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New Insights into the Slope and Deep Water Regions of the Southern Grand Banks Area, Offshore Newfoundland, Canada

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SUMMARY

The Southern and South-eastern Newfoundland and Labrador regions cover an area approximately one-third the size of the US Gulf of Mexico. This vast offshore region remains underexplored both on the shelf, and in the slope and deep water area. Additionally, the slope and deep water areas historically have only partial seismic coverage with acquisition in 1999 (Western Geophysical Petrol Ltd.) and 2000 (Geco Geophysical Canada Ltd.). As a result of this sparse seismic dataset, Mesozoic basin extents have not been fully delineated over the slope and deep water regions. Recently, Nalcor Energy partnered with TGS and PGS, has acquired regional 2D seismic surveys over these frontier offshore regions in an effort to better understand their resource potential. Prior to the recent acquisition of 36,325 line kilometres of regional 2D broadband seismic that began in 2014 little information existed about the extent and nature of the stratigraphic section over the remaining portion of the Southern Newfoundland offshore. Interpretation of the newly acquired seismic data is revealing increased extents of previously defined basins, thickness of Mesozoic stratigraphy, as well as the complex deformation history of these regions.
Introduction

The Southern and South-eastern Newfoundland and Labrador regions cover an area approximately one-third the size of the US Gulf of Mexico exceeding 500,000 km² (Figure 1). This vast offshore region remains underexplored both on the shelf, where the last well was drilled in 1974, and in the slope and deep water area (only two wells over ~1500km strike distance). Additionally, the slope and deep water areas historically have only partial seismic coverage with acquisition in 1999 (Western Geophysical Petrol Ltd.) and 2000 (Geco Geophysical Canada Ltd.). As a result of this sparse seismic dataset, Mesozoic basin extents have not been fully delineated over the slope and deep water regions. Recently, Nalcor Energy partnered with TGS and PGS, has acquired regional 2D seismic surveys over these frontier offshore regions in an effort to better understand their resource potential. An update of the exploration potential of a portion of the South-eastern Newfoundland and Labrador slope and deep water region was conducted by Enachescu (2013) based on the limited dataset. Prior to the recent acquisition of 36,325 line kilometres of regional 2D broadband seismic that began in 2014 (Figure 1 - red lines – 2014; blue lines 2015) little information existed about the extent and nature of the stratigraphic section over the remaining portion of the Southern Newfoundland offshore.

Interpretation of the newly acquired seismic data is revealing increased extents of previously defined basins, thickness of Mesozoic stratigraphy, as well as the complex deformation history of these regions, with Southern Newfoundland containing a region of highly dynamic salt.
Discussion

Rift basins associated with the break-up of North America and the African and European continent underwent a number of rift phases. The phases of extension affecting the Southern and South-eastern Newfoundland regions are the rift events, occurring within the Late Triassic to Early Jurassic and Late Jurassic to the Early Cretaceous that ultimately led to the continental lithospheric break-up at the Aptian-Albian boundary (c. 112 Ma) (Mohn et al. 2015; Tucholke & Sibuet, 2007). New insights obtained from the recent seismic acquisition over the shelf, slope and deep water regions have resolved structural complexities, and have identified in more detail the stratigraphic framework of these frontier regions. The Southern and South-eastern Newfoundland Mesozoic and Cenozoic sequences evolved through two periods of riftting and subsidence associated with seafloor spreading (Grant & McAlpine 1990). The megasequence division of Grant and McAlpine (1990) has been utilized in this study. Stratigraphic response to tectonism across the area is commonly described as involving an early rift phase – Late Triassic to Early Jurassic – followed by a period of thermal subsidence – Early to Late Jurassic. The second rift phase – Latest Jurassic to Early Cretaceous – is subsequently followed by the transition to drift – Barremian to Paleocene – then finally to passive margin deposition – Tertiary (Grant & McAlpine 1990). Major unconformities, in general, bound the megasequence packages and can be mapped over regional distances. These include the base Cretaceous unconformity (J_145 marker), the Aptian-Albian unconformity (K_114 marker) and the base Tertiary unconformity (C_65 marker). Regional mapping of these internal markers, combined with the top of Argo salt (J_195 marker), base of Argo salt (T_201 marker) and existing depth to basement map, megasequence packages are defined on the Southern and South-eastern Newfoundland and Labrador regions. Evolution of the Southern and South-eastern offshore regions shares some similarities at the megasequence scale, but distinct differences exist between the two regions.

