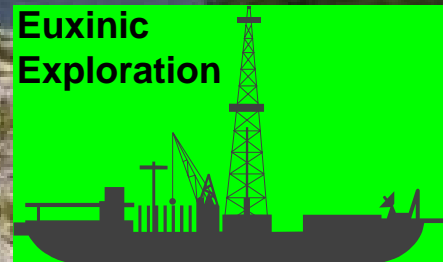


Call For Bids NL06-2 Sydney Basin

**Dr. Michael E. Enachescu,
Euxinic Exploration and Memorial University
On Behalf of NLDNR**



November, 2006
St John's, NL

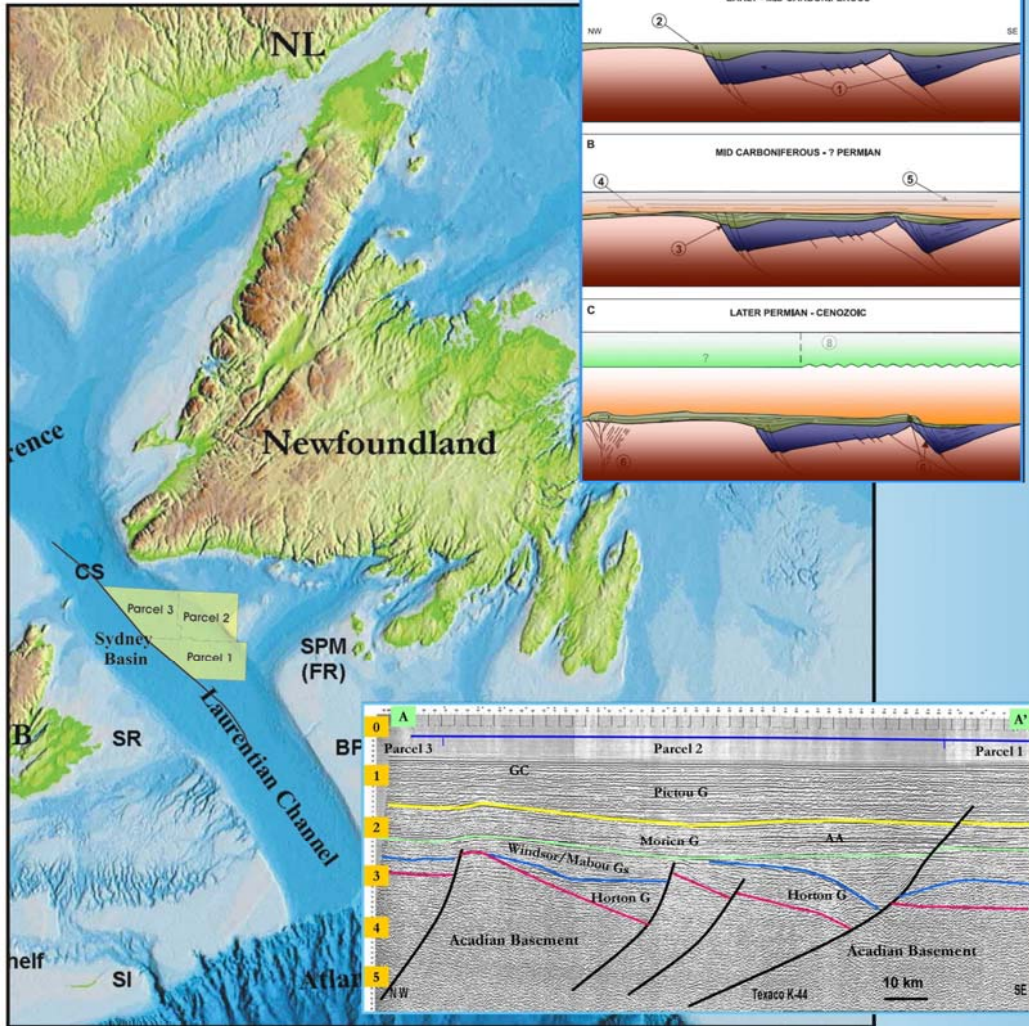


Acknowledgements

- This report draws heavily on past work by Drs. Pascucci, Gibling (DU) and Williamson (GSC)
- Dr Gibling of Dalhousie University and Dave Brown of C-NSOPB have provided additional information and access to their collection of papers
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- Discussions with Phonse Fagan of A.J. Fagan, Consulting Inc. were of great help
- Reviews by Larry Hicks and Wes Foote of the NL Department of Natural Resources greatly improved the text
- Thanks are extended to Leona Stead of NLDNR for graphics assistance and final report organizing
- David Hawkins of C-NLOPB for facilitating access to reports and seismic data
- Also thanked is Trevor Bennett who provided some graphic material
- The work could not be done without information provided by C-NLOPB, Government of Newfoundland and Labrador Department of Natural Resources and Pan-Atlantic Petroleum Systems Consortium (PPSC)
- Memorial University
- Jaime, Vincent and Monika Enachescu

Report Content

- **Foreword**
- **Introduction**
- **Exploration and Development Background**
- **Regional Geology of the Sydney Basin**
- **Petroleum Geology of the Sydney Basin**
- **Petroleum Potential of Call for Bids NL06-2
Parcels 1 to 3**
- **Discussion**
- **Conclusions**
- **Acknowledgements**
- **Further Reading**



