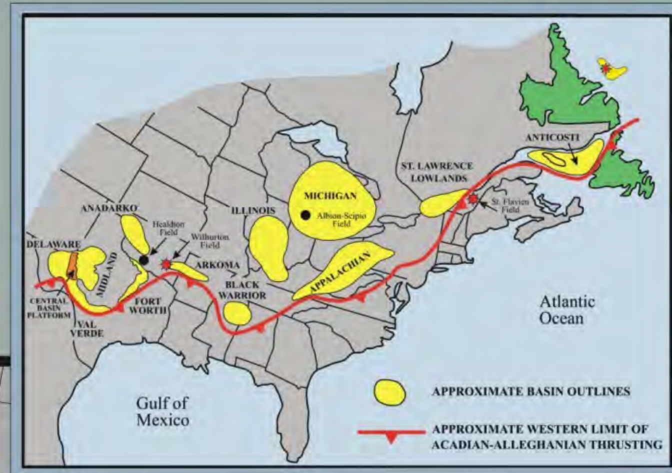
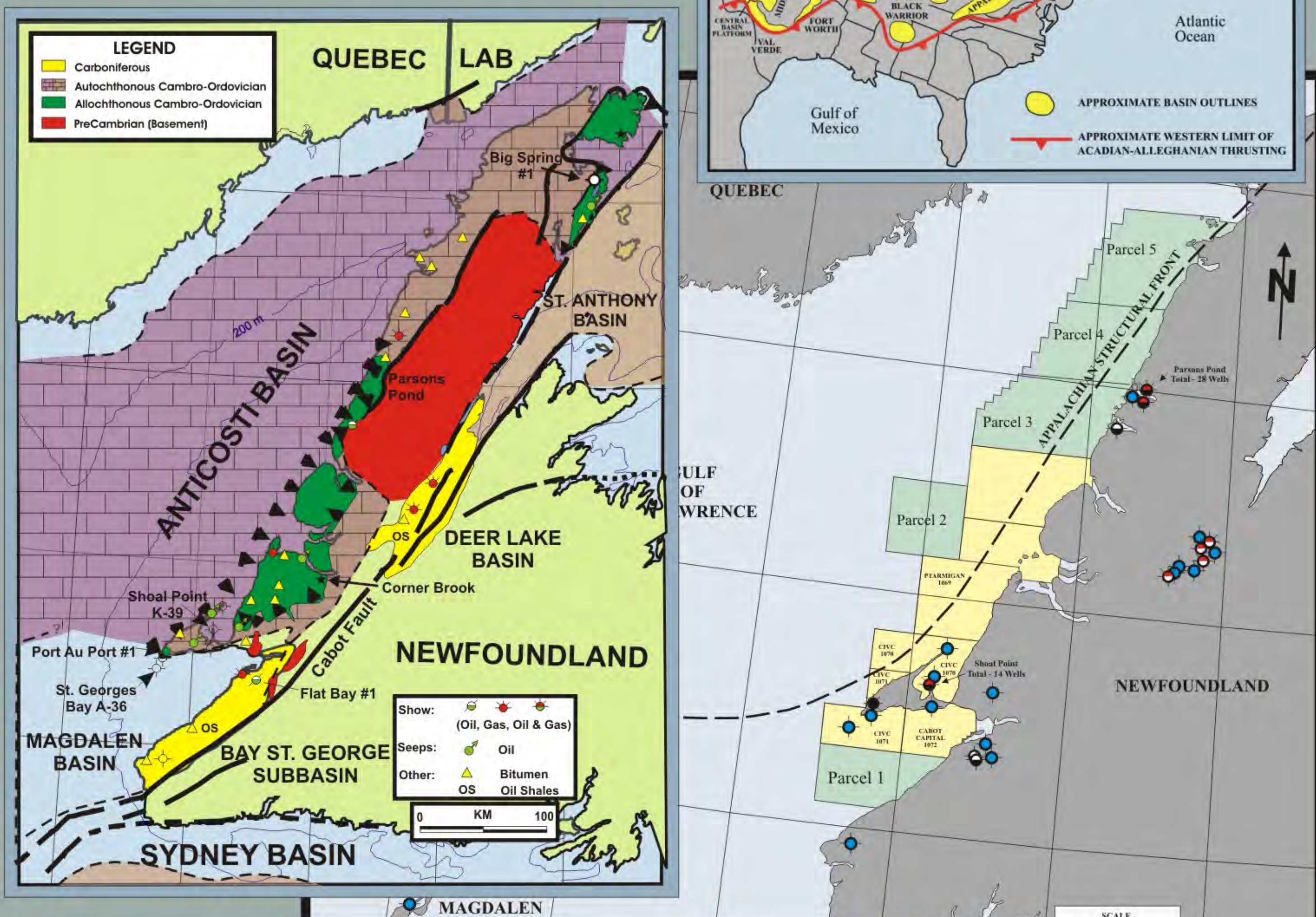
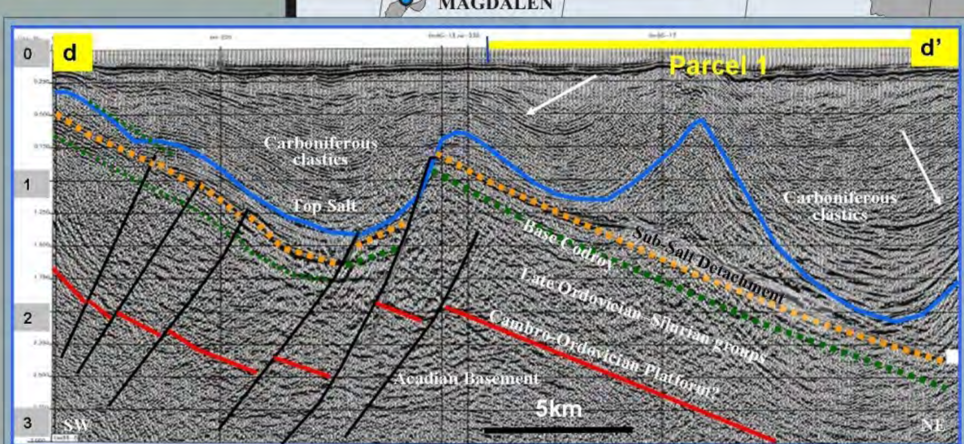
GOVERNMENT OF
NEWFOUNDLAND
AND LABRADOR

Department of
Natural Resources







Newfoundland and Labrador

Call for Bids NL06-3

Western Newfoundland and Labrador Offshore Region

September 2006

Foreword

This report has been prepared on behalf of the Government of Newfoundland and Labrador Department of Natural Resources (NLDNR) to provide information on land parcels being offered in the Canada-Newfoundland & Labrador Offshore Petroleum Board's (C-NLOPB) 2006 Call for Bids NL06-3. This year the Board has issued three separate Calls for Bids, including:

1. **Call for Bids NL06-1** (Jeanne d'Arc Basin) consisting of three parcels;
2. **Call for Bids NL06-2** (Sydney Basin) consisting of three parcels; and
3. **Call for Bids NL06-3** (Western Newfoundland and Labrador Offshore Region) where five parcels are offered.

These eleven parcels comprise a total of 1,712,758 hectares. Interested parties have until 4:00 p.m. on November 15, 2006 to submit sealed bids for Call for Bids NL06-1 (Jeanne d'Arc Basin) and Call for Bids NL06-3 (Western NL Offshore Region) and until 4:00 p.m. on November 30, 2006 to submit sealed bids for the Sydney Basin Call for Bids NL06-2.

This report focuses on Call for Bids NL06-3 that includes five parcels with a total area of 867,896 hectares (2,143,814.6 acres) within the Paleozoic Anticosti and Magdalen basins. These Gulf of St. Lawrence parcels are located within a Frontier exploration area with a proven petroleum system and significant oil and gas potential. Two separate reports available at http://www.nr.gov.nl.ca/nr/ provide information on the other two Calls for Bids.

This report should be referenced as ***Enachescu, M.E., Call for Bids NL06-3, Parcels 1 to 5, Regional Setting and Petroleum Geology Evaluation, Government of Newfoundland & Labrador Department of Natural Resources.*** I acknowledge the contribution to the writing of this report from Phonse Fagan and Larry Hicks who earlier summarized the regional geology of the area in a report available from Newfoundland and Labrador Department of Natural Resources website. For information on how to submit a bid in this Call for Bids go to: http://www.cnlopb.nl.ca/ and see the March 22, 2006 News Release. Pursuant to this release, the C-NLOPB has announced minor amendments to land descriptions posted under Schedule 1 - Land Description; Call For Bids No. NL06-2 (Sydney Basin), in the original March 22 Call for Bids document. These amendments may be viewed on the C-NLOPB website under the What's New! category - September 26, 2006 heading.

Acronyms used in this report:

NL = Newfoundland & Labrador (the legal name of the Province)
C-NLOPB = Canada-Newfoundland & Labrador Offshore Petroleum Board
NLDNR = Government of Newfoundland and Labrador-Department of Natural Resources
NL06-1, 2 and 3 = identifiers for the three 2006 Call for Bids
GSC = Geological Survey of Canada
PL = Production Licence
EL = Exploration Licence
EP = Exploration Permit (onshore only)
SDL = Significant Discovery Licence
DPA = Development Plan Application
TD = Total Depth
bopd = barrels of oil per day
mmcfd = million cubic feet per day
tcf = trillion cubic feet
bcf = billion cubic feet
mmbbls = million barrels

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1. Introduction

This report focuses on Parcels 1-5 of the C-NLOPB Call for Bids NL06-3 which are located off the west coast of the island of Newfoundland, in water depths ranging from zero to 250 metres. Parcel 1 is located within Bay St. George, while parcels 2-5 run along the open coastline on the eastern margin of the Gulf of St. Lawrence. The offered parcels are adjacent to several active Exploration Licenses both on land and offshore and are close to or on trend with the Port au Port Peninsula where light oil and gas were tested at significant flow rates from the Port au Port #1 exploration well in 1995. The report provides general background information on petroleum exploration on the Newfoundland's West Coast and general geological information on the hydrocarbon prospectivity of the West Newfoundland basins, emphasizing the offshore area. It also discusses the specific geology and petroleum potential of the five parcels in Call for Bids NL06-03 – four of which are located in the Anticosti Basin, and one within the Magdalen Basin (Bay St. George sub-basin).

More information on the geology of the West Newfoundland and Labrador (NL) petroleum potential, including evaluations of earlier Call for Bids parcels (some of which became the active Exploration Licences 1069 to1072, 1097 and 1098) can be accessed at:
http://www.nr.gov.nl.ca/mines&en/oil/call_for_bids_nf04_01.stm and
http://www.nr.gov.nl.ca/mines&en/call_for_bids/NL05.pdf

The accompanying Call for Bids Report NL06-1 that presents in detail the geology of the Mesozoic basins, future exploration areas and exploration potential of the three Jeanne d'Arc parcels included in the 2006 landsale is available at http://www.nr.gov.nl.ca/nr/. The Call for Bids Report NL06-2 that presents the geology of the Sydney Basin and exploration potential of Parcels 1 - 3 included in the 2006 landsale is also available at the same website.

Additional petroleum related reports from the Department of Natural Resources are available at:
http://www.nr.gov.nl.ca/mines&en/publications/.

Selected references on the geological setting and petroleum potential of Western Newfoundland are also provided at the end of this report.

2. Exploration and Development Background

Exploration for oil and gas onshore and offshore Western Newfoundland is less known about than the much larger scale efforts that have been undertaken on the Grand Banks to the east, Labrador Shelf to the north and on the Scotian Shelf to the south. The following sections will discuss within a provincial, regional and international context, the setting and history of petroleum exploration in Western Newfoundland (Figure 1).

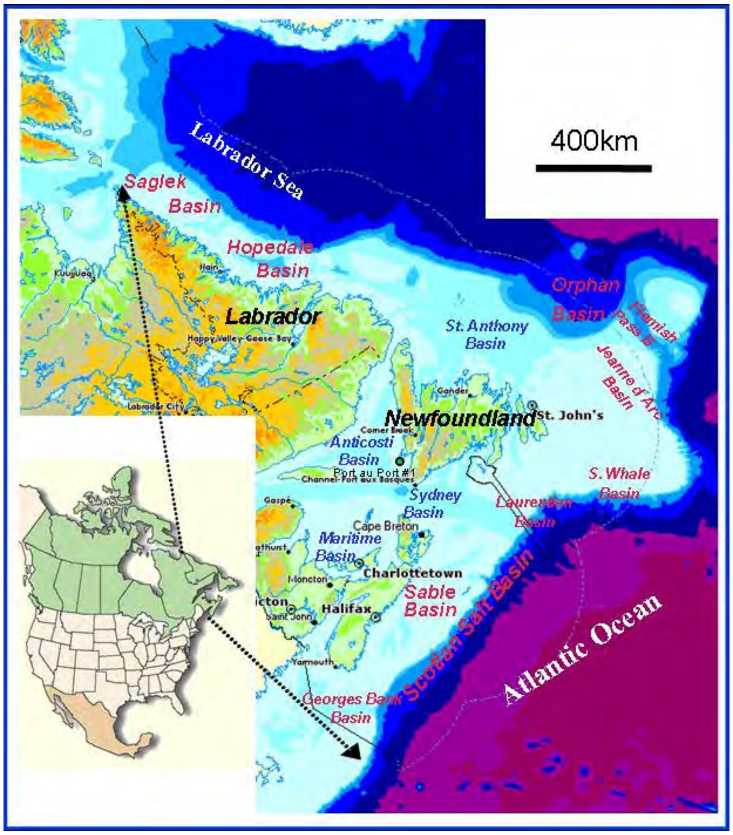

Figure 1. Atlantic Canada offshore basin map. Mesozoic basins are labelled in red, Paleozoic basins are labelled in blue (bathymetry map from Natural Resources Canada).

2.1. NL Petroleum Production

Three large fields (Hibernia, Terra Nova and White Rose) have been developed in the Jeanne d'Arc Basin which lies to the east of the island of Newfoundland in 80 to 150 metres of water. These fields typically produce from 300,000 to 350,000 barrels per day of light crude from Mesozoic sandstones, and are the only producing offshore oilfields on the Atlantic coast of North America. A fourth development, the Hebron-Ben Nevis field (731 million barrels recoverable reserves/resources) is expected to be developed sometime in the future, along with a number of smaller fields that may be brought on as satellite developments.

The Jeanne d'Arc Basin is only one of the many Mesozoic basins and sub-basins located in Atlantic Canada (Enachescu and Fagan, 2005 and Figure 1). More than 10 tcf of technically recoverable gas has been discovered in the Jeanne d'Arc and Hopedale basins, but to date only oil developments have occurred in the Province. The oil is delivered by tanker to markets in eastern North America and the solution gas produced with the oil (about 350 mmcf/d) is being reinjected. However, given the tightening supply demand picture in the North American gas markets the stakeholders in NL gas are already investigating the commercial and technical aspects of natural gas development from Newfoundland and Labrador waters. Except for the rapidly declining Sable Project on the Scotian Shelf there are no other proven sources of gas on the eastern Coast of North America. The McCully development onshore New Brunswick which is expected to reach 25 mmcf/d by year end is bringing greater attention to the petroleum potential of the Atlantic Canada Paleozoic basins, which are the subject of this report.

Sporadic episodes of petroleum exploration in the Appalachian fold belt and Paleozoic foreland of western Newfoundland have been ongoing since late 1800s. Up to now these efforts have been rewarded only by small or hard to evaluate finds and shows, and there has been only minor commercial production (from the Parsons Pond area) during the early part of the twentieth century. Offshore drilling of the area occurred for the first time in the mid 1990s with one well being drilled by a jackup and four wells being directionally drilled from land to nearshore targets. All of these wells were located on and around the Port au Port Peninsula in the vicinity of the Hunt Pan Canadian Port au Port #1 discovery (Figures 1 and 4). The Port au Port #1 well was the first ever drilled in western Newfoundland with the benefit of seismic data in choosing the location. Two zones, which are believed to be in communication, tested at rates of about 1500 barrels per day of light oil, with gas rates of about 2.5 mmcf/d. Extended testing showed the pressure to be dropping, and subsequent sidetrack drilling by a farmin operator (Canadian Imperial Venture Corp. - CIVC) indicated a complex reservoir near the wellbore. A Production Lease was granted for the discovery (renamed the "Garden Hill field") and CIVC and partners have indicated plans for further work (3D seismic, horizontal drilling).

From a logistics point of view Western Newfoundland is less challenging than the Grand Banks and is closer to the main North American markets, with easy access to export venues. Any significant production offshore or onshore West Newfoundland will also have a rapid and significant impact on the Province's and region's economy and is supported by the government and local population.

2.2. Large Paleozoic Offshore Under Explored Area

Newfoundland and Labrador's area of petroleum potential extends outside of the confines of the Jeanne d'Arc Basin where the Hibernia, Terra Nova and White Rose fields are located. The continental margin of Atlantic Canada stretches on for more than three thousand kilometres from the Georges Bank, at the Canada/United States border to the northern tip of Labrador (Figures 1 and 2). Mesozoic sedimentary basins are found all along the East Coast of the province trending from the Laurentian Basin in the south, across the Grand Banks basins, through the deeper waters of the Flemish Pass and Orphan basins and extending north-westward to include several basins along the Labrador shelf and slope (Figures 1 and 2). Some of these basins are incised on a Paleozoic pre-rift basement that sometimes contains secondary reservoirs. True Paleozoic offshore basins are located in the Gulf of St Lawrence area and surrounding the island of Newfoundland (Sydney Basin to the south, St. Anthony Basin to the north and Bonavista Platform to the east) and forming the upper part of the pre-rift basement of the Grand Banks and Labrador Sea (Figures 1 and 2).

A total of 146 exploration wells have been drilled in a 1.6 million km^2 offshore NL area. Only 5 wells were drilled for Paleozoic plays in the West Newfoundland offshore basins and about a dozen have penetrated Paleozoic strata, including good quality reservoirs while drilling for Mesozoic synrift targets on the Grand Banks, Orphan and Labrador basins. On the west coast of

Newfoundland, under-explored areas of potential are found in the large Paleozoic sedimentary basins within the Gulf of St. Lawrence. The Gulf excluding all contained islands and the St. Lawrence estuary has a water area of approximately 220,000 km^2, or approximately one fourth the size of the Western Canada Basin. Water depths on average are less than 100 m except within the Laurentian Channel and associated feeder tributaries where depths range from 200 to 535 m.

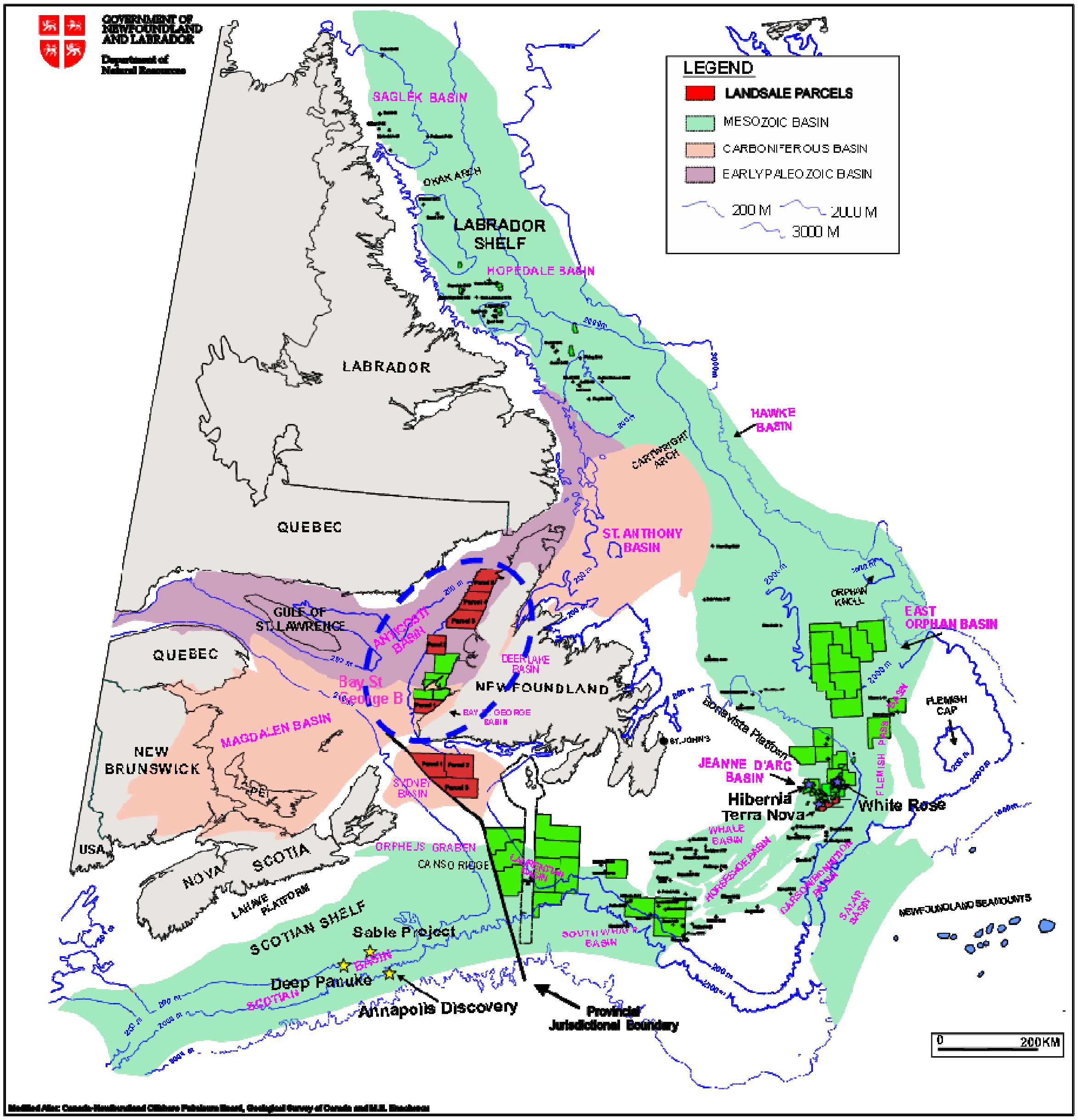

Figure 2. Regional map of the Mesozoic and Paleozoic basins of Atlantic Canada including NL land tenure as of summer 2006. Call for Bids NL06-3 parcels are located within the dashed blue area; Landsale Parcels 1 to 5 are shown in red (modified after the GSC, C-NLOPB and Enachescu, 2005).

Geologic mapping and past drilling for hydrocarbons indicate that the Gulf of St. Lawrence is underlain by a thin veneer of glacial sediment covering two adjacent, relatively thick, Paleozoic aged sedimentary basins known as the Magdalen Basin and the Anticosti Basin. These basins are large and virtually unexplored. The Anticosti Basin (named after Anticosti Island) of Ordovician to Silurian age (approximately 510-415 million years old), underlies the northern part of the gulf. The Magdalen Basin (named after the Magdalen Islands) of Pennsylvanian (Late Carboniferous) to Permian age (approximately 350-250 million years old), underlies the south. The Bay St. George sub-basin is an arm of the predominantly Carboniferous Magdalen Basin (Figure 2). Together, the Anticosti and Magdalen basins cover an area approximately the size of New Mexico State or half of the Canadian Province of Alberta. These Paleozoic basins also extend eastward into the Province's onshore area and to the northeast into the St. Anthony Basin and beneath the Mesozoic sediments of the Labrador Sea (Enachescu and Fagan, 2005; Fagan and Hicks, 2005). It is worth mentioning that Canada has a significant part of its light oil and gas production from Paleozoic sedimentary rocks and over 20% of world oil reserves originate in Paleozoic strata.

The most active phase of exploration in Gulf of St. Lawrence waters on the Newfoundland side took place in the early-mid nineties when several large Exploration Licences were operated by major companies such as Hunt, PanCanadian, Talisman, BHP and Mobil, and 5 wells were drilled. As previously noted, the Garden Hill oil field (Port au Port #1) discovered at the time and covered by a Production Lease awarded to CIVC still awaits development. While oil was locally produced in the Parson's Pond area and oil and gas were recently encountered and tested onshore in the Deer Lake and Bay St. George sub-basins no oil or gas is currently being commercially produced in western Newfoundland (Fagan and Hicks, 2005; Atkinson, 2005).

