Comprehensive Basin Analysis and Petroleum Potential Evaluation of Ayoluengo Oil Field, Basque-Cantabrian Basin, Spain.

ABSTRACT

This study presents a comprehensive basin analysis and petroleum potential evaluation of the Ayoluengo oil field in the Basque-Cantabrian Basin, Spain. Using an integrated approach combining geological, geophysical, and geochemical data, we analyzed the basin's evolution and petroleum system elements. The dataset included 2D and 3D seismic data, well logs, formation tops, and geophysical maps. Our analysis revealed a complex structural framework characterized by salt diapirism and halokinetic structures. Well log interpretation and sequence stratigraphic analysis identified two genetic sequences with associated systems tracts. Four reservoir units were mapped, with the main structural traps related to salt diapirs. Seismic facies analysis highlighted high-amplitude convergent (CBH) and high- and low-amplitude convergent (CBHL) facies as the most promising for reservoir quality. The study identified one play (Jurassic) and two prospects: Lias Limestone (80% geologic chance of success) and Carniolas Dolomite (85% geologic chance of success). Volumetric calculations estimate significant hydrocarbon potential, with STOIIP (Stock Tank Oil Initially In Place) ranging from 3.4 to 4.2 x 10^16 barrels for the Lias Limestone reservoir and 1.26 to 1.56 x 10^16 barrels for the Carniolas Dolomite reservoir.

INTRODUCTION

The Basque-Cantabrian Basin, located in northern Spain, has been a focal point of hydrocarbon exploration and production since the discovery of the Ayoluengo oil field in 1964 (Martínez del Olmo, 2019). As the only onshore oil field in Spain, Ayoluengo has played a significant role in understanding this complex geological region's petroleum system and basin evolution. This study aims to conduct a comprehensive basin analysis and evaluate the Ayoluengo oil field's petroleum potential within the Basque-Cantabrian Basin's broader context. The Basque-Cantabrian Basin formed due to Mesozoic rifting and subsequent Alpine compression, creating a complex tectonic and stratigraphic framework (García-Mondéjar et al., 1996). The basin's evolution has led to the development of various source rocks, reservoirs, and trapping mechanisms, making it an intriguing subject for petroleum geologists and researchers alike. The Ayoluengo field, situated in the southwestern part of the basin, has produced over 17 million barrels of oil since its discovery (Álvarez et al., 1996). Despite its relatively modest production, the field provides valuable insights into the basin's petroleum system and offers potential analogs for future regional exploration targets. This research will focus on integrating geological, geophysical, and geochemical data to reconstruct the basin's evolution, identify key elements of the petroleum system, and assess the remaining hydrocarbon potential of the Ayoluengo field and surrounding areas. By combining traditional basin analysis techniques with modern analytical methods, this study aims to contribute to understanding the Basque-Cantabrian Basin's hydrocarbon resources and guide future exploration efforts in this geologically complex region.

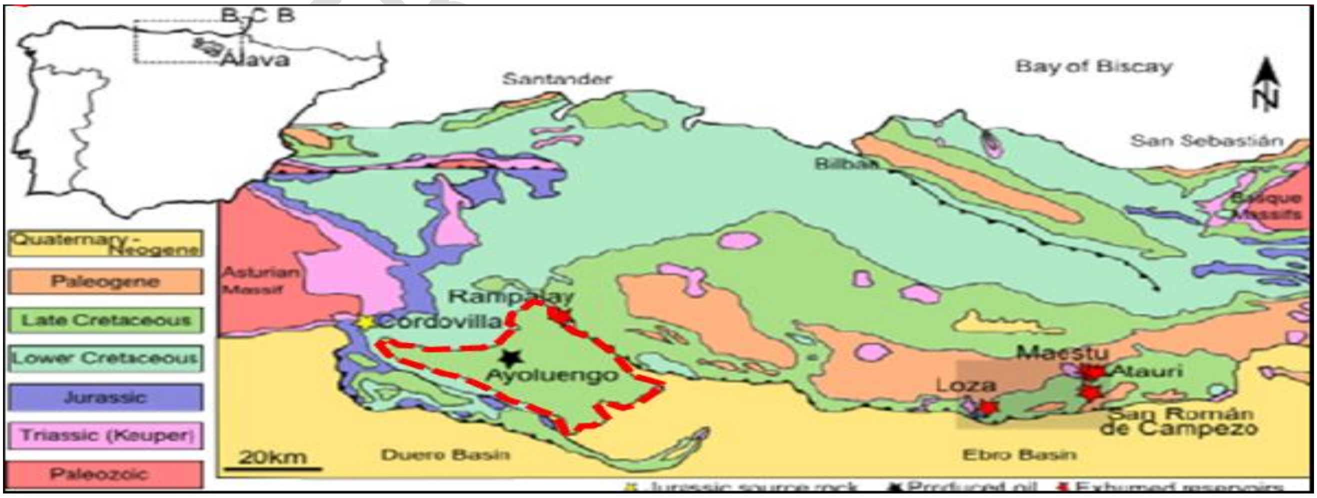


Figure 1: Location map showing the regional setting of the Ayoluengo oil field in the Basque-Cantabrian basin, Spain, and the Basin Extent (Marin et al., 2012)

GEOLOGY AND STRUCTURAL SETTING

Basque-Cantabrian Basin

The Ayoluengo oil field is located within the Basque-Cantabrian Basin, a significant geological province situated in northern Spain. This basin is renowned for its complex geological history and structure.

Formation and Evolution:

Rift System: The Basque-Cantabrian Basin originated during the Mesozoic era as part of the North Atlantic Bay of Biscay rift system. This rifting event resulted in the initial subsidence and formation of the basin, characterized by extensional tectonics.

Alpine Compression: The basin's geological history was profoundly influenced by Alpine compression during the Cenozoic era. This tectonic event led to significant structural modifications, including the formation of folds and thrusts. The compression associated with the Pyrenean orogeny is a key factor in the current geological configuration of the basin (Tavani, 2012).

Stratigraphy:

Paleozoic Basement: The basement of the basin is composed of Paleozoic rocks, which provide a stable foundation for the overlying sedimentary sequences.

Sedimentary Fill: Overlying the Paleozoic basement is a thick sequence of sedimentary rocks deposited through various geological periods:

Triassic Evaporites: These include thick layers of evaporitic deposits such as salt and gypsum, which are crucial in the basin’s structural and hydrocarbon trapping mechanisms.

Jurassic Carbonates: During the Jurassic period, the basin experienced the deposition of extensive carbonate platforms, which are important for reservoir potential.

Cretaceous to Paleogene Deposits: This interval features a mix of clastic and carbonate sediments, reflecting changing depositional environments and contributing to the basin's overall complexity (Quintà & Tavani, 2012).

Structural Geology

Folding and Thrusting*:*

E-W Trending Structures: The basin's structure is dominated by east-west (E-W) trending folds and thrusts, which resulted from the compressional forces of the Pyrenean orogeny. These structures have played a critical role in shaping the basin’s current geological framework (Hernáiz et al., 2000).

Anticlinal Structures: The Ayoluengo oil field is situated on an anticline, a prominent fold structure created during the compressional event. This anticline serves as a key feature for hydrocarbon accumulation, as it provides structural traps for hydrocarbons.

Salt Tectonics:

Triassic Evaporites: The presence of Triassic evaporites, including salt, has significantly influenced the basin's structural evolution. Salt tectonics, including diapirism and halokinesis, have led to the formation of various structural and stratigraphic traps.

Diapirism and Halokinesis: Salt diapirs and associated halokinetic movements have created complex subsurface structures, including salt-cored anticlines and salt-induced folds. These features are critical for hydrocarbon trapping and migration, as they can act as both traps and barriers for hydrocarbons (Carola et al., 2015).

Petroleum System

Reservoir Rocks:

Lower Cretaceous Sandstones: The primary reservoir rocks in the Ayoluengo oil field are sandstones from the Lower Cretaceous Wealden facies. These sandstones were deposited in fluvial and deltaic environments, providing significant reservoir potential due to their porosity and permeability.

Interbedded Shales and Siltstones: These shales and siltstones serve as seals, preventing the upward migration of hydrocarbons and contributing to the field's overall reservoir capacity.

Source Rocks:

Jurassic Marine Shales: The source rocks for the Ayoluengo oil are primarily organic-rich marine shales from the Jurassic period. These shales are crucial for hydrocarbon generation due to their high organic content and thermal maturity (Permanyer et al., 2013).

Implications for Hydrocarbon Exploration

Structural Complexity: The structural features of the basin, including salt tectonics and folding, have created a variety of potential traps and migration pathways for hydrocarbons. Understanding these structures is essential for effective exploration and development.

Reservoir and Seal Identification: Accurate identification and characterization of reservoirs and seals are critical for evaluating the hydrocarbon potential of the Ayoluengo oil field. The integration of stratigraphic and structural data will enhance the understanding of hydrocarbon accumulation and improve exploration strategies.