Government of Newfoundland and Labrador
Call for Bids NL06-2
Sydney Basin

October 2006

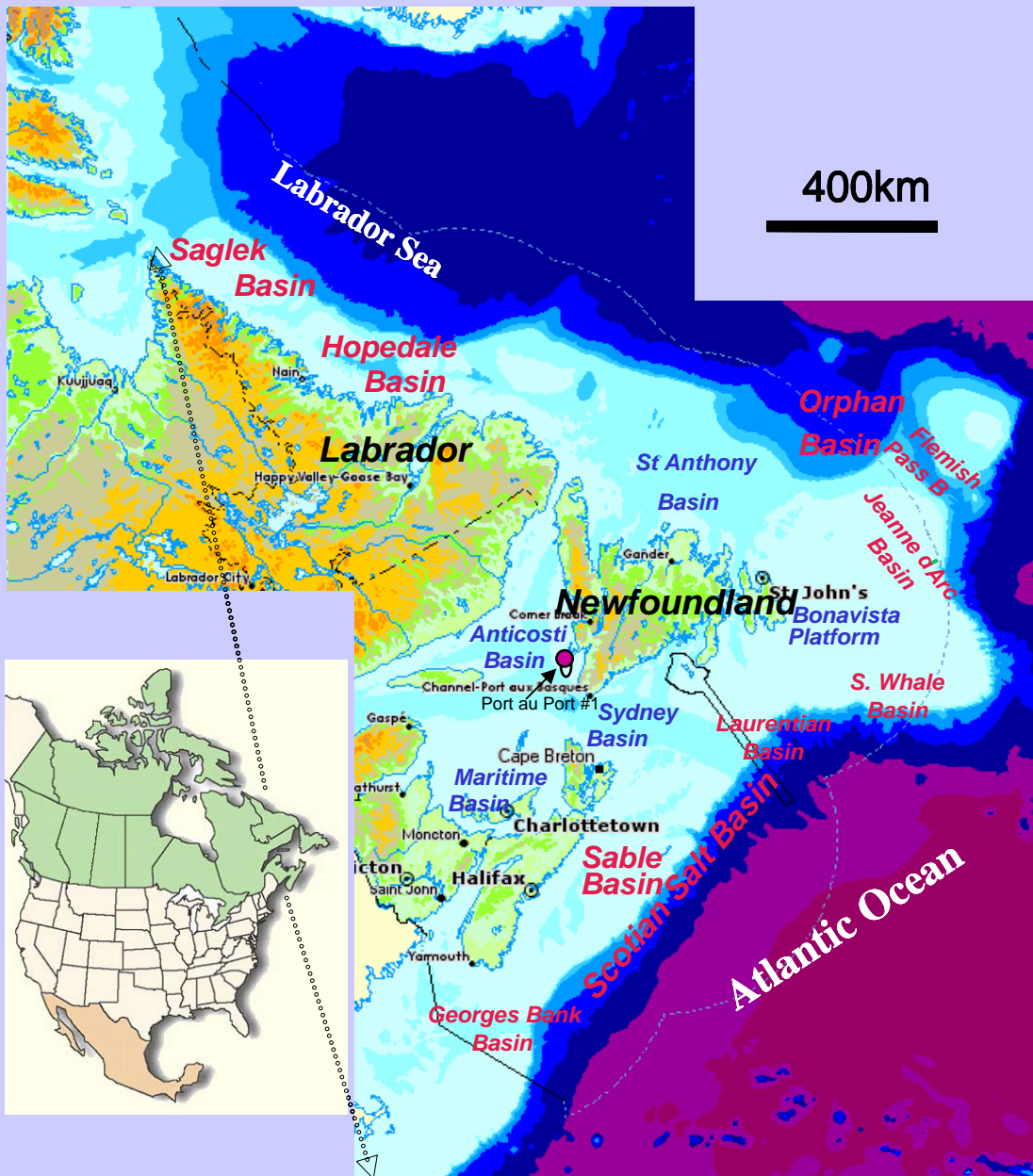
- 51 pages of text
- 10 pages of references
- 30 illustrations

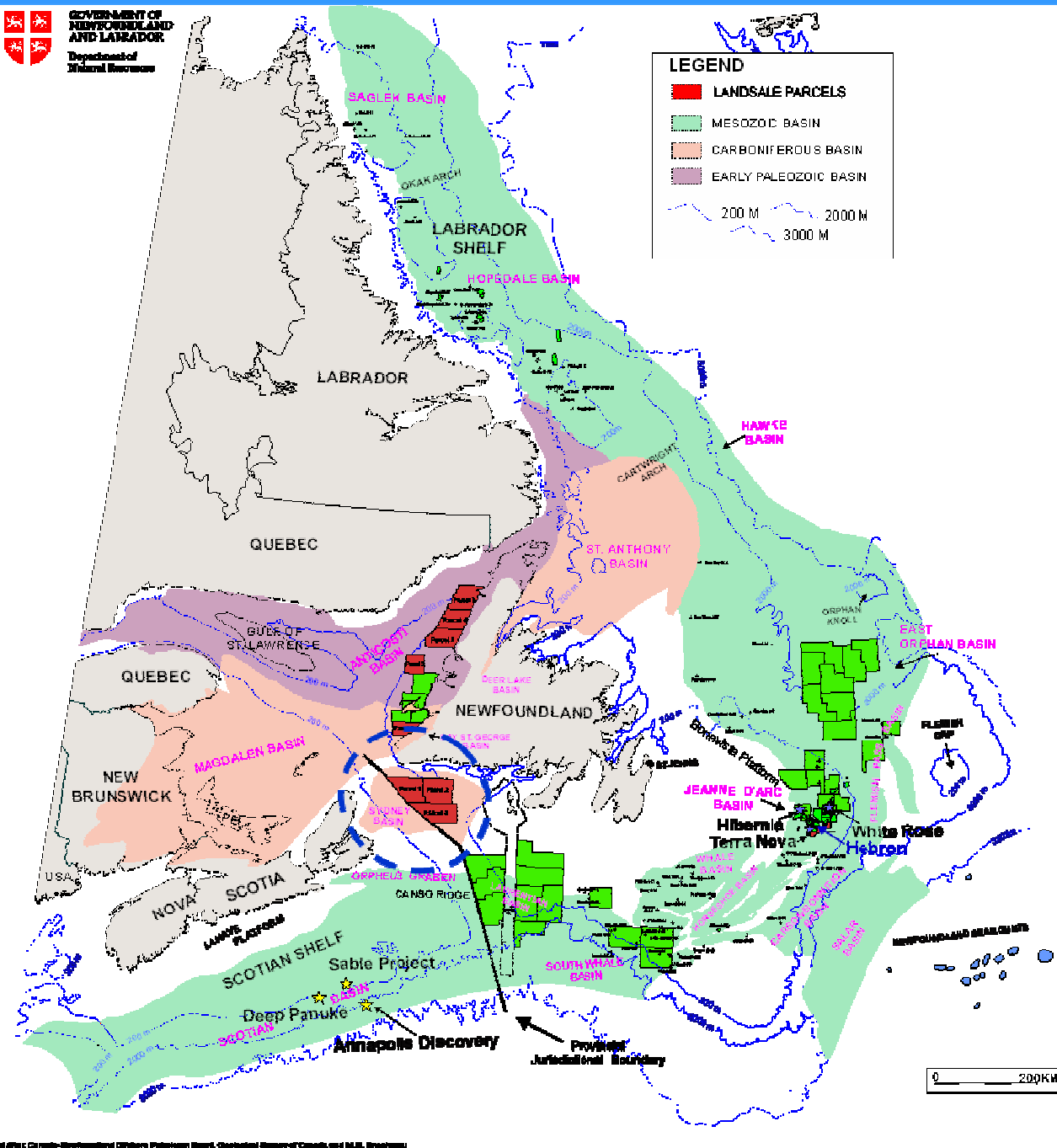
Exploration for oil and gas in the Sydney Basin (Newfoundland side) is in its infancy

- *Atlantic Canada Carboniferous basins*
- *Used work done mostly in Nova Scotia and New Brunswick*
- *Built large reference list*
- *Visit outcrops in the region*

