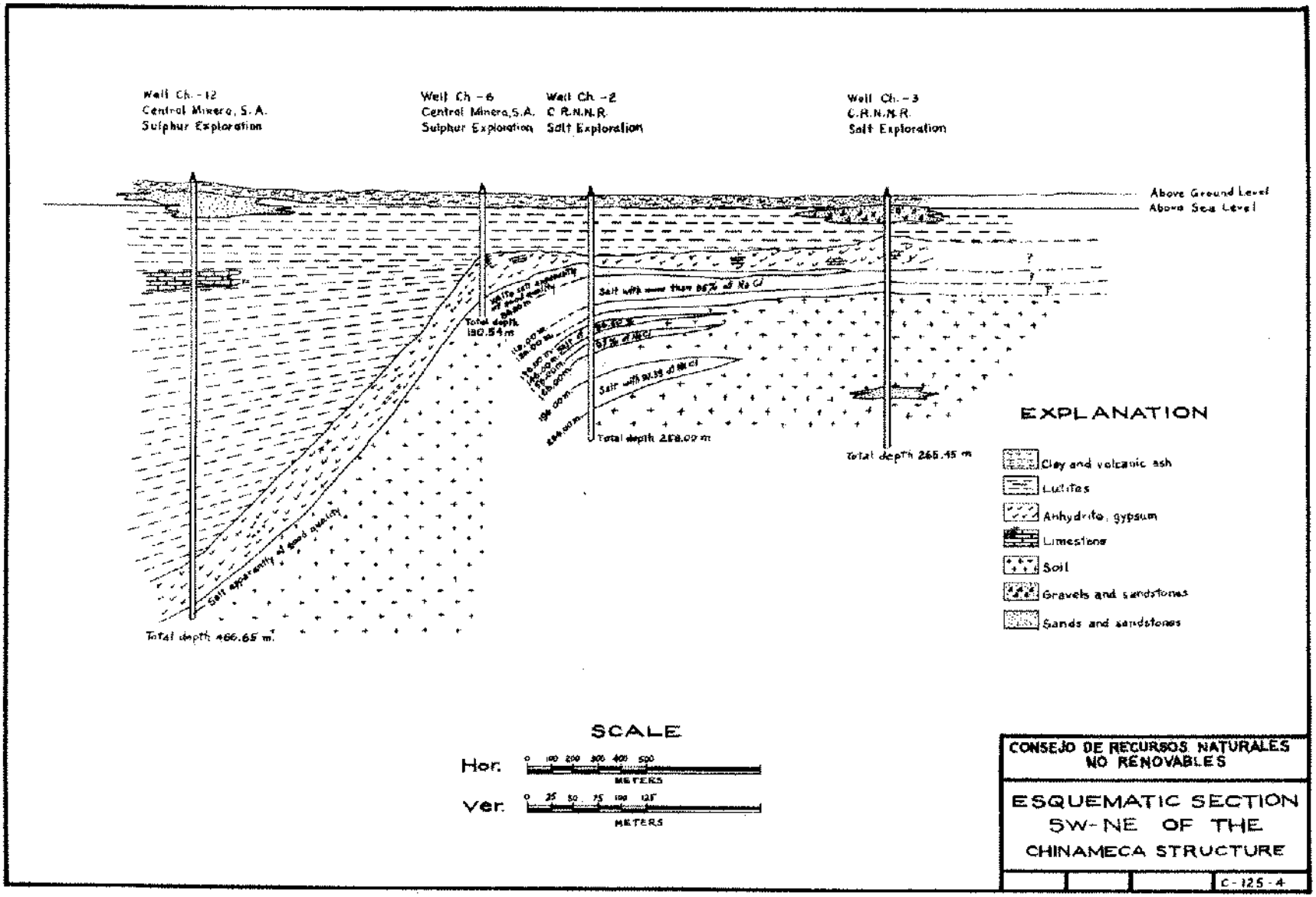
   b. Mazate.

   c. Los Muertos.

   d. Tecuanapa.