METHODOLOGY

1. Data Collection and Integration

The study incorporated a comprehensive dataset to ensure a thorough analysis of the Ayoluengo oil field. The dataset included:

- **Seismic Data**: 203 2D seismic lines complemented by 3D seismic data. This combination allowed for detailed subsurface imaging and interpretation across different scales.
- **Wells**: Data from eight wells, each providing complete well log suites, which include measurements such as gamma ray, resistivity, and sonic velocities. Additionally, Check-shot Surveys for four of these wells provided time-depth relationships, crucial for accurate depth conversion.
- **Formation Tops**: Formation tops for four wells were used to correlate geological layers and establish stratigraphic frameworks.
- **Auxiliary Data**: Geomagnetic data, gravity maps, surface geologic maps, and geopolitical and geological posters were used to provide context and additional insights into the regional geology.

2. Workflow and Methodology

The workflow was implemented through several stages:

a. Basin Analysis

- **Tectonic Framework Study**: Detailed examination of the basin's structural features, including fault systems and deformation history, was performed to understand their impact on sedimentary fill and petroleum potential.
- **Paleogeographic Reconstruction**: Historical reconstruction of the basin's paleogeography was conducted to infer past depositional environments and sedimentary processes.

b. Petroleum System Analysis

- **Source Rock Evaluation**: Identified and assessed source rocks for their potential to generate hydrocarbons based on maturity and type of kerogen.
- **Migration Pathways**: Analysed potential migration pathways for hydrocarbons, considering both primary migration from source rocks and secondary migration within reservoirs.

- **Reservoir Rocks**: Evaluated the quality of reservoir rocks in terms of porosity and permeability.
- **Seal Rocks**: Investigated the presence and integrity of seal rocks to ensure effective trapping of hydrocarbons.

c. Well-log Interpretation

- **Correlation and Mapping**: Well logs from multiple wells were correlated to map and identify sand tops, using a northwest-southeast direction to create a coherent regional stratigraphic framework.
- **Synthetic Seismogram Generation**: Created synthetic seismograms from density and sonic logs from the AYO-1 well to tie the well log data to seismic data. This process involved generating a theoretical seismic response to correlate well data with seismic reflection data.

d. Seismic Interpretation

- **Structural Interpretation**: Analysed seismic sections to define structural features such as faults, folds, and other deformations. This included generating:

    Seismic Time Maps: Maps depicting the time it takes for seismic waves to travel from the surface to different subsurface layers.

    Depth Maps: Converted time maps to depth maps using velocity data to accurately represent the subsurface structure.

    Fault Planes: Mapped fault planes to understand the distribution and orientation of fault systems.

    Isochore Maps: Produced maps showing the thickness of geological layers.

e. Sequence Stratigraphy

- **Galloway Sequence Model**: Applied the Galloway Sequence Model to well-log data to identify and classify genetic sequences and system tracts. This model utilizes:

    Reflection Amplitudes: Variations in reflection strength to interpret changes in lithology and depositional environments.

    Reflection Geometry: The shape and continuity of seismic reflections to deduce sedimentary processes and sequence boundaries.

    Continuity of Reflection: The persistence of reflectors across the seismic sections to define stratigraphic units and system tracts (as outlined by Prather et al., 1998; Anomneze et al., 2015).

f. Seismic Facies Analysis

- **Identification of Facies**: Key seismic traverses were examined to identify different seismic facies, which represent distinct depositional environments and potential exploration play facies.
- **Play Maps**: Generated maps depicting various play types, and their potential based on seismic facies analysis.

g. Prospect Identification

- **Petroleum Play Maps**: Integrated seismic facies and play maps to locate potential sweet spots, leads, and prospects within the basin.
- **Volumetrics**: Estimated the volumes of hydrocarbons potentially present in the identified prospects, using methods such as Monte Carlo simulations to assess uncertainties.

h. Risk Assessment

- **Exploration Risks**: Evaluated risks associated with drilling and exploring the identified prospects, considering factors like geological uncertainty, reservoir quality, and potential economic viability.

3. Software and Tools

- **Petrel Interpretation Software**: All geological and geophysical interpretations were performed using Petrel, a leading software for integrated reservoir modelling and interpretation. The software facilitated the integration and visualization of seismic, well log, and geological data.
- **Workstation**: The analyses were conducted on a workstation at the Petroleum Geoscience Laboratory, Nnamdi Azikiwe University, Awka, equipped with the necessary software and computational resources for detailed geoscience analysis.

RESULT AND DISCUSSION

1. Lithostratigraphic Correlation

The lithostratigraphic correlation was performed by flattening the formation tops on the top Albian. This method aligns the geological data to a consistent reference horizon, allowing for a clearer comparison and correlation of subsurface formations across different wells.

- **Formation Tops**: The flattening on top Albian facilitated the correlation of formation tops across the basin, revealing the extent and continuity of various lithostratigraphic units.
- **Extent of Rocks**: The well-log data indicated that source rocks, reservoir rocks, and seals are extensive throughout the basin. This finding is crucial as it suggests a widespread potential for hydrocarbon accumulation and trapping across the study area.
    - **Source Rocks**: These rocks, identified through their organic content and maturity, are distributed broadly within the basin, implying that the basin has a robust potential for hydrocarbon generation.
    - **Reservoir Rocks**: The reservoir rocks were found to be well-distributed, offering multiple potential targets for hydrocarbon exploration.
    - **Seal Rocks**: The seals, consisting primarily of shale and other low-permeability rocks, were also extensive. Effective seals are vital for trapping hydrocarbons and preventing their migration from the reservoir.

Figure 2 illustrates the distribution of these rock types, highlighting their spatial relationships and indicating areas with favourable conditions for hydrocarbon accumulation.

2. Sequence Stratigraphic Interpretation

The sequence stratigraphic analysis was carried out using the Depositional Sequence Model II, which helped in identifying and classifying sedimentary sequences within the well-log data.

- **Genetic Sequences**: Two distinct Genetic Sequences were identified in the sequence stratigraphy analysis. Each sequence represents a complete depositional cycle, encompassing a range of sedimentary environments and changes over time.
    - **Sequence 1**: This sequence is characterized by specific depositional environments and sedimentological features observed in the well logs.
    - **Sequence 2**: Another depositional cycle was identified, reflecting different sedimentary conditions and processes compared to Sequence 1.
- **Systems Tracts**: Each Genetic Sequence was further divided into Systems Tracts, which represent distinct stages in the depositional cycle. The following Systems Tracts were identified:
    - **Lowstand Systems Tract (LST)**: Associated with periods of low sea level, where sediment deposition typically occurs in fluvial or deltaic environments. The LSTs identified in the well logs are considered potential reservoirs due to their favourable conditions for reservoir rock development.
    - **Transgressive Systems Tract (TST)**: Formed during periods of rising sea level, characterized by the deposition of shales and fine-grained sediments. The TSTs in the study area are primarily composed of shales, which act as source rocks and seals in the petroleum system.
    - **Highstand Systems Tract (HST)**: Develops during high sea levels and is characterized by the deposition of sands and other reservoir-quality rocks. Shales within the HSTs serve as seals and contribute to the overall containment of hydrocarbons.

Figure 3 illustrates the stratigraphic framework, highlighting the spatial distribution of the LSTs, TSTs, and HSTs, and showing their potential roles as reservoirs and seals.

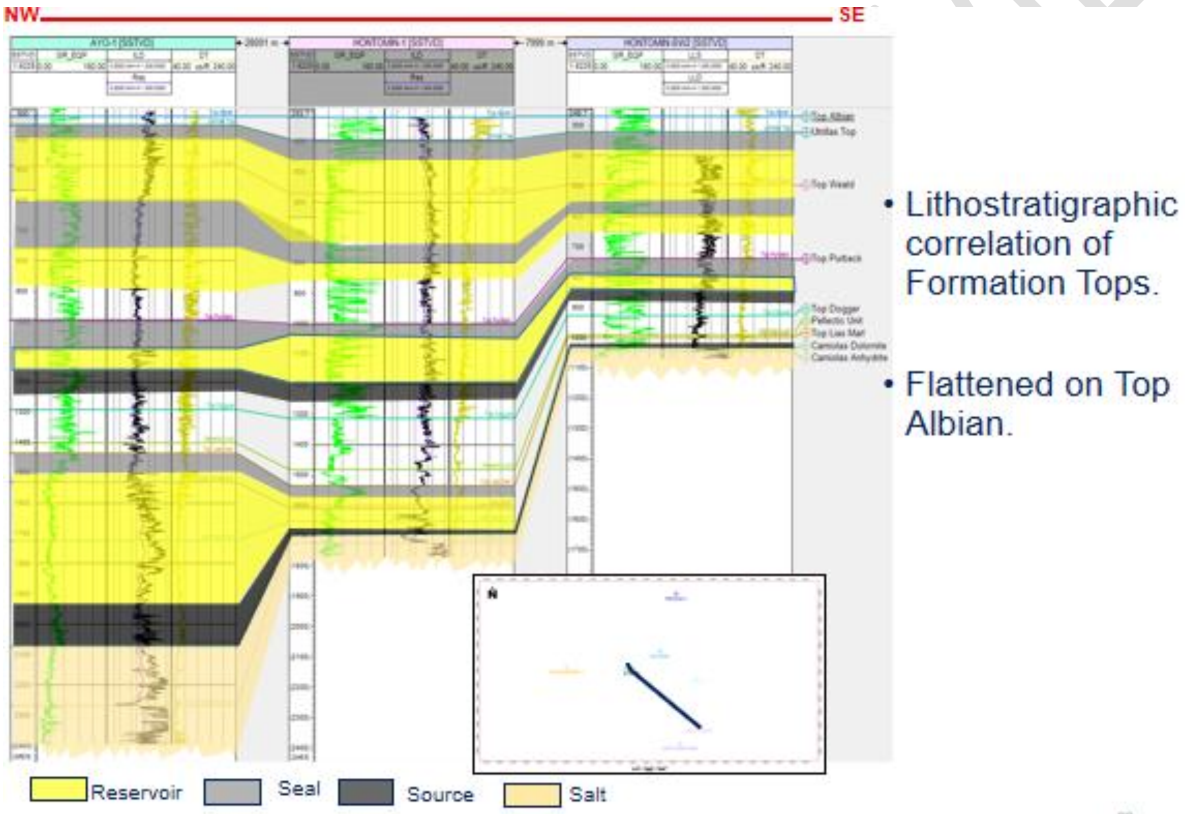
3. Reservoir and Seal Potential

- **Potential Reservoirs**: The identified LSTs and HSTs were found to possess favourable characteristics for reservoir rocks, including good porosity and permeability. These intervals are promising targets for hydrocarbon exploration.
- **Source and Seal Units**: The shales within the TSTs and HSTs were determined to be effective source and seal units. These units are crucial for the generation and trapping of hydrocarbons, providing a complete petroleum system within the basin.

