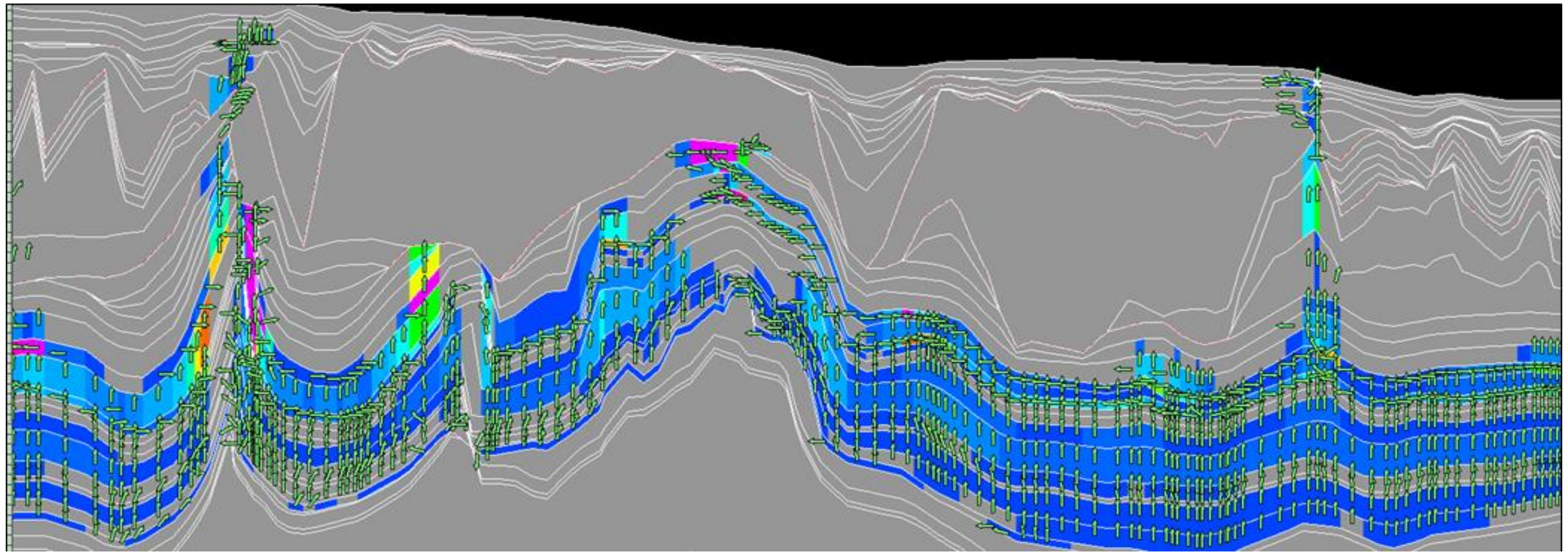
PERDIDO FOLD BELT
SUBSALT BELT
MEXICAN RIDGES

PETROLEUM GEOLOGICAL SYNTHESIS



December 2015

GULF OF MEXICO – DEEP WATER - NORTH SECTOR

Introduction

The Article 39 of the "Ley de los Órganos Reguladores Coordinados en Materia Energética", provides that Comisión Nacional de Hidrocarburos perform its duties in ensuring that the projects are carried out according to the following rules:

- Accelerating the development of knowledge of petroleum potential in the country.
- Increase the recovery factor and obtaining the maximum volume of crude oil and natural gas in the long-term, economically viable conditions, of wells, fields and abandoned reservoirs, in process of exploitation and abandonment.
- The replacement of hydrocarbon reserves, as guarantors of energy security of the Nation and, from the prospective resources, based on the available technology and according to the economic viability projects.
- The use of the most appropriate technology for exploration and extraction of hydrocarbons, according to the productive and economic results.
- Ensure that administrative processes responsible, with respect to the exploration and extraction of hydrocarbons activities, are conducted with adherence to the principles of transparency, honesty, accuracy, legality, objectivity, impartiality, effectiveness, and efficiency.
- Promote the development of the exploration and extraction of hydrocarbons activities for the benefit of the country.
- Ensure the advantage of associated natural gas in the exploration and extraction of hydrocarbons.

As part of the next bidding rounds for hydrocarbon exploration areas and, in compliance with the above-mentioned functions, this Comisión Nacional de Hidrocarburos prepared this document, which presents a Petroleum Geological Synthesis of the three main geological provinces located in deepwater in the Gulf of Mexico: Perdido Fold Belt, Subsaline Belt and Mexican Ridges.

Perdido Fold Belt: constituted by a fold system with NE-SW direction, reverse faults associated with plane of takeoff in the autochthonous Jurassic salt mass. The potential hydrocarbon traps are anticlinal structures nucleated by salt, long and tight, with water depths ranging from 2,000 to 3,500 m. It has confirmed the existence of oil deposits reservoirs in sandstones placed in environments of lower Eocene turbidities fans and channels of turbidities sandstones in the Oligocene.

Subsalt Belt: it is characterized by the presence of tabular mantles of allochthonous shallow salt, nappes and diapirs formed, evacuees from the Jurassic Callovian basal salt formation, intercalated or overlapped to the folded sedimentary sequence of Jurassic, Cretaceous and Tertiary. Depth varies from 500 to 2,500 m. Westward is individualizes a parallel strip, characterized by a salt tectonic and clay with the presence of folds, diapirs and salt walls, as well as a series of minibasins synclines shafts with Neogene sedimentary fill.

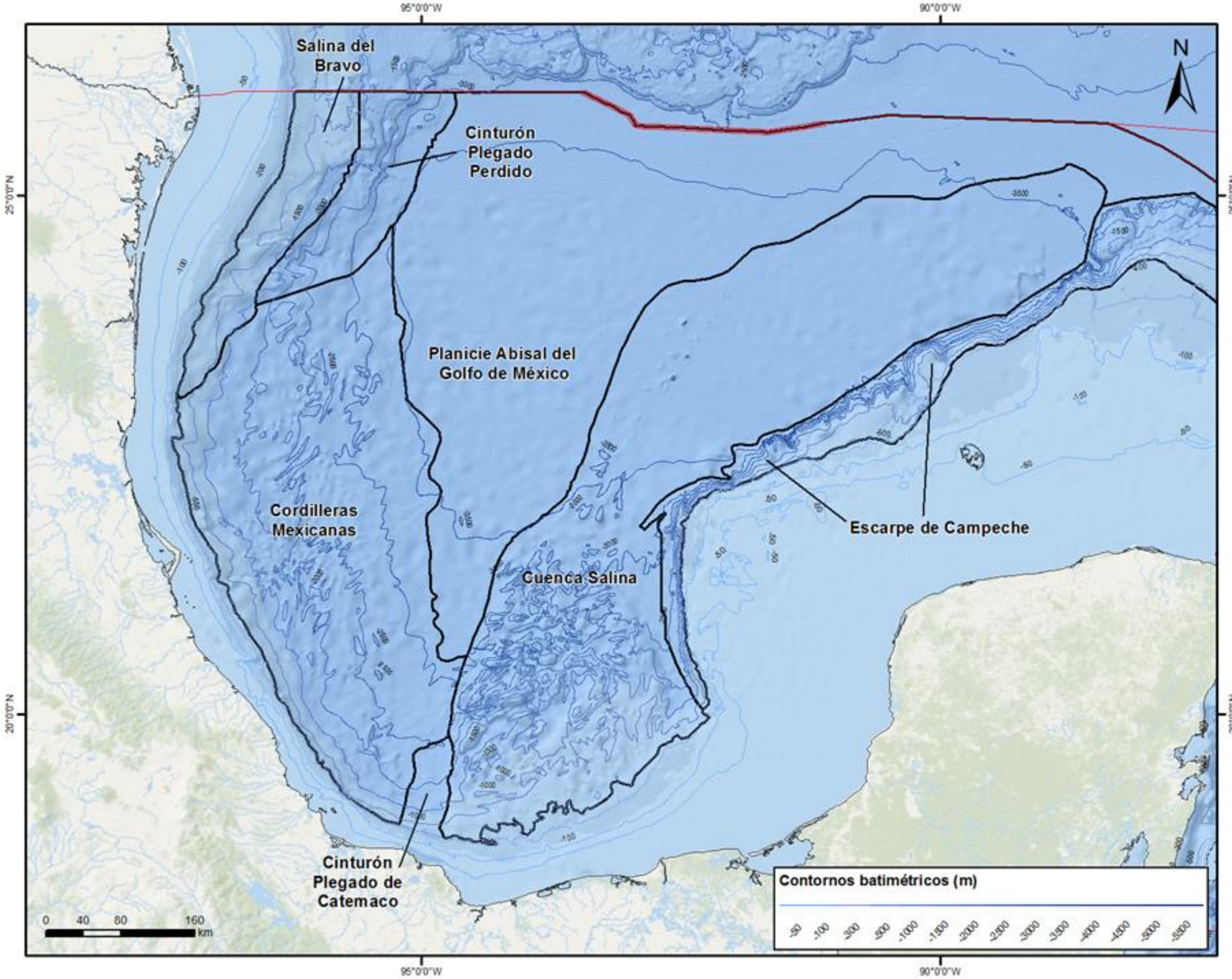
Mexican Ridges: it is a contraction system of elongated folds of NNW-SSE direction, which stretches 500 km and covers nearly 70,000 km^2 in water depths between 1,000 and 3,000 m. It is characterized by asymmetric anticlines long and narrow, usually with vergence to the East. The dual system extension - compression had as main detachment takeoff plane of argillaceous horizons of the upper Eocene and some other secondary detachment takeoff planes the Tertiary sequence.

To each province morph-structural is addressed the next:

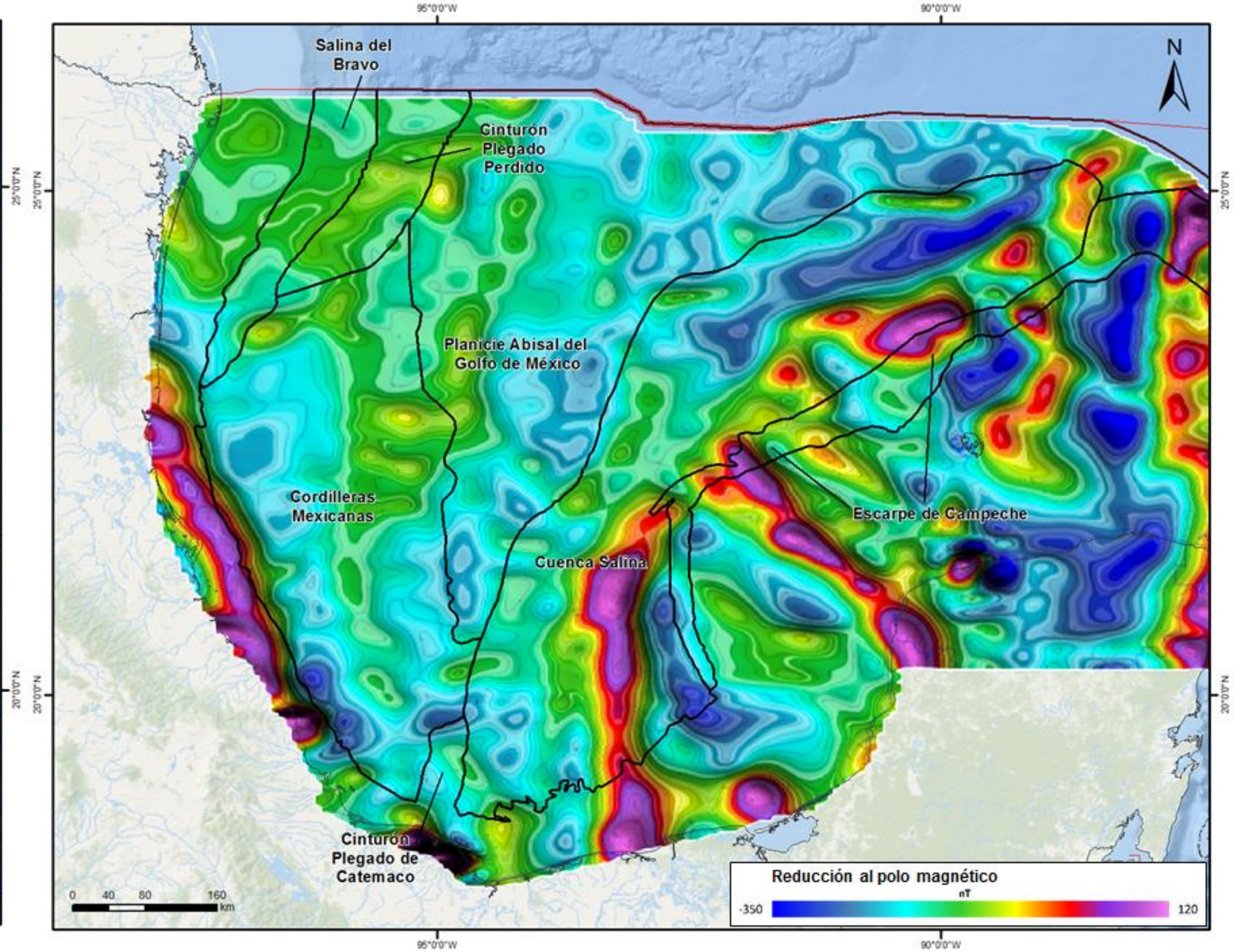
- Regional geological context.
- Stratigraphic framework, from Jurassic to Pliocene, a description of sedimentological aspects and distribution of sedimentary facies sequences of petroleum interest.
- Structural framework, chapter that describes the sedimentary sequences deformation processes and the resulting topology oil traps.
- Petroleum systems, defining the elements and processes of generation, migration and entrapment of hydrocarbons.

Regional Geological Context

Deep Water – Regional Context – Geological provinces



Geological provinces map



Magnetic pole reduction map

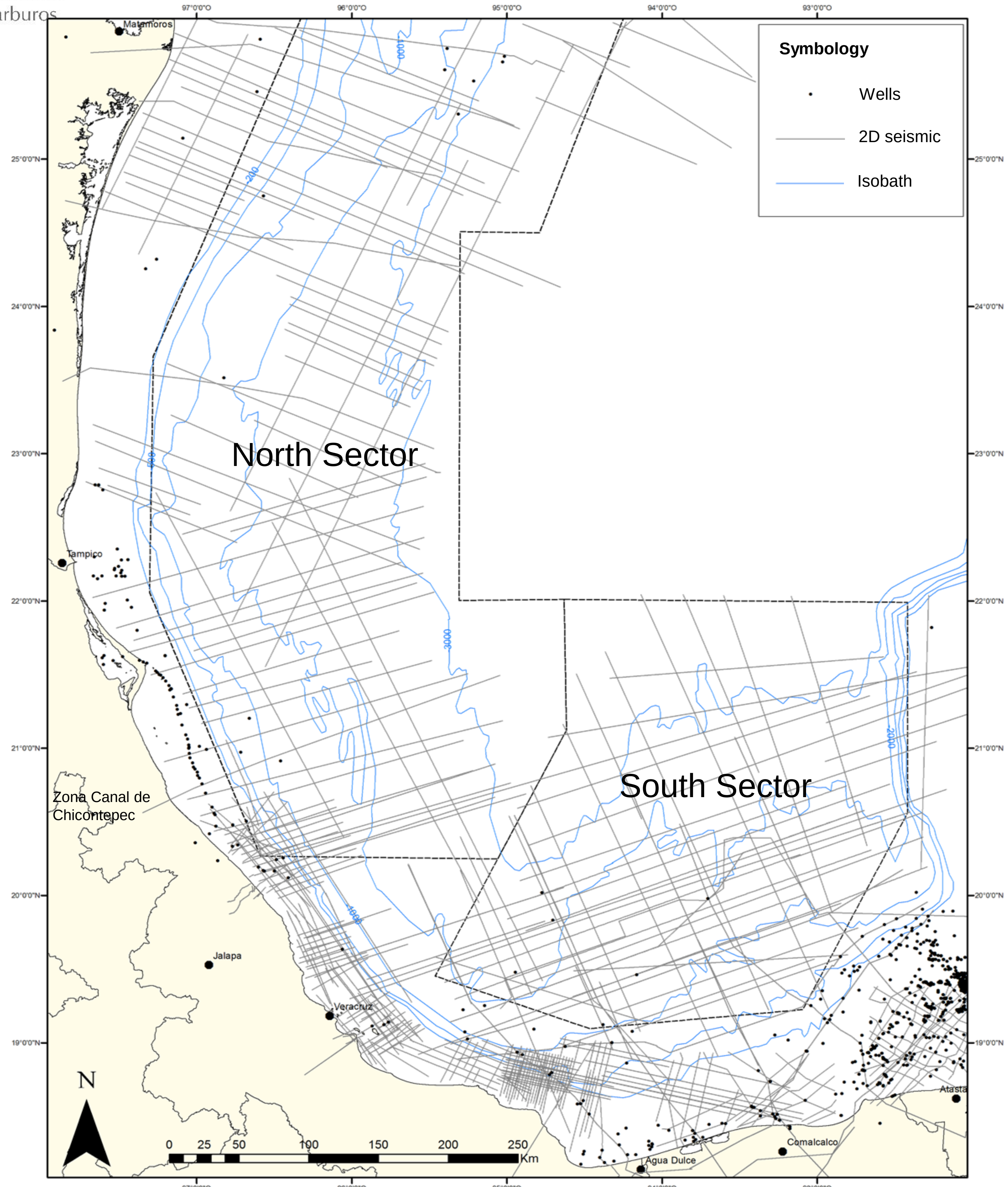
The Deep Water area in the Gulf of Mexico extends from the 500 m isobath to 1,500 m depth in the open sea. The ultra-deep water term refers to depths greater than 1,500 m. The Gulf of Mexico depths register more than 3,500 m.

Magnetic pole reduction of the Gulf of Mexico map, relating the position of the magnetic anomalies to the direct position of the underground of morphologically positive elements from the basement.

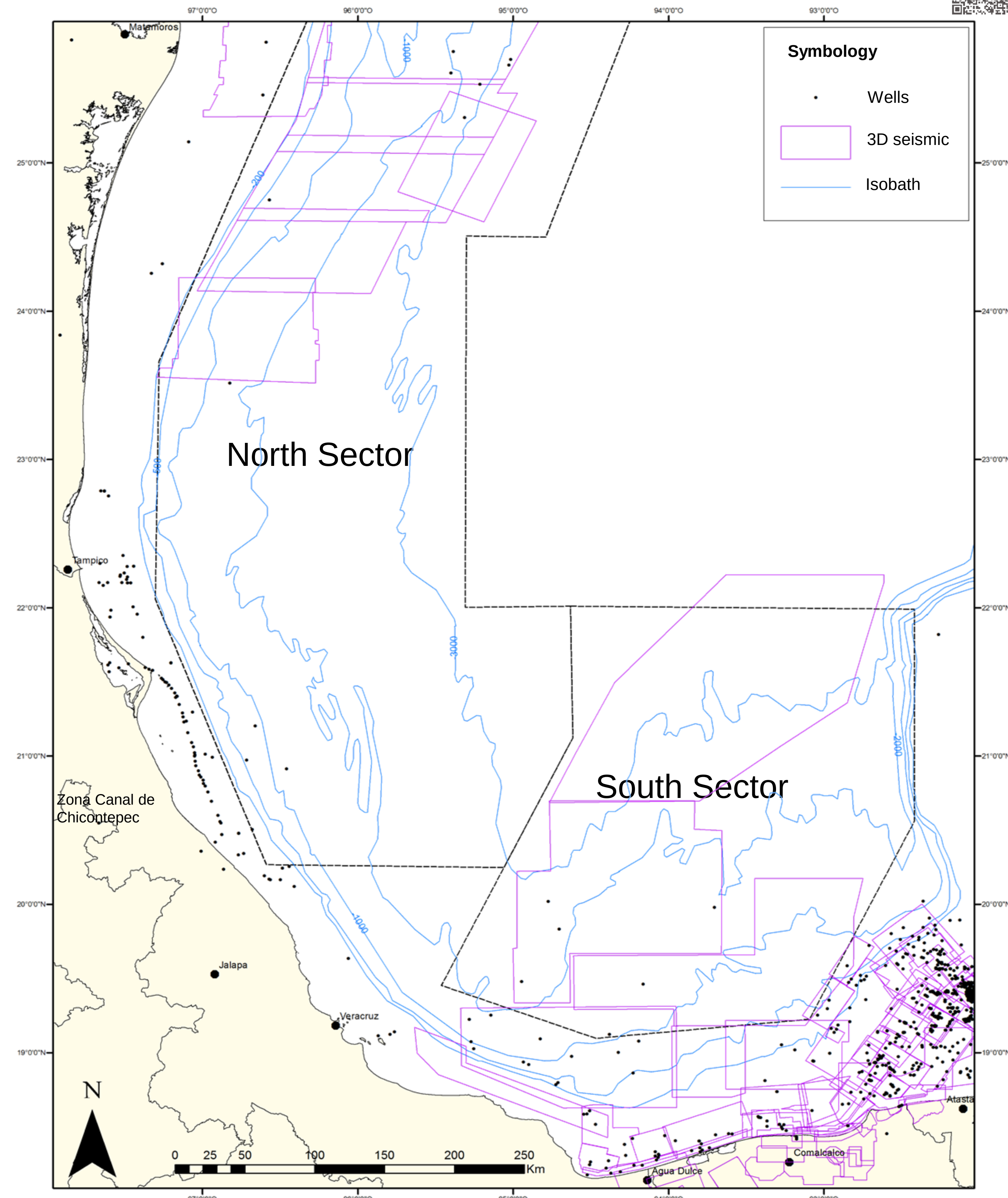
The Deep Water Geological Provinces in the Gulf of Mexico are:

Salina del Bravo Province (Salina del Bravo) – Perdido Fold Belt (Cinturón Plegado Perdido) – Mexican Ridges (Cordilleras Mexicanas) – Catemaco Fold Belt (Cinturón Plegado de Catemaco) – Salt Basin (Cuenca Salina) - Campeche Escarpment (Escarpe de Campeche).

Deep Water – Regional Context – 2D and 3D Seismic cover map

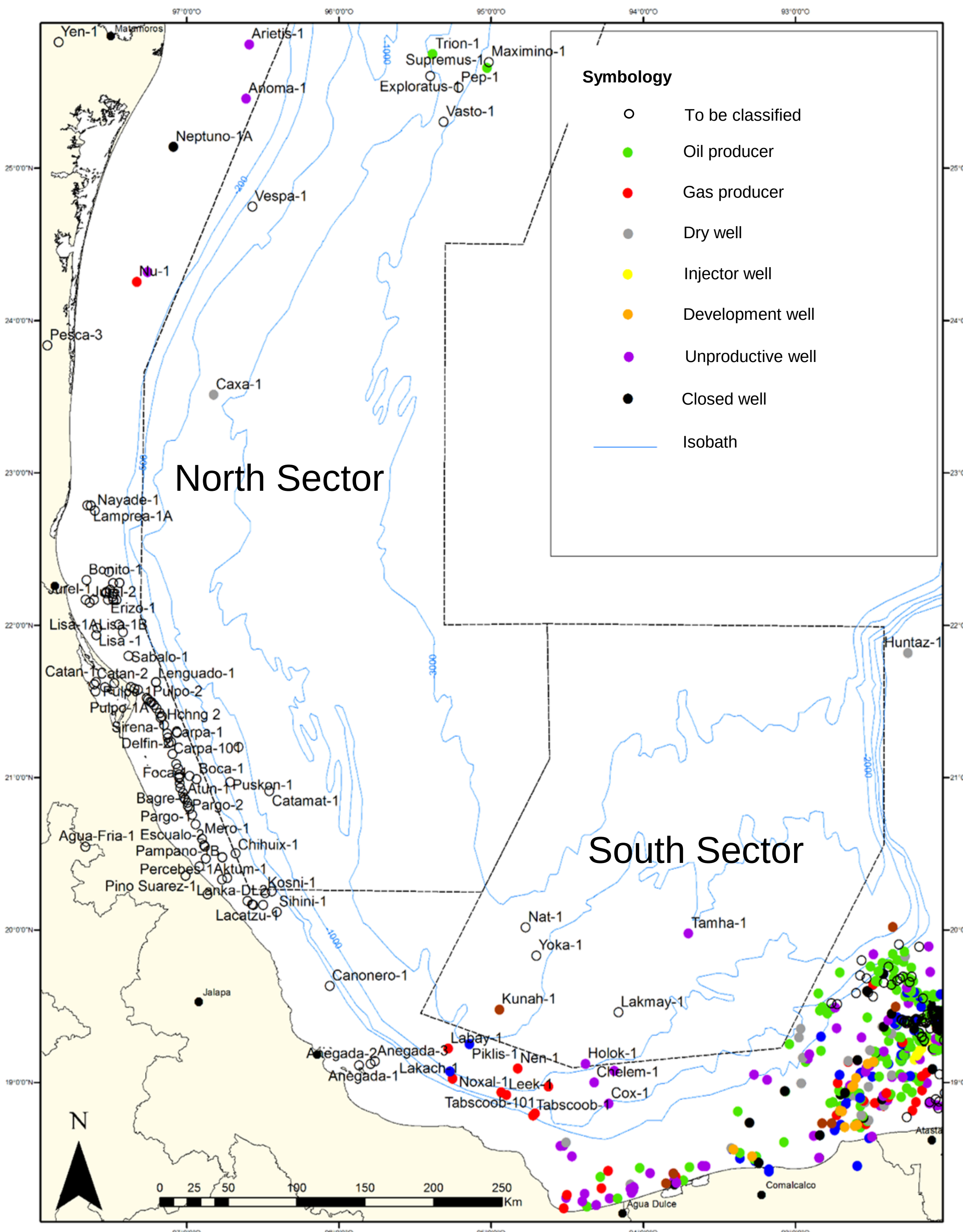


2D Seismic

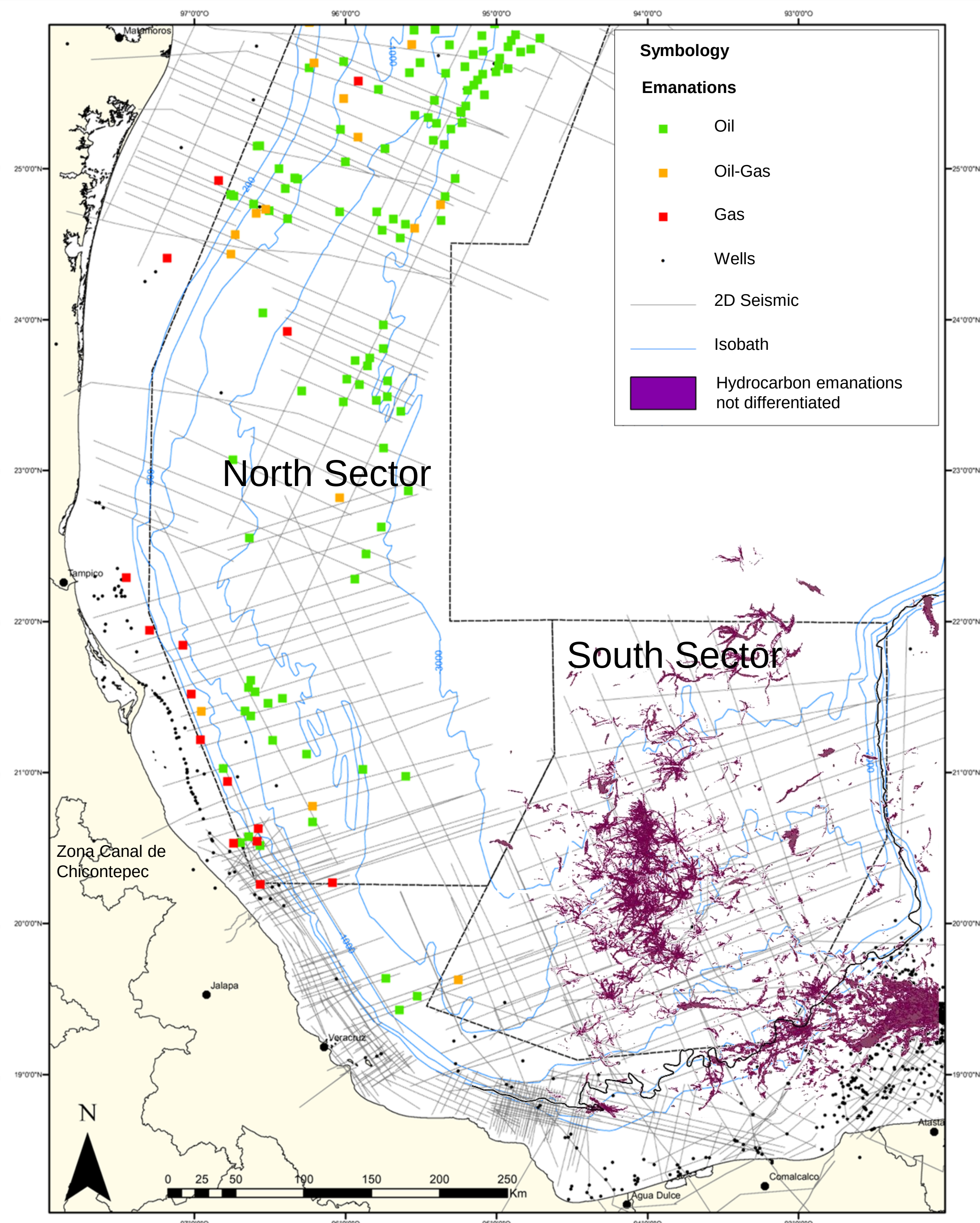


3D Seismic

Deep Water - Regional settings - Exploratory Wells and HC Seeps



Wells



Emanations

Exploration and discoveries in the West Sector

Recent discoveries in the Perdido Fold Belt confirmed the Tertiary oil potential. The reservoir rocks are of good quality and prospective resources estimated are promising.

In the Perdido Fold Belt have been drilled exploratory wells which confirm the operation of oil active systems, such as Trion-1, Maximino-1, Supremus-1 and Exploratus-1. Analogues of these wells are Trident-1, Baha-2, constituting fields already known and with significant resources in the United States.

On the other hand, accumulations of hydrocarbons has been reported in the Miocene sands during the Vespa-1 well drilling, which confirm the existence of another additional active petroleum system in the minibasin area.

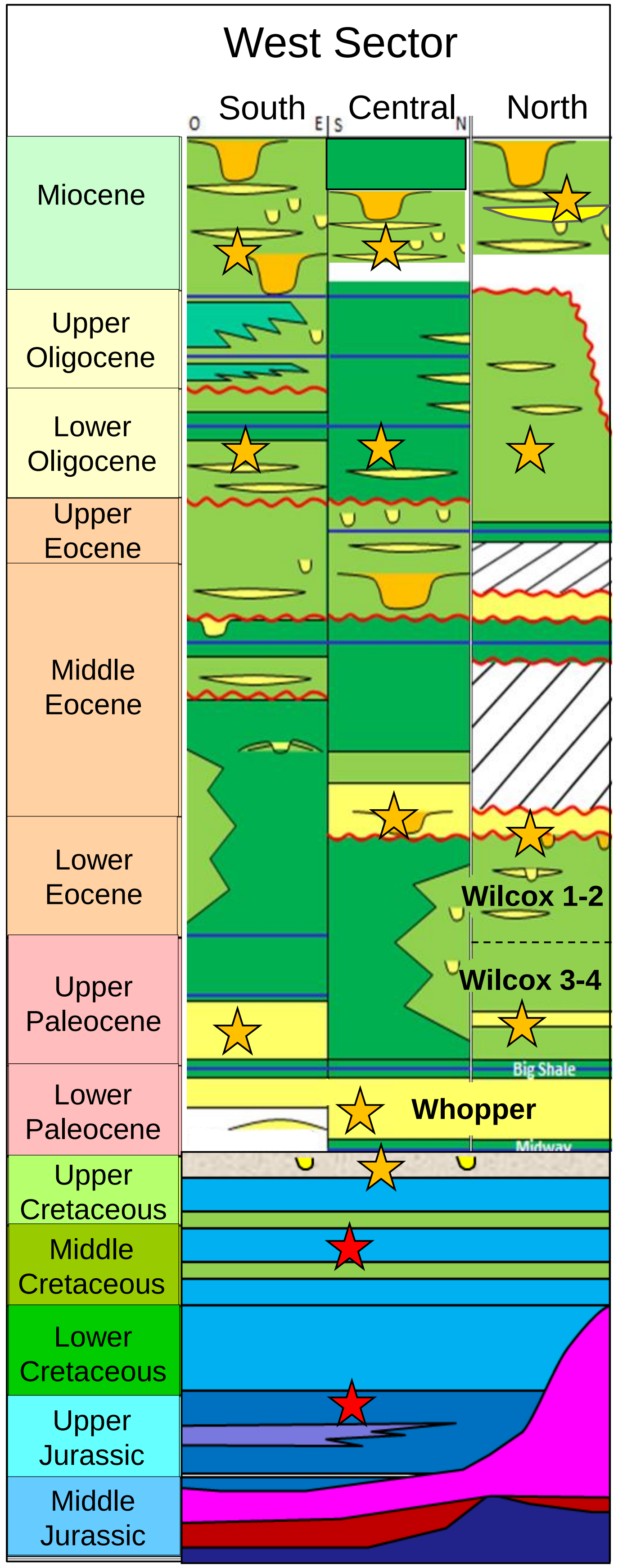
It is then confirmed, the existence of active petroleum systems with significant resources in a train of structures that extend from the Alaminos Canyon in the United States up to the area of Perdido Fold Belt and Subsalt Belt in Mexican side.

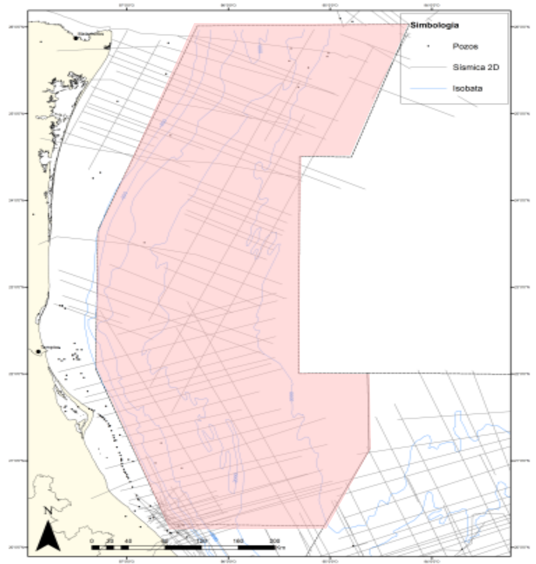
Hydrocarbons emanations

It has been reported many emanations of oil and gas in the seafloor, showing the functioning of an active petroleum system. These emanations are mainly concentrated in the area of the Perdido Fold Belt, Subsalt Belt and the minibasins sector, also in relation to the salt diapirism, and the distal face of the compression system front with a detachment level in the Eocene clays from Mexican Ridges.

Stratigraphic Framework

Geological Context - Stratigraphic Frame – West Sector





Reservoir Rock

Source Rock

Clay

Clay and fine sandstone

Sandstone

Fluvial-deltaic sandstone

Canyon

Channel

Lobes

Levee channel

Siliciclastic channels, turbidite systems

Marls and basin carbonates

Carbonates, terrigenous and dolomite

Salt, red beds and basement

Miocene-Pliocene: Sedimentation in bathyal and neritic environments, facies mainly clayley and silty related to turbiditic environments, sandstones packages associated to submarine fans and channels.

Oligocene: Corresponds to fine-grained sands interbedded with clays, deposited in meandering channels and distal lobes, contemporary to the first episodes of deformation caused by the allochthonous salt movements. Therefore, at this epoch the structural configuration modifies due to the plastic deformation of the salt bodies.

Middle-Upper Eocene: Sedimentation was carried out in a lower bathyal environment, forming a seal of good thickness in the Middle Eocene, composed of clays with thin interbedded siltstones in hemipelagic environments. There are also thin layers of sandstones facies related to lobes and crevasse splays from channels in the Upper Eocene.