3. The so-called Chinameca dome of about 7 x 4 kilometers, which is probably connected with the great uplifted salt structure that includes both: Jaltipan, whose closure is still unknown, and the Cosoleacaque dome, that is in the same conditions as the latter.

4. The Las Limas and Cascajal domes, to the south of the upper salt Remolino del Carmen-Tecuanapa structure, as well as the Laguna Nueva, San Pedro and Pedregal structures,


Well Ch. - 12
Central Minera, S. A.
Sulphur Exploration
Well Ch. - 6
Central Minera, S.A.
Sulphur Exploration
Well Ch. - 2
C.R.N.N.R.
Salt Exploration
Well Ch. - 3
C.R.N.N.R.
Salt Exploration
Above Ground Level
Above Sea Level
Salt with more than 96% of Na Cl
Salt with 97.35 of Na Cl
Salt apparently of good quality
Total depth 466.65 m.
Total depth 265.45 m
EXPLANATION
Clay and volcanic ash
Lutites
Anhydrite, gypsum
Limestone
Soil
Gravels and sandstones
Sands and sandstones
SCALE
Hor.
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METERS
METERS
CONSEJO DE RECURSOS NATURALES NO RENOVABLES
ESQUEMATIC SECTION SW-NE OF THE CHINAMECA STRUCTURE
C-125-4

Figure 6.

further to the east, all of them with known closures of scarcely 150 meters. It is quite possible that these dome structures join at the depth forming uplifted salt structures of the type previously mentioned.

Colorado-El Rosario Area (north of the Chinameca-Laguna Nueva Syncline

Between this syncline and the Gulf of Mexico, uplifted salt structures are characterized by being deeper, their culminations are found more than 1,000 meters below sea level, with only two exceptions.

It comprises the following structures:

1. The great uplifted salt Rabón Grande-Moloacán structure, 25 kilometers long by 20 kilometers wide. In this structure are included the following apophysis, with culminations from 500 to 1000 meters below sea level:

   a. Rabón Grande

   b. Pajaritos

   c. Tuzandepetl

   d. Santa Rosa

   e. Nuevo Teapa

   f. Ixhuatlán

   g. Moloacán

   The Rabón Grande-Moloacán structure includes also the Minatitlán dome, in which the salt is about 1,200 meters below sea level, as well as the Los Abanicos dome of the same characteristics as the former and being to the north.

2. The Colorado dome, possibly a part of the same salt uprising, appears to the west and culminates 1,100 meters below sea level.

3. Eastward of the Rabón Grande-Moloacán structure, the morphologic expression of the uplifted salt structures apparently changes, appearing as independent and isolated structures about 7 kilometers long by 4 kilometers wide. We believe that the sinking of the basin to the north and east, and the rather limited explorations in a zone in which the uplifted salt structures are at a great depth, afford much more appearance than reality to the salt morphology of this extensive zone.

   Recent seismological data indicate an unquestionable tendency to form great salt masses, like the ones appearing south of the basin but with closures possibly over 2,500 (or 3,000 meters), and deeper culminations. Thus, the whole situation there appears as follows:

   a. Acalapa, 6 x 5 kilometers, possibly a part of the great Rabón Grande-Moloacán uprising.

   b. Tortuguero, Punta Gorda and Tonala, Tortuguero being the first found in the continental shelf of the Gulf of Mexico. These three structures, with independent closures of about 700 meters, form part of a single salt uprising.

   c. El Plan and Los Soldados. The first is a great oil producer in the zone. As shown in Figure 7, these two salt domes are connected, having together a closure of about 3000 meters.

   d. La Venta (Figure 8), El Roble (Figure 5), Magallanes, Pailebot and Yucateco, in the State of Tabasco, probably all form a single uplifted salt structure.

   e. The Ogarrio, Palo Blanco and La Central structures. So far, only the first one has been tested by direct methods and proved to be a good oil field, the other two have been subjected only to seismology determinations.

   f. El Rosario, southeast of the latter group, is possibly a part of the same uprising.