2.3. West Coast Newfoundland Exploration History

Exploratory drilling offshore Newfoundland and Labrador began in the mid 1960's, and to date a total of 146 exploration wells have been drilled in twelve Mesozoic and Paleozoic basins. From a frontier exploration point of view, all the basins along the margin can be considered to have hydrocarbon potential. Most of the basins are sparsely drilled, and some have been explored only by reflection seismic and are yet to be drilled (Fagan and Atkinson, 2000; Eaton, 2004; Enachescu, 2005, 2006a and b; Enachescu and Hogg, 2005; Fagan and Hicks, 2005; Enachescu and Fagan, 2005a and b). Up to now, large discoveries have been made in two areas: the Hopedale Basin on the Labrador Shelf and Jeanne d'Arc Basin within the Grand Banks, with only oil being presently produced from the latter area (Enachescu, 2005 and 2006a and b; Enachescu and Fagan, 2004 and 2005a and b; Figures 1 and 2). To date the main exploration target offshore NL has been the Mesozoic basins, which are: petroleum proven; contain a prolific Late Jurassic source rock; have high quality Late Jurassic to Tertiary sandstone reservoirs; present a multitude of structural, stratigraphic and combination traps; and all formed during a Wilson cycle that started 200 million years ago with the intra-continental rifting of Pangea.

However, earlier in their geological history, the Atlantic Provinces including Newfoundland and Labrador were affected by an older Wilson cycle that took place during Early Paleozoic and culminated with the build up of the Appalachian fold belt and its corresponding foredeep, which extends from the southern US into the western Newfoundland onshore and offshore areas. Significant volumes of source rock and reservoirs have accumulated during this Paleozoic cycle of ocean opening and closing.

Exploration for oil and gas has been carried out for more than 100 years within the Appalachian basins of the Atlantic Provinces. It first started with drilling on land and then extended to the offshore Gulf of St. Lawrence during the 1960s. The Appalachian fold belt and its foredeep areas has for more than a century and a half been a region of intensive oil and gas exploration in the United States where it has yielded discoveries in classic petroleum basins such as the Delaware, Midland, Anadarko, Michigan, Illinois, Ohio etc. – all of which are located along the ancient Cambro-Ordovician paleo-shore line. The Anticosti and Magdalen basins that extend into NL provincial waters and also into several smaller Paleozoic basins on land within the Humber Zone, are recognized to have petroleum potential by the widespread occurrence of surface oil seeps and frequent oil and gas shows in water wells, mineral exploration wells and petroleum exploration wells. Ordovician and Carboniferous carbonate and sandstone plays are targeted in these areas. Very large accumulations were recorded in similar aged lithologies of the Ellenburger and Arbuckle groups within the USA. The following paragraphs based on Fagan and Hicks (2005) and Atkinson and Fagan (2000) present an historic account of exploration in the Paleozoic Basins of Atlantic Canada. These reports are available from the Newfoundland & Labrador government website: http://www.nr.gov.nl.ca/mines&en/publications/offshore/

Onshore drilling for hydrocarbons in Atlantic Canada began around 1859 in southern New Brunswick (Moncton area), 1860 in Quebec (Gaspe area), 1867 in western Newfoundland (Parson's Pond) and 1869 in Nova Scotia (Inverness County - Cape Breton Island). Although limited production was achieved in some areas (e.g., a few thousand barrels at Parson's Pond a century ago), to date, with few exceptions, there have been only a few commercial, small-scale oil or gas discoveries of significance made in the Paleozoic rocks of Atlantic Canada. The Stoney Creek Field (Figure 3) discovered south of Moncton, New Brunswick in 1909 produced approximately 804,000 barrels of oil and 28.7 billion cubic feet of natural gas up to the time of field depletion in 1991. Recently Contact Exploration announced their intention to drill a horizontal well in this field, re-start production and acquire 2D seismic over a large area south of the field (Fyffe and St. Peter, 2006).

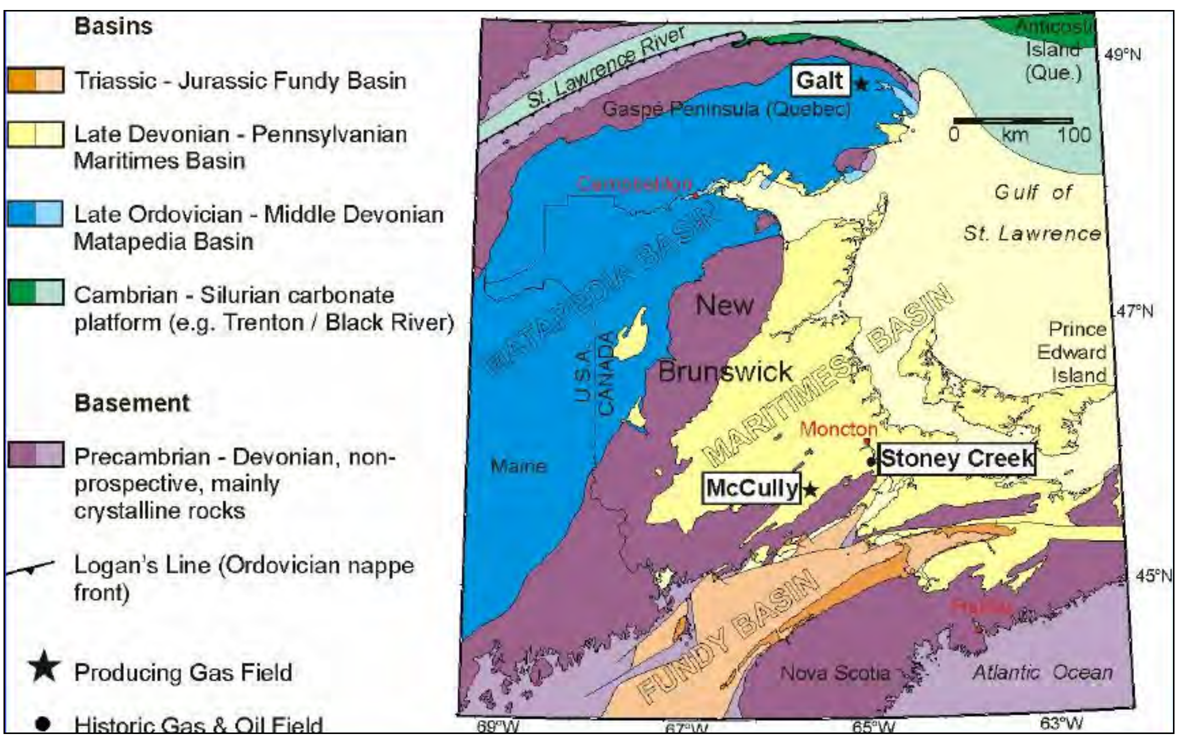

Figure 3. Regional geology map of the Paleozoic basins of Nova Scotia, New Brunswick and Quebec including the locations of the Paleozoic producing Stoney Creek oil field, McCully and Galt gas fields (after the Fyffe and St. Peter, 2006).

The Galt gas field was discovered by Soquip et al. on the Gaspe Peninsula in 1983 (Bourque, 2004) and has been producing since 2002. Gas production is from Lower Devonian carbonates that locally display considerable fracturing and are highly brecciated and infilled by saddle dolomite (Lavoie, 2004). Corridor Resources made a significant gas discovery - the McCully field - in a Carboniferous sub-basin in the province of New Brunswick. This field is currently producing approximately 2 mmcf/d, which is being consumed in the local market. Several successful wells with tests between 1.0 and 5.7 mmcfd were added during 2005 and a connection to the Maritime & Northern pipeline is envisaged in the near term (Figure 3). This Carboniferous production is very encouraging for the Province of Newfoundland & Labrador due to an abundance of similar aged rock in the Sydney, Bay St. George, and Deer Lake areas (Figure 4).

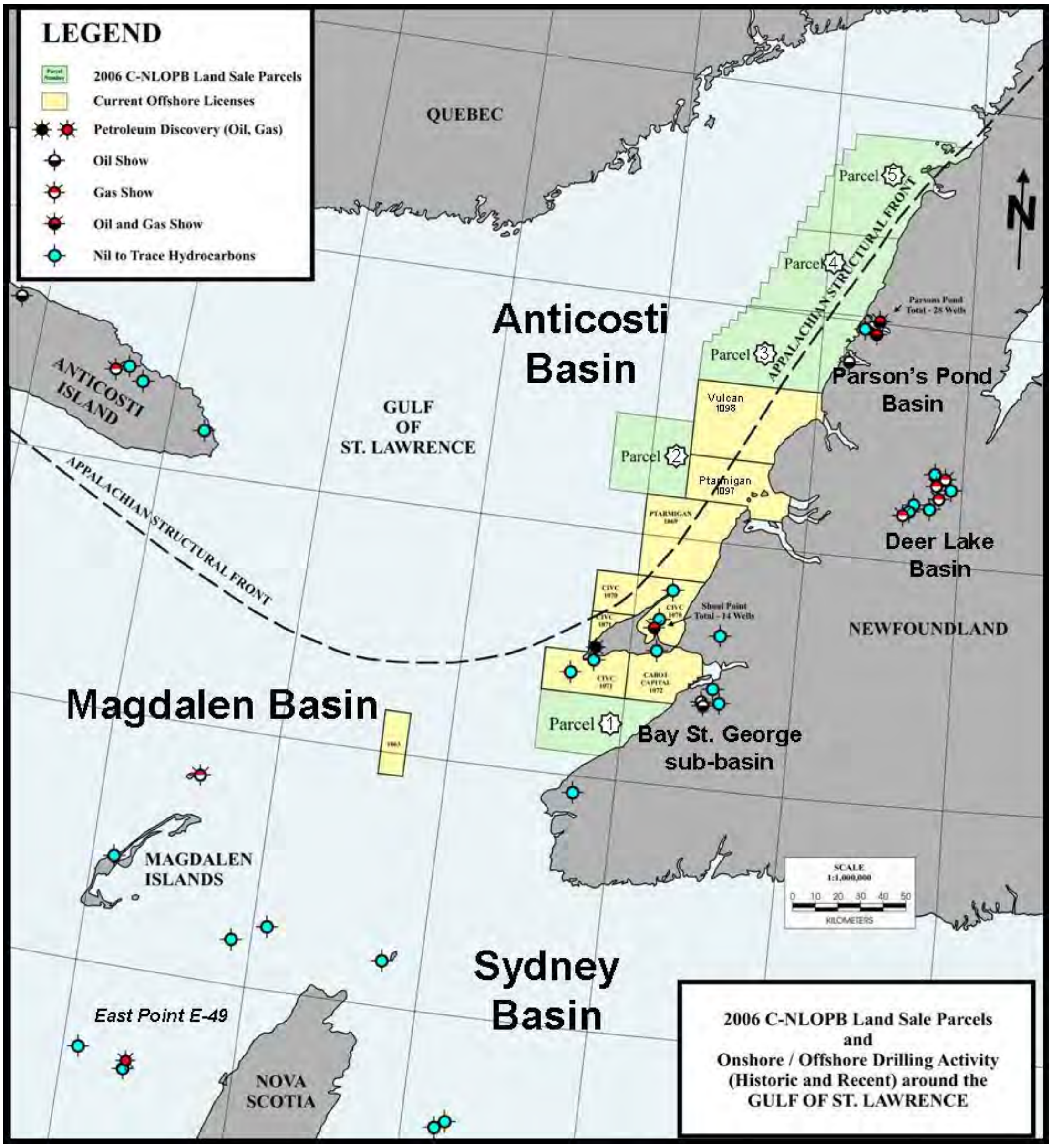

Figure 4. Regional geology map of the Paleozoic basins of the Gulf of St. Lawrence and West Newfoundland, including location of historical and most recent exploration wells, the West Coast Newfoundland active ELs and Call for Bids NL 06-3 Parcels (modified after NLDNR).

Several large Gulf of St. Lawrence seismic programs in the 1970s and early 1980s operated by companies such as Mobil, Chevron, Shell, Petro-Canada, etc., culminated with the drilling of ten offshore wells, one of which - the East Point E-49-drilled in 1970 - flow tested at 5 million cubic feet of natural gas per day (Figure 4). This well was drilled midway between Cape Breton Island and Prince Edward Island and is estimated to contain in-place gas reserves of 77 billion cubic feet in Carboniferous sandstone. This early exploration cycle ended with the oil price collapse of 1982. Since then, several large leads and prospects (e.g., Old Harry prospect mapped by Corridor Resources: http://www.corridor.ns.ca/properties/old_harry/index.xml have been defined in the maritime border area stretching between Nova Scotia, PEI, NL and Quebec.

During the 1990s, a number of large companies (Mobil, Norcen, BHP, Hunt, Talisman and PanCanadian) along with several local junior companies explored for petroleum in the onshore and offshore Paleozoic basins of western Newfoundland. This exploration cycle resulted in several nearshore and shallow water marine seismic programs extending from the southern portion of Bay St. George to Hawkes Bay in the north (Figure 5).

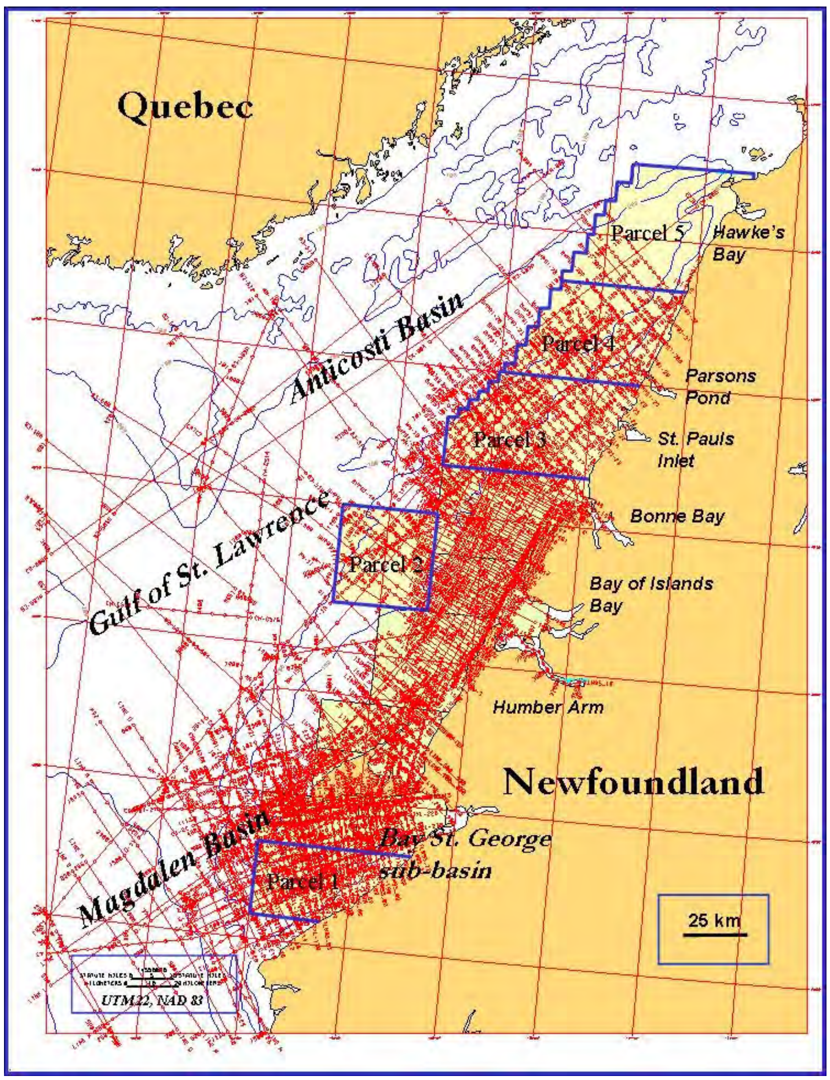

Figure 5. Call for Bids Parcels 1 to 5, previously awarded Exploration Licences and existing seismic coverage in the West Newfoundland offshore area (spring 2006, modified after C-NLOPB).

In 1994-95 Hunt Oil of Dallas Texas and partner PanCanadian Petroleum drilled the Port au Port #1 well at the Garden Hill area on the southwest corner of the Port au Port Peninsula. As previously noted this was the very first well location in western Newfoundland based on seismic data. The well encountered several reservoirs, one of which was hydrocarbon bearing. Two intervals within the autochthonous, platformal Aguathuna Formation (Figure 8) (at approximately 3,400 m KB) flowed at 1,528 and 1,742 bopd of high quality oil (51 degree API) and 2.6 and 2.3 mmcfd of natural gas, respectively, with associated water (Figures 4 and 6). An extended test over one of the zones flowed a total of 5,012 barrels of oil and 9.2 million cubic feet of gas over a nine day period, but the flow diminished with time. There are a number of possible explanations why flow rates dropped off at the time of these initial tests. Follow-up work by CIVC who farmed into the project, demonstrated that the reservoir around the well bore was probably an isolated porous zone within a larger trend. Cooper et al. (2001) proposed that this reservoir is likely to have been hydrothermally dolomitized.

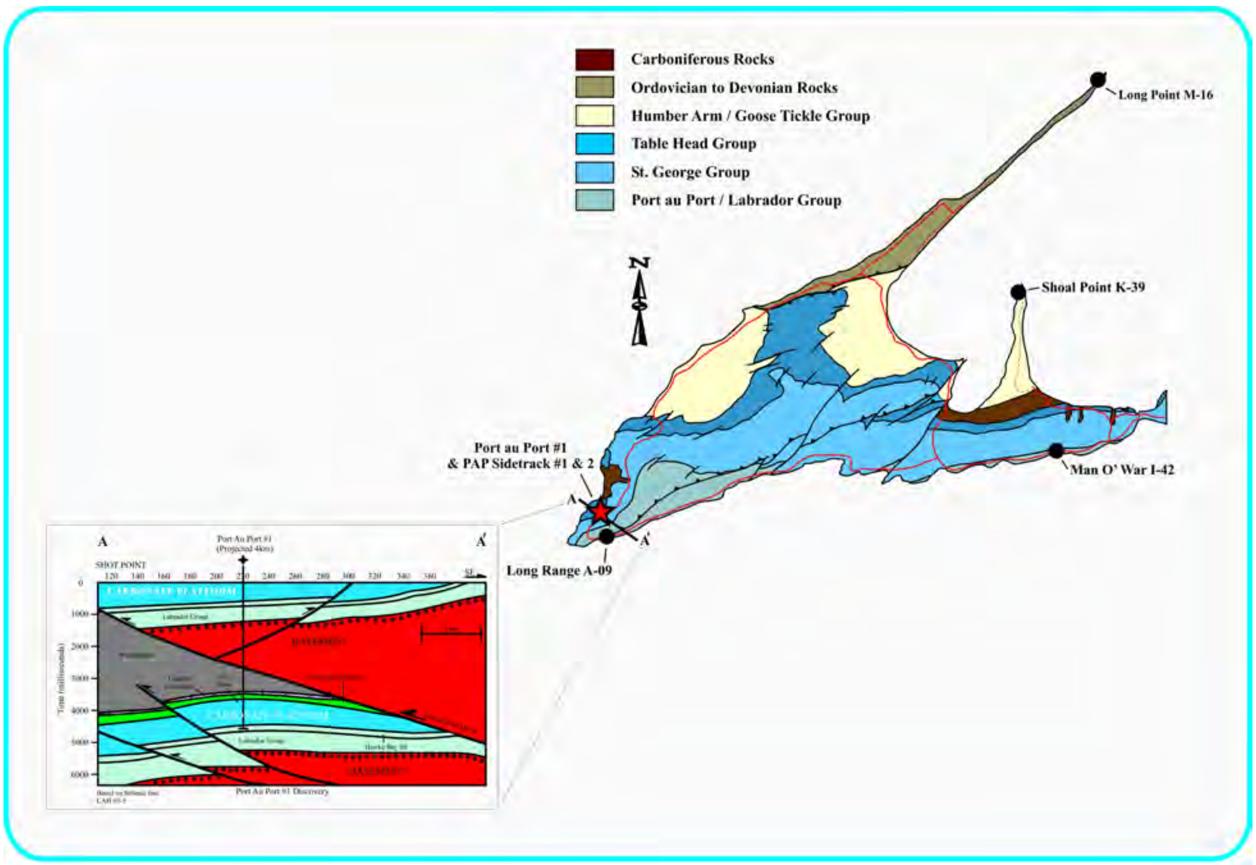

Figure 6. Regional geology map and location of the Port au Port #1 discovery - Garden Hill oil field operated by CIVC (after NLDNR). Insert shows the geological interpretation of the seismic line through the well (modified after Stockmal and Waldron, 1993; Cooper et al., 2001 and Government of Newfoundland and Labrador Department of Natural Resources).

This oil and gas flow to surface from the first modern well in the area caused a great deal of excitement among participant companies and local players. Subsequent drilling of four deep wells to test the same target zone in the immediate area encountered only shows and based on these results the major operators departed the province. Junior companies continue to hold lands and explore both Ordovician and Carboniferous targets. Interest in a regional hydrothermal dolomite play has more recently been given a boost by success in similar rocks in New York State (Eaton, 2004; Atkinson, 2005) and exploration of the trend is ongoing elsewhere in Atlantic

Canada - on the Gaspe Peninsula (Galt), New Brunswick (away from the McCully field), on Anticosti Island as well as western Newfoundland.

Successful exploration of the hydrothermal dolomite play in New York and in the Rocky Mountain Foothills has been aided by use of 3D seismic, which can under the right circumstances allow the direct detection of porosity. Porosity can also be inferred by association with basement faulting, karstification and platform collapse zones. Unfortunately only 2D data has been recorded to date, both onshore and offshore West Newfoundland. The early nineties marine seismic data is good to fair quality, but the older data acquired prior to 1989 is of very poor quality and largely un-interpretable. Modern offshore data (about 5,000 km) acquired by several major and intermediary companies during the 1990s provides good imaging of the subsurface along most of the coastline and is available from C-NLOPB in hardcopy for the cost of reproduction and for sale in digital form from the data owners. Further offshore and to the north, the seismic coverage is sparse, and older data is available only on microfiche.

Only five offshore wells have been drilled in the West Newfoundland jurisdiction, of which four were directionally drilled from land and one of these had to be abandoned before reaching its target depth due to operational problems. The four offshore wells drilled from land are all located on the Port au Port Peninsula and the only one "true" offshore well (St. Georges Bay A-36) lies to the SE of the Port au Port Peninsula (Figures 4 and 7). The key challenge in terms of hydrocarbon prospectivity in the Paleozoic has been in finding good quality continuous reservoir that contains hydrocarbons. Good quality reservoirs have been encountered (eg., Catoche and Watts Bight in the Port au Port #1 well) but thus far have tested water.

2.4. Most Recent West Newfoundland Exploration

A one year extension (to July 2007) for the Anticosti Basin onshore Production Lease #2002-01 on the Port au Port Peninsula has been granted to Canadian Imperial Venture Corp (CIVC) (Figure 7). This PL which includes the Port au Port #1 discovery well and the follow-up development well ST #2 at Garden Hill South is the only production lease awarded under the petroleum regulations of the Province of Newfoundland and Labrador and covers an area of approximately 33,000 acres along a prospective Cambro-Ordovician thrust belt fairway. CIVC and its partners, PDI Production Inc. (Ireland) and Gestion Resources Limited (UK) plan to establish commercial production at Garden Hill South and to explore the northern areas of the lease. Re-entry, re-work and completion of ST #2 will be the first operations conducted on the extended lease and this will be followed by more seismic and re-mapping to outline additional prospects.

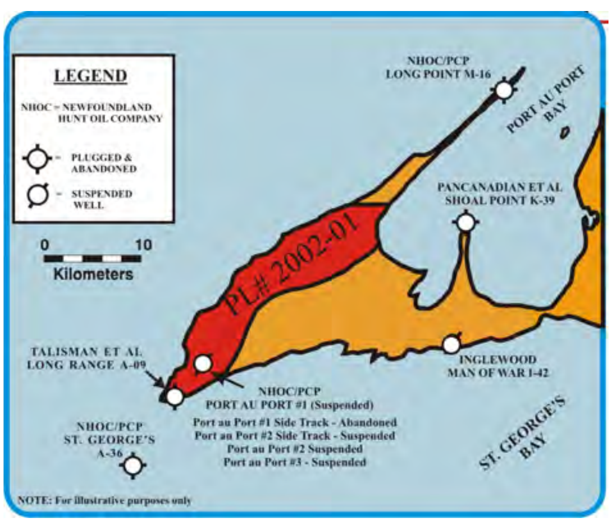

Figure 7. Production Lease #2002-01 and location of exploration and development wells on and near Port au Port Peninsula, West Newfoundland (after NLDNR).