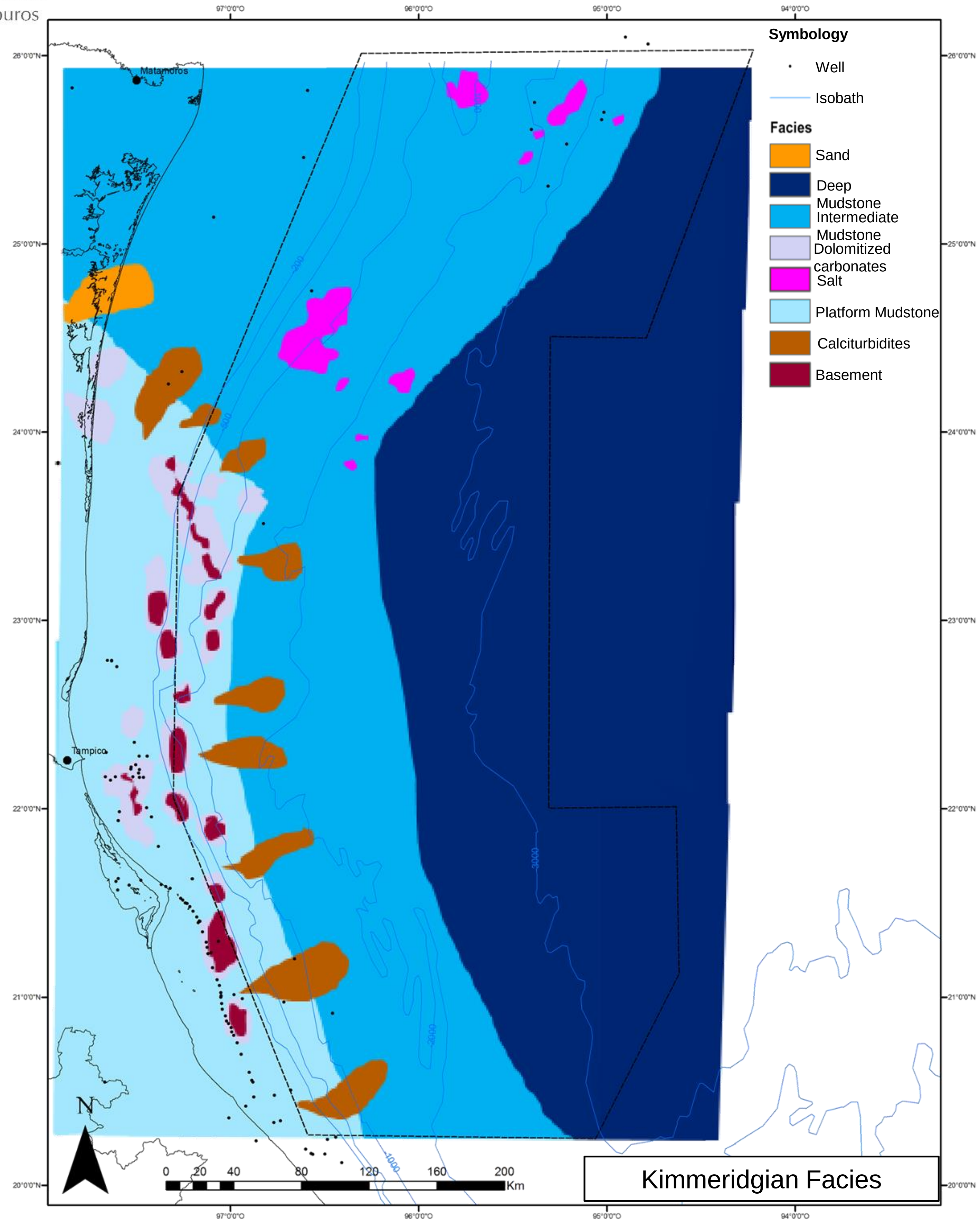
Lower Paleocene-Eocene: The Paleocene corresponds to a period of low sea level in the Gulf of Mexico. Lower Paleocene is composed of basal sandstones bodies with a long lateral extension called the “Whooper” sand (equivalent to Lower Wilcox Formation) in channel facies and turbiditic layers, evolving to a sandy submarine fan system with lobes and amalgamated channels to the Lower Eocene, with a high clay content corresponding to a high sea level period. There are silt-clay intervals deposited in hemipelagic basin facies interbedded with sandy Paleocene intervals (Midway Formation and “Big Shale” member).

Cretaceous: Carbonate facies identified in deep basin environments with high cyclical fluctuations of sea level. To the middle part, a of secondary source rock level is inferred of Turonian age, with high content of organic matter deposited in anoxic basin environments. In the Upper Cretaceous are identified calcareous-sandy bodies locally distributed, related to turbiditic lobes.

Upper Jurassic: Mainly carbonate sediments from inner to external ramp facies, with lateral variations to dolomites and terrigenous sediments deposited in middle ramp environments. Toward the top, a maximum transgression level represented by basin carbonates rich in organic matter, particularly in the Tithonian, shows features of anoxic environments deposition.

Middle Jurassic: Formed by red beds overlaying igneous-metamorphic basement, evolving to evaporitic rocks of great thickness related to the Gulf of Mexico opening.

Geological Context – Jurassic Sedimentology



Middle Jurassic

It is mainly characterized by evaporitic deposits associated with the opening of the Gulf of Mexico. During the Callovian and at the beginning of the Oxfordian, marine conditions gradually extent across the basin.

Upper Jurassic

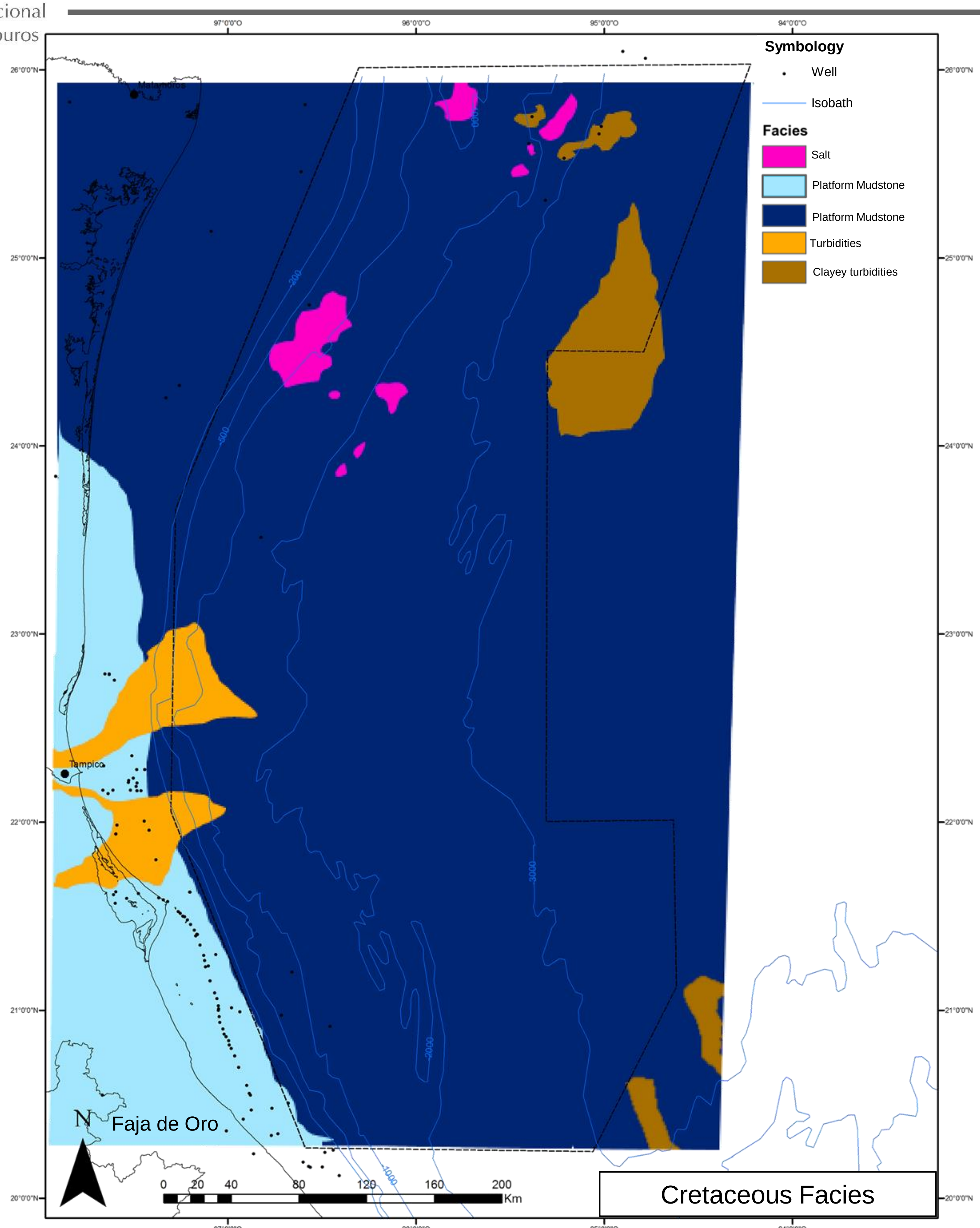
It consists of a period of marine transgression from the Oxfordian to Tithonian.

In general, during the Oxfordian and Kimmeridgian, carbonate facies are present ranging from inner to external ramp environments with local sandy lobes bodies in the intermediate ramp portion.

There exist also basement highs bordered by dolomitized limestones. There is no well that have reached this level to confirm its quality as a reservoir rock, therefore is considered as an hypothetical play.

During the Tithonian, a maximum marine transgression occur, related to worldwide anoxic events in the Upper Jurassic time. Carbonates were deposited as thin layers with carbonaceous siltstones, rich in organic matter and deposited in anoxic basin environments, leading to the greatest potential source rock of the Gulf of Mexico.

Geological Context – Cretaceous Sedimentology

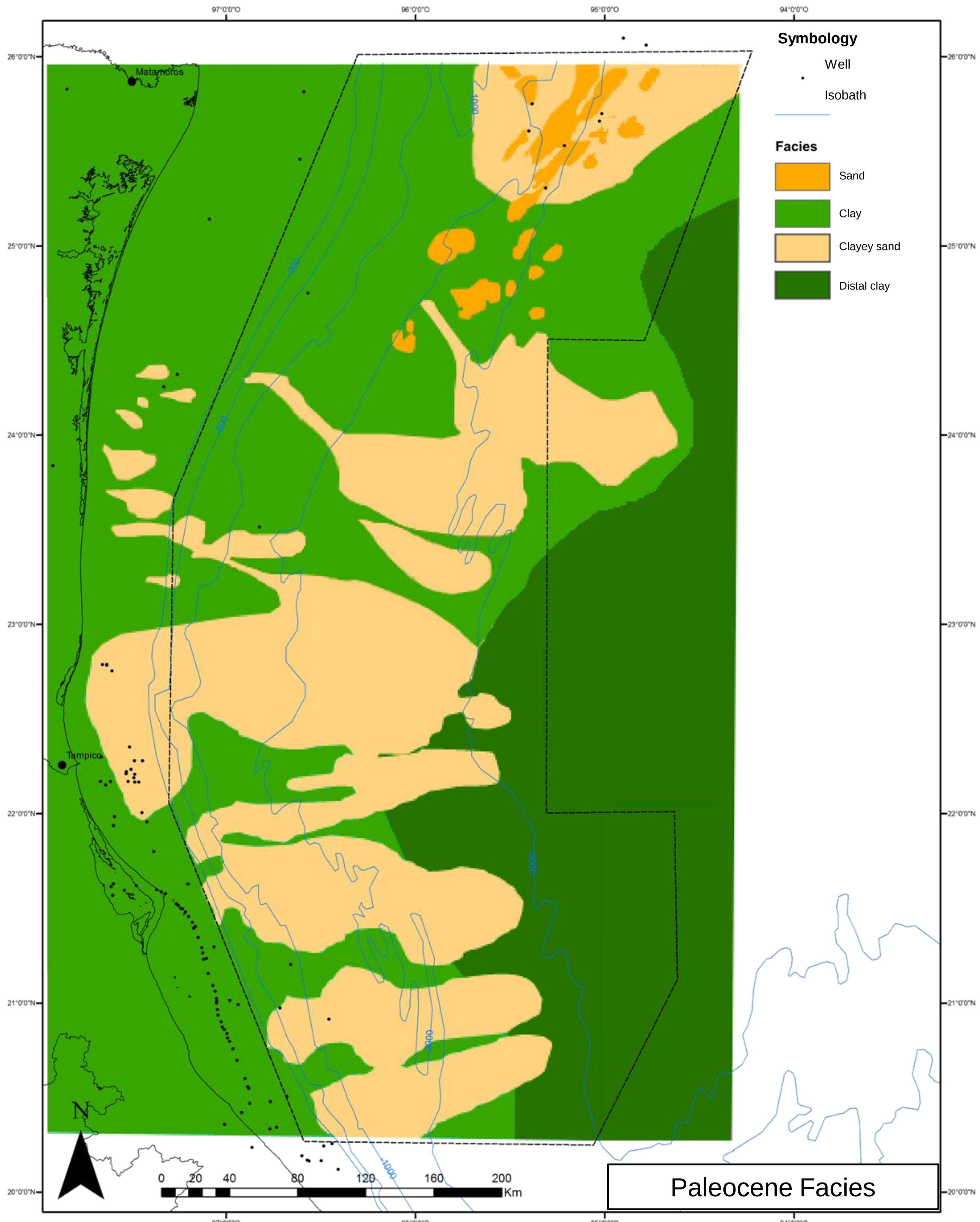


Lower and Middle Cretaceous

The Lower and Middle Cretaceous are represented by a bathyal environments dominated by basin carbonates deposition, with intercalations of clastics related to synsedimentary slides and turbiditic flows composed by calcarenites from the carbonate platform.

Currently, the are no well that have reached Cretaceous units to check its quality as reservoir rock, but by analogy with wells drilled in the northern portion of the US Perdido Fold Belt, the presence of fractured carbonate facies is predicted and in some instances carbonate debris flows eroded from external platform collapses. Because of the depth of the Cretaceous formations in this region, more than 6,000 m, possibly low porosities and permeabilities are expected

Geological Context – Paleocene sedimentology



Paleocene is mainly represented by bathyal turbiditic sediments formed by fine-grained sandstones and shale interbeddings. The main source of the clastic sediments come from the North and Northeast, in which the main sedimentary contribution are from the Houston Delta and the Grande or Bravo River. For the central and southern areas, sedimentary source come from the West and correspond to deltas and canyons that discharged sediments into the Gulf of Mexico, creating a sedimentary system of turbiditic character.

Paleocene sequence is divided into the following units from the base to the top:

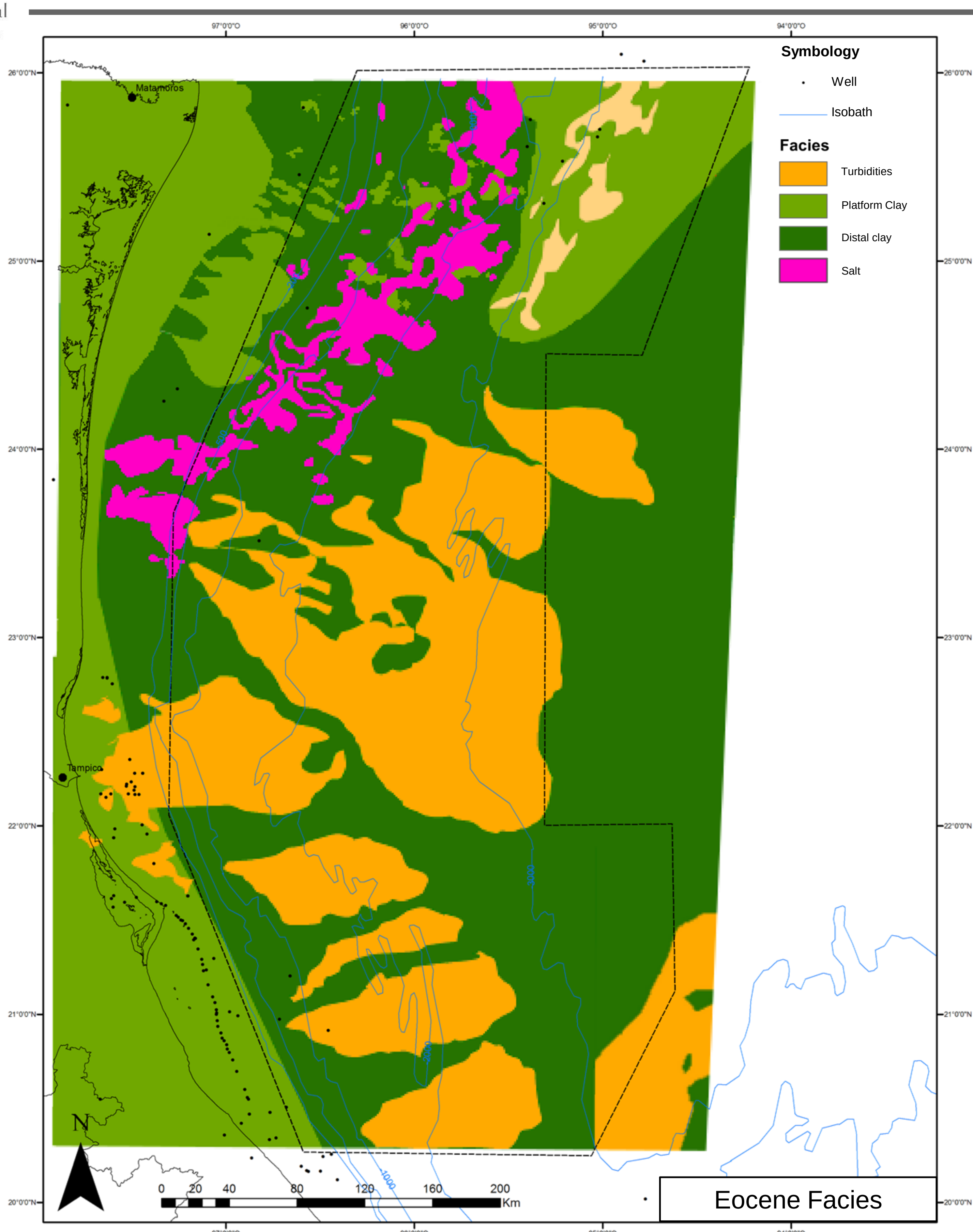
Lower Paleocene Midway Formation, this unit consists mainly of interbedded shales and siltstones with a good potential as a regional seal above the Upper Cretaceous.

Upper Paleocene- Lower Eocene Wilcox, corresponds to a limited extension system of sandy bodies represented by turbiditic lobe facies, sandy channels and siltstones sediments extending into the basin-floor. The main sediment supply comes from the North-Northwest and a secondary contribution of the West. The porosities and permeabilities are preserved, ranging from high to moderate, resulting in as good quality as reservoir rock.

The member called as "Whopper" sand at the base of **Upper Paleocene Wilcox** correspond to the sandiest facies, interbedded with siltstones and other fine-grained sands. They have a wide extension spread pattern, with geometries showing layers of sand, sandy channels and finally siltstones sediments to the deepest portion of basin. The quality of reservoir rock has already been proved by wells within the Perdido Fold Belt, with high porosities and permeabilities.

The clayley sequence called "Big Shale" that separates the upper and lower members of the Wilcox Group, consists of interbedded siltstones and shales deposited in deep basin environments, which works as a regional seal with a homogeneous coverage.

Geological Context – Eocene sedimentology

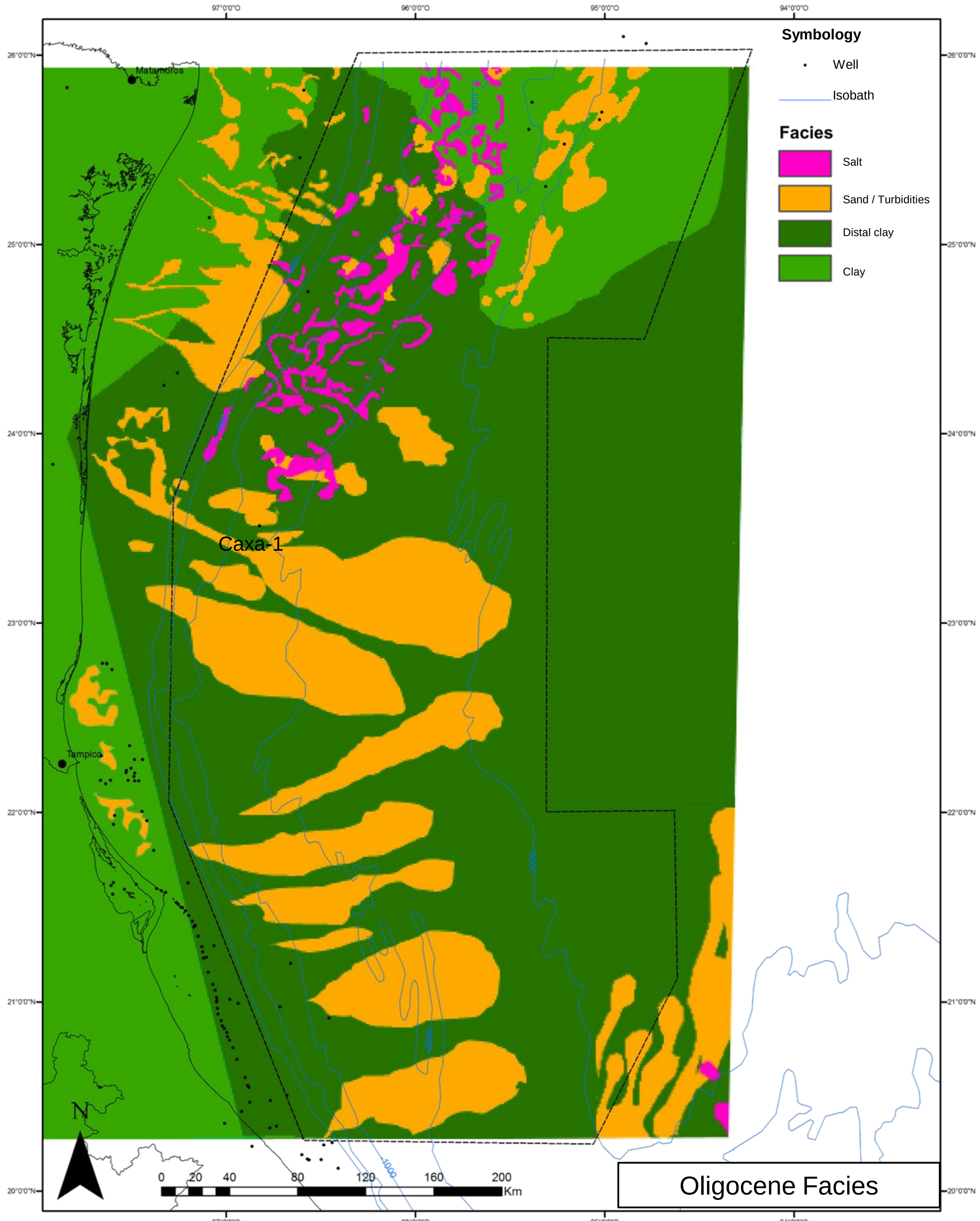


The **Lower Eocene** is characterized by a clayley bathyal environment with sandy amalgamated channels and distal fans whose origin comes from the Northwest and the West, primarily from the Houston Delta and the Rio Grande. Its base corresponds to the upper member of the Wilcox group and is characterized by a higher content of siltstone and shale that gradually turns in thin interbedded fine-grained sands to the top ("Yoakum" shale). The reservoir quality has been confirmed by wells within the Perdido Fold Belt, showing from good to excellent reservoir quality.

The **Middle Eocene** is the most important regional seal rock of the area. Is mainly composed by interbedded shales and siltstones with low permeabilities and high capillary pressures. Its distribution is homogeneous in most part of the area.

The **Upper Eocene** also serves as seal rock unit composed by siltstone and shale with some sandy lobes intervals and extensive sandy turbiditic layers. During the **Upper Eocene,** the sediment transport was strongly influenced by the salt tectonic deformation, that was very intense at that time, particularly in the mini-basins area.

Geological Context – Oligocene sedimentology



During the **Lower Oligocene** bathyal to neritic environments dominate, with a greater amount of sandy clastic sedimentation from the west deposited in the slope and deep basin, and a decrease of sand bodies from Northwest (Frio Formation).

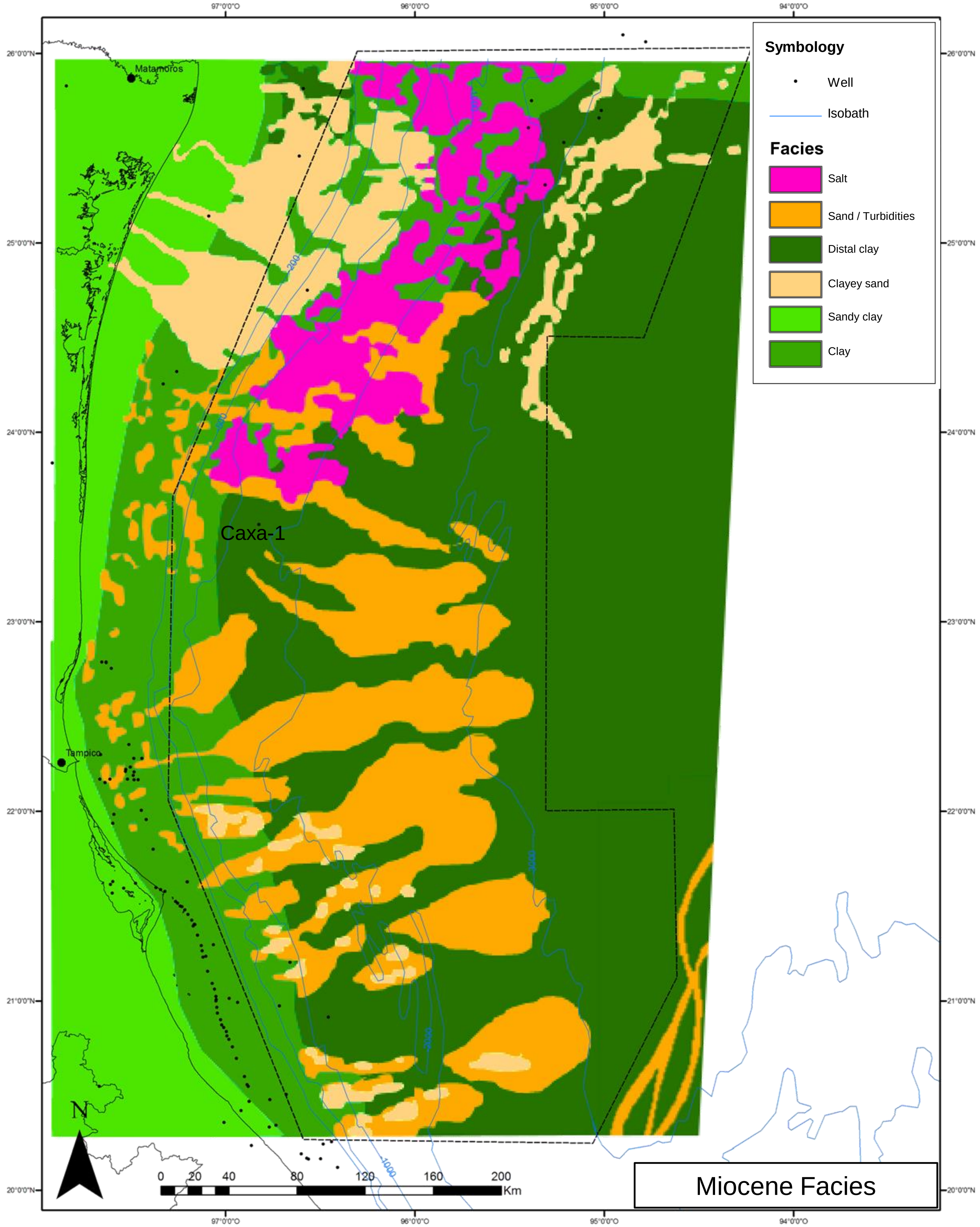
Reservoir facies are composed of interbedded fine-grained sand and siltstones facies related to turbiditic lobes confined in a clay matrix.

The seafloor palaeotopography, modified by the allochthonous salt deformation, restrict the deposits coming from West to the sedimentation coming from the Northwest.

The reservoir rock quality has been confirmed by wells within the Perdido Fold Belt, showing a good quality with significant sandy interval thicknesses.

The **Upper Oligocene** present properties of mainly seal rock because of its higher content of siltstone and shale with a regional distribution.

Geological Context– Miocene sedimentology



During the **Miocene** bathyal to neritic dominated environments with an increase in the sediment input from the West, deposited in slope and basin environments, and a decrease in the sediment input from the Northwest.

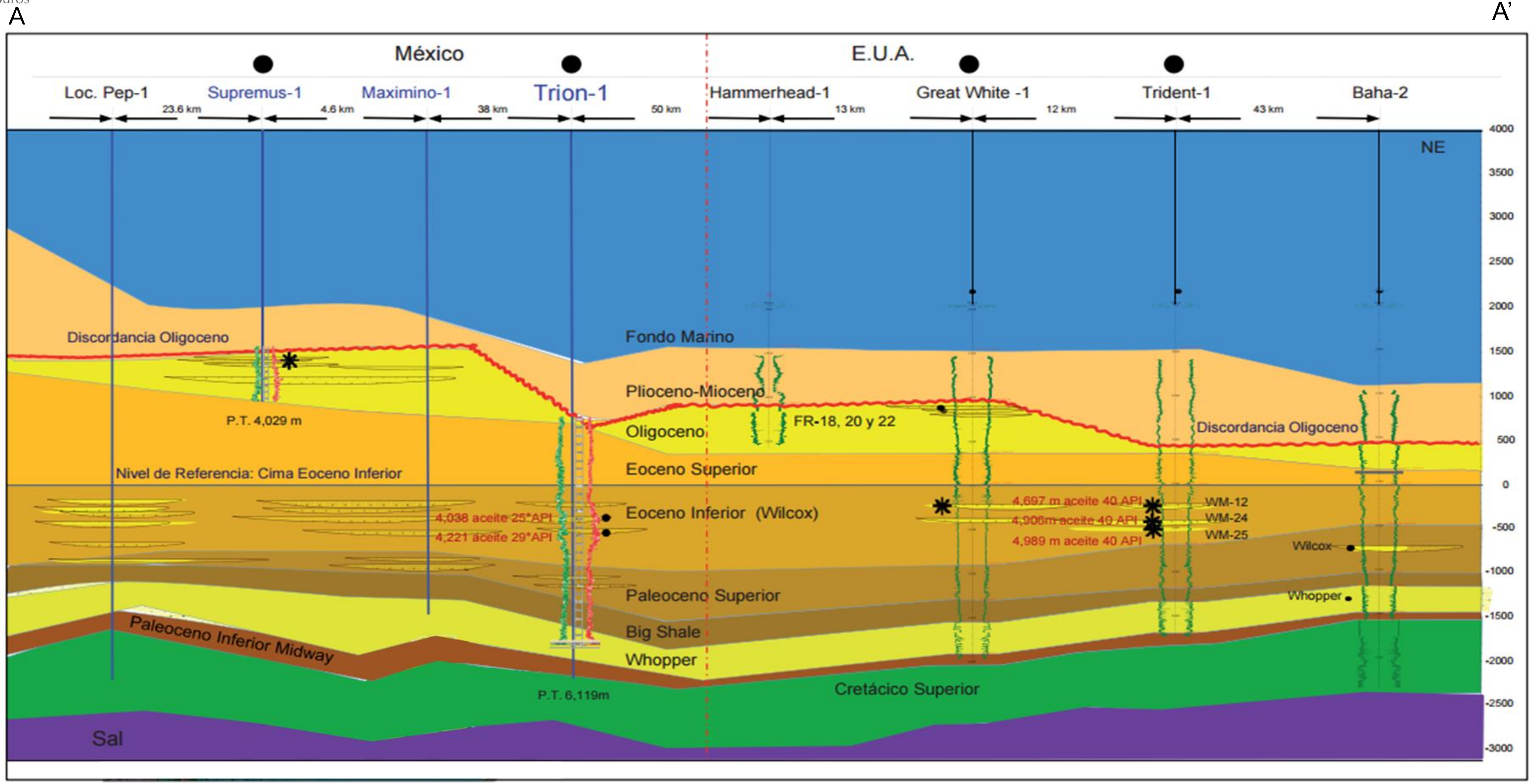
In the mini-basins area, facies are composed of thin interbedded siltstone and fine-grained sand related to turbiditic lobes with a high clayley component.

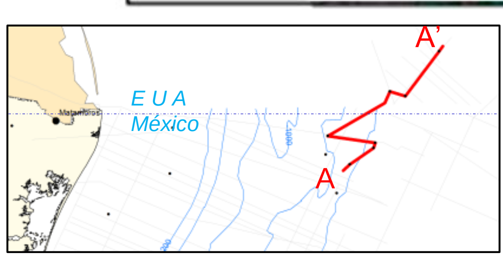
The seafloor palaeotopography continued changing by the allochthonous salt deformation, restricting the basinward sediment influx and separating deposits of Western origin from Northwest sedimentary provenance.

The salt and shale tectonics and in the minibasins sector, leads to the creation of a negative paleogeography developing various interdiapiritic basins due to the salt or clay withdrawals.

The main reservoir rocks are found in the Lower and Middle Miocene. The reservoir quality has been recently checked by a well within the minibasins sector, showing good to moderate rock quality properties related to thin intervals of fine-grained sandstones embedded in silt-clay matrix.

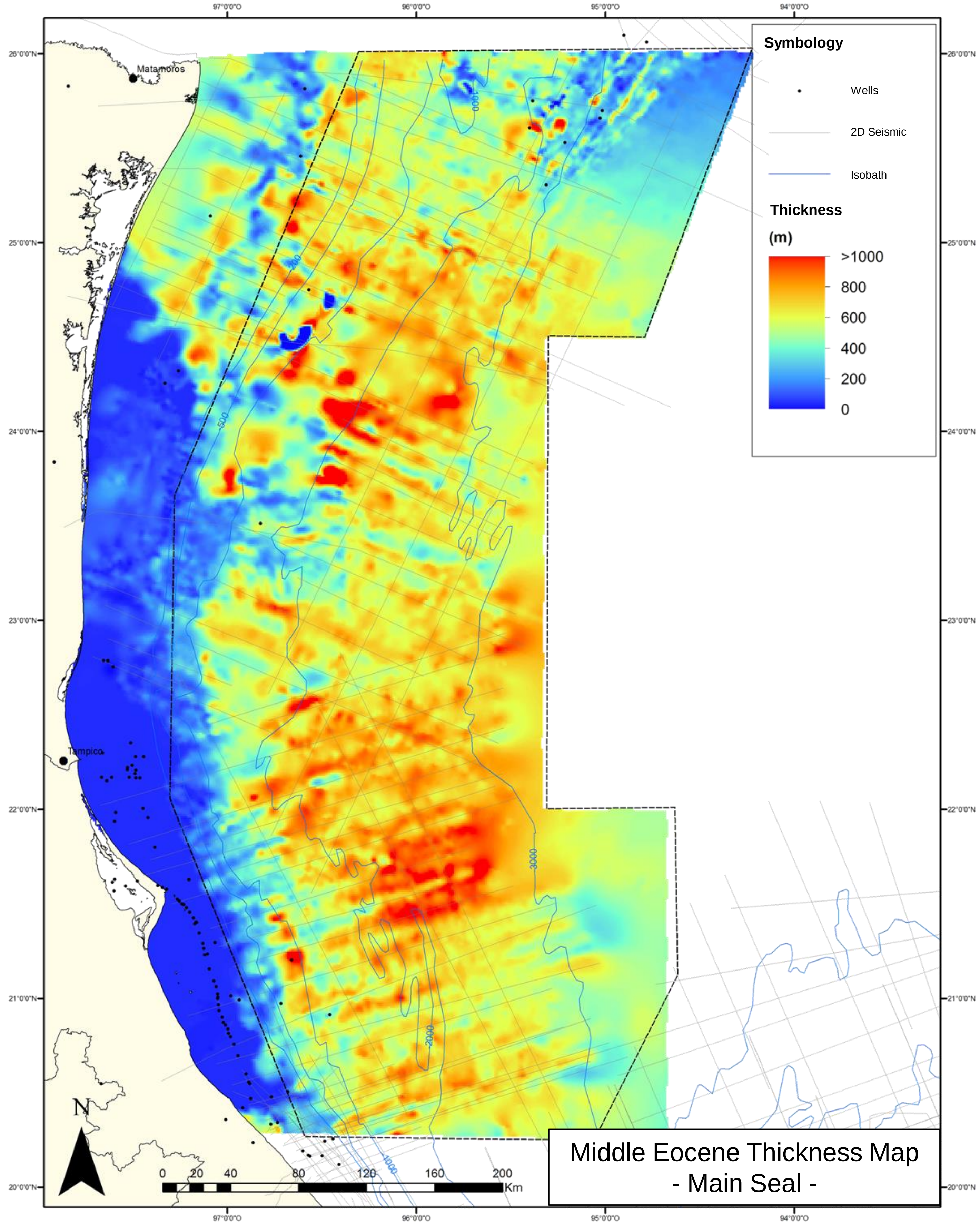
Geological Context – Stratigraphic Correlation





The correlation of wells within in the Perdido Fold Belt, in the Mexican portion as well as in the US, demonstrate the continuity of the Paleogene sedimentary system, composed by sand lobe bodies and turbiditic amalgamated channels confined in a clay matrix. Correlations also show an increase in sand content at the base of Paleogene (Lower Wilcox, "Whopper" sand member) varying toward the top to thinner thickened sandy intervals (Upper Wilcox), interbedded with seal clayley rocks (Middle Eocene). A regional unconformity at the top of the Oligocene is observed, related to a regional erosive event.

