Petroleum System Modeling Implications in a Prospect Geological Risk, Western Interior Range, Venezuela*

Linda Montilla¹, Migdalys Salazar³, Solanyer Rojas², and Angel Gonzalez²

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1Exploration, PDVSA, S.A., Puerto La Cruz, Anzoategui, Venezuela (montillalp@pdvsa.com)
2Exploration, PDVSA, S.A., Puerto La Cruz, Venezuela
3Jackson School of Geosciences, Austin, TX

Abstract

The present report is an appropriated example of petroleum system modeling in exploratory frontier areas, to study an attractive prospect of 200 km² located in the western end of the Interior Range, close to the productive fields (Quiamare and Anaco). The risk for timing between the hydrocarbon expulsion and formation of the trap histories has been interpreted using 1-D model analysis. In this opportunity 3-D petroleum system modeling was used to provide a low risk prediction prospect model.

The structural and forward modeling allowed to determine the high risk of timing taking into account the following aspects: 1- The structure was formed after 16 Ma (Middle Miocene), 2- The thermal maturity level for the Cretaceous source rock has been inferred as high (>2%) in present expulsion area, by geodynamic and geochemical interpretation, and 3- The previous 1-D model shows that the maximum expulsion peak from Cretaceous source rock was close to 20 Ma.

Several calibrations performed using subsurface and outcrop data (BHT, %Ro, porosity, hydrocarbon saturation levels in known areas) provide reliability in this 3-D model. The results show, that the trap was 70% thrusted at 15.0 Ma and the maximum expulsion phase of generated hydrocarbon from the Cretaceous source rock occurred between 16.0 and 11.8 Ma.

Due to the understanding of spatial and time evolution of the source kitchen area and the relevance of 3-D Petroleum System Modeling, the geological risk in the prospect was assumed considerable lower than the one interpreted from 1-D model.
References


Olivares C., 2005, Propuesta de inversión de perforación prospecto Capairicual A Petróleos de Venezuela, Informe interno.


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**ABSTRACT**

**METHODOLOGY**

**HYPOTHESIS**

**DATA**

**GEOL]C MODEL**

**CALIBRATION DATA**

**THERMAL MODEL**

**GEONEED AND EXPLOSION MODEL**

**GEOSTRATIGRAPHIC CHART**

**STUDY AREA**

**CRONOSTRATIGRAPHIC CHART**

**WORKING HYPOTHESIS**

**PETROLEUM SYSTEM ANALYSIS**

**KINEMATIC MODELING**

**STRUCTURAL MODEL**

Seismic cross-section showing the structural interpretation. The prospect area is interpreted as an anticline that was formed due to compression, structural inversion of Jurassic normal faults and thrusting (Alloctonous block). Southern part of the area is characterized by subtle compressive structures associated with giant light oil discoveries.

**LOCATION MAP:** showing cross-section, area of 3D model and well data available.

**PREVIOUS STUDIES:** During 2000 to 2003, two different exploration teams studied the area, after performing 1D and 2D (North – South) modeling. Both concluded that the prospect had high geological risk, for Cretaceous source rock charge, due to lack of synchronization between HC’s expulsion and trap formation.

**LOCATION MAP:** showing cross-section, area of 3D model and well data available.

**CALIBRATION DATA** (%Ro, BHT, DST)

Barinas Basin

Cerro Grande Fault

Urica Fault System

Seismic Cross-section showing the structural interpretation. The prospect area is interpreted as an anticline that was formed due to compression, structural inversion of Jurassic normal faults and thrusting (Alloctonous block). Southern part of the area is characterized by subtle compressive structures associated with giant light oil discoveries.
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**GEOCHEMICAL MODEL**
- Thermal maturity (%) of Querecual Formation
- Streamlines of temperature (°C)
- Streamlines of thermal maturity (%Ro)
- Streamlines of maturation (%Ro)
- Streamlines of generation rate (%Ro)

**THERMAL MODEL**
- The present Heat flow: 35 y 42 mW/m²
- Thermal maturity map (%Ro) of Querecual Formation
- Temperature (°C)

**2D MODELING**
- 3D Modeling
- 2D Modeling
- 1D Calibration data using vitrinite reflectance (%Ro) and borehole temperatures showing good match between theoretical and measured data

**GENERATION AND EXPULSION MODEL**
- Chart composite showing: Transformation rate, thermal maturity, generation and expulsion history charts in two different positions of the basin, each point corresponds with the deepest location on each cross-section.
- Point A: Showed at 15 Ma (70% kerogen formation) Cretaceous SR maturity level is 1.2% Ro and 70% Transformation rate
- Point B: Showed at 15 Ma (70% kerogen formation) Cretaceous SR maturity level is 0.7% Ro and 70% Transformation rate
- The two points modeled have different thermal history and evolution, obviously because the difference in the geographic location related to the “kitchen” area. They are affected by different subsidence, tectonic and sedimentation rates. The later supported the 3D modeling to better understand expulsion and migration pathways.

**3D MODELING**
- Cretaceous Source Rock Maturity Level
- Transformation Rate (%Ro)

2D Model portrays evolution of Cretaceous source rock from 21 Ma to Present day, showing kitchen and drainage area evolution related to prospect and field (control point) location within the study area.
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**GEOLOGICAL RISK ANALYSIS**

<table>
<thead>
<tr>
<th>FACTORS</th>
<th>SCALE</th>
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<tr>
<td>Closure volume</td>
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<td>Seal</td>
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<tr>
<td>Trap</td>
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<tr>
<td>Lateral</td>
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<tr>
<td>Timing</td>
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<td>TOTAL</td>
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<table>
<thead>
<tr>
<th>FACTORS</th>
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<tbody>
<tr>
<td>Adequate reservoir thickness</td>
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<td>Porosity</td>
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<td>Permeability, Continuity</td>
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<tr>
<td>Maturation (adequate time, temperature, pressure)</td>
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<tr>
<td>Migration (adequate time, temperature, pressure)</td>
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<td>TOTAL</td>
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<td>Preservation (biodegradation, no bad flushing)</td>
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<tr>
<td>HC's Quality and concentration</td>
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<tr>
<td>Recovery (drive, Pressure, depth)</td>
<td>1.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1.00</td>
</tr>
</tbody>
</table>

PROBABILITY OF SUCCESS NARCUAL Fm. 0.33

**GEOLOGICAL RISK** 0.67

**REFERENCES**


**ACKNOWLEDGEMENTS**

- The authors wish to acknowledge Petróleos de Venezuela, S.A. (PDVSA) who supported and permitted publication of this work.

**CONCLUSIONS**

- The results of the kinematic model suggest that prospect’s structure is 70% formed approximately at 15 Ma.
- Considering the results of modeling, the age of hydrocarbon expulsion pick from Cretaceous source rock is about 11.8 Ma., therefore a low risk in synchronization is interpreted.
- A moderate risk for reservoir quality using the petrography and provenance analysis, was defined and corresponding to a critical aspect.
- A total geological risk of 67% was considered during hydrocarbon volume calculation.
- The Capirucual prospect has been studied since the year 2000, it was considered an area with high geological risk and low hydrocarbon potential. Nevertheless, now with 3D understanding of the pod area the geological risk has decreased considerably and the prospect is considering to be drilled.

**REFERENCES**


**ACKNOWLEDGEMENTS**

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