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Renewed Exploration and New Insights into the Slope and Deep Water Regions of the Flemish Cap and Labrador Sea, Offshore Newfoundland and Labrador, Canada

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Summary

Exploration initiatives over the past 4 years have led to renewed interest in exploration in the Slope and Deep Water Regions of the Flemish Cap and Labrador Sea areas, offshore Newfoundland and Labrador, Canada. New multi-client regional 2D seismic surveys (2011-2014) guided by satellite slick mapping have led to approximately 80,000 line kms of long offset, broadband 2D seismic data acquired in areas where possible hydrocarbon seepage and new exploration leads suggest working petroleum systems (likely oil) in unexplored frontier basins. Commonly these are areas with limited or no seismic data coverage prior to these surveys. The goal for this phase of data acquisition was to provide new data to better understand the petroleum potential of these frontiers. In conjunction with the seismic data acquisition, Nalcor Energy has initiated a number of important geoscience studies to build on this new knowledge base and help to de-risk exploration in these areas. These regional studies include met-ocean, biostratigraphy, seabed coring and geochemistry projects as well as regional geopressure and rock physics studies. These studies aim to assist in providing foundational insight to the regional operational and subsea risks, as well as reasonable insight into the observed AVO effects within Tertiary and Cretaceous fan complexes that are imaged in the new seismic data. In addition, a multi-year, multi-client Controlled Source Electromagnetic (CSEM) survey by EMGS started in 2014. This CSEM survey has calibrated the EM inversions to the existing discovery wells and old dry holes in the Flemish Pass Basin and covered interesting leads and prospects on the 2015 Call for Bids area of the basin. The results of these initiatives are in the process of being integrated into identification of leads and prospects that will ultimately become the basis of a regional resource assessment that begins its first phase in mid-2015. This integrated approach to regional exploration data collection will act as a template for future work in other Newfoundland and Labrador offshore areas.

Introduction

Covering an area approximately ten percent larger than the U.S. Gulf of Mexico (over 600,000 km^2) the Canadian Labrador Sea region and East Orphan - Flemish Cap areas remains largely under explored. Dormant exploration activity has led to a 30 year gap over some regions in acquiring large regional data for exploratory purposes. In 2009 Nalcor Energy and Airbus (formally Astrium) engaged in a satellite survey of the Labrador Sea to map surficial, naturally occurring hydrocarbon slicks throughout the eastern margin of Newfoundland and Labrador. Results from that work led directly into a proposed Nalcor invested and partnered TGS-PGS multi-client 2D regional seismic survey into the deep-water extents of the Labrador Sea and over the Orphan and Flemish regions (Figure 1). As of 2014, this new regional long-offset seismic survey has now added over 80,000 line kms of high quality 2D seismic

data to the area. Early interpretational results of that data have forced a revision of the regional model including extended limits to the Mesozoic depo-centres in the slope and deep water of the Labrador Sea.