Geological Context – Regional seal



Middle Eocene Thickness Map
- Main Seal -

Middle-Upper Eocene seal rock thicknesses

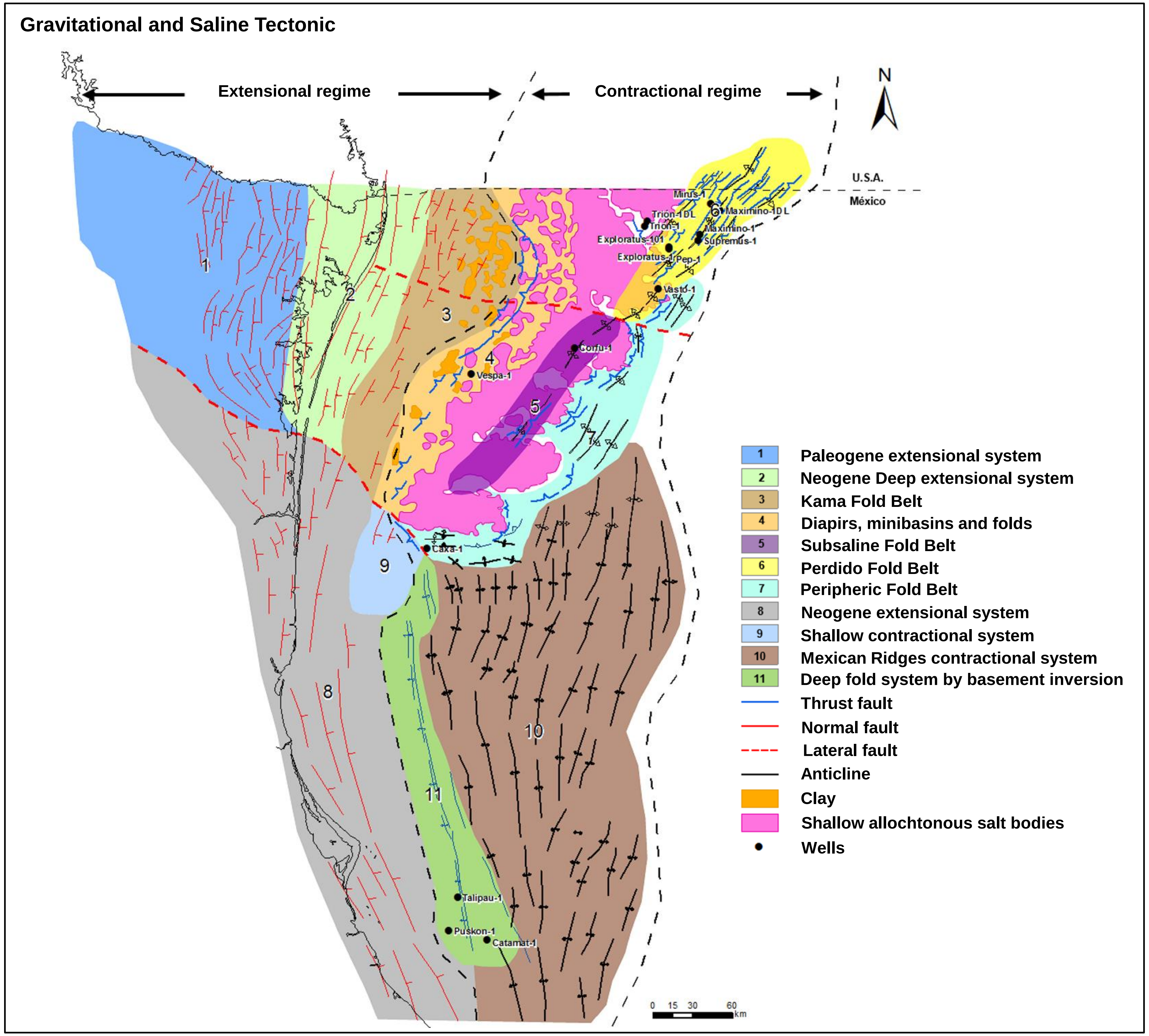
The regional seal rock of Middle Eocene age is composed by clays and siltstones deposited in lower bathyal environments that shows significant thicknesses ranging from 400 to 1,000 m.

Low permeability and high capillary pressures properties make this unit as an excellent seal quality rock. The low permeabilities created by compactional effects and probably clay diagenesis, allow a good oil retention in the underlying reservoir rock and therefore, a reduced leakage risk towards shallower levels.

Generally, leakage to shallower levels occur when high seal capillary pressures are exceeded by the fluid pressure, and/or throughout faults that cuts the seal rock.

Structural Framework

Deepwater – Structural Framework - Geological Provinces



Gulf of Mexico, West Sector geological provinces, structural styles map

1. Salina del Bravo Province: Located in the Northwestern sector of the Gulf of Mexico in front of the Rio Bravo delta, in water depths ranging from 500 to 2,500 m. It includes Subsalt Belt and Minibasins subprovinces:

The subsalt belt formed under a compressive regime, is composed by wide folds due to thrust faults propagation, with a NE-SW preferential orientation, they are cored by authoctonous salt and are in turn covered by allochthonous salt canopies. The canopies occurs above Middle Eocene sediments, so is inferred that the intrusion of the allochthonous salt bodies are at least from the same age.

The Mini-basin area is located to the West and is represented by an almost parallel to the edge of the continental slope fringing area, affected by the presence of salt or clay diapirs associated to a eastward gravitational extensional system with a detachment level on the Upper Eocene clays, creating and filling Neogene aged synsedimentary synclinal structures and sedimentary wedges against the salt or clay diapirs.

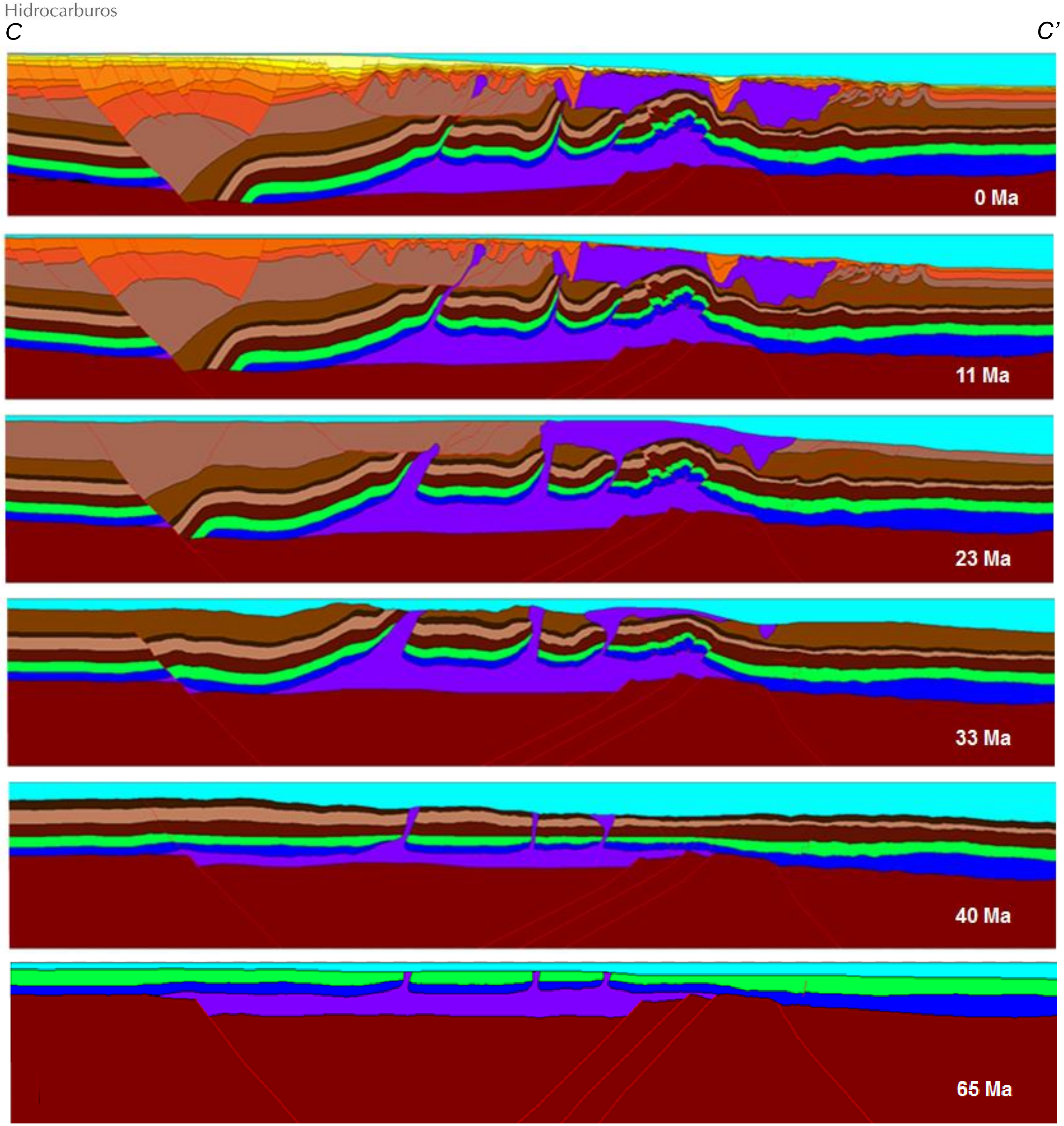
2. Perdido Fold Belt: Located East from the Salina del Bravo Province, constitutes a set of spread fault detachment folds oriented in a NE-SW trend, in which the Jurassic authochtonous salt is the detachment level. The fold belt is related to compressional deformation mechanisms caused by the gravitational and salt tectonics occurred at the West of the area, within the Burgos platform Province during the Oligocene-Miocene time.

The foldbelt extents to the US part of the Gulf of Mexico, where there have been several important discoveries like the Baha, Trident, Great White, Tobago, Silvertip and Tiger. On the Mexican side, several recent discoveries as Trion-1, Supremus-1, Maximino-1 and Vasto-1 wells discovered significant hydrocarbon accumulations within Paleogene and Neogene plays.

3. Mexican Ridges: Located East from the continental shelf of the Gulf of Mexico, offshore Veracruz and Tamaulipas states. In this area, a large and long folds were formed during the Neogene time from the southern part of Salina de Bravo Province to the Southern Gulf of Mexico.

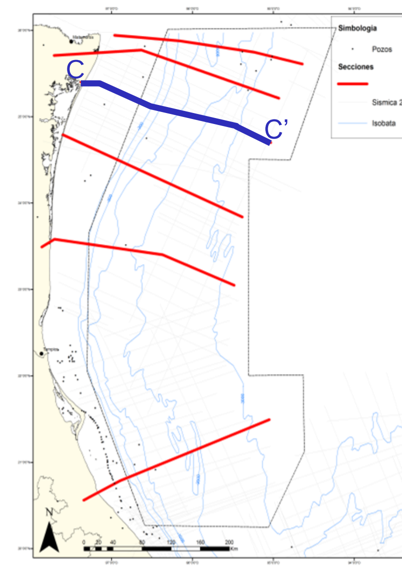
It covers over 500 km long in a surface area nearly of 70,000 km², in water depths between 1,000 and 3,000 m, Mexican Ridges were generated in response to the gravitational extensional processes developed from the south of Burgos and Tampico – Misantla Basins. It is composed by long and tight eastward oriented symmetrical anticlines. The extensional-compressional combined deformation system of this Province is extended through more than one detachment level within the Paleogene interval, as well as other secondary detachment levels within the Tertiary sequence. The structures are mainly present in the Tertiary sedimentary sequence, particularly deforming the Miocene to Recent rocks. The younger and broader folds are located towards the central part of the Mexican Ridges.

Structural Framework – Structural evolution (1)



Oligocene - Middle Miocene (33-11 Ma):
A deltaic system took place by this period from the ancient sediment influx of the Bravo River. The extensional system orientation pattern induced a gradual shift from north-south to northeast-southwest of the deformation trend in the continental shelf. The first normal faults of this system detached and spread on salt levels, while the successive basinward faults, detach within the Paleocene-Eocene boundary or within the Eocene. This system created the Perdido Fold Belt and within the salt province, squeezed salt diapirs and canopies were developed.

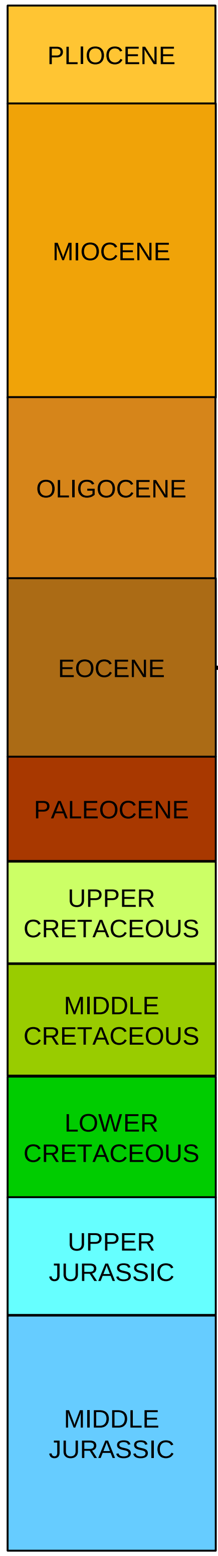
To the west boundary of the Gulf of Mexico, a listric faults system were developed near the Mexican Ridges Geological Province (also known as Quetzalcoatl Extensional Belt), which corresponds to a series of eastward oriented long and narrow anticlines that sometimes turns into opposite directions, which constitute detachment surfaces located within the Tertiary sequence. Folding age in this province varies from west to east, from Late Miocene to Recent time.

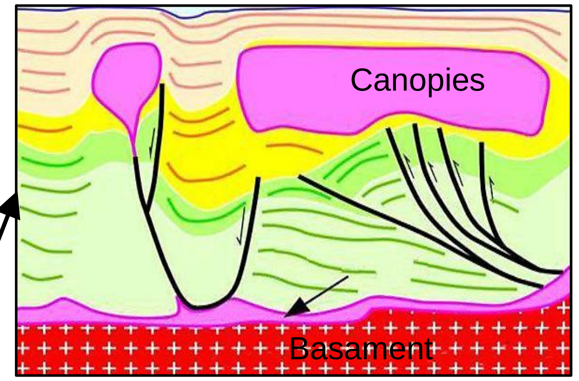


Lower Eocene - Late Eocene (56-33 Ma):
The Laramide Orogeny establishes a compressional tectonic system, uplifting and eroding pre-existing rocks with a consequent increase in the sedimentary load and deformation under a gravitational system regime, forming anticlinal folds by the transfer of the stress into the deeper parts of the basin. To the west, in the Burgos Basin, the Tertiary sedimentary units are affected by gravitational extensional tectonic regime due to a regional extensional block tilting processes in an eastward orientation. Progradation of sediments to the east stimulates the mobilization of salt masses, creating allochthonous salt bodies as diapirs and domes that evolve to canopies and salt tabs that shifts eastward. Belt Subsalt structures date from the Late Eocene.

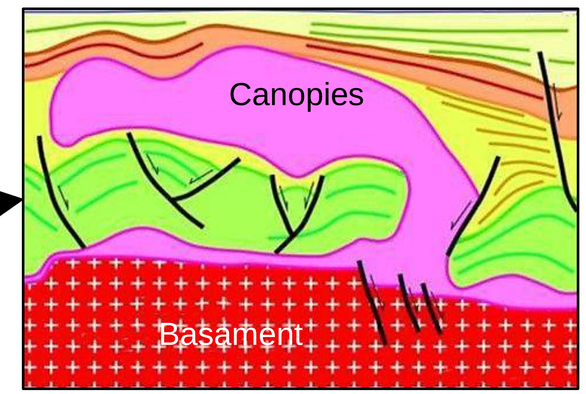
Middle Jurassic - Late Paleocene (163-56 Ma):
A rift basin type was developed, favoring red bed and evaporitic sedimentation during the Callovian time, followed by salt layer gently deformation that structured the overlying sedimentary cover. The thickness of the allochtonous salt layers were controlled by the pre-existing basement block highs. During the Lower Cretaceous a passive margin was developed until Late Paleocene time, in a thermal subsidence context. The salt tectonics process and the differences in the sedimentary load, create a redistribution of the salt bodies within the Tertiary sedimentary sequence, as well as intrusions and salt diapirs within fault zones.

Structural Framework – Structural evolution (2)

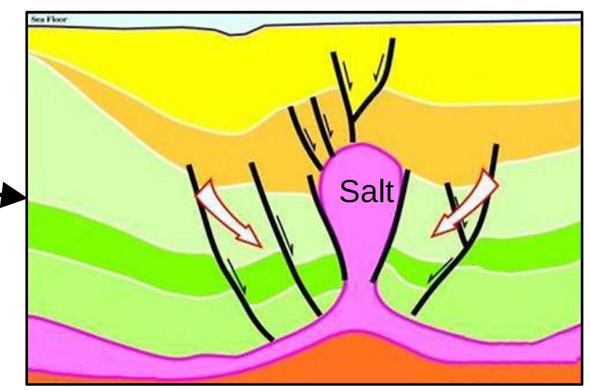


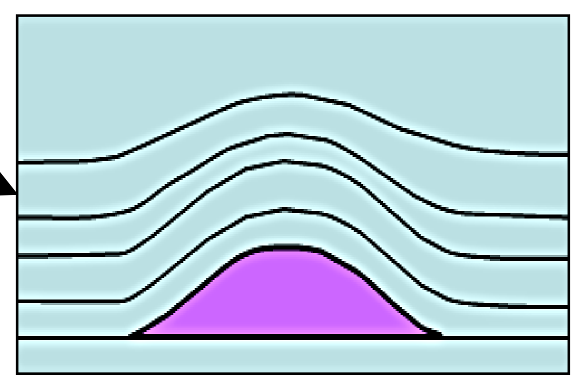


Lower Miocene (16 My): Diapir enclosure by salt welding.



Lower Oligocene (30 My): Salt withdrawals trough canopy geometries.





Upper Jurassic – Middle Eocene (150-35 My)
Deposit of sedimentary units over salt pillows and domes (isopach).

Callovian (160 My): Authoctonous salt sedimentation.

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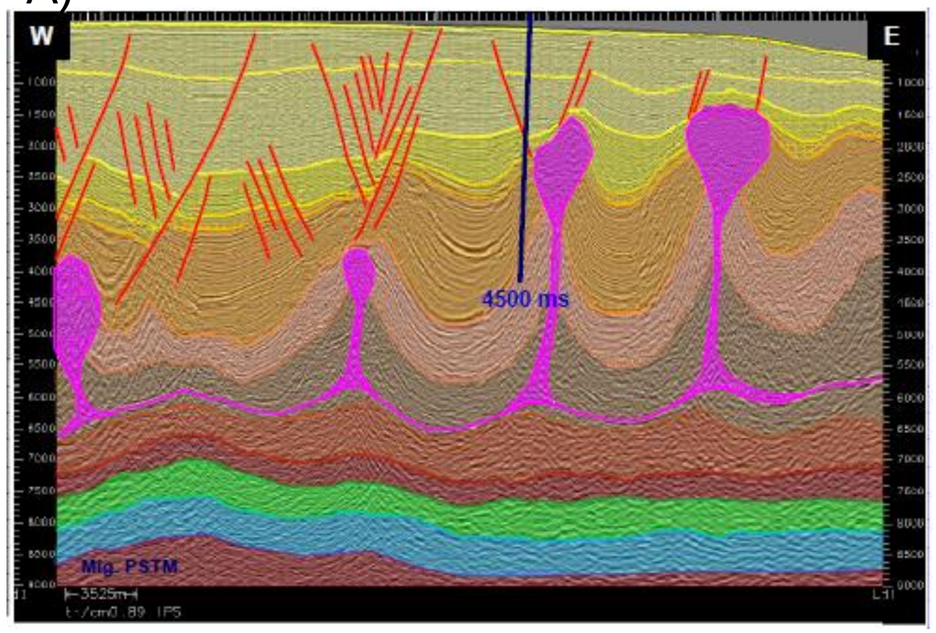
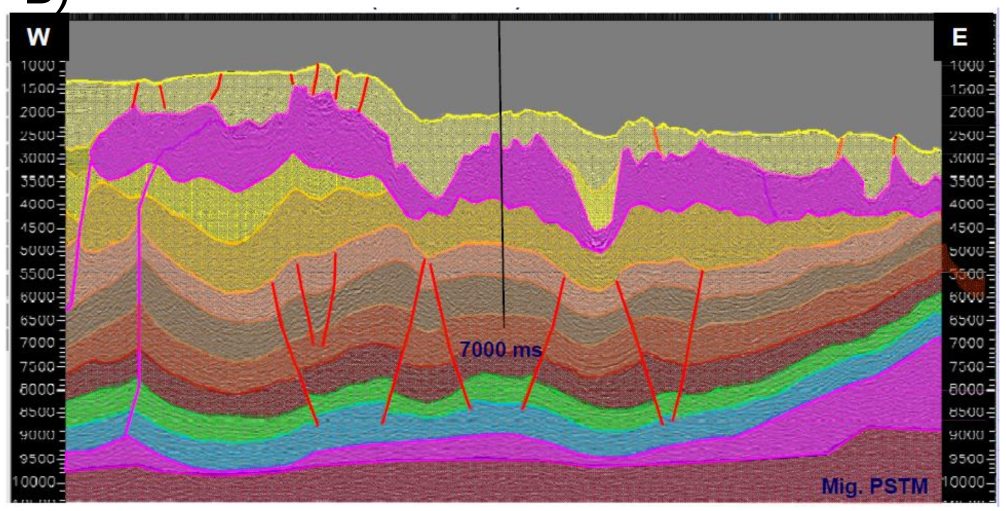
Structural Framework – Traps types (1)

A)



B)



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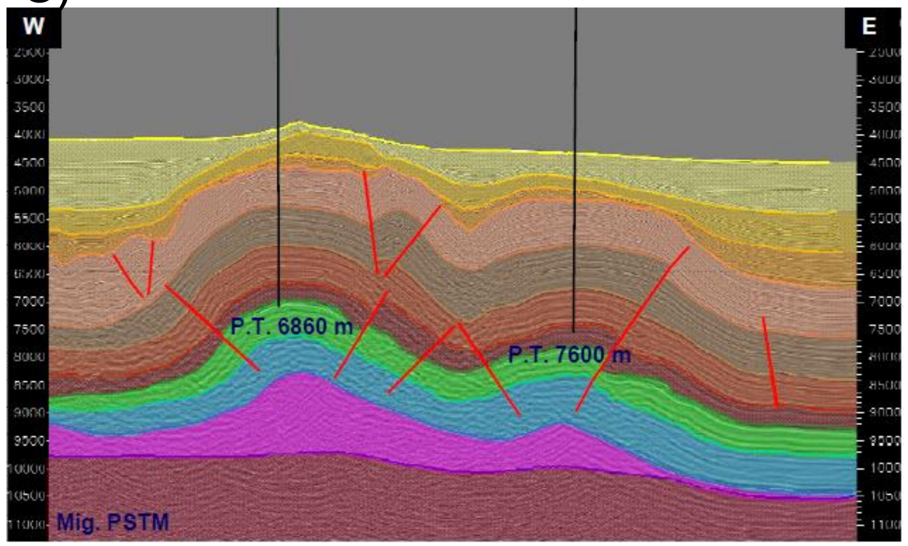

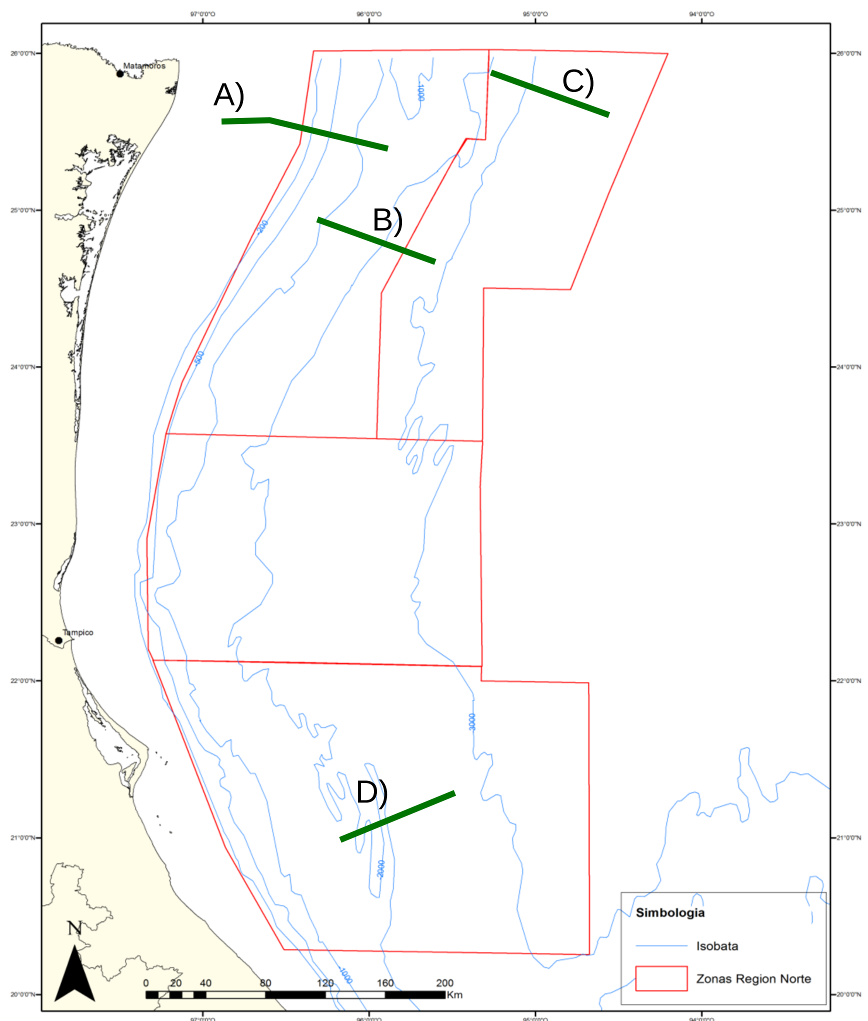

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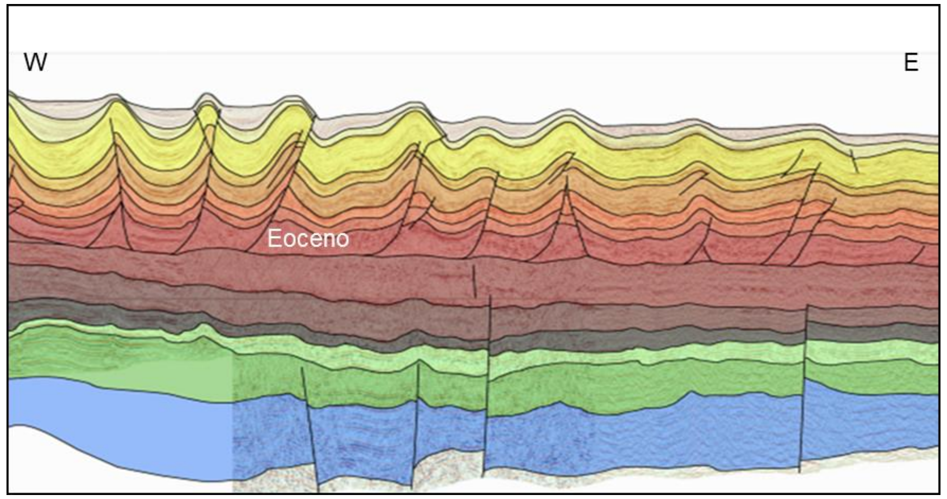


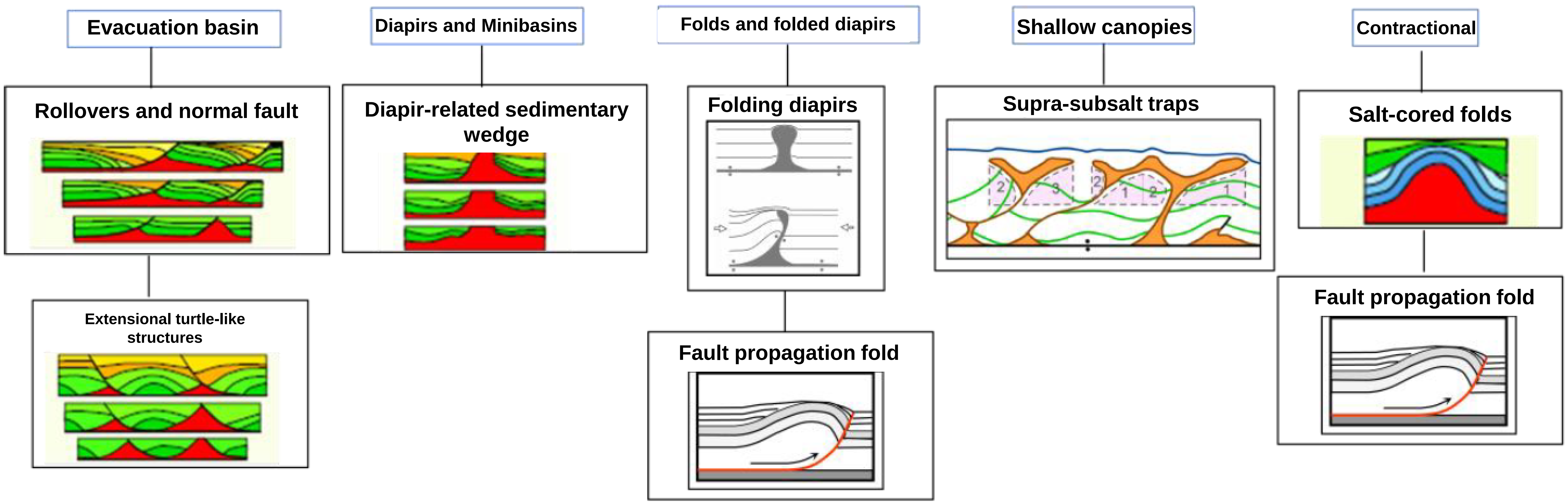
A) Mini-basin zone:
Traps: Extensive gravitational structures with shallow detachment levels in Lower Oligocene shales with a regional orientation forming filling sedimentary structures (minibasins).
Plays: Neogene Siliciclastic: Miocene - Oligocene.

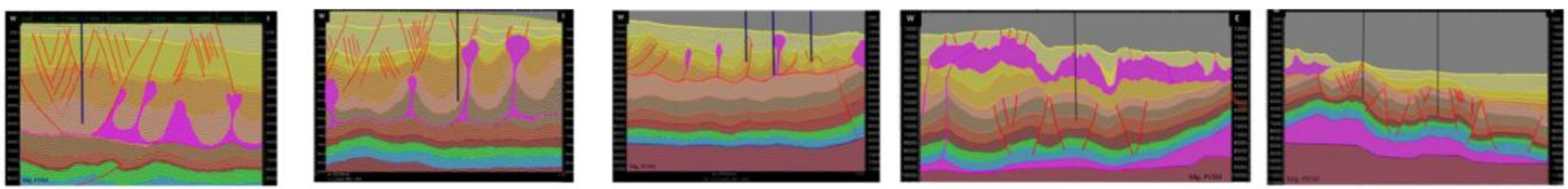
B) Subsalt Belt zone
Traps: Faulted anticlinal on its flanks or ridge, cored by salt domes and buried or covered by allochthonous salt canopies.
Plays: Wilcox Paleogene Sandy levels.

C) Perdido Fold Belt zone
Traps: Series of salt cored fault detachment folds, faulted at their flanks and at the top of the structures.
Plays: Paleogene Sandy levels : Paleogene-Eocene Wilcox and Oligocene Frio.

D) Mexican Ridges
Traps: Series of fault propagation folds with a Eocene shale detachment level.
Plays: Paleogene Sandy levels: Paleocene-Eocene Wilcox, Oligocene Frio and Miocene.

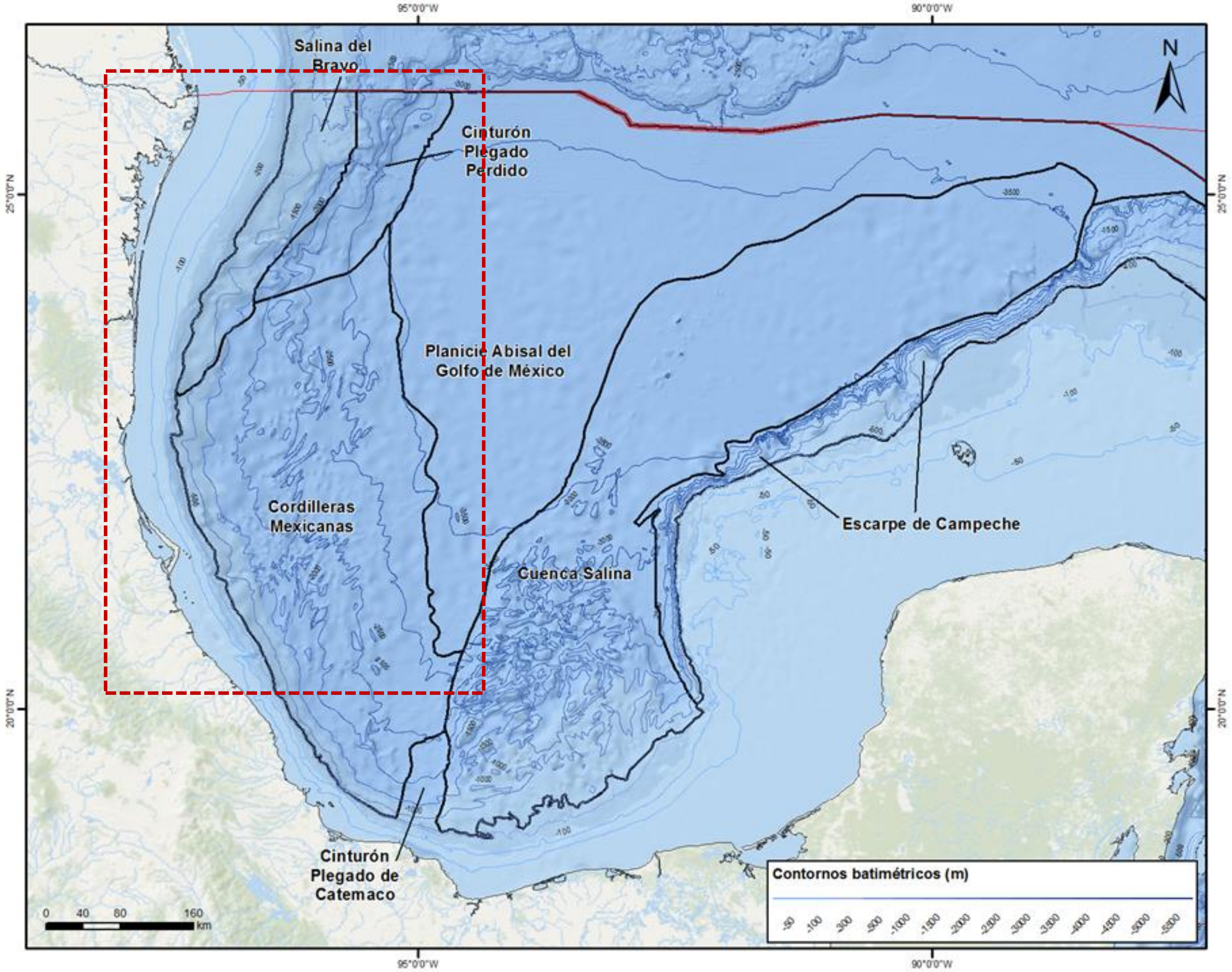
Types of traps



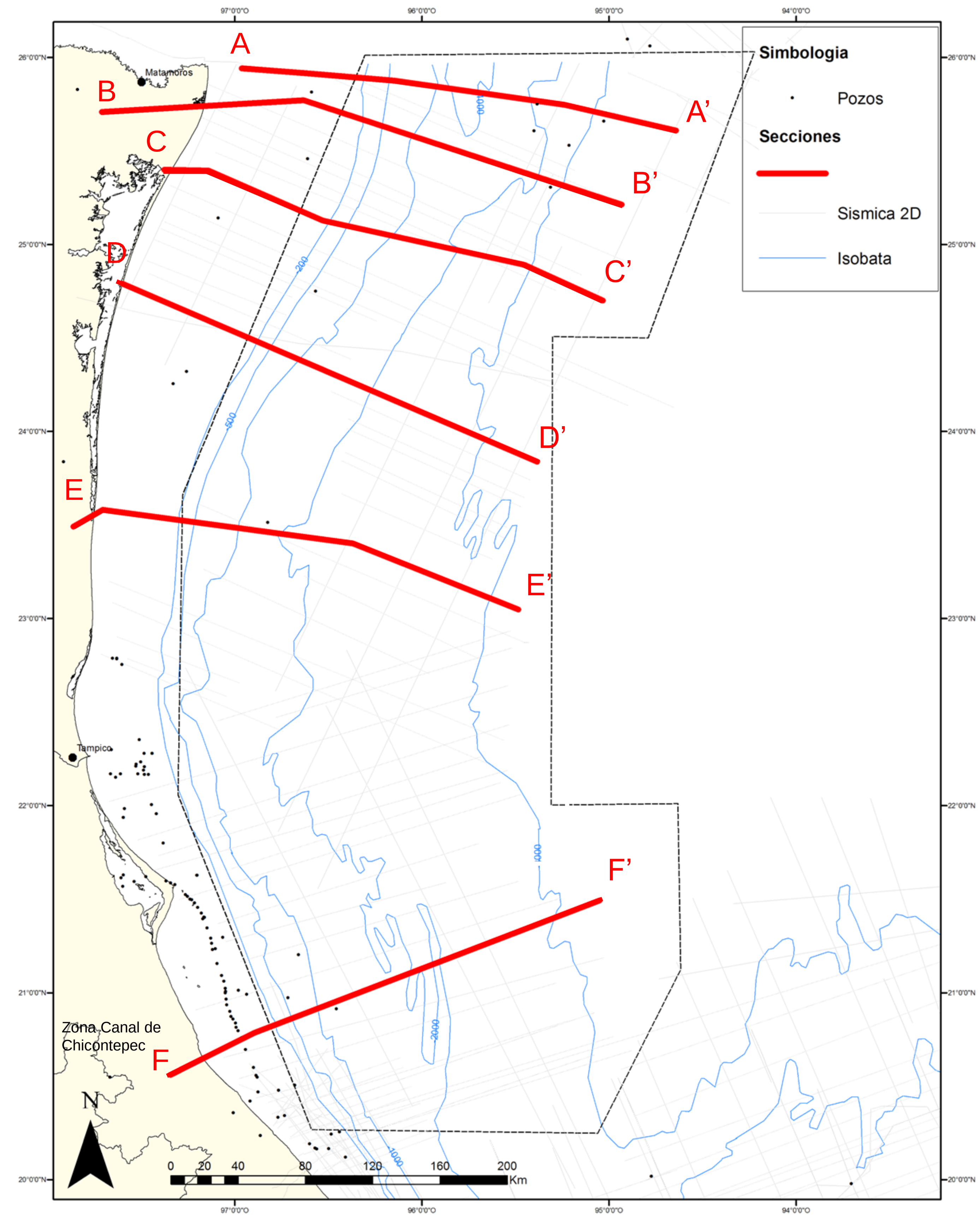


Turtle-type traps | **Sedimentary diapir-related wedges** | **Folds and folded diapirs** | **Subsalt traps** | **Salt-cored folds**

