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Direct Hydrocarbon Indicators and Structural Inversion in the South of the Macuspana Basin, an Addition for Hydrocarbons Search

Abstract

The interpretation of seismic 3D and regional lines, let us establish a geological structural inversion model in two events; first at Middle—Late Miocene and the second during Middle Pliocene-Early Pleistocene. The sedimentary package associated with this is mainly interpreted as marine to transitional in nature, being the marine sediments the best hydrocarbons reservoirs facies represented in the Hormiguero, Jose Colomo, Chilapilla, Cafeto, ernet, Fortuna Nacional and Shishito Fields.

Special seismic processing applications like AVO Acoustic Inversion, Frequency and Amplitude Attributes and DHI's are the support for new reservoirs discoveries, used as powerful tools in the exploration process and reservoir development to increase the probability of geological success.

In normal rollover systems, the sedimentary section thins and pinches out towards the top of the structure. However, in the case of structural inversion, the thicker portion and the best quality of the reservoir are usually found at the top, with four way closure presenting DHI's features. After drilling several wells, most cases resulted in the discovery of new hydrocarbon accumulations for example Lotatal-1, Vernet-601, Shishito-1, etc. Even so, there are other cases like Jose Colomo-1001 and Akaito-1, that during drilling and testing presented shows, pressure accumulation, but not enough; therefore not conclusive due to mechanical problems. As a result of the application of these techniques there are other opportunities being detected that are expected to become new reservoirs.

Geological Framework

Macuspana Tertiary Basin is located in Southeast Mexico, being part of the southeastern Province with an approximate 9,100 square kilometers, limited by the Yucatan Platform to the East, the Reforma-Akal Horst to the West, the Chiapas Mountains to the South and deep down in the Gulf of Mexico to the North. (Figure 1).

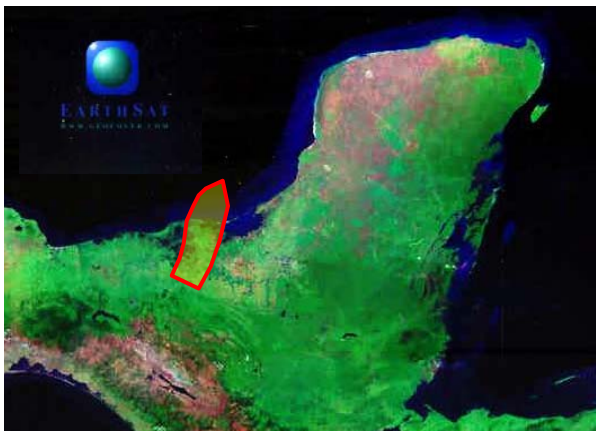

Figure 1.- Relative location of the Macuspana basin in the southern Gulf of Mexico

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Early - Middle Miocene was a period of carbonates deposition to the Southeast (Acachu and Tepetitan Fields) and thick shales alternating with thinner sandstones to the Northwest (Fortuna Nacional and Hormiguero Fields), in concurrence with listric and growth faults. The contractional event from the Chiapas Mountains at the end of the Middle Miocene was the main driving element for the structural inversion in the Macuspana Tertiary Basin.

In Late Miocene-Early Pliocene times there was a major sands supply associated with growth faults dipping to the Northwest, rollover structures (Jose Colomo, Chunel, Hormiguero, Vernet, Fortuna Nacional, and others fields) and concurrent shale evacuation in the same direction.

At the end of the Early Pliocene, a major transgression represents the end of the growing stage and leveled out sediments were deposited. Being the shales the best rock seals and sandstones the good reservoirs.

Finally, in the Late Pliocene-Pleistocene a thick sandstone package was deposited (Jose Colomo, Cafeto, Vernet and Shishito Fields), in the west side of the basin where a growth fault system generation dips to the southeast, the strata are pinching out over level out sediments and a reactivation phase of a shale mass is observed in the opposite direction. At the same time a new structural inversion is caused by basin contraction, as a result, the Late Miocene growth faults were reactivated in opposite direction creating tight, elongated anticlines, synclines, and pop up structures in the central part of the basin (Boca del Toro field).

As a summary, the structural evolution of the Central-South portion of the Macuspana Tertiary Basin during Neogene is considered as follows: 1).- expansion system (normal and growth faulting during the Early-Middle Miocene); 2).- structural inversion at the end of the Middle Miocene lower-Late Miocene highlighted by an unconformity at the end of this event; 3).- expansion system during Late Miocene-Early Pliocene with northwest dipping normal and growing faults; 4).- Peneplane stage at the end of Early Pliocene; 5).- Normal and growth faults generation in the northwest side of the basin dipping to the southeast and shale mass mobilization, structural inversion related to basin contraction, reactivation in the opposite direction of the Late Miocene growth faults, tight and elongated anticlines and synclines related to these faults and pop up structures and the most important, the best traps configuration for hydrocarbons reservoirs. (Table I).