The five exploration wells drilled on or around the Port-au Port peninsula during 1995-1999 tested Cambrian-Ordovician-Silurian rocks within the triangle zone and the Appalachian structural front (Figures 6 to 8). A triangle zone (or tectonic wedge) similar to the situation at the edge of the Rocky Mountains Foothills was first recognized by Stockmal and Waldron (1990 and 1993) by analysing marine seismic sections perpendicular to the West Newfoundland shore. The Appalachian deformation front and the triangle zone are present in several of the parcels currently offered for bid.

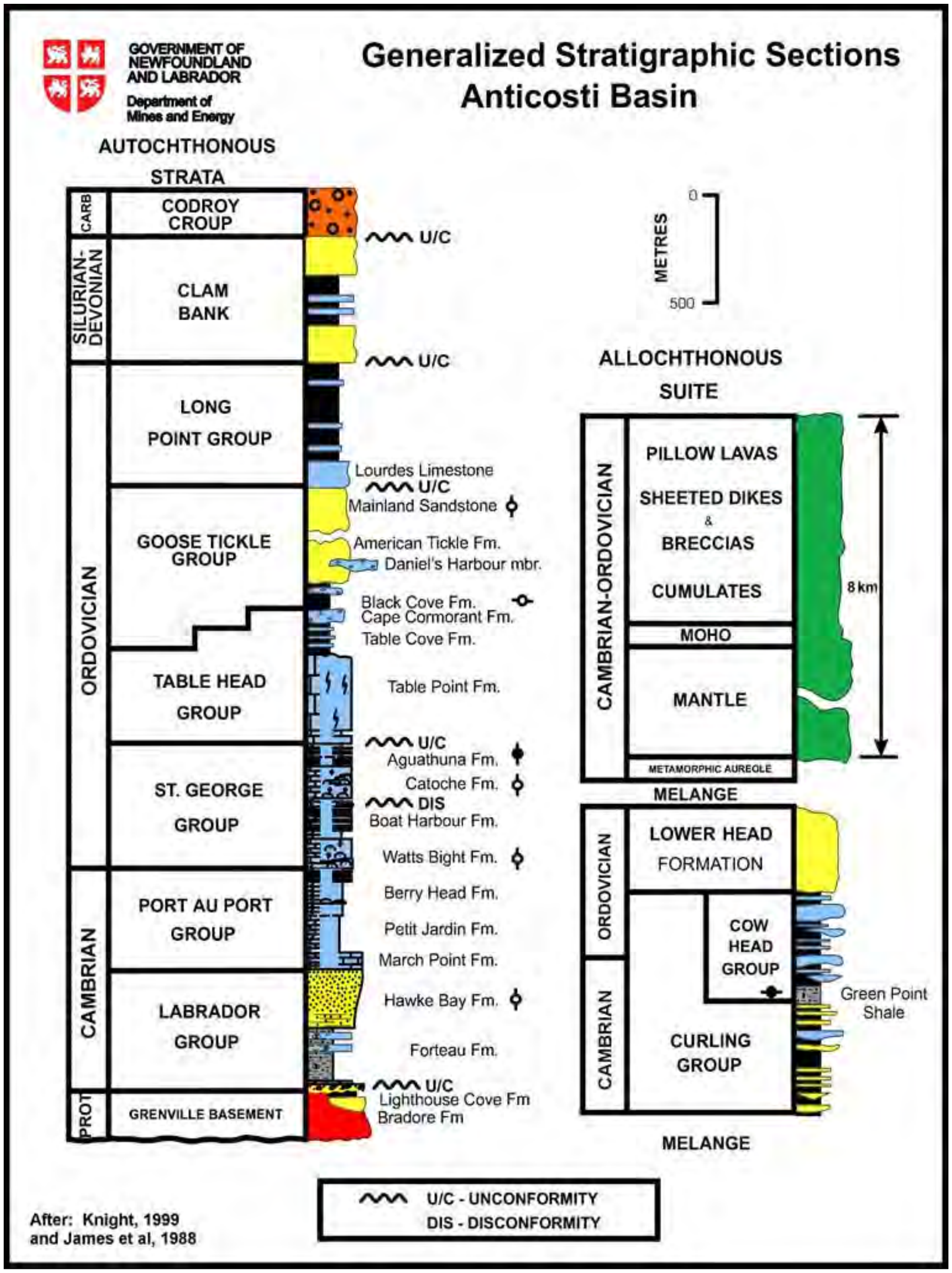

Figure 8. Generalized stratigraphy of the autochthonous and allochthonous sequences forming the West Newfoundland offshore and onshore Lower Paleozoic sedimentary basins (modified after James et al., 1988; Knight, 1999 and NLDNR).

A well was also recently drilled (2003) by Contact Exploration of Calgary and its partners within Cambro-Ordovician rocks in the Parsons Pond area. These rocks represent the onshore continuation of the Anticosti Basin. The well was a shallow test of the allochthonous sequence

(Daniels Harbour Member), targeting enhanced porosity due to thrust-induced fracturing (Figure 4). The area is part of the Appalachian fold belt and contains several stacked thrust sheets in the shallow subsurface, emplaced on top of a slightly faulted carbonate platform. The Parsons Pond #1 well (TD 1,060m) contained some shows, but the well failed to penetrate anticipated Daniels Harbour carbonate and possible Goose Tickle sandstones (Figure 8) and a deeper (approximately 2,500 m), large anticlinal closure within the carbonate platform. Additional seismic data will be needed to better delineate several large leads located in less deformed, Ordovician carbonate platform at depths between 2,500-3,500 m. These platform sequences may contain dolomitized units within large closure fault bounded blocks.

In addition to the Cambrian-Ordovician play numerous oil and gas shows have been encountered in Carboniferous rocks in the Deer Lake and Bay St. George Basins onshore western Newfoundland. The Deer Lake Basin (Figures 2 and 4) is an inverted Paleozoic rift basin where the plays involve rotated and inverted blocks containing porous and permeable North Brook sandstone (Carboniferous) and the deeper dolomitized Ordovician carbonates. The source rocks are Mississippian lacustrine shales and dolostones of the Forty Five Brook and Rocky Brook Formations. Two modern wells (Western Adventure #1 and #2) were drilled by Deer Lake Oil and Gas (DLOG) in this basin. The Western Adventure #1 well drilled in 2000 tested 100,000 cu ft of gas per day, with some condensate from sandstone units within the North Brook Formation (Figure 4 and http://www.deerlakeoilandgas.com/npei.pps).

Vulcan Minerals of St. John's has drilled seven shallow land wells (less than 1,000 m) in the Bay St. George sub-basin in order to test large, seismically mapped structural features (http://www.vulcanminerals.ca/properties/onshore.html). The Bay St. George sub-basin is part of the larger Carboniferous aged Magdalen Basin. Historically, most of the activity has been in the north end of the sub-basin where crude oil was encountered at shallow depths beneath a gypsum quarry in the Flat Bay area, and natural gas was discovered and flared as part of the same mining operation approximately 50 years ago (Figure 4). In the same area, Vulcan has encountered a thick oil zone in a shallow low permeability reservoir (Anguille conglomeratic sandstone) in several wells. The oil zone is up to 150 m thick, with the top as shallow as 50 m. The oil is light (34° API) and sweet and appears to be derived from a lacustrine source rock. New seismic lines and high resolution aeromag data collected during 2005-2006 in the Bay St. George sub-basin, has allowed the identification of several large structural closures located away from the Flat Bay anticline. Two to three wells are to be drilled to intermediate depth (approximately 1,000 m) during 2006 and additional seismic is planned to better define some of the deeper leads (http://www.vulcanminerals.ca/images/VulcanMineralsWesternNewfoundlandProspects.pdf).

No drilling or seismic recording has occurred offshore Western Newfoundland since the late 1990s. However, six offshore licences have been issued by the C-NLOPB - 3 in 2001, and 3 in 2005 (Figures 4 and 5). A new round of offshore drilling is anticipated in the near future in order to evaluate these licences.

2.5. Recent Offshore Landsale Results

Offshore Newfoundland and Labrador exploration areas are licensed by the C-NLOPB to the party submitting the highest bid in the form of work commitments, which are secured by a refundable deposit equal to 25% of the bid amount (http://www.cnlopb.nl.ca/). The minimum bid for all parcels in the Western Newfoundland Offshore Region is $250,000 (approximately US $220,000) per parcel.

A total of 0.96 million hectares (2,372,212 acres) are held under exploration permit (EP on land) or licence (EL offshore) at present time (Figure 9). Six offshore Exploration Licences (ELs) for a total 0.7 million hectares (1,729,738 acres) are presently active. ELs 1070 and 1071 were awarded in 2001 to CIVC, who also holds the Production Lease for the Garden Hill oil field (Figures 6 and 7). Also awarded in 2001, EL 1069 is held by Ptarmigan Resources and EL 1072 is held by Deer Lake Oil and Gas. Most recently, in 2005 EL 1097 was awarded to Ptarmigan and partners and EL 1098 to Vulcan Minerals and partners.

No new marine seismic data has been acquired offshore western Newfoundland since these licences were issued. The current offshore licence holders are junior companies who are re-interpreting the existing geological and geophysical data, and seeking partnerships for eventual drilling.

Figure 9. Land tenure in the West Newfoundland offshore region; includes previously awarded Exploration Licences in green, 2006 Call for Bids NL06-3 Parcels 1 to 5 in yellow and Port au Port #1 discovery well location (spring 2006, modified after C-NLOPB).

3. Regional Geology of the West Newfoundland Basins

The island of Newfoundland forms the northeastern North American terminus of an extensive, once continuous Texas to Northern Europe, Paleozoic aged mountain chain developed during the Appalachian Orogen. The Appalachian Orogen evolved through a Wilson cycle, starting 600 million years ago and closing with continental collision and the formation of Pangea approximately 300 Ma ago. The geologic divisions of Newfoundland record the development of the intra-continental rifts, Lower Paleozoic continental margins, Iapetus oceanic basement, and terranes resulting from the docking of several island chains and final continent-continent collision (Laurentia and Gondwana).

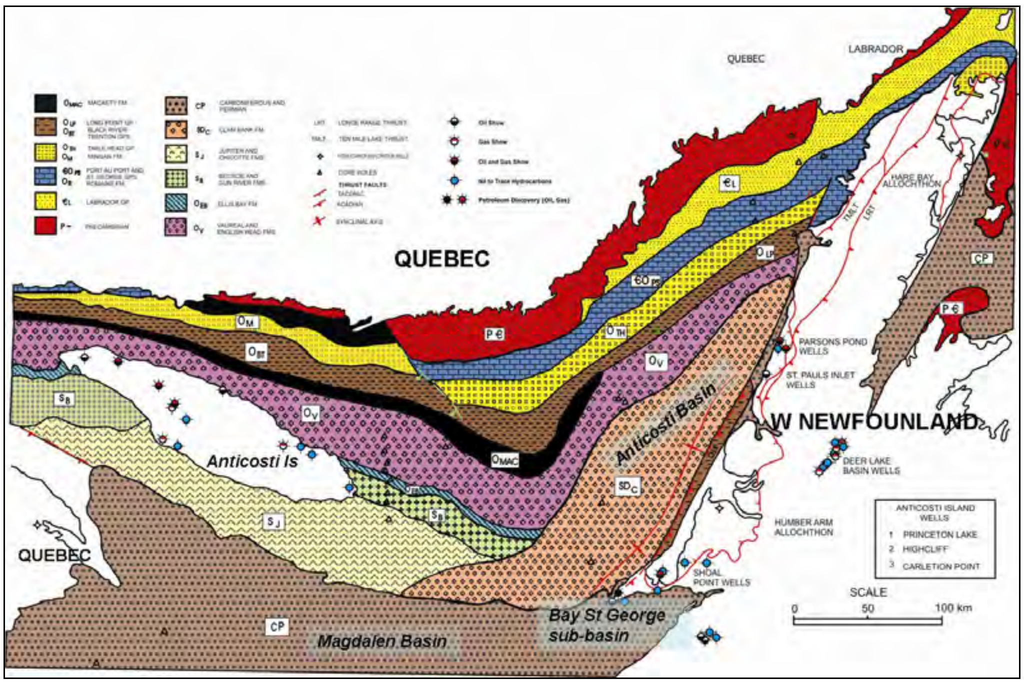

Figure 10. Bedrock geology of the offshore area between Quebec and West Newfoundland; diagram includes the Anticosti Basin and Bay St. George sub-basin where 2006 landsale parcels are located. Historical wells and hydrocarbons shows are indicated (modified after Sinclair, 1990).

After the Early Paleozoic North American continental margin rifted in early Mid-Ordovician, the West Newfoundland area was formed during three orogenic phases: Taconic (late Mid-Ordovician), Salinic (late Silurian) and Acadian (Devonian). These phases were associated with docking and thrusting of several microplates to the Laurentia continental margin.

The Acadian orogeny resulted in the raising of the Appalachian Mountains along the eastern North America continent (http://gsc.nrcan.gc.ca/mindep/synth_prov/appalachian/index_e.php). A final Alleghenian orogenic phase during the Carboniferous completed the formation of the supercontinent of Pangea including the island of Newfoundland. Erosion through Late Paleozoic to Tertiary almost peneplained the Appalachians before renewed regional uplift during the Tertiary and selective erosion (including glaciations) shaped the mountain chains and hills now forming the Newfoundland landscape. Regional uplift may have been related to plate movement readjustments during opening of the Atlantic Ocean.

The westernmost geological unit of the island of Newfoundland is the Humber Zone (Figures 10 and 11). The rocks and structures of this unit illustrate the break-up history of an ancient North American continent, formation of the Laurentia continental margin and spreading of the Iapetus Ocean. The area's evolution began with rifting of existing continental crust, dated at around 600 to 550 Ma. The rifting is evidenced by magmatic injections that filled fractures in the older crust and fed volcanic eruptions at surface. It also led to deposition of coarse grained sedimentary rocks (Figure 8). This was followed by the development of a passive continental shelf with mainly thick limestone deposition, like that of the present Bahamas, and also with synchronous continental slope and rise deposits. This stage lasted for about 100 million years. It ended with deposition of clastic rocks of easterly derivation, which are the first suggestion of offshore disturbance and an indication of forthcoming orogenic events (after Williams, 2003). The destruction of the margin is marked by the transport of rocks from the compressed, uplifted continental slope and rise prism landward above the former continental shelf. These transported rocks are, in turn, structurally overlain by slabs of oceanic crust and mantle, such as the Tablelands in the Bonne Bay/Trout River area. After closure of Iapetus, Appalachian sedimentation consisted mainly of subaerial red and grey sedimentary rocks that include fluvial and lacustrine strata, coal measures, shallow marine limestone, and evaporites. These rocks are present in western Newfoundland and extend offshore underlying much of the Gulf of St. Lawrence, the southern Grand Banks (Sydney Basin), and the northeast Newfoundland shelf (St. Anthony Basin) (Figures 1, 2, 6, 8, 10 and 11). Some of the sub-basins seen now on land and offshore started as extensional rifts, others evolved as wrench structural basins (geological evolution modified from Williams, 2003).

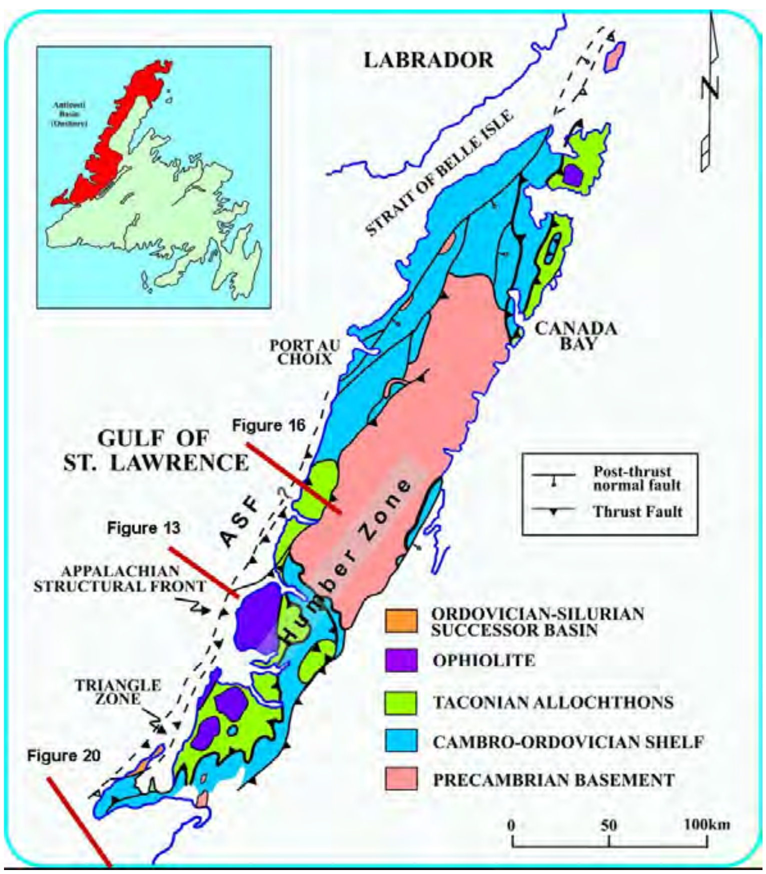

Figure 11. Geology map of the onshore Anticosti Basin (Humber Zone). Similar geologic successions continue offshore all the way to the Appalachian structural deformation front (ASF). A carbonate platform with a veneer of Carboniferous rocks forms the Appalachian foreland (modified after Colman-Sadd et al., 1988). Also indicated are the locations of the seismic line 91-1491 shown in Figure 13 and the structural cross-sections shown in Figures 16 and 20.

Upon synthesizing results of the mid-late 1990s round of exploration in the West Newfoundland basins, Cooper et al. (2001) has divided the Paleozoic strata of the Humber zone into six tectono-stratigraphic megasequences. The following classification from older to younger sequences is reproduced in this report with minor modification from their work (Cooper et al., 2001):

1. *Siliciclastic synrift sediments* (Late Proterozoic-Early Cambrian) deposited as the Iapetus Ocean opened up;
2. *Passive margin strata* (latest Early Cambrian-Early Ordovician) that consists of shallow water carbonates passing eastward into basinal shales;
3. *Flexural forebulge sediments* of the Taconic foreland basin that migrated westward through the region during (latest Early Ordovician to earliest Middle Ordovician), creating the regional St. George unconformity (Knight et al., 1991). A Middle Ordovician sequence of subtidal carbonates and shales was deposited in this early Taconic foreland basin;
4. *Culmination of the Taconic orogeny sequence*. This episode resulted in the westward overthrusting of basinal sediments (Humber Arm allochthon) and ophiolites. During this period, siliciclastic shallow marine sediments were deposited in the quiescent Taconic foreland basin (Late Ordovician to Salinic) and onlapped the Taconic allochthons;
5. *Emplacement of the Taconic allochthon sequence*. The Silurian Salinic orogeny caused additional displacement of the orogenic belt toward the west (Cawood et al., 1994) and exposure and erosion of the metamorphosed hinterland. Sedimentation in the Salinic foreland basin and deformation of the eastern Cambrian-Ordovician carbonate platform took place during this period;
6. *Successor basin fill*. Transtensional dextral reactivation of pre-existing basement faults (Bradley, 1982) followed the compressional deformation of the Late Devonian Acadian orogeny, creating successor basins with thick Carboniferous clastic fill (e.g., Deer Lake and Bay St. George basins) (Knight, 1983).

Lavoie et al. (2003) have also summarized the main extensional and compressional stages of the Lower to Middle Paleozoic evolution of the Western Newfoundland basins (Figure 12).

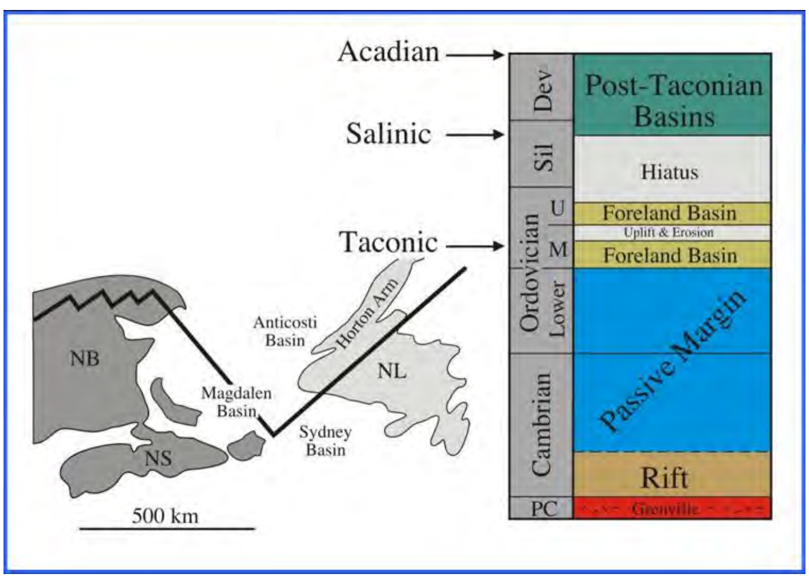

Figure 12. Paleozoic evolution of Western Newfoundland (modified after Lavoie et al., 2003).

As illustrated by seismic sections recorded in the Anticosti Basin, most of the rocks of the passive margin stage usually identified as the "Paleozoic Platform" (Figure 8) are only slightly deformed, mostly along major fault lines where block rotation, down dip failure, minor inversion and transtension may occur (Figure 13).

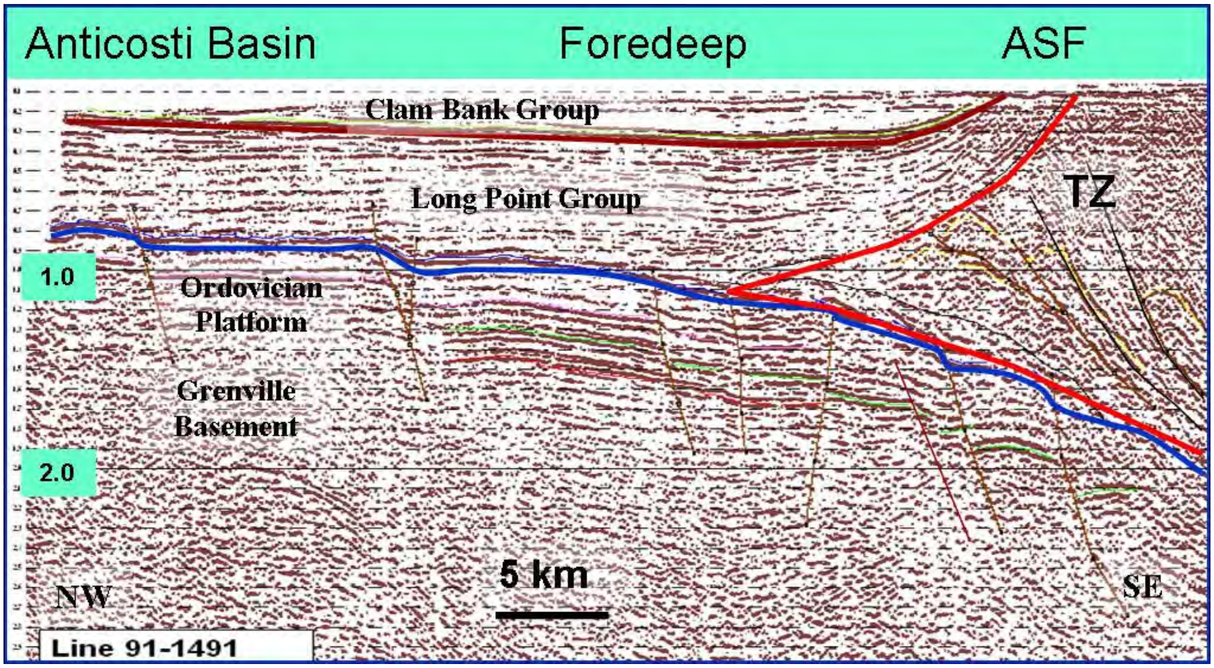

Figure 13. Marine seismic line from the Anticosti Basin to near the West Newfoundland coast line showing the faulted Cambro-Ordovician carbonate platform, the Permo-Carboniferous almost flat laying layers, the Foredeep, the Appalachian Structural Front (ASF) and the Triangle Zone (TZ) including several thrust sheets (modified after Fagan and Hicks, 2005).