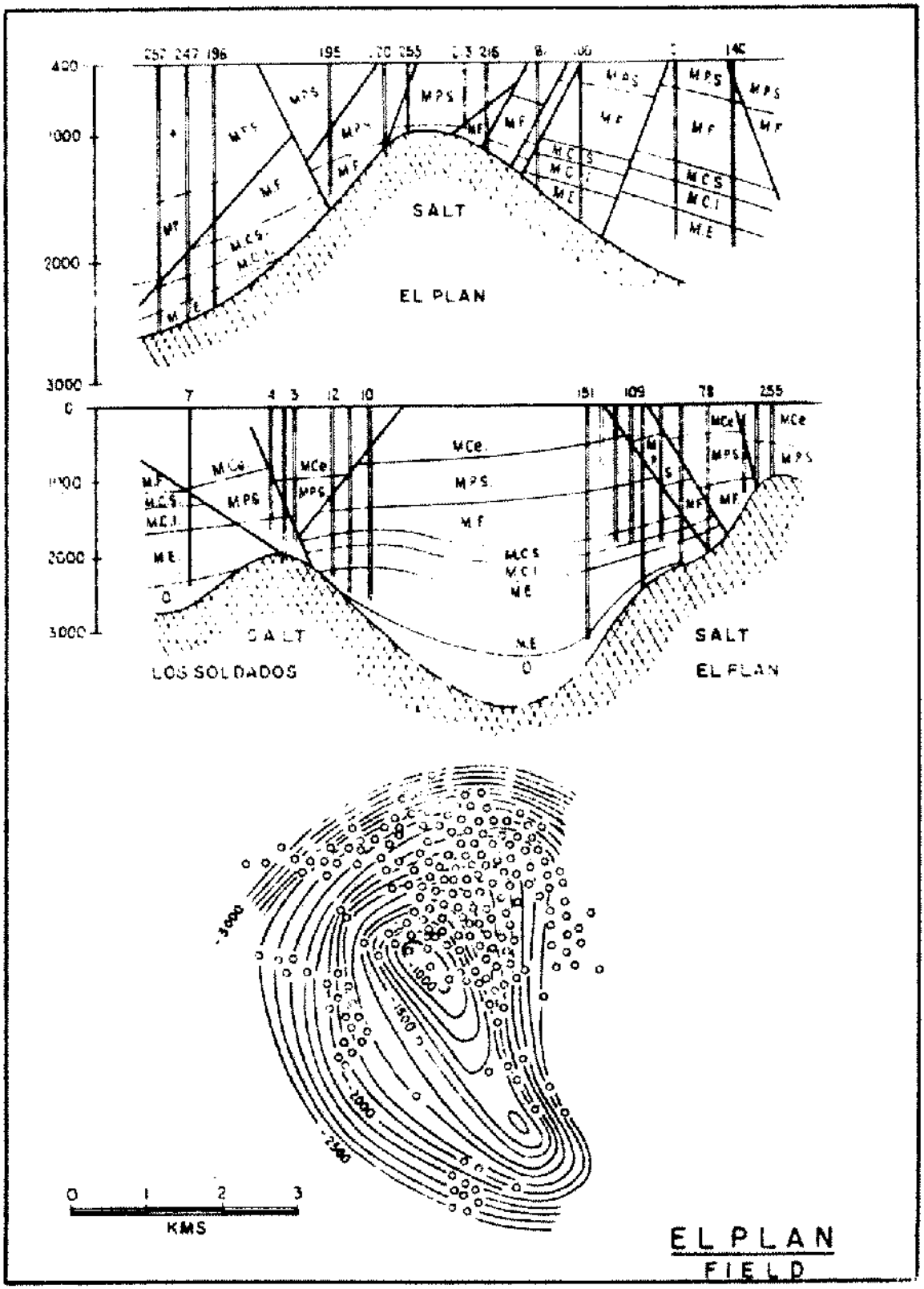
SALT
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