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Petroleum Potential of the Carson-Bonnyton and Salar Basins, Offshore Southeastern Newfoundland and Labrador, Canada

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Summary

The vast frontier area offshore Southeastern Newfoundland and Labrador, including the Carson-Bonnyton and Salar basins, contains approximately 27,000 line kilometres of long offset, broadband 2D seismic data acquired between 2014 and 2016. This region is relatively underexplored with four wells drilled along the shelf, leaving immense opportunity for exploration in the remaining shelf, as well as the slope and deepwater regions. Through seismic interpretation and mapping of key stratigraphic events, along with structural restoration techniques, much insight can be gained in order to define and understand the potential for elements creating an active petroleum system. This study utilizes well and seismic data, historical reports, to build upon and create new ideas in the definition of a petroleum system chart for this vast frontier region.

Introduction

The Southeastern region of Newfoundland and Labrador covers an area of approximately 150,000km². Since 2014, approximately 27,000 line kilometres of long offset broadband 2D seismic data in the Carson-Bonnyton and Salar basin areas of the Newfoundland offshore region have been acquired (Figure 1). This new seismic data paired with existing seismic, well data, as well as existing publications and reports can aid in the advancement of understanding the petroleum system potential of this underexplored area. The study area contains four wells, all of which are within the Carson-Bonnyton basin (Figure 2). New insights from recently acquired seismic data allow for increased understanding of basin architecture and aid in the development of a petroleum system model.

Figure 1. Mesozoic basin configuration (light blue polygons) of the Southeastern Newfoundland and Labrador offshore region. Schematic section for Figure 3 is located within the boundary box labelled I-I'. WH – Whale Basin; HS – Horseshoe Basin; CB – Carson Bonnyton Basin; SL – Salar Basin; JD – Jeanne d'Arc Basin (Modified from Carter, 2013).

Hydrocarbon exploration in the Carson-Bonnyton-Salar basins began in the late 1960's with the first wells drilled in the early 1970's. The Osprey H-84 and Skua E-41 wells were drilled in 1973 and 1974 respectively and targeted Gulf of Mexico like salt features (Enachescu, 2013) with the Bonnyton H-32 well also being drilled during this period. All were dry holes, but provided valuable stratigraphic information. The last exploration well drilled in this region was St. George J-55 (1986) where significant reservoir of Late Jurassic to Early Cretaceous age was encountered, with no hydrocarbon shows. Seismic activity increased in the late 1990's into the early 2000's where 2D shelf to deepwater lines were shot throughout the region, as well as a 3D seismic survey over a portion of the Salar basin. No wells have been drilled since the St. George J-55 well and exploration activity has been dormant since the early 2000's. 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 Southeastern Newfoundland region. Improved imaging of seismic marker horizons allows for stronger ties from the shelf into the slope and deep water areas allowing for higher confidence in mapping potential source and reservoir intervals (Norris, 2016).

Figure 2. 3D view of the Base of the Mesozoic Structure of the Carson-Bonnyton and Salar Basins (basin outlines are white dashed lines). The main regional structural elements are also labelled on this map. Complete separation of the Carson-Bonnyton and Salar basins is evident with a ridge of pre-Mesozoic (basement) rock providing the structural separation. Note continuation of Flemish Pass Basin, Flemish Cap Graben and Anson Graben into the Southeastern Newfoundland region.

Data courtesy of TGS and PGS.

