New Exploratory Gas Opportunities in the Roblote Area, Anaco District, Eastern Venezuela.

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ABSTRACT

Exploratory Roblote area is located westward of the Maturin Sub-Basin, in the Anzoategui state, forming part of the Eastern Venezuela Basin. In this area drilling campaigns were performed in the fifties, and significant associated gas accumulations were discovered, with high gas/oil ratio were performed. Despite these results, the area was abandoned, because gas exploitation was unappealing.

PDVSA Exploratory efforts were reactivated in 2004, with the acquisition of a 3D seismic survey in the area. Re-exploration studies started in 2006 in order to visualize and identify new exploration opportunities in the area, emphasizing on the establishment of the sedimentary deposits geometry of the: Colorado member, Oficina Formation of Neogene, Merecure Formation of Paleogene and Tigre Formation of Cretaceous.

These re-exploration studies included the interpretation of about 1150 km2 of 3D seismic data, applying techniques of seismic inversion, AVO *(Amplitude vs. Offset)* and attribute analysis. Additionally, a review and updating of the stratigraphical, sedimentological, petrophysical and reservoir modeling were made, with the aim of visualizing and defining new exploratory opportunities. All of this has allowed to demonstrate that potential traps present in the area are primarily stratigraphic and that there is a high probability of finding gaseous hydrocarbons accumulations.

As outstanding results were defined four exploratory opportunities, which have an estimated potential of 80 MMSB for oil and 2200 MMMSCF for gas. Part of these results were validated between 2013 and 2014, by drilling exploratory Locations ROBLOTE AX (well R-3) and ROBLOTE BX (well R-4), yielding satisfactory results which confirmed the existence of dry gas in the middle basal sandstone of the Colorado member, Oficina Formation (Early Miocene).

1. Introduction

In the Roblote, Las Ollas and Cascaroncito areas different drilling campaigns were conducted during the 1940's and 1950's decades.

The majority of these wells gave evidence of the presence of hydrocarbons, showing significant levels of gas, through production testing, which results vary between 0,12 MMPCGD and 7,2 MMPCGD, hence the high gas/oil ratio.

These wells were abandoned by the operating companies since they sought substantial oil reserves and abandoned exploratory wells that were distanced from production facilities, with potentials under 500 barrels per day, plus the gas exploitation was considered little attractive (Finno et al., 2008 [1]).

Due to the need of seeking areas of high gas prospectivity, to help increase the production of the district, and reactivate these areas that had been abandoned, PDVSA Exploration began in 2006 the recover of the Roblote area, whose main objective was to visualize the stratigraphic component of the traps and define exploratory opportunities, emerging from these studies four new opportunities. In 2012 the activity in the area was started with the drilling of the exploratory Roblote-AX (Well R-3) location, followed by Roblote-BX (Well R-4) in 2013 (currently in evaluation). The results obtained so far corroborate the geological prognosis and the presence of dry gas in this area.

2. Location of the Study Area

The study area is located in the eastern region of Venezuela, northwest of Anaco's alignment, between the areas of Las Ollas, Roblote and Cascaroncito, 5 km from Campo El Toco and west of Anzoategui State, Venezuela (Figure 1).