The western limit of the Humber Zone is located where deformed rocks of the Appalachians belt pass into flat-lying rocks of the Anticosti Basin. This is called Logan's Line or the Appalachian Structural Front (ASF) (Figures 4, 11, 13 and 14). The eastern boundary of the Humber Zone is a steep belt marked by discontinuous occurrences of Dunnage Zone oceanic crust and mantle rocks along the Baie Verte or Cabot Fault Line (Figure 14). All oil and gas activity in West Newfoundland occurs west of the Baie Verte Line within the onshore Paleozoic sub-basins and the offshore Anticosti and Magdalen basins.

3.1. Anticosti Basin.

The Early Paleozoic Anticosti Basin is one of several basins that preserve Cambrian to Ordovician shelf and foreland basin rocks along the Appalachian trend of eastern North America (Figures 1, 2, 4, 9 to 15). Except for the wells drilled from Anticosti Island, the Port au Port Peninsula and shallow wells drilled on land in the Parson's Pond area, no other wells have been drilled in this basin (Figures 4, 6, 10 and 14).

Cambrian and Ordovician rocks of the Anticosti Basin include sandstones and carbonates that were deposited along the continental shelf and slope that bordered the ancient continent of Laurentia (Figures 8 and 10 to 15). The warm and vast Early Paleozoic Iapetus Ocean stretched to the south of the Laurentia margin. The closing of Iapetus and associated continental collision deformed the continental margin into a sinuous mountain belt that is preserved today as the Appalachian Mountains.

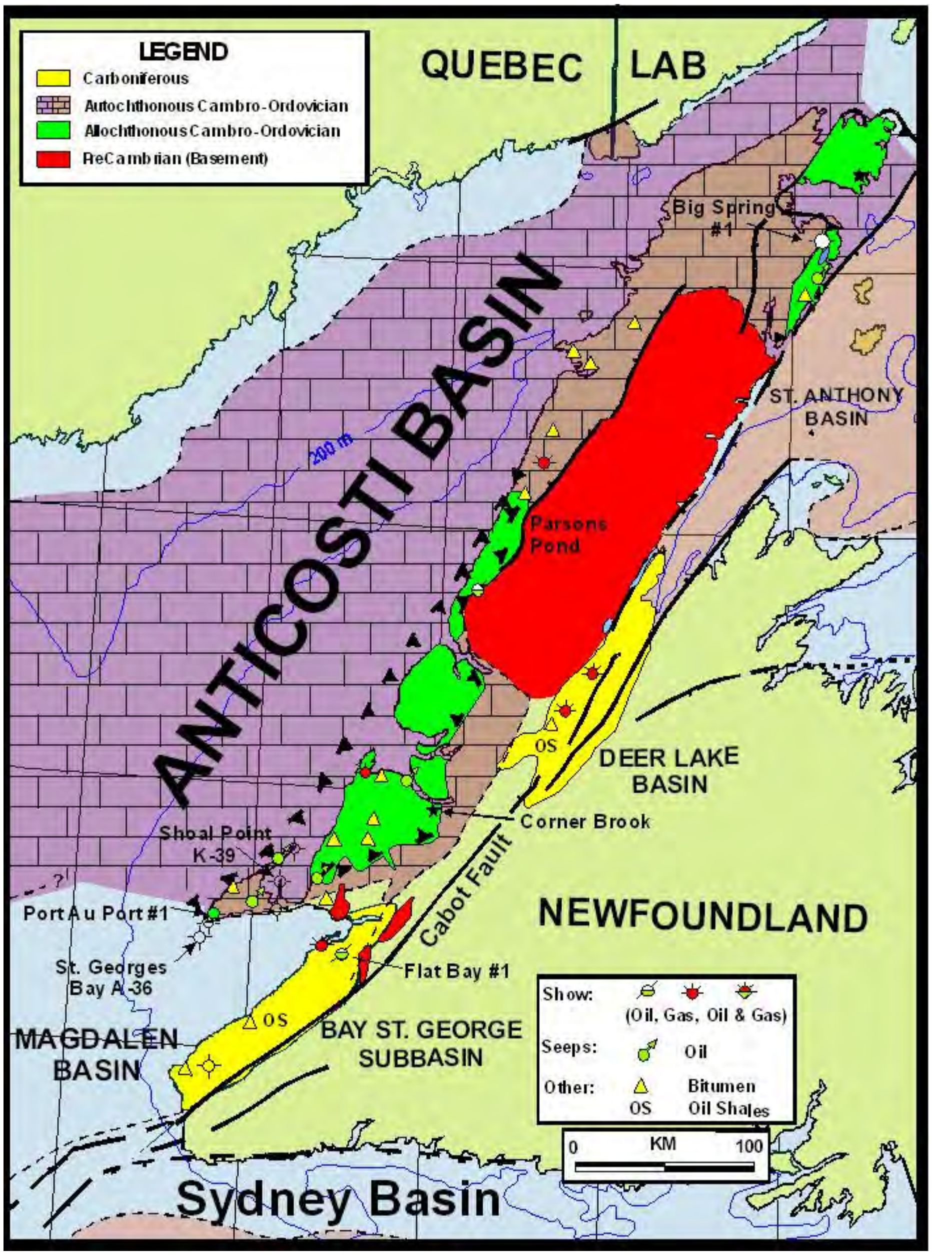

Figure 14. Geological map of the offshore Lower Paleozoic Anticosti and Magdalen basins and the onshore Appalachian belt including sedimentary sub-basins and oil and gas shows and seeps (modified after NLDNR).

Today the Early Paleozoic shelf is preserved in western Newfoundland as a lightly deformed, mainly carbonate, autochthonous platform sequence that is locally overlain (onshore and nearshore western Newfoundland) by transported slope to basin sediments and ophiolites that were thrust westward during continental collision (Figures 11, 14, and 15). Major reserves have been produced from similar age rocks (Ellenburger and Arbuckle groups in the Midland, Val Verde, Anadarko, Fort Worth and Arkoma basins) along this trend in the United States (Figure 15; Atkinson and Fagan, 2000; Fagan and Hicks, 2005). The Ordovician petroleum potential in carbonate rocks extends to the Hopedale Basin and Labrador Sea where two wells, Hopedale and

Gudrid tested gas from porous limestone and dolomites (Figure 15; Enachescu and Fagan, 2005a; Enachescu 2006a and b).

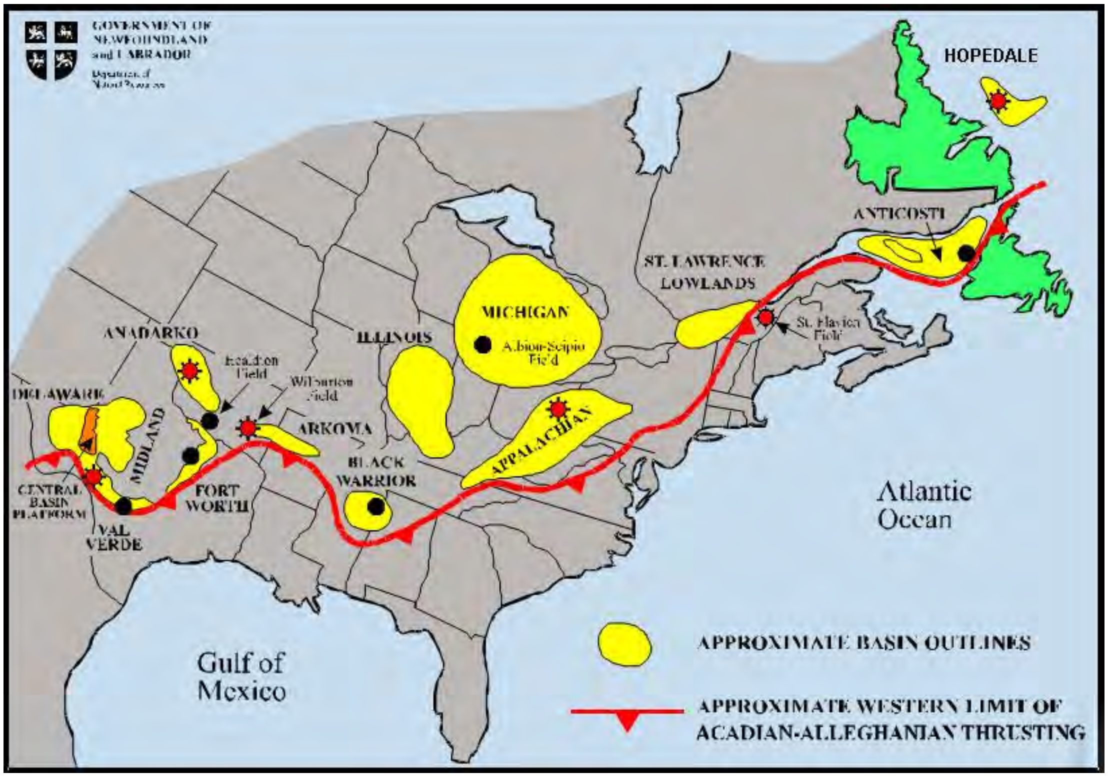

Figure 15. Map of North America indicating approximate location of petroliferous basins associated with the Appalachian deformation front and Ordovician coastline (modified after NLDNR).

Logan's Line or the Appalachian Structural Front (ASF) is a major thrust zone separating moderate to intensely deformed, transported rock (on the south-eastern side of the fault in the Anticosti Basin) from their non-deformed to weakly deformed, non-transported equivalents (to the north-western side of the fault) (Figures 10 to 15).

Based on field work, 2D seismic interpretation and well results, Stockmal et al. (1993 and 1995) and Cooper et al. (2001) have described in detail the structural complexity and geological evolution of Western Newfoundland. Likewise, Atkinson and Fagan (2000) and Fagan and Hicks (2005) have shown more examples of seismic sections through the deformation front, which can be seen as a true triangle zone in the area north of the Port au Port Peninsula (e.g., Figure 12). More examples of seismic data are available from the Vulcan Minerals website (http://www.vulcanminerals.ca/). Several other examples of seismic sections in a similar structural setting will be described in section 5 of this report. Parcels 3 to 5 straddle the thrust front and present many hydrocarbon play possibilities within the triangle zone and the foreland basin (Figures 4, 10, 13 to 15).

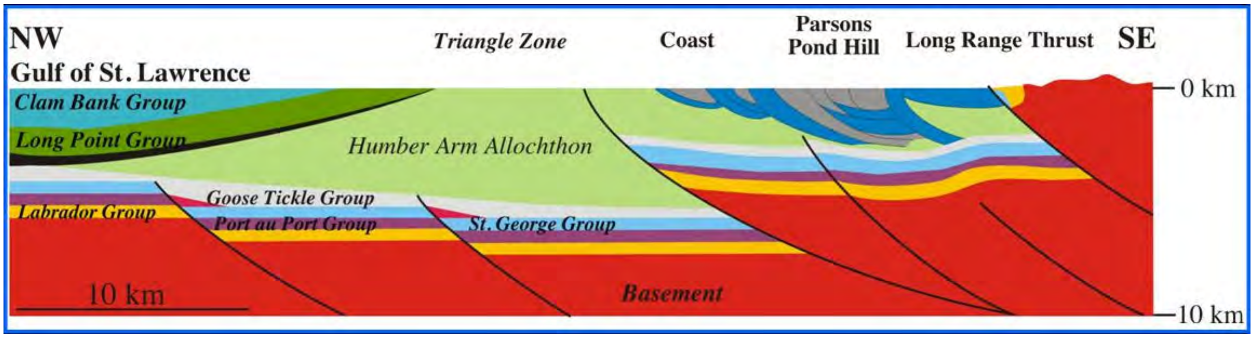

Figure 16. Geological Cross-section of the Anticosti Basin and Appalachian Triangle Zone within the Humber Arm structural unit (modified after Cooper et al, 2003).

Cooper et al. (2003) has constructed several geological cross-sections by synthesizing information from West Newfoundland seismic lines and well results. These sections show the geometry of the deformation front and foreland on the eastern margin of the Anticosti Basin at the approximate latitude of Parcel 1 to 5. The cross-section in Figure 16 also shows the many possible structural-stratigraphic trapping mechanisms within the extended and slightly inverted platform, and within the Appalachian structural front (ASF).

3.2. Bay St. George sub-basin

This is a sub-basin of the larger Permo-Carboniferous Magdalen Basin, which in turn is part of a broader Maritime Basin that stretches between Quebec, New Brunswick, PEI, Cape Breton Island and Newfoundland (Figures 1 to 5, 9, 10, 12 and 14). The basin was initiated during the late stages of the Acadian Orogeny in an extensional setting that included periods of dextral transpression (Williams, 1995). The Magdalen Basin encompasses an area of 160,000 km^2 and has a succession of continental and shallow marine strata up to 15 km thick. The succession contains mainly clastic and evaporite strata, resting on Grenville age crystalline basement (Acadian Orogeny basement) (Hayward et al., 2002).

The sedimentary rocks were deposited in two major tectono-stratigraphic units: a lower Carboniferous succession of clastics and volcanic rocks in fault-bounded sub-basins, and a middle to upper Carboniferous (post-rift) succession of carbonates, evaporites and clastics (Figures 17 and 18). Coal beds are abundant in the upper Carboniferous. Basin structures are associated with rift faulting (and related inversion structures) and salt tectonics (Knight, 1992; Dietrich, 2003). These sequences have been drilled in several offshore wells south of Newfoundland (Dietrich, 2003). This succession is similar to the one found in the Permian Basin of West Texas or in certain areas of the Gulf of Mexico.

Nine offshore wells, located around the northern and eastern sides of Cape Breton Island and PEI and about 20 onshore wells, located in the Maritime Provinces plus several in the Port au Port to Bay St. George area have been drilled in this basin (Figures 3, 4, 7, 10 and 14). Most of the wells tested anticlines associated with salt diapirs and pillows. Carboniferous rocks on land and offshore are deformed due to faulting and salt tectonism. Both crystalline basement structuring and salt induced folding indicate that the main direction of tectonism is NNE to NE. Faults and structures are offset by approximately E-W trending transfer faults that suggest association to the regional dextral transpressive regime associated to the major Cobequid-Chedabucto fault zone (Hayward et al., 2002).

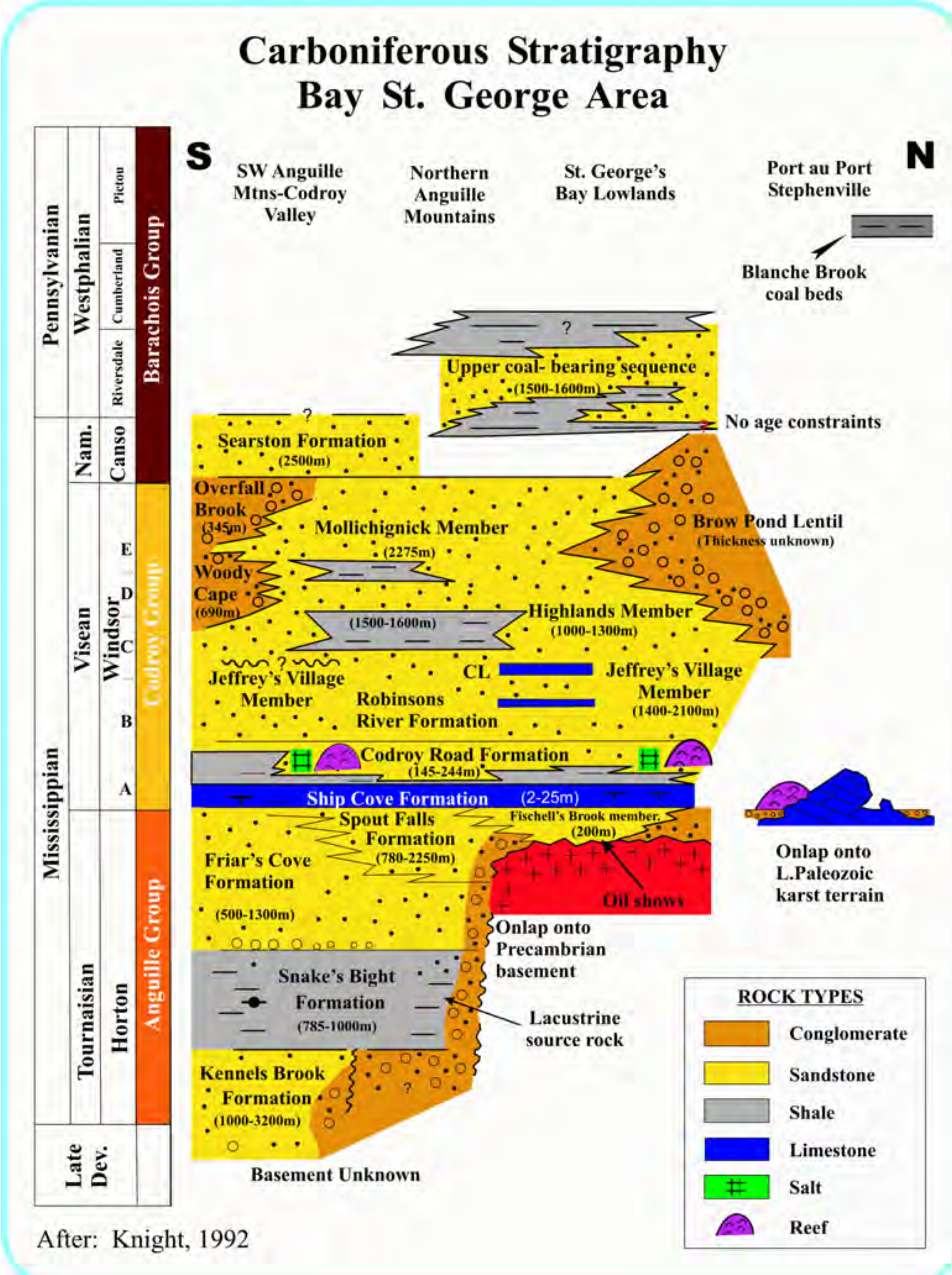

Figure 17. Age and lithology of main stratigraphic formations in the Bay St. George sub-basin (modified after Knight 1992).

A lengthy hiatus and angular unconformity named the Visean Unconformity marks the transition from pre-Carboniferous basement (Precambrian and/or Cambro-Ordovician platform sequence) and the Carboniferous infill (Lynch and Keller, 1998). The St. George's Bay A-36 well penetrated a 400 m Carboniferous sequence consisting of Barachois and Codroy sediments before crossing this unconformity into Late Ordovician Long Point Group (Allison, 1996) (Figures 18 and 19). According to Robbins (2000), who studied the Carboniferous infill of the Bay St. George sub-basin using released industry seismic data, the structure of the basin consists of two northeast trending asymmetrical half-grabens separated by a central basement high bounded by a regional fault (Figure 19). These grabens are filled with south-easterly thickening sedimentary fill. The northern graben, first mapped by Robbins (2000), has a width of more than

10 km and a fill reaching more than 3500 m above the pre-Carboniferous basement (Figure 19). This half graben is characterized by the presence of a north-westerly dipping domino fault system and of a large salt roller in the hanging wall of the master fault. The southern half-graben is larger, has a width of more than 30 km and is contained between the Central Bay Fault and the Bay St. George Fault that extends along the south-eastern shore of the bay (Robbins, 2000 and Figure 19). The graben contains numerous salt pillows, more complex salt anticlines and fault bounded highs resembling structures encountered to the south in the Magdalen Basin and on land in the Bay St. George area (http://www.nr.gov.nl.ca/mines&en/publications/onshore/west/ and Fagan, 2002).

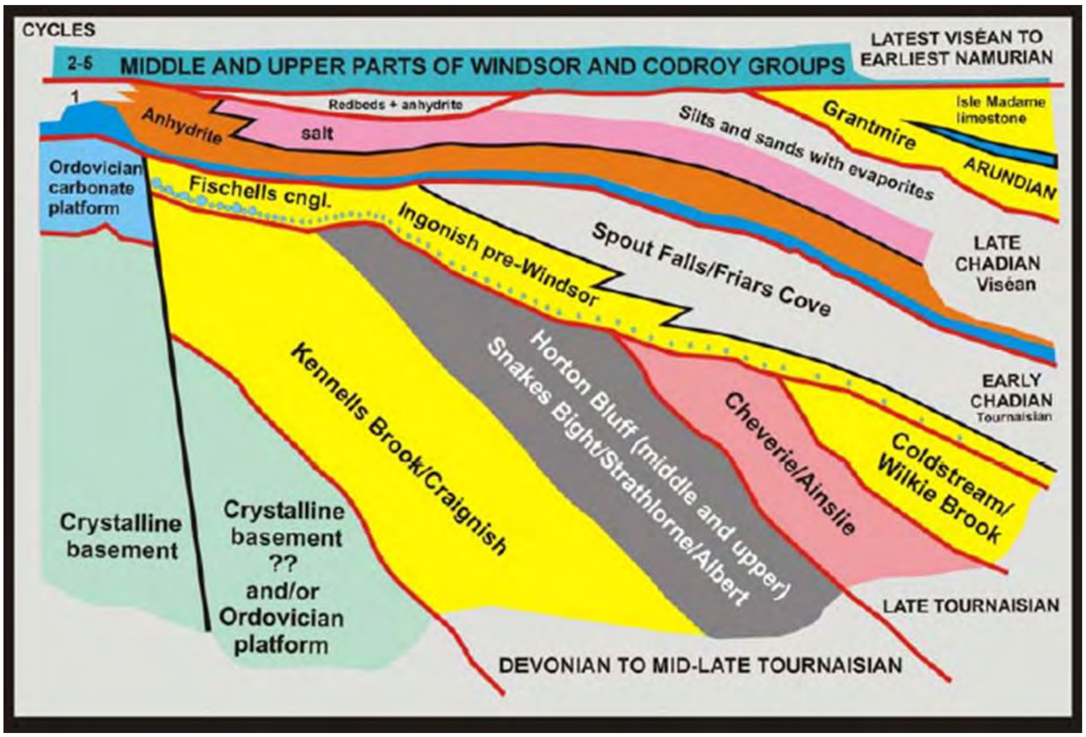

Figure 18. Structural and stratigraphic relationships of geological units forming the Carboniferous Bay St George basin infill (Giles, 2006).

The Carboniferous half-grabens of the Bay St. George sub-basin were formed through crustal extension during Visean time. Halokinesis of the Windsor salt started before the deposition of the Codroy clastics due to differential loading. Subsequently salt walls and more complicated flow patterns were formed due to transtensional movement along the NE-SW faults.

On land lying to the east of Parcel 1 (Figure 4, 5 and 9) Vulcan Minerals has mapped several fault block and salt related plays. Vulcan has encountered both oil and gas in the Anguille Group clastics and plans to drill at least two wells in the area during 2006, as well as shoot additional seismic (Source: http://www.vulcanminerals.ca).