4. Implications for Exploration

The lithostratigraphic and sequence stratigraphic results provide a comprehensive understanding of the basin’s petroleum system. The extensive distribution of source rocks, reservoir rocks, and seals across the basin suggests significant potential for hydrocarbon accumulation. The identified genetic sequences and systems tracts offer valuable insights into the sedimentary and structural framework of the basin, guiding future exploration and development efforts.

- **Exploration Targets**: The identified LSTs and HSTs present prime targets for drilling and exploration due to their favourable reservoir characteristics.
- **Resource Assessment**: The extensive seal units enhance the probability of successful hydrocarbon trapping, making the basin a promising candidate for further exploration and potential resource development.



- Lithostratigraphic correlation of Formation Tops.
- Flattened on Top Albian.

Figure 2: Lithostratigraphic Correlation between Ayo-1, Ayo-35, and Hontomin-1 Wells.

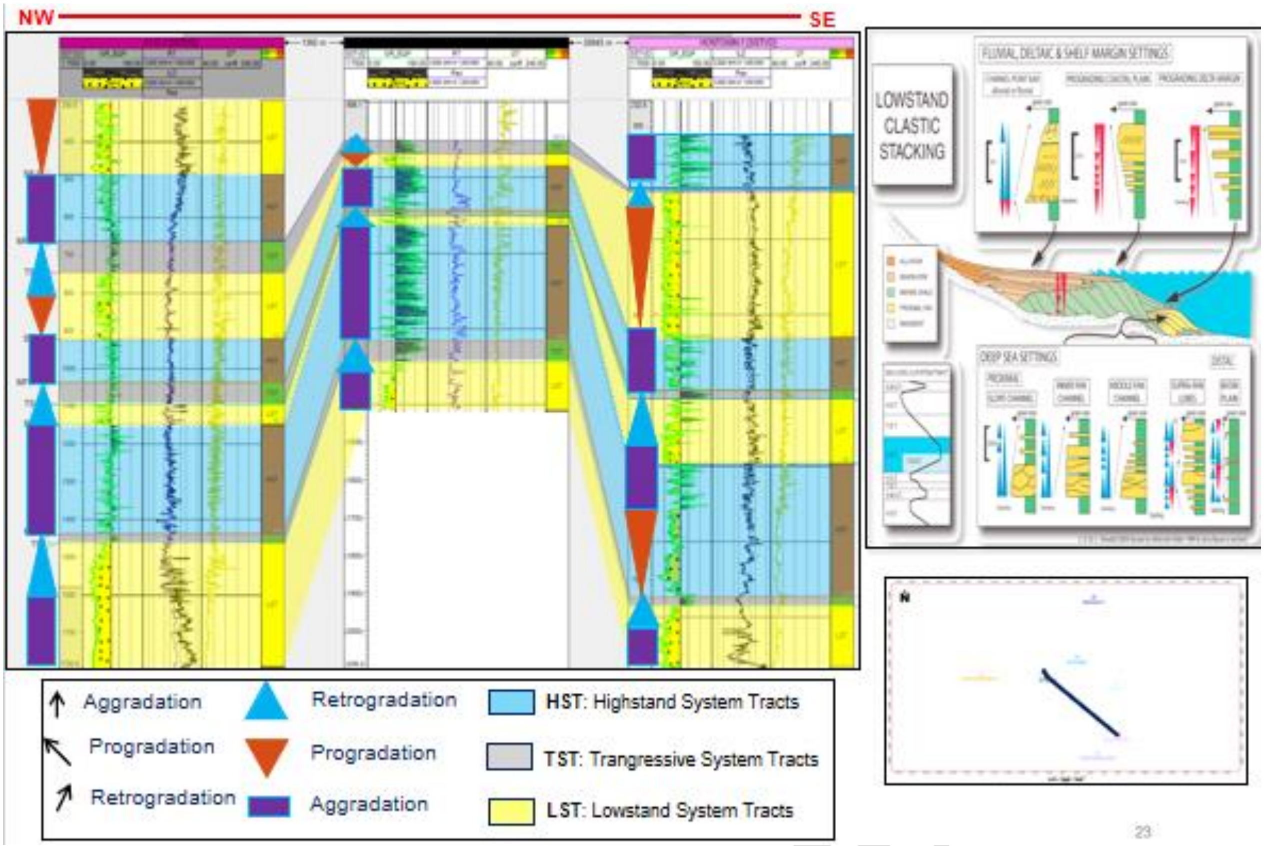
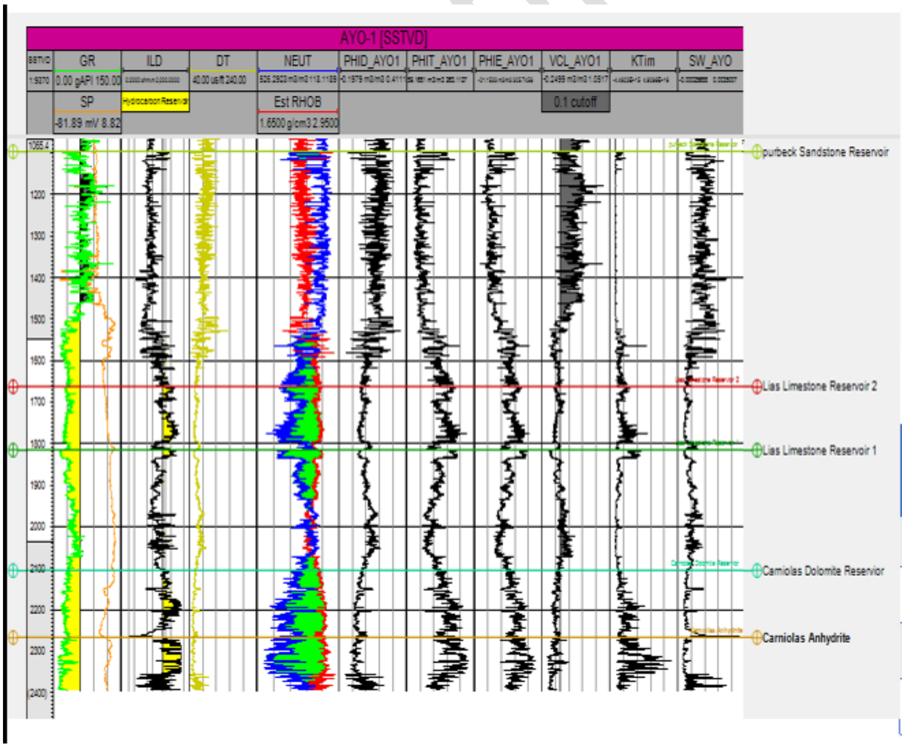
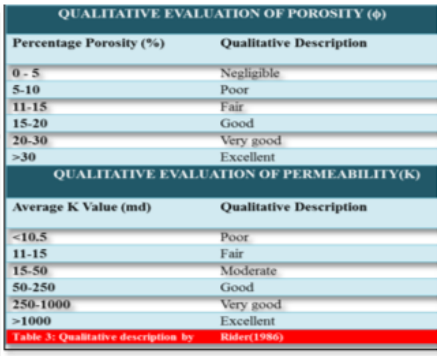


Figure 3: Sequence Stratigraphic Interpretation using Depositional Sequence Model II

Four Reservoir were identify from the formation evaluation





QUALITATIVE EVALUATION OF POROSITY (ϕ)	
Percentage Porosity (%)	**Qualitative Description**
0 - 5	Negligible
5-10	Poor
11-15	Fair
15-20	Good
20-30	Very good
>30	Excellent
QUALITATIVE EVALUATION OF PERMEABILITY(K)	
Average K Value (md)	**Qualitative Description**
<10.5	Poor
11-15	Fair
15-50	Moderate
50-250	Good
250-1000	Very good
>1000	Excellent
Table 3: Qualitative description by	Rider(1986)

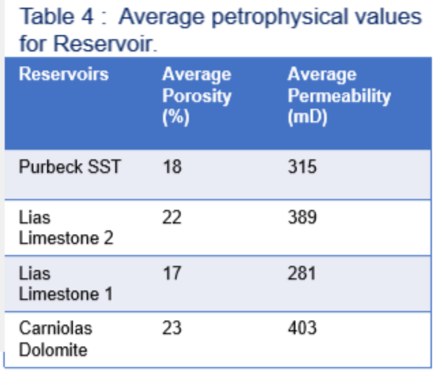


Table 4 : Average petrophysical values for Reservoir.