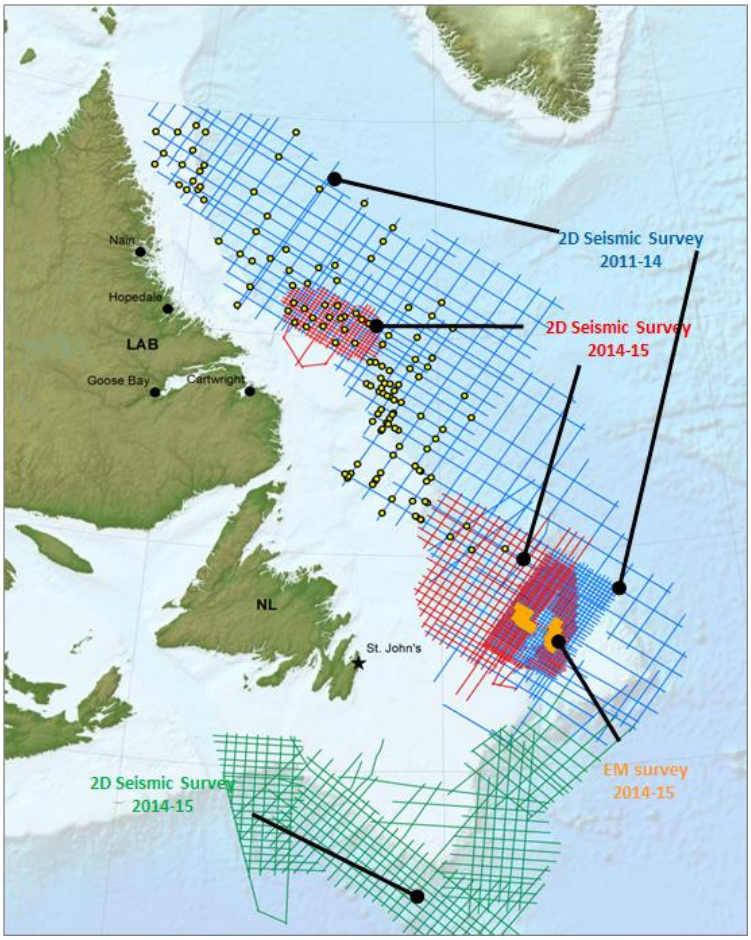

Figure 1 – Newfoundland and Labrador offshore areas, showing the different surveys Nalcor has participated in this year, Satellite slick mapping, more regional seismic coverage, an EM survey, and incorporating the area in which the geopressure, rock physics and basement mapping projects were conducted. Yellow dots are proposed or acquired seabed coring locations.

Initiatives

Through the acquisition seasons of 2011 through 2014, new long offset 2D broadband Geostreamer seismic data was acquired covering the Labrador Sea shelf, slope and deep water regions (Figure 1). A large percentage of the survey in areas of the Labrador Sea were never before imaged by seismic. Seismic data acquisition will continue in 2015 stretching the regional coverage into the southern regions of the Newfoundland offshore. Insights from the data have then led to the initiation of a number of studies including continued satellite seep assessment, regional geopressure, regional rock physics, the acquisition of CSEM data, and the use of on-board gravity acquisition to help with potential basement definition.

Satellite seeps surveyed along the Eastern Margin of Newfoundland and Labrador have been used to map naturally occurring hydrocarbon slicks identifying potential presence of active petroleum systems in these frontier basins. The early results from this study provided an encouraging proof of concept example where a mapped slick was present over an oil discovery and a seismic line through the discovery well indicated the presence of vertical hydrocarbon migration from reservoir to the seabed (Figure 2). This blind test provided enhanced confidence to utilize the slick mapping technology to plan data acquisition programs targeting frontier areas for hydrocarbon potential. Many seeps have been identified over the past few seasons, with some regions showing repeatability.

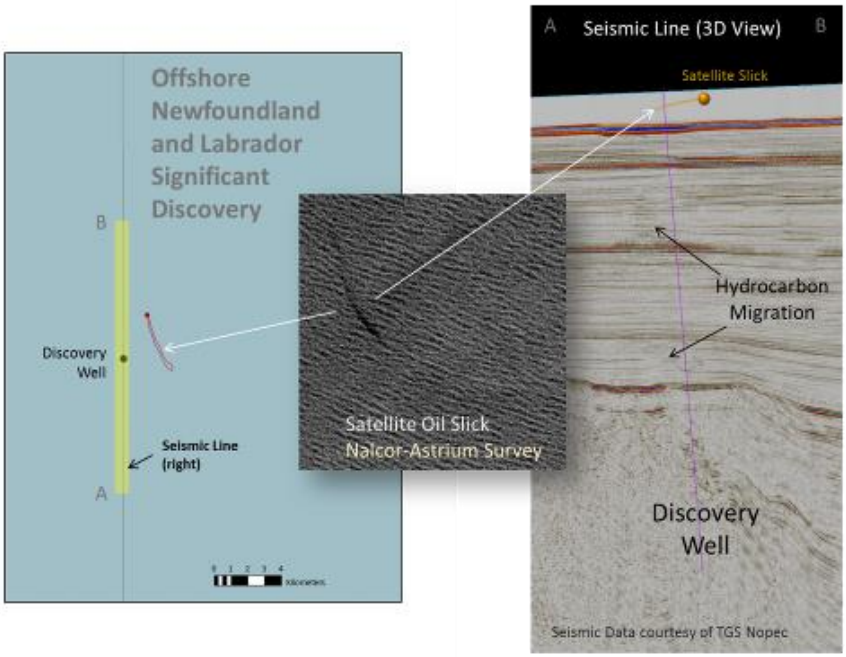

Figure 2 – Example of a blind test for the satellite slick mapping program, showing the slick, the associated seismic, and the satellite image.