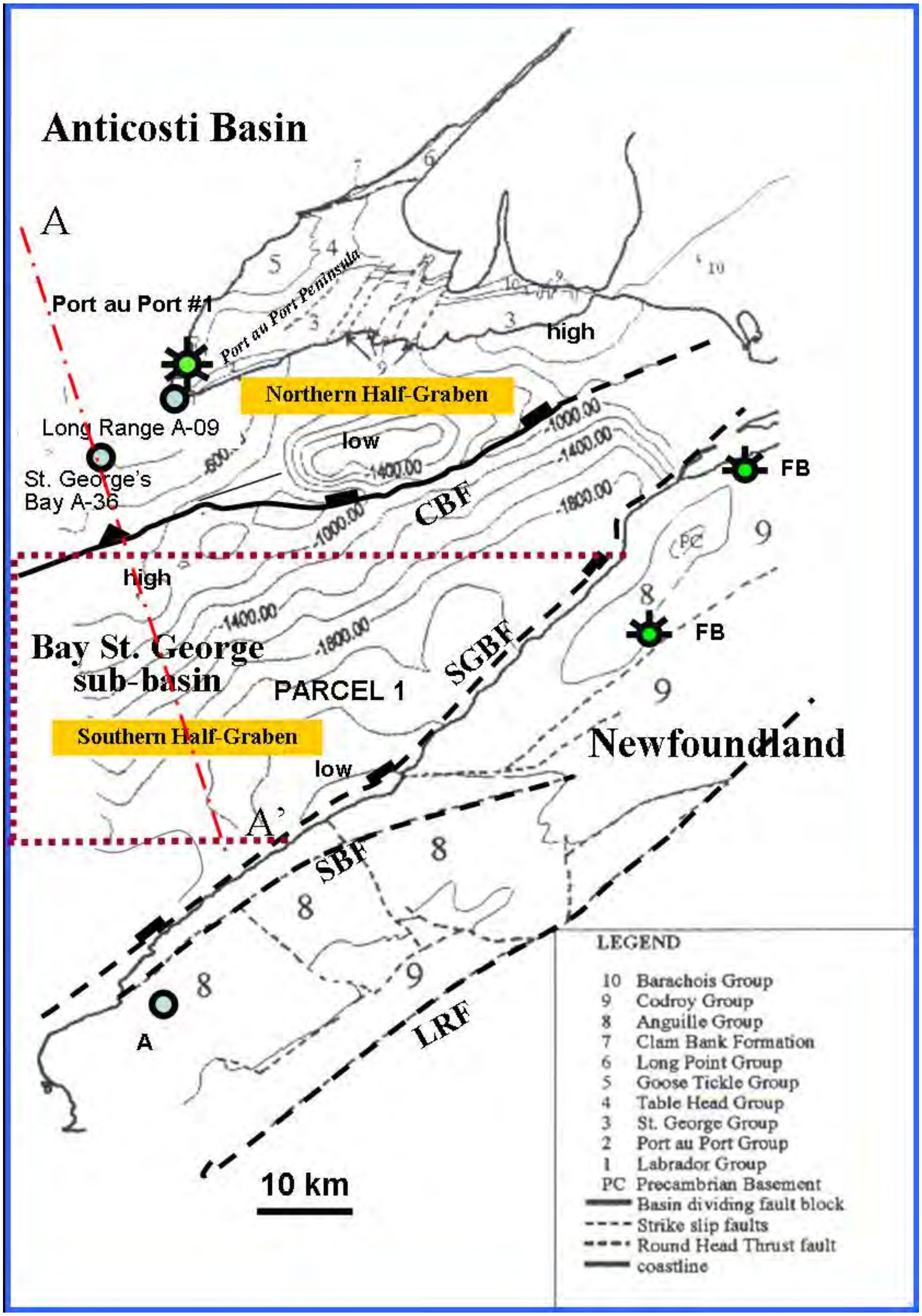

Figure 19. Time structure map (TWT) of the Base Carboniferous (Visean) Unconformity in Bay St. George area showing two distinct half-grabens (modified after Robbins, 2000). Parcel 1 and A-A' geological cross-section in Figure are shown. Abbreviations are FB = Flat Bay wells, FBA = Flat Bay Anticline; A = Anguille H-98 wells; LRF = Long Range Fault, SGBF = St. George Bay Fault, CBF = Central Bay Fault.

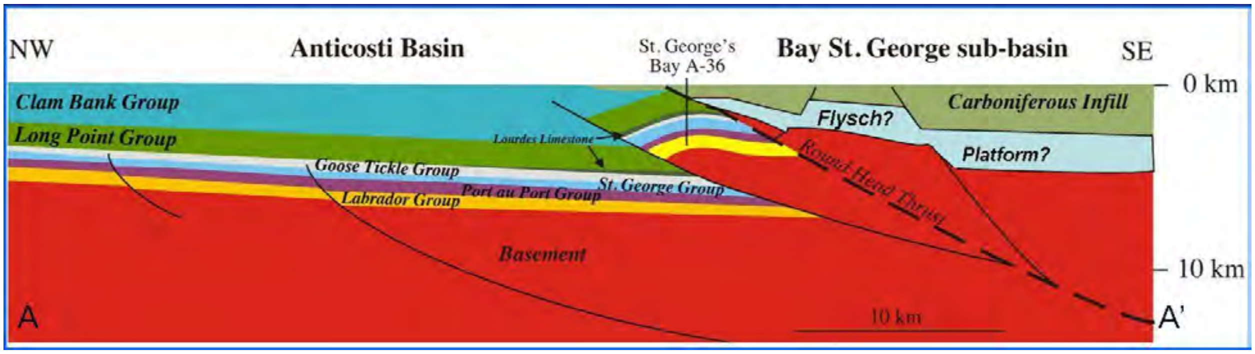

Figure 20. NW-SE Regional cross-section through the Anticosti Basin, location of St. George's Bay A-36 exploration well and Bay St. George sub-basin (modified after Cooper et al., 2001). The position of cross-section is indicated on Figure 19.

The schematic cross-section A-A' (Figure 20) shows the location of the St. George's Bay A-36 well within the Bay and the tectonic contact between the Anticosti Basin and the Bay St. George sub-basin. As no wells have penetrated the Carboniferous basin the nature of its underlying basement is unknown. Nevertheless the extension of the Carbonate Platform under the basin is justifiable by its presence on land where it is well expressed on recent seismic data. Structural complication due to salt tectonics and transtensional faulting are also present on the onshore seismic discussed by Fagan (Pers. Comm.) and shown on the Vulcan website. (http://www.vulcanminerals.ca/images/VulcanMineralsWesternNewfoundlandProspects.pdf).

4. Petroleum Geology of West Newfoundland Paleozoic Basins

This section is written following accounts by Sinclair (1990), Fowler et al. (1995), Atkinson and Fagan (2000), Cooper et al. (2001), Fagan and Hicks (2005), Atkinson (2005a and b), Atkinson and Wright (2006) and reviewing the limited petroleum geology literature on the area.

4.1. Source Rock

Several Paleozoic intervals with medium to rich source rocks have been recognized from drilling and outcrop sampling (Figures 8 and 17).

Green Point shale. The proven source rock for the Anticosti Basin onshore western Newfoundland is a shale within the late Cambrian aged Green Point Formation. This formation is present in the Humber Arm allochthonous sedimentary suite (Figure 7). Analysis of Green Point samples by the C-NLOPB yielded a TOC of 1.74% to 3.04%, but values up to 10% were also reported by Fowler et al. (1995) and Cooper et al. (2001). Hydrogen Index (HI) of 367-451 and Oxygen Indices (OI) of 4-26 were reported in the literature (Sinclair, 1990). Physical and chemical analyses indicate that Green Point strata are significant type I/II source rocks (Fowler et al., 1995). Geochemical fingerprinting has identified the Green Point shale as the likely source rock for the oil shows at Parsons Pond and for the Port au Port #1 discovery. Average thickness for the Green Point shale is 50 m. East of the ASF, the Green Point source rock is widespread as evidenced by hydrocarbons encountered at both Parsons Pond and on the Port au Port Peninsula, as well as the numerous source rock outcrop locations seen in the Anticosti Basin portion of western Newfoundland. The source rock is marginally mature to mature when sampled in outcrop.

McCasty shale. Additional source rock potential to the west of the ASF is provided by the Late Ordovician McCasty Formation which is the recognized source rock on Anticosti Island. The McCasty shale has not been encountered in western Newfoundland but may be present in the undrilled offshore foreland basin. Seismic data indicates that Parcels 2 to 4 being offered in this landsale would contain the foreland basin sequences including the McCasty source rock.

Black Cove-Cape Cormorant shale. The Middle Ordovician Black Cove-Cape Cormorant Formation, part of the autochthonous suite (Figure 7) has also been sampled from outcrop in western Newfoundland and should be present in the foreland basin to the west. Analysis of outcrop samples from these rocks by the C-NLOPB yielded an average TOC of 1.2% (but values up to 8% were reported by Atkinson and Wright, 2006). The shales have a HI of 246, and an OI of 18 (Sinclair, 1990).

An important distinction between the Green Point shales and the Black Cove/Cape Cormorant and McCasty sequences is that the latter are present in the autochthonous foreland basin, and should therefore be widespread throughout the Gulf of St. Lawrence (Sinclair, 1990).

Carboniferous coals and lacustrine shales and limestones. A final possibility for source rock charge would be the Carboniferous strata that contain numerous interbedded coals (e.g., Westphalian coals), lacustrine shales (e.g., the thick Tournesian Snake's Bight Shale) and algal limestones (e.g., Ship Cove Limestone) (Figure 16 and 17). These sediments would act as a direct source rock for prospects in Parcel 1 and could laterally charge the reservoirs of the Anticosti Basin parcels.

4.2. Reservoir Rock

Reservoirs rocks in the Anticosti and Magdalen basins are predominantly dolomitized carbonate rocks and sandstone. Both primary and secondary porosity have been encountered in wells and outcrop.

Anticosti Basin.

Ordovician carbonates. Well and outcrop information indicates that all of the Ordovician carbonate reservoirs are within dolostones of the Early Ordovician St. George Group and Middle to late Cambrian Port au Port Group. The factors controlling porosity within the Aguathuna Formation (the productive zone at Port au Port #1) are not well understood and the porosity appears to be highly variable. However, deeper reservoirs such as the Watts Bight and Catoche Formation may provide more regional and predictable dolostone targets. At Port au Port #1 the Watts Bight formation flow-tested water at 4,000 barrels per day and the Catoche flow-tested water at 800 barrels per day. The Catoche formation has been mapped in outcrop by Knight who indicates broad-based occurrence of Catoche porosity in western Newfoundland. All these carbonates are included in the early Ordovician St. George Group.

In the Port au Choix area the Ordovician Carbonates (including the Catoche, Aguathuana and Spring Inlet dolomites) are inundated with bitumen and Cooper et al. (2001) concluded that the Port au Choix Peninsula contains a large exhumed oil field.

Dolomite porosity may be microcrystalline, inter-crystalline and vugular. Secondary porosity creation in Ordovician carbonates depends on exposure and karstification of the platform carbonates during extension in Middle Ordovician time as well as fracturing, solution injection and preferential dolomitization of previously karsted and high energy grainstone zones during the Devonian (Cooper et al., 2001).

Lower Paleozoic sandstones. In addition to the carbonate reservoirs the Hawke Bay Sandstone (Cambrian Labrador group) was porous in the hanging wall at Port au Port #1 but was tight in the repeated section in the footwall. Additional reservoir potential is recognized within the autochthonous Late Ordovician Goose Tickle Formation that contains Mainland and American Tickle sandstones.

Other reservoirs. The Goose Tickle Group also contains dolomitized carbonate conglomerates (Daniels Harbour Member) and calcarenites carried in hanging wall thrusts (Knight – pers comm.). Other reservoir intervals were encountered in the Watts Bight Formation.

The Late Ordovician Long Point Group and Silurian-Devonian Clam Bank groups are not abundant at surface in western Newfoundland and may provide surprises when drilled offshore. Current knowledge would indicate the Long Point Group will be dominated by shales with minor limestones. The Clam Bank sequence offshore may also present unexplored porous clastic and carbonate zones. Other mentioned clastic reservoirs are the Eagle Island Sandstone and Blow-Me-Down Brook Sandstone, as well as the Misty Point Formation of the Long Point Group. The Misty Point Formation located along the western edge of the Port au Port Peninsula measures approximately 16% outcrop porosity (Quinn et al., 1999).

Porosity is best developed in the upper Catoche Formation, spottier in the peritidal Aguathuna and Spring Inlet Member, and extends as high as the lower Table Point Formation. The possibility of directly mapping hydrothermal dolomite porosity on high quality 3D seismic data and fluid indicator seismic attributes in this area remains to be explored.

Bay St. George sub-basin.

Cambro-Ordovician carbonate and sandstone reservoirs of the Autochthonous Platform described above may also constitute a significant portion of the underlying basement within the Carboniferous successor basins. This “platform series” is targeted on land and offshore when the Carboniferous infill is thin. Additionally, the Carboniferous sequence contains a significant thickness of mostly continental clastic rocks. Targeted Carboniferous reservoirs are present in the Codroy and Barachois groups on Parcel 1, which may also be underlain by the erosional remnants of the Cambro-Ordovician platform – similar to the situation encountered at the Gudrid and Hopedale discoveries offshore Labrador.

Trenton-Black River exploration model

Trenton-Black River reservoir is a very successful hydrocarbon exploration trend in the northeastern US, Lake Erie region, southern Ontario and St. Lawrence Lowlands. An exploration model including four prerequisites in the search for porosity development in carbonate rocks was recently presented by Dr. Taury Smith of New York State Museum (http://www.pttc.org/solutions/sol_2004/534.pdf). They are reproduced here as summarized at the PTTC Appalachian Region (2004) workshop.

1. Appropriate tectonic settings such as basement-rooted intra-platform wrench faults and fault intersections, fault-controlled margins, and the first carbonates deposited on newly-rifted/heavily-faulted continental basement is needed for increasing the chance of finding porous carbonate.

2. Evidence of fault movement soon after deposition: much of the alteration takes place in the first kilometre of burial, so faults with minor vertical offset at the time of alteration may be in the best locations.
3. Indication for brecciation; breccias may be either karst or hydraulic, so look for saddle dolomite-cemented breccias.
4. Petrographic evidence of hydrothermal alteration in cores and cuttings.

All these prerequisites have been identified and confirmed within drilled carbonates and dolomites and likewise within Anticosti Basin and Bay St. George sub-basin surface exposures. This is a strong indication that similar plays will be present in Western Newfoundland.

4.3. Seals

Numerous tight intervals are present in both allochthonous and autochthonous successions represented by shales, carbonates and various evaporite intervals. Finding good seals should not be a problem in the offshore Paleozoic Anticosti Basin and Bay St George sub-basin. The Mid-Ordovician Black Cove shale is a regional top seal for the foreland Carbonate platform (Figure 8 and 17).

4.4. Hydrocarbon traps

Traditional traps drilled in the southern part of the Magdalen Basin are salt induced anticlines. The anticlines are caused by salt movements or salt mobilization during transtension and they may or may not be faulted. The structures are usually elongated and aligned in a NNE-SSW direction.

Plays in the Anticosti Basin have been associated with structuring of the platform along the ASF. In the Port au Port area the deformation front is represented by a classic triangle zone with trapping possibilities in the overlying thrust sheets and underlying faulted and sometimes tightly folded autochthonous platform (e.g., Figures 6, 11, 16 and 20). The deeper traps in the autochthonous or foreland carbonate platform are rotated fault blocks or inverted fault blocks including footwall shortcuts within the thick skinned thrusts (Cooper et al., 2001; Atkinson and Fagan, 2000; Atkinson and Wright, 2006). This deformation zone should underlie the eastern, shallow water portion for most of the Anticosti Basin parcels. In the Bay St. George sub-basin strong structurally deformed areas, representing regional tectonic fracture zones are observed at the contact with the Anticosti Basin and also closer to the islands shore line. More structural complication is introduced in the southern part of the Bay by salt tectonics (Windsor Salt).

The Humber Arm Allochthon presents both thin and thick skinned structures. Cooper et al., (2002) and Atkinson (2005) summarized numerous possible structural (horst blocks, tilted fault blocks, thrust sheet slices) and stratigraphic (sand lenses, pinchouts, fans, erosional edges, karstified and leached carbonates, dolomitized carbonates) plays in representative geological cross-sections (e.g., Figures 16 and 20). These diagrams highlight plays both offshore and onshore within the Anticosti Basin and Bay St. George sub-basin.

Fagan (2002) has described and illustrated with seismic data several possible plays in the Bay St. George onshore area: rotated blocks, 2 - 4 way fault bounded closures, salt anticlines, etc. (see this link: http://www.nr.gov.nl.ca/mines&en/publications/onshore/west).

4.5. Maturation and Migration

The Paleozoic source rocks should be all in the mature to overmature range. Port au Port #1 oil and gas tests and the presence of oil in seeps and drilled wells demonstrate that source rocks are mature and that oil and gas was generated and migrated into traps. After trap formation there were direct migration routes through porous beds or faults from the Green Point shale into allochthonous reservoirs.

With source rocks in the oil window or dry gas window, trap preservation and presence of adequate reservoir remains the main risk factors in the Paleozoic basins. One example of field destruction is the Port au Choix exhumed oilfield located on shore just north of Parcel 5. This bitumen field with an area of 80 km^2 that has up to 300 m of good porosity in dolomitized carbonates and 100 m "pay" was described by Cooper et al. (2001). Offshore, where thicker section is expected, the risk of trap preservation should be lower.

5. Petroleum Potential of 2006 Call for Bids Parcels 1 to 5

The five Call for Bids NL06-3 parcels cover a total area of 867,571 hectares (2,143,815 acres). Four parcels with a total area of 743,251 hectares (1,836,815 acres) are located within the eastern part of the Anticosti Basin while one parcel covering 124,320 hectares (307,201 acres) is situated in the northeastern part of Magdalen Basin (Bay St. George sub-basin). These five shallow water parcels (0-250 m water depth), are located close to the West Newfoundland coastline and in the vicinity of proven hydrocarbon occurrences on the Port au Port Peninsula, and in the Bay St. George, Parsons Pond, Deer Lake and Port of Choix areas (Figure 4). Several location maps of the West Newfoundland offshore showing the Call for Bids parcels, existing Exploration Licences within the framework of Atlantic physiography and the Appalachian structural front are shown in Figures 2, 5, 9 and 14.

Structurally, Parcels 2 to 4 are located within the foreland, foredeep and deformation front of the Appalachian Foldbelt within the marine portion of the Anticosti Basin. Parcel 1 is entirely situated within the southern half-graben of the Bay St. George sub-basin of the Magdalen Basin (Figure 19). As mentioned before, the West Newfoundland onshore-offshore area is characterized by thin-skinned deformation associated with Middle Ordovician to Silurian Taconic and Salinic orogenesis and Devonian Acadian orogenesis, overprinted by thick-skinned late Acadian deformations (Figures 11 to 16, and Stockmal et al., 2000). The upper detachment of the triangle zone, named the Tea Cove Thrust by Stockmal and al. (2000) is mostly a submarine feature in parcels 3 to 5, but outcrops at several locations north of Parcel 5 and on the Port au Port Peninsula. Farther offshore, in the western part of the parcels, the Cambro-Ordovician carbonate platform is compartmentalized by many normal and a few reverse faults. Several compressional folds and pop-up blocks are also observed on the seismic data.

The Paleozoic source rocks are mature throughout the area covered by the Call for Bids parcels (see also Fagan and Hicks, 2005; Atkinson and Wright, 2006). No exploration wells have been drilled on these offshore parcels, but a few exploration wells have been drilled in the adjacent area. As mentioned in Section 4, only 5 deep exploration wells were drilled in the deformation front, testing 4 different subsurface configurations within the carbonate platform. The historic wells drilled onshore (about 60 in total) are mostly shallow and they all TDed in the Humber Allochthonous sequence (Anticosti Basin) or the deformed Carboniferous cover (Bay St. George sub-basin and Deer Lake Basin).

Several exploration wells will be discussed in more detail when describing the potential of individual parcels but more information on the onshore and offshore wells situated in the vicinity of the parcels can be obtained from C-NLOPB Schedule of Wells (C-NLOPB, 2005 and http://www.cnlopb.nl.ca/ under Publications → Other Publications → Schedule of Wells), GSC Atlantic East Coast Basin Atlas (http://cgca.rncan.gc.ca/BASIN/DEMO/basin-f-swf.cgi) or from the Government of Newfoundland and Labrador Department of Natural Resources (NLDNR). Complete well history reports and cores for offshore wells are available from the C-NLOPB and onshore well history reports for modern wells are available at NLDNR.

Seismic data quality is very good for Parcel 1, but multiples can be a challenge in the Anticosti and Magdalen Basins because of the hard water bottom, although modern data (acquired since 1990) processed with proper multiple suppression is generally of good quality. Seismic imaging is more challenging in the more complexly structured areas such as within the Appalachian Structural Front (eastern side of Parcels 3, 4 and 5), where Humber Arm Allochthonous nappes and overlying flysch layers lie close to the surface (e.g., Figures 12 and 16). Fair to good quality post-1990 data exists for the Magdalen Basin as well, but imaging is difficult below thick mobilized salt zones, and in areas of complex wrench faulting.

5.1. Parcel 1

This large size parcel is located just west of the several onshore exploration permits and south of the Garden Hill Production Licence on the Port au Port Peninsula, and two other ELs in the Bay St. George basin (Figure 20). The parcel covers an area of 124,320 hectares (307,201 acres) in water depths ranging from 70 m to 190 m, with most of the parcel within the 100 m depth range. No wells have been drilled in the parcel. To the north the parcel borders with ELs 1071 (CIVC) and 1072 (Deer Lake Oil and Gas) and to the east with onshore Exploration Permits held by Vulcan Minerals (EP 03 – 107) and Contact Exploration (EP 03 - 108) (Figures 4, 5, 8, 18 and 20).

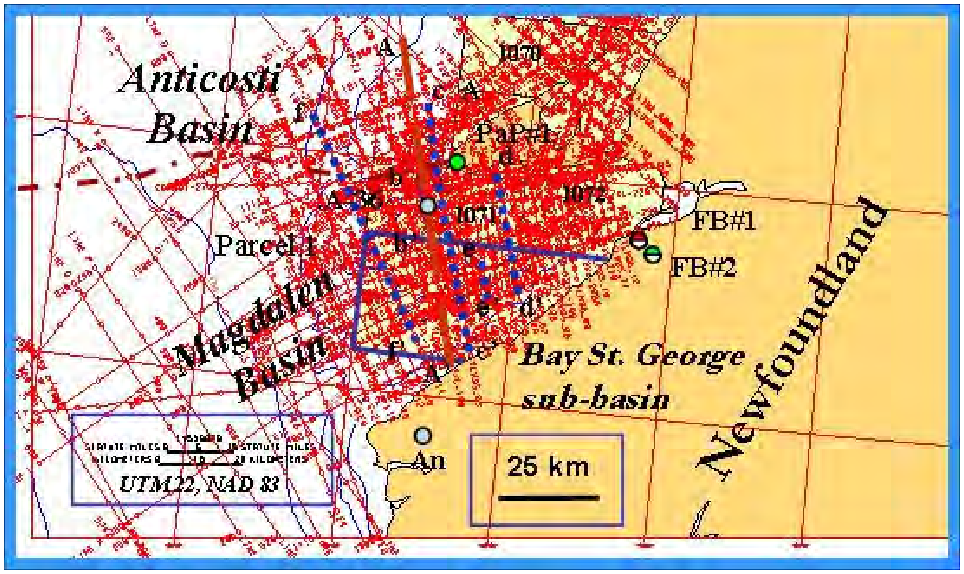

Figure 21. Parcel 1, Exploration Licenses, current seismic coverage, location of geological cross-section A-A' (Figure 20) and of seismic lines (Figures 23 to 26) used to illustrate the petroleum potential of Parcel 1. An=Anguille H-98 and FB#1 and #2 are only three wells shown on the onshore Vulcan permits.

The parcel lies entirely within the Carboniferous Bay St. George sub-basin. More precisely Parcel 1 lies within the southern half graben of the Carboniferous basin (Figure 19 to 21; Robbins, 2000). The St. Georges Bay A-36 exploration well which was drilled on the now expired EL #1021 in 1996 by Hunt/PCP using a jack-up is located just 10 kms north of Parcel 1 (Figures 4, 14 and 19 to 22.). The well was drilled in 84 m of water and tested a large structural high created by a footwall imbricate of the Round Head Thrust (Figures 20 to 22). The well was TDed at 3,240 m and abandoned with shows after penetrating thin Carboniferous fill of the Bay St. George sub-basin (Barachois and Codroy groups) and then the typical Cambro-Ordovician-Silurian suite of the Appalachian foredeep. No DSTs were performed but porosity was encountered in the Aguathuna and Watts Bight formations (Figure 8, 20, 22 and 23). Cores from these two zones are available for inspection from C-NLOPB core repository.