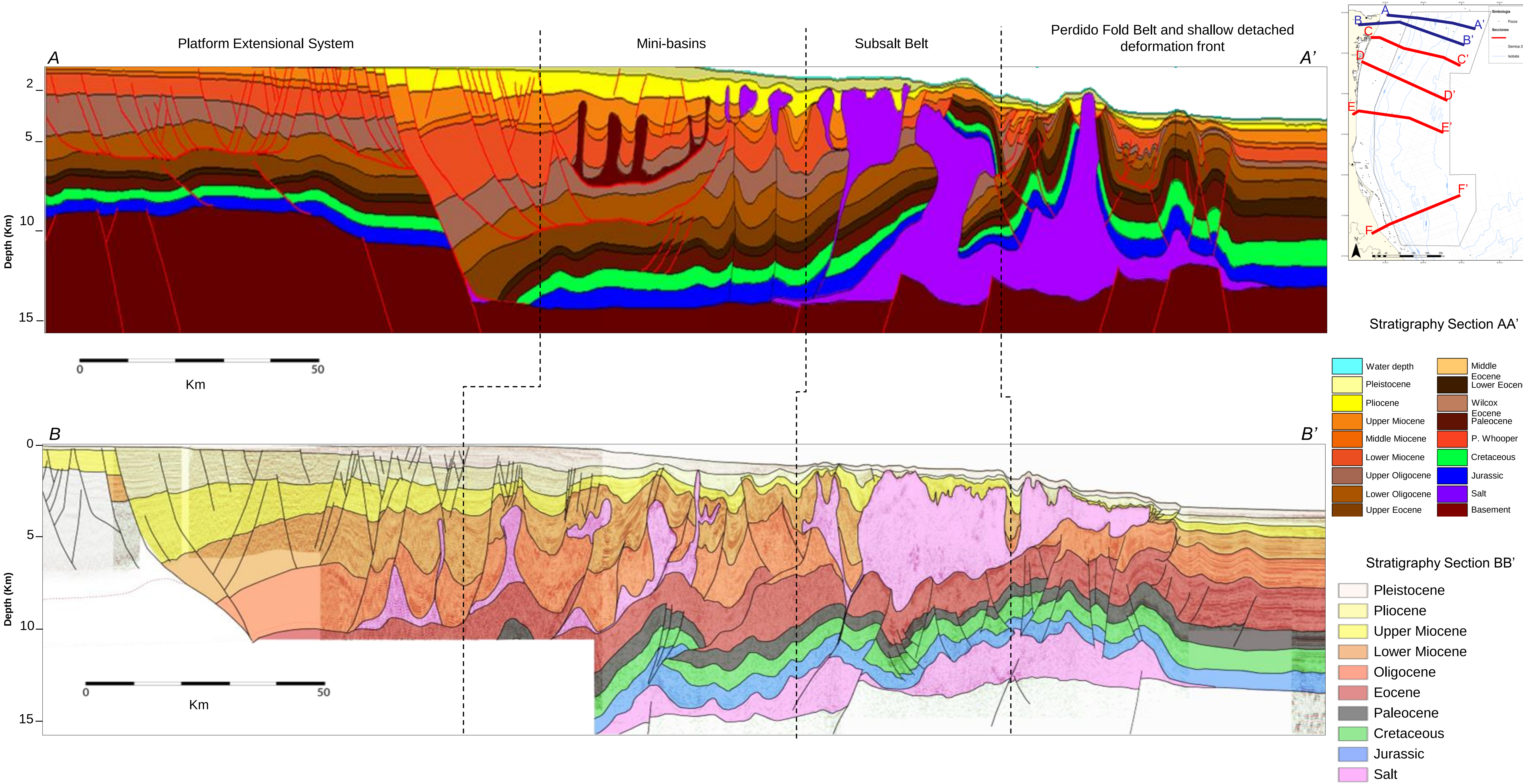
Structural framework – Geologic Sections location



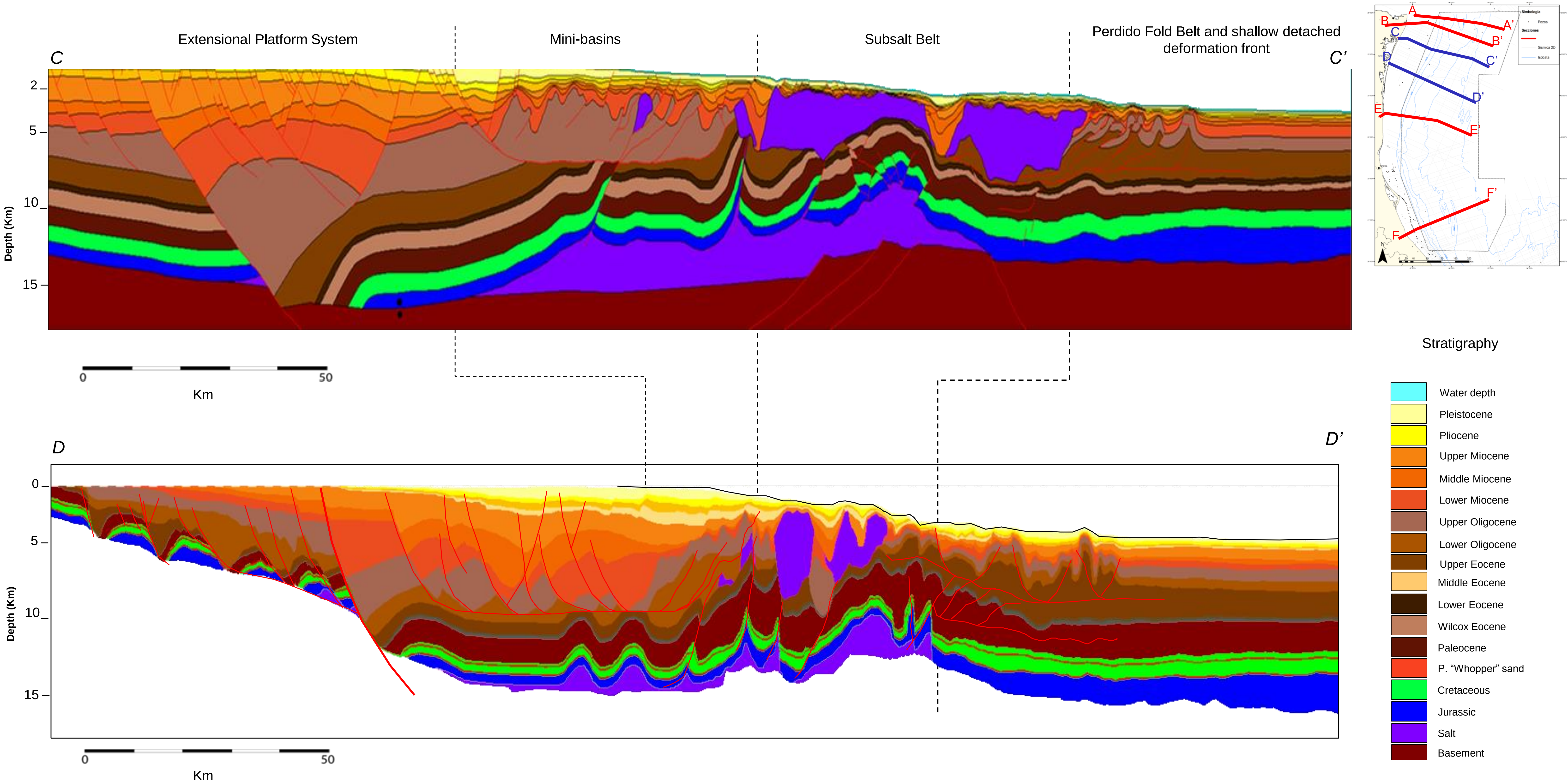
Interpreted regional sections location map



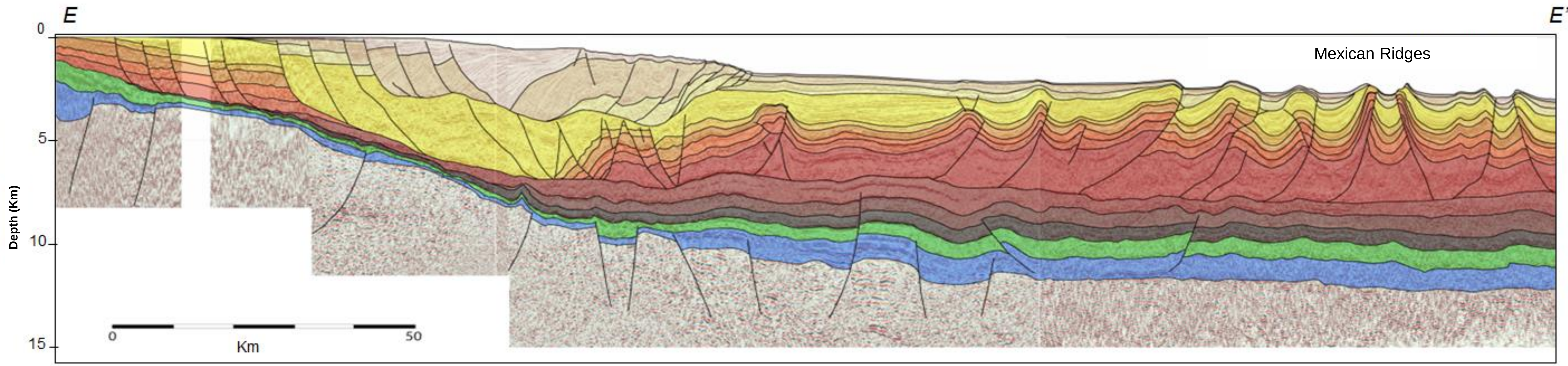
Structural Framework - Sections (1)

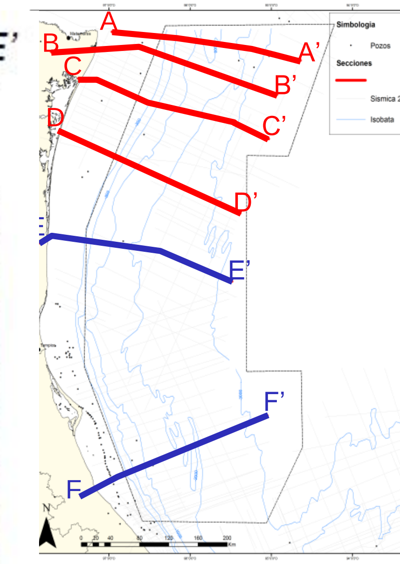


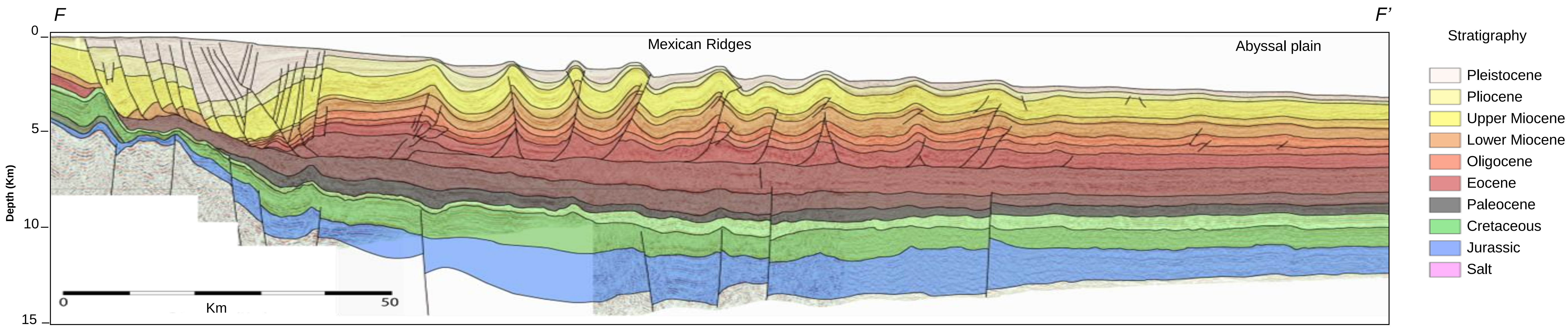
Structural Framework - Sections (2)



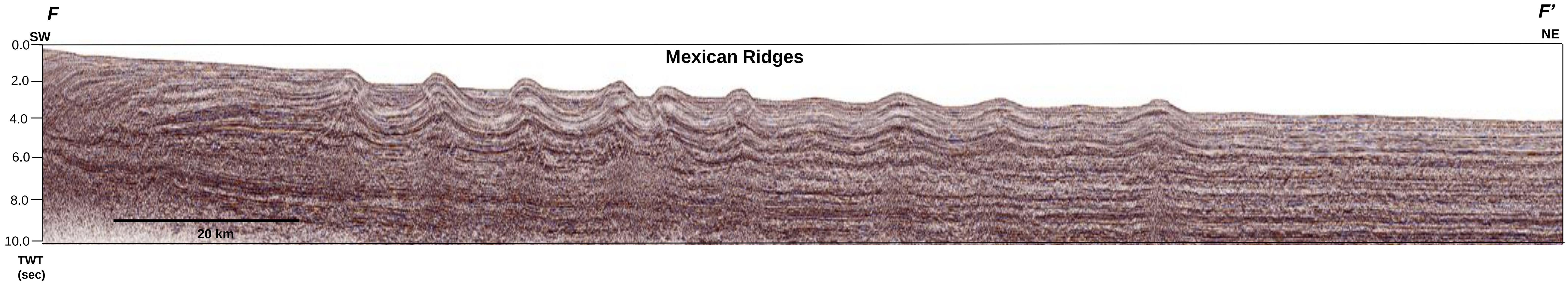
Structural Framework - Sections (3)

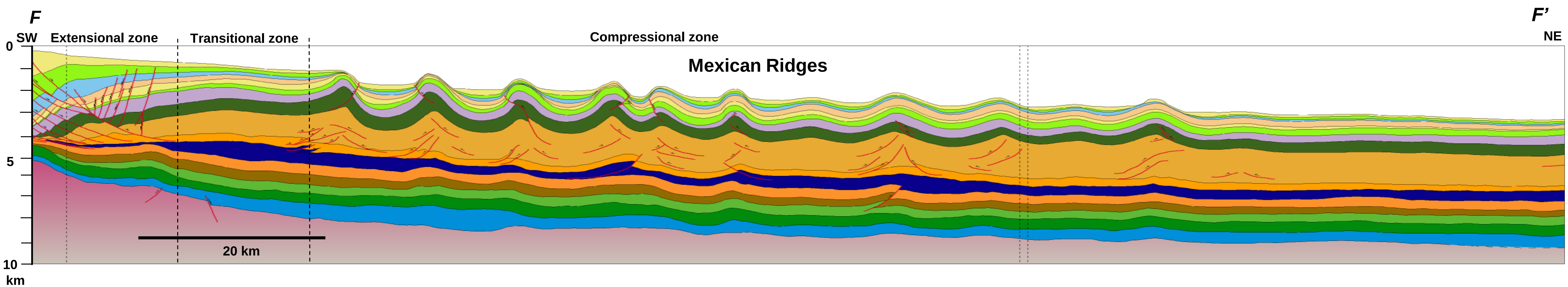






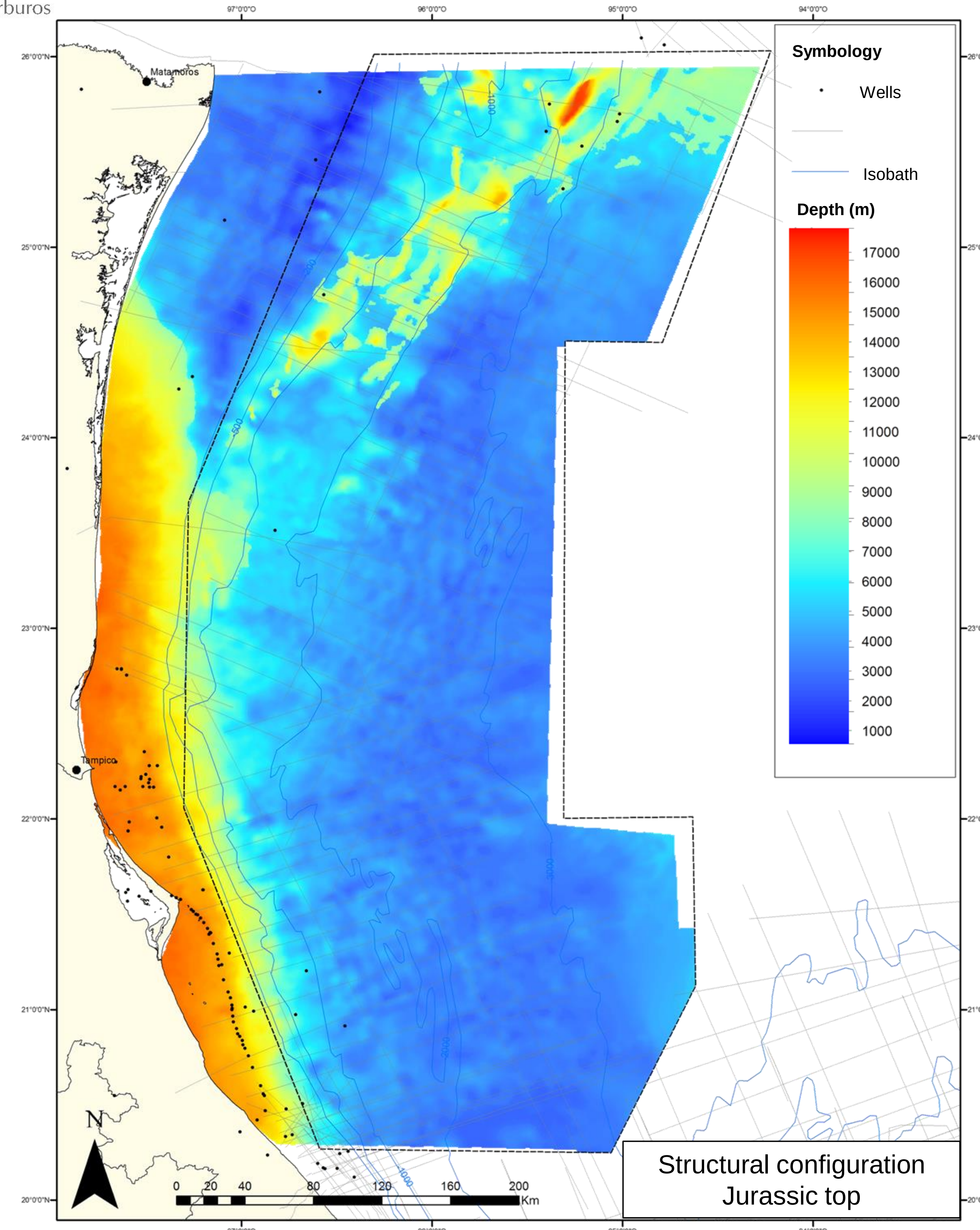
Structural Framework - Sections (4)



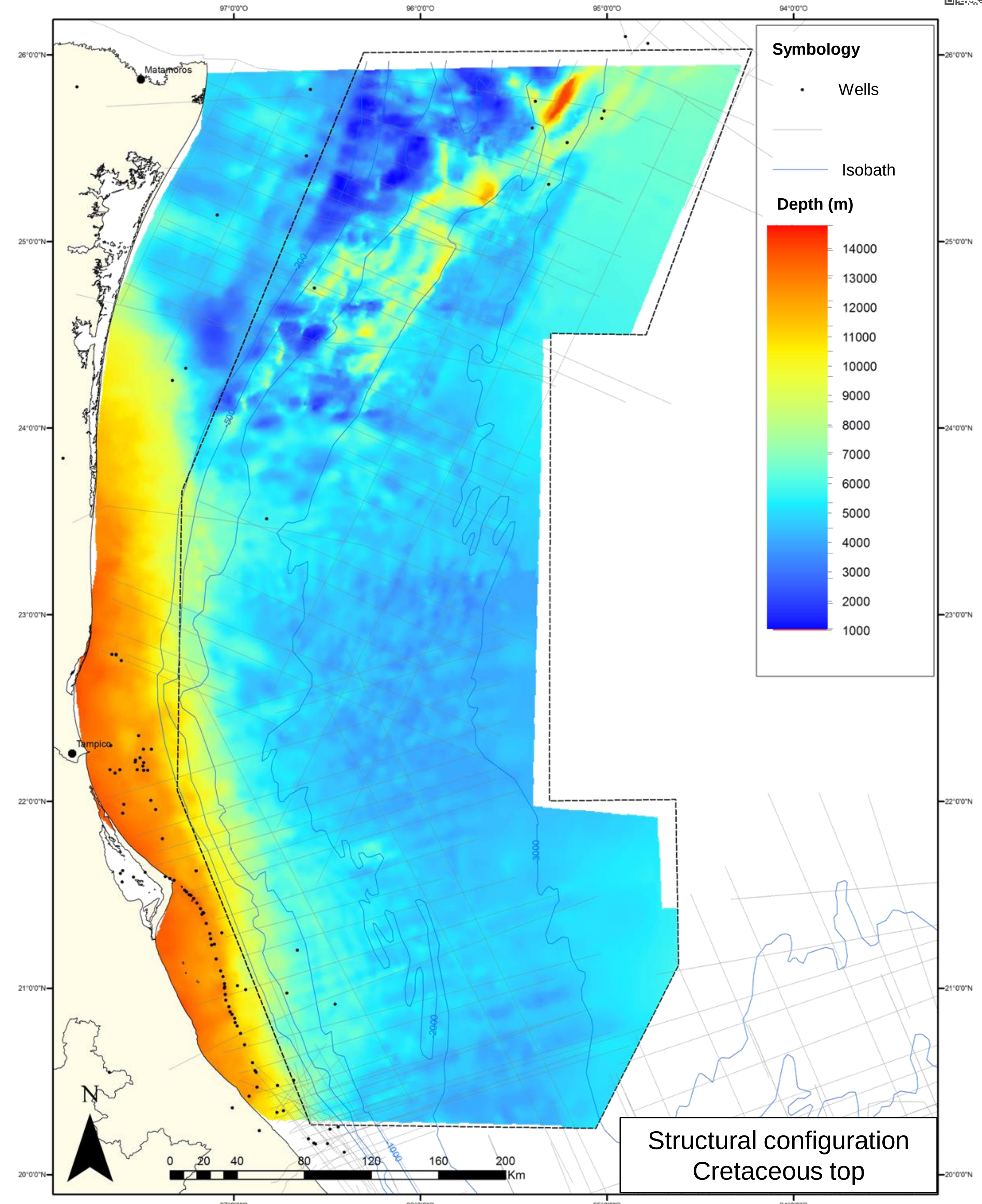


The Mexican Ridges contractional domain is characterized fault-related anticlines formed in the Neogene time. Showing different structural styles (dipping folds, fault propagation and detachment folds).

Structural Framework – Structural maps (1)



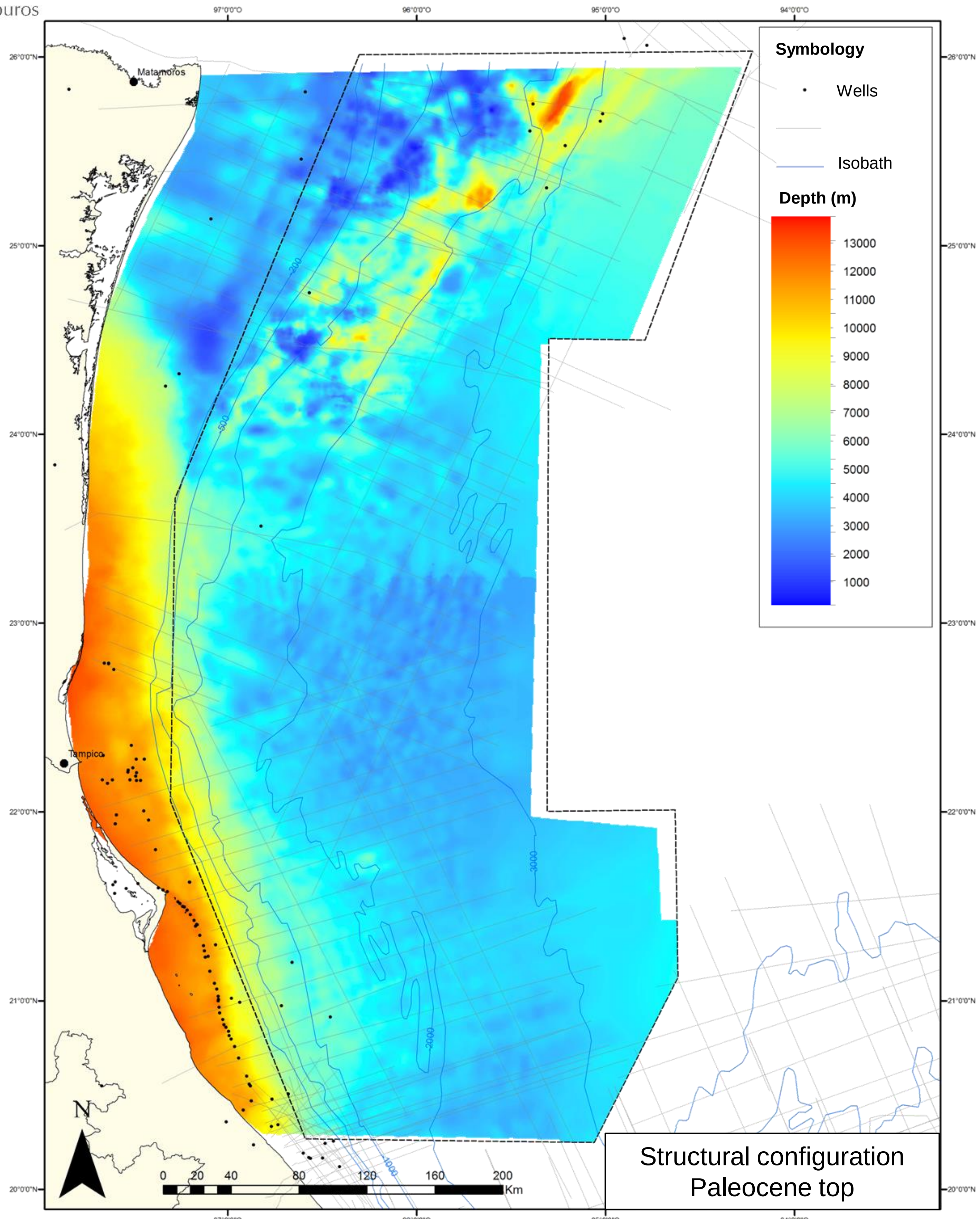
Structural configuration
Jurassic top

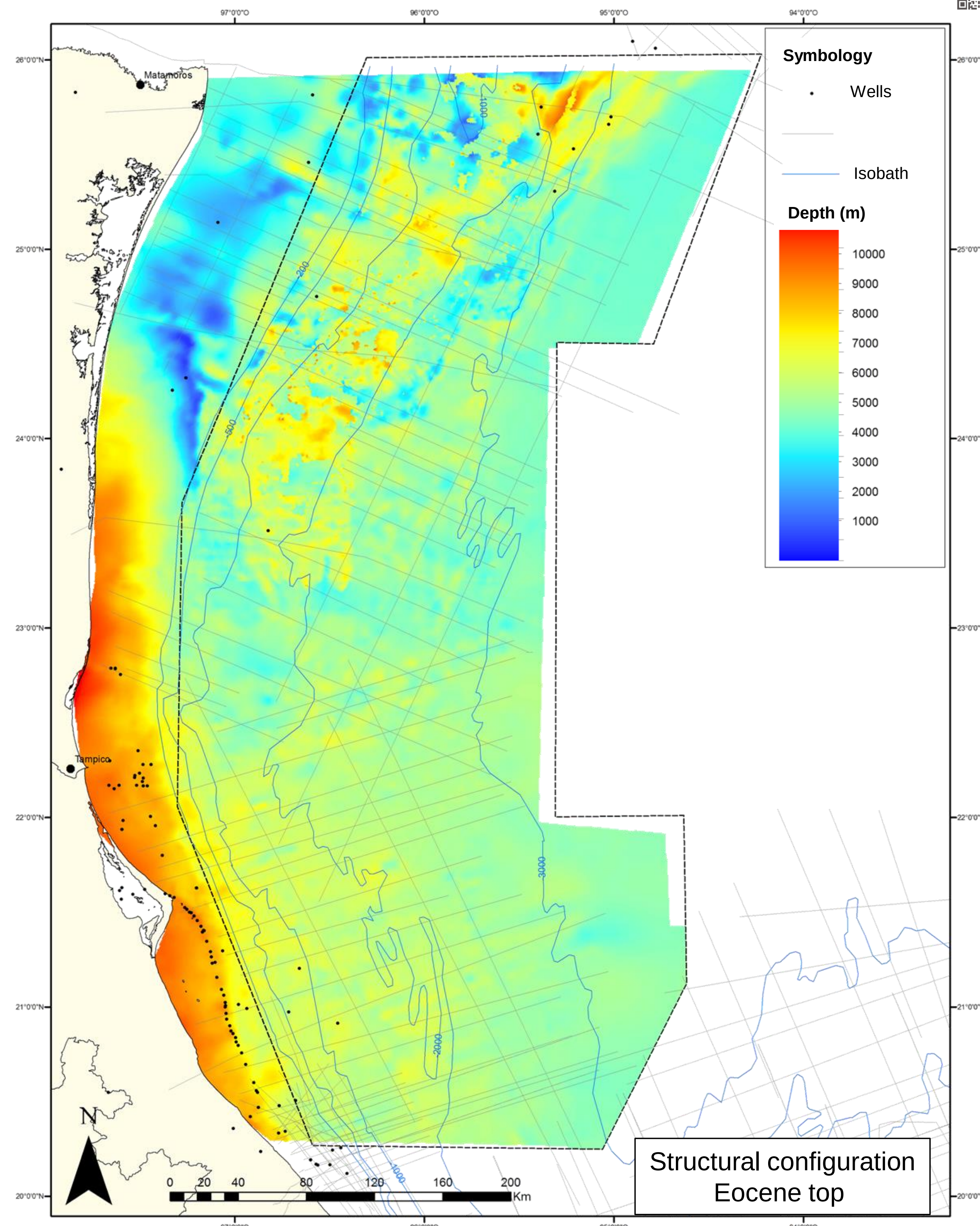


Structural configuration
Cretaceous top

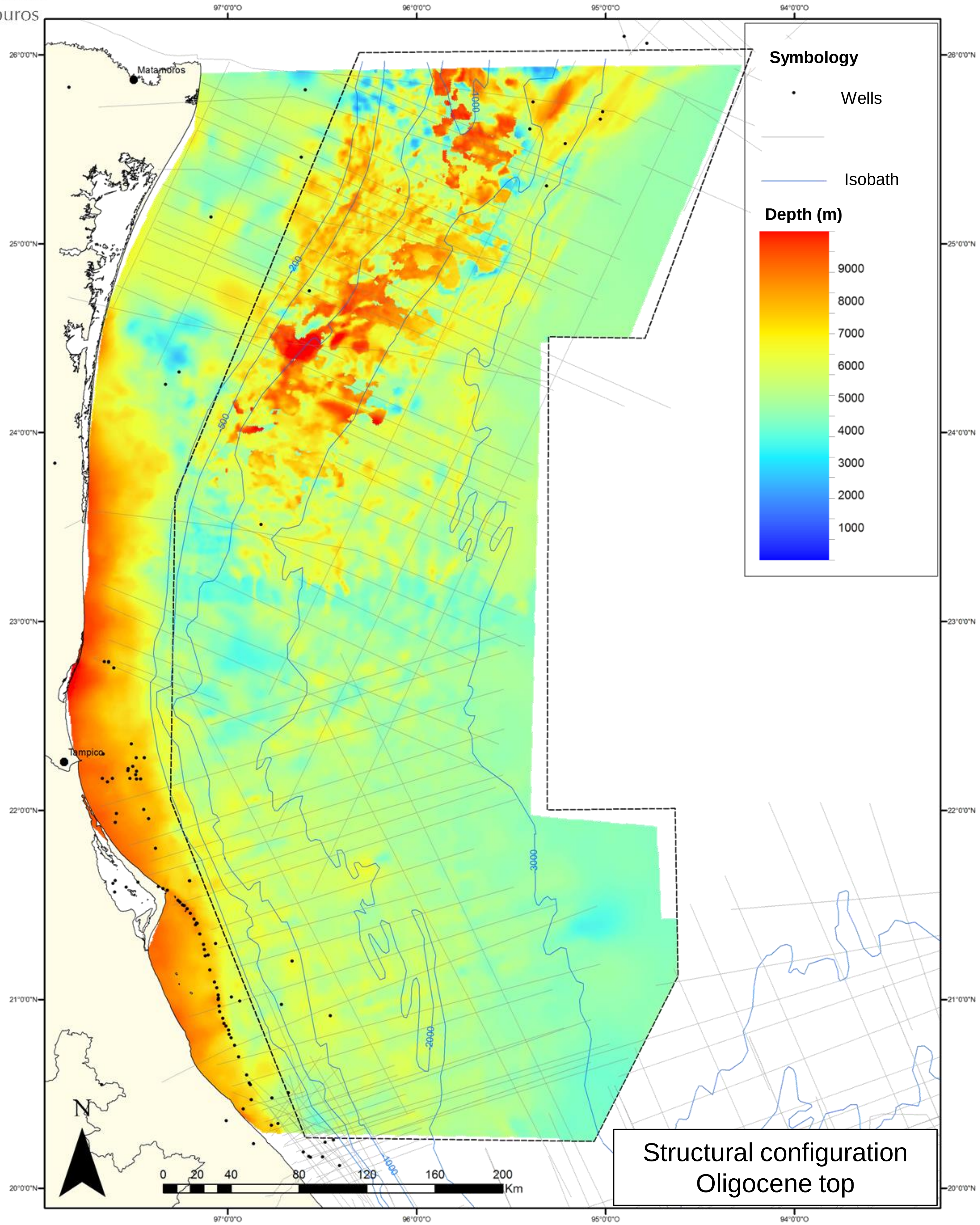
CNH
Comisión Nacional de Hidrocarburos

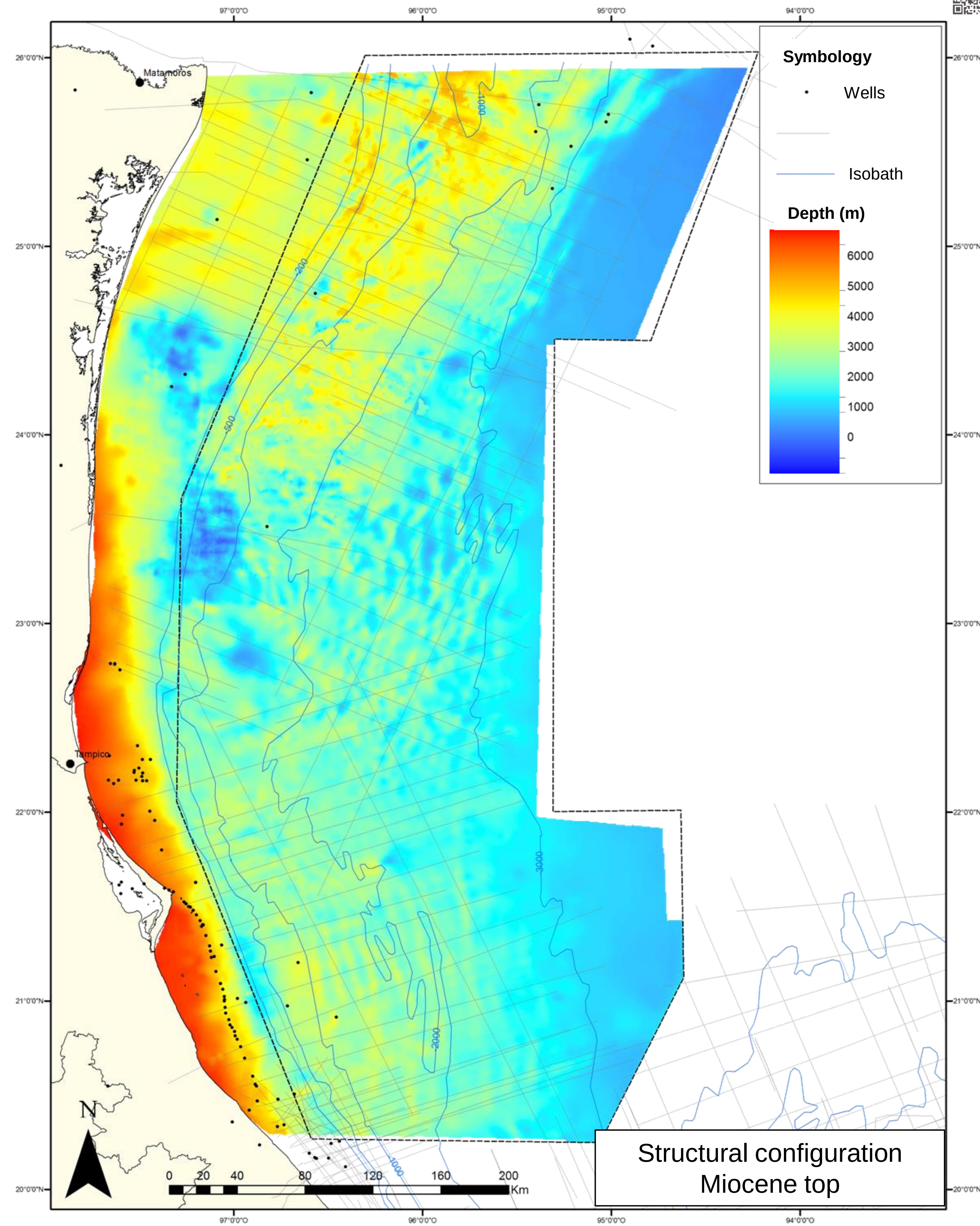
Structural Framework – Structural maps (2)





Structural Framework – Structural maps (3)

