HYDROCARBON POTENTIAL OF PARCELS 4-7
CANADA-NEWFOUNDLAND AND LABRADOR OFFSHORE PETROLEUM BOARD
CALL FOR BIDS NL05-01

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FOREWORD

The Canada-Newfoundland Offshore Petroleum Board (C-NLOPB) has issued Call for Bids NL05-01 which includes seven land parcels totaling 571,984 hectares. Parcels one to three are located in the southern Jeanne d'Arc Basin on the Grand Banks of Newfoundland and have a combined area of 44,072 hectares. Parcels four to seven are located in the offshore waters along the west coast of the island of Newfoundland and have a total area of 527,912 hectares. This document has been prepared by the Newfoundland and Labrador Department of Natural Resources to provide information on the petroleum potential of parcels four to seven. The report should be referenced Fagan, P. and Hicks, L., 2005, Call for Bids NL05-01, Parcels four to seven. A similar document providing information on parcels one to three is available at www.nr.gov.nl.ca/mines&en/call_for_bids/NL05.pdf

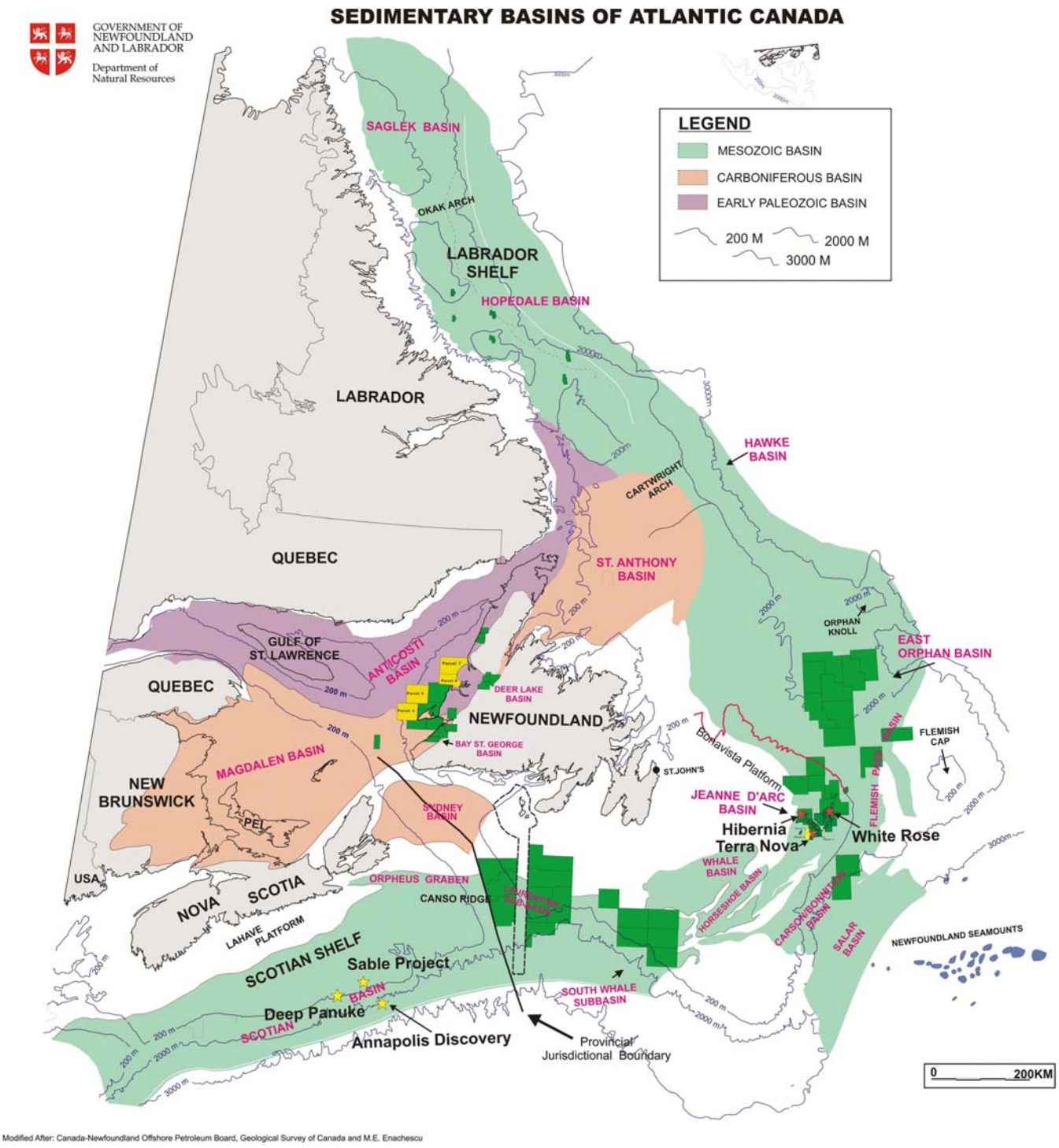

Figure 1

Atlantic Canada Basins with Petroleum Rights. The NL05-01 Call for Bids parcels are shown in yellow.