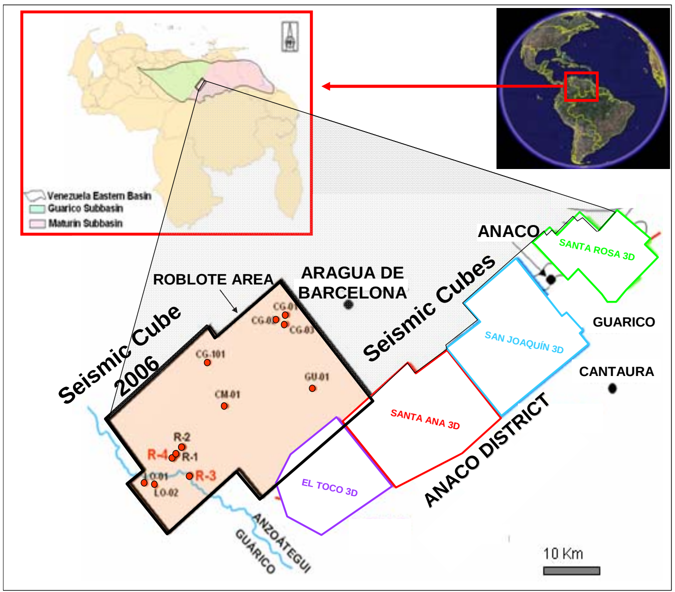


Figure 1. Roblote area location.

3. Chronostratigraphy of the Roblote Area

The chronostratigraphy of the Roblote area lies within four (4) tectonostratigraphic megasequences (Chigné *et al.*, 2000) or first-order stratigraphic cycles, which are separated by four first-order discordances, which have been recognized and identified from seismic information and data from wells at regional level. These megasequences have been termed as: 1) *"Rift"* Megasequence, 2) *Passive Margin* Megasequence, 3) *Fore deep* Mega sequence, 4) *Post-fore deep* Mega sequence (Finno *et al.*, 2008 [1]).

These megasequences have been subdivided into twelve (12) tectonosequences that correspond to second-order depositional cycles (defined by VIPA, 2000), ranging from Pre-Cambrian to the Plio-Pleistocene. In the Roblote area, eighteen (18) 3rd order stratigraphic sequences were identified (Figure 2).

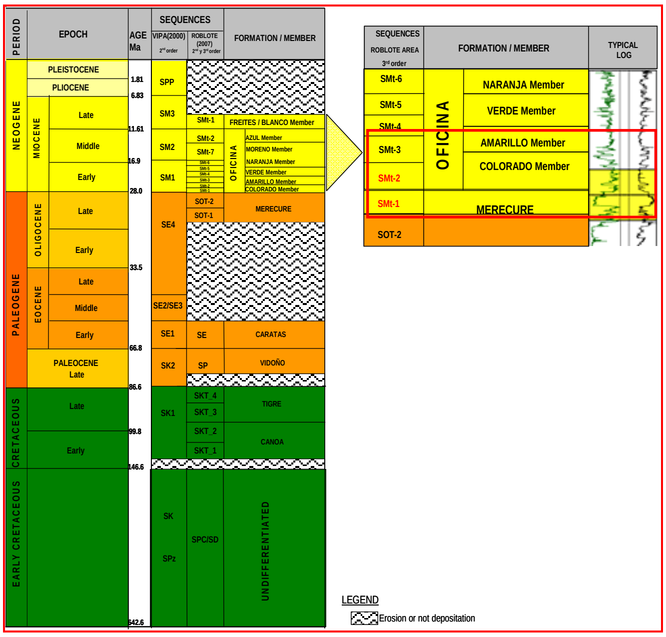


Figure 2. Chronostratigraphy chart of the Roblote Area. (Audemard et al., 2000 [2] modified by Finno et al., 2008 [1]).

The interest intervals in wells R-3 and R-4 are represented by third-order (3rd Order) stratigraphic sequences SMt-1, SMt-2 (mainly) and SMt-3. The SMt-1 sequence of Oligocene age is lithologically associated with the Merecure Formation, while SMt-2 and SMt-3 sequences of Early to Middle Miocene age, are associated with the Oficina Formation (Colorado and Amarillo Member), as shown in Figure 2.

4. Exploratory Opportunities from AVO Techniques

Techniques of AVO and Seismic Inversion made in the Roblote area is within the Roblote 3D seismic cube of 550 Km2, where the T-1 and T-2, R-1 and R-2, CC-1X and LO-2 wells are located.

With the goal of identifying and defining the lateral extensions of the seismic anomalies associated with sandstone bodies and identify possible areas of interest, an integration of the products obtained from AVO and Simultaneous Investment analysis, such as Fluid Factor cube and difference in the Poisson relation, was conducted applying the 3D Seismic Visualization technique of "Sculpting Formation", anomaly polygons of an amplitude over 40 horizons between the Oficina and Merecure formations generating (Figures 3 and 4).