Background

Several key references were used in order to lay down the central ideas discussed along this work, to support the fundamentals concepts as well as the glossary been used. The ideas presented by McClay (1992 and 2000) on how to differentiate structures.

This study was focused on the Neogene sequence where the Macuspana Tertiary Basin includes cumulative reserves in the order of 5200 MMMpcg. and Hormiguero, Jose Colomo, Chilapilla, Vernet, Fortuna Nacional, Chunel and Shishito fields represent 71% of the total basin reserves and are hosted in deltaic sands (originated from the highlands of the Chiapas Mountains), during the Late Miocene to Early Pliocene and were protected by thick seals except the Pleistocene reservoirs.

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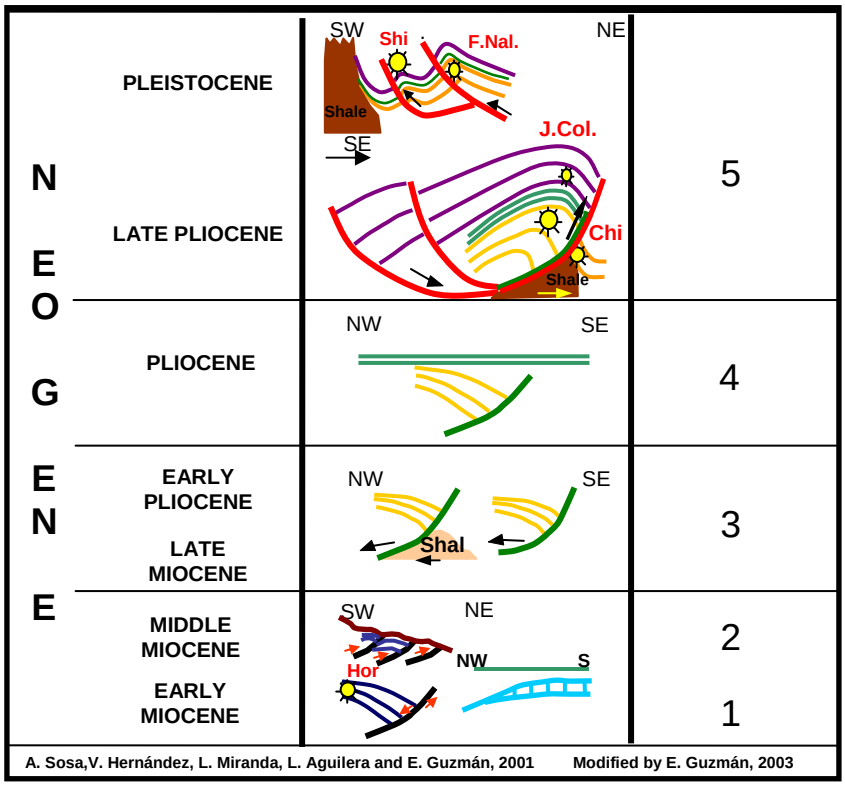

Table 1.- The Neogene Major events in the Macuspana Basin

The fields mentioned above are associated with SW-NE and NW-SE anticlines, related to tight, elongated, structures, always close to original listric or growing faults originated from a structural inversion. (Figure 2).