Introduction

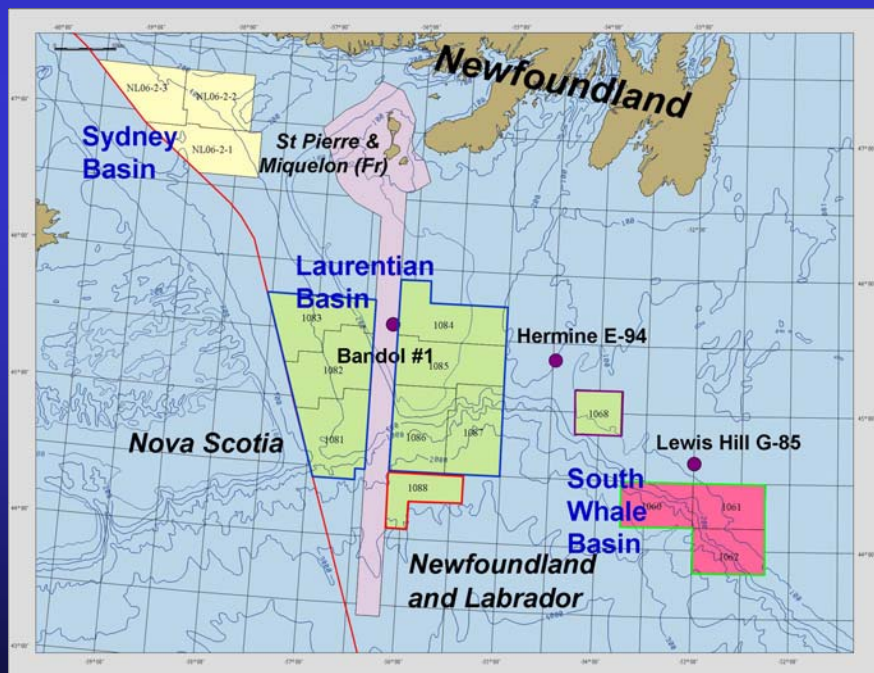
This report provides background information on petroleum exploration and development in the Province, a general overview of geological prospectivity of Sydney Basin and neighbouring Paleozoic basins, and a discussion of the specific geology and petroleum potential of the three offshore parcels available for bidding





No other licences are currently extant within the Sydney Basin on the NL side of the boundary, several offshore licences are held on the Nova Scotia side and onshore rights in Carboniferous basins are held throughout the Atlantic Provinces – including on the west coast of the island of Newfoundland

Despite an early exploration phase (in the 1960s and 70s) that included regional potential field mapping and seismic acquisition, it is fair to say that exploration in the Sydney Basin is still at an early stage.



- For more than 25 years, much of the Sydney Basin and the adjacent Laurentian Basin were off limits to exploration due to an international boundary dispute between Canada and France
- With the boundary questions settled, this is the first time that lands on the NL side of the border are being offered in a landsale
- With the minimal exploration that has occurred, particularly on the NL side, the geology of Sydney Basin is not well documented or understood, especially when compared to producing areas such as the Grand Banks or Scotian Shelf

2. Exploration and Development Background

2.1. NL Petroleum Production

2.2. Large Paleozoic Under-Explored Area

2.3. Atlantic Canada Exploration History in Paleozoic Basins

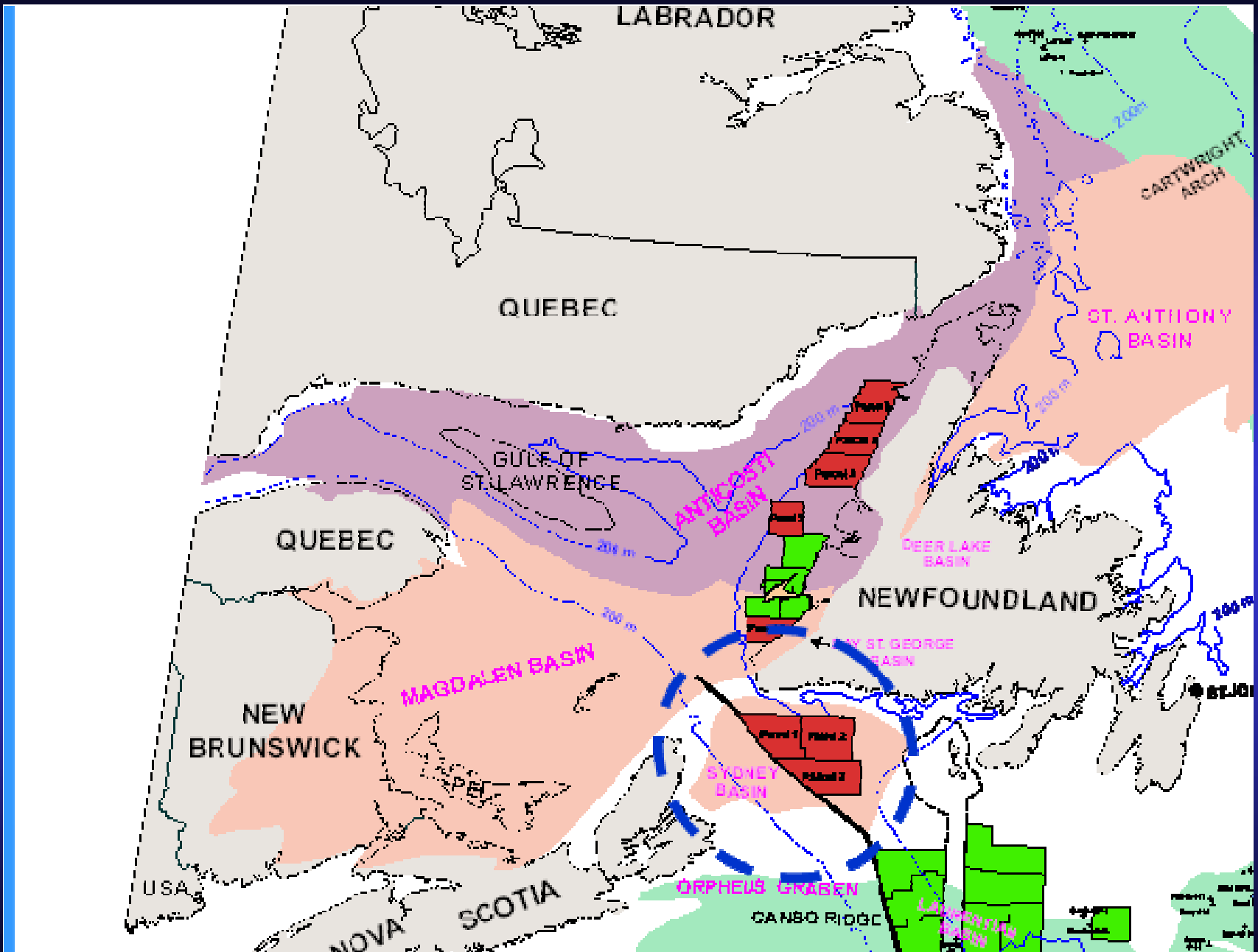
2.4. Recent Sydney Basin Landsale Results