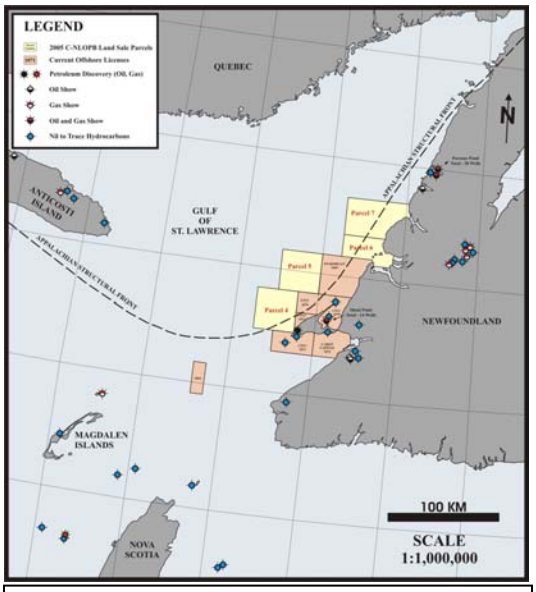

Figure 2
West Nfld Land Parcels and wells. The dashed line is the Appalachian Structural Front (ASF).

Section 1.
Introduction

The Gulf of St. Lawrence excluding all contained islands and the St. Lawrence estuary has a water area of approximately 220,000 sq. km., or approximately one third the size of the province of Alberta (661,185 sq. km.). Water depths on average are less than 100 meters except within the Laurentian Channel and associated feeder tributaries where depths range from 200 to 535 meters. Past and present geologic mapping indicate that the Gulf 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. The locations of these basins are as shown in figure 1, but seismic data shows that Cambrian-Silurian age rocks of the Anticosti Basin underlie the Carboniferous sediments of Magdalen Basin rocks in some areas.

Despite having very different geologic histories the Anticosti and Magdalen basins are both recognized to have petroleum potential by the widespread occurrence of surface oil seeps and oil and gas shows in water wells, mineral exploration wells and petroleum exploration wells. Historically, onshore drilling for hydrocarbons in Atlantic Canada began around 1858 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). Early attempts were focused around known surface oil seeps or shows and in more recent times structural highs observed through surface geologic mapping and seismic surveys.

Although limited production was achieved in some areas (e.g., a few thousand barrels in Parson's Pond a century ago), to date 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 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. The East Point E-49 well drilled offshore midway between Cape Breton Island and Prince Edward Island in 1970 flow tested at 5 million cubic feet of natural gas per day and is estimated to contain in-place gas reserves of 77 billion cubic feet in Carboniferous sandstone.

During the 1990s several large companies (Mobil, Norcen, BHP, Hunt, Talisman, PanCanadian) explored for petroleum in the western Newfoundland onshore and offshore areas, along with a cadre of predominantly locally based junior companies. This exploration cycle included the acquisition of large regional seismic programs in the near-shore area and smaller onshore programs in selected areas - Parsons Pond, Deer Lake, Port au Port Peninsula and Flat Bay.

In 1994-95 Hunt Oil of Dallas Texas and partner Pan-Canadian Petroleum drilled the Port au Port #1 well at the Garden Hill area on the southwest corner of the Port au Port Peninsula – this was the first well location in western Newfoundland to be based on seismic data. The well encountered several reservoirs, one of which was hydrocarbon bearing. Two intervals within the Aguathuna Formation (at approximately 3400 metres KB) flowed at 1528 and 1742 barrels of

high quality (51 degree API oil) and 2.6 and 2.3 million cubic feet per day of natural gas, respectively, with associated water. An extended test over one of the zones flowed a total of 5012 barrels of oil and 9.2 million cubic feet of gas over a nine day period. There were a number of possible explanations of why the flow rates dropped off at the time of these initial tests. Follow-up work by Canadian Imperial Venture Corporation, 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.

Having significant oil and gas flow to surface from the first modern well in the area caused a great deal of excitement. 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 area. Junior companies continue to hold lands and explore both Ordovician and Carboniferous targets. But interest in a regional hydrothermal dolomite play has more recently been given a boost by success in similar rocks in New York State (Eaton; AAPG Explorer) and exploration of the trend is ongoing elsewhere in Atlantic Canada - on the Gaspe Peninsula (Quebec), on Anticosti Island as well as western Newfoundland. Successful exploration of the hydrothermal dolomite play in New York has been aided by use of 3D seismic, which can under the right circumstances allow the direct mapping of porosity. Porosity can also be inferred by association with basement faulting and platform collapse zones. Advances in horizontal drilling and multilateral completions have significantly improved the economics of the play by providing a means to tap multiple pools from a single well bore.

Significant oil and gas shows have also been encountered in Carboniferous rocks in the Deer Lake Basin and Bay St. George Sub-basin onshore western Newfoundland. Vulcan Minerals of St. John's spudded the first of several planned wells in the Bay St. George Basin on July 20, 2005 to test large structural features mapped on seismic data. Carboniferous exploration in the Province is also being encouraged by the success of Corridor Resources who made a significant gas discovery in the Moncton sub-basin in the province of New Brunswick. This field is currently producing at approximately 2 mmcf/d, all of which is being consumed by the local New Brunswick market.