The most significant well for the area, Port au Port #1 was drilled approximately 20 km north of Parcel 1 (Figures 4, 6, 7 and 19). This well tested oil and gas from two Aguathuna Formation intervals at an initial rate of 1528/1742 bopd and 2.6/2.3 mmcf/d, respectively, and was suspended as a potential oil well (Figures 6 and 23). No cores were taken. The well penetrated a higher imbricate block set by a footwall thrust, situated under the main Round Head Thrust (RHT) (Stockmal et al., 2000; Cooper et al., 2001; Atkinson and Fagan, 2000; Fagan and Hicks, 2005). The RHT sets a large basement block above the platform carbonates (Figures 6 and 14). Over a six day extended test, both pressure and GOR were seen to decline. The reasons for this decline are unclear and require further testing to clarify. Two sidetrack holes were drilled by Canadian Imperial Venture Corp. (CIVC) who farmed into the project. The first one which kicked off towards the west was tight and the second, drilled to the north, hit reservoir. CIVC and partners have announced plans to re-enter the well to see if it can be brought to commercial production.

The geological cross-section reproduced from Cooper et al. (2001) and located on both maps in Figures 19 and 21, indicates the regional setting of Parcel 1 within the Carboniferous Bay St George sub-basin. This sectional view contains the only offshore well in the area - St George's Bay A-36 (Figures 20). As no wells have penetrated the basement on the Bay St. George sub-basin side of the thrust front and the seismic quality deteriorates under the salt, there is some debate regarding the sense of movement along the basin bounding fault, the thickness of the Cambro-Ordovician Platform and the depth to the Grenville basement in the basin (Figures 20 and 22).

The seismic section in Figure 22 was re-interpreted from Robbins (2000) to show how the thrust fault bounding the structure toward the south minimally affects the Carboniferous infill but suggests over-thrusting within Grenville basement. The seismic interpretation also shows the Cambro-Ordovician platform series, thinned by erosion but continuing under the Carboniferous sediments within the southern part of the basin.

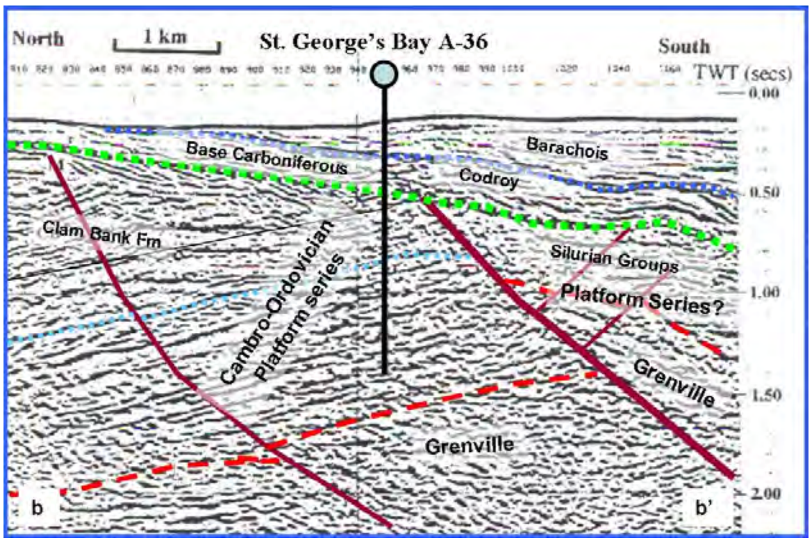

Figure 22. N-S seismic section section b-b' through the Bay St. George sub-basin showing location of St. George Bay A-36 exploration well (modified after Robbins, 2000). To the south, beneath the Base Carboniferous there are Silurian and Cambro-Ordovician rocks, overlying Grenville Basement.

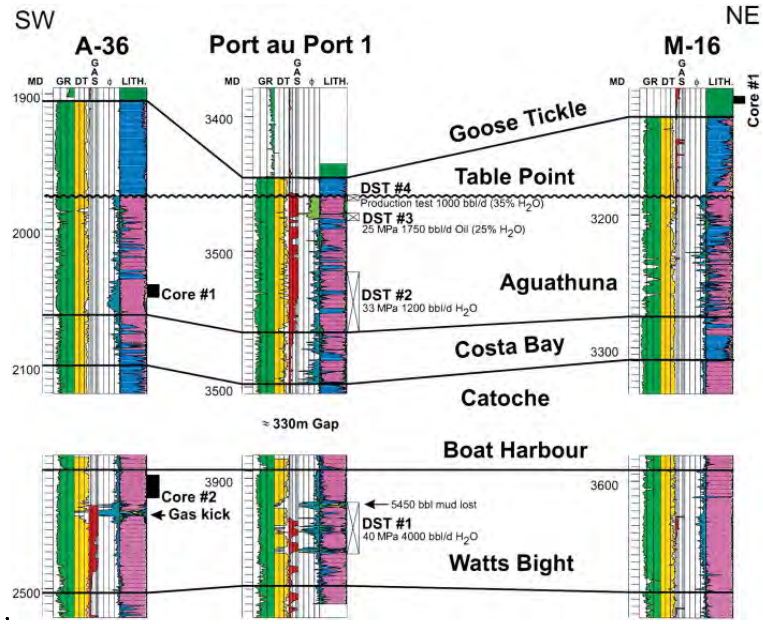

Figure 23. Log correlation of stratigraphic formations between the St. George's Bay A-36, Port au Port #1, and Long Point M-16 wells. MD = measured depth in meters; GR = gamma ray in API units; DT = sonic in microsecs/meter; GAS = total mud gas in units; Φ = porosity % (blue = water-filled; green = oil-filled); LITH = calculated lithology (green = shale; blue = limestone; pink = dolomite). Locations of cores and DST intervals are shown (reproduced from Cooper et al., 2001).

Onshore, the Carboniferous outcrops in the Bay St. George Lowlands and Anguille Mountains, where they represent the uplifted eastern sector of the Bay St. George sub-basin. Several unsuccessful shallow wells have been drilled on land in the past. They were based on surface geological mapping, seeps and porosity indicators. Most recently, Vulcan Minerals used older reprocessed and newly acquired seismic lines to map subsurface features and locate several, shallow target exploration wells. Three wells encountered a thick oil zone in a shallow low permeability reservoir. The oil zone is up to 150 m thick, with the top as shallow as 50 m beneath ground surface. The oil is light (34^o API) and sweet, generated from a lacustrine source rock.

Presently, Vulcan Minerals has identified deeper targets (2-3 km) that should hold rocks of similar age (lower Anguille) to the McCully discovery in New Brunswick. Evaporites of the Early Visean Codroy Group (Magdalen Basin's Windsor Group equivalent) provide anticlinal features above the Anguille Group onshore, and above the pre-Carboniferous Unconformity offshore. Within Bay St. George, several pre-Carboniferous targets are also observed on seismic in what is interpreted to be the Cambro-Ordovician allochthonous and autochthonous sequences - but these features are more difficult to image beneath the mobilized evaporites of the Codroy Group and the hard unconformity which is located at the base of the Codroy. (http://www.vulcanminerals.ca/images/VulcanMineralsWesternNewfoundlandProspects.pdf).

Hydrocarbon shows were encountered in about 50% of the wells drilled on land, attesting that a working petroleum system is present in the basins. Numerous seeps and bitumen impregnations of sediment is also known. In the Bay St. George area, several pockmarks on the water bottom and a significant gas plume were mapped by GSC using multibeam surveying (GSC, 1995 and http://gsca.nrcan.gc.ca/pubprod/of1698/subvalley_e.php).

Within Bay St. George, the Carboniferous sequences show minor deformation in the northern half-graben and deformation of moderate intensity in the southern half-graben (Figures 19, 21, 24-26 and Talisman, 1996 and Robbins, 2000). In the southern part of the bay including Parcel 1, the Carboniferous layers are more deformed due to normal and wrench faulting and also due to Codroy (Windsor) Group halokinesis. The movements of middle Carboniferous salt has produced several diapirs and pronounced salt walls, some with expression at the water bottom. The salt diapirism was coeval with deposition of the Carboniferous clastics. The structural style is similar with the tectono-stratigraphy mapped in the southern Magdalen Basin (Hayward et al., 2002). Numerous salt induced features are mappable using the dense 2D seismic coverage in the Bay St. George region (Figure 21). Significant erosion (approximately 1,000 m) of the Late Carboniferous sedimentary package has been documented on land.

Data quality for the early and mid nineties seismic data collected mainly by Talisman (1995 - recording of 680 km), Marathon (1993) and Hunt (1993) is fair to good. The hard bottom of the bay creates strong multiple trains and reverberation that can be properly attacked with demultiple algorithms. Processing is also challenged by a lack of velocity information and the presence of shallow velocity anomalies. The Talisman data has the best quality at depth due to long offset recordings (5,142 m). Marathon data has better resolution in the shallower section. Structural complexity is a major factor affecting the quality of reflectors. Several episodes of faulting and folding, fault reactivations and change of movement direction on some of the fault planes, salt mobilizations and complex strike slip movement along border faults complicate the interpretation of the complex 3D subsurface geometry with 2D data. The synthetic seismogram from the Long Range A-09 well can be used to correlate the offshore geology to the seismic reflectors. The distinctive halokinetic signature of the Codroy Group and the strong parallel reflectors of the carbonate platform provide some confidence in regional correlations carried out with few well ties.

The major markers in the area are (Talisman, 1996 and Figures 23 to 25):

1. Top Carboniferous Salt is a good marker related to the thick Codroy limestone that overlies the Windsor Salt. The marker shows significant geometry due to diapirism of the underlying salt.

2. Base Windsor Marker is an excellent marker, often showing the character of an angular unconformity; highlighting in the northern part of the basin the Base of Carboniferous while in the south highlighting the Base of Visean (Codroy Group) and the underlying Anguille Group.

3. Lourdes Limestone Marker, which tied in wells from the Port au Port peninsula, correlates to the base of the passive roof complex of the Triangle Zone. The marker has variable quality and is affected by numerous faults.

4. Table Point Marker is a strong marker correlated to the Long Range A-09 well; the marker ties at the top of the autochthonous Carbonate Platform

5. Big Cove Marker is an excellent reflector, conformable with a series of other strong markers above and below. It was correlated to a thick shale interval situated toward the base of the thick carbonate platform.

6. Base Labrador Marker is the lowest consistent marker in the sequence ascribed to the platform. This marker is about 150 m above the Grenville Basement, which does not have a strong continuous marker associated with it.

The dip seismic section c-c' (Figure 23) shows the regional setting of Parcel 1. To the south the Bay St. George sub-basin has three mega seismic sequences: 1) the Grenville (Acadian) Basement at the base; 2) the fractured and thrusted Carbonate Platform and a possible flysch sequence under the pre-Carboniferous Unconformity, and 3) the Carboniferous basin infill, including diapiric Windsor salt in the upper part. The basin is bordered to the north by a large strike slip fault that shows a normal relationship on the basin side and drops the Cambro-Ordovician Platform creating space for the successor basin. An upper imbricate of this fault identified as the Triangle Zone shows reversal and creates an overthrusted block cored by the carbonate platform and Grenville basement in the area close to the Port au Port Peninsula. This compressional anticline was tested by the St George's Bay A-36 well that is projected into the plane of the seismic section c-c'. To the north there is the thick Cambro-Ordovician sedimentary sequence of the Anticosti Basin. Beneath the Carboniferous sequences, the Silurian sequences and the Cambro-Ordovician Platform dip southward. The quality of the seismic data is poor under the Codroy Marker but it seems that the Carbonate Platform continues, dips gently to the south and is segmented by normal faults within the basin and reverse faults close to the Triangle Zone. Within Parcel 1, seismic line c-c' shows a number of well defined salt anticline traps and poorly imaged Lower Paleozoic rotated blocks beneath the pre-Carboniferous Unconformity.

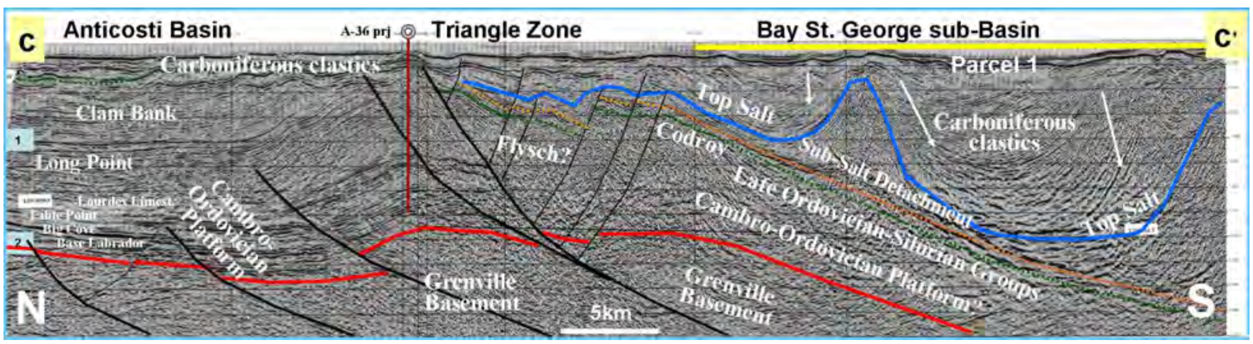

Figure 23. Regional 2D seismic line c-c' through Bay St. George showing the structural and tectonic setting of the Anticosti Basin (North), Triangle Zone (Center) and Bay St George sub-basin (South). Projected location of the St. George A-36 and extent of Parcel 1 are also shown. White arrows indicate high amplitude reflectors within the Upper Carboniferous clastic sequence. Seismic line c-c' is located on the seismic base map in Figure 21.

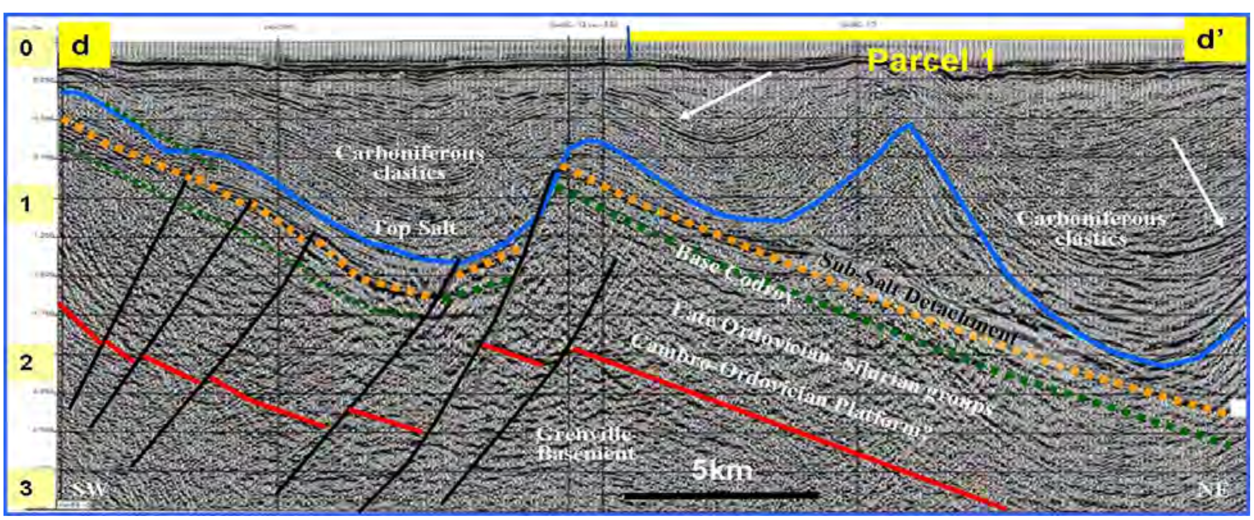

Figure 24. 2D dip seismic line d-d' through Parcel 1, showing several salt-cored anticlines and salt withdrawal synclines about a faulted Cambro-Ordovician-Silurian sequence. White arrows show amplitude anomalies. Seismic line d-d' is located on the seismic base map in Figure 21. Gas seeps are seen at surface in this area.

A similar image of the Carboniferous infill and the Cambro-Ordovician substratum is shown by the dip seismic line d-d' contained in Figure 24. The older sedimentary and the Grenville basement rocks are fragmented by numerous normal faults, probably antithetic to the basin-bounding fault (CBF in Figure 19). Carboniferous clastics are draped over salt core anticlines and several amplitude anomalies are indicated by white arrows.

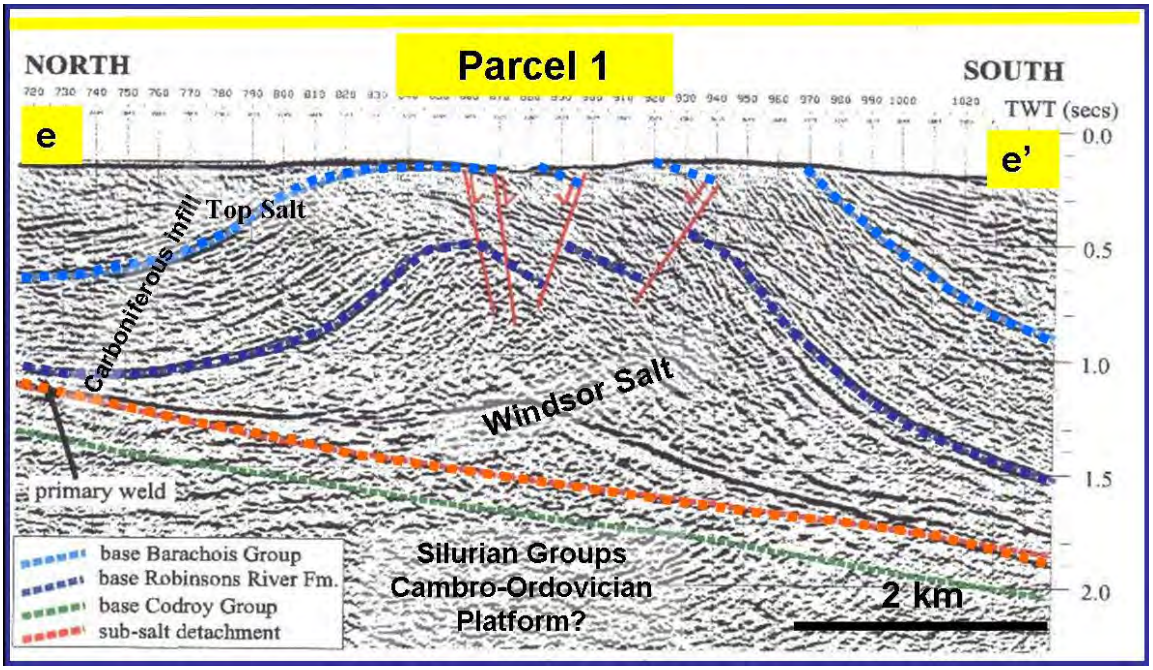

Figure 25. N-S 2D dip seismic line e-e' through Parcel 1 showing a salt induced anticline in the post-Windsor Carboniferous sequences. Salt detaches on top of the Ship Cove Limestone (in orange). Please observe significant velocity pull-up of the detachment. The Base Codroy Group (in green) is the Visean unconformity truncating Lower Paleozoic sequences (modified after Robbins, 2000). Seismic line d-d' is located on the seismic base map in Figure 21.

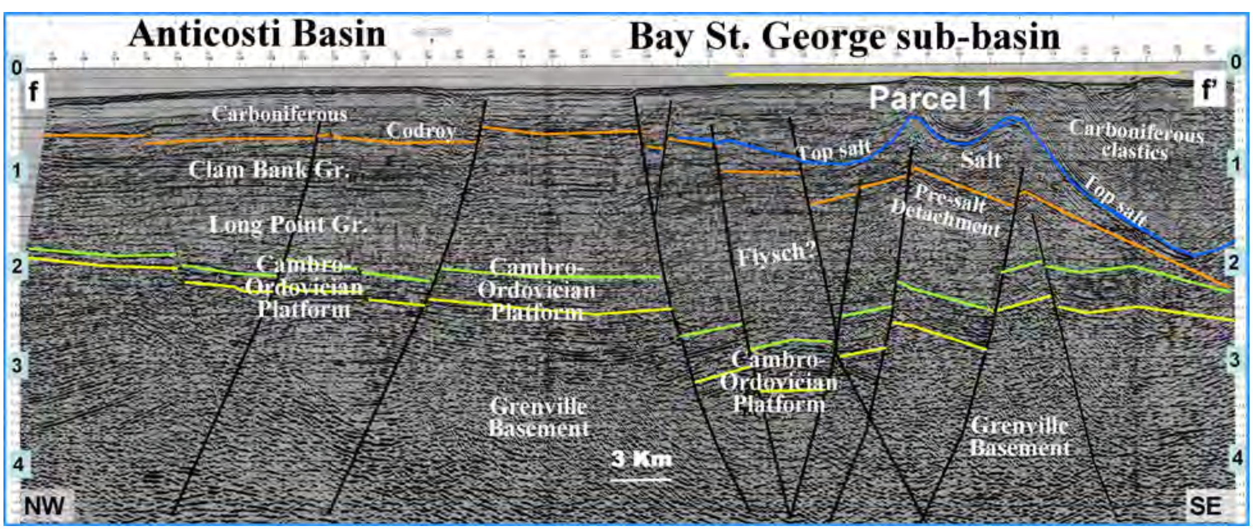

Figure 26. NW-SE 2D dip seismic line f-f' through southwestern part of Parcel 1 showing tectonic contact between Anticosti Basin and Bay St George sub-basin. Within Parcel 1 there are several induced anticlines in the post-Windsor Upper Carboniferous sequences. Salt detaches on top of the Ship Cove Limestone (in orange). Seismic line f-f' is located on the seismic base map in Figure 21.

Numerous salt induced features occupy the central and south-eastern portion of the parcel. The salt anticlines such as those present in Figures 22 to 26 show either radial symmetry or form elongate features in map view. Occasionally, large pillows and diapirs have crestal collapse and segmentation (e.g. Figure 25 adapted after Robbins, 2000). Structurally, the entire Parcel is located in the southern large asymmetric graben defined by Robbins (2000) in the Bay St. George sub-basin (Figures 20 and 26). The north-western part of Parcel 1 is occupied by high basement blocks, where the Carboniferous infill thins over the ridge separating the basin into two half-grabens. The salt seems to detach at the top of the Ship Cove Formation carbonates. Northwest of the parcel, the Carbonate Platform is rarely affected by faulting and generally dips at 12º SE. Figure 26 shows how the Carbonate Platform within the parcel drops near the half-graben bounding fault and ascends gradually toward the shore line (southeast). The quality of the data does not allow establishing with certainty whether the rise of the Platform results from normal or thrust faulting, or a combination of both mechanisms (Figure 26). Also in the downthrown section of the half-graben border fault, there is a significant thickening of the post-Ordovician sequence that might include either flysch or stacked thrust sheets (similar to the setting illustrated in Figure 16).

The primary targets in this parcel are the Carboniferous sandstones within structural traps created by salt diapirism. Several anticlines show four way closures. The Barachois sandstone, the Ship Cove Formation limestone and in the southern bay, clastics of the Anguille Group are possible reservoirs. Several Mississipian reefal build-ups were sampled in outcrop and may be present within the Carboniferous of the Bay St. George region (Figure 17). Seismic amplitude anomalies are visible within the Carboniferous clastics flanking Windsor salt diapirs (Figures 23 and 24). Secondary targets (if present) may be provided by dolomitized limestones and porous sandstones of the underlying Cambro-Ordovician platform (Goose Tickle Sandstones, Limestone, Aguathuna Formation, Watts Bight, Catoche Limestone and Lower Paleozoic clastics). These sequences are more likely to be seen within extensional anticlines, rotated blocks or slightly inverted, fault bounded blocks or fairways. The source rocks, which are expected to be mature in this parcel, are the Green Point shales, the McCasty Formation shale, other shales within the autochthonous platform and Carboniferous lacustrine shales and coals. Finding good seals such as tight sandstones and carbonates, and shales should not be a problem. The key risks on this parcel are the quality of the reservoir, finding unbreached anticlines (fault breaching) and access to sufficient source rock. Another risk is that some of the seismically interpreted Paleozoic rocks are metamorphic or metasediments with no porosity.

The parcel is covered by modern time migrated 2D seismic data that is available in paper copy from the C-NLOPB and for purchase from oil companies previously active in the area (Talisman, Marathon and Canadian Hunter being the more recent and Mobil active in the seventies and eighties). Seismic grids older than 1990 are very poor quality and were acquired with shorter offsets that are detrimental to the elimination of multiples. These need to be reprocessed prior to inclusion into interpretation. However, there are a sufficient number of modern lines available to define and map all the large leads in Parcel 1.

