[PS]Using Advanced Seismic Attribute Analysis to Reduce Risk in Frontier Exploration – West Newfoundland Offshore*

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Abstract

The study, covering 3D data set from the Western Newfoundland in Parsons Pond area, is of high interest with the estimated potential of 2-4 Billion BOE.

The primary target reservoir consists of the dolomitized carbonate bank of St. George Group of Middle Ordovician age.

The objective is to de-risk a frontier prospect, using the latest seismic interpretation techniques, and to integrate it with the knowledge of regional geology. To identify areas with preferential reservoir properties reservoir characterization techniques were applied. The sequence build-ups and internal architectures were investigated using the digital sequence stratigraphic workflow. Then a neural network based multi-attribute classification is applied to determine the areas of high potential reservoir (dolomitization). In addition, a similarity cube has provided further indications of shear zones and karsting which is critical to identify play productivity. The data were further investigated for signatures of vertical fluid migration that could identify either dolomitization due to hydrothermal brines and/or the presence of leaking hydrocarbons.

The sequence stratigraphy workflow allowed us to break out packages with specific stacking patterns (aggradation, progradation), type of stratal termination and internal architecture of the reflectors. These observations were used to identify zones with prospective reservoir properties.

Hydrothermal dolomitization has been one of the major processes of reservoir development in many areas of North America. As karsting within a formation triggers the dolomitization process, we used seismic attributes and neural networks to identify areas with karst morphology, such as rounded collapse features and radial fracturing.

Analysis of the similarity cube helps in finding areas of faulting, shearing and karsting. The karst features are visible on strata slice through similarity cube at 76 ms below the top carbonate platform.

Neural Network based facies analyses helped us reduce the risk especially related to lithological variations. Identification of the right seismic facies brings us one step closer to the answer but not having a modeled well does not allow us to verify the type of rocks. Instead, the features were interpreted using their morphology to identify sedimentary origin and diagenesis.

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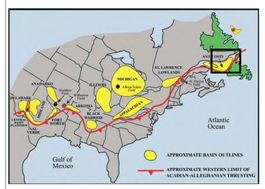
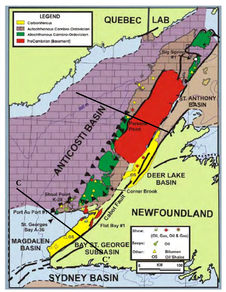
Regional Setting

West Newfoundland is one of the few areas in Canada which has not been explored extensively. Although earlier wells were drilled onshore Newfoundland back in 19th century and numerous oil seeps are present in the area, the offshore part of the basin remained undrilled. The recent interest in all Paleozoic basins of North America and the discovery of extensive reserves in Marcellus, Ellenberger, Knox etc have renewed interest for the basin.

The Appalachian orogeny of late Ordovician to Devonian have produced numerous prolific basins on the hinterland side of the fold and thrust belt. Cambro-Ordovician carbonate banks are prolific throughout the United States and Canada from West Texas to Labrador Shelf.





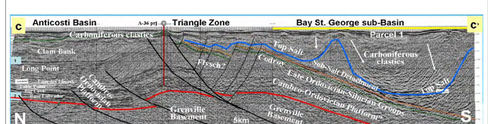
Regional Appalachian Basins

Western Newfoundland's Anticoste basin is on trend with Paleozoic back arc basins west of the Appalachian thrust belt like the Knox, Ellenberger and Beekmantown producing areas.

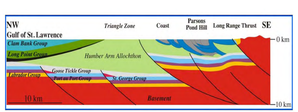
Parsons Pond Area

The study covers 3D data set from the West Newfoundland in Parsons Pond area with hydrocarbon potential of up to 2 to 4 Billion BOE (Government of Newfoundland and Labrador Study).

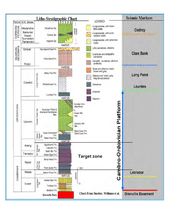
Data available—3D seismic (GSI Inc.) and geological cross-section



Schematic Cross-section Parson's Pond



Some regional discoveries and oil shows in the carbonate bank to the south of the area are encouraging. The position of the carbonate bank is similar to the one in the south and could bear a significant up-side.

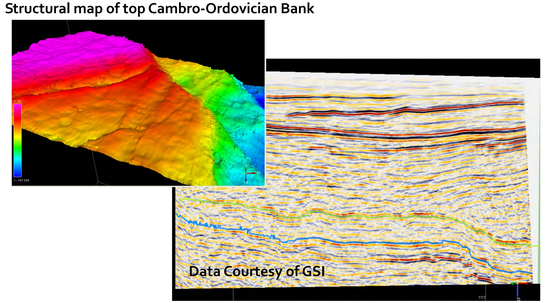


Stratigraphic Column of the Parson's Pond area

Various Reservoir Characterization methods were applied to an offshore 3D. Using the analogues from various basins and defining rock types based on seismic geomorphologic features the exploration risk is better understood. In addition with the help of neural network based chimney analysis (OpendTect), hydrocarbon migration network is detected which also provides another aspect of risk assessment before drilling.