Reservoirs	Average Porosity (%)	Average Permeability (mD)
Purbeck SST	18	315
Lias Limestone 2	22	389
Lias Limestone 1	17	281
Carniolas Dolomite	23	403

Figure 4: Ayo-1 well showing Petrophysical Logs

From the seismic to well Tie, It has a SEG Normal polarity zero phase seismic data. Ricker 35Hz wavelet, Good tie at well point and all Reservoirs top corresponds to Peaks.

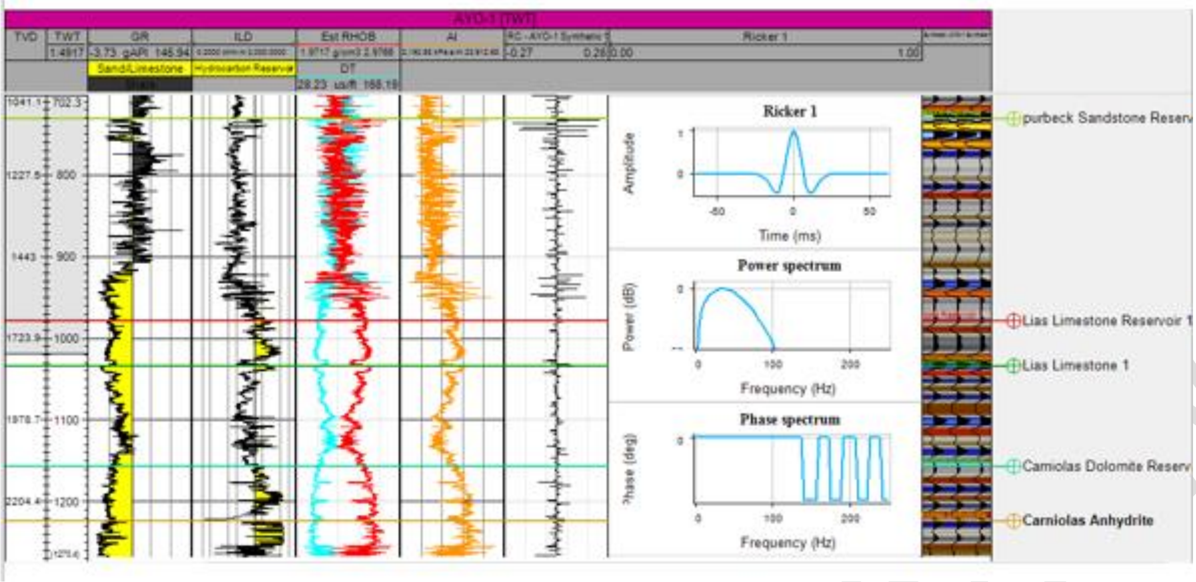


Figure 5: Seismic to Well Tie using Ayo 1 well

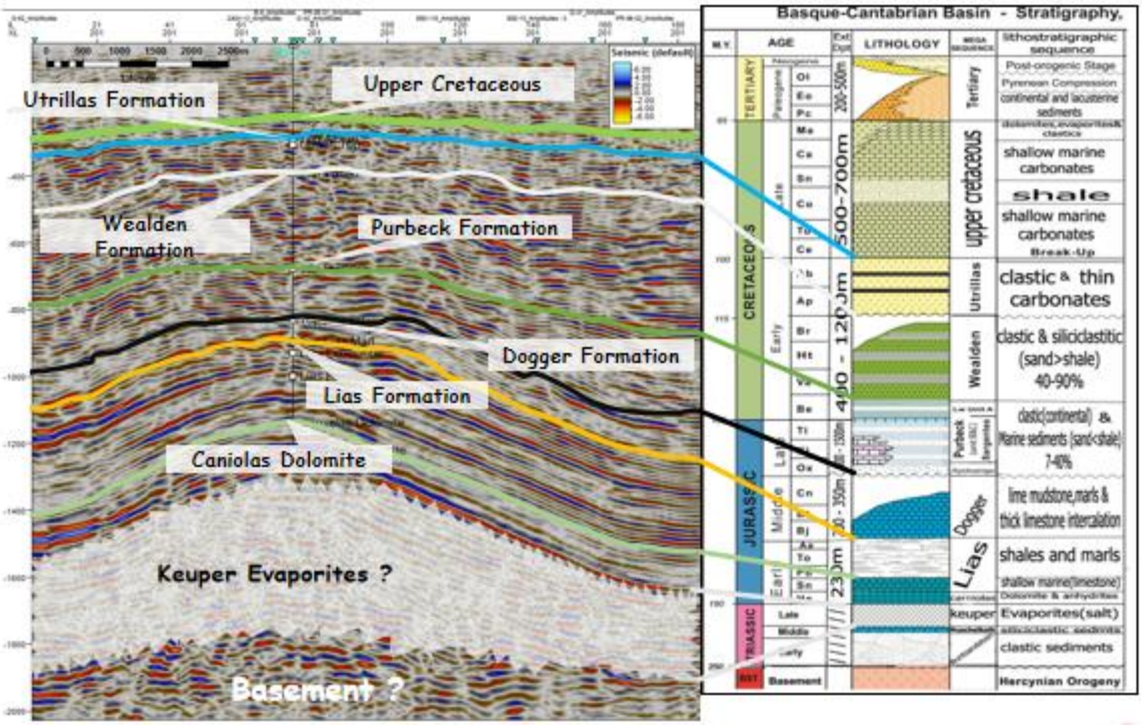


Figure 6: Interpretation of Lithostratigraphic units with stratigraphic chart at Xline 201

The identification and interpretation of these seismic facies provide valuable insights into the depositional environments and potential hydrocarbon-bearing zones within the Ayoluengo oil field. Each facies type offers distinct characteristics that are critical for understanding the spatial distribution of reservoir and seal rocks, as well as the overall petroleum system.

- **Figure 7**: Illustrates the High-Amplitude Convergent (Cbh) and High- and Low-Amplitude Convergent (Cbhl) facies, showing their reflection patterns and potential implications for reservoir characterization.
- **Figure 8**: Depicts the High- and Low-Amplitude Discontinuous, Shingled to Chaotic (Bhl) and Low-Amplitude Convergent (Cbl) facies, highlighting the variability and complexity in sedimentary deposition.