5.2 Parcel 2

This parcel is located just north of the Port au Port Peninsula and west of existing ELs 1069 (Ptarmigan), 1097 (Ptarmigan) and 1098 (Vulcan Minerals et al.), (Figures 4, 9 and 27). Parcel 2 occupies an area of 134,620 hectares (332,011 acres). Water depths range from 97 m to 230 m.

No exploration wells have been drilled in this parcel or in its immediate vicinity. The closest exploration wells are to the south on the Port au Port Peninsula (discussed above) or on land in the Parsons Pond area (Figures 4 and 27). The Parsons Pond wells were drilled within the Appalachian overthrust and did not penetrate the autochthonous Carbonate Platform that is expected to be the main play in Parcel 2. The Parson Pond #1 well drilled in 2004 by Contact Exploration et al. penetrated a thrust sheet of Cow Head Group and TDed above a major thrust fault. A number of oil shows were encountered within fractures while drilling. Many of the earlier Parsons Pond wells had either oil or gas or both (see sections 3 and 4 and Figure 27).

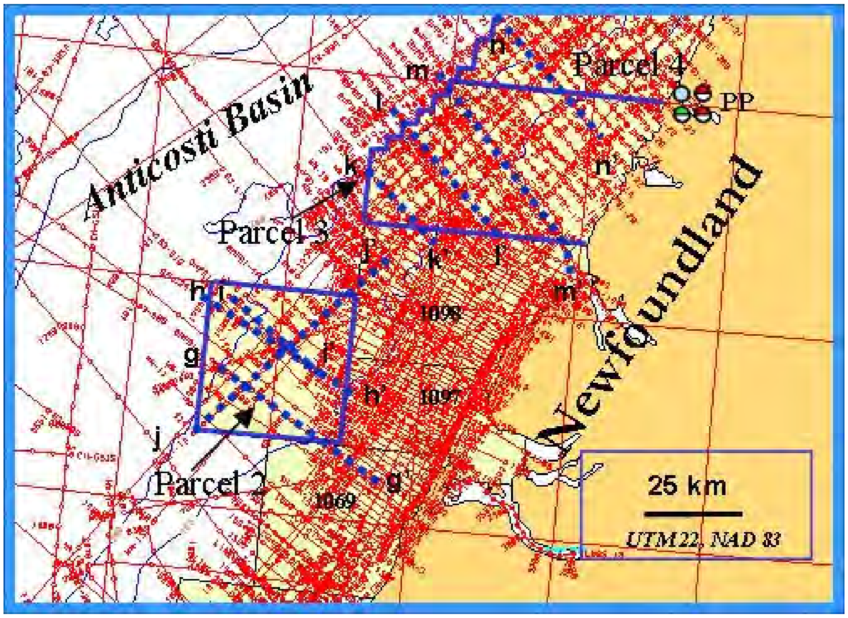

Figure 27. Location of Parcel 2 and 3, seismic coverage, existing Exploration Licenses and location of seismic lines used to illustrate the petroleum potential of these parcels. PP=Parson Pond wells.

The parcel is located entirely within the Anticosti Basin (foreland of the Appalachian Foldbelt). The basin has the general aspect of a monocline dipping and thickening towards the southeast. This sequence of rocks is interrupted by thick-skinned normal faults affecting the platform and the Grenville basement. Deformation of the overlying Silurian and Carboniferous layers in the upper basin fill is minimal; however several major faults may penetrate these sequences (Figures 28 and 30, 31, 32). Small strike-slip or reverse displacement is observed on some faults, but the main hydrocarbon play in the basin results through block rotation due to deep penetrating normal fault movements.

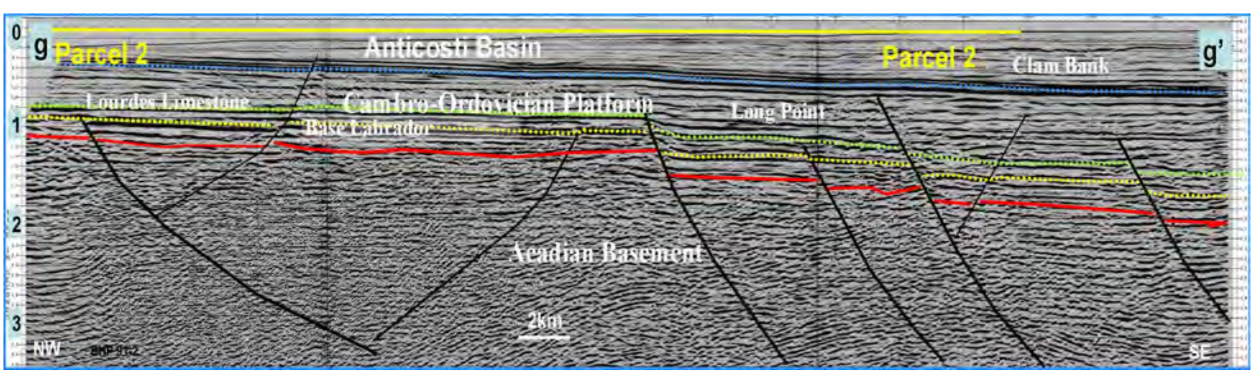

Figure 28. NW-SE 2D dip seismic line g-g' through Parcel 2 showing segmentation of the Cambro-Ordovician Platform by normal faults. Several rotated blocks and a horst are potential plays. Late Ordovician and Silurian groups (Long Point and Clam Bank) overlie the Carbonate Platform. Seismic line g-g' is located on the seismic base map in Figure 27.

The strike line in Figure 32 proves that faults affect the platform in both the strike and dip direction and therefore they can set a considerable number of fault dependent closures within the basin. Faults are deep penetrating; however the throw is relatively small, from tens of meters to several hundred meters in the exceptional case.

It is understood that for the Anticosti offshore basin the full Cambrian to Devonian sequence described in the past from outcrop and core (Figure 29, courtesy of Elliott Burden) is present in Parcels 2 to 5. In order to simplify and illustrate the seismic sections presented in this report, the stratigraphic column shown on the left side of Figure 29, has been simplified to show only a few markers and formations.

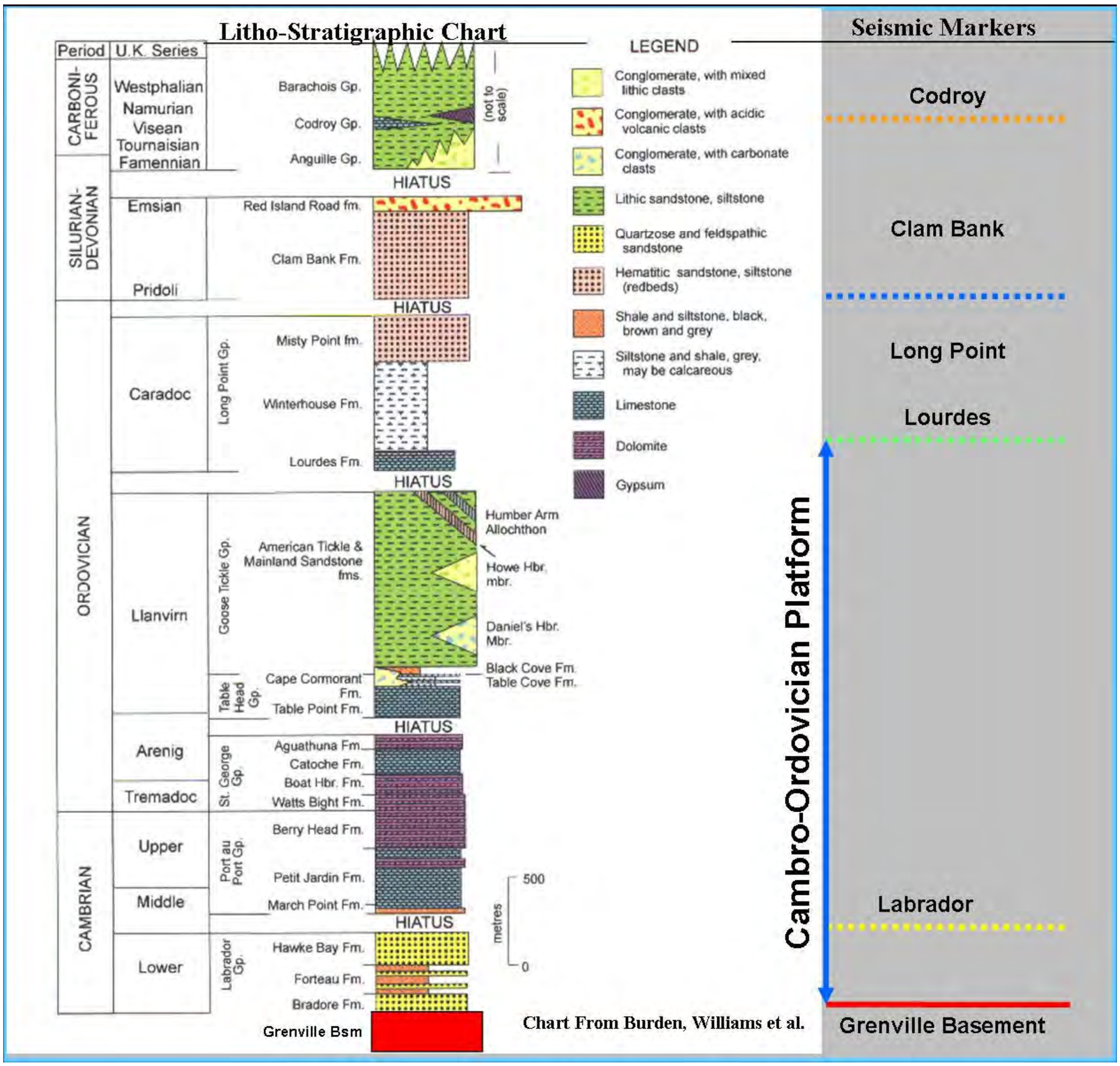

Figure 29. General stratigraphic/lithologic chart of the Anticosti Basin (after Burden and Williams et al.) including main seismic markers interpreted on the representative seismic sections.

The depth to the top of platform in the parcel varies from 1300 m in the northwest to about 4000 m in the northeast. The main hydrocarbon play is structural: porous Lower Paleozoic carbonates, dolomites or sandstones (Goose Tickle Sandstones/Limestone, Aguathuna Formation, Watts Bight, Catoche Dolomite and various Lower Paleozoic clastics) within large fault bounded highs. Several fault dependent closures capable of holding several hundred million barrels of oil can be mapped within Parcels 2 to 5. Overlying Carboniferous sands provide secondary targets. Source rocks can be found in the synrift sequence above the Grenville basement, in the shales and carbonates and within organic shales contained in the flysch and overthrusted sequences of the structural front. Coal seams within the Carboniferous are also capable of generating significant volumes of natural gas. Numerous seismic amplitude variations are observed in both Lower and Upper Paleozoic sequences. The variation of seismic amplitude along the Carbonate Platform markers and amplitude anomalies around faults may indicate flow of hydrothermal solutions and dolomitization.

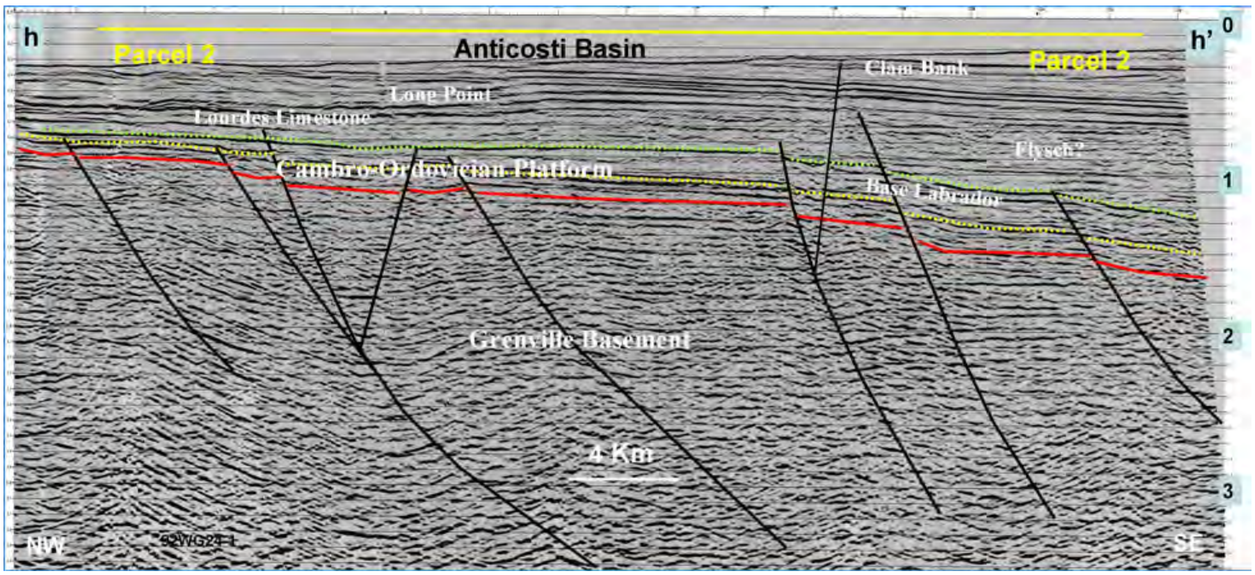

Figure 30. NW-SE 2D dip seismic line h-h' through Parcel 2, showing the southerly dipping Cambro-Ordovician Platform and its segmentation by normal faults. Several rotated blocks and a horst are potential plays. Late Ordovician and Silurian groups overlie the Carbonate Platform. The seismic line h-h' is located on the seismic base map in Figure 27.

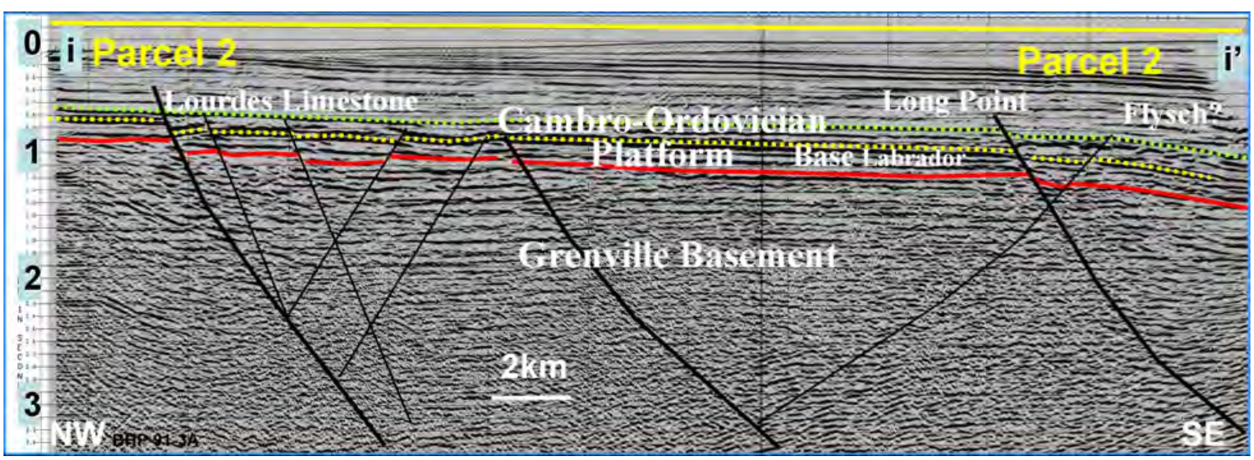

Figure 31. NW-SE 2D dip seismic line i-i' through Parcel 2, showing the Cambro-Ordovician Platform fragmented by normal faults. Several rotated blocks and a horst are potential structural plays. The seismic line i-i' is located on the seismic base map in Figure 27.

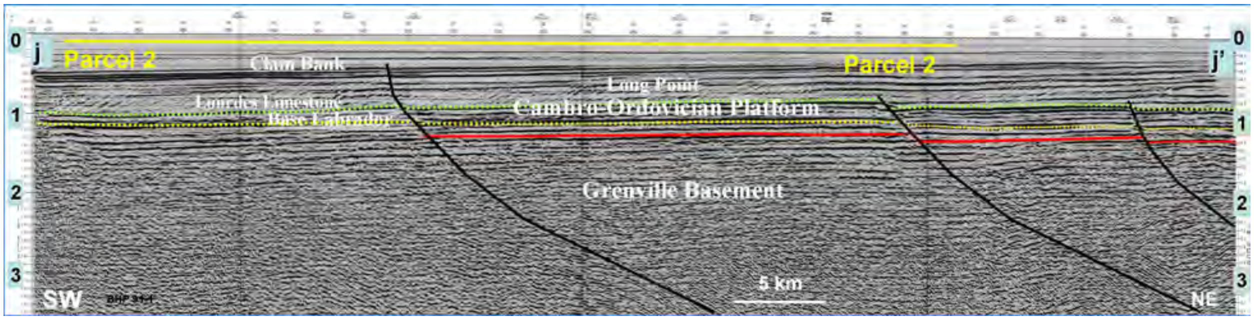

Figure 32. SW-NE regional 2D seismic strike line j-j' through Parcel 2 and environs illustrating segmentation of the Cambro-Ordovician Platform by thick skinned normal faults. The platform rises gently and thickens toward the NE.

Good seals such as tight sandstones and carbonates, and shales are present. The main geological risks on this parcel are quality of reservoir and access to sufficient source rock. These comments are valid for all the parcels located in the Anticosti Basin and therefore will not be repeated when discussing Parcels 3 to 5.

Parcel 2 is covered by modern time migrated 2D seismic data that is available in paper copy from the C-NLOPB and for purchase from the oil companies previously active in the area (Talisman, Marathon and Hunt Oil being the more recent and Mobil active in the seventies and eighties). Seismic grids older than 1990 are of very poor quality and were acquired with shorter streamers, which severely constrains the suppression of multiples. This data needs to be reprocessed prior to inclusion into interpretation. However, there are a sufficient number of modern lines available to define and map all the large leads in Parcel 1.

5.3 Parcel 3

This is the largest parcel offered in this landsale and covers an area of 215,839 hectares (533,350 acres). The parcel is located on the Gulf of St Lawrence shelf, just west of Parsons Pond (Figures 4 and 27). Water depth varies from zero to 210 m and the seabed is gently dipping toward the northwest. To the south the parcel borders with EL 1098 (Vulcan Minerals et al.) and to the north with Parcel 4.

Geologically, the parcel straddles the Anticosti Basin, the Appalachian Foredeep and comes close to the structural deformation front in its easternmost part. Several representative seismic lines are used to illustrate the petroleum potential of this parcel (Figures 33 to 36). Since the deformation front is close to the shoreline only the rare seismic line recorded into the bays has managed to cross it (Figure 35). No wells have been drilled in this parcel or in its offshore vicinity. Several onshore wells, immediately northwest of the parcel, have encountered good oil and gas shows and one of the wells produced oil for a small refinery at Parsons Pond (Sections 3 and 4 and Figures 4 and 27) in the early 1900s.

Seismic lines recorded on the parcel show the easterly dipping monoclinal Lower Paleozoic Platform that is normal faulted and is overlain by the easterly thickening Long Point and Clam Bank groups (Figure 33 to 36). As with the entire Anticosti Basin, the faults are Taconic in age and they affect both basement and sedimentary cover. The faults closer to the deformation front may show small strike-slip and reverse movements acquired during the Late Taconic Orogeny.

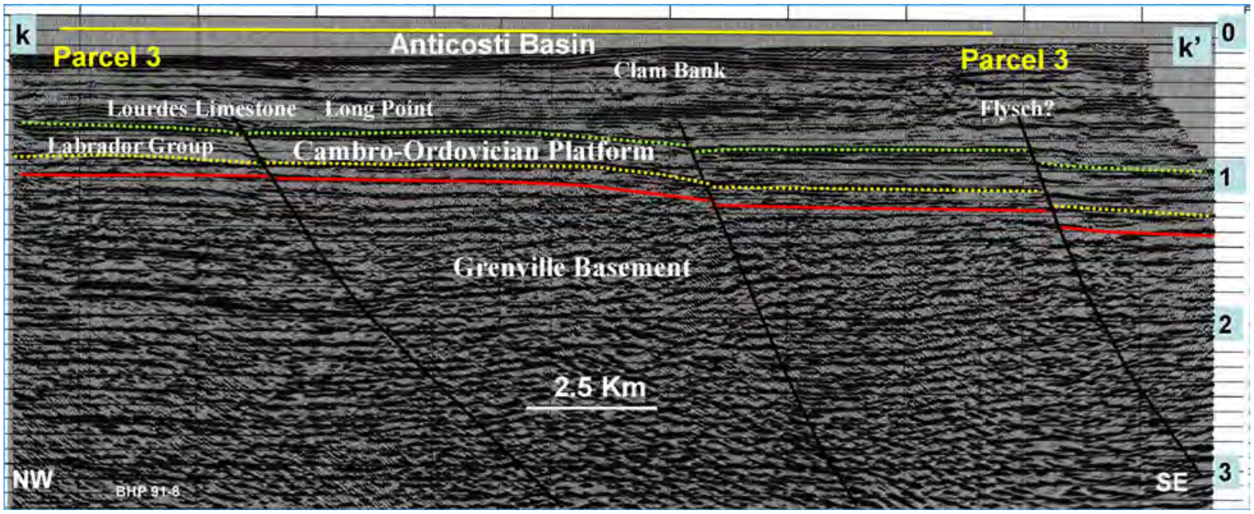

Figure 33. NW-SE 2D dip seismic line k-k' through Parcel 3, showing the familiar foreland Cambro-Ordovician Platform fragmented by normal faults. Several rotated blocks with Lower Paleozoic successions are potential structural plays. Thick Late Ordovician-Devonian clastics overlie the Platform. Goose Tickle Group (Flysch) may thicken above the platform in the eastern part. The seismic line k-k' is located on the seismic base map in Figure 27.

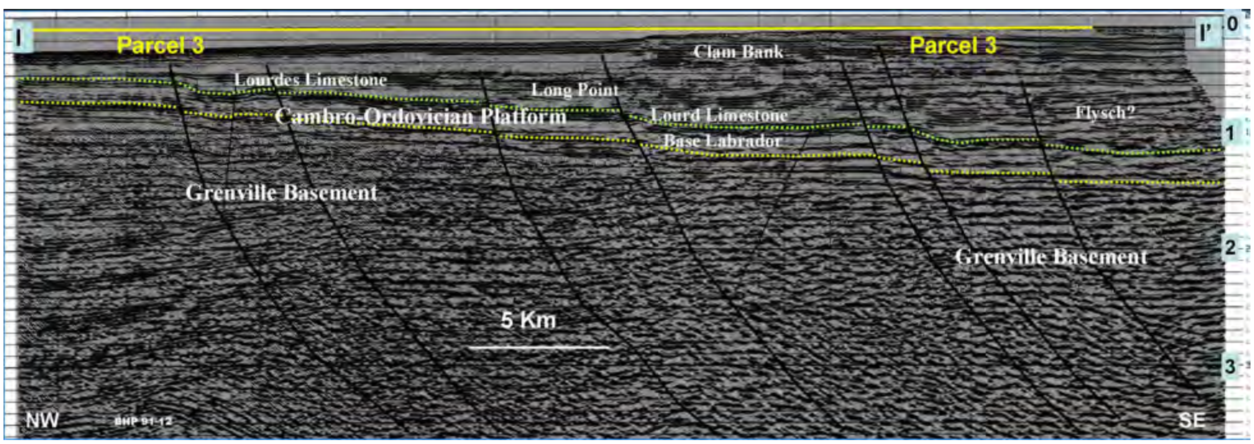

Figure 34. NW-SE 2D dip seismic line l-l' through Parcel 3, showing the Cambro-Ordovician Platform fragmented by normal faults. Several rotated blocks and a horst with Lower Paleozoic successions are potential structural plays. Long Point and Clam Banks groups overlie the Platform. An incipient Triangle Zone can be placed in the eastern side of the seismic section. The seismic line l-l' is located on the seismic base map in Figure 27.

The seismic line in Figure 34 was acquired closer to shore. The line shows the Paleozoic Platform plunging in the Appalachian foredeep and also the beginning of the Triangle Zone manifested by thickening of a chaotic seismic sequence (probably representing Goose Tickle flysch deposits). Further landward and properly on land this Triangle Zone thickens and forms the Humber Arm Allochthon.