The AVO techniques conducted allowed to identify four possible exploratory opportunities. The interpretation of the generated AVO cubes, presented anomalies in different seismic levels for each of the opportunities, being selected as geographical sites for the locations those where the greatest number of possible anomalies would be drilled, two of them corresponding to the place where wells R-3 and R-4 were drilled.

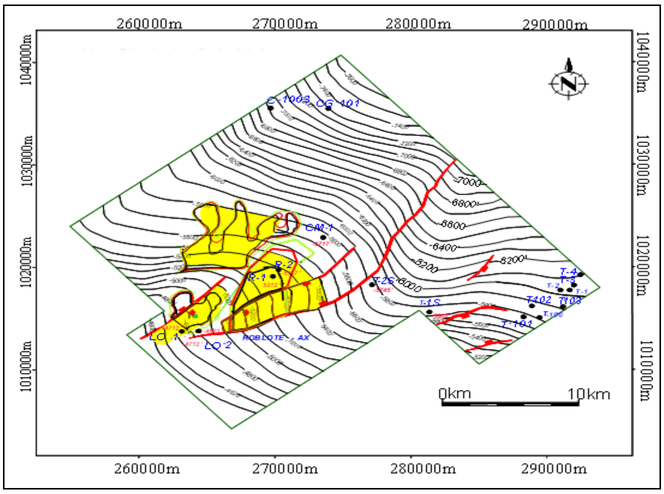


Figure 3. Anomalies map from AVO techniques, top of Colorado Member, Oficina Formation (Finno et al., 2008 [1]).

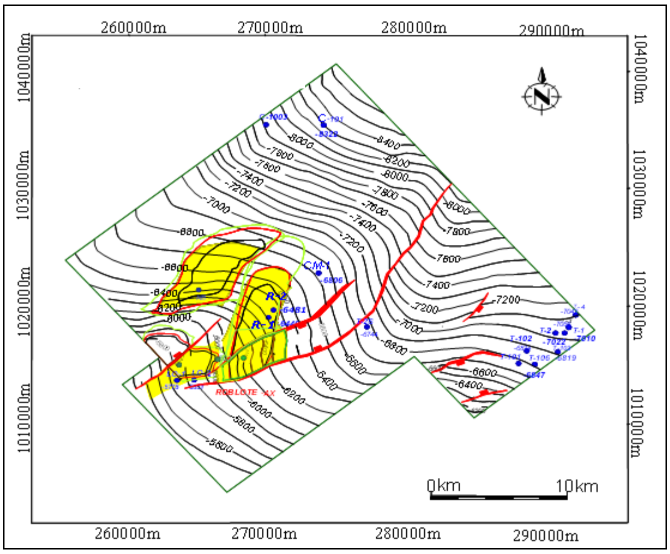


Figure 4. Anomalies map from AVO techniques top of Merecure Formation (Finno et al., 2008 [1]).

5. Methodology

Work begins with the review of the exploratory opportunities defined with the AVO analysis (geological prognosis), followed by a review of the seismic interpretation and the information of neighboring wells in the area to adjust the formational tops to be drilled. The drilling of new exploratory wells allowed to acquire a higher quantity and quality of geological information (cores, well logs and fluid samples), which, analyzed and interpreted, enabled the actualization of sedimentological, stratigraphic and structural models and to make a reliable petrophysical assessment.

Finally, with the evaluation of new wells the existence of hydrocarbon deposits is confirmed, allowing the quantification and incorporation of new reserves. A summary of the work methodology is presented in Figure 5.