3D Interpretation

Structural map of top Cambro-Ordovician Bank

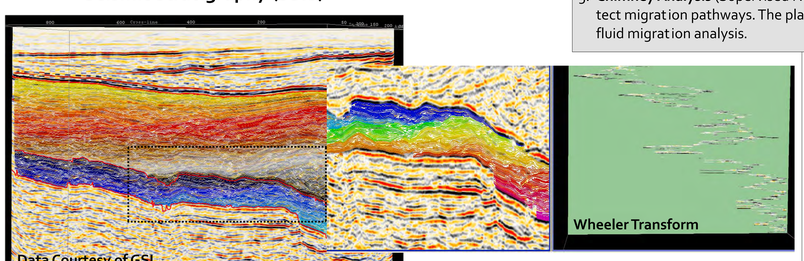


Risk Reduction Workflow

On the basis of regional understanding, the Cambro-Ordovician carbonate shelf is the most prolific zone for hydrocarbon occurrence. Following workflow in the application of Seismic, reservoir Characterization techniques allow us to reduce the exploration risk over the frontier play in Parson's Pond area:

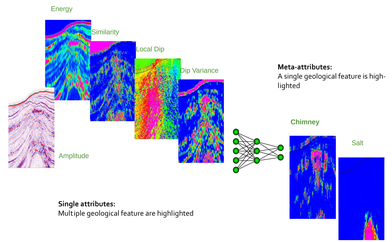
1. **3D Interpretation** and visualization (macro surfaces).
2. **Sequence Stratigraphic Analysis** (Detailed Surfaces) and interpretation validation. There are various layers of carbonate (dolomites) and marls within the carbonate bank which are not parallel to either top or bottom of the unit. Seismic Stratigraphy helps create new surfaces parallel to depositional cycles.
3. **Seismic Geomorphology** over the depositional surfaces become more meaningful and interpretive.
4. Data based **Neural Network Segmentation** (Interval based) to detect the right lithology.
5. **Chimney Analysis** (Supervised Neural Networks) to detect migration pathways. The play integrity is based on fluid migration analysis.

Seismic Stratigraphy (SSIS)

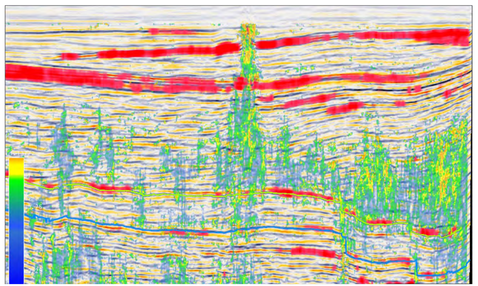


Seismic stratigraphic interpretation (SSIS) provides a framework where more information can be derived about the play prior to drilling. The SSIS workflow allowed us to break out packages with specific stacking patterns (aggradation, progradation), type of stratal termination and internal architecture of the reflectors. These observations were used to identify zones with higher probability of having good reservoir properties. The internal stratigraphy of the carbonate platform shows the prospective facies thickening towards SE. SSIS analysis of St. George Group reveals internal architecture prone to dolomitization.

Chimney Analysis (SNN)



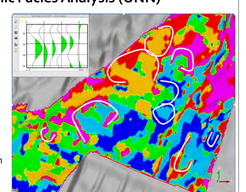
Supervised Neural Network brings the interpretation and attributes together . By using the guided patterns recognized over the seismic section the software creates meta-attributes which help classify the hydrocarbon migration pathways.



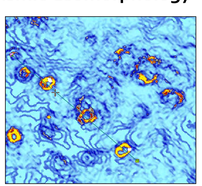
The chimney effect analysis to detect hydrocarbon migration pathways helps understand the petroleum system and play integrity.

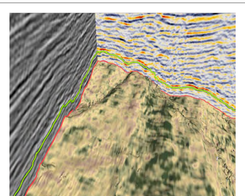
Seismic Facies Analysis (UNN)

Unsupervised Neural Network (UNN) is applied upon the intervals based on sequence stratigraphic bounds. A 50 ms window is used to create segmentation of seismic data. The areas of maximum correlations are grouped in one facies class. Neural Network based seismic segmentation over the zone of interest. Semi-circular features possibly relate to karsting within the carbonate platform.



Seismic Geomorphology





Using the tools of seismic geomorphology along the depositional surfaces the Cambro-Ordovician carbonate bank shows karsting features which are indicator of dolomitization and porosity as seen in Western Canada, Wabamun dolomites.

Conclusions

The risk in frontier exploration can be reduced by analyzing fully the burial history through sequence stratigraphic principles and by finding indicators of right lithology through multi-attribute seismic facies analysis and advanced reservoir characterization.

Reservoir characterization tools have shown great success in the areas of in-fill drilling but are rarely used to detect interpretation integrity and risk analysis for exploration frontiers.

This study explains the schematic application of the integrated reservoir characterization and sequence stratigraphy in Parson's Pond area.

Acknowledgements

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