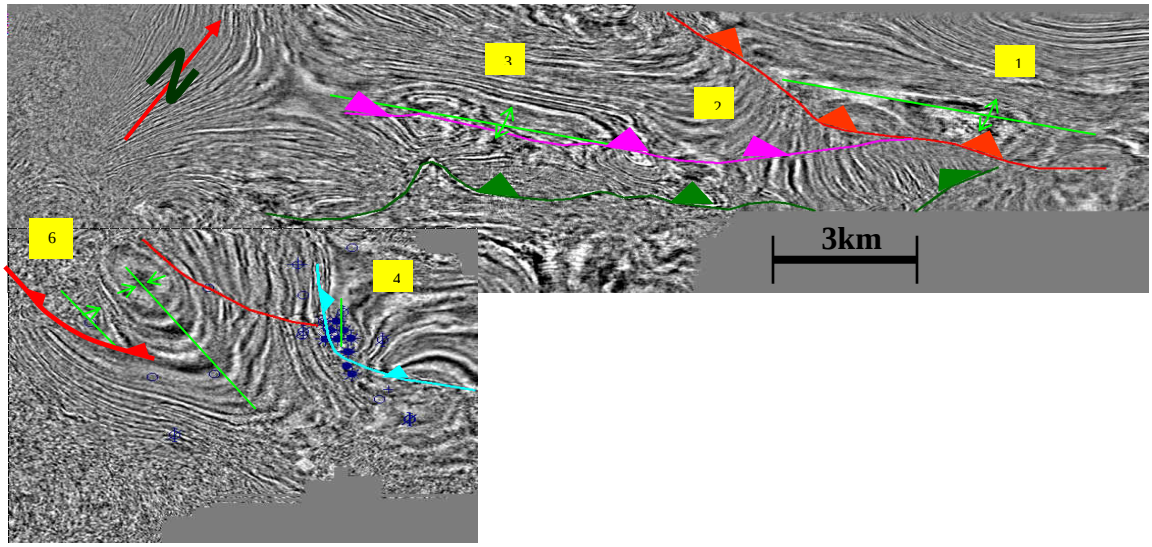

Figure 2.- Map View of the studied area(1. José Colomo, 2.Chilapilla, 3. Vernet, 4. Fortuna Nacional and 5. Shishito) on a Time slice at 1320 milliseconds.

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Paleontological data and Structural Geology were the key tools used in the interpretation of regional lines, geological columns and well logs. (Figure 4)
Special seismic processing for 3D seismic cubes like AVO, seismic inversion, amplitude attributes and DHI's were the fundamental tools used to support new discoveries, improving geological success for exploratory and developmental projects in order to increase_reserves.

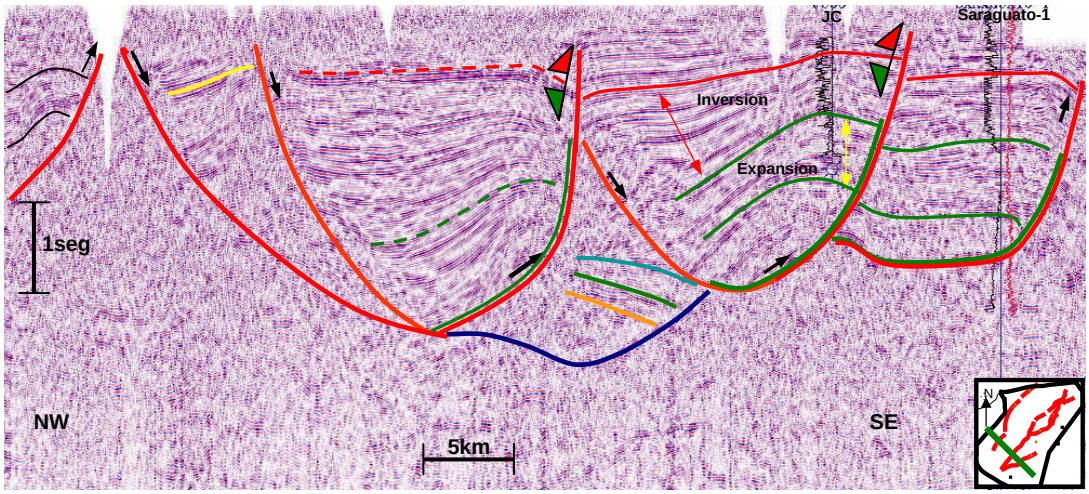

Figure 3.- Regional NW-SE seismic profile, across the the Jose Colomo Field and Saraguato well

Structural Interpretation of Fields

Jose Colomo.- Outlined as an elongated and moderately tight, full closure anticline with a low relief apex to the northwest where Bibiloni-1 well was drilled on. A major expansion of the Late Miocene- Lower Pliocene sequence show clear evidence of inversion due to compression, the inversion dating is also evident along this profile for the Upper Pliocene section (Figure 4) it is possible to appreciate DHI's in some reservoirs from 3D seismic.

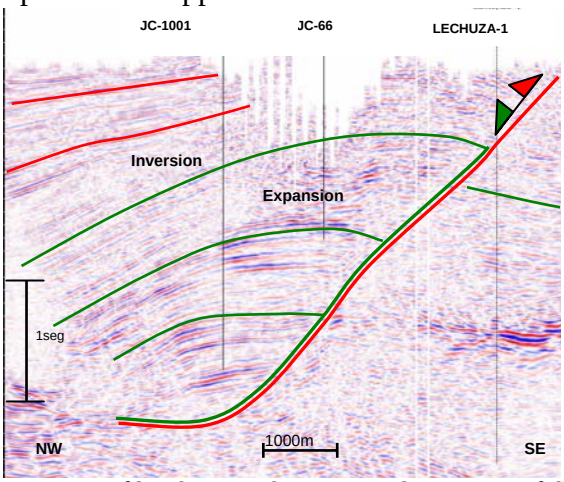

Figure 4.- NW-SE seismic profile, showing the structural inversion of the Jose Colomo field.

