EXECUTIVE SUMMARY

PLAY FAIRWAY ANALYSIS PROJECT – OFFSHORE NOVA SCOTIA

2011Nova Scotia Offshore: Play Fairway Analysis
New Geoscience – New Opportunity

Introduction

The history of petroleum exploration in Nova Scotia Offshore spans more than 50 years. During this period, more than 200 exploration, delineation and production wells have been drilled with discovered in place reserves ~2.1 Bboe (billion barrels of oil equivalent). Recent exploration has not been successful. Since 1998, a total of 29 wells have been drilled at a cost of over $1 billion, but with only one commercial gas discovery, Deep Panuke in 1998. The lack of recent exploration drilling success is reflected in the decline in exploration licenses from a high of 59 in 2002 to only 10 in early 2008, most of which have now been relinquished.

Strategy to attract exploration investment

In 2007 the Nova Scotia Department of Energy commissioned a number of studies to investigate the reasons for the decline in exploration with a view to designing a strategy to rekindle exploration interest in the offshore. These concluded that the region has a perception of being a high cost environment associated with high geological risk.

In 2008 the Government of Nova Scotia committed funding of approximately $18 million to the OETR (Offshore Energy Technical Research) Association to enable it to undertake research to support offshore energy development. A significant portion of this (in the order of $15 million) funded the Play Fairway Analysis (PFA) program, with the goal of stimulating renewed offshore petroleum exploration activity.

The Play Fairway Analysis Project

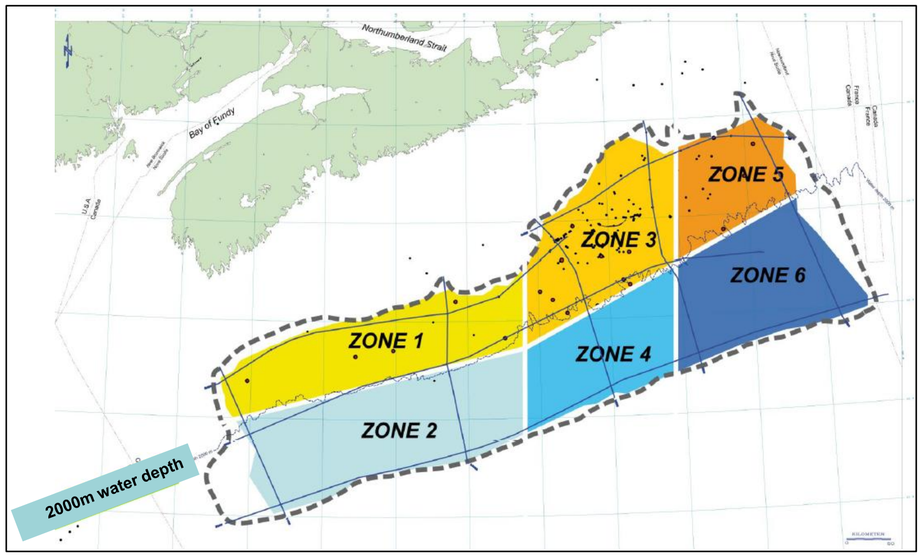
In April 2009, the OETR Association awarded the contract to RPS Energy of the United Kingdom to manage the creation of an industry standard Play Fairway Analysis project for offshore Nova Scotia. The objective of the project is to demonstrate to the industry that there is a commercially attractive hydrocarbon province offshore Nova Scotia.

The core interpretation work and analysis was awarded to Beicip-Franlab in August 2009. Beicip-Franlab also integrated results from a number of special projects. The project recognized that there was a vast amount of knowledge about the offshore geology in Halifax and it was important to incorporate this knowledge into the overall 'Play Fairway' story. The project was therefore split into a number of components in which the Halifax research community was able to contribute their specific technical expertise into an integrated geoscience analysis.