NL Petroleum Production

- NL petroleum production and Paleozoic Basin exploration was discussed in detail in Call for Bids NL06-1 and NL06-3
- No production or offshore significant shows exist for Sydney Basin
- The Sydney Basin encompasses for the most part a large, mostly shallow water, offshore region between Newfoundland and Nova Scotia. Onshore, basin rock exposures are abundant on the east side of Cape Breton Island (Nova Scotia) and to a much lesser extent on the Burin Peninsula (on the south coast of Newfoundland)
- From a logistics perspective the Sydney Basin is less challenging than the Grand Banks and is closer to North American markets, with easy access to export venues. If gas is discovered, it could be tied into the North American grid by a lateral line to the nearby Maritimes & Northeastern Pipeline which delivers Sable gas to New England and various Atlantic Canada markets. Any significant oil and gas production in the Sydney Basin will also have a rapid and significant impact on the Province's and region's economy and is very likely to have the strong support of the government and local population

Large Paleozoic Offshore Under Explored Area

- **The Sydney Basin is a subdivision of the predominantly Carboniferous Magdalen Basin. Together, the Anticosti and Magdalen basins cover an area the size of the State of New Mexico or about half of the size of the Canadian Province of Alberta**
- **The Basin is well exposed on Cape Breton I. but has only minor onshore outcrops on the south coast of Newfoundland. Only two medium depth wells have been drilled on the Nova Scotia side and along with available industry seismic data provide the fundamental information on the offshore geology of the basin. Due to its rich coal exploration and production history the onshore Nova Scotia part of the Sydney Basin is well known and described in detail in numerous publications**
- **The most active phase of exploration within NL's Gulf of St. Lawrence waters took place in the early - mid nineties when several large Exploration Licences were operated by companies such as Hunt Oil, PanCanadian, Talisman, BHP and Mobil. This exploration cycle, which resulted in the drilling of 5 deep wells by the bigger companies and a number of shallower holes by smaller players was focused on Ordovician and Carboniferous rocks of the Anticosti and Deer Lake basins and the Bay St. George sub-basin. No exploration took place within the Sydney Basin**



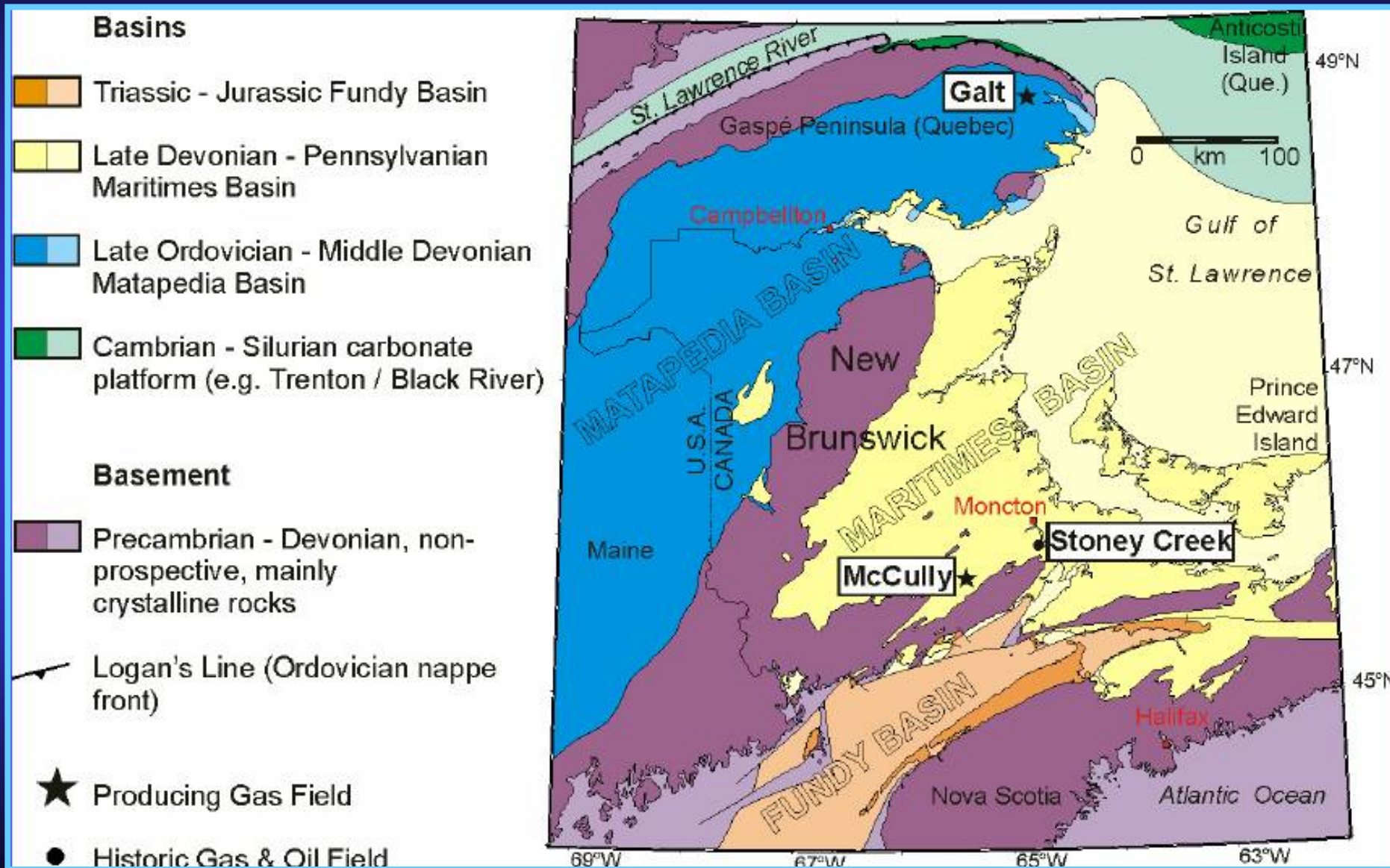
Large Paleozoic Offshore Under Explored Area