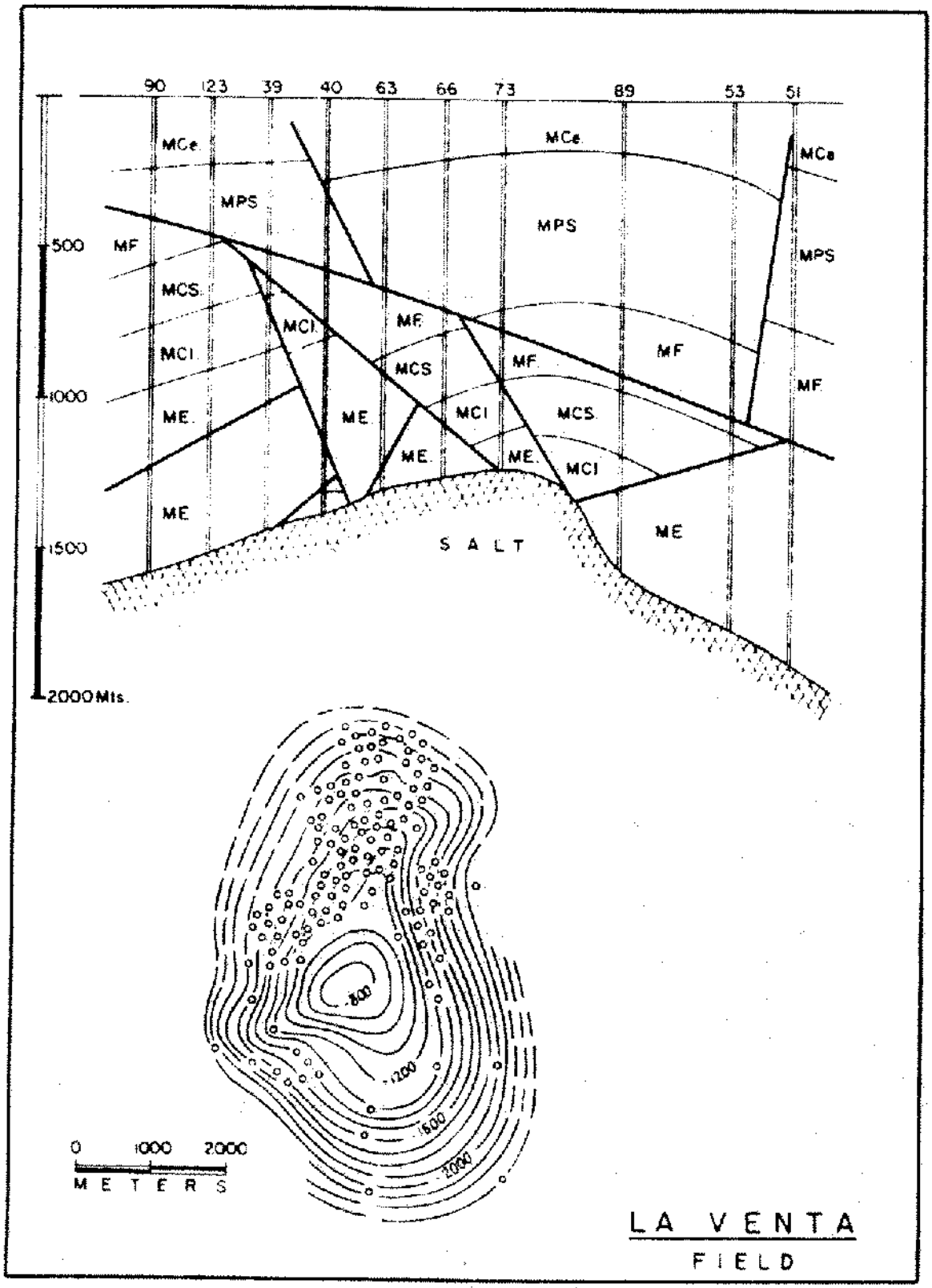
Figure 7.