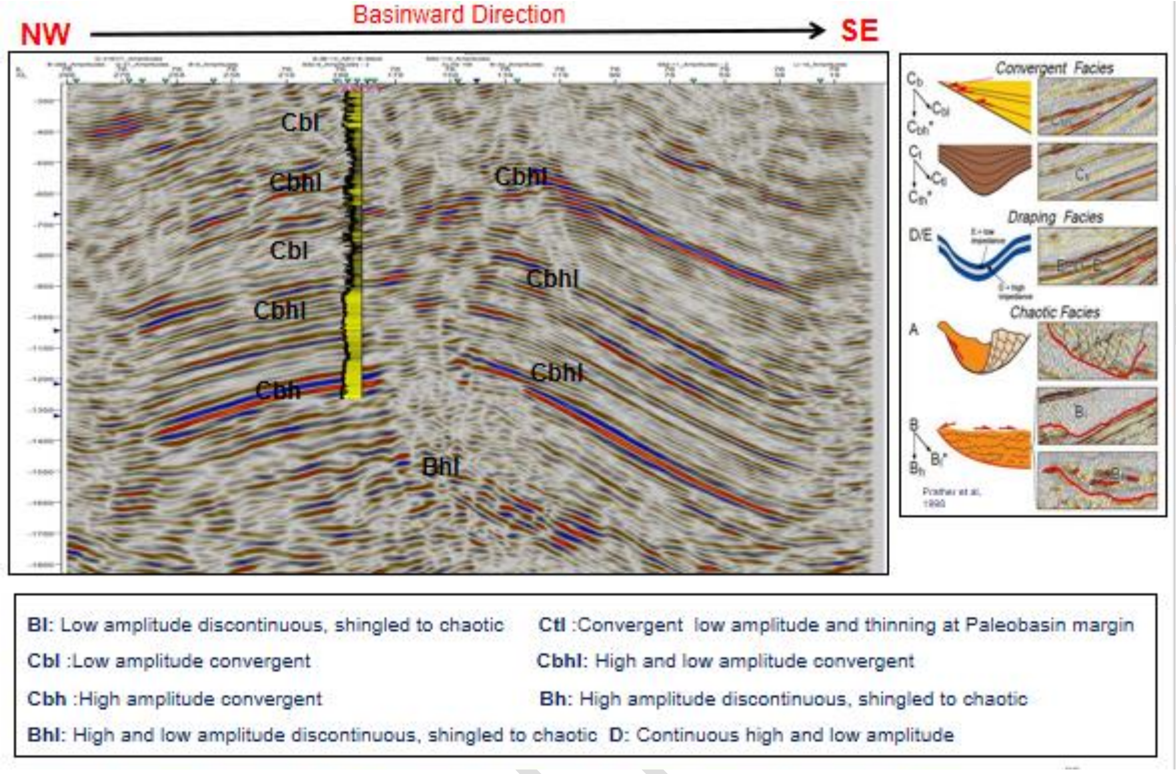


Figure 7: Seismic Facies analysis on seismic Dip Line 76

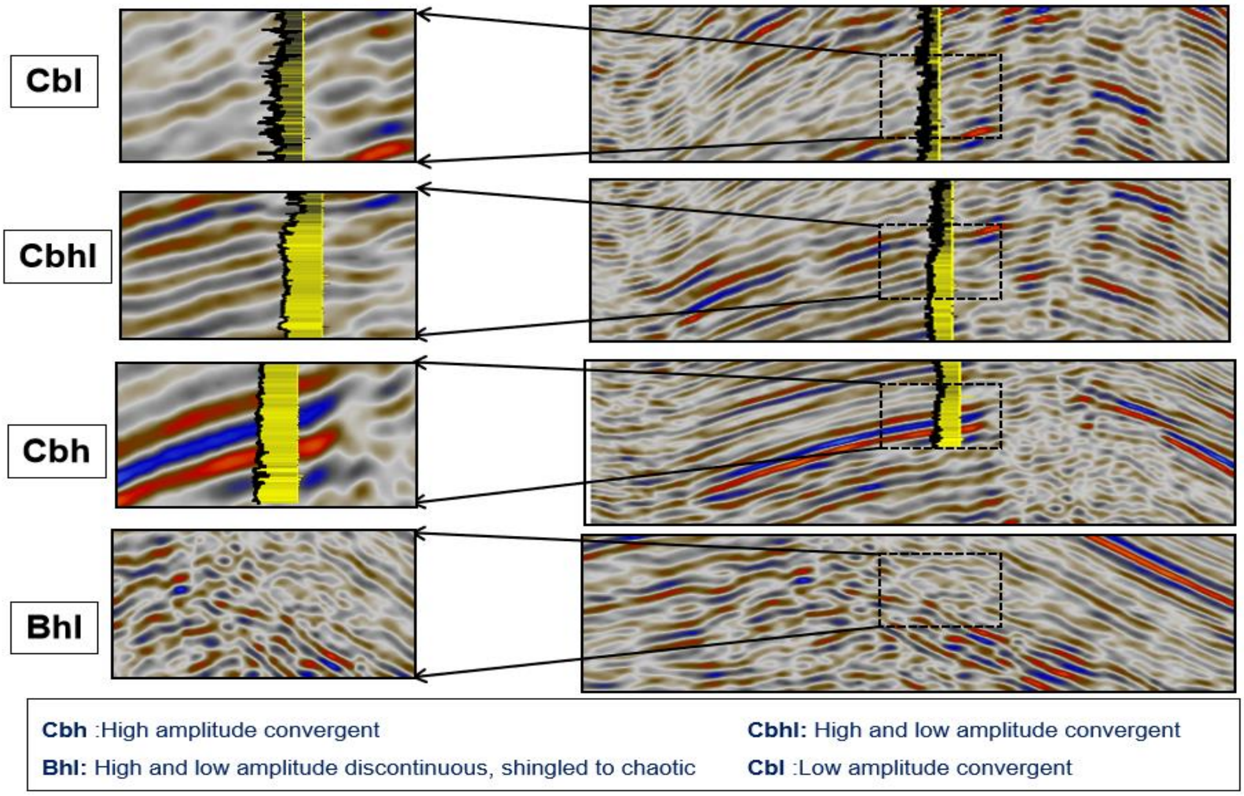


Figure 8: Seismic Facies Interpretation (cont'd)

The ‘CBH’ and ‘CBHL’ seismic facies shows the highest reservoir percentage and therefore ranked higher than other seismic facies identified. (Figure 9)

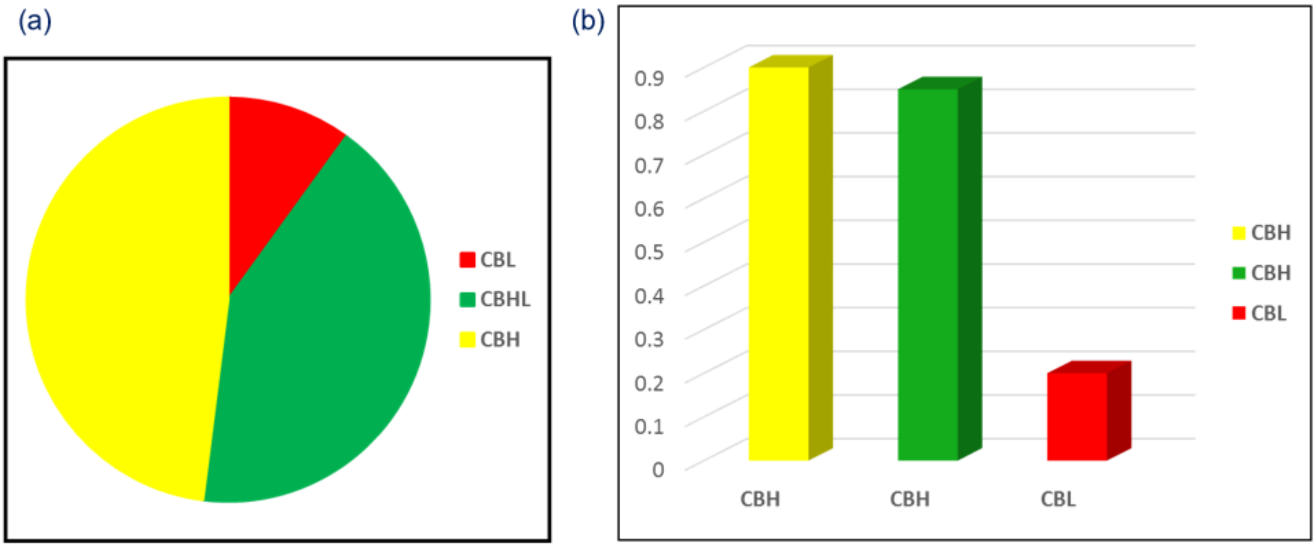


Figure 9: Reservoir Percentage/Ranking of Seismic Facies

In the seismic data interpretations, we observed the Presence of salt diapirs which is a Geologic feature, Reflections terminating against the upwelling feature and Chaotic reflections at deeper section.

1. **Presence of salt diapirs**

- **Description**: Salt diapirs are vertical or near-vertical intrusions of salt that pierce through overlying sedimentary layers. These diapirs result from the buoyant rise of salt due to its lower density compared to surrounding sediments. In the seismic data, salt diapirs are typically characterized by distinct high-amplitude reflections and a characteristic "domal" or "antiform" shape.
- **Seismic Signature**: Salt diapirs often appear as bright, high-amplitude reflections on seismic sections. They can create complex seismic patterns due to their irregular shape and the way they interact with surrounding sediments. The seismic signature includes:

  High-Amplitude Reflections: The diapirs themselves exhibit high-amplitude reflections due to the contrast in acoustic impedance between salt and the surrounding rock.

  Structural Distortion: The presence of diapirs can cause significant deformation in overlying and surrounding sedimentary layers. This often results in warping or tilting of reflections around the diapir, producing an anticline or dome-like structure on the seismic data.
- **Geological Implications**: Salt diapirs can influence petroleum exploration in several ways:

  Trapping Mechanisms: Diapirs can act as cap rocks, creating structural traps for hydrocarbons. They can also create complex trap configurations by folding or faulting the surrounding strata.

  Migration Pathways: The movement of salt can also influence fluid migration pathways, potentially affecting the distribution of hydrocarbons.
- **Figures**: Seismic sections displaying salt diapirs often show these features as prominent, high-amplitude reflections with associated structural deformation in the surrounding strata.

2. Reflections Terminating Against Upwelling Features

- **Description**: Reflections that terminate against upwelling features indicate geological structures where sedimentary layers have been interrupted or displaced due to an upwelling or intrusions, such as salt diapirs, magma bodies, or tectonic activity.
- **Seismic Signature**: On seismic data, these features are observed as abrupt terminations or terminations of reflections at the boundaries of the upwelling feature. The seismic signature includes:

  Termination of Reflections: Reflections may abruptly end or show significant disruption where they intersect the upwelling feature, reflecting the discontinuity or disturbance in sedimentary layering.

  Distortion Patterns: Reflections might be bent, warped, or offset as they approach the upwelling feature, indicating structural deformation.
- **Geological Implications**:

  Structural Analysis: The termination of reflections provides insight into the shape and extent of the upwelling feature and its impact on the surrounding sedimentary layers.

Exploration Considerations: Understanding where and how these features disrupt reflections can be critical for identifying potential hydrocarbon traps or areas of significant geological interest.

- **Figures**: Seismic images showing reflections terminating against upwelling features often reveal clear boundaries or disruptions in the continuity of reflections, illustrating the influence of the upwelling on the surrounding geology.