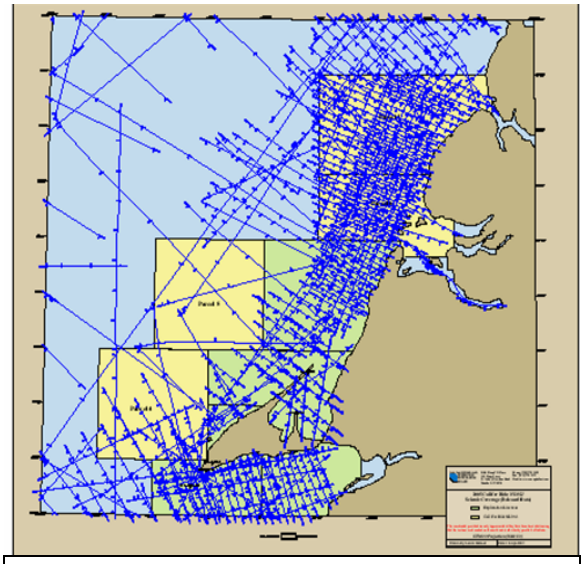

Figure 3
Seismic coverage on parcels 4-7. The more densely packed lines nearer the coastline were acquired during the 1990s and are of good quality. Other lines are older vintage (poor quality) and difficult to interpret.

Existing seismic coverage onshore western Newfoundland is sparse (a total of about 800 km) and is mostly concentrated in four areas – Parsons Pond, the Deer Lake Basin, the Bay St. George Sub-basin and the Port au Port Peninsula. Offshore seismic coverage (Figure 3) is much better but the older data (acquired prior to 1989) is very poor quality thus making interpretation difficult at best. As well, this data is only available in the form of poor quality micro-fiche images from the C-NLOPB. Modern offshore data (about 5000 km) acquired by Hunt Oil, Mobil, BHP Petroleum, Talisman and Marathon during the 1990s provides good interpretable imaging of the subsurface along most of the coastline. Further offshore, on parcels 5 and 6 the coverage is sparse. For this report we were

unable to locate any interpretable seismic data that crossed parcel five and had very limited coverage on parcel four.

Only five western Newfoundland offshore wells have been drilled in the Newfoundland jurisdiction, of which four were directionally drilled from land (one of these wells - a continuous cored, slim hole operation was 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 one "true" offshore well (St. Georges Bay A-36) lies to the SE of the Port au Port Peninsula (Figure 2). The key challenge in terms of hydrocarbon prospectivity 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 – see Table 1) but thus far have tested water.

In this Call for Bids the four parcels being offered for bidding are all located within the Anticosti Basin, although seismic data shows Carboniferous sediments onlapping from the south and thinning to zero edge as one moves to the northwest on parcel number six.