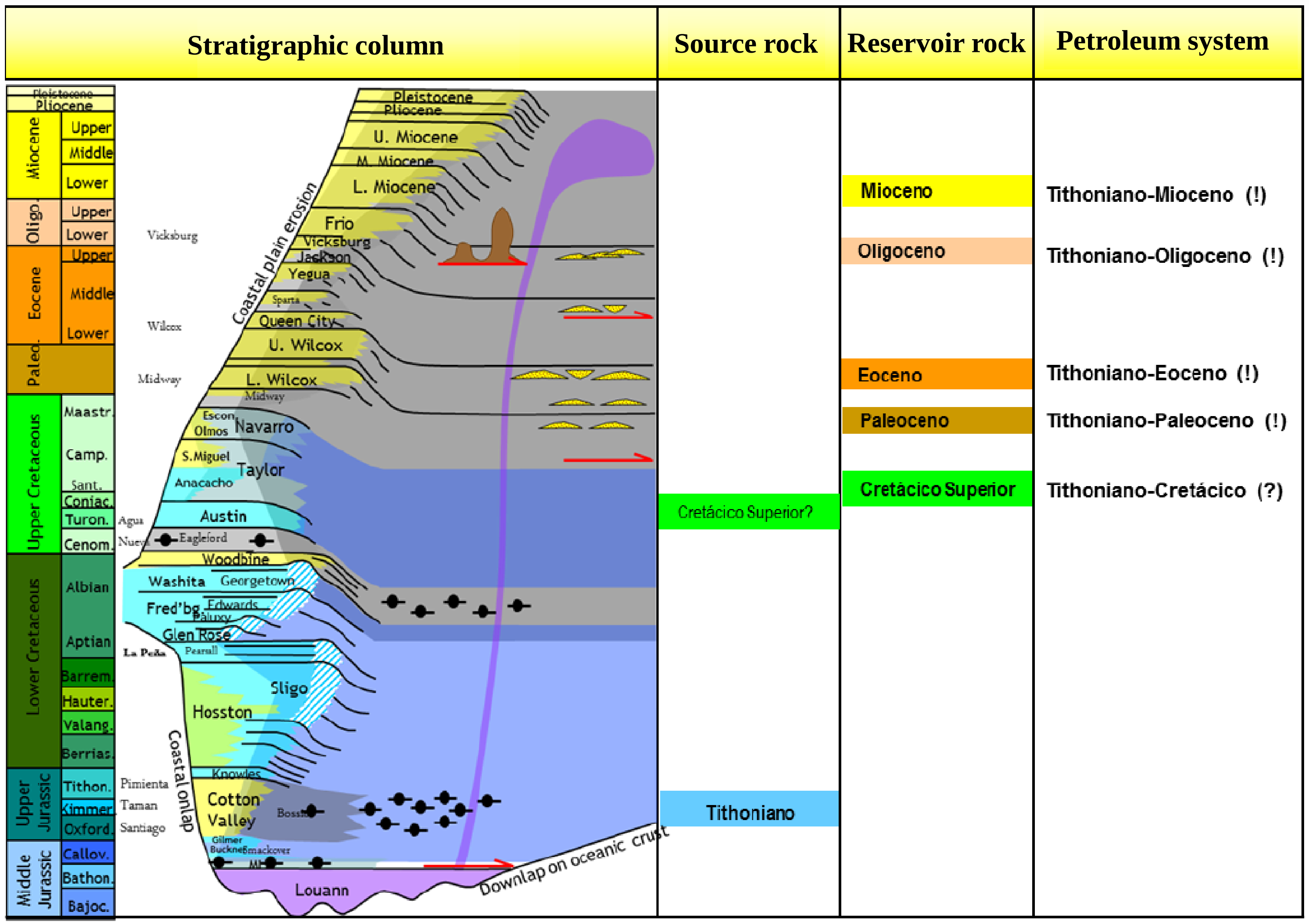




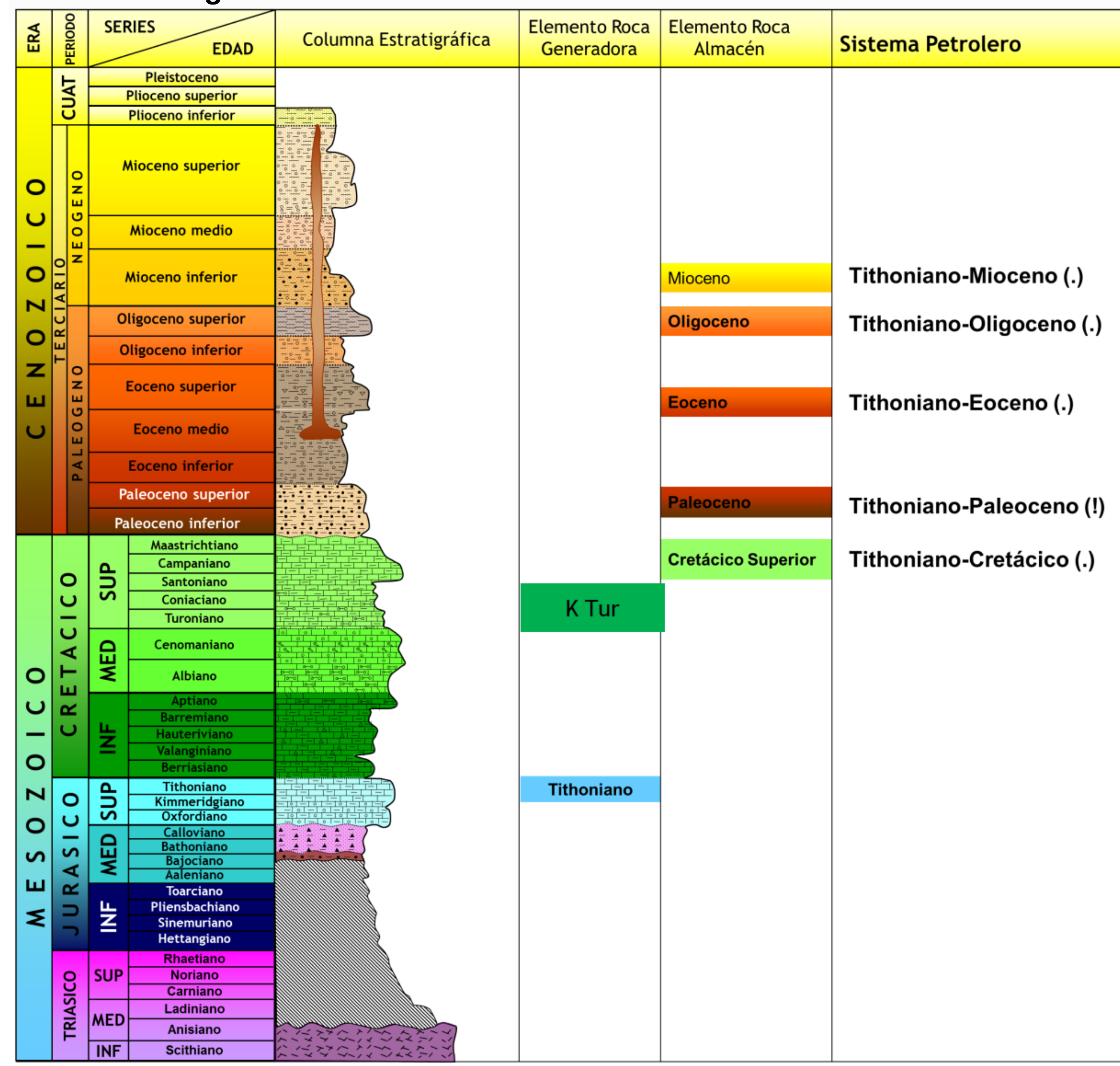
Petroleum Systems

Petroleum Systems - Source Rocks - Generation

Perdido Fold Belt

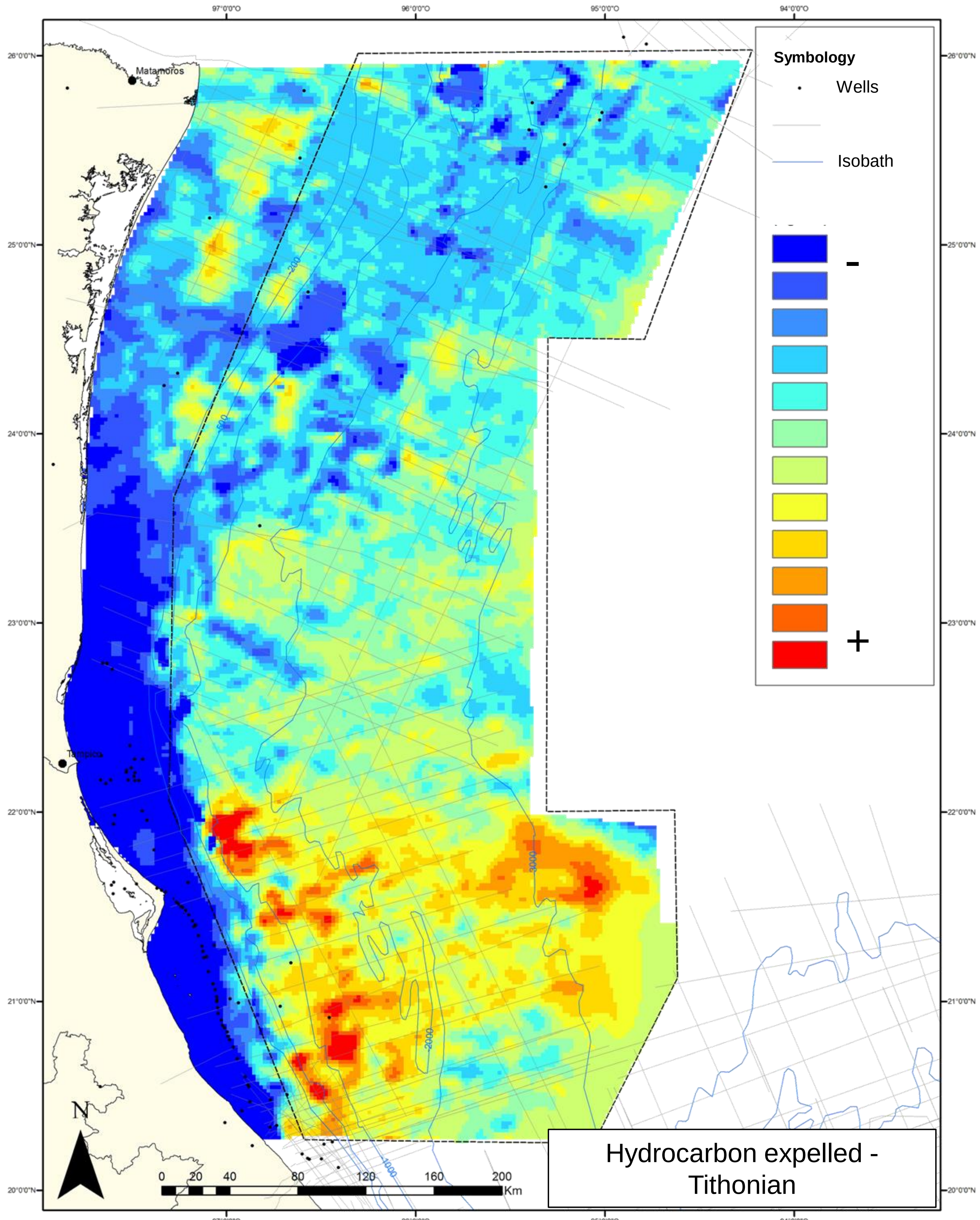


Mexican Ridges

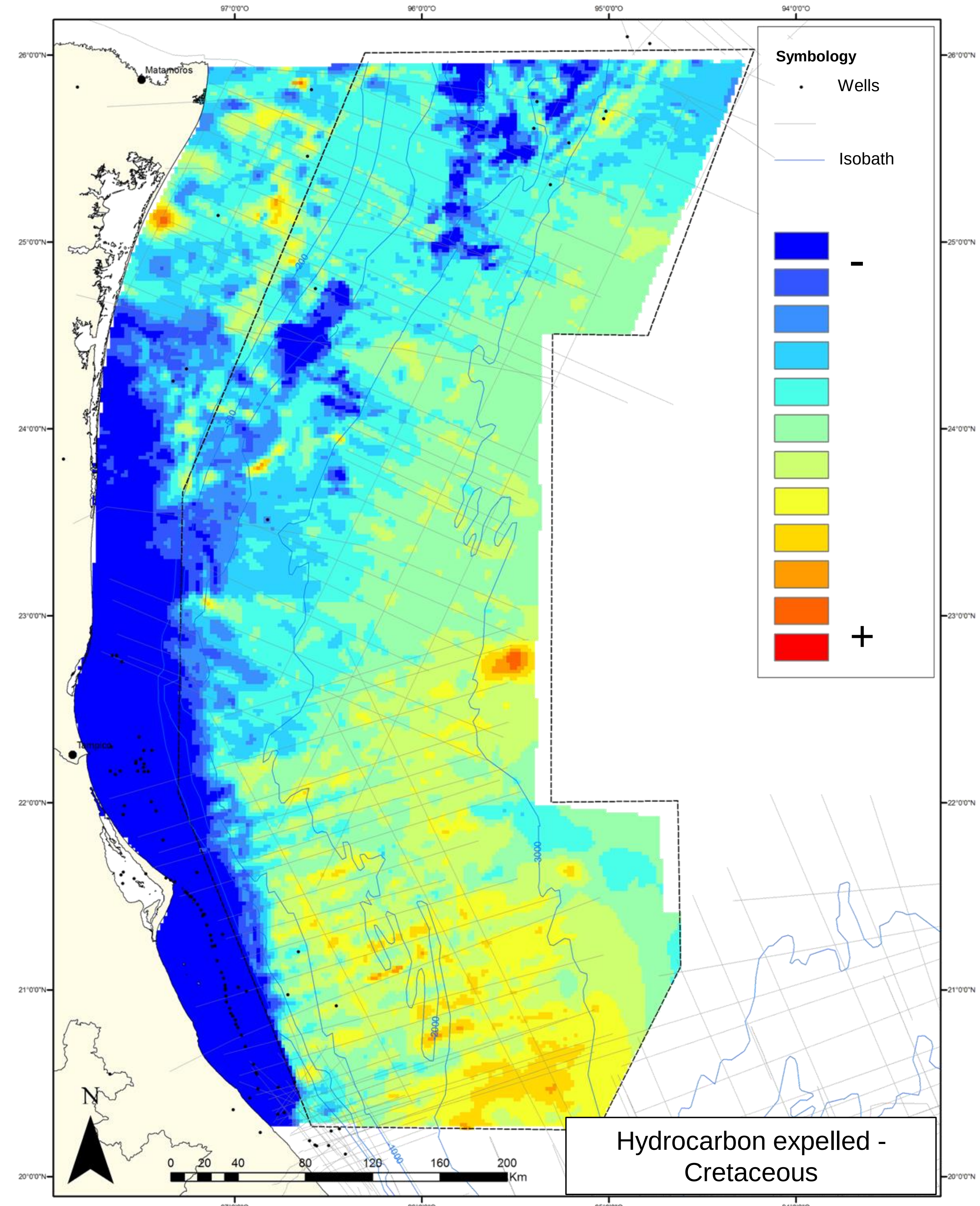


Petroleum systems, North Sector Gulf of Mexico

Petroleum Systems – Source rocks - Expulsion

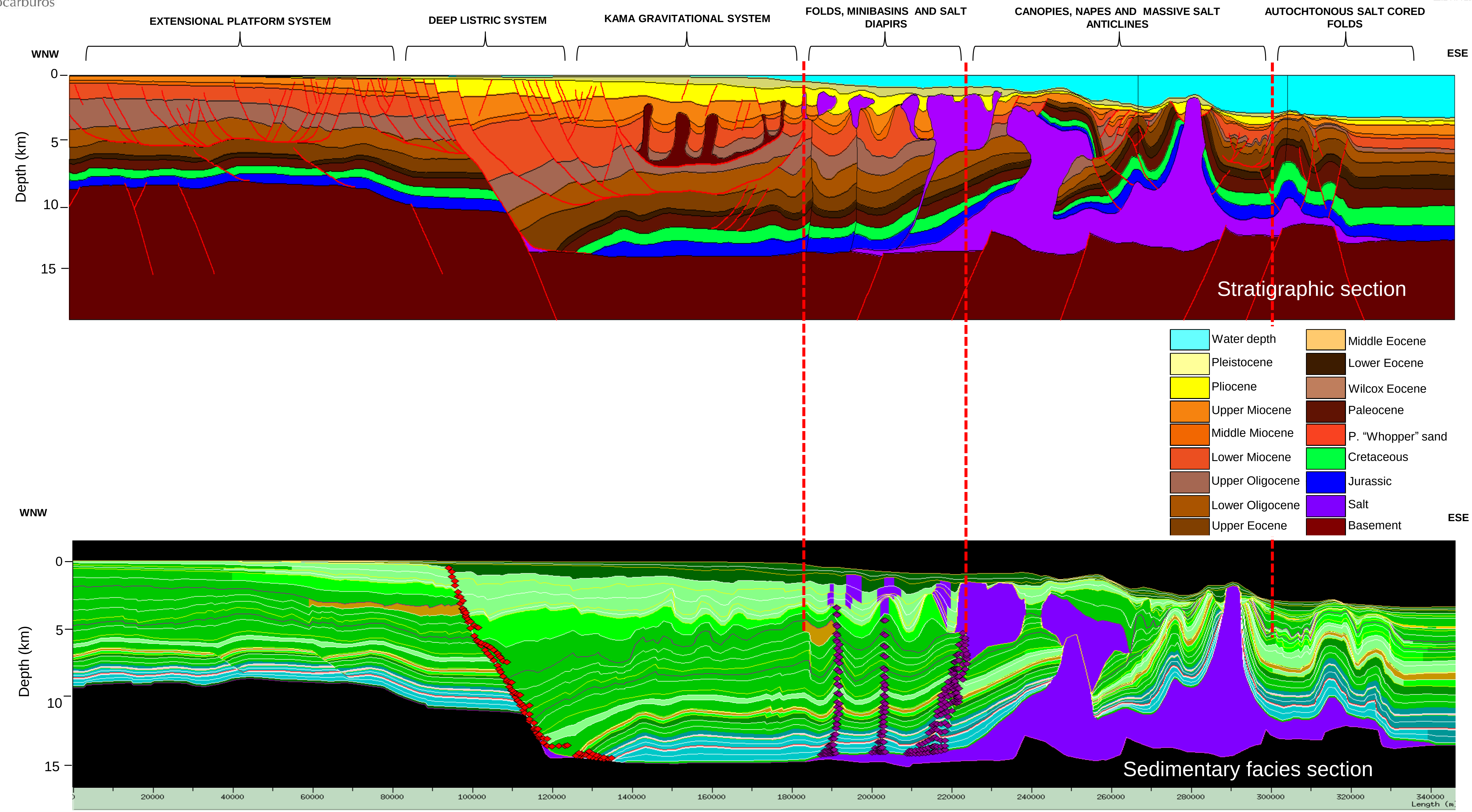


Hydrocarbon expelled - Tithonian

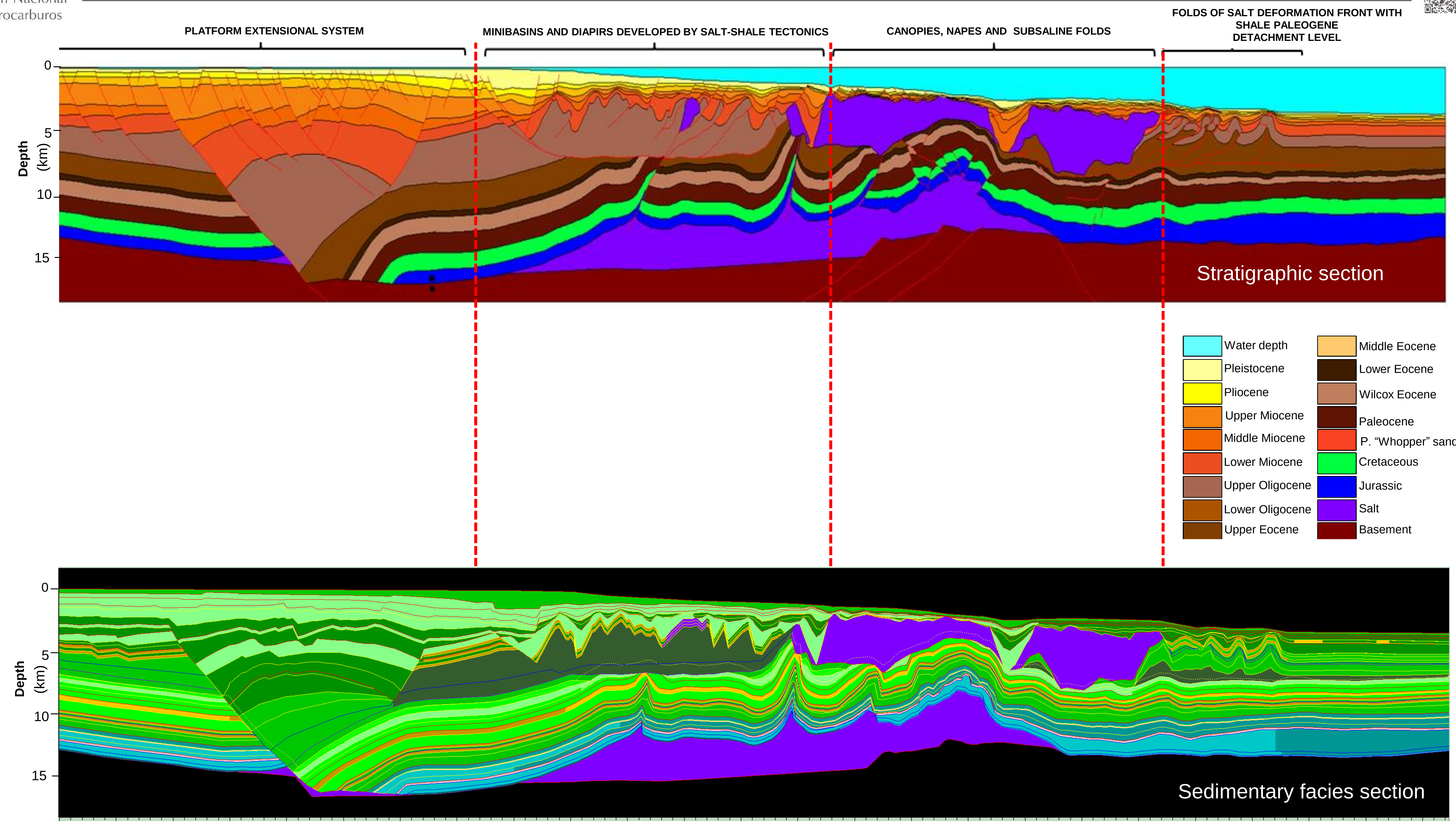


Hydrocarbon expelled - Cretaceous

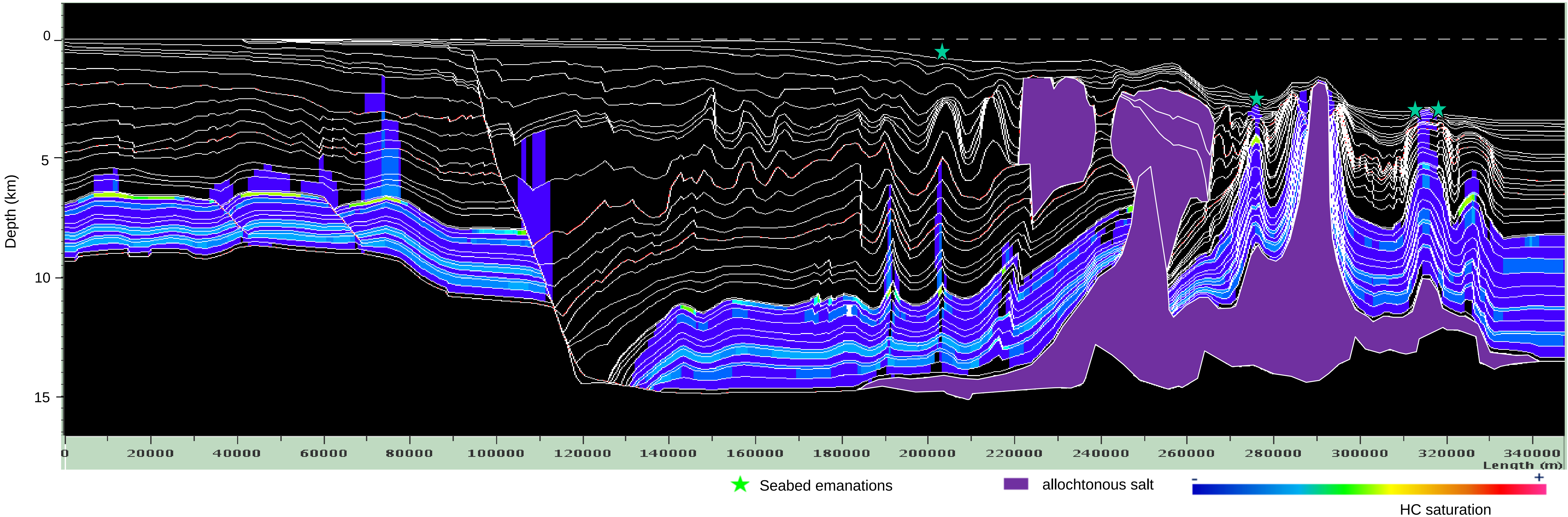
Petroleum Systems – Geological Models - Section A-A'



Petroleum Systems – Geological models - Section C-C'



Petroleum Systems – Migration and HC´s charge models - Section A-A’

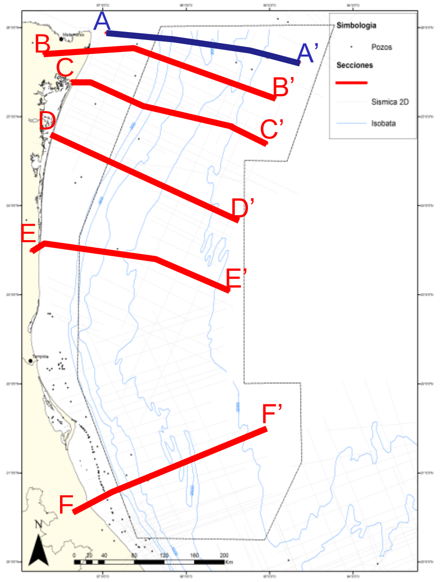


Model of hydrocarbons saturation.

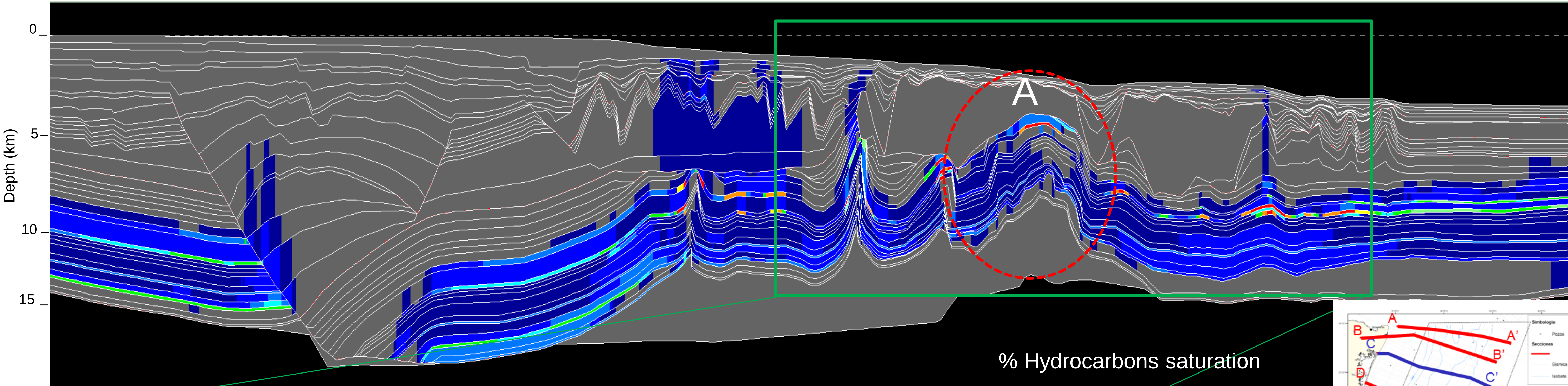
In general, the migration controlling factors in the area are:

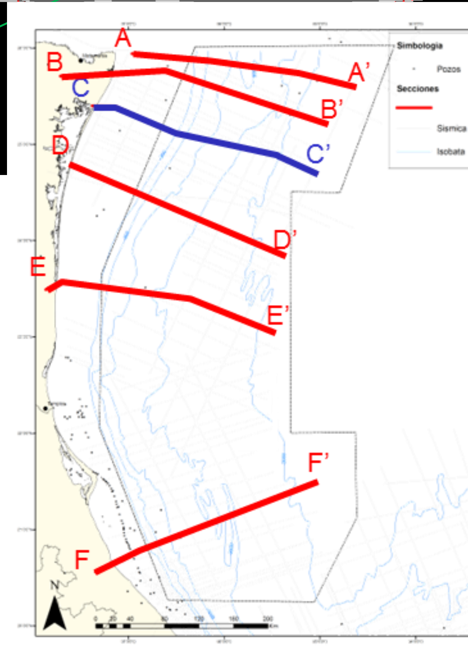
- The lateral continuity of permeable facies of Paleocene / Upper Cretaceous age
- The role of fault migration routes: the contribution of several compartments vs local migration compartment
- The efficiency of the seals based on fracturing and thickness
- The mobility of hydrocarbons according to the hydrocarbon phase (maturation or degradation grade)
- Tilt angle and surface of drainage areas.

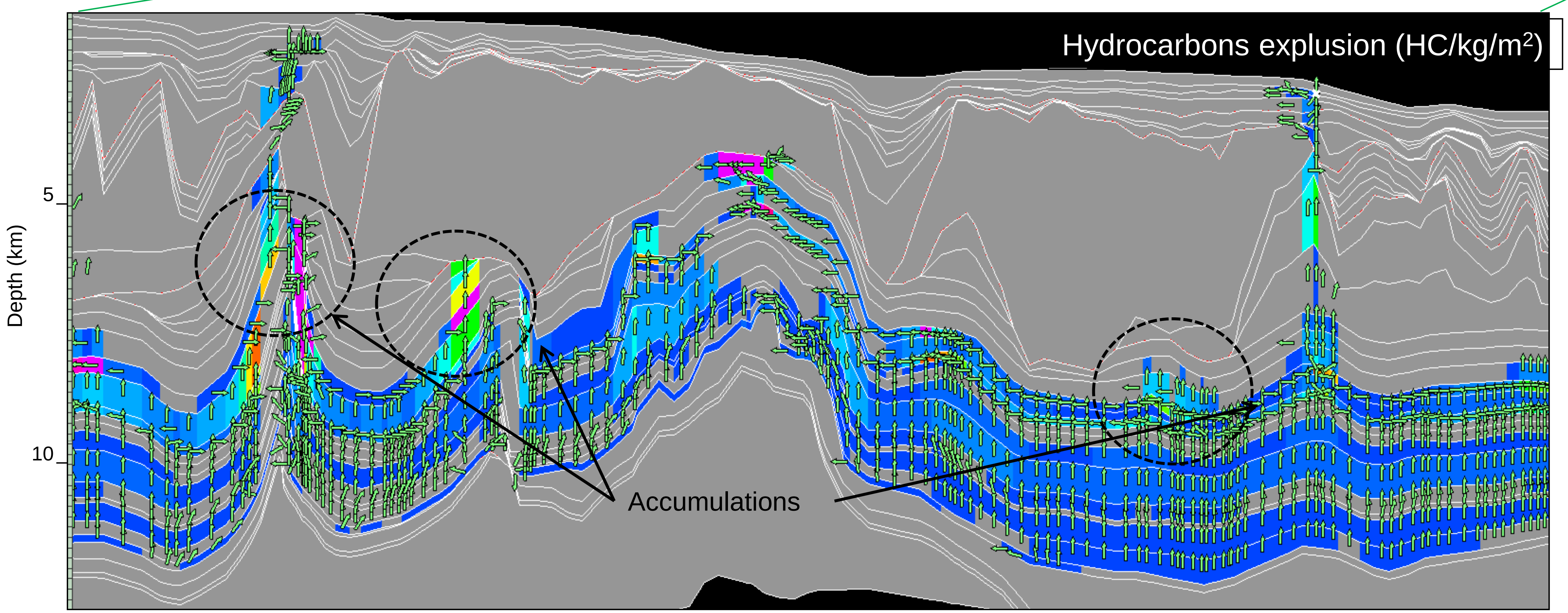
Tertiary gas is charged mostly by light hydrocarbons, condensed or gas with an RGA> 300 m^3/m^3 and an API grade>30. For reasons of synchronization, this load occurs most likely in the areas where the Tithonian is in condensed or dry gas generating window to present day. Similarly, the structures charge will be more efficient in a larger drainage area.