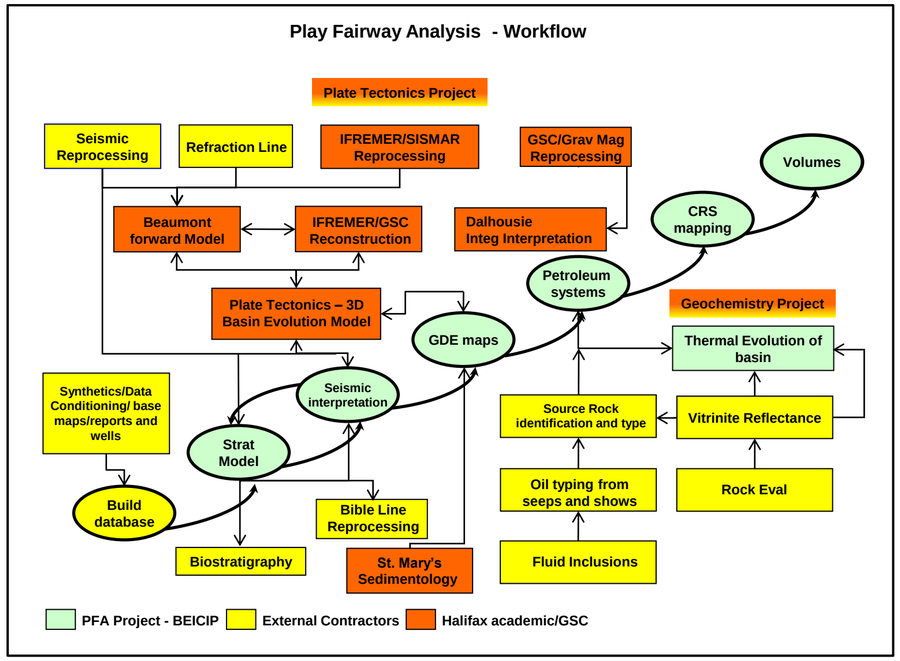
These special projects were combined into an integrated play fairway review. An extensive data base was used as the foundation of the project. This included some 70,000 km of 2D seismic and ~30,000 sq km of 3D. Of particular note are the '20 key wells'. The stratigraphy of these wells was re-constructed from a full biostratigraphic analysis. The wells were tied to a set of 2D 'bible lines' from TGS and GXT. These lines were reprocessed to further enhance the imaging. Of critical importance was the ability to tie the stratigraphy from the slope onto the shelf.

Scale of the oil and gas opportunity: Nova Scotia Offshore

The Play Fairway Analysis (PFA) project has identified rich hydrocarbon potential offshore Nova Scotia with unrisked 120TCF of gas and 8Bbbls of oil in place. This potential has diverse characteristics and scales. In present day shallow water, there is a substantial opportunity for traps with potential for both oil and gas. The shallow water depth makes this attractive to a wide range of oil companies and this opportunity is relatively straightforward to explore.



The PFA has also identified and mapped very large-scale potential traps that could contain gas, condensate and/or oil in present day deepwater. The major innovative result of the work is the prediction of a substantial oil play in the South West of the margin (Zones 1 & 2 below). Using conservative parameters ~3.3 Bbbls of oil in place are predicted in this area (because of the methodology used for this assessment, this figure is likely to be an underestimate). Large-scale gas/condensate opportunities also exist in the proven Late Jurassic and Early Cretaceous clastic plays in the North East part of the margin in deep water (Zones 3, 4, 5 & 6). These plays in deep water will be of interest to the large oil majors, who have the capability and capacity to operate in this challenging environment.

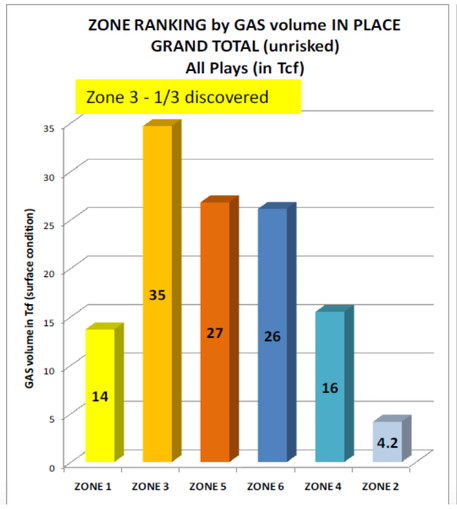


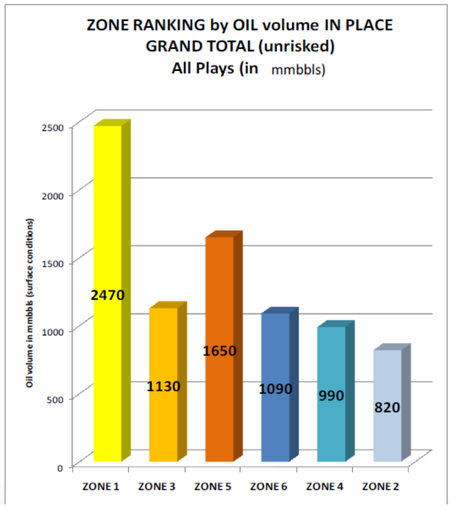
Key Conclusions

There are four important insights arising from the work. Three conclusions address the geological risk and the final, fourth conclusion concerns the potential for hydrocarbon volumes.

Source Rocks

The PFA has developed a model that allows the potential for a regional Lower Jurassic oil prone (Type II) source rock that extends beyond the Sable sub-basin and underlies the whole margin. The presence of this regional source rock is confirmed by isotope and molecular analysis of the oils discovered in piston cores taken along the length of the margin and supported by evidence from offset locations around the conjugate margin system. Analysis of these oils proves the presence of a distinct separate regional source rock. The presence of oil in the piston cores suggests that the source rock is oil prone in the Western half of the Scotian margin. The eastern half is gas dominated as demonstrated by the existing production although with the potential of an oil rim round the Sable Sub Basin.





