New Lower Tertiary play trend identified in the West Orphan Basin, Offshore Newfoundland

Richard Wright, James Carter, Ian Atkinson, Erin Gillis, Deric Cameron, and Leona Stead, Nalcor Energy*
Tom Neugebauer, TGS
Jerry Witney, PGS
Daniel Hughes and Michael Hall, Airbus Defence and Space

Summary

Over the past five years, extensive 2D long offset broadband seismic data (110,000 line km) has been acquired offshore Newfoundland and Labrador, Canada. These new seismic programs have targeted the underexplored slope and deepwater areas of the province's offshore and were planned using potential fields and satellite seep data. In the West Orphan Basin portion of the program, a new Lower Tertiary fan and turbidite play trend has now been identified. This newly identified play trend is characterized by Class II AVO signatures and was not visible in legacy short cable seismic data. To further delineate this area, a 3D long offset broadband seismic survey was acquired over a part of this play trend in the summer of 2015 and the early data from the new 3D has provided enhanced definition of the depositional setting and sediment pathways, provided evidence of potential hydrocarbon sourcing and migration, and has imaged material sized prospects.

Introduction

Newfoundland and Labrador's large offshore of 1.5 million square kilometers contains significant regions that are underexplored, particularly in the slope and deepwater areas. To better understand the potential for hydrocarbon source rock presence throughout the frontier offshore area and to prepare for planned regional 2D seismic programs, in 2010 Nalcor and Airbus Defence and Space undertook a regional satellite oil slick mapping survey covering all of Newfoundland and Labrador's offshore area. This satellite mapping survey located slick anomalies in areas of known discoveries (Jeanne d'Arc Basin, Grand Banks) and also imaged slicks potentially from in situ sources in frontier areas of the offshore. One of the areas that contained a number of satellite slick anomalies was the West Orphan Basin. Using the slick data as a component of planning, Nalcor invested and partnered with TGS and PGS in acquiring new 2D long offset (8 km) broadband (Geostreamer®) seismic data in the Newfoundland and Labrador offshore - including this area of the West Orphan Basin - to better understand the basin architecture, play types and potential prospectivity. 2D seismic lines were acquired in this area starting in 2012 and based on finding evidence of a new Lower Tertiary play trend in the 2D, in 2015 a 4,600 km^2 3D long offset (8 km) broadband survey was acquired to further investigate a region of the newly identified play trend as shown in Figure 1. The recent 2D lines that uncovered the play trend demonstrated that the long offset cable length was highly important in finding this play as the Oligocene, Eocene, and Paleocene sands in this area are characterized by Class II AVO responses and the turbidites and fans are only properly imaged by looking at the full range of angle stacks out to far angles (47 degrees in this example) as shown in Figure 2. The shorter cable legacy data in the area did not image these features due to the limited angle range available.

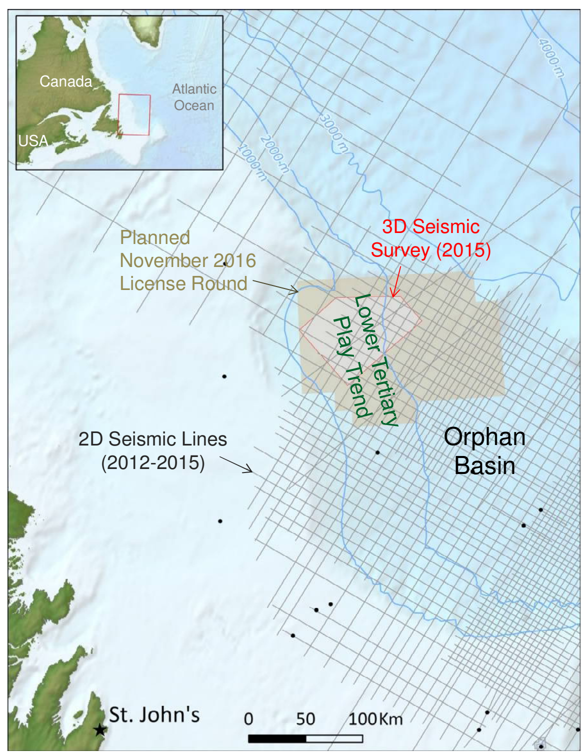

Figure 1. *Map showing the location of the newly identified Lower Tertiary play trend and the location of the recent (2012-2015) long offset 2D seismic lines and the 3D long offset seismic survey acquired in 2015. The planned November 2016 License Round area which covers a portion of this trend is also shown.*