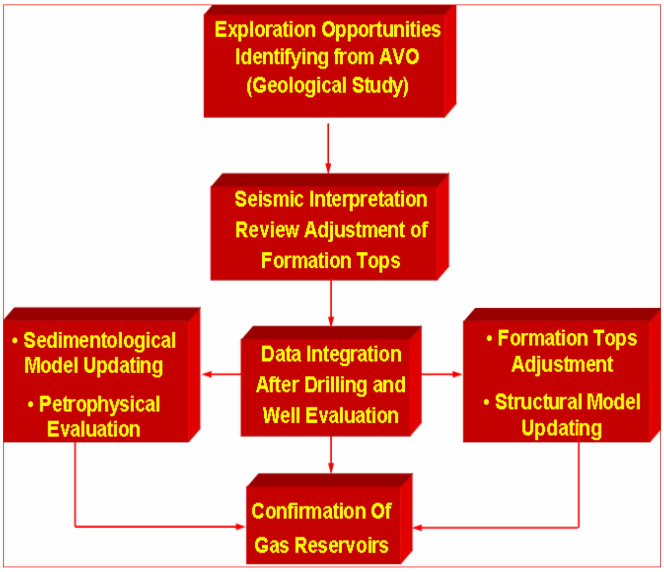


Figure 5. Work methodology.

6. Results

The geological prognosis review allowed a preliminary adjustment of the formational tops estimated to drill the exploratory locations.

Once completed the drilling of the exploratory wells R-3 and R-4 in the Roblote Area, the results allowed to define exactly the formational tops of the informal members of the Oficina Formation, of Early to Medium Miocene age, and the tops of the Merecure Formation, of Oligocene age, as well as the Cretaceous, Tigre Formation.

Based on this data, significant variations were observed in the formational tops, regarding to those visualized in the geological prognosis, which allowed the adjustment of exploratory formations of interest thicknesses. These new data led to the generation of five structural depth maps in the corresponding levels to the tops of the discovered reservoirs in the Merecure and Oficina (Colorado Member) formations.

Column drilled by well R-3 is presented in Figure 6.

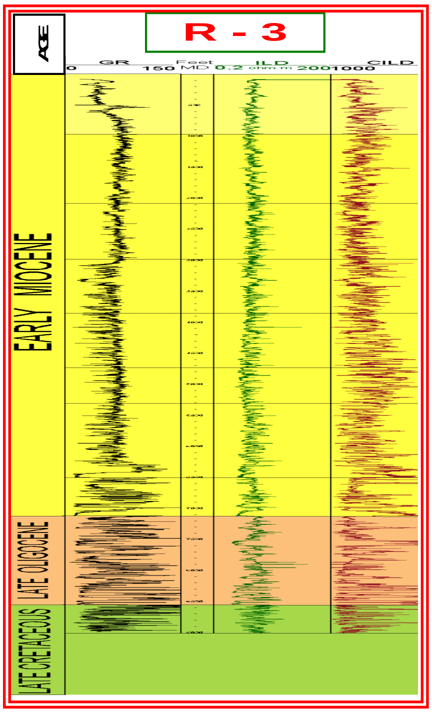


Figure 6. Column drilled by well R-3.

The acquisition, analysis and interpretation of electric logs of modern wells, such as induction gamma ray, density-neutron, dipole sonic, spectral gamma ray, mineralogical and magnetic resonance, allowed the integration of all the information generated during the drilling (descriptions of cuttings samples, operational parameters and biostratigraphic analysis). Then with the help of the seismic data, the adjustment of the formation tops were made, which let observe the continuity of reflectors for the tops defined in the area, as shown in the structural section and in the regional seismic line of Figures 7 and 8, respectively.