Petroleum Systems – Migration and charge models - Section C-C’





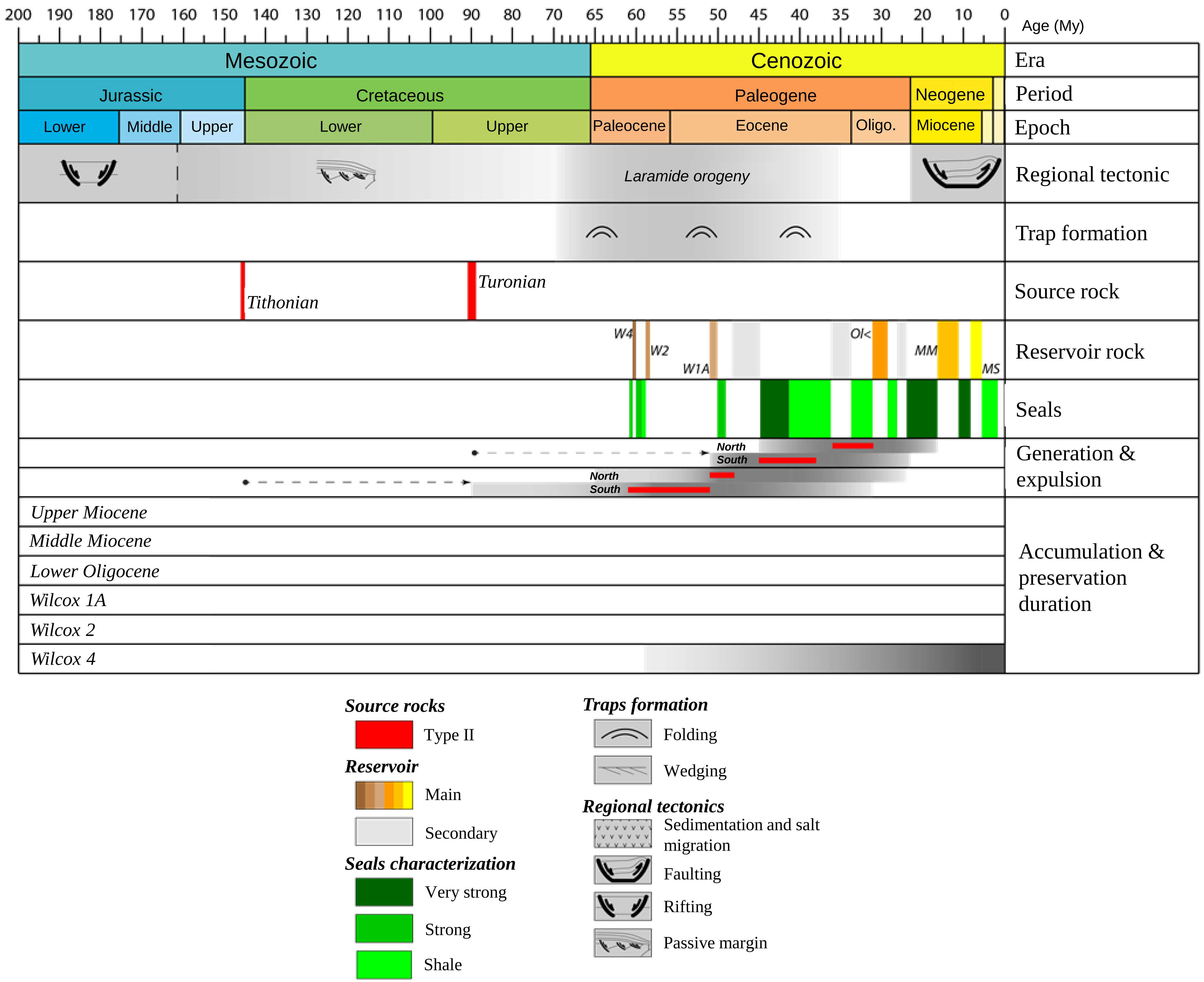


Model of hydrocarbon migration:

1) Source rock expulsion (Primary migration)
2) Cretaceous vertical migration
3) Paleocene charge and lateral drainage
4) Vertical migration to the Lower Eocene through capillary pressure breaks or faults
5) Tertiary migration to the seafloor

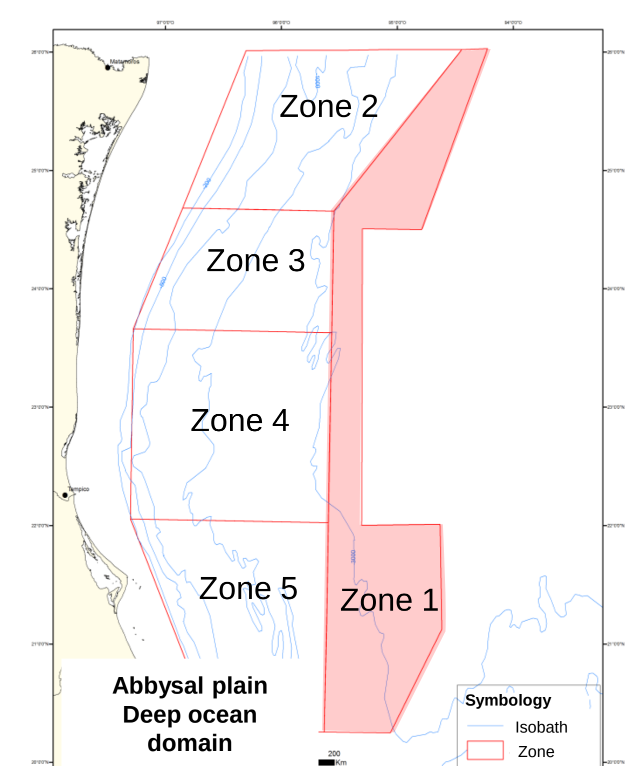
Petroleum Systems – Synchrony Diagram (1)

Zone 1

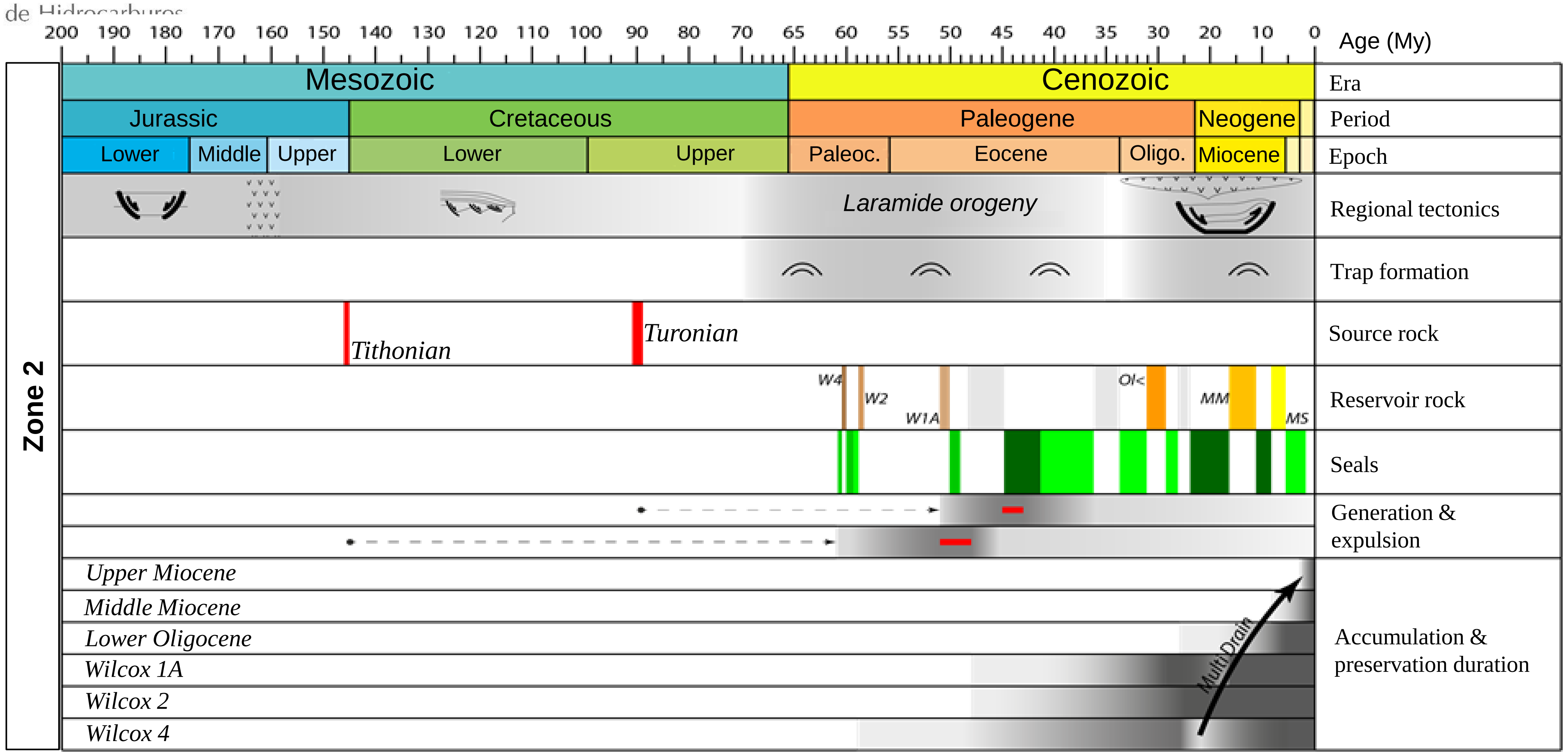


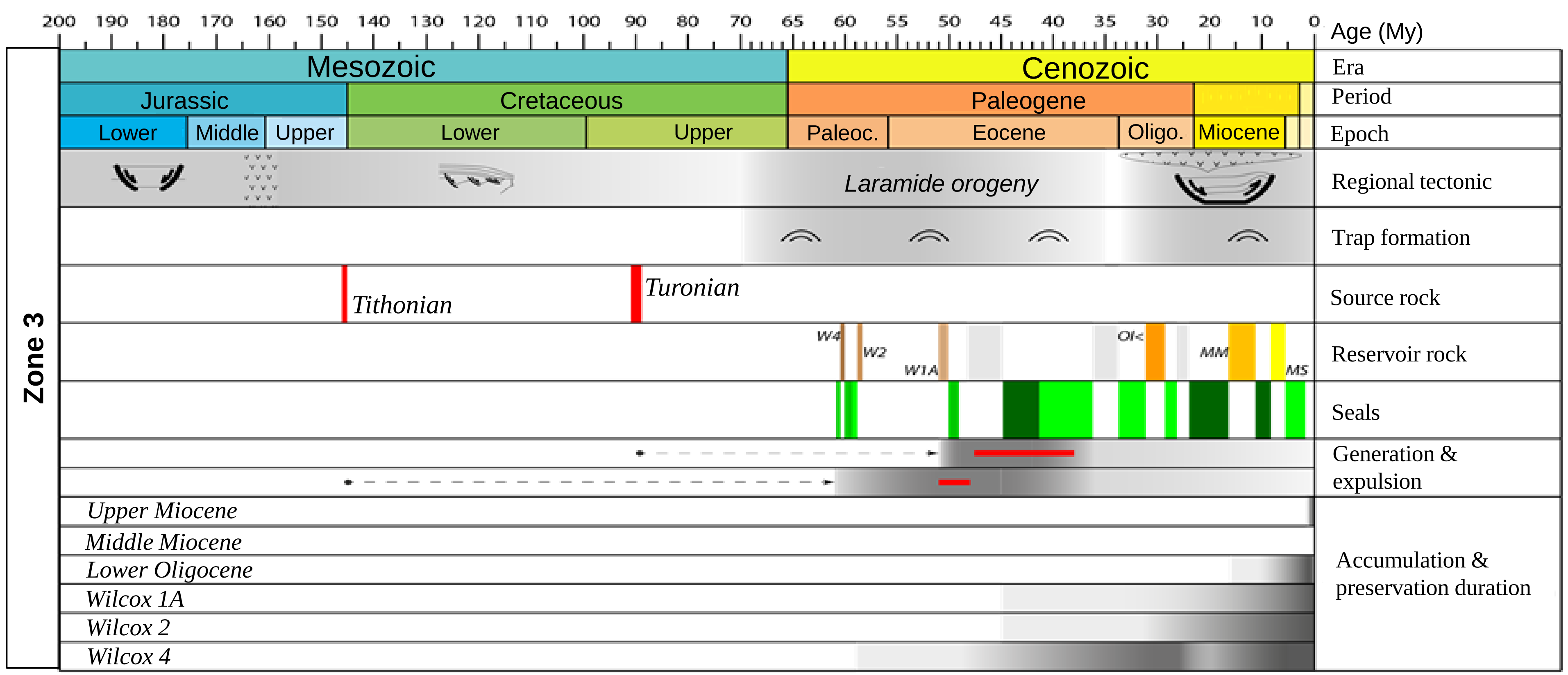
Deepwater zone covers an area of over 250,000 km. It is divided into six sub-zones based on factors such as bathymetry, basement estimated depth and salt presence.

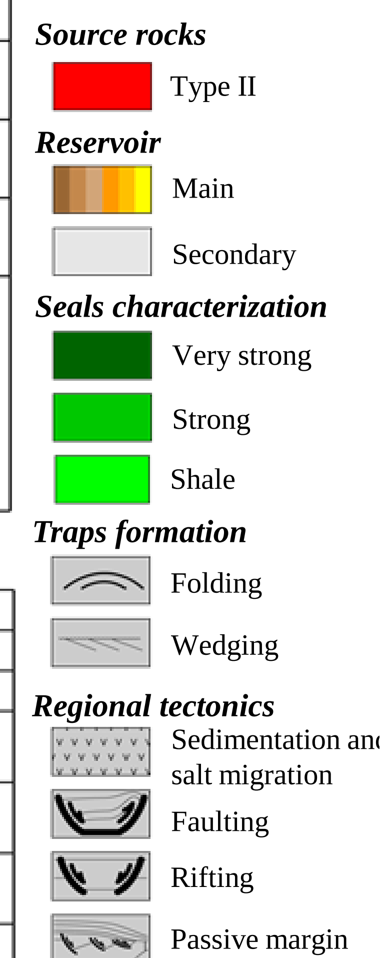
- **Z1**: 36,500 km² → Corresponds to the **Abyssal Plain Zone** or **Deep Ocean Domain**. Oceanic crust, without salt, low tectonic deformation.
- **Z2**: 23,500 km² → Includes **Salina del Bravo (North) and Perdido Fold Belt** areas**.**
  Greater thicknesses of salt (Callovian). Slope and Neogene sedimentary platform, highly deformed by salt tectonics, with a thin continental crust or transitional crust.
  Z3: 17,500 km² → **Salina del Bravo (South)**
  Similar to Zone 2, but with a deeper depth (towards the south), the crust appears thinner and possibly with less presence of salt.
- **Z4**: 31,000 km² → **Mexican Ridges (North)**
  Slope and abyssal plain (oceanic crust), without salt, strong tectonic deformation during the Tertiary (gravitational).
- **Z5**: 26,000 km² → **Mexican Ridges (South)**
  It is similar to zone 2, but a slightly deeper.

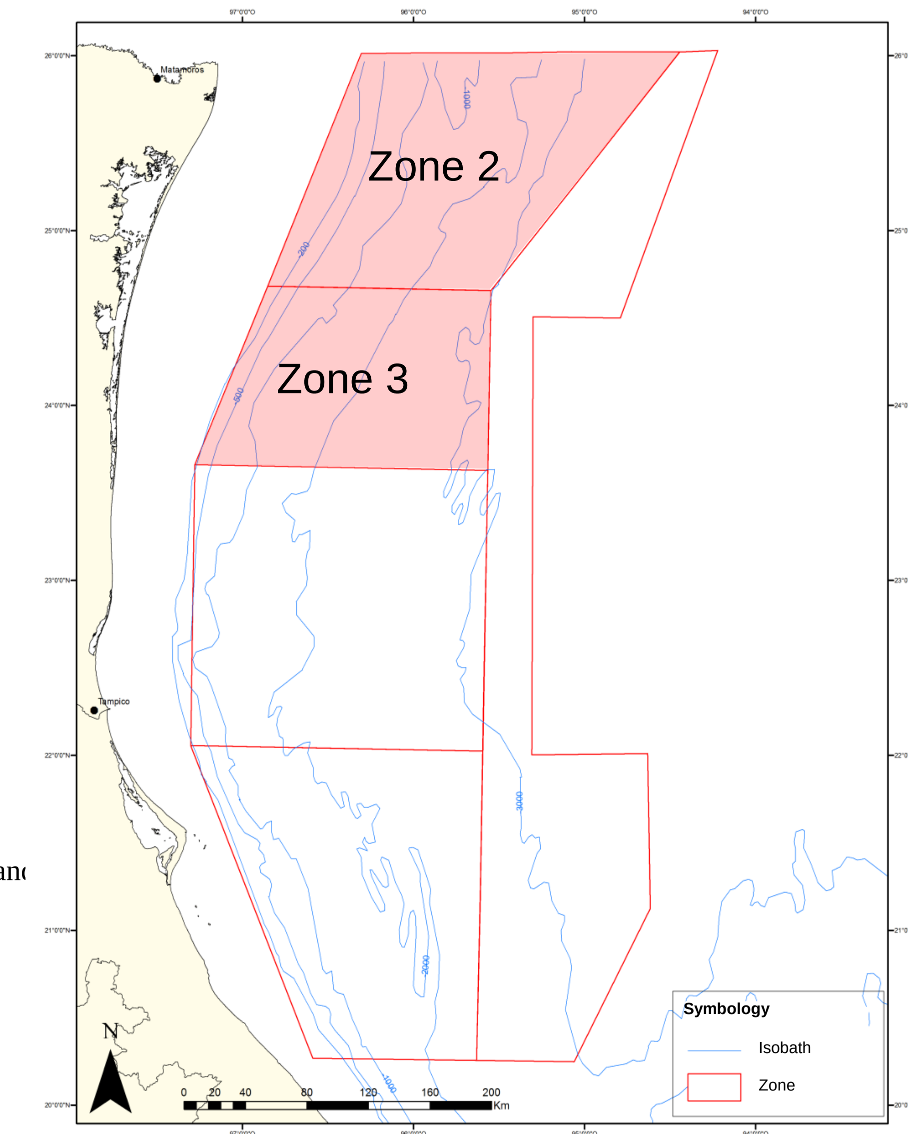


Petroleum Systems – Synchrony Diagram (2)

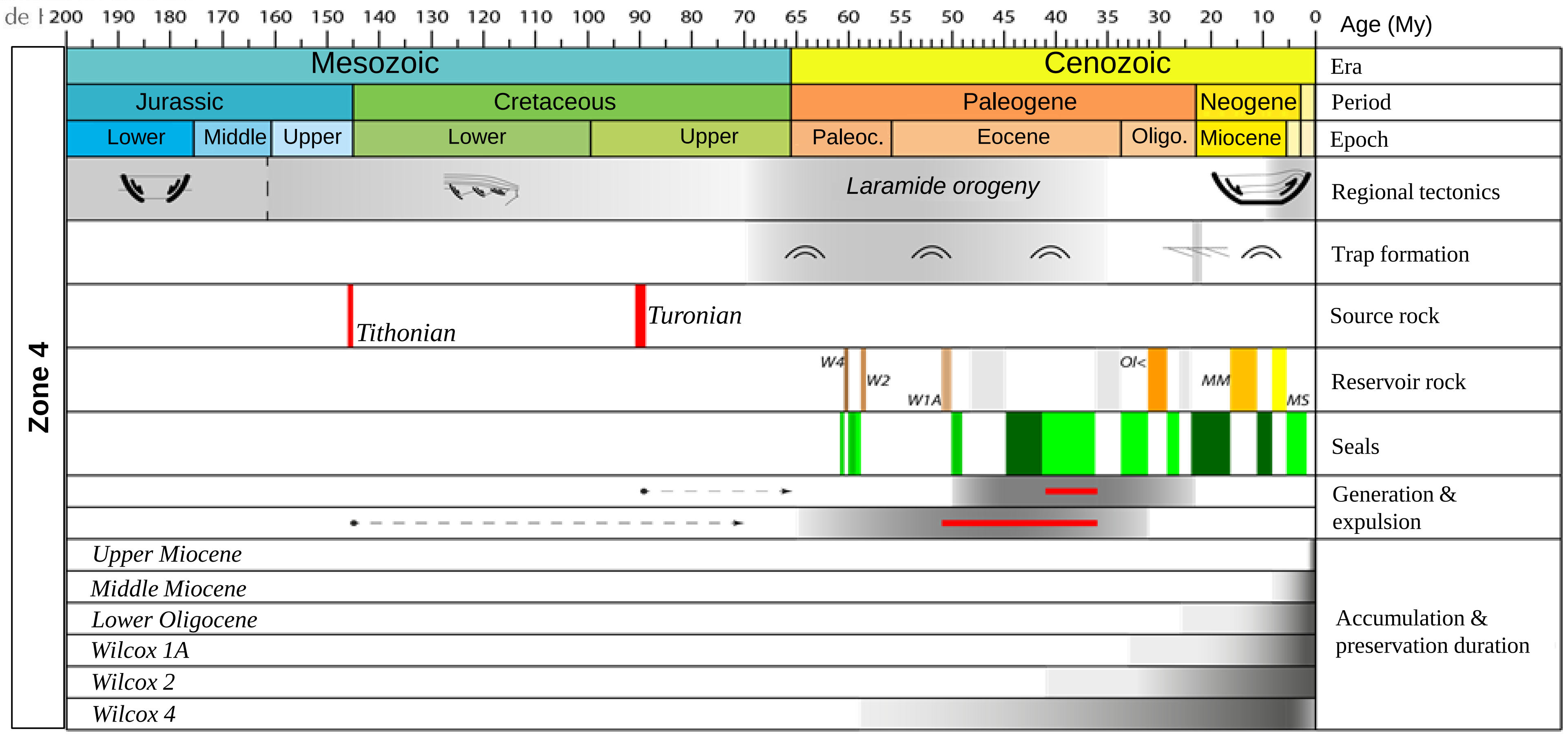


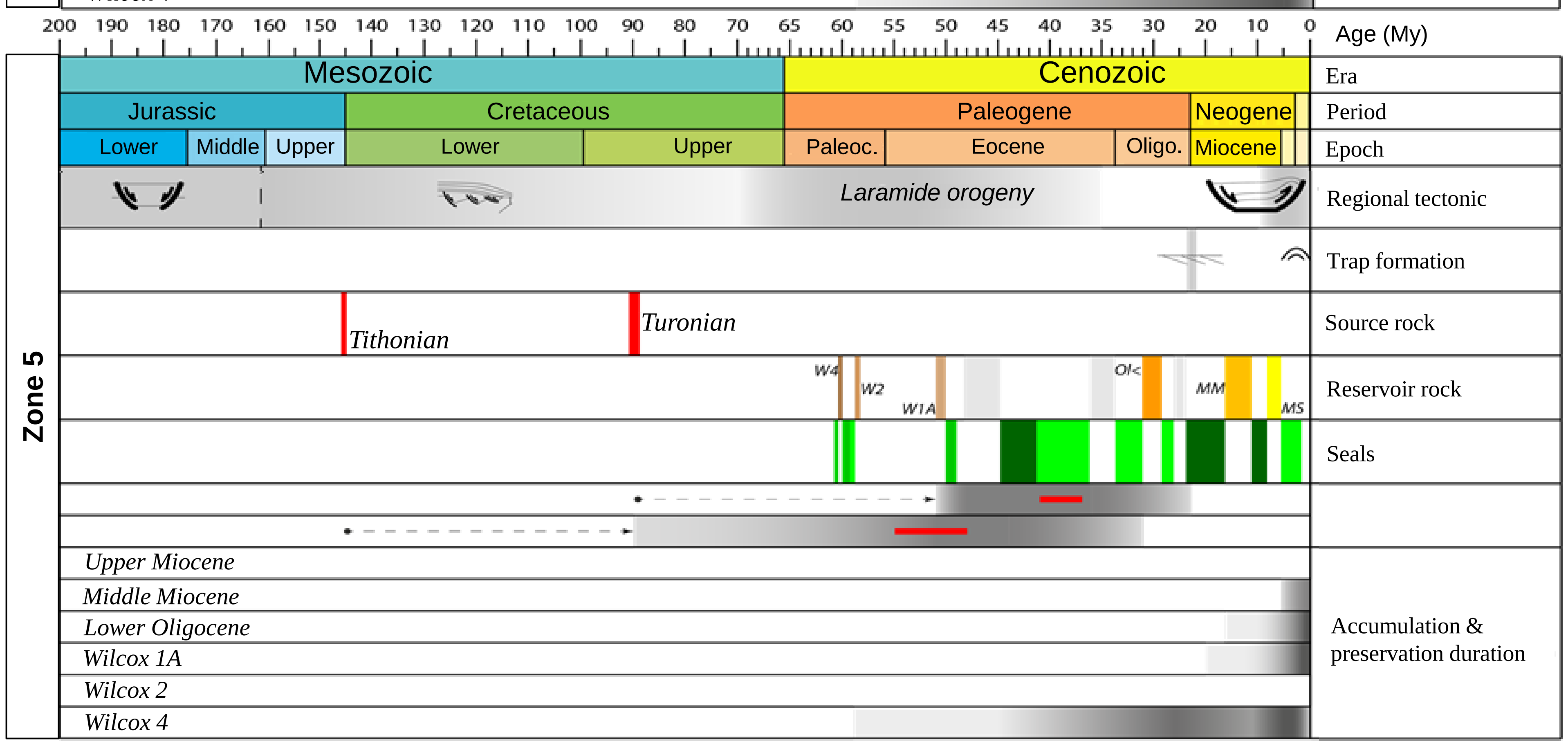


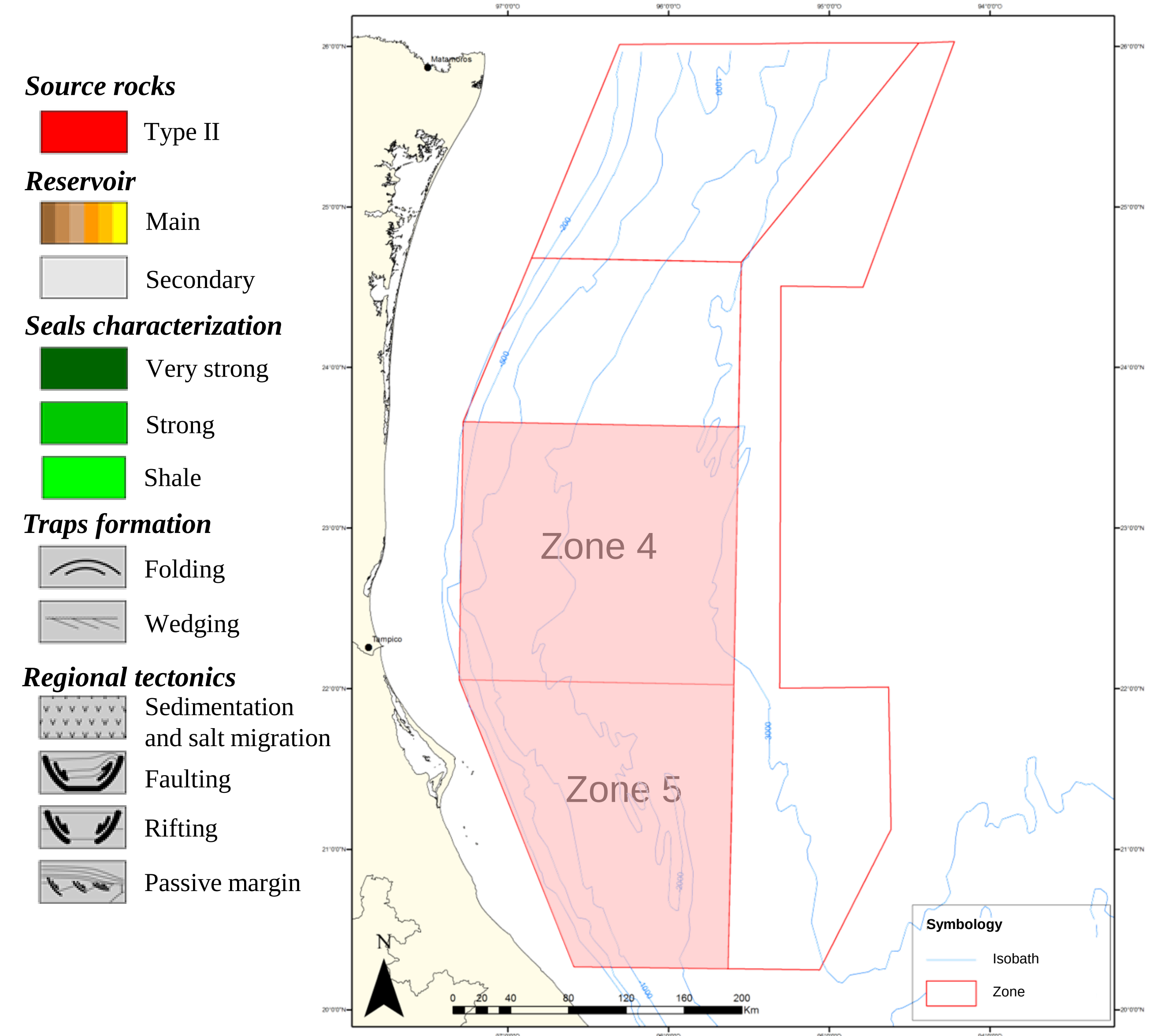




Petroleum Systems – Synchrony Diagram (3)



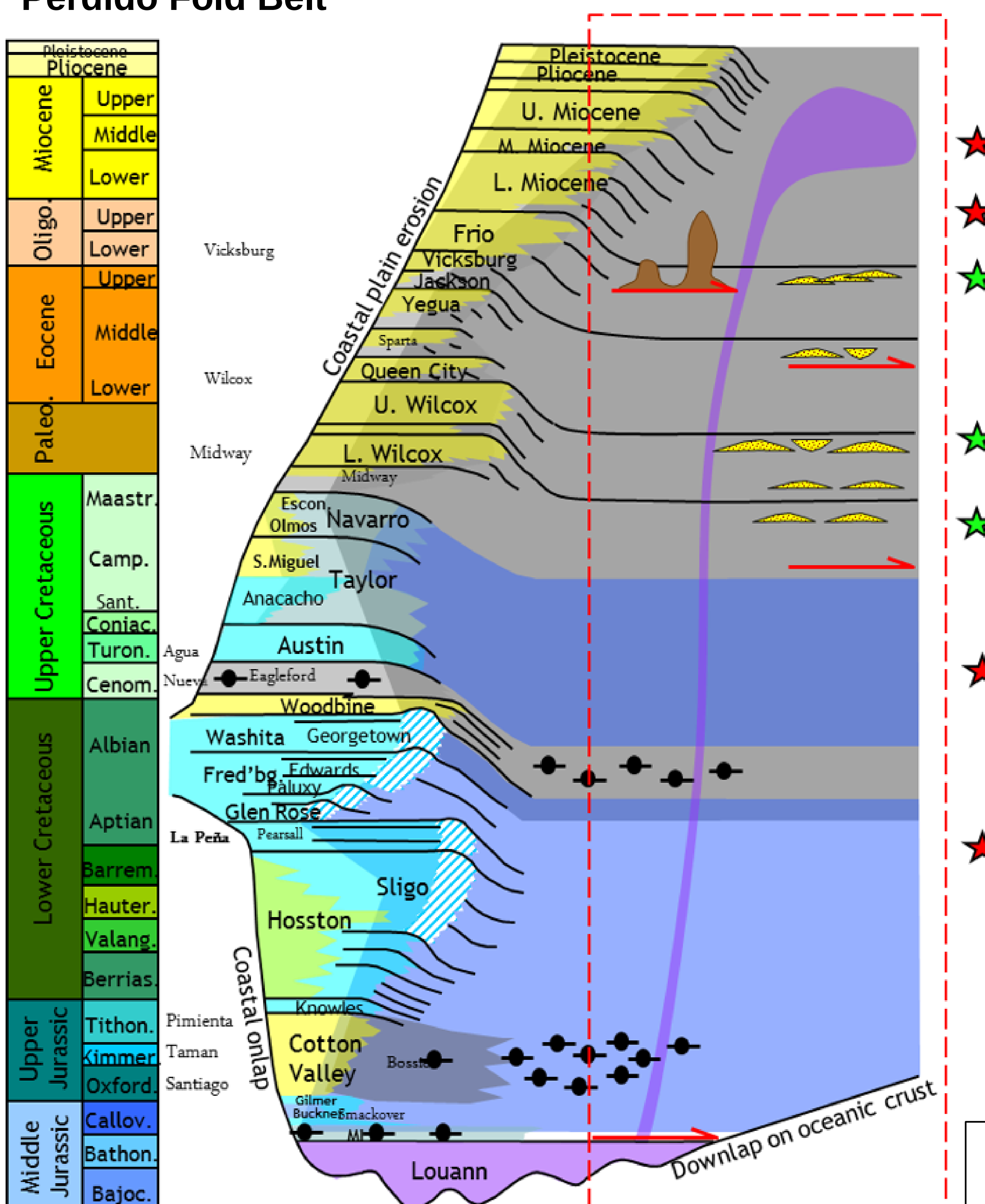




Delimitation of *Plays*

Delimitation of *plays*

Perdido Fold Belt

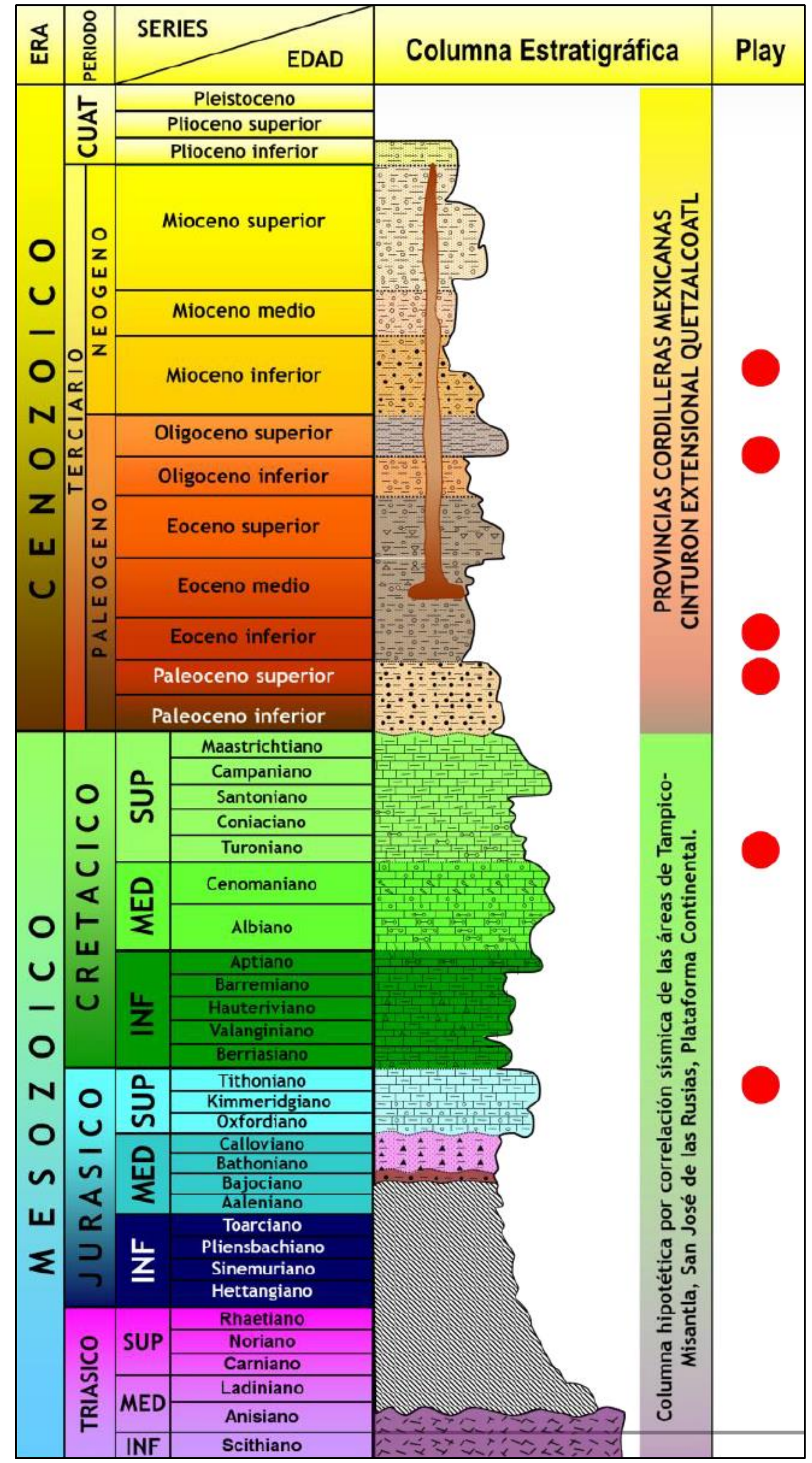


Types of Plays

- Channels and fans within minibasins
- Basin floor channels and fans
- Basin floor channels and amalgamated splays
- Basin floor channels and fans
- Fractured basin carbonates
- Fractured basin carbonates

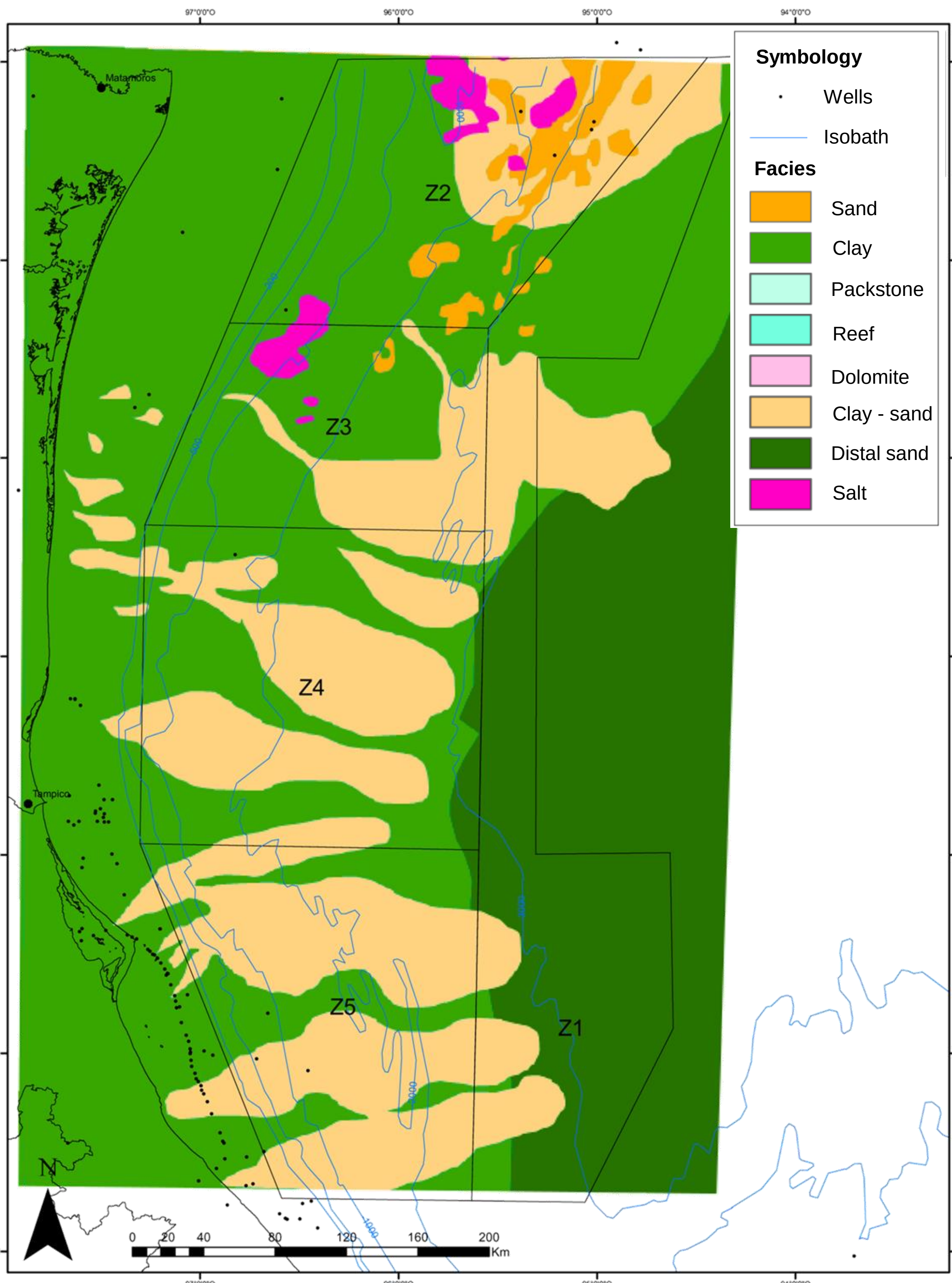
- Miocene (E)
- Oligocene (E)
- Lower Eocene (E)
- Upper Paleocene (H)
- Cretaceous (H)

Mexican Ridges

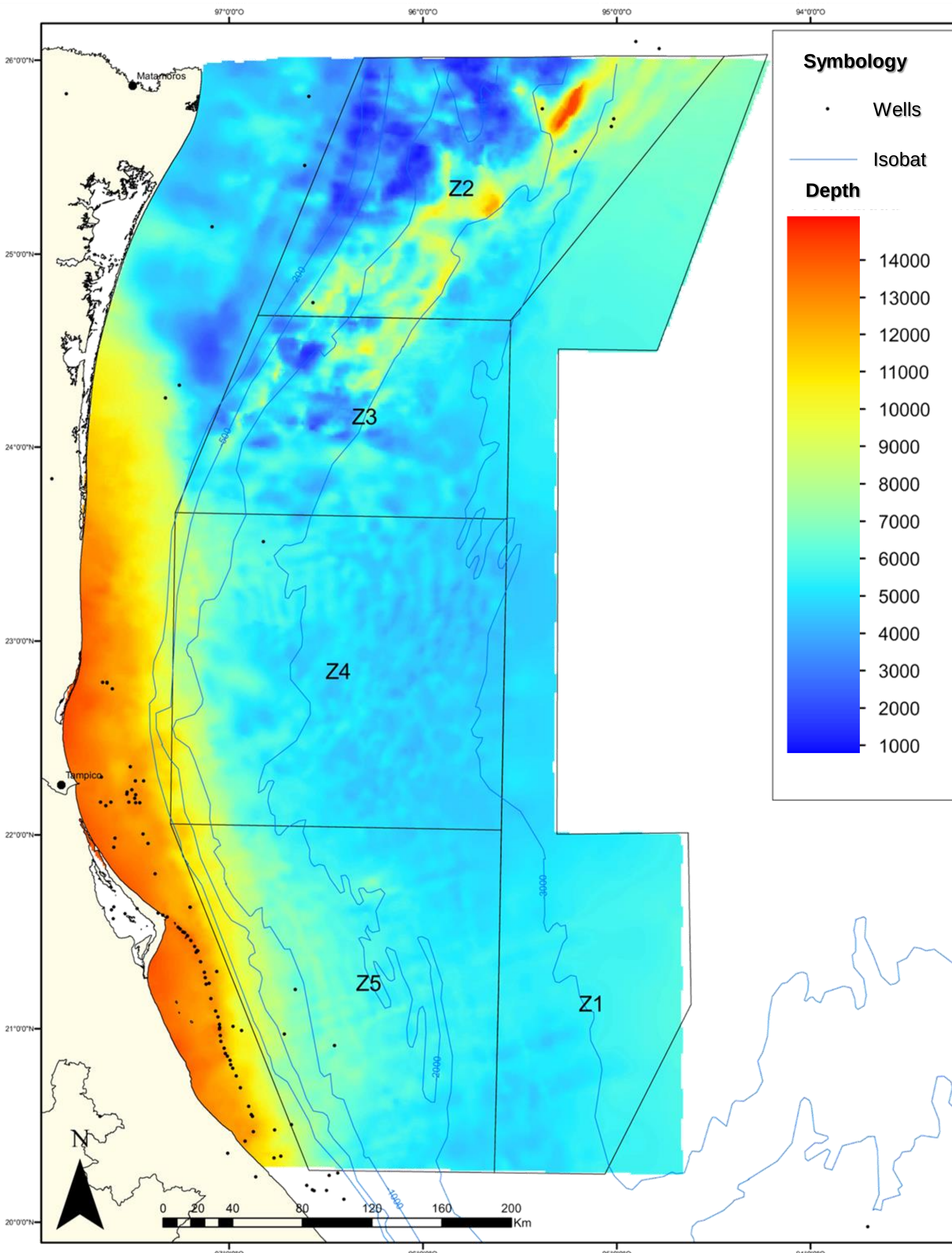


- Miocene (E)
- Oligocene (H)
- Eocene (H)
- Upper Paleocene (H)
- Cretaceous (H)
- Jurassic (H)

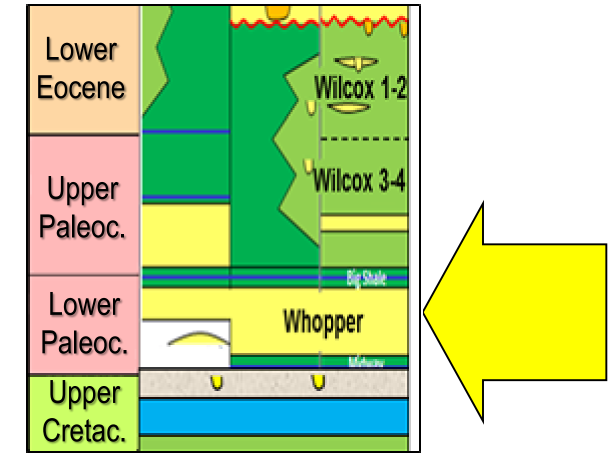
Delimitation of *Plays* - W4 Lower Paleocene Wilcox



Facies Map



Depth Map



Facies

The lithologies distribution map shows an increased potential of reservoir rock to the north (Zone 2, Zone 1 north – the source the of sediments were located to the north). To the south (Zones 4 and 5) is associated with fans/smaller lobes. Abyssal plain area (south of Zone 1) unfavorable to Paleocene reservoir lithology presence.