3. Chaotic Reflections at Deeper Sections

- **Description**: Chaotic reflections in deeper seismic sections are characterized by irregular, non-uniform, and disorganized seismic patterns. These chaotic reflections typically occur in deeper sedimentary layers and can indicate complex subsurface conditions.
- **Seismic Signature**: Chaotic reflections appear as scattered, high-amplitude, and low-amplitude reflections with no clear, continuous pattern. The seismic signature includes:

  Irregular Reflection Patterns: Reflections may appear disordered, with varying amplitudes and irregular geometry.

  Lack of Continuity: Unlike well-defined, continuous reflections, chaotic reflections lack a consistent pattern and do not correlate well with other seismic features.
- **Geological Implications**:

  Sedimentological Interpretation: Chaotic reflections can be indicative of complex depositional environments or structural disturbances, such as those associated with deep-seated salt movements or tectonic activity.

  Exploration Challenges: The presence of chaotic reflections can complicate the interpretation of subsurface geology and make it challenging to delineate potential reservoirs or traps.

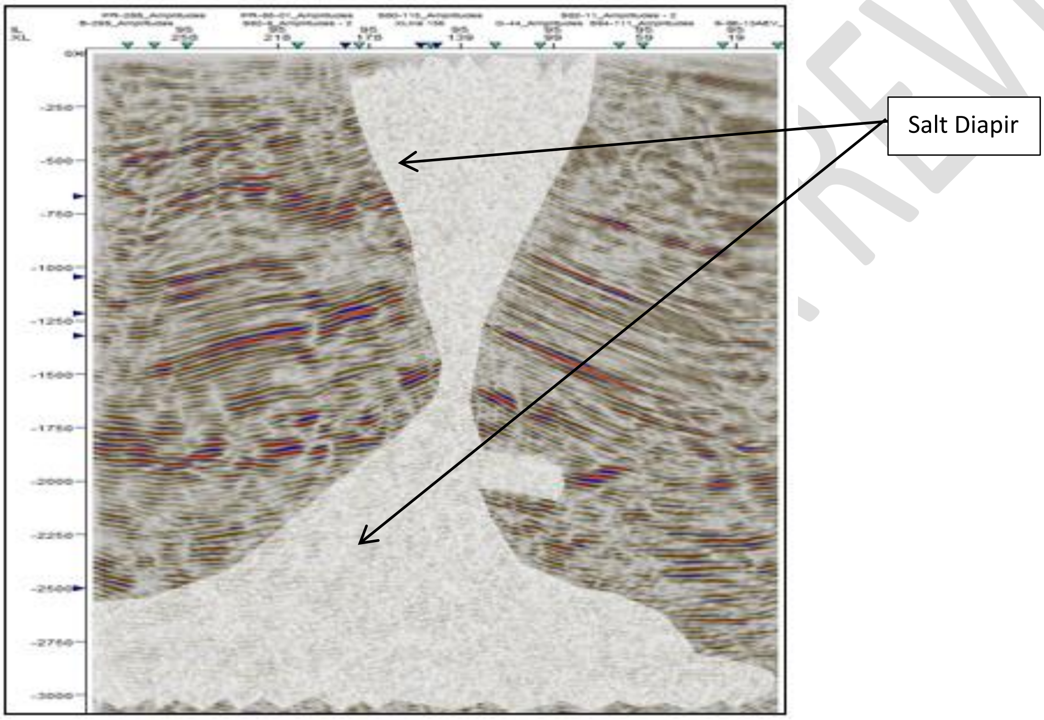


Figure 10: Seismic dip line 95 showing Geologic features

In the Development of salt diapir which was analyzed using variance slices at 900ms, 1184ms, and 1500ms, we observed that faults are not prominent but fractures are present, the presence of Halokinetic structures and folded structures due to salt diapiris.

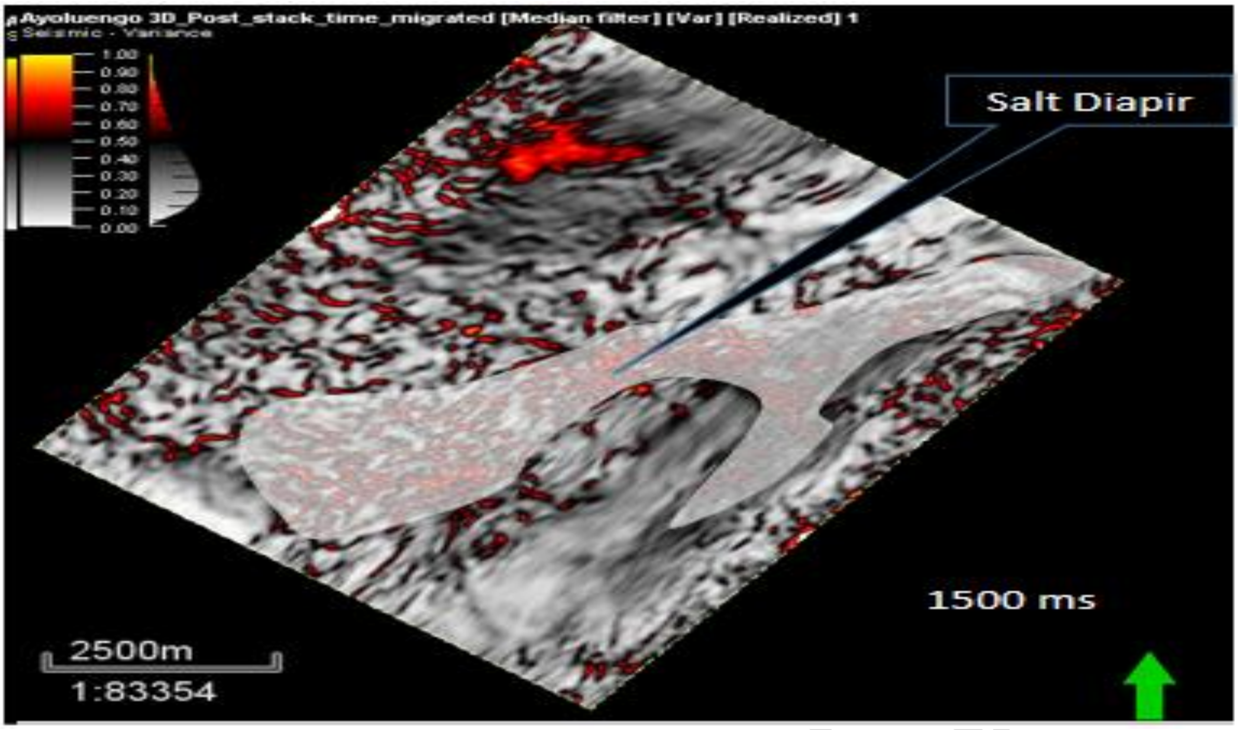


Figure 11: Development of salt diapir analyzed using variance slices at 900ms, 1184ms, and 1500ms

The structural framework interpretation indicates the presence of minor and major normal faults, which play essential roles in migration pathways and hydrocarbon traps. Halokinetic structures and folded structures are also present. The presence of salt diapirs, which is the main structural feature. Four reservoirs were mapped in total. The reservoirs terminate against the salt diapir. (Figure 12)

