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

Linda Montilla[1], Migdalys Salazar[3], Solanyer Rojas[2], and Angel Gonzalez[2]

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Abstract

The present report is an appropriated example of petroleum system modeling in exploratory frontier areas, to study an attractive prospect of 200 km^2 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

Chigne, N., B. Blanco, C. Giraldo, W. y Rodriguez, 2000, Evaluación petrolera del Norte de Guárico y Anzoátegui. Petróleos de Venezuela, Informe interno.

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ABSTRACT

The present report is an appropiated 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 1D model analysis. In this opportunity 3D petroleum system modeling was used to provide a low risk prediction prospect model.

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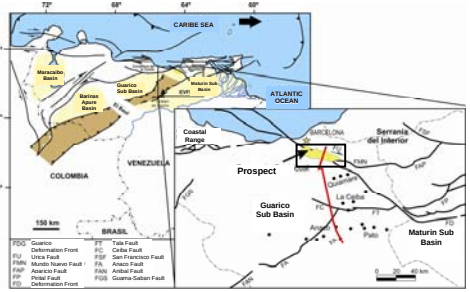
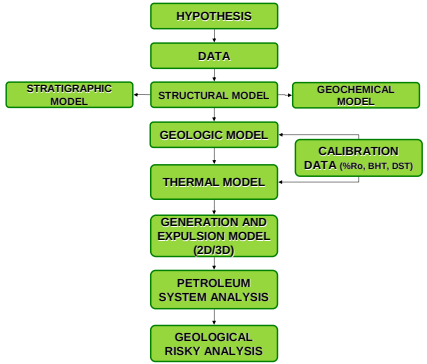
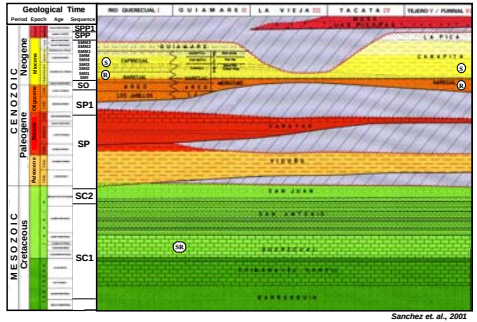
STUDY AREA



METHODOLOGY

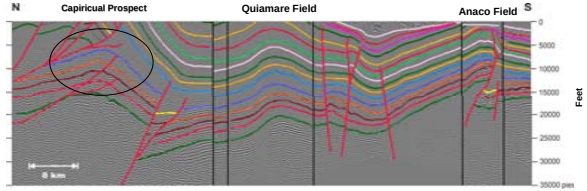


CRONOSTRATIGRAPHIC CHART



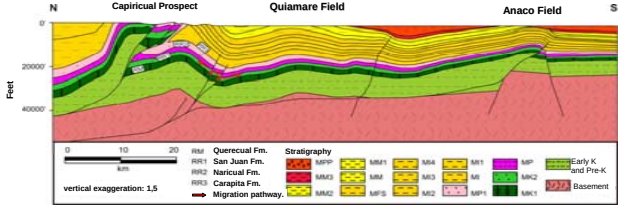
Major Erosion: 12 Ma. and 62 Ma. **No deposition: from 36 Ma. to 28 Ma.**

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 (Allоctonous block). Southern part of the area is characterized by subtle compressive structures associated with giant light oil discoveries.

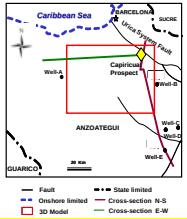
WORKING HYPOTHESIS



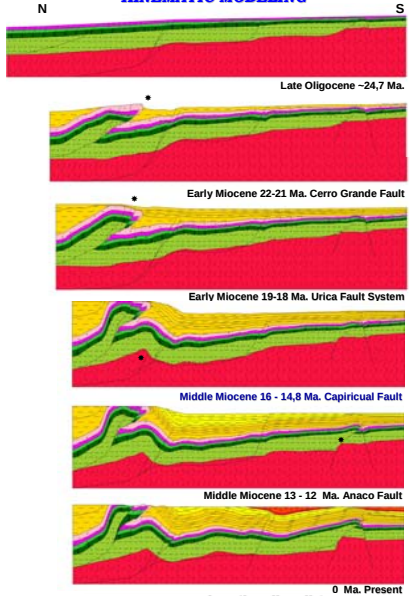
WORKING HYPOTHESIS: To evaluate the oil migration's feasibility from the basin's foredeep to the prospect area and geological risk assessment.