90
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MCe
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SALT
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1500
2000 Mts.
0
1000
2000
METERS
LA VENTA
FIELD

Figure 8.

Completely isolated and scattered through an extensive area in the eastern part of the basin are found the following uplifted salt structures:

a. Santa Ana, in the continental shelf of the Gulf, culminates at 2,600 meters.

b. El Dorado, north of Huimanguillo town and on the left margin of the Grijalva river, with the salt to 2,300 meters.

c. Jalapa, 20 kilometers to the northeast of Villahermosa, its top at 2,500 meters.

d. Medellin, 23 kilometers to the southeast of Ciudad Pemex and the most eastern dome known to date, with the salt to 1,650 meters below sea level.

The only one missing in this list is the Zanapa dome, described before and located in the western boundary of the state of Tabasco.

The Zanapa is the only case, north of the Chinameca-Laguna Nueva syncline in which the salt is quite close to the surface (100 meters). As stated before, its completely vertical flanks including small "overhangs" are well known. It is the only typical dome in the basin (made up of a real column of salt) that has been raised perhaps more than 5000 meters according to the seismology data of the surroundings.

It has been written about the possibility that the salt foldings being due to a buttressing effect of the San Andres massif acting against tectonic forces originated by foldings in the front of the Sierra Madre.

Though no quite clear tectonic evidence exists, it is believed that the salt foldings could have been originated by reverse faulting and that this folding could have initiated the formation of the uplifted salt structures. Today it is well known that the latter were finally produced by the static pressure of thick sedimentary deposits above the salt.

By measurements taken, particularly in the southeastern part of the basin, it is supposed that the thickness of the salt attains a figure on the order of 3000 meters. This seems to coincide with the experimental results obtained for the formation of domes, in which have been taken into account the great size of the salt structures in the Isthmus.

HISTORICAL GEOLOGY

According to the work of Hugo Contreras and based on the explorations accomplished by Pemex in the zone, the historical geology of the salt basin is as follows:

During the Permian, the seas extended throughout most of the Isthmus, at least as far as Tehuantepec, and inclusive occupied the latter totally, since the gneiss forming the southern part of the basin could have been derived from Permian sediments by an intense metamorphism. The latter statement seems to be indicated by the presence of intrusive gneisses, outcropping along the route of the National Railroad of Tehuantepec, and serpentines to the east of La Ventosa.

The metamorphozed sediments of the Isthmian region afford some evidence in regard to the ancient existence of a Permian sea, because 90% of them consist of schists and minor quantities of marbles and typical carbonaceous limestones.

In late Permian, or at the beginnings of the Triassic, the southern portion must have been raised to form a higher relief area, from which could have been derived all the sediments (mainly continental in origin) which presently form the Red Beds.

This intense orogeny seems to correspond to the Appalachian Revolution.

The salt basin must have been formed when the high relief areas interrupted the passage of winds loaded with humidity. The sea went away, northward, and a deposition of sediments under semicontinental conditions took place. The basin must have been closed on the north side.

Westward, we do not know anything yet regarding the existence of salt cores, but taking into account both the Texiutlán massif and the more theoretical San Andres Tuxtla massif, it is not risky to suppose they could be interconnected and that the latter could represent the remains of what has been known as Llanoria in the southern portion of the United States.

It is unknown how far the basin extends to the north, but many authors suppose that Llanoria covered a great portion of what today is the Gulf of Mexico, allowing in this way the formation of salt basins in the bordering low, flat, land areas.

Eastward, the partially closed basin must have been extended to the Yucatán Península, in accordance with the gravimetric results obtained.

At the beginning of the Cretaceous, a great sinking throughout the region took place, causing the Llanoria to disappear and the sea to be extended further south than the Cretaceous outcrops of today.

It is quite possible that in Upper Jurassic time the sediments deposited in the basin had already been folded up, to form a relatively high area in its southwestern portion (between the route of the Tehuantepec National Railroad and the Pedregal river) in the site now occupied by the big salt masses of the basin. If this is true, the salt went up along with the sediments, being maintained this way throughout all the Middle Cretaceous; that is, from the Hauterivian to the Cenomanian, as sediments of these epochs are lacking in that portion of the basin. This latter statement is partially proved by a discordant deposition of Upper Cretaceous sediments over the typical Chinameca Formation of the Cerro Pelon region.