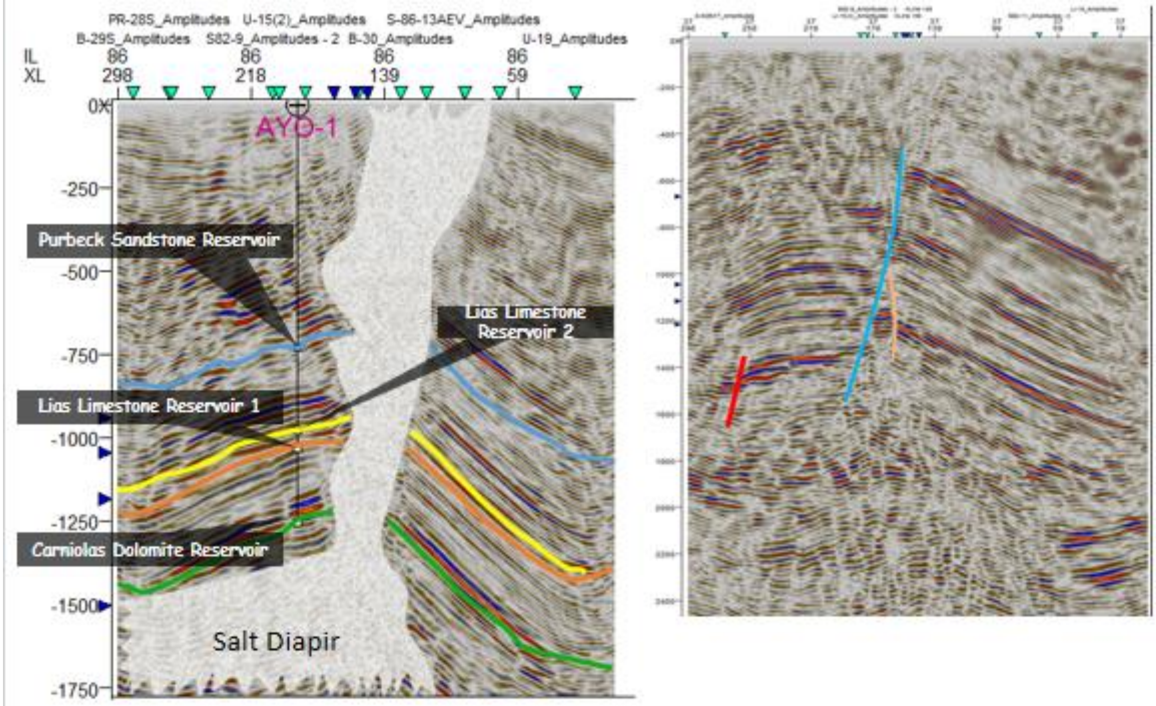


Figure 12: Seismic dip line showing interpreted (a) Horizons and (b) faults

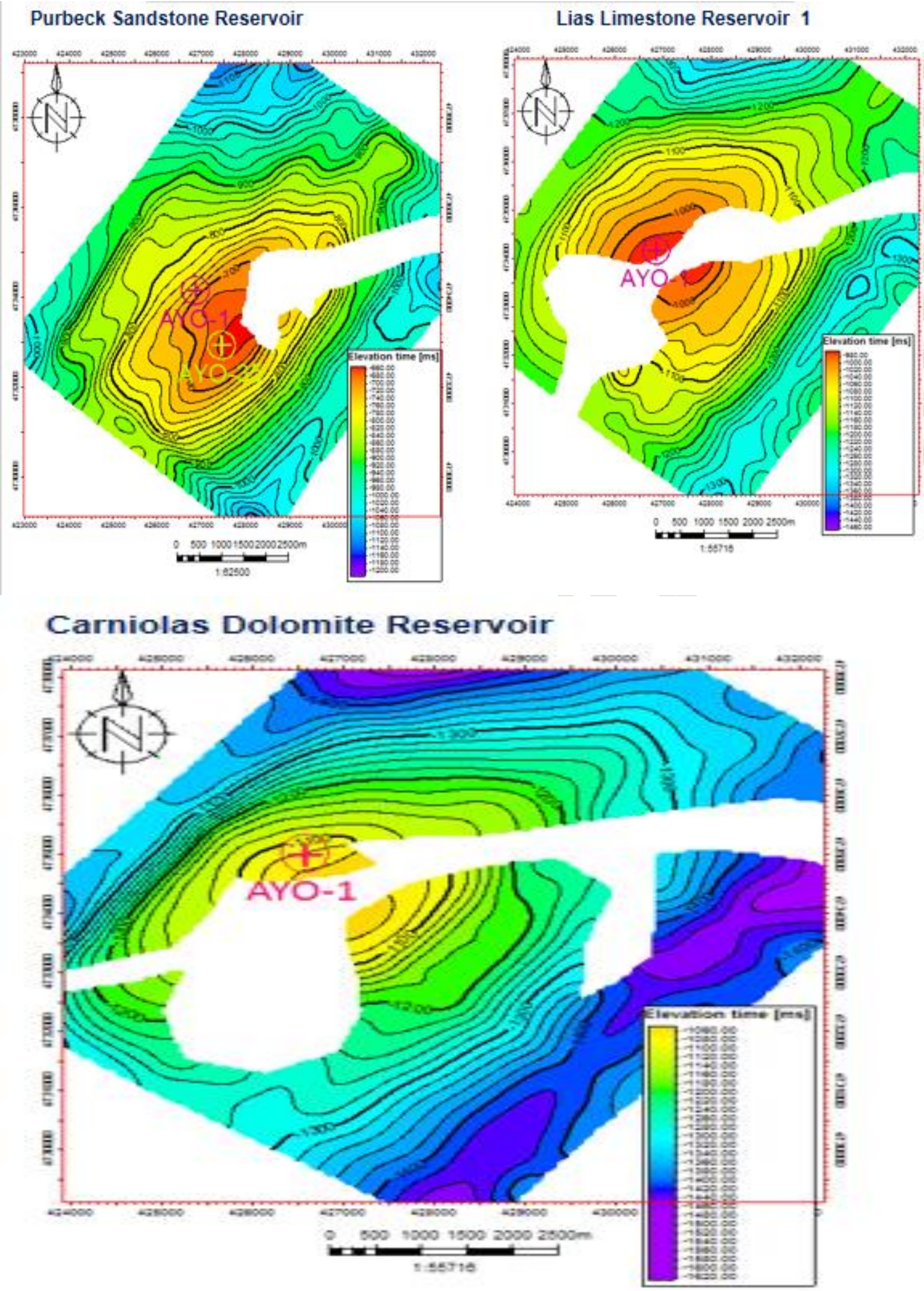


Figure 13: Surfaces generated in Time domain

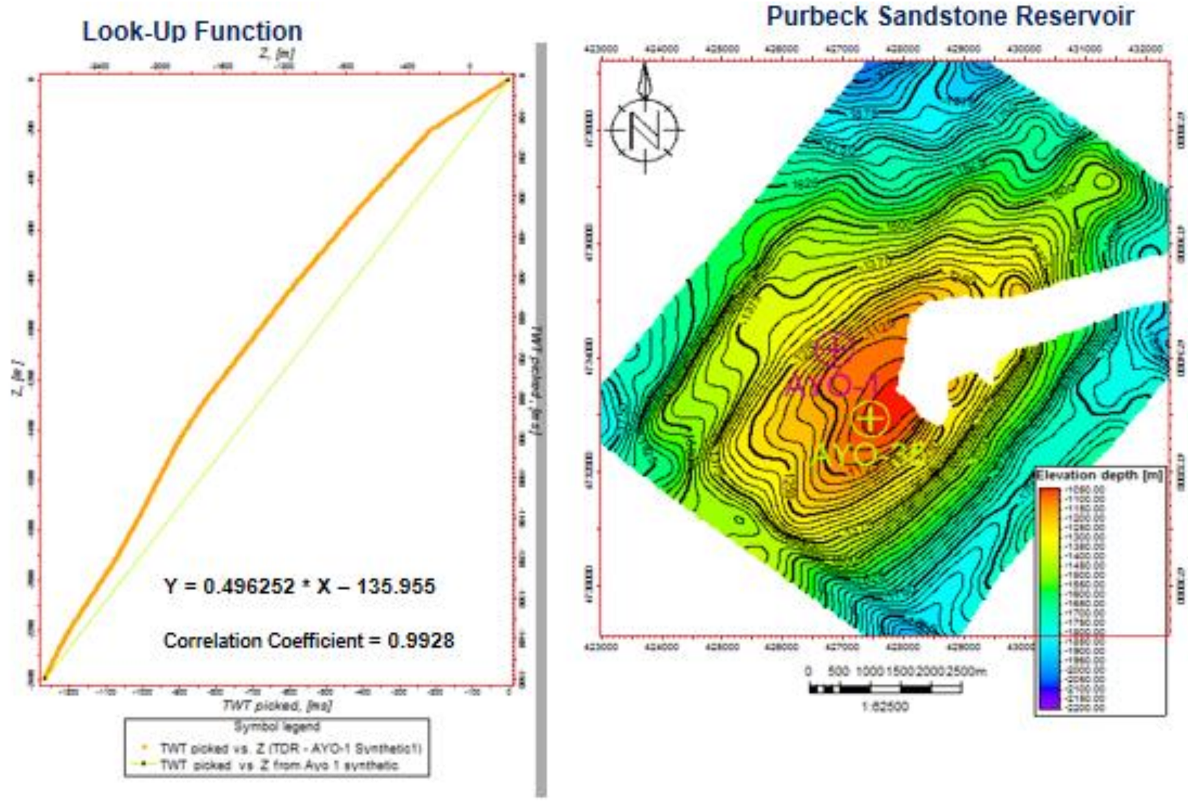


Figure 14: a). Look-up function from checkshot data. B). Depth Surface map of Purbeck Sandstone Reservoir

