New Exploration Traps in the Espino Graben, Eastern Venezuela Basin*

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Abstract

The Espino Graben has an area of 50,000 Km², its axis has a N60°E direction. The Pre-Cretaceous sedimentary thickness exceeds 20,000 feet, practically all of which remains unexplored. Eight sequences were defined between basement and the Cretaceous-Jurassic unconformity. The sequences included lacustrine deposits that generate good seals and source rocks (Solorzano et al., 2001). This graben was formed during the Jurassic rifting, produced by the separation of the North and South American plates. The work focused on the Pre-Cretaceous also allowed the delineation of Cretaceous-Neogene structures along the main faults that formed the shoulders and other related faults. In these prospective alignments already are important oilfields that need to be extended.

Most interpretations made in the area were concentrated in the producing Cretaceous and Tertiary formations; however, in Venezuela the Pre-Cretaceous sedimentary rocks have been poorly studied. New 2D3C and 3D seismic surveys have very good resolution. Stratigraphic seismic sequence analysis was used to define the Pre-Cretaceous sequences. Paleozoic sediments have not been drilled in the graben, but probably they are present considering that the Cambrian rocks are found outside the graben, deposited under tidal influence (Solorzano et al., 2001). The Jurassic deposits have mostly a fluvial origin, with some indications of marine influence indicating that the Espino Graben was frequently connected to the open sea.

The study accurately determined structure of the graben interpreted as intense block faulting and inversion structures. The bounding faults of the graben have great extension and slip, however they are not continuous; this discontinuity is associated with important transfer zones that generate positive structures and depocenters with lacustrine deposits which favor the prospectivity of the area. The
graben has been reactivated on several occasions, producing three types of structures: rotated blocks, transfer zone and roll over, evidenced by the propagation of faults at different levels during the Cretaceous-Oligocene and Miocene.

The Espino Graben represents one of the most important exploration opportunities in the country and according to the economic evaluation, the expectations associated with the six structural traps are significant.

Selected References

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NEW EXPLORATION TRAPS IN THE ESPINO GRABEN. EASTERN VENEZUELA BASIN.

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Notes by Presenter:

• Ladies and gentleman Good afternoon and welcome to the oral presentation.
• First of all, I’m going to talk about: New Exploration traps in the Espino Graben. Eastern Venezuela Basin.
The presentation will be developed through these seven points.
THE MAIN GOAL

SEARCHING FOR NEW STRUCTURAL TRAPS IN ESPINO GRABEN, BELOW THE TRADITIONAL ORINOCO HEAVY OIL BELT (THE BIGGEST OIL RESERVES IN THE WORLD)
The Espino Graben is a structural depression located in the middle part of Venezuela, between Guárico and Anzoátegui states. It is bounded on the south by the Orinoco Heavy Oil Belt, on the north by the Cordillera de la Costa, on the west by El arco Baul, on the east by the Urica Fault. This graben was formed during Jurassic rifting, produced by the separation of the North and South American plates. Total area is approximately 40,000 km². Its axis has a N60°E direction.
For the accomplishment of the objectives of this study we executed the following activities:
This diagram to represent the methodology of this work.

- A review of the previous studies
- Data Source

2. Processes
3. Results
Considering that all process were developed with a synergy between all disciplines involved.
Notes by Presenter:
Seismic
On the other hand, here it showed the available data and project area:
• The 2D seismic data to be used in the interpretation covers an area of 15,000 Km.
• Additionally, we have the following 3D seismic surveys, but we only used it for the calibration with the F Well.

Well
• 28 wells were used. The selection was based on the quality of log data, total depth, picks (well tops), logs quality and regional location.
• The objectives of this study is only to focus on the middle part of the graben, where the structural prospects are concentrated and the Pre-Cretaceous sediment exceeds 20,000 feet, practically all of which unexplored.
Notes by Presenter:

• This image shows how along the main faults that formed the shoulder of the Espino Graben there are important oil fields that need to be extended in deeper sequences.
• Important example is The Boyacá block. It contains significant deposits with certified reserves of 41.6 Billion oil, in the Orinoco heavy oil belt.
• Most interpretations made in the area were concentrated in the producing Cretaceous and Neogene, for this reason we can see all these oil fields, but this work is focused on the Pre-Cretaceous.

• One interesting question from the stratigraphic perspective is why are we exploring in the Pre-Cretaceous?
• The main reason is that the sedimentary thickness exceeds 20,000 feet, practically all of which remains unexplored. Actually we have new seismic information on the south part with very good resolution and well information on the north (drilled in 2007). All these clues help us to understood better the tectonics and sedimentary processes in the area.
Notes by Presenter:

Here we have the stratigraphic chart used in this work. Can see the formations deposited during different phases in the Guárico Subbasin.

**Prerift state:** Is characterized by Paleozoic deposits. At this moment with the well information we can determined only the Cambrian period and it is represented by two formations: Hato Viejo and Carrizal. It is important to noticed that for this state not only we have rift fill, previous sedimentary sections can be preserved. Almost no subsidence.
Notes by Presenter:

**Synrift state:** Is characterized by the Jurassic. At this moment with the well information we can determined only the Jurassic period. The lithology corresponded to Ipire Formation.
- Jurassic sediment shows a dramatic growing toward graben axis.
- The stage is characterized by strong subsidence.