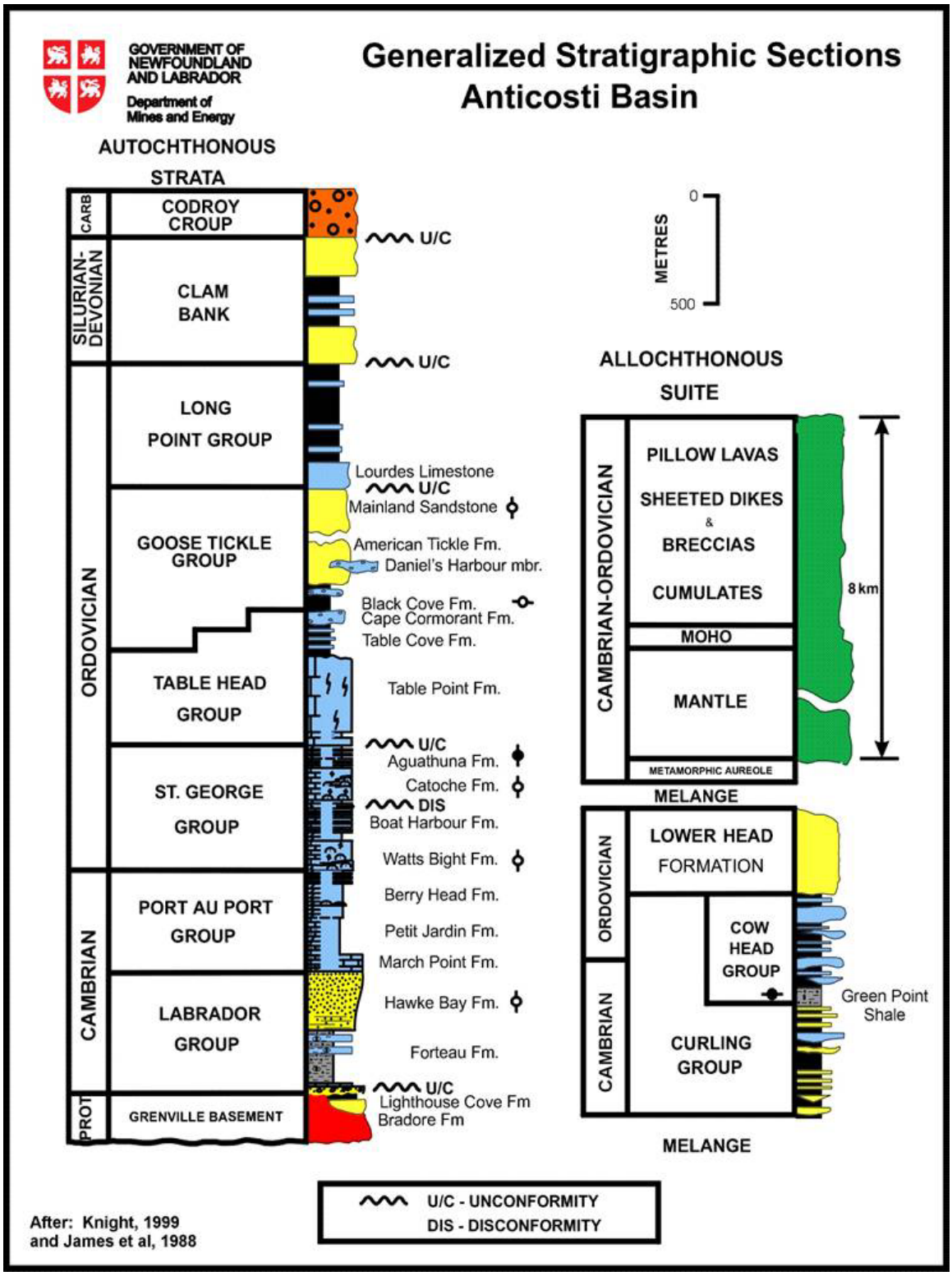

Figure 4

Possible Reservoir — Possible Source rock

Proven Reservoir — Proven source rock

Section 2.
Regional Petroleum Geology

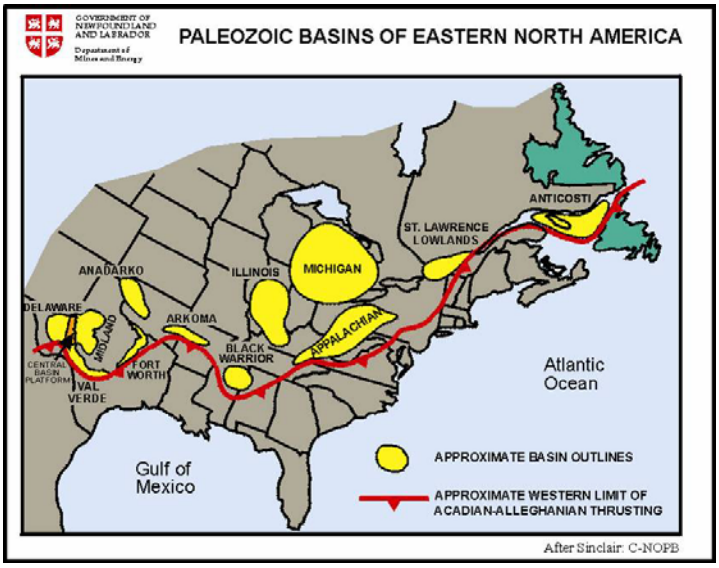

Figure 5
Major reserves have been produced from basins on trend with the lightly explored Anticosti Basin.

The Early Paleozoic Anticosti Basin is one of a series of basins that preserve Cambrian to Ordovician shelf and foreland basin rocks along the Appalachian trend of eastern North America (Figure 5). 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. To the south of this margin stretched the wide expanse of the warm, Early Paleozoic, Iapetus Ocean. 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. Today the Early Paleozoic shelf is preserved in western Newfoundland as a lightly deformed, mainly carbonate, autochthonous 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. Major reserves have been produced from similar age rocks (Ellenburger and Arbuckle groups in the Midland, Val Verde, Anadarko, Forth Worth and Arkoma basins) along this trend in the United States. (Atkinson-Fagan, 2000)

Figures 2 and 5 show the Appalachian Structural Front (ASF), a major fault separating moderate to intensely deformed, transported rock (on the south and east side of the fault in the Anticosti Basin) from their non-deformed to weakly deformed, non-transported equivalents (to the north and west side of the fault). Figures 10 and 11 are seismic sections through the thrust front which can be seen as a "triangle zone" in the area running north from the Port au Port Peninsula. Parcels six and seven straddle the thrust front (Figures 2, 10 and 11) and present many play possibilities within the triangle zone and the foreland basin.

Source Rock:
The recognized source rock for the Anticosti Basin onshore western Newfoundland is a shale within the late Cambrian aged Green Point Formation. Analysis of Green Point samples by the C-NLOPB yielded a TOC of 1.74% to 3.04%, Hydrogen Index (HI) of 367-451 and Oxygen Indices (OI) of 4-26 (Sinclair, 1990). 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.

To the east of the ASF, the Green Point source rock is known to be present by hydrocarbons encountered at both Parsons Pond and on the Port au Port Peninsula, and from sampling in outcrop. However 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 foreland basin sequences lying offshore to the west. Seismic indicates that all four of west Newfoundland parcels being offered in this land sale would contain the foreland basin sequences.

The Middle Ordovician Black Cove-Cape Cormorant formation 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 a TOC of 1.2%, 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). A final possibility for source rock charge would be in the form of lateral migration from adjacent Carboniferous strata.

Reservoir Rock

Released well information indicates that all of the Ordovician carbonate reservoirs are within dolostones. 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 4000 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. 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 conclude that the Port au Choix Peninsula contains a large exhumed oil field. In addition to the carbonate reservoirs the Hawke Bay Sandstone 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 allochthonous sandstones (Mainland and American Tickle) as well as within dolomitized carbonate conglomerates (Daniels Harbour Member) and calcarenites carried in hanging wall thrusts (Knight – pers comm.). The Late Ordovician Long Point Group and Silurian-Devonian Clam Bank groups are not widely outcropped 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. Porosity is most extensive 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 in this area remains to be explored.