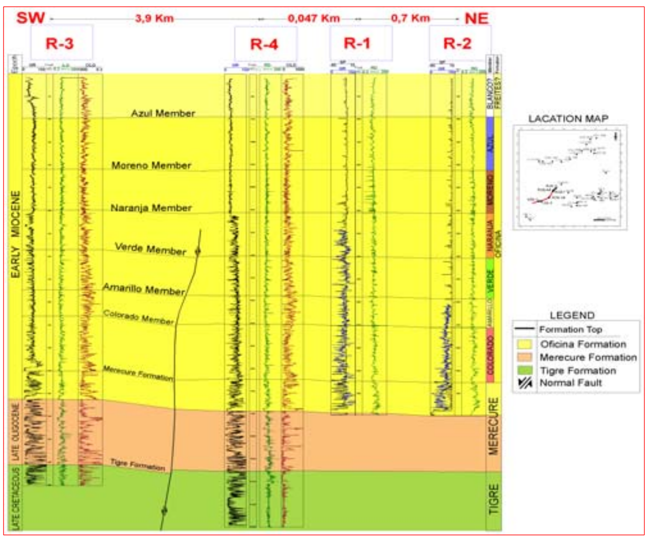


Figure 7. Structural Section SW-NE

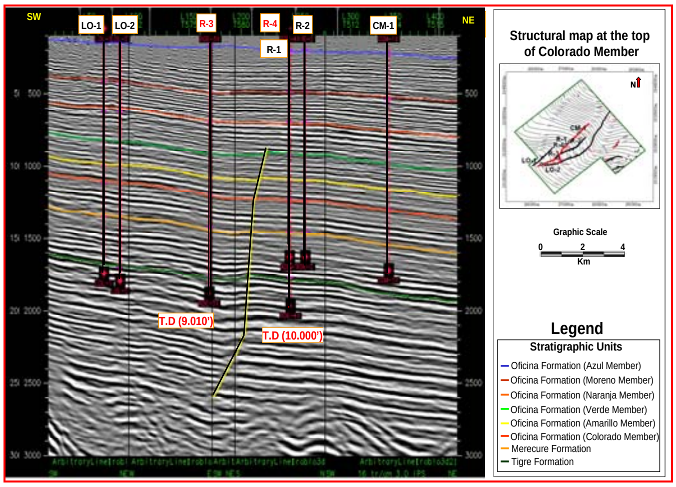


Figure 8. Regional seismic SW-NE.

The sonic log and the integration of the previously exposed information allow the actualization of the structural model of the area, where wells R-3 and R-4 are located. This is represented by a monocline with a dip of 6° – 8° to the northeast, which confirms the non-sealing character of the existent faults. These faults have a greater vertical jump in depth (Merecure and Tigre formations), but as they shoal (Colorado Member) the jump becomes lesser, showing the nearly horizontal strata and proving the stratigraphic nature of the traps (Figure 8).

In the R-4 well 152 feet of core were cut, which were divided into 91 feet for the SMt-2 sequence (Colorado Member, Oficina Formation) corresponding to the objective sands C-R1 and C-R2 and 61feet for the SMt-1sequence (Merecure Formation), the objective thus obtained was the sedimentological characterization of the stratigraphic sequences of interest as indicated in Figure 2.

In these core hydrocarbon impregnation were observed and two types of depositional environments were interpreted: for the SMt-1 sequence (Merecure Formation) a transitional palaeobathymetry dominates and the environment is interpreted as a deltaic system (fluvial domain), specifically between the delta plain intermediate to low. For this sequence the reservoir rock is represented by crevasse splay, abandoned meander channels and point bar. The seal rock is represented by the flood plain (shales), the vertical seal is generated by the retrogradation of sedimentary environments developed on the coast, caused by the rising sea levels, thus producing the isolation of porous-permeable sedimentary bodies, which makes possible the stratigraphic type entrapment.

For the SMt-2 sequence (Oficina Formation) the predominant palaeobathymetry is transitional, with deltaic type environments influenced by tides. The associated deposits are those of tidal flatlands and deltaic front. For this sequence the reservoir rock is represented by tidal bars.

Taking into consideration the data obtained through the analysis of cores, such as texture, sedimentary facies, sedimentary structures, ichnofossils and fossils, among others, the facies architecture model was updated and a better characterization was proposed using the Papua Delta as recent analog (New Guinea, modified according to Fisher *et al.*,1969 [4]) (Figures 9, 10 and 11).