A regional geopressure study was conducted (IKON Science) in order to examine and interpret pressure and related data from wells drilled on the Labrador Shelf. The area studied included the Saglek, Hopedale (including Nain, Hamilton and Harrison sub basins) and Orphan basins, and additionally the newly mapped aerial extents for the slope and deep-water Henley, Chidley, Hawke and Holton basins (Carter et al., 2013) where there are no wells drilled to date. The objective was: (a) to provide a framework for future drilling by helping to define the elements of the drilling window (pore and fracture pressure) and (b) to examine how pressure data may improve the quantification and exploration risk of future prospects by, for example, analysis of the risk for mechanical seal failure. A further objective of this study has been the utilization of analogues from either present or ancient deep-water settings globally to help understand how relationships in the shallow water manifest in the deep-water. Using a combination of theoretical modeling based on offset relationships, and seismic interval velocity data the study has produced five vertical pressure profiles termed TPP's. Overall, the profiles suggest that in the deep-water, pore pressures will be in a higher range relative to the shelf with narrower drilling windows, which is typical of deep-water environments globally.

A regional rock physics study has also been undertaken with IKON Science in order to establish some fundamental understanding of the relationships between the elastic properties, as sensed by the seismic wave, and the rock properties measured in the well. By coupling these two domains we have created site-specific rock physics models that reconcile the well data, seismic data and theory for use in forward modelling scenarios to match seismic anomalies. The models, applicable for uncemented and slightly cemented sediments, are based on a hybrid approach, where we combine theoretical and heuristic models to describe medium to high porosity clastic sediments. The strength of these models is that the physics behind them are understood and theoretically generalized, hence making them a powerful tool for extrapolating outside well control to match seismic amplitudes of interest.

EMGS has completed year one of a comprehensive multi-year, multi-client campaign to acquire 3D wide-azimuth CSEM and 3D Magnetotelluric (MT) data over the Flemish Pass and Eastern Orphan basins. The 2014 campaign covered the North Flemish Pass and eastern-most Orphan basins including the Mizzen, Harpoon and Bay du Nord discoveries as calibration points. CSEM measures the electrical properties of the subsurface from the seafloor, in a similar way as logging tools measure the formation resistivity in wells. The calibration data acquired over known wells show that integrated interpretation of

resistivity volumes together with available well information and recent 2D seismic data provide an excellent tool to identify and de-risk leads and prospects in the Flemish Pass basin. EM techniques can also give an indication of resistivity trends and information of deep resistors to improve the geologic model of the complex structural and depositional geology of the East Canada Flemish area.

At the crustal-scale, gravity data can provide information on crustal structure while also helping to hone the seismic interpretation along the newly acquired seismic reflection lines. While well ties from the shelf allow interpreted syn-rift, drift, and post-drift intervals to be extrapolated to slope and deep water regions, due to the variable nature of the basement and overlying strata, the character of the basement marker can change from fault block to fault block resulting in local confidence in the correlation of the horizon, but less confidence between faulted regions using seismic alone. Consequently, gravity data modelling was incorporated into the seismic interpretation process in order to help refine the range of depth to basement and hone the interpretation to allow for regional mapping of the rift package thickness. The integration of these two data types has resulted in the revision of basement trends, has led to the refinement of the basin extents and thicknesses, and has provided further constraints on crustal thickness variations along the Newfoundland and Labrador margin.

Conclusions

Recent activity and technical work offshore Newfoundland and Labrador will continue to unlock and minimize the risk in exploration for years to come. The integrated approach to data collection underpinning the broad regional studies discussed above have identified new exploration fairways along the margin and have begun to reduce risk in key elements of prospectivity. While further investigation is required, the results of these initiatives have led to identification of leads and prospects that will ultimately become the basis of a larger regional resource assessment. This approach will be applied in other areas of the Newfoundland and Labrador offshore in years to come.

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