Section 3. Land Parcels

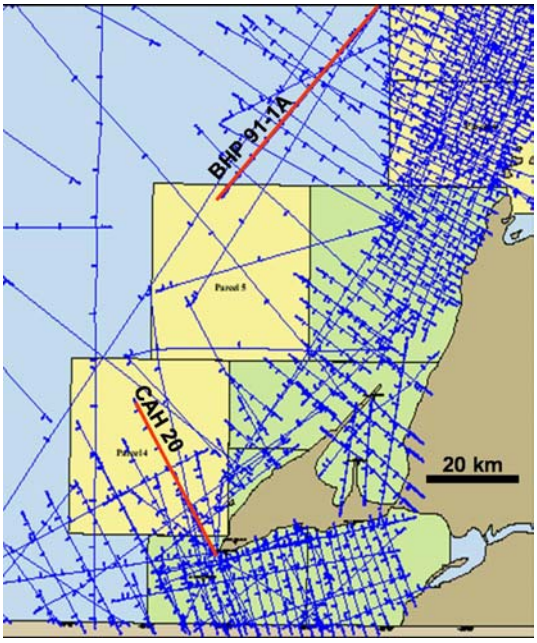

Figure 6 shows the location of seismic line CAH 20 (Figure 7) which runs diagonally across parcel four and line BHP 91-1A (Figure 8) which runs northeast from parcel five (authors were unable to find a good quality line that crossed parcel five). Line CAH 20 shows how parcel four is located to the west and north of the ASF (refer to Figure 2) within the foreland basin. The carbonate platform is the recognized target zone in this area and tested oil from the Aguathuna Formation at Port au Port #1. This well is located on the southwest corner of the Port au Port Peninsula. The platform is well imaged at the SE end of the line and appears to thin dramatically when crossing the second fault from the left.

Figure 6
Locations of seismic lines shown in figures 7 and 8. The Port au Port #1 discovery well is located on land near the SE end of the highlighted portion of CAH 20.

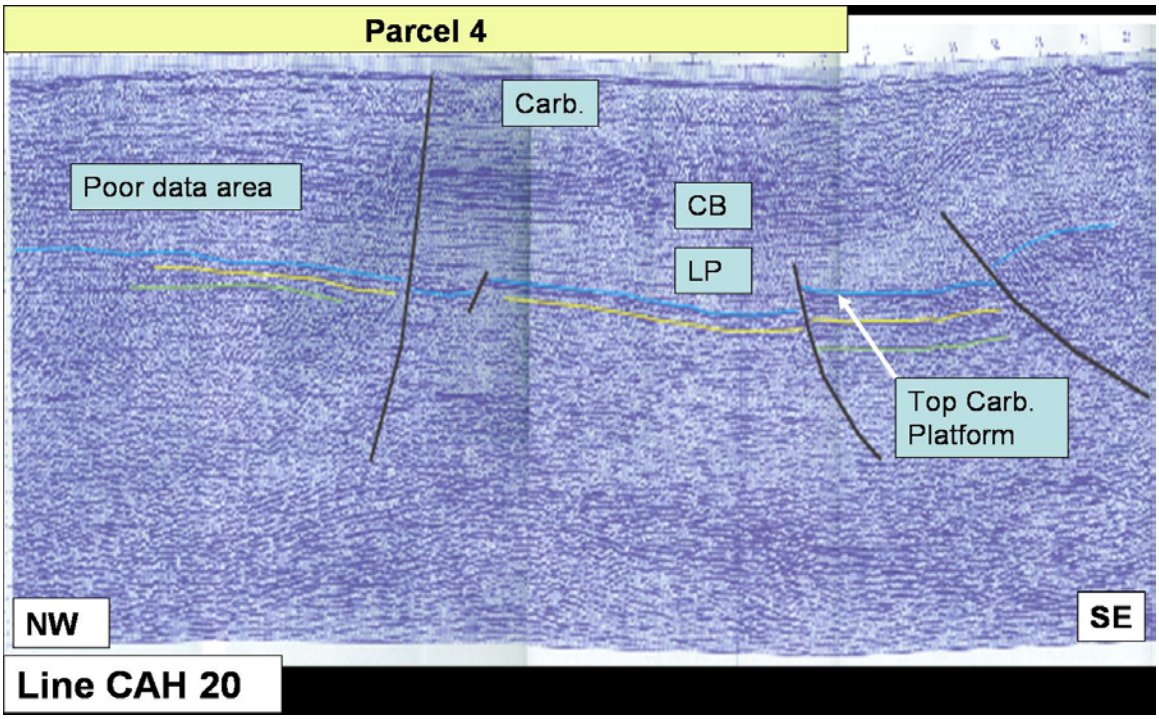

Figure 7
Line CAH 20 (Hunt Oil) shows parcel 4 to be located in the foreland basin. Carb. = Carboniferous, CB=Clam Bank and LP= Long Point. The ASF lies immediately SE of the portion of the line shown here.