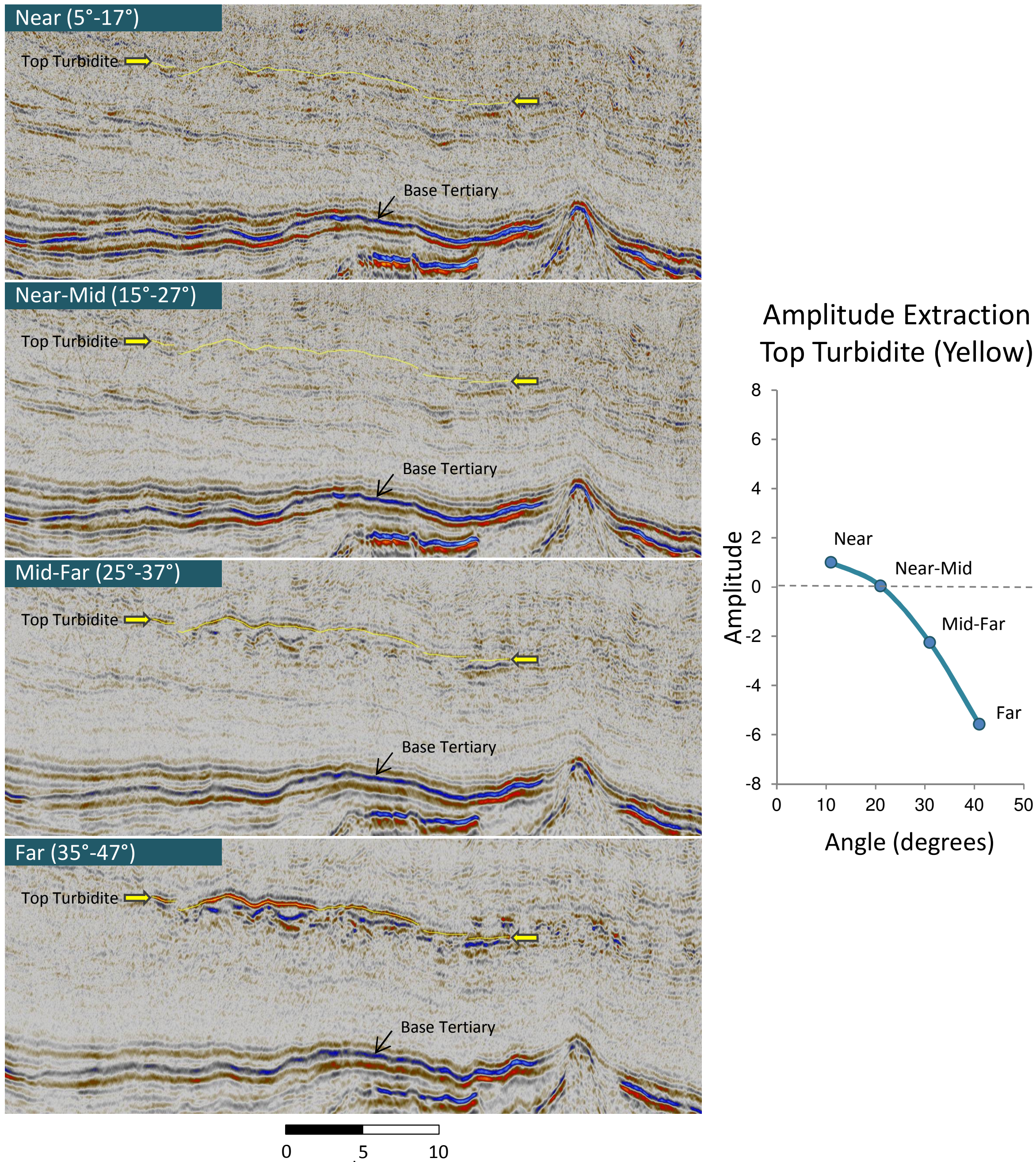

Figure 2. *Recent long offset broadband 2D seismic line in the West Orphan Basin showing the first Eocene turbidite complex in the trend that was imaged – a Class IIp AVO anomaly imaged through four angle stacks. The turbidite complex in this sequence is in 1300 m of water and approximately 3100 m below mud line. The plot on the right is an averaged amplitude extraction along the yellow horizon at the top of the turbidite. The general amplitude of the section weakly dims with angle, with the anomalous turbidite complex amplitude increasing monotonically with angle through the angle stack range.*

Discussion

When the Lower Tertiary play trend was initially identified with the long offset section shown in Figure 2, the nearest 2D line in the regional program was over 60 km away. Infill lines to a 10x10 km grid were then acquired to better determine the regional extent of the play. These infill lines allowed for the general definition of the play trend, which as we understand it today generally follows the present day 1000 – 2000 m bathymetric contour in this part of the West Orphan Basin. Some of the earlier acquired satellite slick data now had a more meaningful potential context as well. As shown in Figure 3, there were a number of satellite slicks imaged around the present day shelf break updip from the turbidite complexes at the paleo toe of the slope.