- Although minor oil production was achieved at Parsons Pond in the early 1900s and oil and gas has recently been encountered and tested onshore in the Anticosti Basin, Deer Lake Basin and Bay St. George sub-basin, no oil or gas is currently being commercially produced in western or southern Newfoundland
- Nevertheless, hydrocarbons were discovered in Carboniferous rocks in other Atlantic Provinces and gas is presently produced and marketed from the McCully gas field in New Brunswick (Moncton sub-basin)
- Significant Carboniferous production is also obtained from the US Appalachian Foldbelt, Illinois Basin, North Sea, the Netherlands, Vienna Basin, Dnieper-Donets Basin, Ural Foldbelt, Timan-Pechora Basin, Barents Sea, Australia and the Middle East. In the eastern North Atlantic region (offshore Ireland), Carboniferous source rocks have charged the Coribb gas field and have produced shows in several other exploration wells. This area was once part of the same intra-continental marine/lacustrine system as the Atlantic Canada basins prior to the breakup of Pangea

Large Paleozoic Offshore Under Explored Area

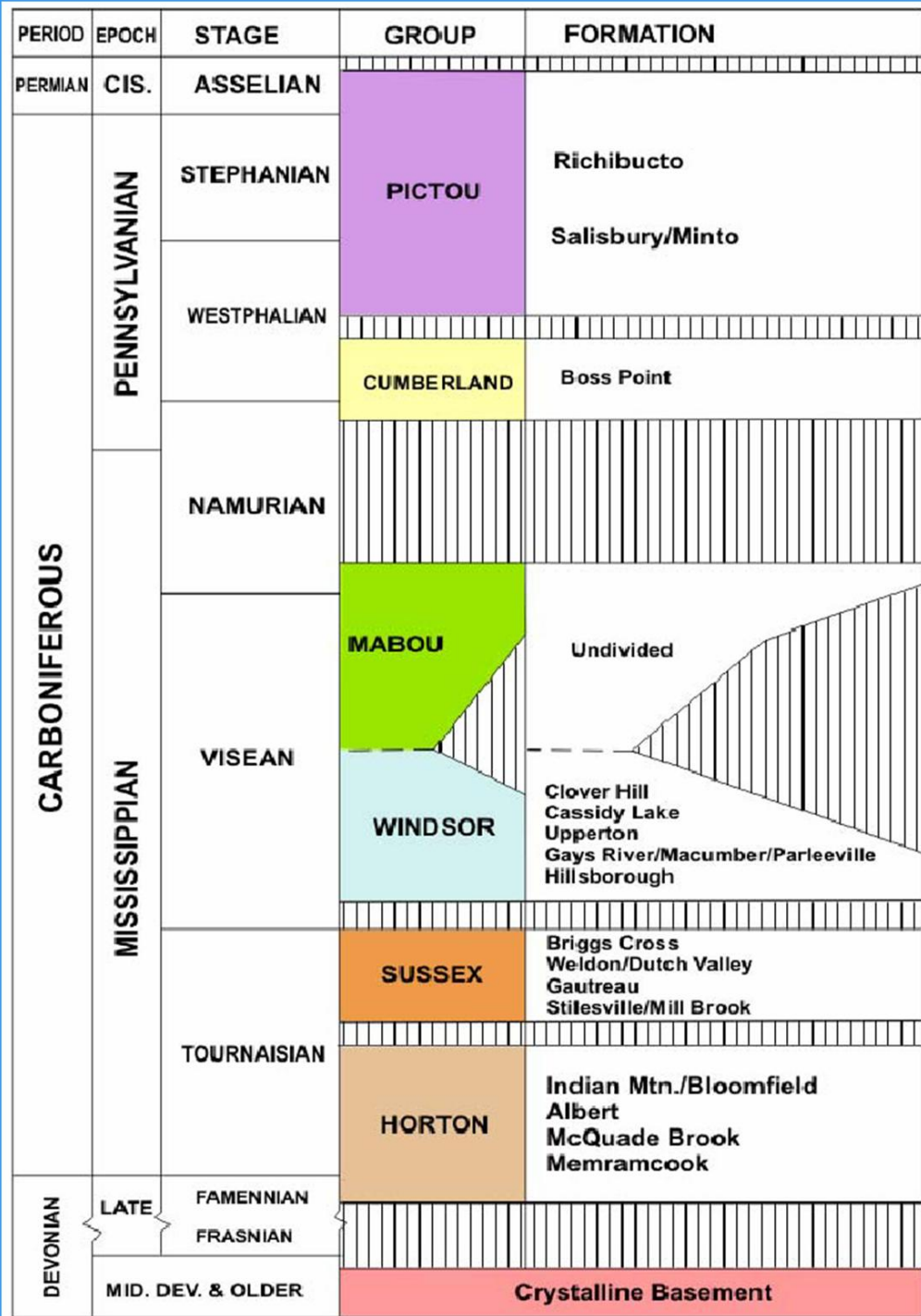
- the Atlantic Provinces including Newfoundland and Labrador were affected by an older Wilson cycle that was initiated during Early Paleozoic and culminated with the build up of the Appalachian fold belt and its corresponding foredeep, extending from the southern US into the western Newfoundland onshore and offshore areas
- This cycle ended with the Alleghenian Orogeny which was accompanied by the formation of several Carboniferous successor basins - the largest being the Maritime Basin. Significant volumes of source and reservoir rock were accumulated during this Paleozoic cycle of ocean opening and closing
- Petroleum exploration for Carboniferous reservoirs in the Canadian Maritime Provinces southwest of Newfoundland started in the early to mid nineteenth century

Atlantic Canada Exploration History in Paleozoic Basins



(after the Fyffe and St. Peter, 2006)