To the south of this high area, a geosyncline must have been formed theoretically, the Mexican Geosyncline was such a structure. It extended south to Guatemala and allowed the deposition of all the Upper Cretaceous sediments that outcrop, now, along the front of the Sierra Madre.

While the Laramide Revolution started to fold these sediments, the granitic and metamorphic mass to the south of the basin was emerging and starting to move toward the north. By this time, Upper Cretaceous lutites and sandstones began to be deposited, the geosyncline got deeper, and the basin sunk totally under water.

At the end of this period, a well defined basin was already established in the salt zone, as well as a geosyncline along the front of the Sierra through what today is the region comprising the coastal plain of Veracruz, the southern part of Tabasco, all the middle part of Chiapas, and Guatemala and Belice, southward.

The salt intruded and folded along with the Jurassic sediments, began to be uplifted by the isostatic pressure of Upper Cretaceous, Paleocene and, mainly, Eocene sediments. These mechanical effects have given rise to considerable important structures.

In this way, up to 1000 meters of sediments were deposited, thickness that was considerable increased at the beginning of the Oligocene when there was complete deepening of the basin, which by that time was completely opened toward the Gulf of Mexico.

As the total thickness of the Oligocene sediments is quite considerable, they must have formed the main load that completed the intrusional movement of the salt, this theory is especially in accordance with the known hypothesis for the formation of the salt domes of the Gulf Coast.

At the beginning of the Miocene, the seas had a tendency to be shallower, while the folding in the Mexican Geosyncline had left rather high areas immediately to the south of the basin. This latter was inclined to the northeast.

The domes in the western portion must have had only small movement compared with those in the eastern portion, where 2,000 meters of Lower Miocene sediments kept the salt rising continuously.

Since then the basin started to rise, being deposited the Filisola formation (shallow sea sandstones) and the Paraje Solo formation (lagoonal deposits).

In the upper part of the Miocene, clastics almost continental in character were deposited along with the small sea transgression represented by the Aquequexquite formation.

From the Oligocene to the present time, all the basin has been gradually inclined seaward in such a way that the Miocene sediments now form a big wedge, more marine toward the Gulf, as it has happened in similar deposits along the Texas and Louisiana Gulf Coast.

ECONOMIC CONSIDERATIONS

In the Isthmus -- 51,153,169 cubic meters of oil, and 9,950,931 cubic meters of hydrocarburated mixtures (absorption products), have been extracted, up to the 31st of last March, in the Tabasco basin.

The actual monthly production, corresponding also to last March, was 407,902 cubic meters of oil; 343,241,495 cubic meters of gas and 68.429 cubic meters of absorption products.

Today's actual reserves in the Isthmus -- Tabasco basin are on the order of 35 million cubic meters of oil, 20 million cubic meters of condensed and 90 thousand million cubic meters of dry gas. This is approximately equivalent to 100 million cubic meters of liquids.

From five sulphur-fields connected with uplifted structures have been extracted, up to the 31st of last March, 7,627,961 metric tons of sulphur. The actual production in only two of those fields was 11,829 metric tons last March.

The total reserves of sulphur have been estimated at 40 million tons.

Three petrochemical plants producing fertilizers have initiated their operations recently, using gas or sulphur as raw material.

So far, there is not any exploitation of the salt resources in the basin, but Pemex, in cooperation with private investors, are in the process of executing an important project, which consists in building up an industrial complex at Pajaritos, using salt products from brines for the production of tetraethyl lead.

The Isthmian region is becoming industrialized due to its own natural resources. The recent drillings at Chinameca, though not conclusive, have shown halite sections, 98% sodium chloride, which offer good economic perspectives.

We hope that the exploitation of the basin's salt resources, practically unexplored yet, will join both oil and sulphur industries for creating a new source of employment for this country.