PREVIOUS STUDIES: During 2000 to 2005, two diferent exploration teams studied the area, after performing 1D and 2D (North – South) modeling. Both concluded that the prospect had high geological risk, for Cretaceus 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.



KINEMATIC MODELING



Restoration and forward modelling confirmed viability and admissibility of the deformation history and allowed to validate and refine proposed seismic interpretation. Prospect structure was formed between 16 & 10 Ma. (Middle Miocene).

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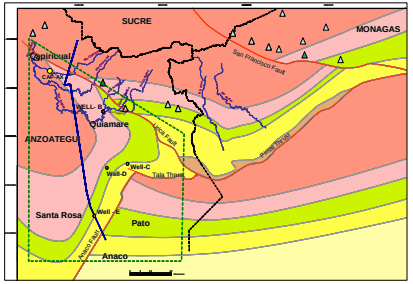
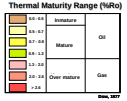
GEOCHEMICAL MODEL



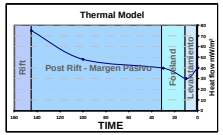
Thermal maturity map (%Ro) of Querecual Formation



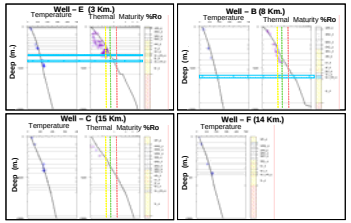
△ Outcrop
△ Measures Outcrop
○ Simulated data (1D Modelling)

- Facies and organofacies changes in Cretaceous source rock (%COT: 7 - 2%; IH: 400 - 120 mgHc/ g TOC).
- Three types of chemical kinetics consistent with three types of kerogen (type II, type II with the influence of continental material and type III)

THERMAL MODEL



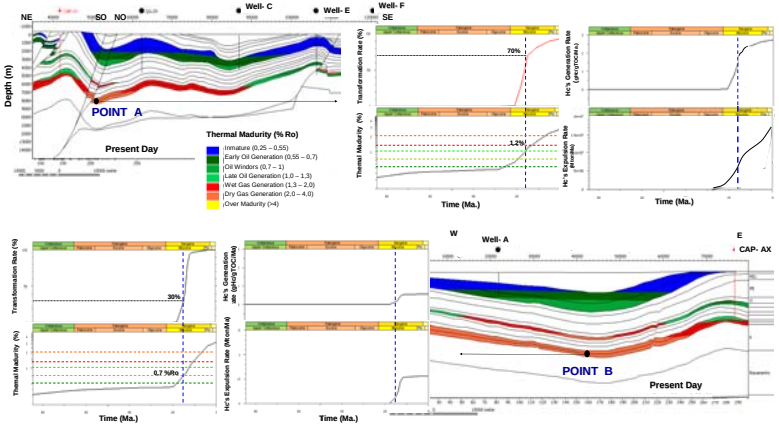
The present Heat flow: **35 y 42** mW/m2



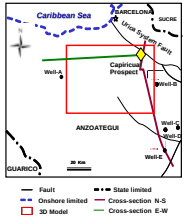
1D Calibration data using vitrinite reflectance (% Ro) and borehole temperatures showing good match between theoric-calculated and measured data, adding confidence for the generation/expulsion model.

GENERATION AND EXPULSION MODEL

2D MODELING

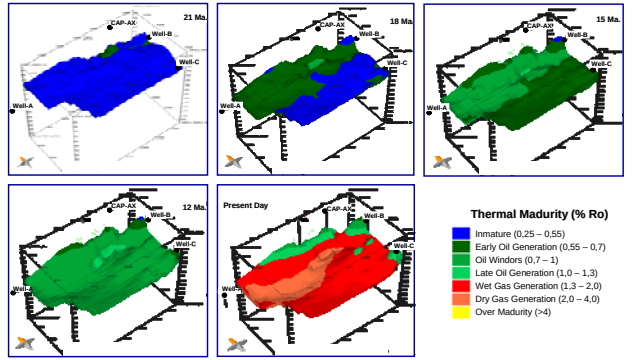


- **Chart composite showing**: Transformation rate, thermal maturity, generation and expulsion history charts in two different position of the basin, each point correspond with the deepest location on each cross-section.
- **Point A:** Showed at 15 Ma. (70% trap formation) Cretaceous SR maturity level is 1.2 % Ro and 70% Transformation rate
- **Point B:** Showed at 15 Ma. (70% trap formation) Cretaceous SR maturity level is 0.7 % Ro and 30% 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.