The fact that this (second from left fault) is steeply dipping (almost vertical) combined with the dramatic change in platform thickness across the fault suggests that it is a wrench fault. Wrench faulting is to be expected in this area given its close proximity to the Carboniferous Bay St. George Sub-basin - which is recognized to have been deposited in major wrench system.

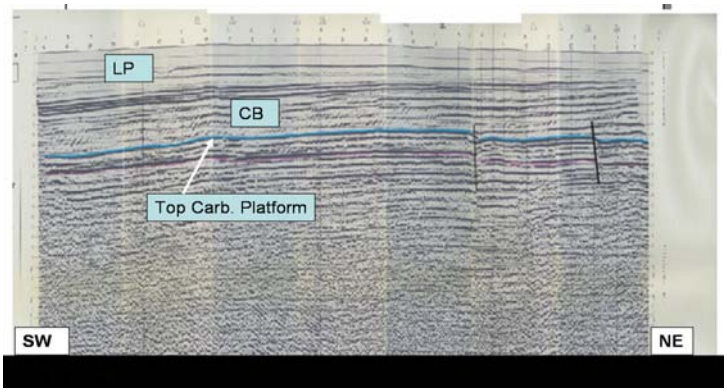

Figure 8
Seismic line BHP 91-1A. This line runs NE from the northern border of parcel 5.

Additionally this is an area where the ASF switches from a roughly NE trend to a rough E-W trend. This may be indication of an Ordovician transfer zone that potentially could have been re-activated during the Carboniferous.

Figure 7 also shows the platform sloping upward toward the north-west and with a possible block fault play against what appears to be a down-faulted collapse zone (second fault from left). Data quality deteriorates to the NW of a large wrench fault that appears to run all the way to the surface, and the platform cannot be interpreted with confidence on this part of the line.

As previously noted, the authors were unable to locate an interpretable line across parcel five. Line BHP 91-1A (Figure 8) shows that the carbonate platform is clearly present on the north boundary of the parcel. Given that the platform is seen to also be present to the south of the block it is a good bet to be present throughout parcel six and it should contain similar potential for block fault type traps at the platform level as exists elsewhere in the foreland basin.

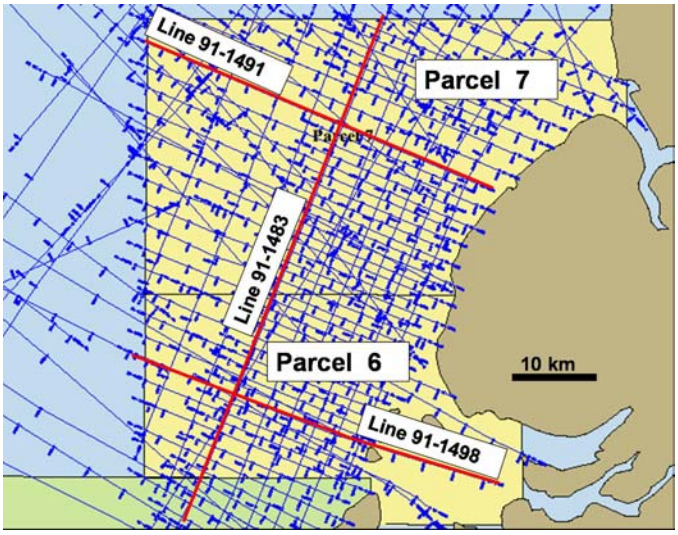

Figure 9
Locations of Mobil lines 1491, 1498 and 1483.

Seismic line 91- 1498 (Figure 10) shows the Appalachian Structural Front (ASF), in the Bay of Islands area near Corner Brook, as a classic triangle zone. Potential plays include large block faults on the carbonate platform and stratigraphic pinchouts in the up-turned beds. The Green Point Shale (source rock) is contained within the thrusted package to the east and may provide lateral charge to closures at the platform level and to clastics in the overlying sequences.