M.E. Enachescu/NLDNR 2006c

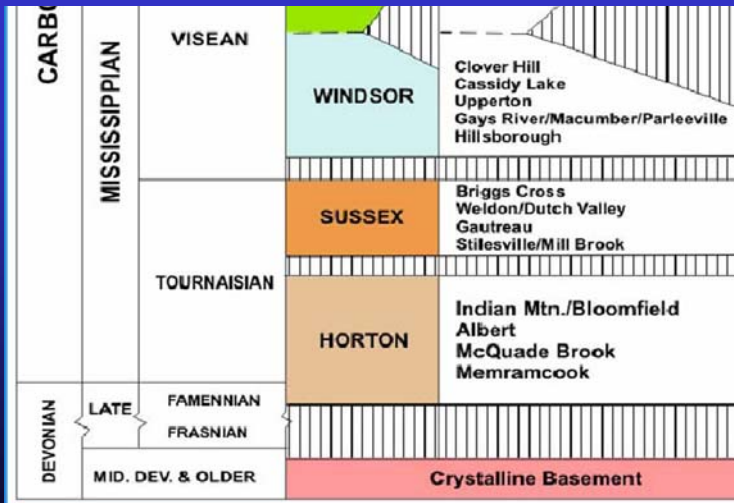
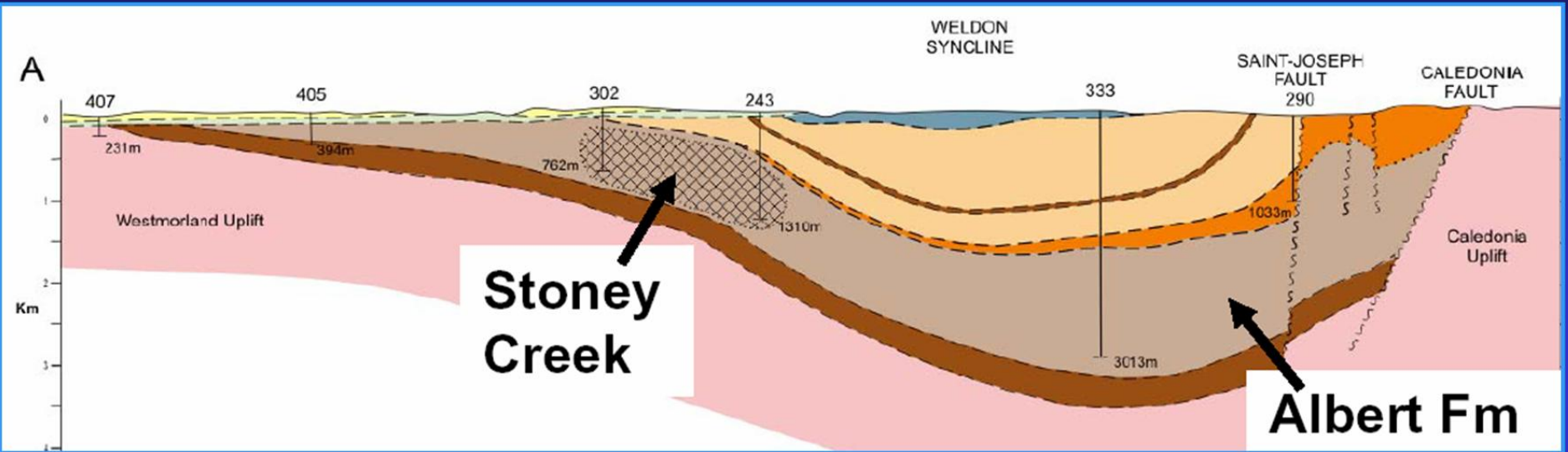


Generalized stratigraphic chart, for the Late Paleozoic onshore sub-basins of New Brunswick including the Carboniferous Stoney Creek oil field and McCully gas field (Fyffe and St. Peter, 2006). With small modifications to recognize localized stratigraphy this chart can be applied to the Carboniferous throughout Atlantic Canada

New Brunswick

- **About 250 wells (generally under 1,000 m deep) were drilled specifically for hydrocarbons. Only two dozen wells were deeper than 2,000 m**
- **The Stoney Creek field is the largest oil field onshore Atlantic Canada and one of the oldest in the country. It has produced approximately 800,000 bbl of oil and 28.7 billion cubic feet of gas from 1909 to 1991**
- **The reservoir is approximately 900 m deep and averages 33 m in thickness. Reservoir quality is excellent with porosity averaging 18% and permeability averaging 160 md**
- **To date, less than 5% of the original oil in place has been recovered. Additional gas reserves may also be proven. Contact Exploration (of Calgary) recently acquired the petroleum rights for the field and began applying modern exploration/development methods (including 3D seismic, reservoir modelling and horizontal drilling) to go after the bypassed pay**

Stoney Creek Oil and Gas Field



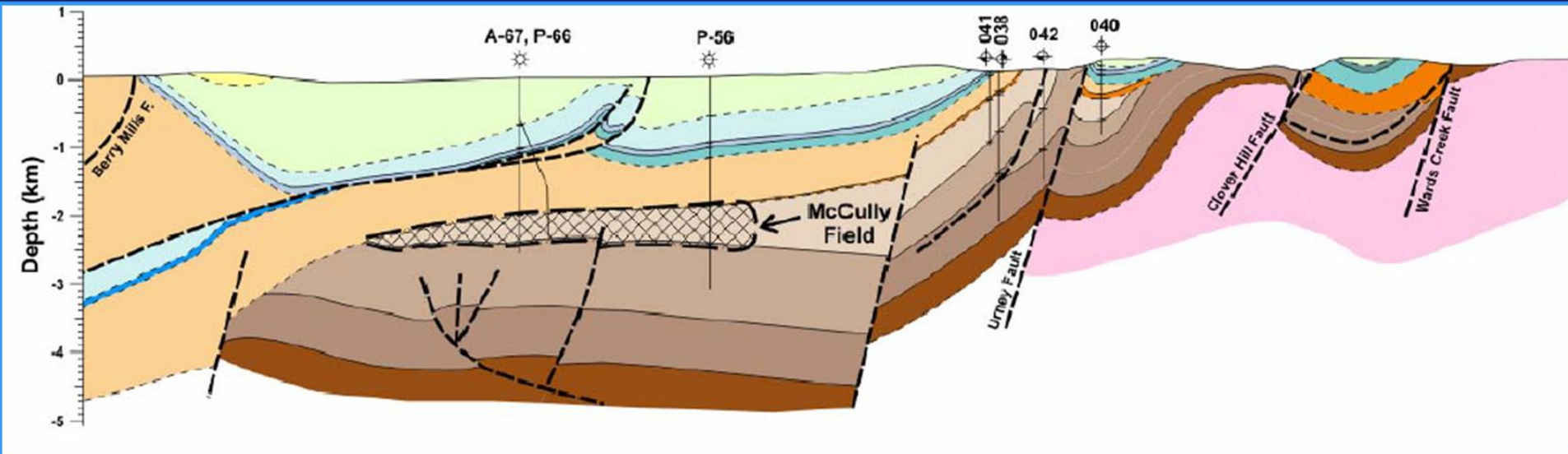
Geological cross-section of the Stoney Creek oil field, New Brunswick (after the Fyffe and St. Peter, 2006). Oil was produced from the Hiram Brook sandstone member of the Albert Formation