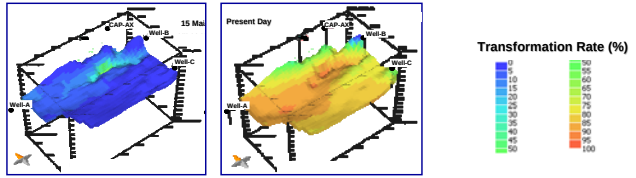


3D MODELING

CRETACEOUS SOURCE ROCK MATURITY LEVEL



CRETACEOUS SOURCE ROCK TRANSFORMATION RATIO



3D Model portraits 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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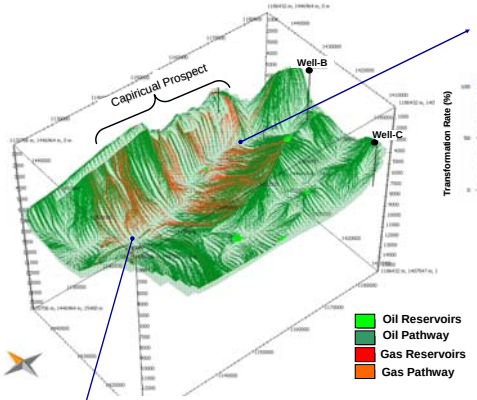
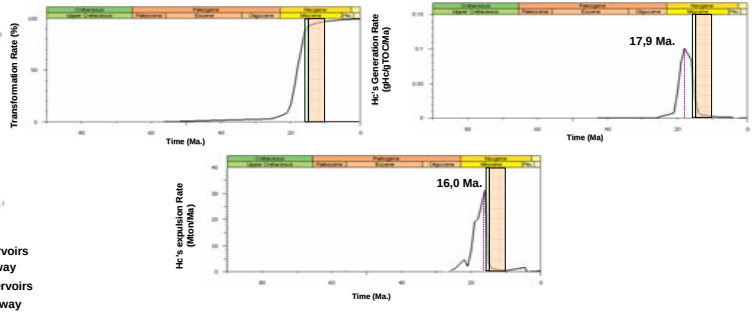
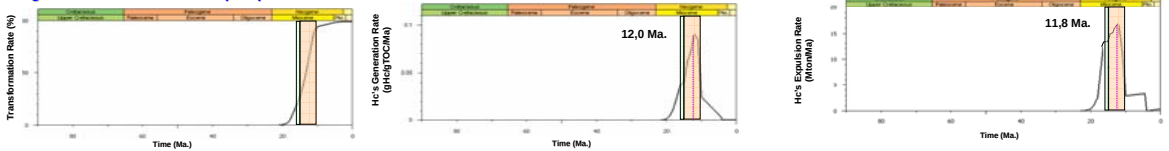
GENERATION AND EXPULSION MODEL



Drainage area 8 Km. South of the prospect



Drainage area 30 Km. West of the prospect



TRAP FORMATION HISTORY

- 16 – 15 Ma 70% trap formation
- 15 – 10 Ma 100% trap formation

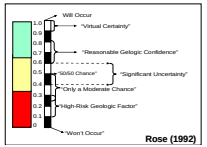
• **Drainage area located 8 Km** South of the prospect has generation and expulsion peaks that occurs during early trap formation, a moderate risk in timing can be considered in a risk assessment analysis.

• **Drainage area located 30 Km** west of the prospect has generation and expulsion peaks that occurs after trap formation, a low risk in timing can be considered in a risk assessment analysis, even though the 30 Km of lateral migration distance.

GEOLOGICAL RISK ANALYSIS

	FACTORS	SCALE (Rose 1992)
TRAP, SEAL, TIMING	Closure volume	0.80
	Seal	0.73
	Top	0.60
	Lateral	0.85
	Timing	0.80
	TOTAL	0.76
RESERVOIR, POROSITY, PERMEABILITY	Adequate reservoir thickness	0.60
	Porosity	0.40
	Permeability, Continuity	0.40
	TOTAL	0.47
SOURCE, MATURATION, MIGRATION	Organic quantity, quality	1.00
	Maturation (adequate time, temperatur, pressure)	1.00
	Migration (adequate time temperature, pressure)	0.80
	TOTAL	0.93
PRESERVATION, HC QUALITY, RECOVERY	Preservation (biodegradation, no bad flushing)	1.00
	HC's Quality and concetration	1.00
	Recobery (drive, Pressure, depth)	1.00
	TOTAL	1.00
PROBABILITY OF SUCCESS NARICUAL Fm.		0.33
GEOLOGICAL RISK		0.67

RISK LEVELS



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 define and corresponding to a critical aspect.

• A total geological risk of 67 % was considered during hydrocarbon volume calculation.

• The Capiricual 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.

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