In addition, there were potential DHI's imaged updip along the Eocene unconformity as noted in the image. This could potentially be evidence of a petroleum system in the region, though much work remains to evaluate the presence and maturity of potential sources in the region. To better evaluate hydrocarbon charge potential, Nalcor in 2015 invested with MG3 and AGI in a seabed coring and heat flow program targeted along 2D seismic lines in the area using multibeam bathymetry to ensure optimal coring location selection, an example of which is shown in Figure 3. The early results from this program indicate potential thermogenic hydrocarbon sources are present in the area, and the sampling results provide additional insight on subsurface anomalies.

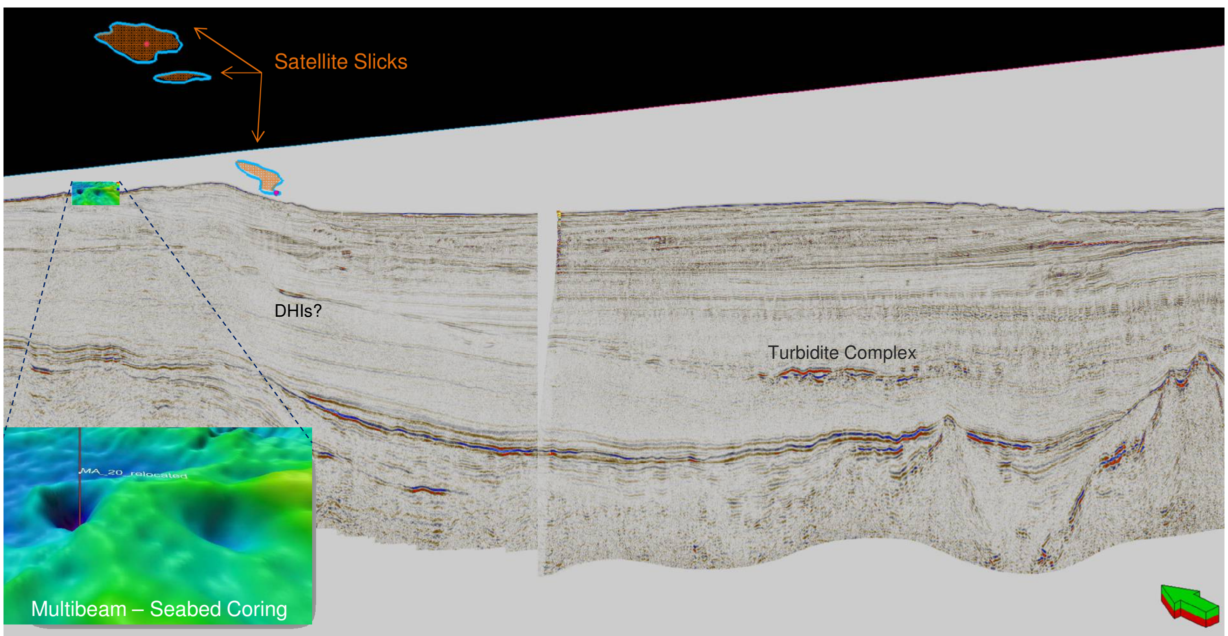

Figure 3. *Perspective view of 2D seismic line in West Orphan Basin showing location of a turbidite complex. There were a number of satellite slicks imaged around the present day shelf break updip from the turbidite complexes at the paleo toe of the slope. In addition, there were potential DHI's imaged updip along the Eocene unconformity as noted in the image. The seabed coring program utilized multibeam bathymetry to ensure optimal coring location selection along the 2D seismic lines.*

The 2015 3D seismic program acquired over a part of the newly defined play trend has provided insight on the sand distribution and potential presence or absence of hydrocarbon charge in the Lower Tertiary units. The 4,600 km^2 survey was completed in October of 2015 and while final processing is ongoing, good quality fast track data was used for this analysis. Shown in Figure 4 is a Far Angle (35°-47°) depth section from the fast track 3D volume.