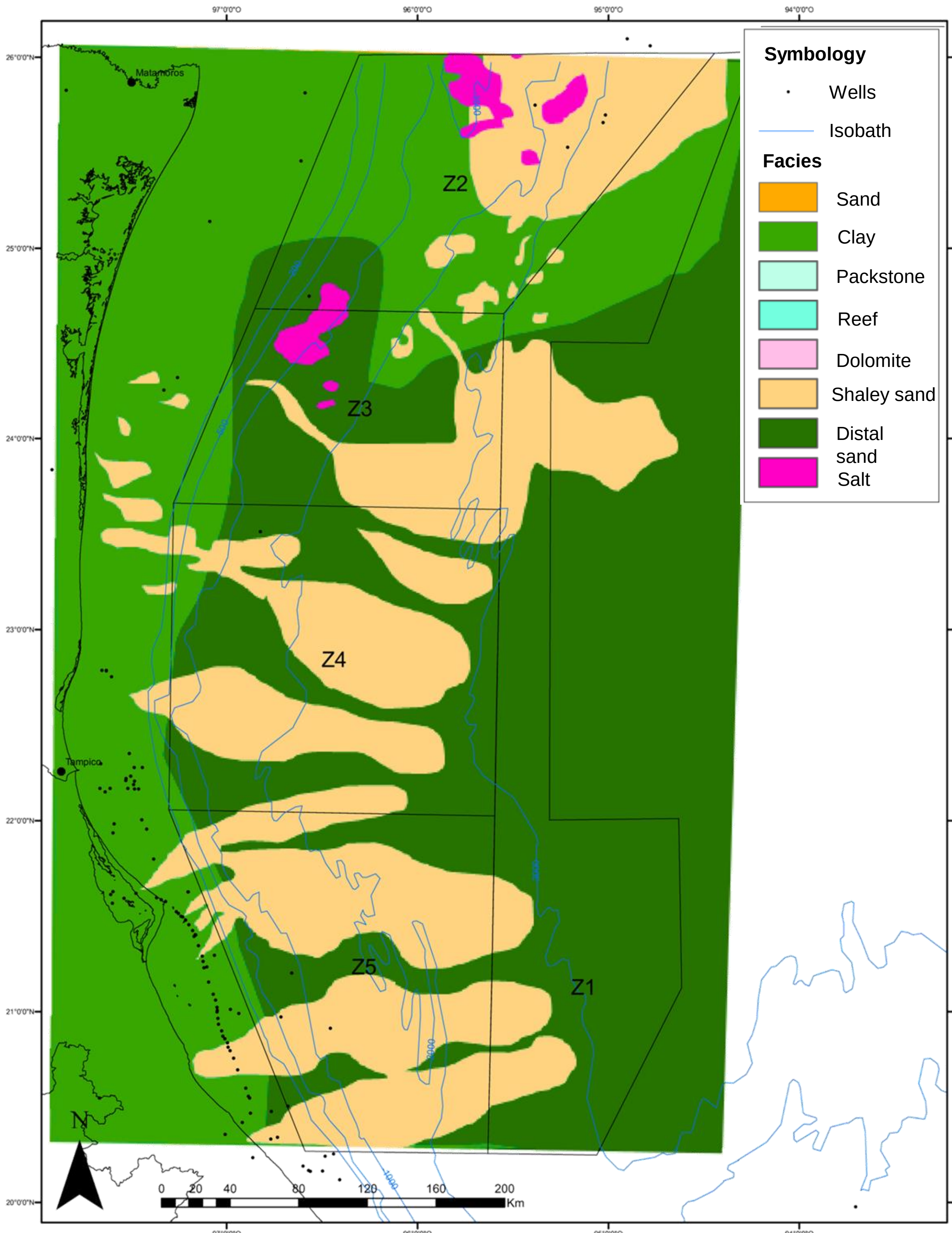
The best sandstone facies would be located in Zone 2 (with few salt intrusions) and at the north of Zone 1.

Structural

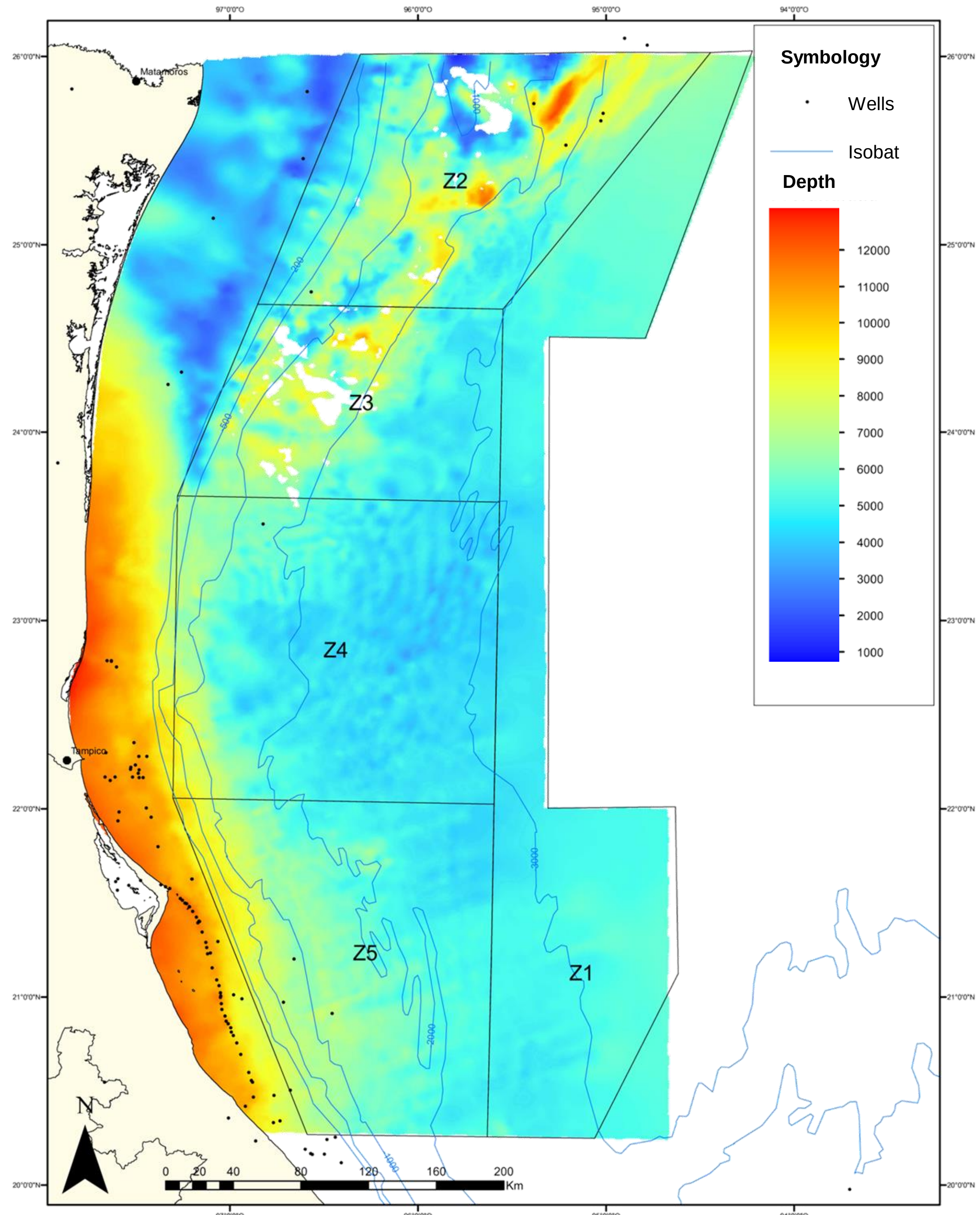
The "Whopper" sandstone member, Lower Paleocene Wilcox equivalent is located at a depth range between 5,000 and 14,000 m (in a water depth > 600 m). In most of Zones 1-5, burial is included between 6,000 and 9,000 m.

The minimum depth (~5000 m), which also corresponds to the minimum burial range (~3500 m), is located at the south of Saline Basin (Zone 6) at the north of Perdido Fold Belt shows the largest salt structures (Zone 2). In addition, there are some locally wedged or stratigraphic traps along the Southern Continental Shelf, at a depth range of 5,000-6,000 m (4,000-5,000 m burial).

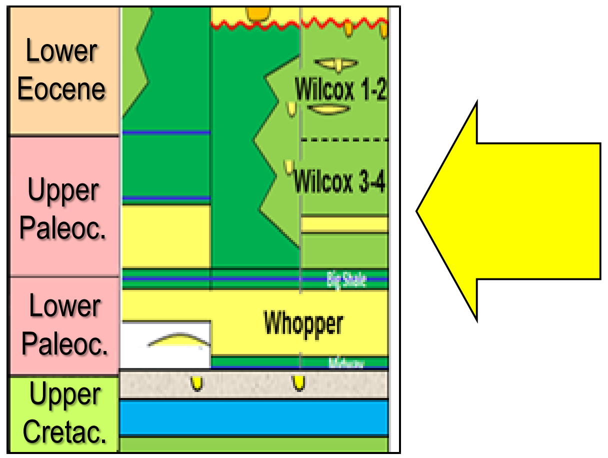
Delimitation of *Plays* – W2 Upper Paleocene Wilcox



Facies Map



Depth Map



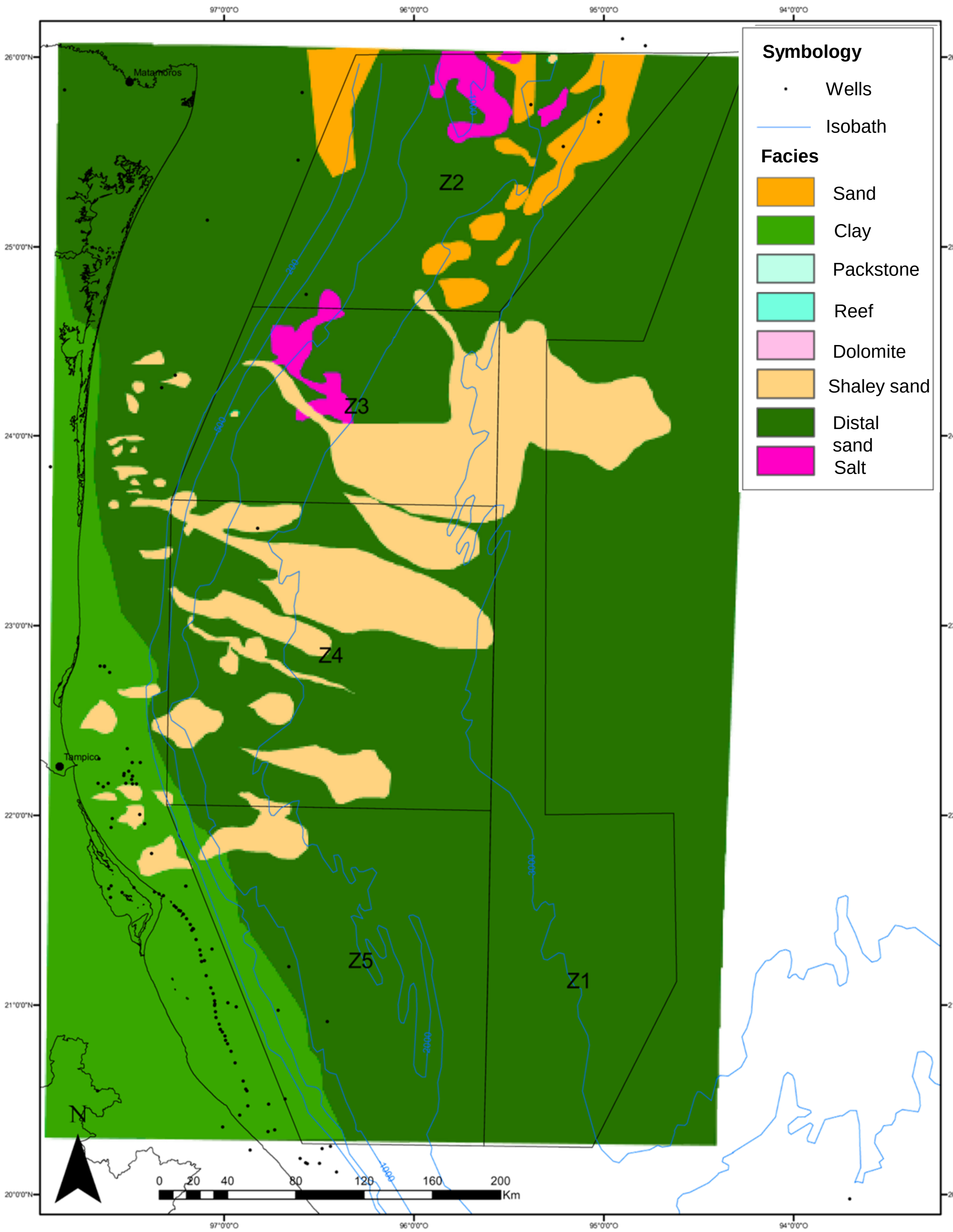
Facies

The lithology distribution maps are very similar between the Upper Wilcox play and the Lower Wilcox play (increased potential of reservoir rock to north - Zone 2 and north of Zone 1).

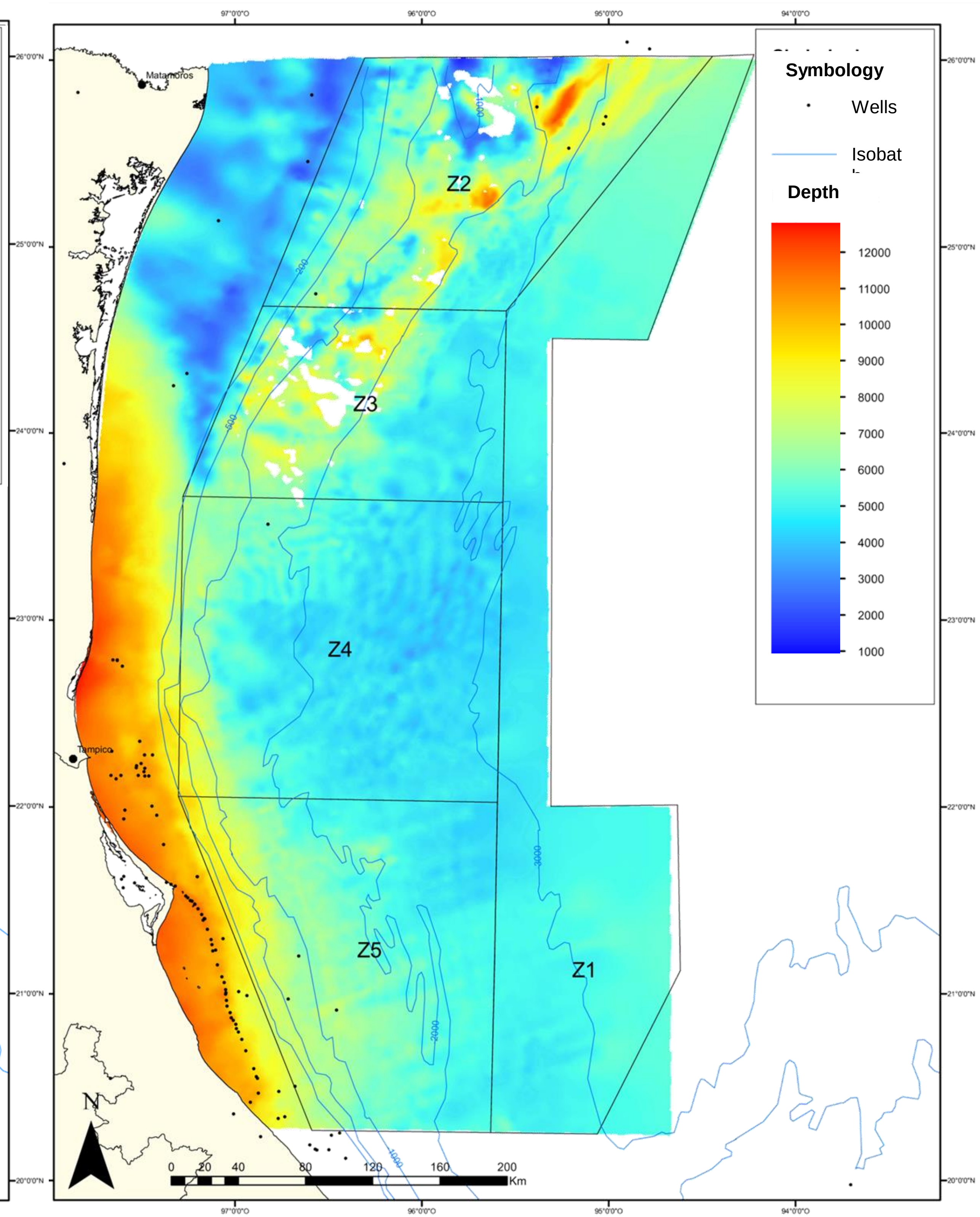
Structural

The difference in depth/burial between the Wilcox Lower Paleocene play and the Wilcox Upper Paleocene play is in general less than 500 m.

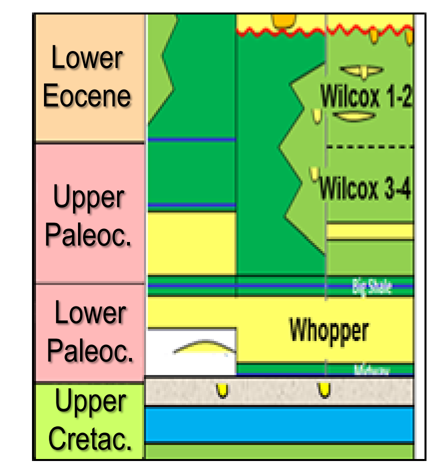
Delimitation of *Plays* – North Zone - W1A Lower Eocene Wilcox



Facies Map



Depth Map



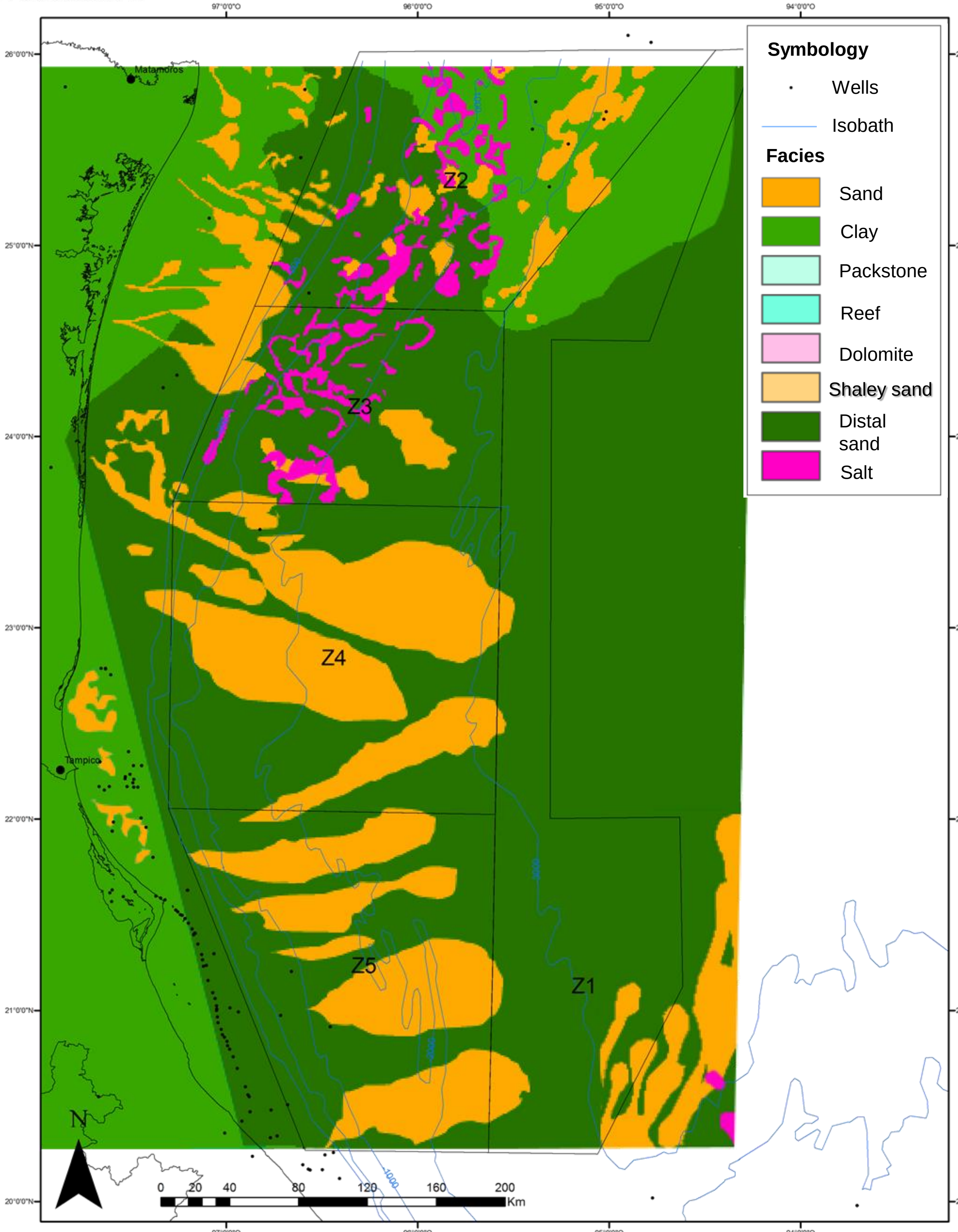
Facies

The distribution of sand bodies in Lower Eocene Wilcox play shows that the best reservoirs are located in the north of Zone 2, and possibly in Zones 3 and 4. The proportion of sediments that come directly from the Mexican platform increases. In other areas, reservoirs are low quality and are deposits related to fans.

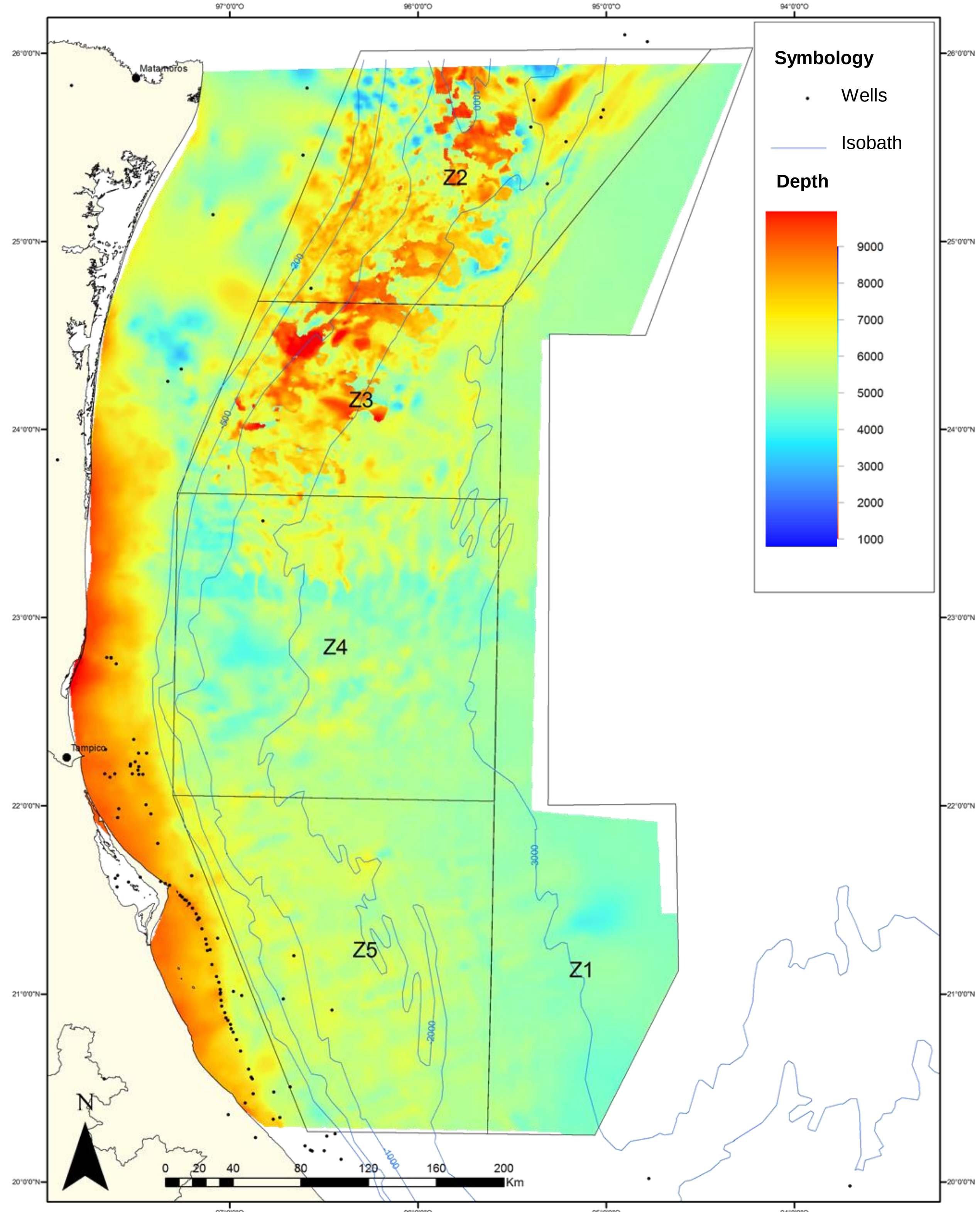
Structural

The Lower Eocene Wilcox is located at a depth range between 4,000 and 12,000 m. The minimum depth, which also corresponds to the minimum burial, is located near the shoreline, outside the deepwater zone. In most of the Zones 1-5, the burial is included between 4,500 and 8,500 m, except in areas with large amplitude structures (Zone 2, 2,500m locally burial - depth of about 4,000 m minimum).

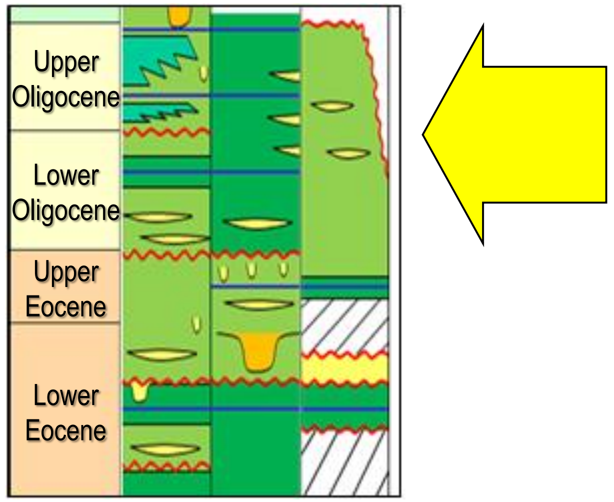
Delimitation *Plays* - Oligocene



Facies Map



Depth Map



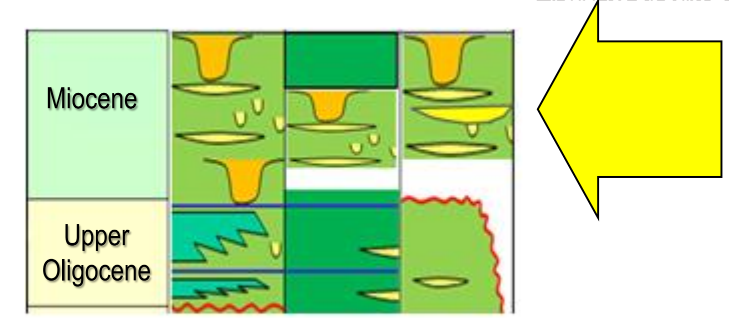
Facies

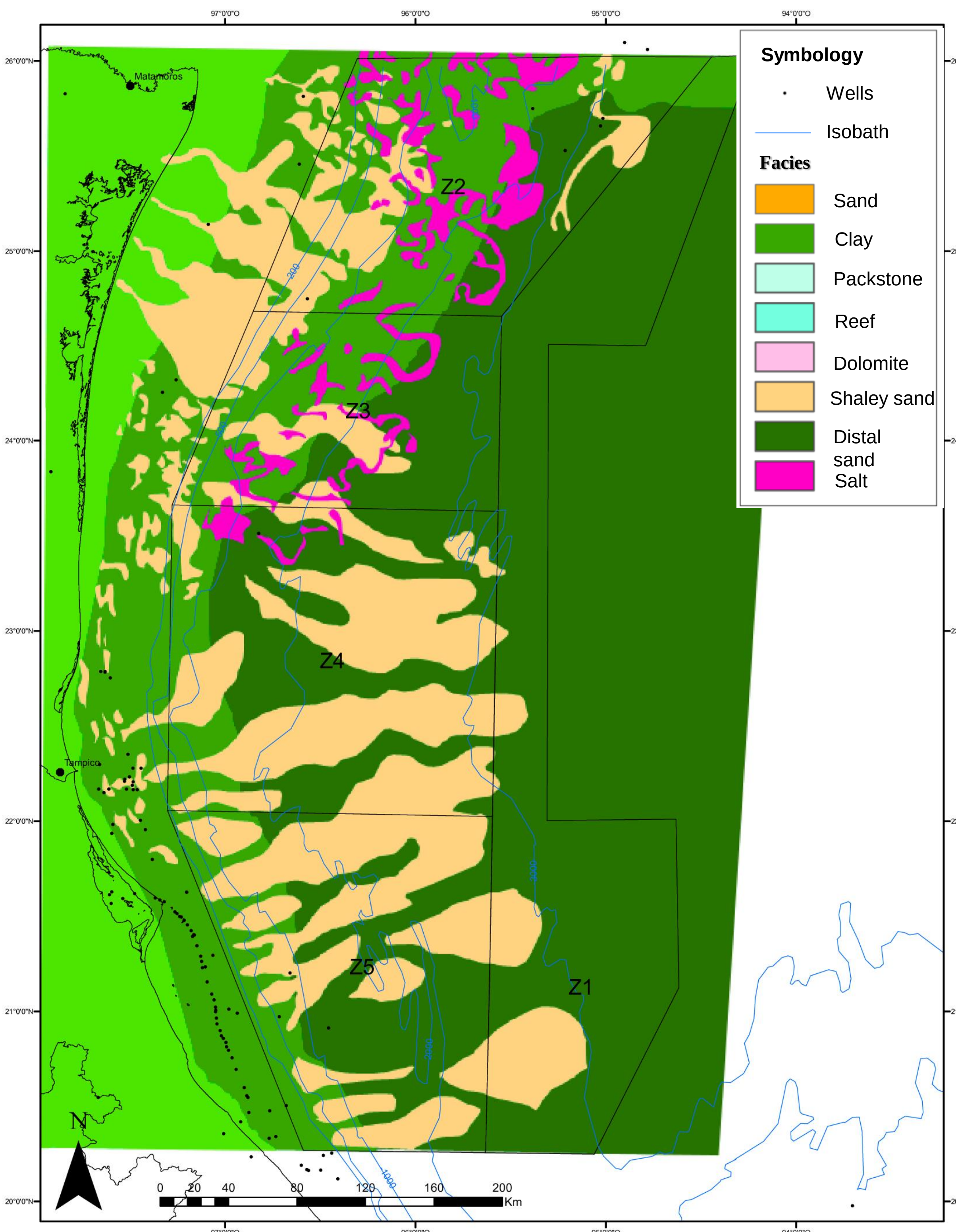
The lithology distribution map in deepwater Oligocene play area shows that the sand bodies are found in almost all areas. It is mainly fans at the toe of the slope with uncertain reservoir quality. Zones 2 and 3 are largely covered with salt intrusions.

Structural

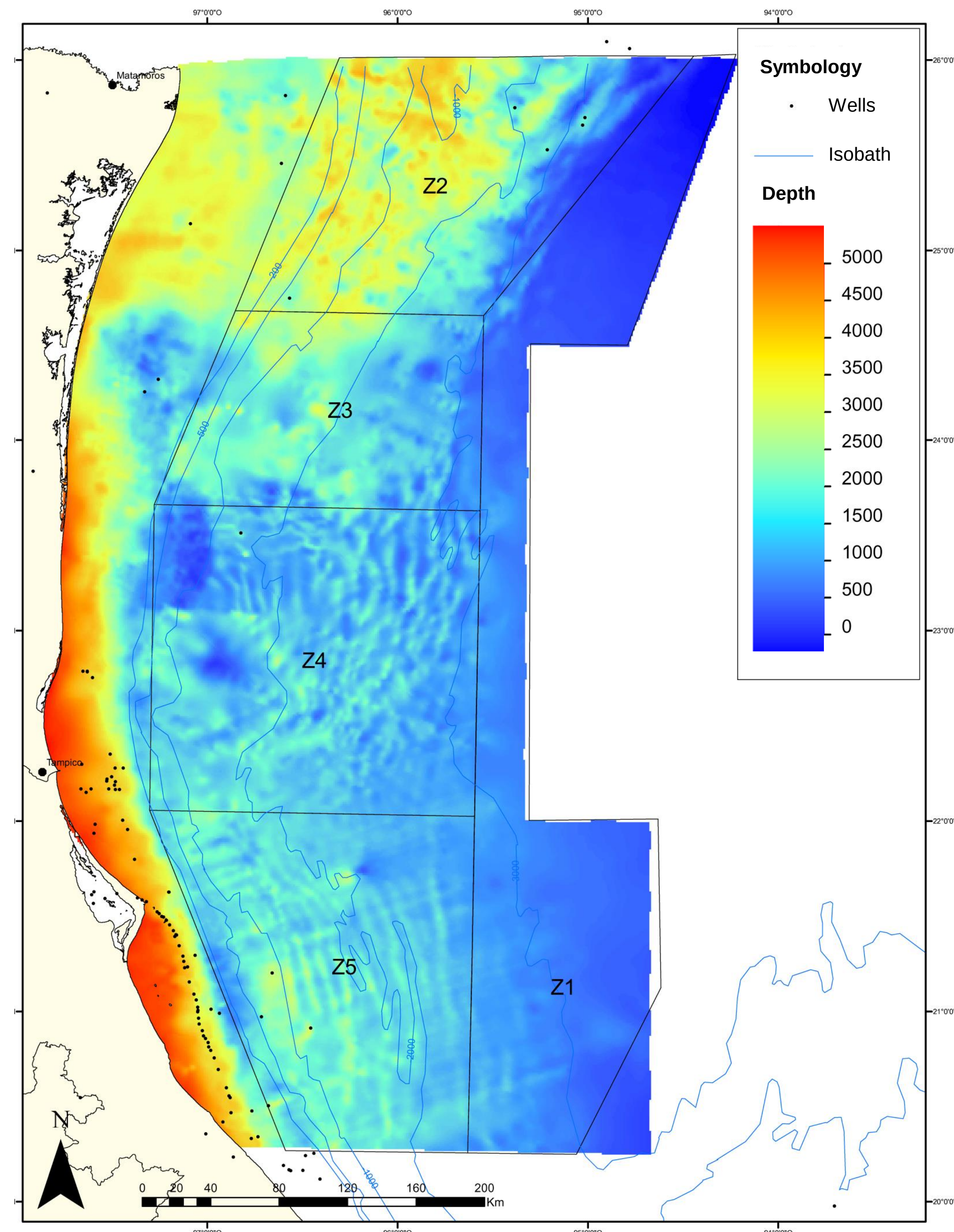
The Oligocene is at a depth range between 3,000 and 7,000 m. The maximum values of depth and burial are on the shoreline in the Burgos Basin and the transitional zone between shelf and slope, where submarine slides are located. In most of the areas 1-5 burial is included between 750 and 3,750 m with minimum values to the west of the Southern Continental Platform and in the structural highs of Perdido Fold Belt (locally 1,500 m of burial to east of Zone 2, 3,000-4,000 depth under the sea level).