As in Parcel 2 and the parcels to the north, the hydrocarbon traps are represented by fault bounded closure of rotated Platform blocks or horsts, which contain carbonate, dolomite (Watts Bight, Catoche or Aguathuna Formation) or sandstone (Hawke Bay Formation, Goose Tickle Group) reservoirs sourced from the lacustrine shales of the synrift sequence, the intra-formational shales and organic limestones within the Platform (e.g. Black Cove) or from the

Green Point shales present in the allochthonous sequences to the east (Figure 7 and 27). As mentioned in Chapter 4, the source rocks should be mature throughout the eastern side of the offshore Anticosti basin especially in the areas covered by Call for Bids Parcels 2 to 4. Stratigraphic traps (e.g., pinchout) and karstification of the carbonate members are possible trapping mechanisms for this and all parcels to the north.

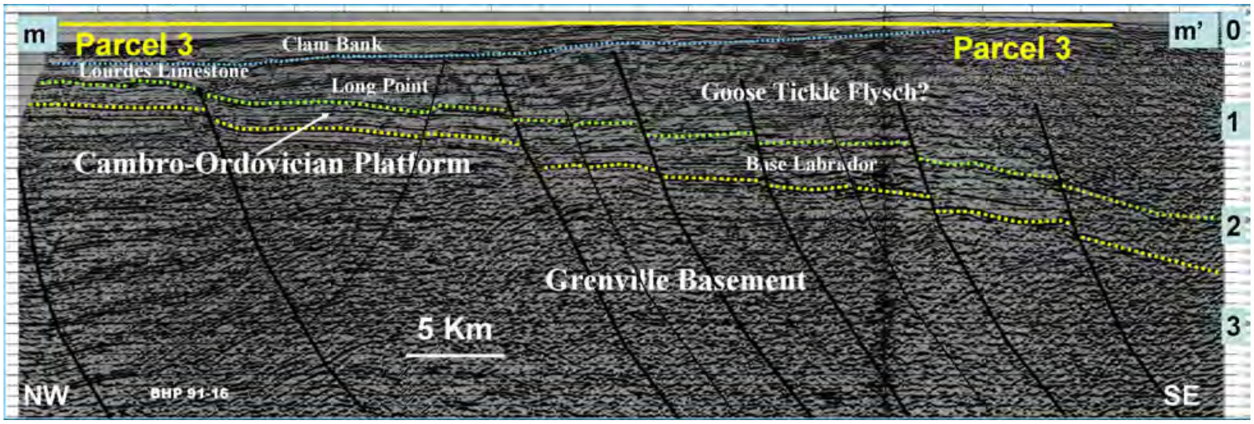

Figure 35. NW-SE 2D dip seismic line m-m' through Parcel 3, showing the Cambro-Ordovician Platform fragmented by normal faults. Several rotated blocks and a horst block with platform successions are potential structural plays. The western side of the Triangle Zone is imaged by a chaotic seismic sequence. The seismic line m-m' is located on the seismic base map in Figure 27.

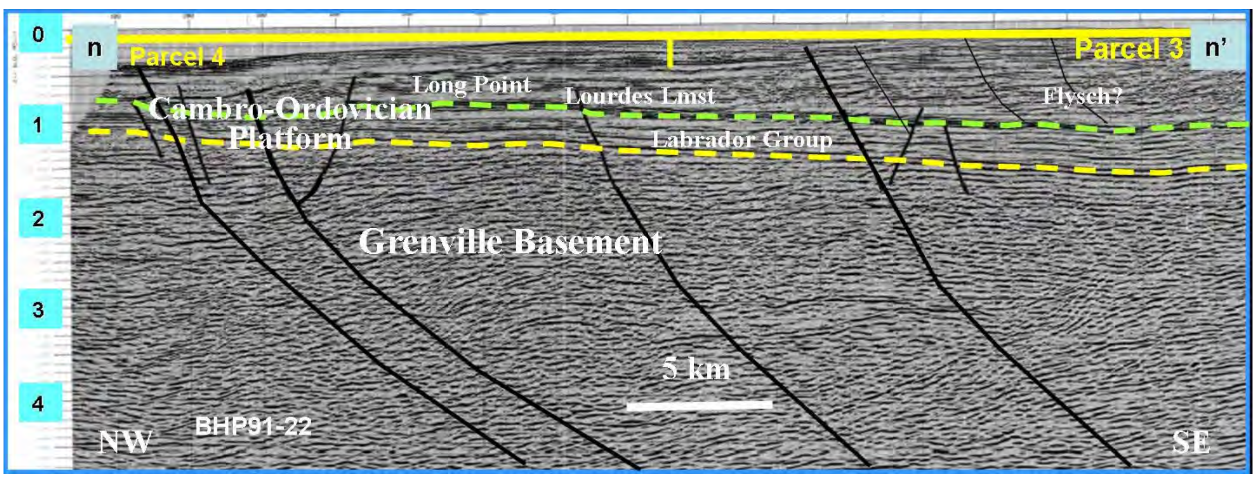

Figure 36. NW-SE 2D dip seismic line n-n' through Parcels 3 and 4, showing the Cambro-Ordovician Platform fragmented by normal faults. Several rotated blocks and a horst block with platform successions are potential structural plays. The seismic line n-n' is located on the seismic base map in Figure 27.

Parcels 3 to 5 are well covered by modern 2D seismic data that is available in paper copy from the C-NLOPB and for purchase from the oil companies previously active in the area (Talisman, Marathon and Hunt Oil). This data is time migrated and is of excellent to fair quality. The majority of the lines are dip lines diagonally covering Parcels 2 to 5. Several strike lines, generally parallel to the shore line are also available. Seismic grids older than 1990, (e.g. Mobil data from the seventies and eighties) are of very poor quality and were acquired with shorter offsets that is detrimental to multiple elimination. However, if the original field tapes can be retrieved, older lines need to be reprocessed prior to inclusion into interpretation. Nevertheless, there are a sufficient number of modern lines available to define and map all the large petroleum leads contained in Parcels 3 to 5.

5.4 Parcel 4

This is also a large parcel covering an area of 187,744 hectares (463,925 acres) within the Anticosti Basin. It is located just west of Parsons Pond where onshore drilling has occurred. The parcel extends from the coastline westwards into a water depth of approximately 250 m. To the south the parcel borders Parcel 3 and to the north with Parcel 5. No offshore drilling has occurred within or in the immediate vicinity of this parcel (Figure 4 and 37). However approximately two dozen "historical" exploration wells were drilled in the Parsons Pond area, just beyond the southeastern corner of the parcel. As previously noted, the recent Contact et al Parsons Pond #1 well tested the first thrust sheet of the Humber Arm Allochthon.

Parcel 4 is positioned in the Anticosti Basin, the Appalachian foredeep and deformation front, and the incipient Triangle Zone. The basin shallows to the western part of the parcel and deepens toward the east (Figures 36, 38 and 39).

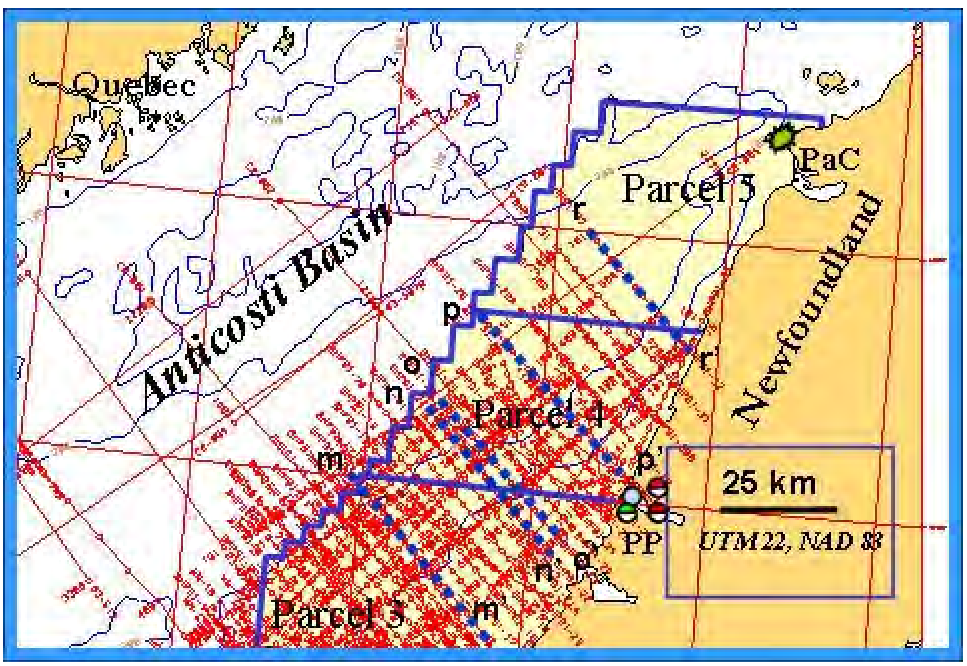

Figure 37. Location of Parcel 4 and 5, seismic coverage and location of seismic lines used to illustrate the petroleum potential of these parcels. Other annotations are: PP=Parson Pond wells; PaC =Port-au-Choix exhumed oil field.

The petroleum system in this area is similar to the one discussed for Parcel 3. The oil shows and seeps recorded on land in the Parsons Pond area demonstrate that source rock is mature and has generated hydrocarbons throughout this part of the basin. The main play is structural, as represented by fault bounded closures of Carbonate Platform reservoirs. On the eastern part of the parcel, the Long Point Group sediments and the successions imaged within the beginning of the Triangle Zone are faulted by thin-skinned faults and show a certain degree of deformation. Better processing of the seismic data is needed to image shallower parts of the basin in order to define potential secondary targets present above the carbonate platform. Lateral oil migration from the adjacent Green Point shale within the thick allochthonous package to the east presents a possibility for charging the structural and stratigraphic traps contained in this and the adjacent parcels.

The most extensive seismic grid in the area is the BHP data set recorded in 1991. This time migrated data set is complemented by additional older and younger lines, all available from the C-NLOPB in hard copy or for possible purchase from the original owners in digital form (SEG files).

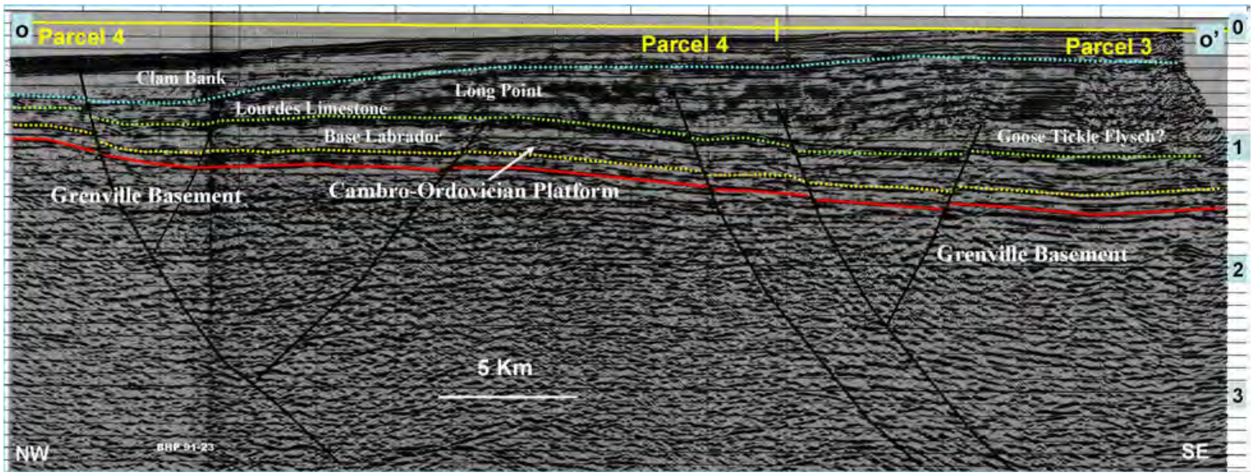

Figure 38. NW-SE 2D dip seismic line o-o' through Parcels 3 and 4, showing the Cambro-Ordovician Platform fragmented by normal faults. The seismic line o-o' is located on the seismic base maps in Figures 27 and 37.

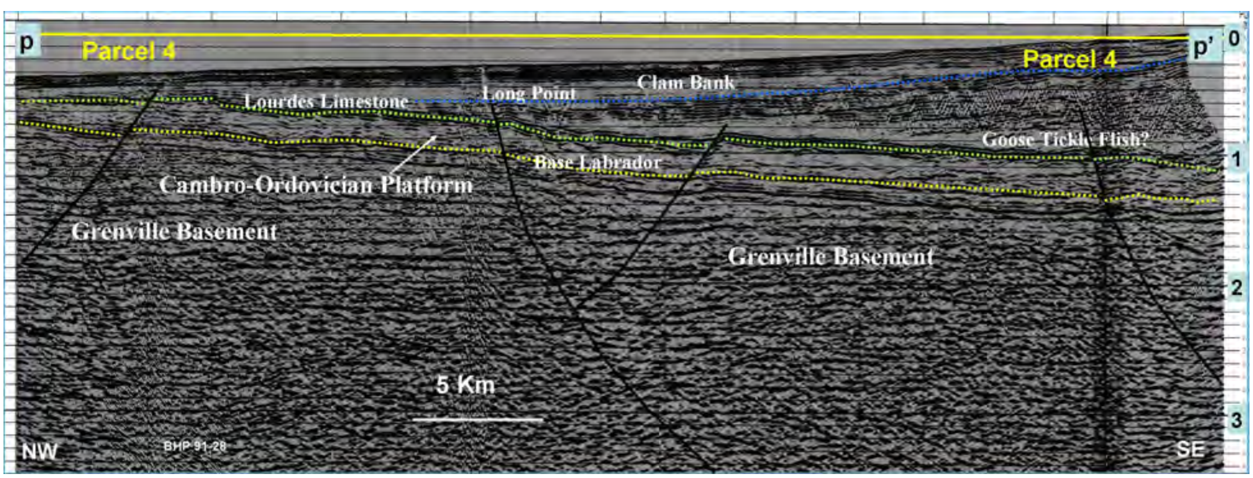

Figure 39. NW-SE 2D dip seismic line p-p' through Parcel 4, showing the Cambro-Ordovician Platform fragmented by normal faults, consequently forming two large horsts and a graben. The seismic line p-p' is located on the seismic base map in Figure 37.

5.5 Parcel 5

This is also a large parcel covering an area of 205,048 hectares (506,685 acres) within the Anticosti Basin and situated just northwest of Parsons Pond (Figure 4 and 37). Water depth varies from zero to 250 m, with a steep slope near the coast and a gentle northwest dipping water bottom over the rest of the parcel. To the south the parcel borders with Parcel 4. There has been no offshore drilling on this parcel or anywhere in the vicinity (Figures 4 and 37).

Several onshore wells have encountered good oil shows and a number of 'historic' wells produced oil for a small local refinery in the Parson Pond area (repeated from above). A very important indication of a significant petroleum system is the nearby Port au Choix Peninsula which appears to contain an exhumed oilfield within the carbonate platform. This exhumed field has been ground traced over an 8 km by 10 km area and appears to extend offshore for an unknown distance. (e.g., Cooper et al., 2001) (Figure 37).

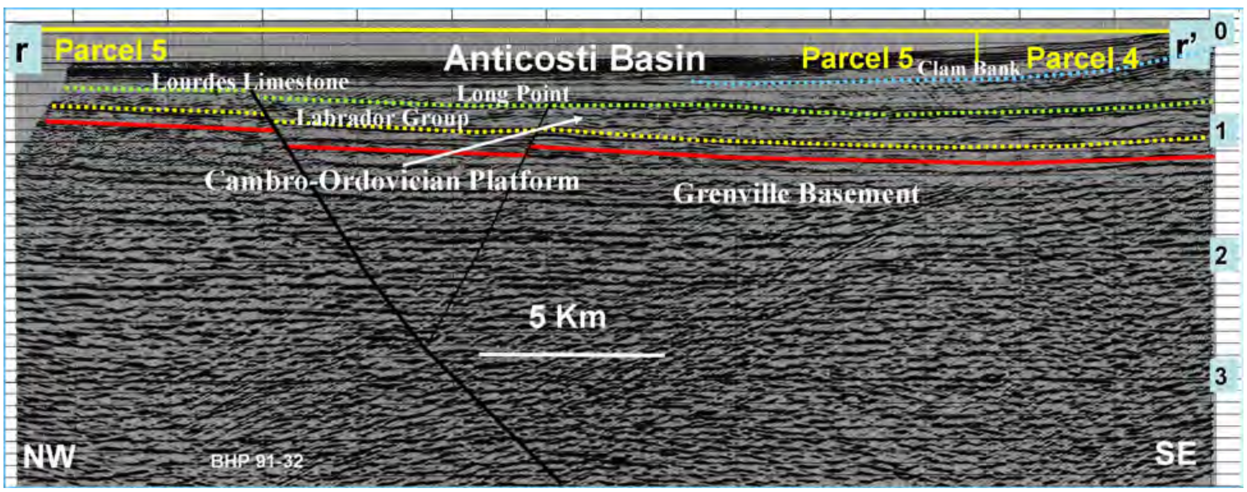

Figure 40. NW-SE 2D dip seismic line r-r' through Parcels 4 and 5, showing the Cambro-Ordovician Platform dissected by normal faults. The seismic line r-r' is located on the seismic base map in Figure 37.

By interpreting the seismic lines covering Parcel 5, a similar geological setting and petroleum potential to those described for the Call for Bids parcels to the south can be inferred for this parcel. The Carbonate Platform is shallower, though and can be drilled in the 1,500 to 2,500 m depth range. As in the case of all other parcels, paleo-karst of the St. George Group carbonates, similar to the Port au Choix reservoir, may be a play in Parcel 5.

The seismic coverage of the parcel is limited and somewhat inadequate for mapping prospects. New seismic acquisition might be needed for this parcel, especially in its northern part.

6. Discussion

Notwithstanding its proximity to the industrially developed regions of central Canada, and to the vast markets of the eastern United States, exploration in the Gulf of St. Lawrence region is still at a very early frontier stage. Numerous oil and gas prospects and leads identified with modern seismic data in this region are still waiting to be explored and drilled.

The five parcels offered in this landsale are located within eastern Canadian, Paleozoic, frontier basins which for the most part have recorded only modest discoveries. However, the recent McCully discovery in Carboniferous rocks in New Brunswick may hold up to 1 tcf gas in place and therefore provides encouragement for further discoveries. Large gas discoveries with flow rates up to 28 mmcf/day have been made offshore Labrador in Paleozoic carbonates (i.e., Gudrid – 924 bcf recoverable, Hopedale – 105 bcf recoverable).

There are two large, virtually unexplored sedimentary basins within the Gulf of St. Lawrence region of eastern Canada. The Anticosti Basin, named after Anticosti Island, of Ordovician to Silurian age (510-415 million years old), underlies the northern part of the gulf. The Magdalen Basin with its Bay St. George sub-basin, of Pennsylvanian to Permian age (350-250 million years old), underlies the south. The size of the five parcels contained in Call for Bids NL06-3 reflects this reality and the parcels are therefore very large when compared with Gulf of Mexico block size (80 to 100 times larger) or Grand Banks offerings. All parcels are located in areas with known reservoirs, mature source rocks and proven migration paths, but risk is recognized in regard to reservoir quality and continuity and the preservation of traps since Paleozoic time. The five parcels contain multiple reservoir targets within Paleozoic carbonate and sandstone sequences. These multiple target zones can be tested by drilling relatively shallow offshore wells using jack-ups or semi-submersible rigs (2000-3500m).

Several prospects have been identified in the previously awarded ELs and numerous large leads are seen on the seismic data in the parcels offered. Offshore prospects have fully risked recoverable resource estimates of between 100 to 200 million barrels oil (Atkinson and Wright, 2006) and 1 to 3 tcf gas.

New mapping with modern data may lower the geological risk, and prospect locations in shallow water environments with less severe climatic conditions will certainly lower the economic risk. No exploration for natural gas resources has been carried out in the past in Western Newfoundland.

Seismic identification of porosity and gas filled porosity within older carbonate sequences can be challenging but it is occurring in areas such as New York State and the Western Canada Sedimentary Basin. The geological risk associated with the Paleozoic is considered higher with regard to hydrocarbon migration, oil biodegradation, and lateral seal. However, risk can be minimized by regional evaluation and dynamic modeling of the petroleum system, and the use of high quality seismic data – which can allow for the direct detection of porosity and fluid type.

The cost of an offshore well in the Gulf of St. Lawrence would likely be in the range of Can$15 - $25 million. On a yearly basis, ocean conditions are generally fair to good, with some ice cover usually between February to early May. Fields can be developed using tie back to shore processing facilities, gravity based structures, bottom founded caissons or sub-bottom completion with FPSO (Atkinson and Wright, 2006).

7. Conclusions

Five large, offshore parcels located west of the island of Newfoundland are available for licensing in the C-NLOPB's Call for Bids NL06-3 which closes on Novembers 15, 2006. Four of the parcels contain Cambro-Ordovician carbonate platform rocks of the Anticosti foredeep basin and Appalachian fold and thrust belt. Carbonate sequences of similar age and setting were found to be productive elsewhere in the North American Appalachian trend. Closer to the landsale area, they also have flow-tested oil and gas at the Port au Port #1 discovery well (presently known as Garden Hill Field). The same "Garden Hill" play is viable in parcels 2 to 5 together with other favourable structural settings for the carbonate and sandstone reservoirs. Large fault bounded blocks at the Ordovician carbonate platform level provide sizable targets on all four Anticosti Basin parcels. The platform sequence is overlain by predominantly clastic sequences of the Long Point and Clam Bank groups which may provide additional reservoir potential. Additional targets may be found within the overthrusted Ordovician sequences within the Triangle Zone that forms the easternmost part of Parcels 3 to 5. High quality and dense 2D or 3D seismic coverage is needed to properly image such targets.

The recognized source rock for the area is the Green Point shale located within the thrusted sequence. This shale may provide lateral charge to the foreland basin structures and a more direct charge into the thrusted sequences. Other potential source rocks such as the autochthonous Cape Cormorant/Black Cove and the McCasty shales are likely to be present in the foreland basin. The proximity of parcels 2 and 3 to the Carboniferous rocks of the Magdalen Basin introduces the additional possibility of lateral charge from Carboniferous shales and coals which are proven source rocks throughout Atlantic Canada.

Parcel 1 is located within the successor Permo-Carboniferous Magdalen Basin. Significant hydrocarbon shows were encountered on land in the immediate vicinity of this parcel. The perceived petroleum system for this basin involves continental sandstone as the reservoir rock with hydrocarbon charge provided by lacustrine shales or coal intervals.

All these parcels are very large exploration blocks situated for the most part in shallow water in areas where drilling by jack-ups could potentially take place all year round. Likewise, the parcels are situated in practically unexplored basins in close proximity to northeastern US and Canadian markets. The recognized risks in regard to reservoir quality and source rock are mitigated by the presence of very large undrilled features. The presence of an 80 square km (as exposed on land) exhumed oilfield on trend at Port au Choix with paleo pay thicknesses of up to 100 metres demonstrates the presence of a significant petroleum system that was likely charged from the east. Seismic indicates that these same rocks are preserved at depth within large fault blocks within the foreland basin. Drilling thus far has only taken place within the more disturbed rocks of the thrust belt while the essentially undisturbed rocks of the foreland basin have never been drilled offshore western Newfoundland.

8. Acknowledgements

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Cooper, M. Fowler, I. Sinclair, I. Knight, G. Stockmal, J. Waldron and H. Robbins. Thanks are due to David Hawkins for facilitating access to reports and seismic data and Wes Foote, Larry Hicks, Government of Newfoundland and Labrador Department of Natural Resources for in depth reviews. Also thanked are Trevor Bennett and Steve Schwartz for providing graphic material. The work could not be done without information provided by the C-NLOPB and the Government of Newfoundland and Labrador Department of Natural Resources. Leona Stead of the Department of Natural Resources is acknowledged for graphics assistance and final report organizing. Finally Pan-Atlantic Petroleum Systems Consortium (PPSC) provided me the chance to learn and become familiar with West Newfoundland petroleum geology.

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