Chilapilla.- It is an anticline with two faults closure, between two inverted normal faults, the one on the east corresponds to the boundary with the Jose Colomo Field. The field is found along the extension of a growth fault marginally inverted because the fault plane is

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subparrallel to the compressional stresses, resulting in a very subtle inversion. In this trap style the Production is either coming from the Chilapilla foot-wall or the Jose Colomo hanging-wall. The hydrocarbon column is close to 800 meters; other areas with similar characteristics are potential exploratory targets.

Fortuna Nacional.- A small, narrow NW-SE oriented anticline, with closure in four directions. It is severely compartmentalized by secondary faults. This structure was formed oblique to the Late Miocene-Early Pliocene original listric fault trend, reflecting a listric growth in the NW-SE direction in contrast to NE-SW projection where only shortening by structural conversion is being observed. The four reservoirs of this field show DHI's and AVO. From this evidence it has been considered necessary to apply acoustic inversion as a current practice for all new exploratory targets (Figures 6).

Shishito- The most recently discovered as a small tight and elongated inverted structure associated to the NW-SE trend developed during Plio-Pleistocene times; an unusual case with seven stacked reservoirs were identified by DHÍ's on 3D seismic (Figure 6).

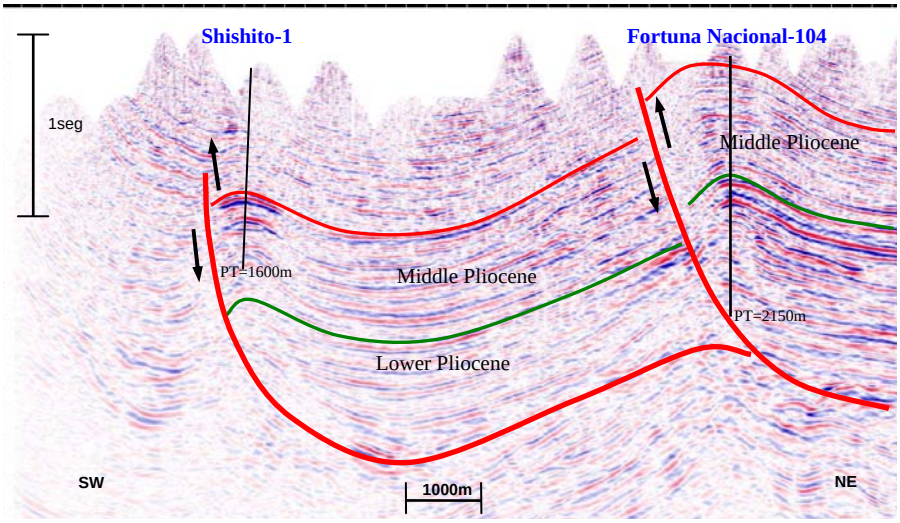

Figure 6.- SW-NE seismic profile, showing the Shishito and Fortuna Nacional structures

New Prospects.- Recent 3D seismic from the Zopo-Medellin area has been interpreted and new targets have been identified in the surroundings of the Macuspana and Sarlat fields. The methodology shown here was extended to the area where the same structural trends NW-SE oriented and they also seem to be related to the Plio-Pleistocene inversion event with evident DHÍ's features.

Conclusions

- Most of the traps in Macuspana Tertiary Basin were originated from a structural control where Vernet, Cafeto, , Chilapilla and Jose Colomo Fields belong to the SW-NE anticlines trends, and Fortuna Nacional, Shishito and Macuspana Fields are of NW-SE orientation.

- Only structures aligned along the SW-NE trend are developed from rollovers.

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- Early-Middle Miocene and Late Miocene-Early Pliocene growth faults are commonly inverted. These structural trends are controlled by inversion due to the basin contraction.

- Anticlines related to structural inversion are as follow: 1),- are found close to the original growth faults, 2).- commonly defined by tight and elongated shapes, 3).- associated with synthetic and antithetic faults, 4).- requiring multiple vertical or deviated wells for their exploitation due to the considerable dip of the axial plane.

- The growth faults influenced the deltaic sand body deposition and the structural inversion regulated the migration pathways and played a major control as they were evolving to their present day configuration for the Macuspana traps

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Key References

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