Delimitation of *Plays* – Middle Miocene





Facies Map



Depth Map

Facies

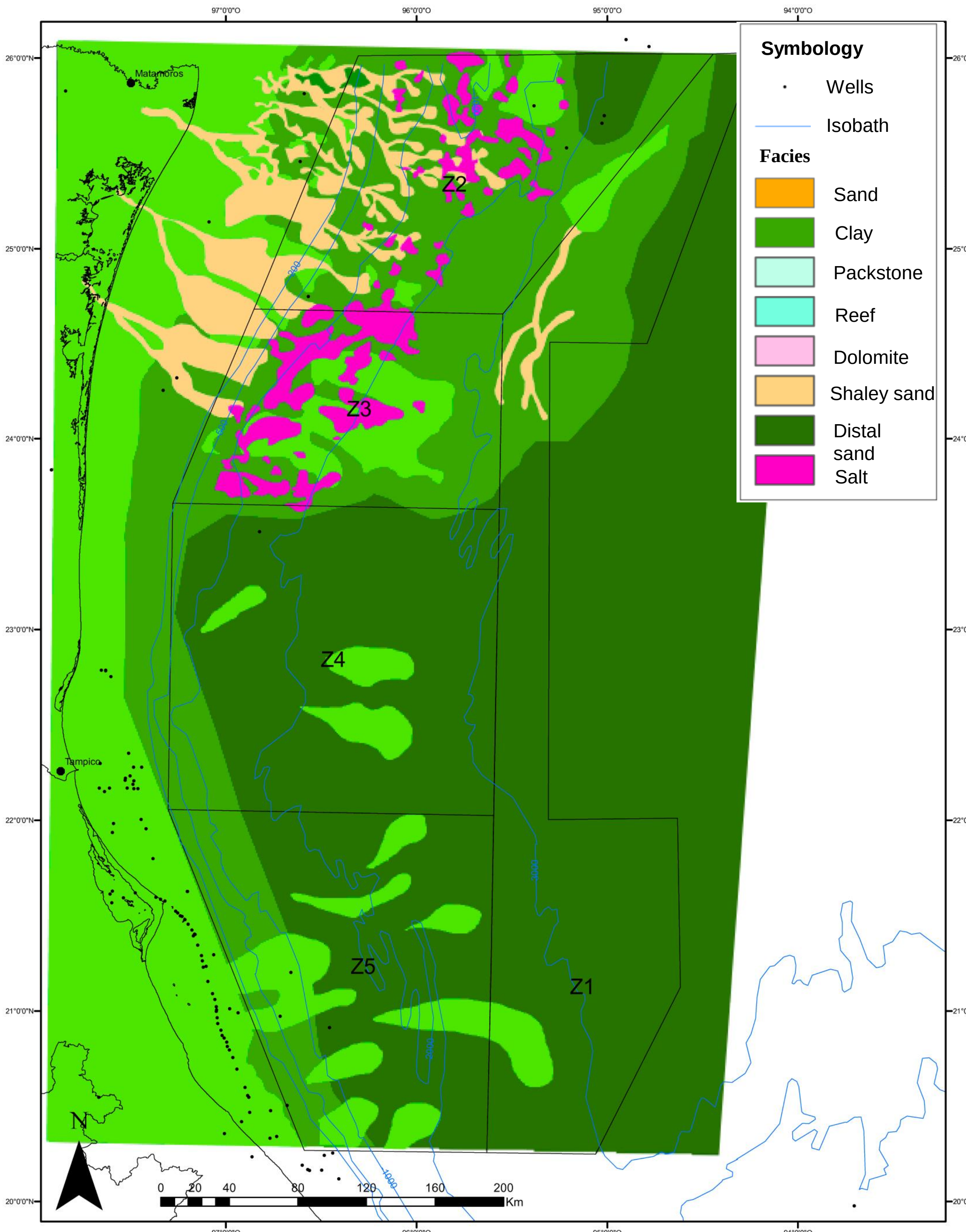
Best reservoir rocks may be found in the northern part of the study area (note: the reservoirs are interrupted by numerous salt intrusions). In the southern part, the reservoir rock quality is lower (in the proposed geological model), but the presence of large lobes are expected.

Structural

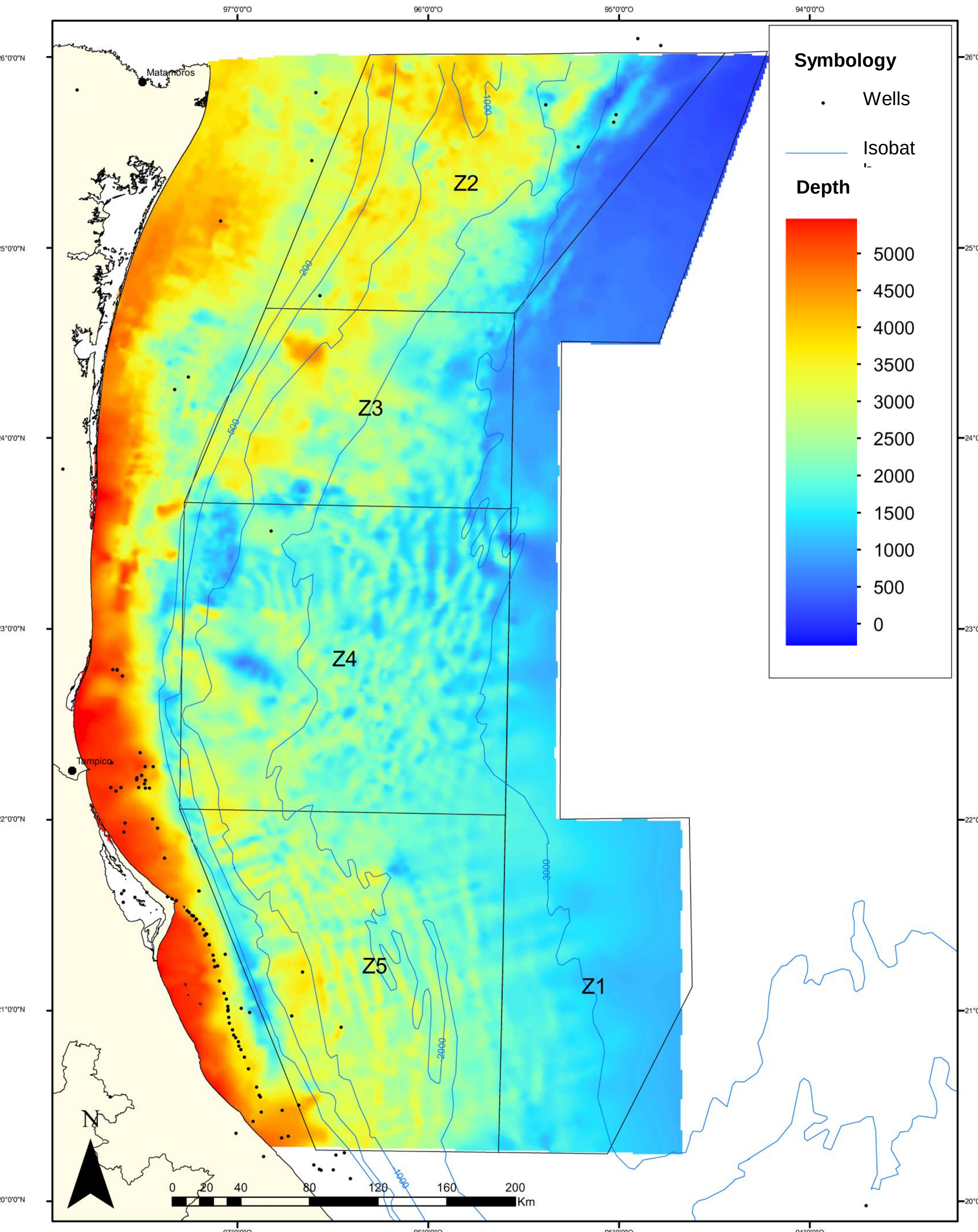
The depth of the Middle Miocene play varies from a few hundred meters at the southern Continental Shelf and of 5,000 m in the abyssal zone. In most of the slope area (Zone 2-5), the Middle Miocene play is in between 3,000 and 4,500 m depht and compressive structures in zones 3-5 are well recognized.

Throughout the entire area, burial rate is the lesser (less than 1,500 m), except where slides occurred (up to 4,500 m). In most of the Salina del Bravo and the Perdido Fold Belt (Zone 2), the burial rate is less than 750 m, which could limit the ability of preservation of hydrocarbon traps (seals may not be efficient enough to maintain an hydrocarbon column in place, particularly if gas is expected).

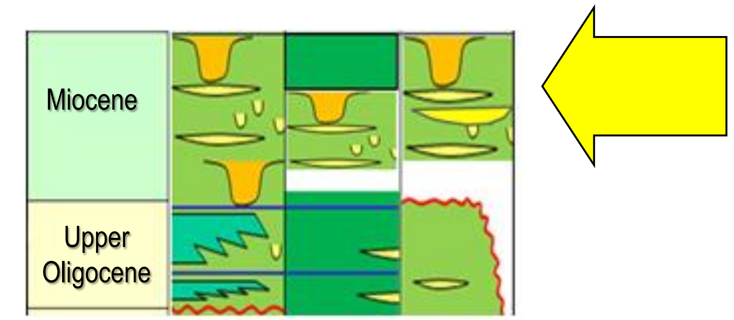
Delimitation of *Plays*– Upper Miocene



Facies Map



Depth Map



Facies

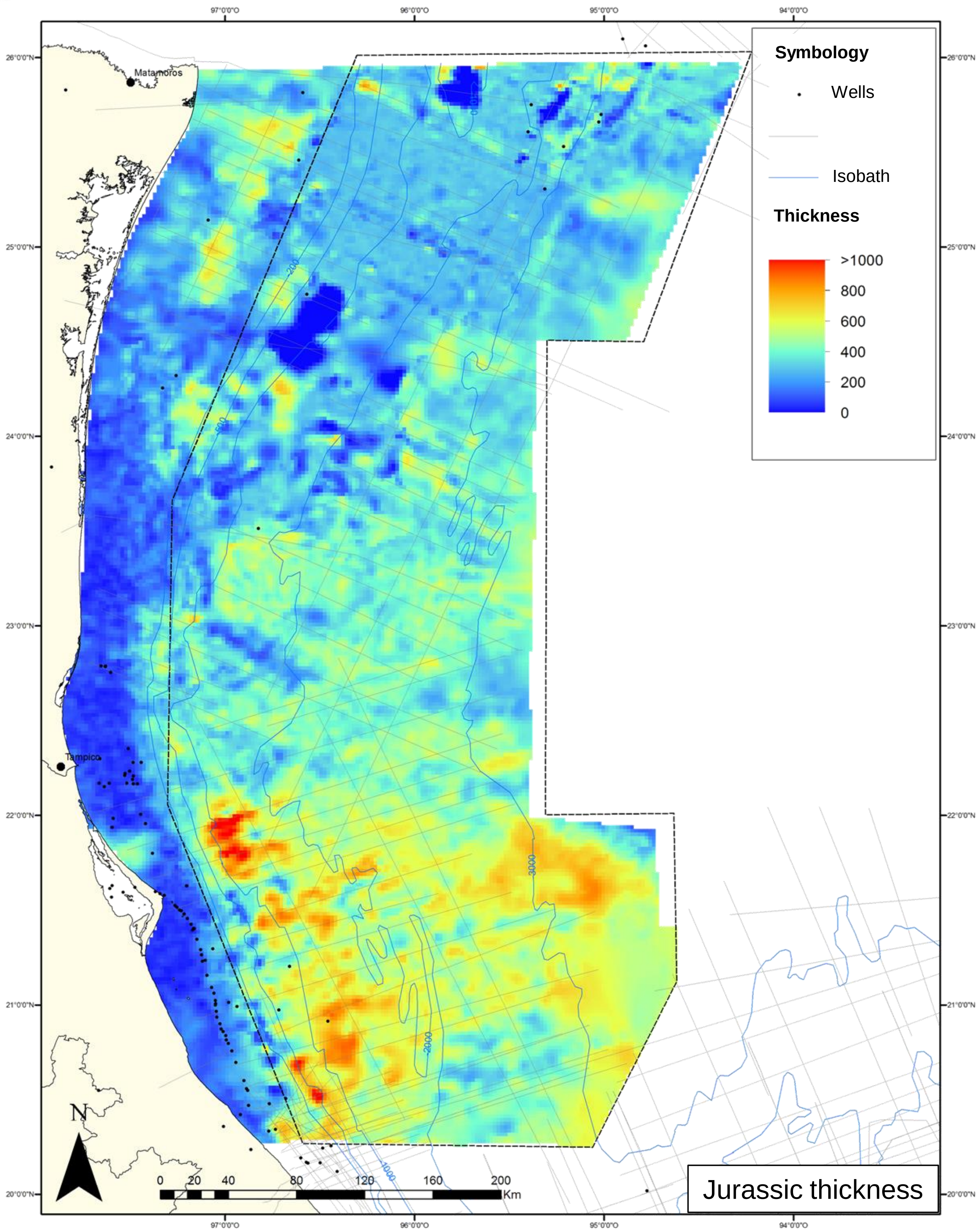
Best reservoir lithologies are inferred at the northern part of the study area, but reservoirs are small and are interrupted by the salt intrusions. The southern part has not good quality reservoir properties in the proposed geological model.

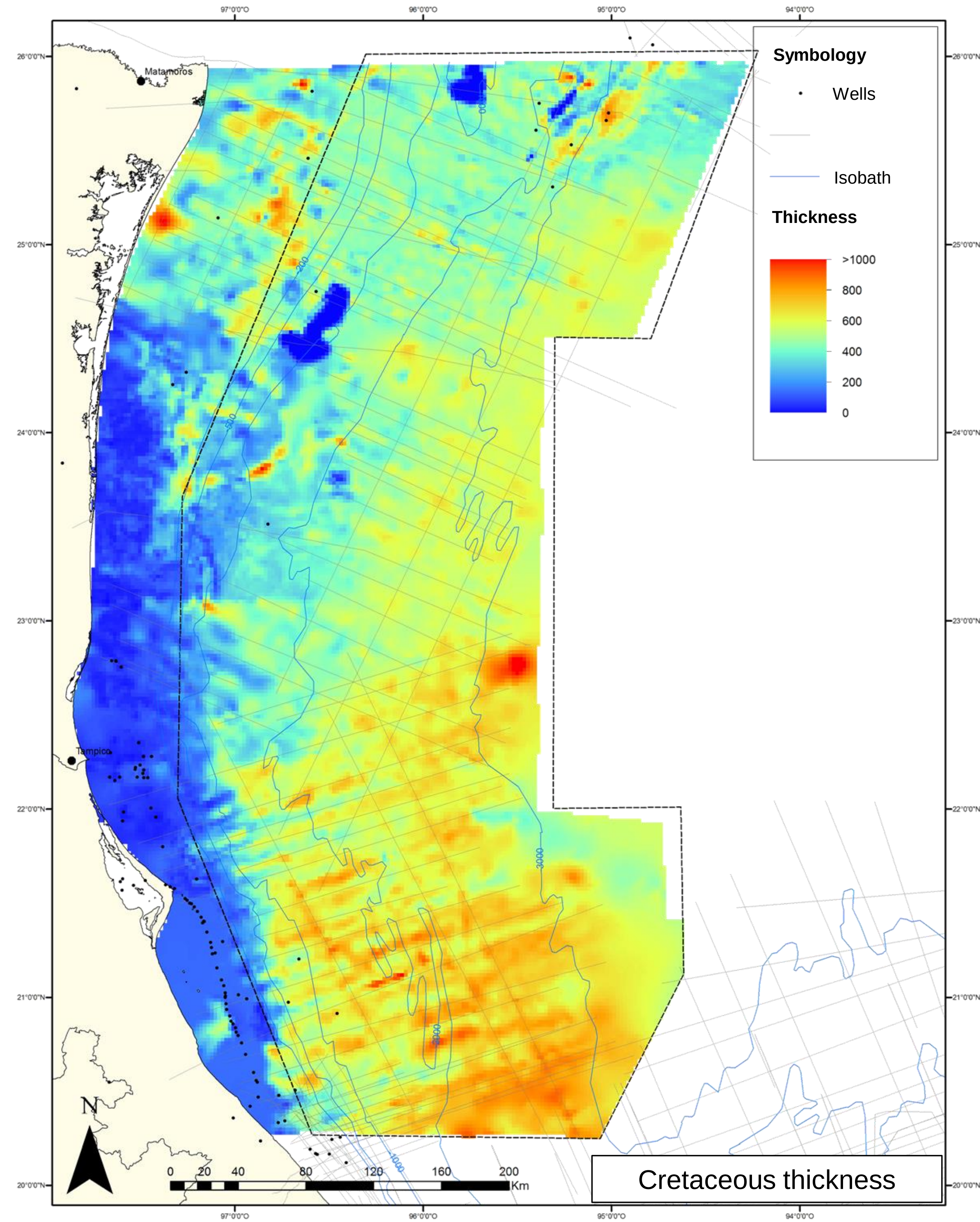
Structural

The Upper Miocene play depth ranges from a few hundred meters on the southern Continental Shelf and about 5,000 m at the abyssal zone. In most of the slope area (Zone 2-5), the Middle Miocene play is between 1,500 and 4,500 m depth.

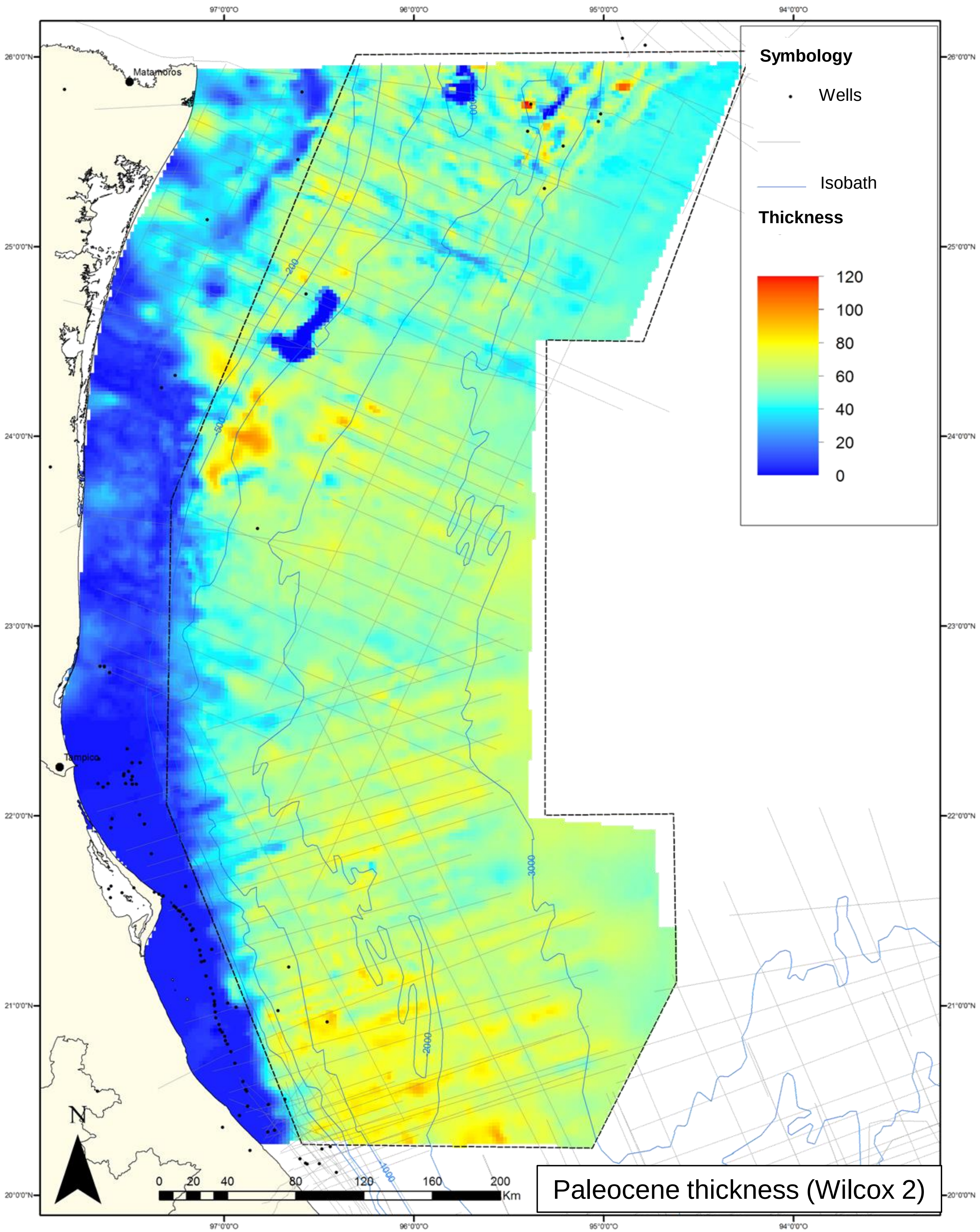
Throughout the entire area, the depth is relatively shallow (less than 1,500 m), except where slides occur (up to 3,500 m). In the most part of the Salina del Bravo, in the Perdido Fold Belt (Zone 2), and in the abyssal plain, the burial rate is less than 750 m, which could limit the ability of preservation of hydrocarbon traps (seals may not be efficient enough to maintain a hydrocarbon column in place, particularly if gas is expected).

Plays – Reservoir rock thickness (1)

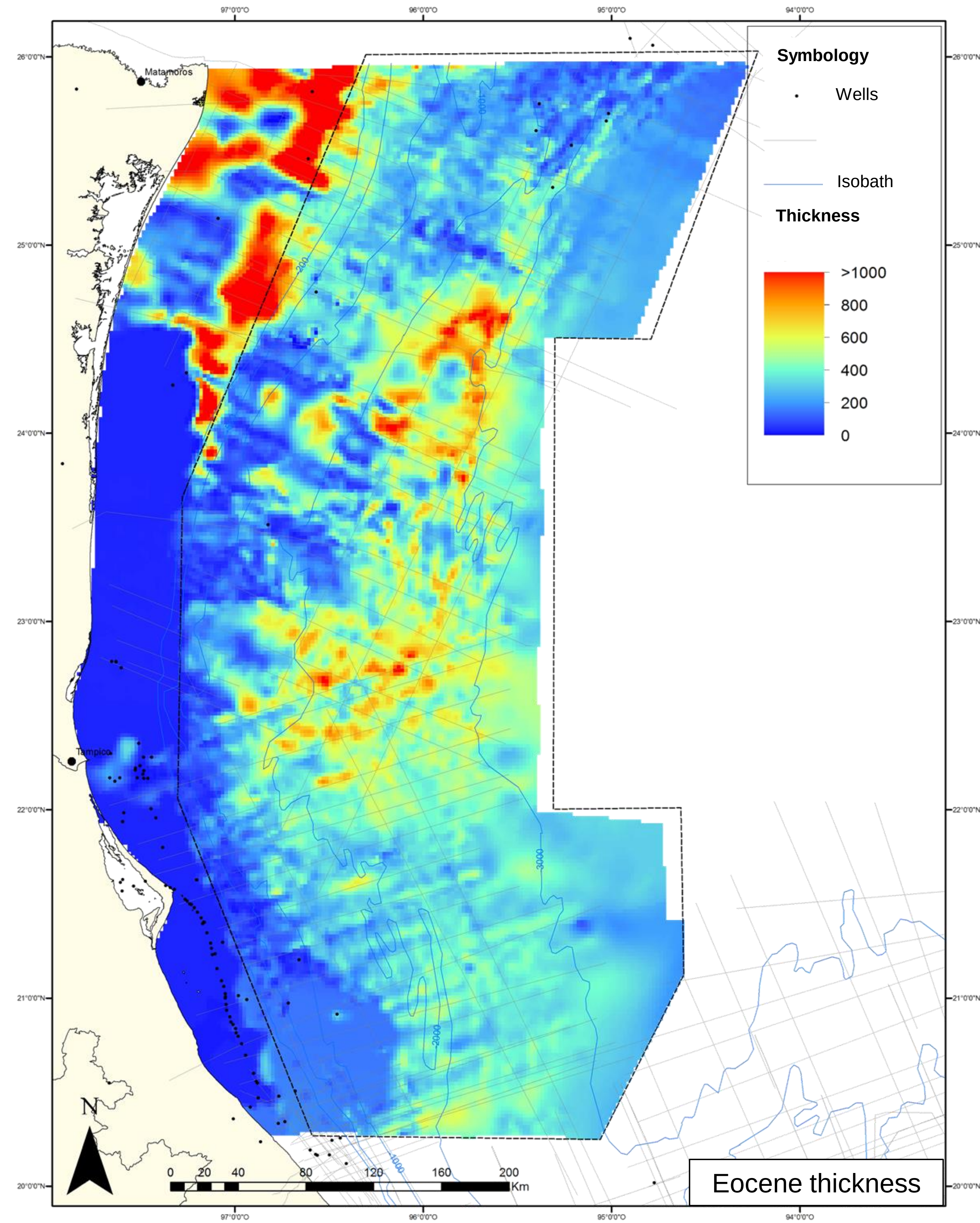




Plays – Reservoir rock thickness (2)

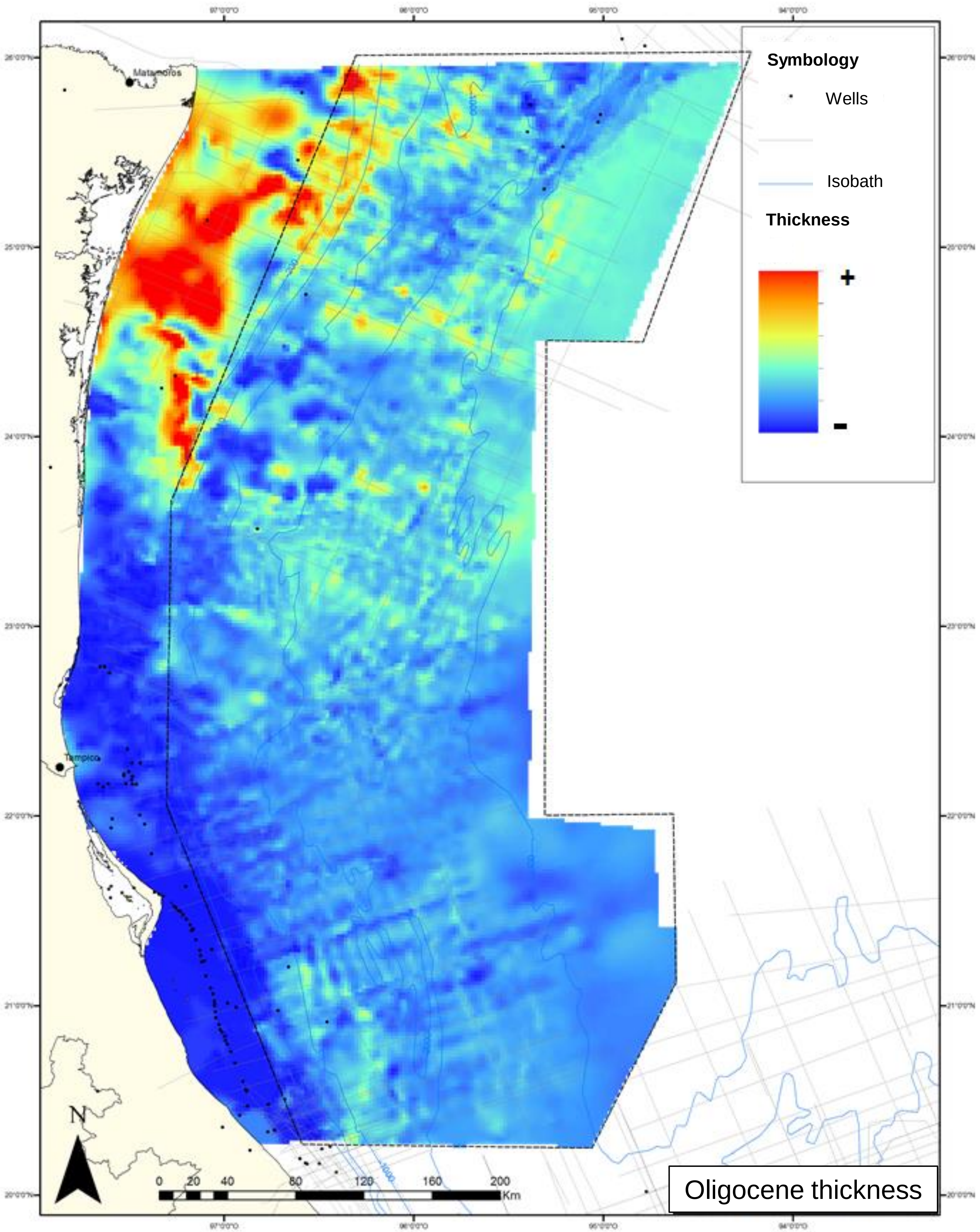


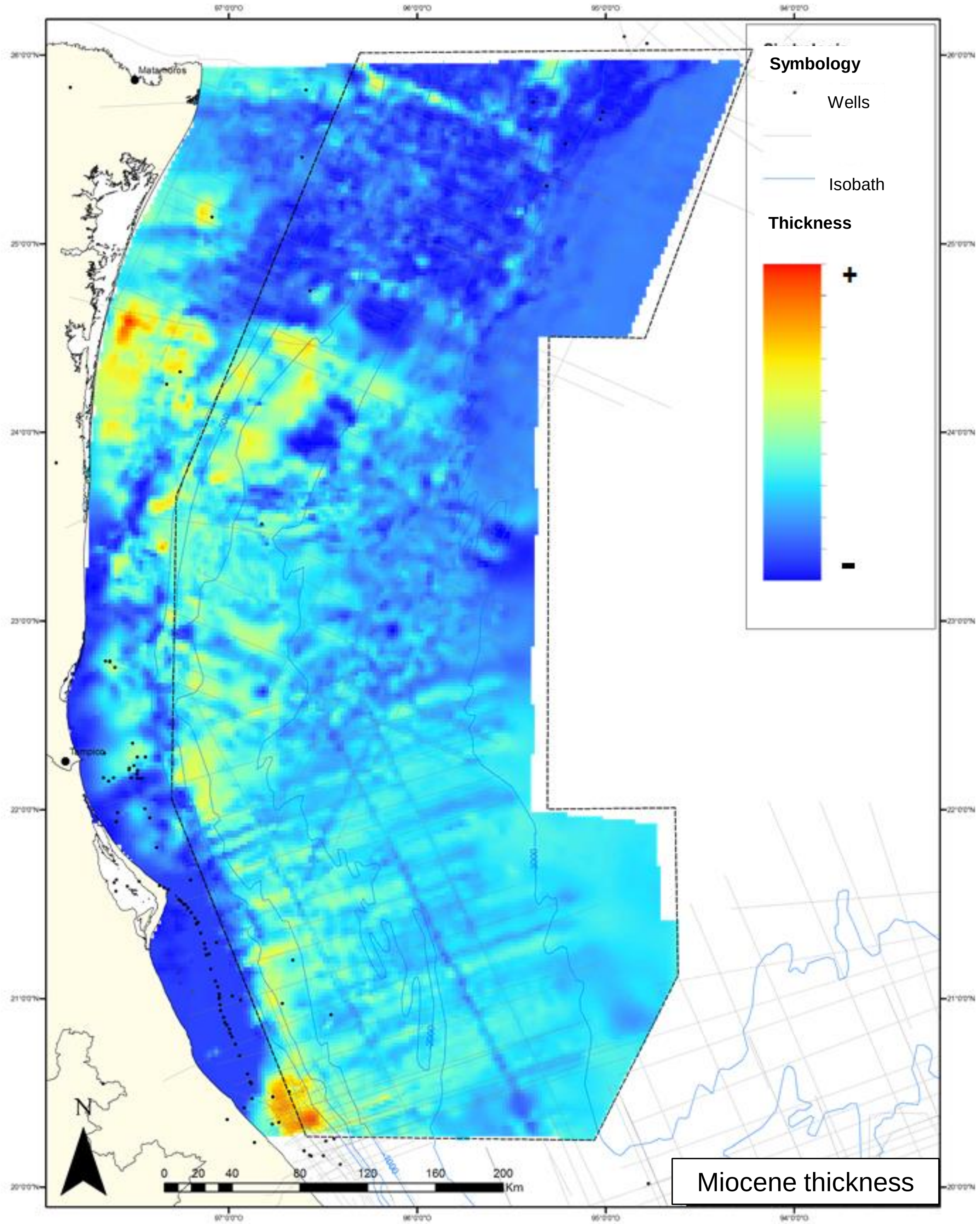
Paleocene thickness (Wilcox 2)



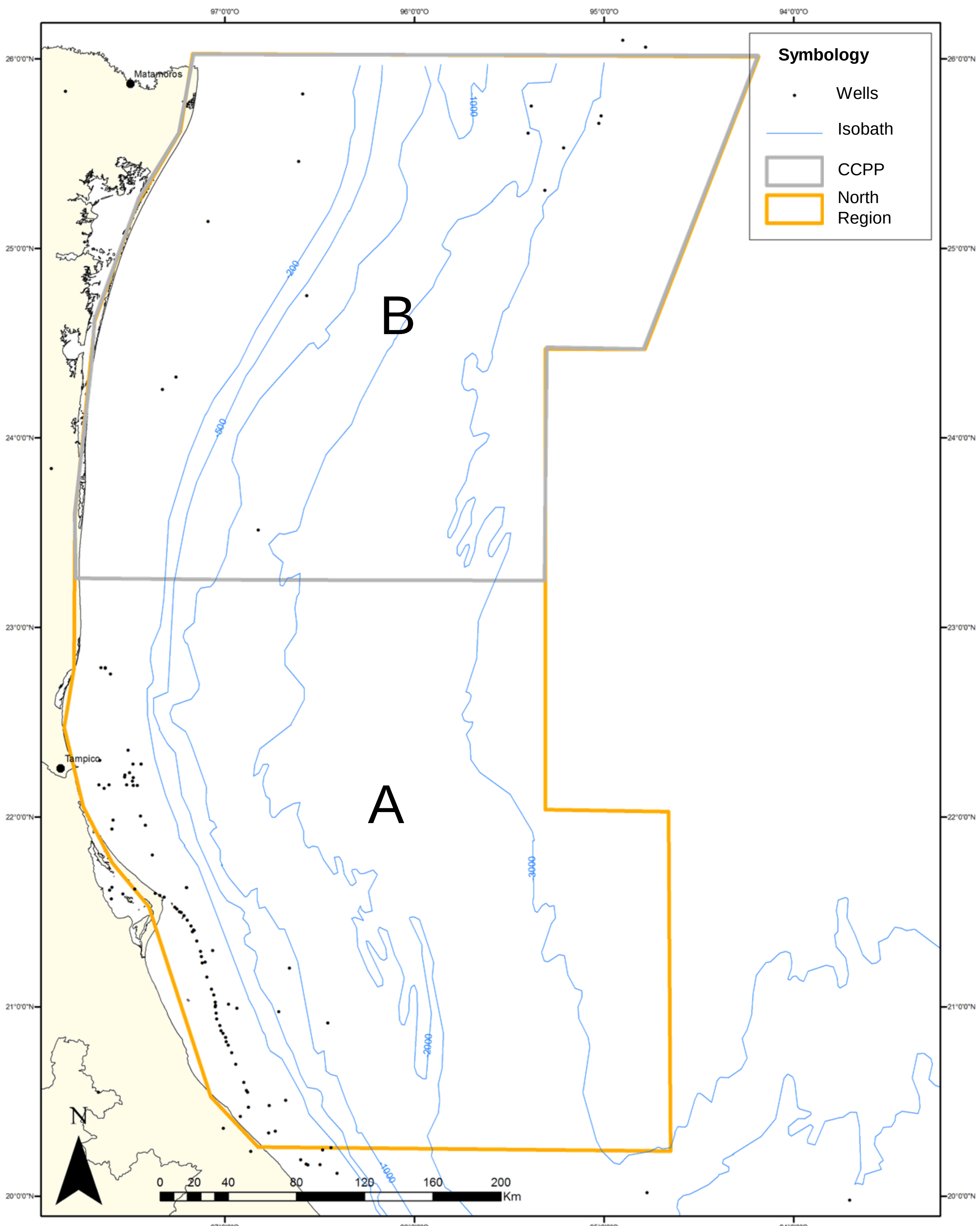
Eocene thickness

Plays – Total thickness (3)





Deep Water - Bibliography



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