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Reservoir Rocks

The presence of reservoir rocks in the Sable area is proven. Detailed sequence stratigraphy along with seismic analysis has developed predictive models for four reservoirs that form the main play fairways for the margin:

- Mic Mac Upper Jurassic Delta sequence in the North East of the margin.
- Baccaro Carbonate Bank forms the reservoir for the deep Panuke field. This reservoir extends to the west along the 'shelf edge'.
- Two Lower Cretaceous Delta sequences are the producing reservoirs in the Sable sub basin. The PFA has developed a model to predict reservoir/seal distribution in the Sable region itself, and with the use of sediment distribution models combined with seismic attributes can predict reservoir into the deep offshore as well as further west and east along the margin (Huron Sub-basin; see location Map - Zone 5).

Note that Logan Canyon and Wyandot reservoirs were not included in the present study.

These four play fairways are proven and with the revised source rock model and de-risking approach are attractive. In addition to these plays the PFA has identified untested reservoirs in the Western part of the basin in the area of the oil prone source rock.

Petroleum Systems Modeling

The 3D petroleum systems model identifies target areas by determining source rock type and maturity at the present day. The following two statements can be made as a result of this modeling:

1. The Lower Jurassic source rock is generating oil today in the Southwest part of the margin. In the Eastern part of the margin it went through the hydrocarbon generation zone earlier and is over mature at present day.
2. The main source rocks for the Sable sub basin fields is the upper Jurassic Tithonian sequence and is in the gas window today. The basin shallows at the margins and in the shallow region of the basin, the source rock is in the oil window. Therefore there is the potential for an 'oil' rim round the Sable delta and Huron sub-basin. This is a credible oil play, which exists in shallow water and is under-explored.

Yet to Find and Prospect Sizes

The confident identification of two major source rock systems (deltaic and restricted marine) enables an assessment of the volumes of hydrocarbons generated. The modeling work indicates an unrisked 120TCF of gas and 8 Bbbls of oil in-place. The volumes of generated hydrocarbons are substantial and sufficient to fill large structures that can be seen on the seismic data.

Exploration Sweet Spots

The Composite Common Risk Segment (CCRS) mapping exercise has highlighted the following prospective areas.

Mature and Shelf Exploration

1. The Sable Sub Basin has significant remaining Yet To Find. The Upper Jurassic and Lower Cretaceous deltas are prospective in this region. A number of relatively small undrilled dip closed features are in the vicinity of the existing infrastructure.
2. The main Sable plays extend to the East of the Sable sub-basin and extends to the Nova Scotia/Newfoundland border (Huron sub-basin). The area is under explored with most of the wells drilled in the 1970's on poor quality 2D data.
3. The Baccaro carbonate bank and clastics also form attractive plays to the West of Sable where they would be sourced by the oil prone Pliensbachian source rock.

Deep Water and Frontier Exploration

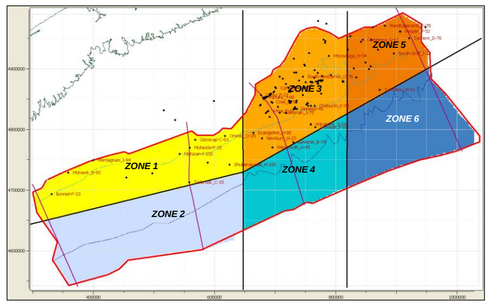
1. The PFA has identified the exciting possibility of an oil play in deep water in the South West of the margin. The area is underlain by the postulated Lower Jurassic source rock, which is in the oil window today. Reservoirs are provided by Lower Cretaceous turbiditic sands that are seen on the seismic and are predicted by facies modeling.
2. The deep water of the Sable Delta and to the `North East is more gas prone, but contains significant undrilled features. The presence of a non commercial gas discovery (Annapolis) shows that the play works. The PFA has developed models to de-risk reservoir distribution in this area using seismic attributes.

Key play risks

A summary of the plays and their play risks is shown in the Table below. This analyses each play sequence in terms of gross environment (delta top, delta front etc.) and by geographic zones. It is clear that the lowest risk plays are in Zones 3 & 5 where the system is proven. The oil prone Zones 1 & 2 are shown as moderate risk as they rely on existence of the predicted Early Jurassic marine source rock (likely to be Low Risk) and secondly the ability to locate reservoirs in the South West.

The PFA has demonstrated that there is significant potential untapped offshore Nova Scotia **(~120 TCF of gas and 8 bnbbls of oil in place and unrisked)** that warrants the attention of industry.

Age	Formation	Facies	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Middle Jurassic	Mohican	Clastics						
	Baccaro	Reef						
		Slump						
		Oolites						
Upper Jurassic	Mic Mac	Delta top						
		Delta front						
Berriasian	Lower Missisauga	Delta top						
		Delta front						
		Turbidite						
Valanginian	Middle Missisauga	Delta top						
		Delta front						
		Turbidite						
Barremian	Upper Missisauga	Delta top						
		Delta front						
Aptian	Logan Canyon	Delta top						
		Turbidite						
Albian		Low stand						



Legend

- Play absent
- Play high risk
- Play medium risk
- Play low risk