**Passive Margin:** Rests unconformably upon the Synrift sediments and it is characterized by the Canoa Formation and Templador Group.
**Active Margin and foredeep Maturín sub-basin** are characterized by oblique collision of the Caribbean Plate.

The integration between stratigraphy with seismic information helps to determined 2nd and 3rd sequences.
Notes by Presenter:

The well correlation stage started interpreting the 2nd and 3rd order sequences, which were previously defined in the sequential analysis. The stratigraphic sections were created in different directions, in order to see the lateral and vertical variations of the different units.
Notes by Presenter:
This slice shows the location of the seismic profiles in the Espino Graben: three in North-South direction and one West-East direction.
Notes by Presenter:

This seismic profile shows structural configuration of the graben in the south part. It is slightly symmetrical. The seismic profile is bounded or restricted by Machete and Altamira faults, grew in the same time. The middle part shows the development of internal faults with small slip. In the south part, the sediment thickness decreases. The most important characteristics are the stacking patterns finning upward. Onlap and Toplap that defined the regional unconformity “Pre-Cretaceous”.

In general, the seismic profile shows a lot of reflection terminations that defined configurations of stratigraphic sequences.
Notes by Presenter:

• This seismic profile is located in the middle part of the Graben and it is restricted by Ruiz Saban and Anibal faults.
• The faults are more active in this area. The activity period is younger, for this reason the thickness is relatively higher in the upper sequences.
• The bounding faults of the graben have a great extension and slip.
• We can see here that the graben has been reactived during several occasions: Jurassic, Cretaceous and Neogene.
• The Well C is important because it drilled a big Jurassic section and drilled alkali basalt (approximately 300 feet), this is unique evidence of volcanic activity in the area.
• According to Motiscka (1985) this basalt was lava flows and not sills, because in the upper sediment was not found thermal changes.
• The erosional truncation and toplap help to determined the big unconformity in the area, as well as sequences boundary.
Notes by Presenter:

- This seismic profile is located in the north part of the Graben.
- It is limited by Guama Saban and Anibal faults. Both of them grew at the same time and continuously.
- On the limited of the fault we recognized aggradation and progradation.
- On the north part, depressions are observed and show the development of internal faults with little slip.
- On the south, three structural highs were interpreted.
• The last cross section is along the axis of the graben.
• The most important thing here is how the sequences are defined by onlap, top lap, and toward the western and northeastern limits show how the truncations eliminated all Jurassic sequences.
Notes by Presenter:

• This 3D view summarizes the architecture of the graben.
• Paleozoic: is characterized by extensional event. (Initial faulting)
• Jurassic: is characterized by extensional, here increase the subsidence and activities in the bounding faults, in other words Morphology development and filling of the Graben.
• Cretaceous: is characterized by regional subsidence.
Notes by Presenter:

Transfer zones and depocenters were formed during the rifting period, which produces these highs and lows that are important as origins of sediments and sources rock lakes.

- **Paleozoic Era**
The analysis of cores and cuttings shows that the sediments in the south are of a continental environment, and towards the north are inner to external neritic.

- **Jurassic Period**
  Only few wells have drilled the upper part of the Jurassic, all of them found continental sediments. However, the underlying sequences have not been drilled.

According to Antenor Aleman (2007) the **Well F** found icnofossils, such as paleophycus, that indicate a probable marine origin, bioturbations and also rounded grains. These are indications of some marine incursions into the Graben.
Notes by Presenter:

• The slide shows the structural traps identified in this work: anticline, transfer zones and rotated blocks.
• The intense normal faulting allows the trap formation, for example this area has intense faulting in the Jurassic sequences.
• The major faults affect the Pre-Cretaceous sequences, some of them were reactivated.
Notes by Presenter:

• Here we have other traps.

• The upper section of the Jurassic has, in general, low porosity; however it has been noticed the sonic velocities decrease with depth which indicate better porosity. At depths more than 20,000 feet the porosity could improve do to fracturing.
Notes by Presenter:

• I want to show this slide, because it illustrates the trap associated with the important Well F, drilled in 2007.
• The interval 18,167-20,001 feet at the bottom of the hole showed gas including C5 in the possible Paleozoic, but it was not tested due to mechanical problems.
• The Paleozoic is questionable.
• This well opened an excellent opportunity to know the prospectivity in the graben, because it showed Diamonddoïdes and indigenous gas that indicate a possible petroleum system.
• The result of this study will be considered for further exploration.
CONCLUSIONS

- Using sequence seismic stratigraphic analysis prospective structures in the Espino Graben that present intense block faulting and inversion zones were determined.

- The graben was reactivated in several periods producing different types of traps like: anticlines, rotated blocks and truncations.

- The graben structure has influence in Neogene and Paleogene formations related to important hydrocarbon fields.

- Transfer zones generate positive structures and depocenters with possible lacustrine deposits that favor the prospectivity of the area.