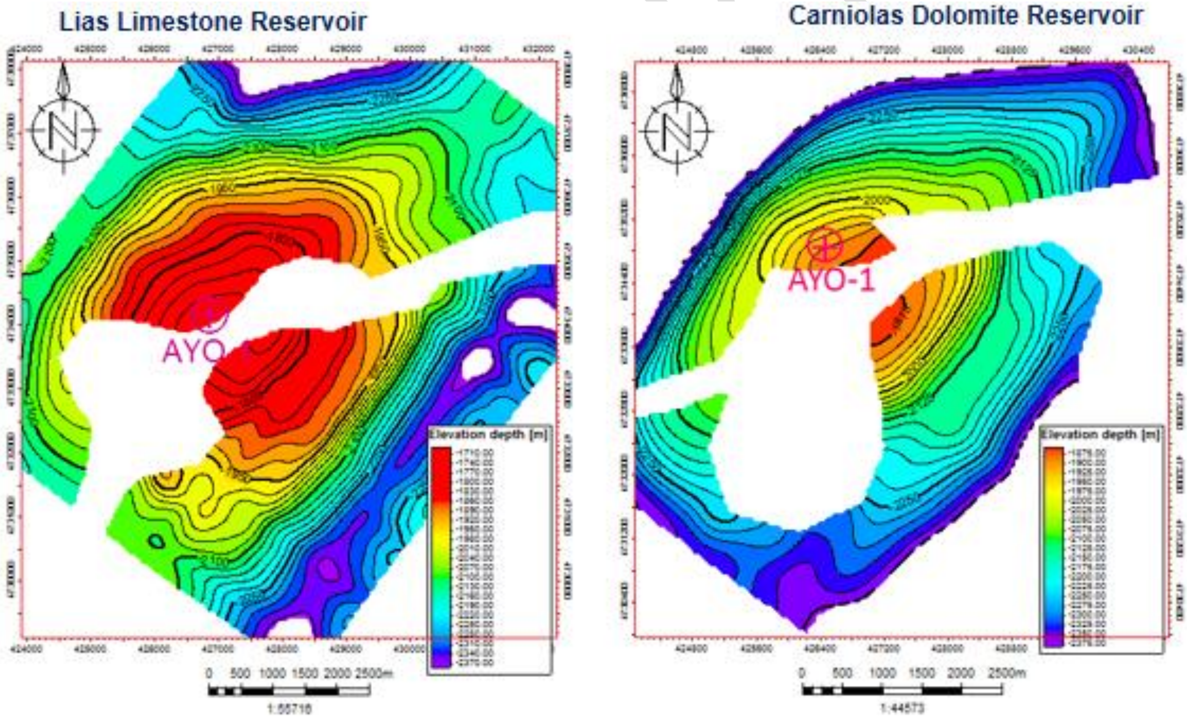


Figure 15: Surfaces generated in Depth Domain

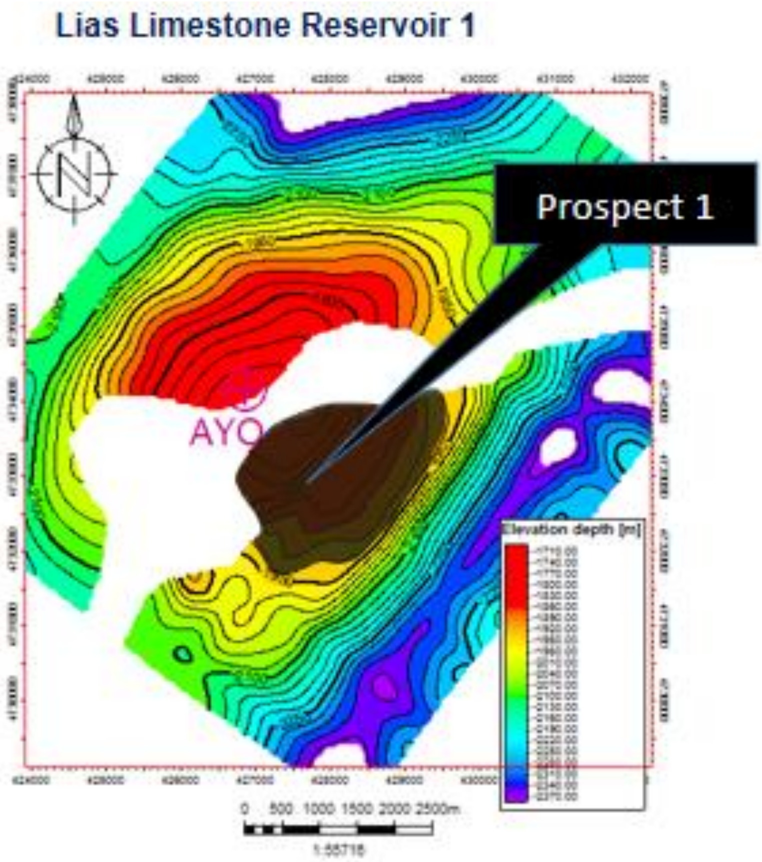


Figure 16: Prospect Identification for Lias Reservoir 1

Prospect Risks

Source Rock (Lias Shale) = 1
-Maturation: thermally mature with Ro of 0.6 – 0.95
Average thickness = 70 m at Ayo-1 well
Average TOC of 3.5 – 5 %
Laterally extensive: penetrated by Hontomin-1, Cantenegro-1, Lora-1
Kerogen Type: Type II
Reservoir (Lias Limestone) = 0.8
Carbonate reservoir ?
Average porosity of 22%
Average permeability of 389mD
Seal (Upper Lias Shale) = 1
Laterally extensive: penetrated by Hontomin-1, Cantenegro-1, Lora-1
Average thickness of 40 m
Average porosity of 0.4%
Trap (Salt Diapir) = 1
3-way closure: Salt bound
Laterally extensive salt Diapirism
Timing = 1
- Surctures already in place before hydrocarbon generation and migration
Geologic Chance of Success = 0.80

Key risk: Overpressure zones due to presence of salt.

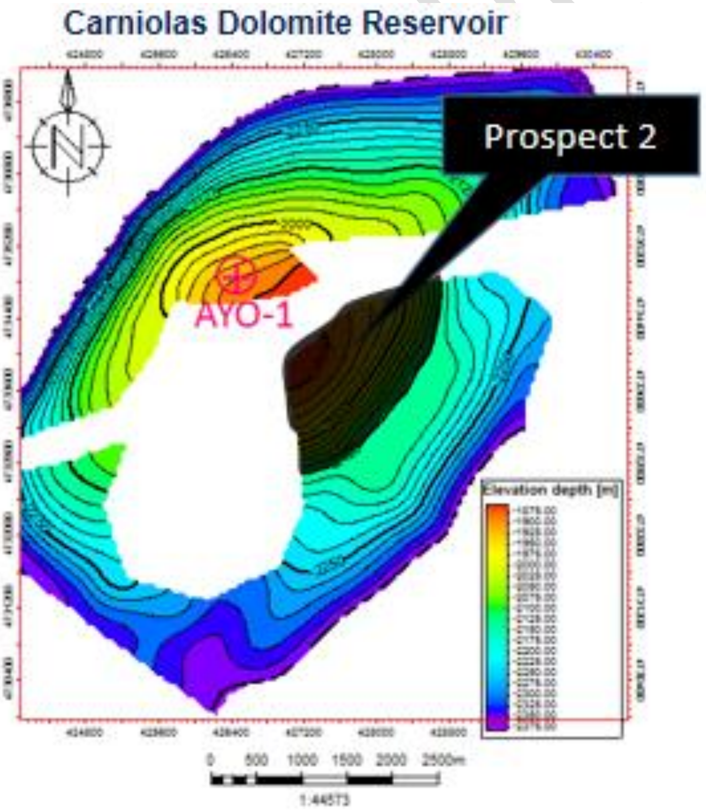


Figure 17: Prospect Identification for Carniolas Dolomite Reservoir

Prospect Risks

Source Rock (Lias Shale) = 1
-Maturation: thermally mature with Ro of 0.6 – 0.95
Average thickness = 70 m at Ayo-1 well
Average TOC of 3.5 – 5 %
Laterally extensive: penetrated by Hontomin-1, Cantenegro-1, Lora-1
Kerogen Type: Type II
Reservoir (Carniolas Dolomite) = 0.85
Carbonate reservoir ?
Average porosity of 23%
Average permeability of 403mD
Seal (Lias Shale) = 1
Laterally extensive: penetrated by Hontomin-1, Cantenegro-1, Lora-1
Average thickness of 70 m at Ayo-1 well
Average porosity of 2%
Trap (Salt Diapir) = 1
3-way closure: Salt bound
Laterally extensive salt Diapirism
Timing = 1
- Structures already in place before hydrocarbon generation and migration
Geologic Chance of Success = 0.85

Key risk: Overpressure zones due to presence of salt

Table 1: Calculation of Volumetrics for **Reservoir 1: Lias Limestone**

Reservoir: Lias Limestone	**P90**	**P50**	**P10**
	7758	7758	7758
Area (m2)	4.1 * 10^6	4.6 * 10^6	5.1 * 10^6
H (m)	65.38	72.65	79.92
Porosity (%)	19.8	22	24.2
Hydrocarbon Saturation	0.9	1.0	1.1
Formation Volume Factor	1.35	1.5	1.65
STOIIP (Bbbl)	**3.4*10^16**	**3.8 *10^16**	**4.2*10^16**

Table 2: Calculation of Volumetrics for **Reservoir 2: Carniolas Dolomite**

Reservoir: Carniolas Dolomite	**P90**	**P50**	**P10**
	7758	7758	7758
Area (m2)	1.1 * 10^6	1.2 * 10^6	1.3 * 10^6
H (m)	142.77	158.63	174.49
Porosity (%)	21	23	25
Hydrocarbon Saturation	0.57	0.63	0.69
Formation Volume Factor	1.35	1.5	1.65

STOIIP (Bbbl)	**1.26*10^16**	**1.4*10^16**	**1.56*10^16**

CONCLUSION

Integration of multiple datasets resulted in the identification of one Plays, and two prospect. Jurassic Play, Lias Limestone Prospect with 80% Geologic Chance of Success, and Carniolas Dolomite with 85% Geologic Chance of Success. Four reservoirs, one major source rock, two regional seal & inter-reservoir seals, laterally extensive salt diapirs acting as traps have been identified. Two Genetic Sequences were identified with their associated Systems Tracts. The LSTs and HSTs are potential reservoirs, the shales of TSTs and HSTs constitute the source/seal units. There were uncertainties in well correlation due to wells located far apart with the closest at 1.3km (Ayo-1 and Ayo-35). The seismic data quality was poor seismic data quality (2D characterized mostly by noise and artifacts). There were uncertainties in depth conversion due to shallow wells. Shallow wells drilled with the deepest at 2397m. The implementation of these will significantly maximize the hydrocarbon potential of the Ayoluengo oil field in the Basque-Cantabrian basin in Spain.

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