This section contains an Eocene turbidite fan prospect underlain by the Paleocene and up to 3.5 km of Mesozoic section. Also shown is a potential chimney feature of anomalous amplitude in a vertical band from a conical feature (potential mud volcano) at the top of the Mesozoic to the base of the turbidite in the Eocene. In addition, there exists a potential flat spot that extends across the feature indicated with a dashed yellow line.

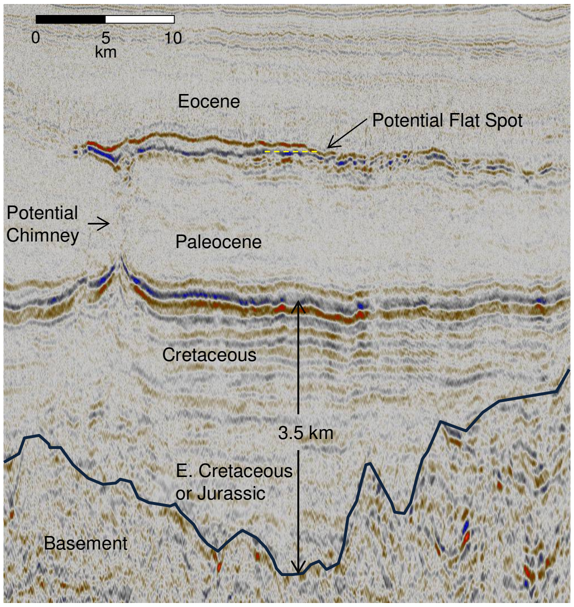

Figure 4 *Depth far angle seismic section from the 2015 3D survey (fast track). Eocene prospect is approximately 3100 m below mudline.*

Above the potential flat spot the negative trough amplitude is higher than it is below the line. There are a number of possible flat spots in various turbidite complexes in this area and further evaluation with seismic amplitude characterization and rock physics modelling is ongoing to separate potential lithology effects from potential fluid effects. With the thickness and nature of units potentially in the maturity window and possible DHI evidence (chimneys, flat spots, etc.), there are early indications of potential hydrocarbon charge existing in this newly defined play trend.

To further advance our understanding of the nature and characteristics of these fan features, we have undertaken additional work on seismic inversion and spectral decomposition. This evaluation is ongoing and some of the early spectral decomposition results are shown in Figure 5 showing a source channel and associated fan complex.

Conclusions

Through the integration of satellite slick data, 2D long offset seismic, 3D long offset seismic and seabed coring

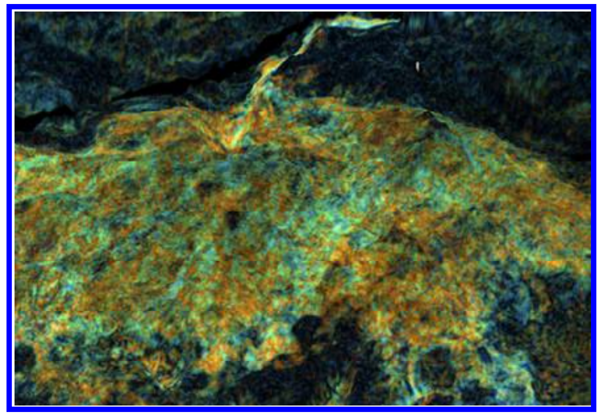

Figure 5. *From the fast track 3D seismic (2015), a 3D perspective view of a spectral decomposition image of a sediment source channel (near top of image) and a deepwater fan complex.*

data, a new Lower Tertiary play trend has been identified in the West Orphan Basin, offshore Newfoundland. The play trend was initially uncovered by using long offset 2D seismic data that allowed for the imaging of the Class IIp anomalies that characterize this trend. While we are early in our evaluation, it is encouraging that we are imaging globally material sized leads and prospects and see evidence of reservoir presence and potential hydrocarbon charge in the system. Ongoing work includes 3D basin modelling to assess the timing, quality, and migration pathways of various potential source intervals from the Paleocene to the Jurassic. Rock physics analysis and modelling work is also ongoing to evaluate the potential direct hydrocarbon indicators in the recent seismic data and separate potential lithology effects from fluid effects. These studies will help to further derisk this region as exploration advances in this newly defined play trend.

Acknowledgements

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EDITED REFERENCES

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