New Brunswick

- The McCully field (2000) produces about 2 mmcf/d from an Early Carboniferous reservoir at 2 km depth. The produced gas is consumed in the local market. Several successful wells with tests between 1 and 5.7 mmcfd were added during 2005 and a connection to the M&N Pipeline is envisaged. The field was mapped by 2D and 3D seismic and is contained in a large faulted anticline covering over 11,400 ha, with four way closure. Production is from a series of sandstones, each several metres thick within a 500 metre gross gas column
- Both the Stoney Creek and McCully fields have the same source rock (Frederick Brook Mbr) and reservoir sandstone (Hiram Brook Mbr) within the Albert Formation of the Horton Group (Lower Carboniferous). The sealing rocks are Upper Carboniferous shales and siltstones
- Presently 250,000 hectares are permitted in New Brunswick to various junior companies for oil and gas exploration. The Carboniferous production from McCully field and the eventual rejuvenation of the Stoney Creek field, are very encouraging for the Paleozoic play in Atlantic Canada – including the Carboniferous basins of western Newfoundland.
- Several large Carboniferous leads and prospects mapped by Corridor Resources (e.g. Old Harry and West Cape Breton prospects) have also been identified within the Gulf of St. Lawrence

http://www.corridor.ns.ca/properties/old_harry/index.xml

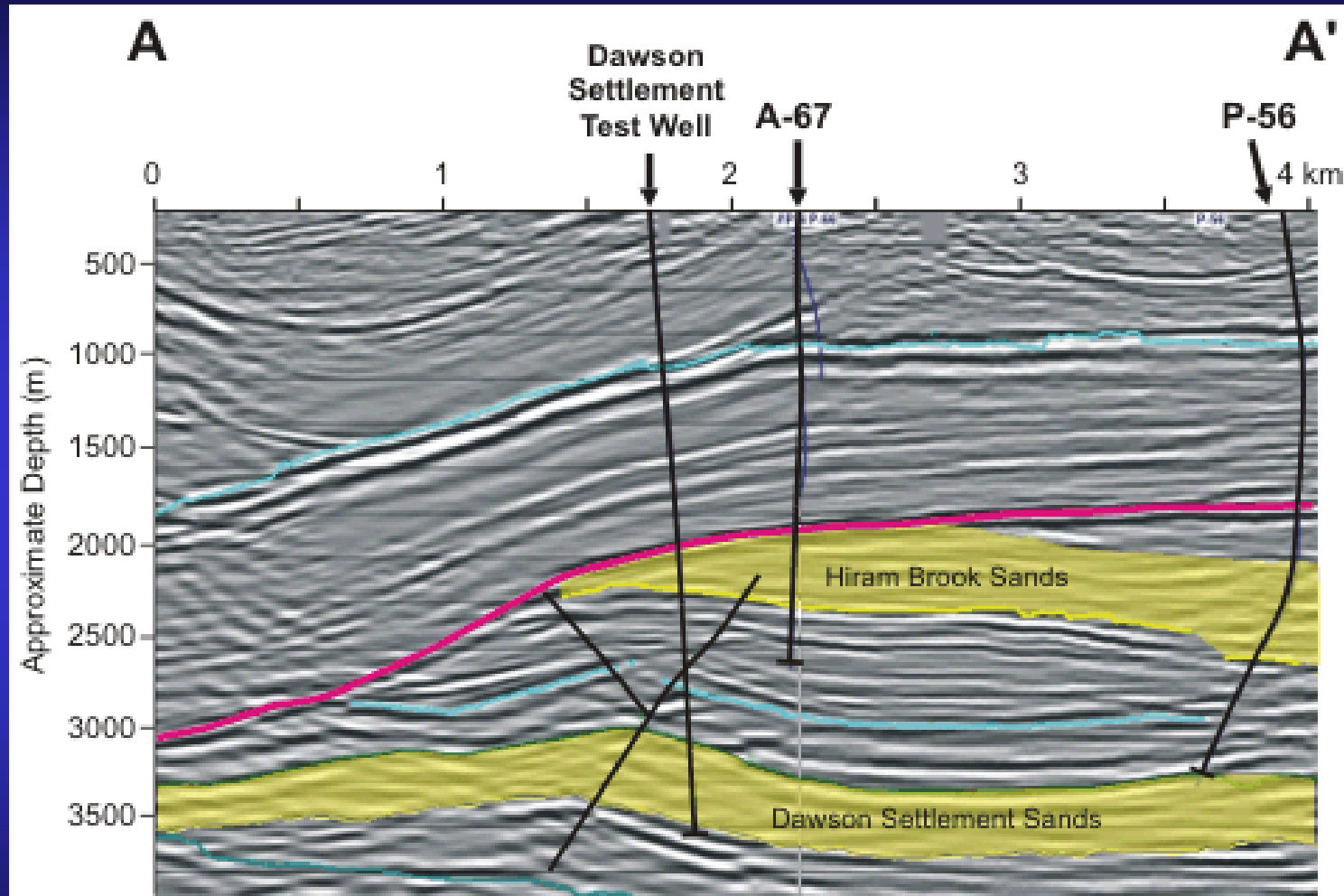
McCully Gas Field



CARBONIFEROUS	MISSISSIPPIAN	WISEAN	WINDSOR	Clover Hill Cassidy Lake Upperton Gays River/Macumber/Parleeville Hillsborough
		TOURNAISIAN	SUSSEX	Briggs Cross Weldon/Dutch Valley Gautreau Stilesville/Mill Brook
	HORTON		Indian Mtn./Bloomfield Albert McQuade Brook Memramcook	
	DEVONIAN	LATE	FAMENNIAN FRASNIAN	
	MID. DEV. & OLDER		Crystalline Basement	

Geological cross-section of the McCully oil field, New Brunswick (after Fyffe and St. Peter, 2006). Gas is produced from the Hiram Brook sandstone member of the Albert Formation (Horton Group)

