Introduction

Since 2014, under the new Scheduled Land Tenure System, the Canada-Newfoundland and Labrador Offshore Petroleum Board (CNLOPB) has announced four calls for bids offshore Newfoundland and Labrador, Canada. This area includes the Jeanne d’Arc, Orphan, Flemish, Carson, Bonnition and Salar basins (Figure 1).

\[\text{Figure 1 Area of interest of successive offshore Newfoundland resource assessments}\]

Nalcor Energy Oil and Gas, the provincial energy corporation for Newfoundland and Labrador lead with Beicip-Franlab independent resource assessments of the different areas ahead of calls for bids. Each project aimed at conducting an integrated study, including G&G basin analysis, play risk analysis and resource assessment based on available geological and geophysical data.

In petroleum exploration, understanding the lithological and stratigraphic basin architecture is a key component of a successful assessment. Such detailed 4D evaluation can only be possible with the use of Forward Stratigraphic Modeling (FSM) tools as a fundamental step within the workflow (Figure 2). Indeed, Numerical Stratigraphic modelling is located at the node between each G&G discipline, because this step is of great help to improve, on one hand, the depositional concept, as well as the geophysical observations, and on the other hand, to assess the prospectivity of each Basin (Figure 2).

Moreover, this numerical approach is at the very base of the recognition and definition of the different play systems in the Eastern Canada margin that has seen repeated successful bid rounds.

Methodology and workflows

FSM allows the definition and characterization of reservoir, seal and source rock distribution and their fine heterogeneity in time and space. This is done by assessing the complex interaction between accommodation space, sediment supply and transport through a combined simulation of sedimentary processes including continental to marine siliciclastic sediments, but also carbonates, evaporites and pelagic sediments (Figure 3).
Backed-up by sound geological and geophysical analysis consisting of sequence stratigraphic analysis and Gross Depositional Environment (GDE) mapping, this technology ultimately provides a geocube with various environmental properties such as lithologies (volume of sand, shale or carbonate, Figure 3) but also water energy, bathymetry, etc.
Calibrated to well and seismic data, the model allows testing hypotheses on depositional environment, structural accommodation history, quantitative and qualitative estimate of eroded volume of sediment, sedimentary source dynamics, pathways and sedimentary object styles. From the geocube, facies are interpreted as a function of their environmental properties allowing lateral and vertical extension of the primary sediment packages and geobodies to be addressed. Based on specific environmental conditions such as sedimentation and organic matter degradation rate within the substratum, source rock deposition and preservation can be modeled.

**Study Results and added values**

We present case studies from the exploration of the Eastern Canada margin where FSM was performed using DionisosFlow™ software. Sampling syn-rift to post-rift stratigraphy, clastic to carbonate to evaporitic systems, with facies ranging from shoreface to deep water turbidites. These studies showcase the added value of FSM for oil & gas exploration with:

- An optimal outline of the petroleum play definition based on the 4D distribution of main organic-prone sediments, reservoir and seal with respect to the stratigraphic framework (Figure 4);

![Image](image1.png)

**Figure 4** Forward Stratigraphic modelling results (Wheeler diagram) for play definition

- A detailed lithological understanding of the area for petroleum system modeling to further test hydrocarbon generation/expulsion/migration & entrapment modelling (Figure 5);

![Image](image2.png)

**Figure 5** Hydrocarbon Migration modelling built on calibrated Forward stratigraphic geocube
- A sensitivity analysis approach which consisted of testing alternative realistic scenarios of basin subsidence, erosion and sedimentation. The resulting alternative Dionisos models, all geologically equiprobable, are calibrated to well and seismic data (Figure 6).

Figure 6 Experimental design of alternative, realistic scenarios to construct FSM

- A workflow for geological derisking at prospect scale, coupling FSM with Seismic Reservoir Characterization in order to test reservoir presence in petroleum leads.

- A better assessment of the geological risk (Common Risk Segment mapping), by considering and mapping reservoir/seal presence and effectiveness as well as source rock presence (Figure 7).

Figure 7 Methodology to extract Common Risk Segment maps for a given play

Acknowledgements

Beicip-Franlab is grateful to Nalcor Energy – Oil and Gas Inc. and the Department of Natural Resources, Government of Newfoundland and Labrador for permission to publish the material presented.