Southern Newfoundland Region

Bounded by extensional faults, the boundaries of the Whale, South Whale and Horseshoe basins are defined in the shelf region of Southern Newfoundland (Grant & McAlpine 1990; Figure 1). Thick (10+km) Mesozoic sequences exist beyond the shelf region where most of the past industry activity has been focused. With the initial interpretation of the recent 2D seismic data set, extension of the existing South Whale Basin (Figure 1 & Figure 2), as well as definition of revised basin extents and depocentres in the region have been identified. The boundary separating the Laurentian Basin in the western portion of the region and the South Whale Basin is somewhat arbitrarily defined, with no concise feature dividing the basins. New insight from the recent seismic confirms that the slope and deep water regions of Southern Newfoundland consist of a salt tectonic regime, similar to that seen in the north-eastern region of offshore Nova Scotia (Deptuck et al. 2014). Features such as diapirs, canopies, and allochthonous salt are present and are observed to affect the structural and stratigraphic geometries throughout the region. Volcanic intervals are also present in the area, as encountered in the Narwhal F-99 well (approximately 55 metres of vesicular basalt) as well as in the eastern limits of the slope and deep water regions, as determined from existing regional magnetic data and interpreted on the regional seismic lines. The Fogo Basin is generally outlined by Grant and McAlpine (1990). The recent seismic acquisition provides new insight into the extents of this basin. Based on the current interpretation, there appears to be a basement ridge separating two basins in the area previously termed the Fogo Basin. As a result, these are given the names Fogo Basin West, and Fogo Basin East (Figure 1).
Figure 2 Line of section in the Southern Newfoundland region illustrating Mesozoic and Cenozoic section.

South-eastern Newfoundland Region
This region is represented by the Carson and Bonnition shelf/slope basins, and the Salar Basin whose extent covers the slope and deepwater regions on the Southeastern Newfoundland margin (Figure 3). The shelf region – primarily consisting of the Carson Basin - is influenced by the Avalon Uplift during the mid-Cretaceous (Enachescu, 2013; Grant & McAlpine, 2009), where large portions of sedimentary section have been uplifted and eroded, and subsequently redeposited within the slope and deep water regions (Bonnition and Salar basins). In the shelf basins, Upper Cretaceous or Lower Tertiary section can unconformably overlie Lower Jurassic or Triassic sediments. Thick Mesozoic (10+km) strata are present within the Bonnition Basin, which is separated from the Salar Basin by a prominent basement high. East of this basement high, the Salar Basin passively thins as Jurassic and older stratigraphy onlaps and a thin Cretaceous and younger strata sit unconformably on Paleozoic basement. Insights provided from the newly acquired seismic provide eastern extents to the Salar basin, and an area where volcanic intrusions appear to be prevalent. Intrusive volcanics are present in the ODP well 1276 (two diabase sills approximately 10m thick), whose extents are correllable on the new seismic dataset. The ODP 1276 well also encountered the occurrence of an oceanic anoxic event at the Cenomanian-Turonian boundary (Tucholke & Sibuet, 2007). In comparison to the Southern Newfoundland offshore, the new seismic data over the South-eastern Newfoundland region has illustrated that there is significantly less dynamic salt, which is present as diapirs with minor canopies in limited, local examples. Salt diapirs are present in the Carson, Bonnition and western extent of the Salar basins.

Figure 3 Line of section in the South-eastern Newfoundland region illustrating Mesozoic and Cenozoic section.
Conclusions

Increased regional seismic coverage, as well as new acquisition techniques has greatly improved the understanding of the basin extents and imaging of megasequence packages in the Southern and South-eastern Newfoundland regions. Improved imaging of seismic marker horizons allows for stronger ties from the shelf into the slope and deep water regions allowing for higher confidence in mapping potential source and reservoir intervals into the deep water regions. Mesozoic section within these regions is variable in thickness, reaching over ten kilometres. Significant increases in resolution of the seismic allow for definition of potential play types including salt structures, potential sub-salt features, rotated fault blocks, and stratigraphic pinch outs. Significant reservoir intervals have been encountered in both the Southern (Lewis Hill G-85 and Tern A-68 wells), and in the South-eastern (St. George J-55 well) Newfoundland offshore regions displaying the potential for significant hydrocarbon volumes to accumulate. Source rock potential exists with the possible southern extension of known Kimmeridgian source interval observed in wells drilled within the shelf region. With deposition and preservation of salt in both areas, the Kimmeridgian interval would have been deposited and preserved where the Avalon Uplift has not eroded this interval. Existing well locations have not penetrated representative rift section, as most were focused on salt cored highs or basement highs, leaving much of the early to mid-Mesozoic section unsampled. The recent seismic imaging suggests the presence of thick Mesozoic intervals away from the well control leading to the possible preservation of a regional source rock. As such, the recent data identifies the potential for an active petroleum system within these frontier regions.

References


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