Petroleum Systems Elements

Source rock is one of the main risk elements to any working petroleum system. Within the Southeastern Newfoundland region much information is yet to be obtained regarding the presence, distribution and quality of potential source rocks. Source rock data such as Rock Eval, as well as derived petrophysical curves that estimate TOC from logs provide indications that there may be a number of intervals with source potential present throughout the stratigraphic column within this region. These analyses also provide details to the quality of the source rock present. Through seismic mapping of these intervals of interest, as well as structural restoration (Figure 3), the distribution of potential source rocks and information on their burial history can be determined. The Kimmeridgian Egret Member of the Rankin Formation source rock is the prolific source for the producing fields within the Jeanne d'Arc Basin (Bell and Campbell, 1990). This interval has been interpreted, through publically available biostratigraphic analysis, to be present within the St. George J-55 (Williams, 2003) and Bonnyton H-32 (Ascoli, 1988) wells (Figure 2). Well data from the Flemish Pass Basin directly north of the study area, suggests that the Upper Jurassic Tithonian interval in Mizzen O-16 (GSC, 2009 and Houssein, 2010) and Mizzen L-11 (Haager, 2003) also contains potential source rock material that may also be present in the Carson-Bonnyton-Salar region. Ocean Drilling Project (ODP) site 1276, in the deepwater extent of this region, encountered Oceanic Anoxic Event (OAE) 2 at the Cenomanian-Turonian interval (Tucholke & Sibuet, 2007). This provides the deep water Salar basin, within the eastern extents of this study area, the potential for a Cretaceous-aged source to expel hydrocarbons to any reservoir potential that may be present. There also exists the possibility for a Middle Jurassic source within the Sinemurian-Toarcian aged interval (Silva et al, 2015). Stratigraphy of this age exists within the Carson-Bonnyton-Salar region and may provide the source rock required to charge this underexplored region.

Figure 3. Cross section I-I'. A. Present day cross section of Carson-Bonnyton and Salar Basins. Note thick Tertiary erosive event (thick blue in eastern Carson-Bonnyton Basin). B. Restored section to Jurassic time. Note in Carson-Bonnyton Basin the variance of the salt from A. Also, the depression in the western Salar Basin at the top of the Jurassic may be due to salt evacuation out of the plane of the section.

Reservoir intervals have been encountered through well control, including over 600m of fining upward, coarse to fine grained sandstone at St. George J-55. This transgressive package contains what is interpreted as fluvio-deltaic at the base to shallow marine siliciclastics in the Jurassic and Cretaceous aged intervals. Within the slope to deepwater transition throughout the Late Cretaceous and Tertiary, the potential for submarine fan and/or contourite deposition exists, with IODP site 1276 containing turbidite sequences within this aged section (Tucholke & Sibuet, 2007). Indications of submarine fan deposition are also present in recently acquired seismic, with features such as lensoid depositional events within this stratigraphic interval as well as significant erosive surfaces throughout the Tertiary section in the Carson-Bonnyton Basin area.

The Carson-Bonnyton-Salar basin areas have undergone two episodes of deformation associated with rifting as North America and Iberia broke apart (Mohn et al. 2015; Tucholke & Sibuet, 2007). Faulting in response to this rifting provides an opportunity for trapping to occur as normal fault movement steepens pre-rift sediments forming rotated half-graben fault blocks. Salt deformation in the region provides multiple trapping types including salt cored anticlines, sub-salt trapping, stratigraphic pinch out against impermeable salt, as well as mini-basin formation from salt evacuation. Salt is prevalent in the Carson-Bonnyton Basin and the western extent of the Salar basin.

Sealing rock has been deposited throughout the Late Jurassic (Fortune Bay Formation), Mid to Late Cretaceous (Nautilus and Dawson Canyon Formation) and Tertiary (Banquereau Formation). The risk of breach of these seals exists where the erosive Tertiary events cut into deeper stratigraphic intervals. Also, the presence of a Late Triassic-Early Jurassic aged Argo Formation salt layer also acts as a potential for seal breach as the salt becomes dynamic and moves vertically through the section, and/or evacuates creating fault bounded mini-basins that were formed post hydrocarbon migration providing pathways for fluid flow.

Conclusions

The Carson-Bonnyton-Salar frontier region in offshore Southeastern Newfoundland is adjacent to known production in the Jeanne d'Arc Basin, as well as an emerging frontier region in the Flemish Pass Basin. Through structural restoration of major stratigraphic intervals, much insight can be gained such as the timing of fault movement, the timing of salt movement, paleobathymetry, as well as burial history of source rock intervals to determine the timing of hydrocarbon expulsion and migration. These insights provide suggestions to many of the key elements that create an active petroleum system and will be integral evidence in the creation of a petroleum system chart for the Carson-Bonnyton-Salar region. Increased regional seismic coverage, as well as new acquisition techniques has greatly improved the understanding of the basin extents and imaging of internal

horizons in the Carson-Bonnyton-Salar Basins of the Southeastern Newfoundland region. 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 (Norris, 2016). Through continued seismic data acquisition and geoscience work in this frontier region, maturing of existing ideas as well as the development new ideas can decrease the risk of the elements that create a working petroleum system.

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