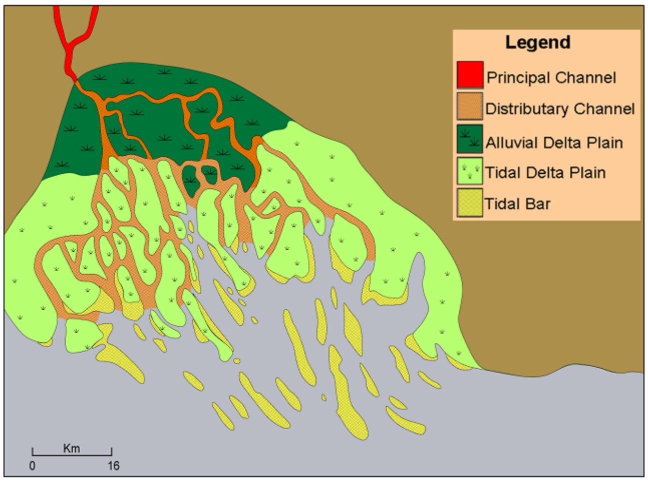


Figure 9. Delta Papúa, New Guinea (modified according to Fisher *et al.*,1969[4])).

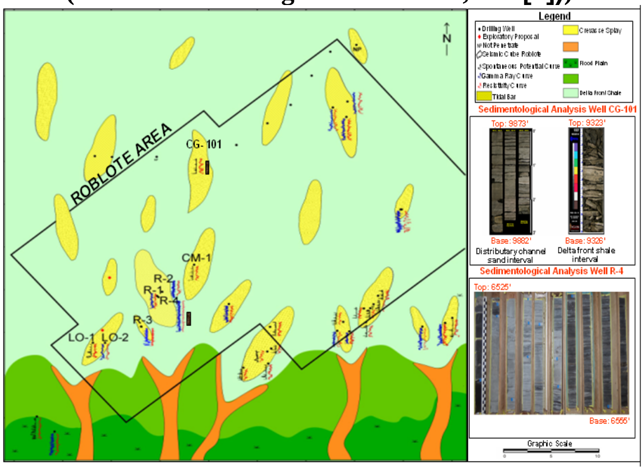


Figure 10. Sedimentological model for the SMt-2 sequence (Colorado Member, Oficina Formation).

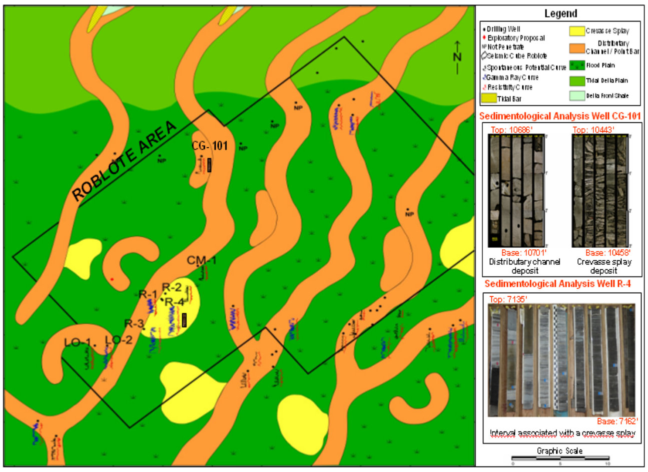
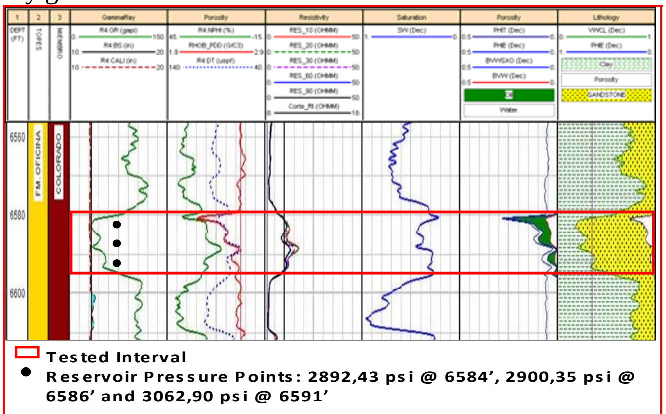


Figure 11. Sedimentological model for the SMt-1 sequence (Merecure Formation).