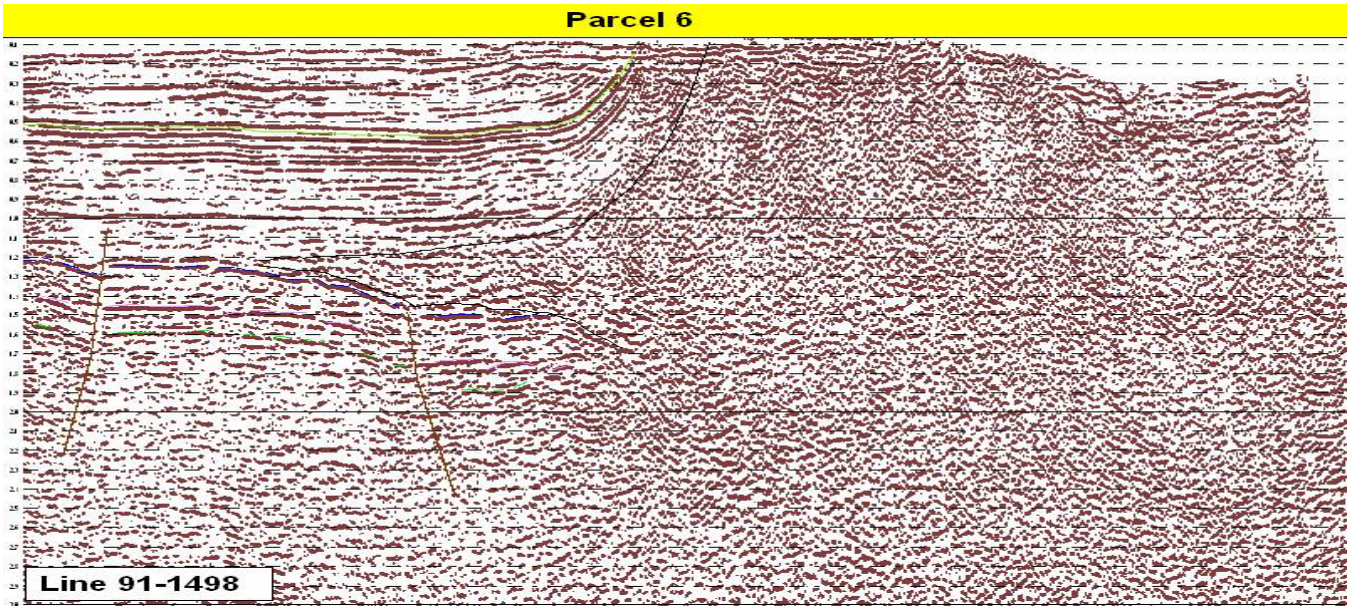

Figure 10
Mobil line 91-1498 shows the Appalachian Structural Front as a classic triangle zone. The line is approximately 45 km long.

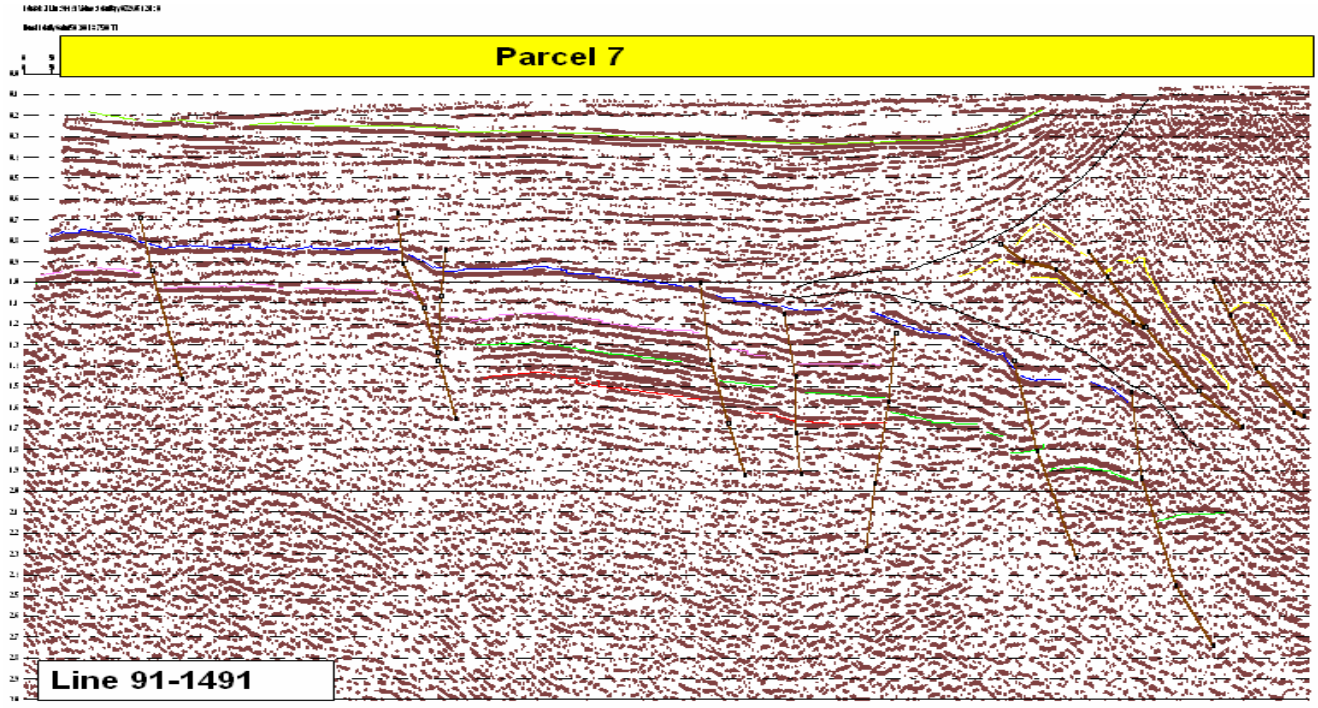

Figure 11
Seismic line 91-1491 through parcel 7. Shows thrust play possibilities and block faults in the foreland basin. Line length is approximately 42 km.

Seismic line 1491 (Figure 11) is another dip line across the ASF that shows similar block fault potential on parcel 7 as well as thrust slices within the triangle zone.

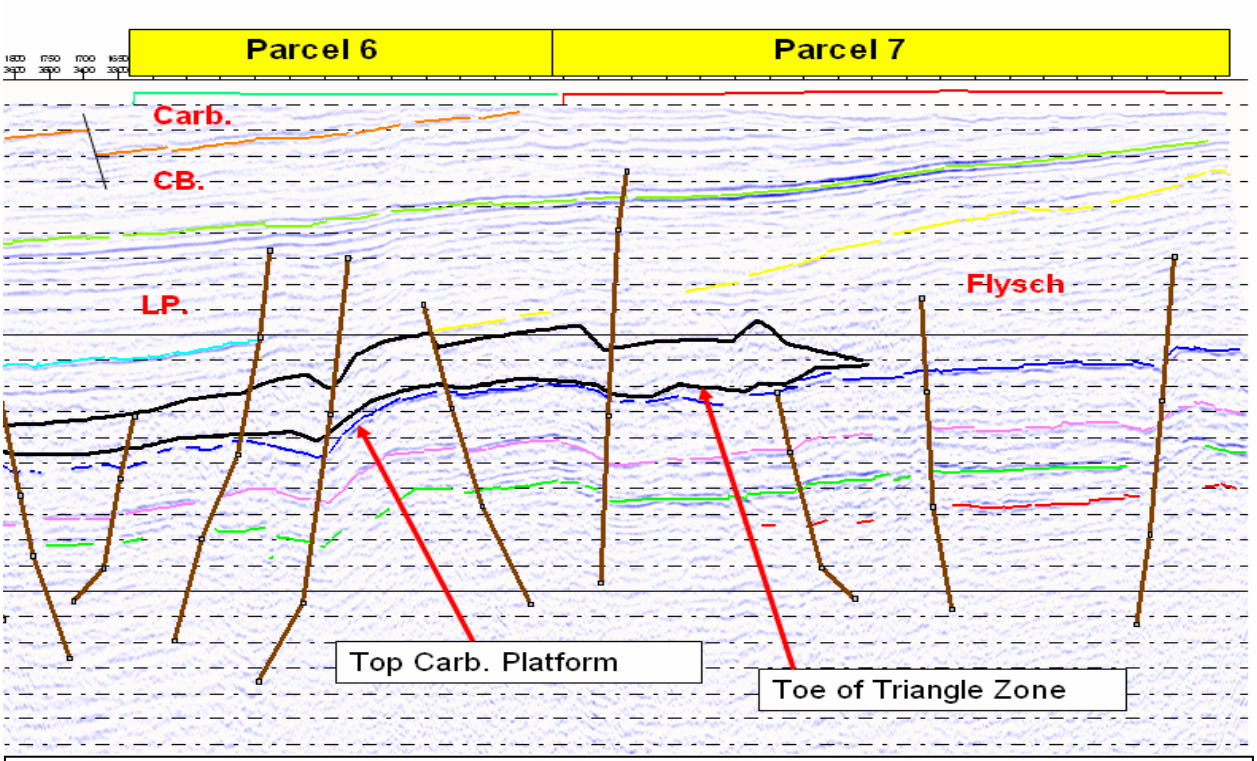

Figure 12
Mobil line 91-1483 is a strike line through parcels 6 and 7 indicates possible fault traps at the platform level and within the overlying clastics. Line length shown is approx. 66 km.

Seismic line 1483 (Figure 12) shows an apparent north trending regional dip on the platform and in the overlying clastic sequences. In fact the regional dip runs in a north-west direction with platform rocks outcropping on the coast of Labrador. A thick down-lapping sequence that appears to be sourced from the north is interpreted to be flysch (Mainland formation). The toe of the triangle zone which has been picked from intersecting dip lines is also shown, as are the Long Point (LP), Clam Bank (CB) and Carboniferous (Carb.) sequences which are roughly picked based on prominent reflectors that may or may not represent the exact lithologic interfaces.

Section 4. Conclusions

Four large parcels located offshore to the west of the island of Newfoundland are available for licensing in the C-NLOPB's Call for Bids NL05-01 which closes on December 1, 2005. All of the parcels contain the Cambro-Ordovician carbonate platform rocks which have proven to be productive elsewhere in the Appalachian trend and which have flow tested oil and gas at the Port au Port #1 discovery well (Garden Hill Field). Large block faults at the platform level may provide sizable targets on all four parcels. Additional targets may be found within the thrusted sequences within the triangle zone, but 3D seismic is needed to properly image such targets. The platform sequence is overlain by predominantly clastic sequences of the Long Point and Clam Bank Formations which may provide additional reservoir potential.

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 may also be present in the foreland basin. The proximity of parcel four to the Carboniferous rocks of the Magdalen basin introduces the additional possibility of lateral charge from the Carboniferous shales which are proven source rocks throughout Atlantic Canada.

Acknowledgements

This report was written by Phonse Fagan and Larry Hicks of the Department of Natural Resources. Thanks are extended to Leona Stead of the Department of Natural Resources for graphics assistance and editing, to Donna Parsons of the Department of Natural Resources for cover design and to students Heidi Murphy and Chris Stargratt for assistance in preparing graphics and compiling materials.

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Additional Sources of Information

- C-NLOPB Schedule of Wells, 2005
- C-NLOPB Released Geological and Geophysical Reports
- Geological Survey of Canada, BASINS Website <http://agc.bio.ns.ca/BASIN/FULL>

From Government of Newfoundland and Labrador (Department of Natural Resources (DNR) – Energy Branch). The reports below, as well as other related materials including generic royalty information is available on the DNR website: **www.gov.nl.ca/nr/**

- Oil and Gas Report, August 2005
- Sedimentary Basins and Hydrocarbon Potential of Newfoundland and Labrador, Report 2000-01 (Atkinson and Fagan)