The integration and analysis of the data acquired with the drilling of the exploratory well R-3 (electric logs, pressure points and fluid samples) made possible to determine two prospective intervals for this well in the Oficina Formation (Colorado Member), the C-R2 interval resulting in success (6302 – 6314 ft MD) (Figure 12), confirming its potential for dry gas in the area.



OFICINA FORMATION COLORADO MEMBER (WELL R-3)							
SAND	TOP (Feet)	BASE (Feet)	NET RESERVOIR (feet)	Rt (OHM.M)	PHIE (%)	VsH (%)	Sw (%)
C-R2	6302	6314	12	18	15	30	34

Figure 12. Prospective interval (6302- 6314 feet, MD) C-R2 Sand, Oficina Formation.

Twelve prospective intervals for well R-4 were determined: seven in the Oficina Formation (Amarillo and Colorado Member), five in the Merecure Formation and three in the Tigre Formation. Seven of this intervals will be evaluated with DST tests. It is important to note that the cores in the Colorado Member showed fluorescence under ultraviolet light (UV), due to a possible hydrocarbon impregnation in the sands C-R1 and C-R2 (Figures 13 and 14).

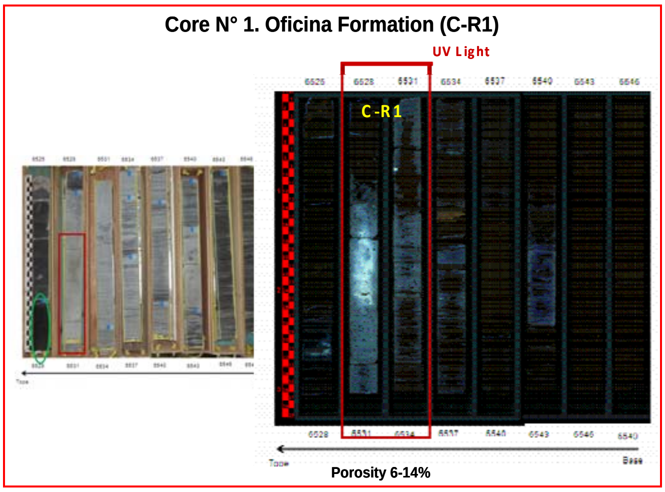


Figure 13. Ultraviolet ligth (UV), core interval (6529-6533 feet), well R-4.

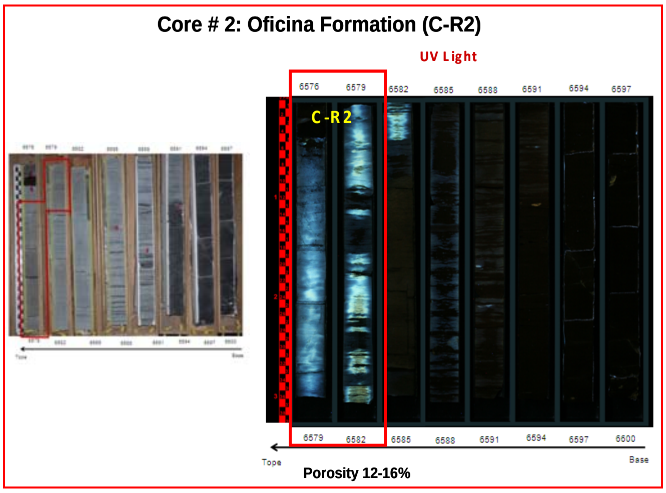
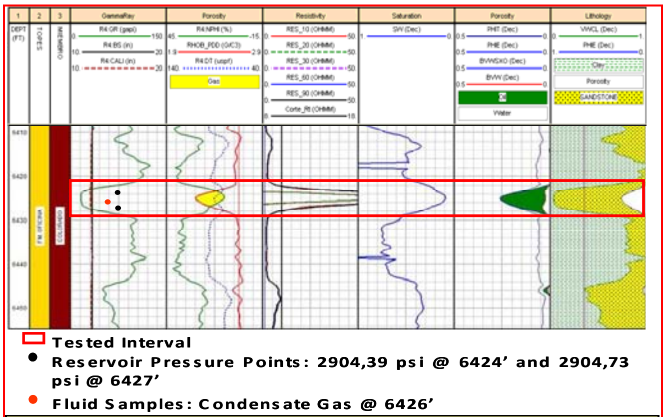


Figure 14. Ultraviolet ligth (UV), core interval (6576-6582 feet), well R-4.

Additionally, in well R-4 three fluid samples were taken, two of them of dry gas and volatile oil of 38 °API in the Merecure Formation level, and the other of condensate gas of 48 °API in the Oficina Formation level (Colorado Member). The intervals with fluid samples are presented in Figure 15.



OFICINA FORMATION COLORADO MEMBER (WELL R-4)							
SAND	TOP (Feet)	BASE (Feet)	NET RESERVOIR (feet)	Rt (OHM.M)	PHIE (%)	VsH (%)	Sw (%)
C	6422	6429	8	58	18	11	16

Figure 15. Prospective interval (6422- 6429 feet, MD) Oficina Formation, Colorado Member

The intervals identified with hydrocarbon potential show good reservoir rock quality, with net sand thicknesses between 8 and 20 feet, characteristic of the types of depositional environments shown in Figures 10 and 11, corresponding to the Oficina and Merecure formations.

Evidence of gaseous and volatile hydrocarbons in the prospective intervals identified in the petrophysical evaluation of well R-4, also prove the Roblote Area's potential for gaseous hydrocarbons. This well is under evaluation for fluid characterization on these days.

In Figure 16, the structural-isopach map of gaseous net sand of the COR2 R3 reservoir is shown, discovered by well R-3, which constitutes a stratigraphic entrapment characteristic in the area.

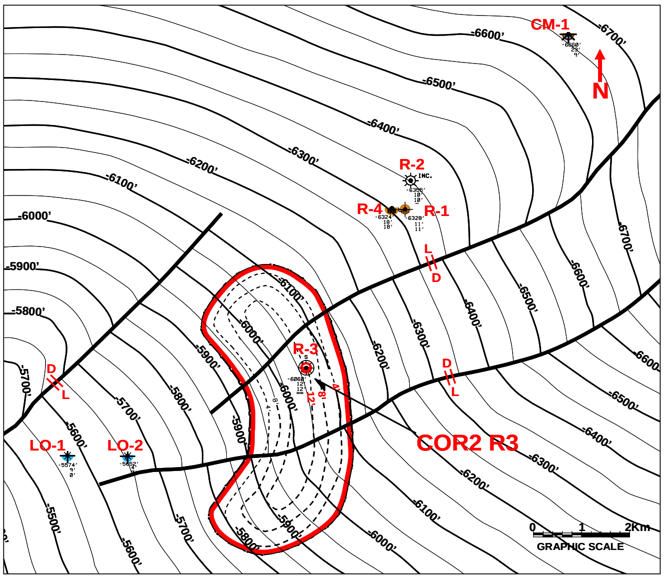


Figura 16. Structural- isopach map of the COR2 R3 reservoir (Finno et al., 2014[5]).

7. Conclusions

1.- AVO techniques in areas with 3D seismic data and similar characteristics of the Roblote area anable to define with the highest certainty the location of new exploratory opportunities.

2.- The description and analysis of the core recovered during the drilling of well R-4 allowed the sedimentological characterization of the Roblote area.

3.- The petrophysical evaluation of wells R-3 and R-4 and the three samples of gas and volatile oil recovered in the formations of interest confirm the hydrocarbon potential of the area.

4.- The entrapment of hydrocarbons in the Roblote area are of a stratigraphic type, in both Oficina and Merecure formations. As shown by the integration of AVO techniques and data from well drilling.

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