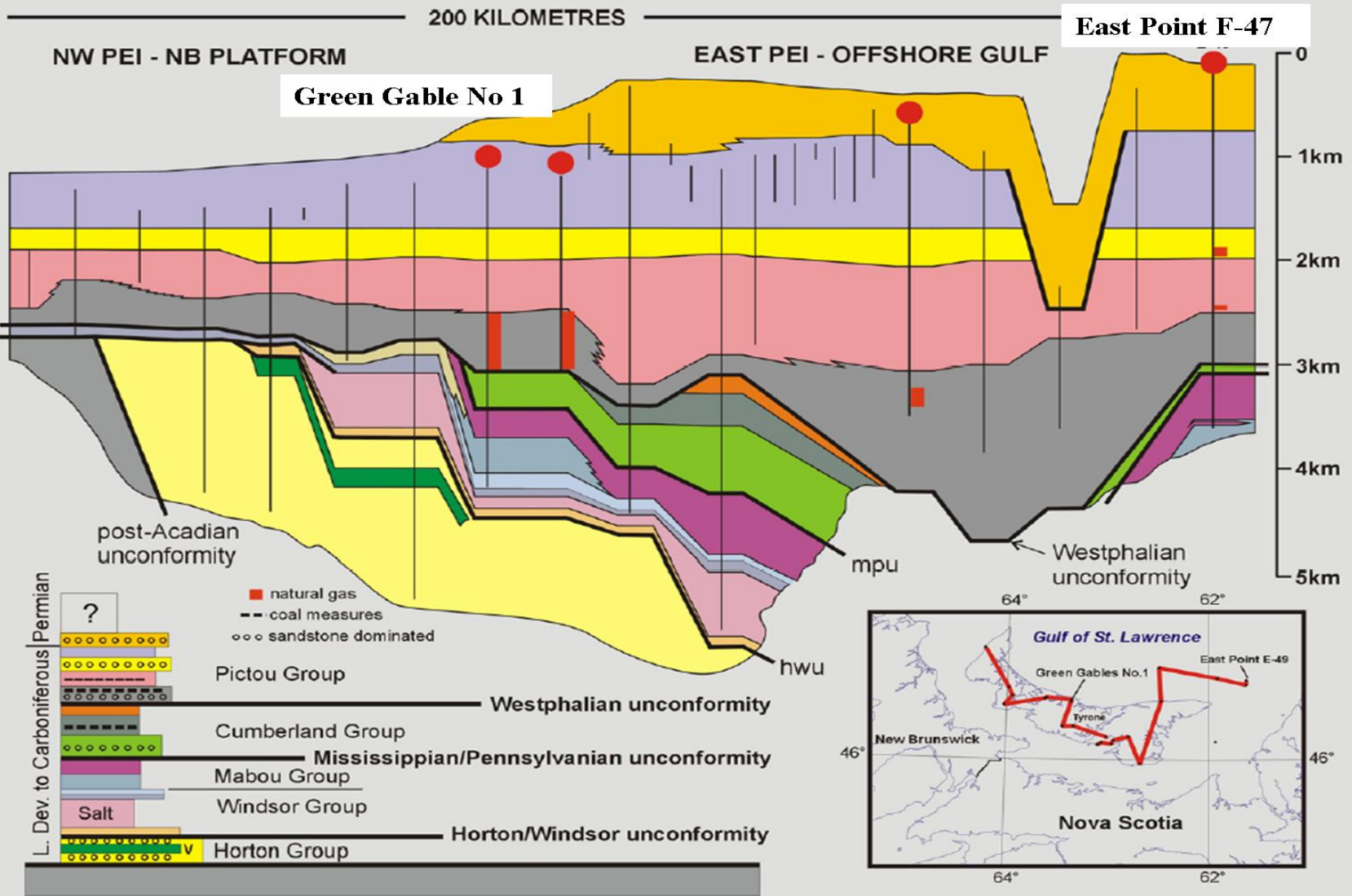
McCully Gas Field



3D seismic section across the McCully oil field (dip direction), New Brunswick showing gas sands within the Horton Group (after Martel and Durling, 2006 and Corridor website)

Prince Edward Island

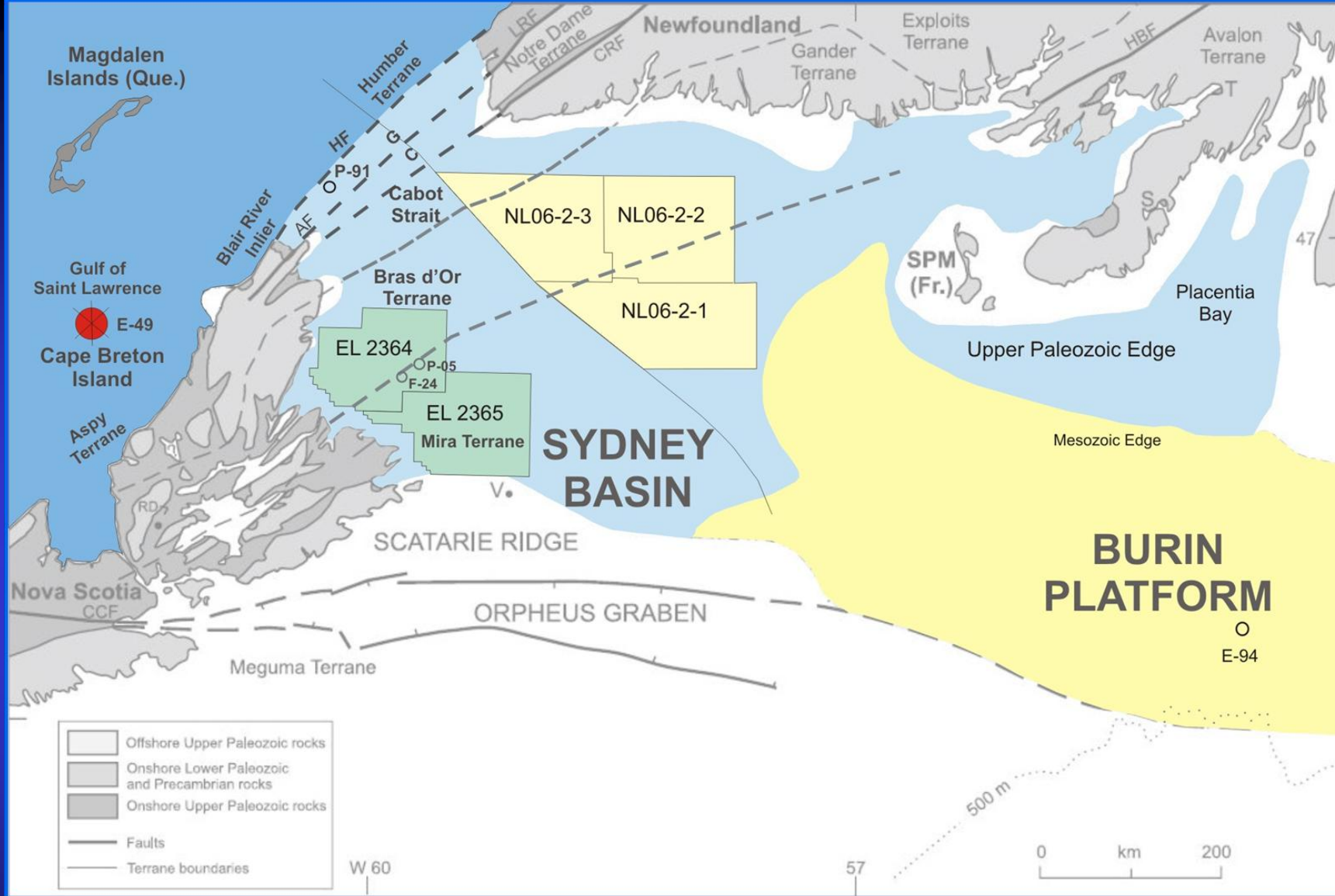
- The East Point E-49 well was drilled off the eastern shore of PEI in 1974 and tested gas at a rate of 5 MMcfd from Pictou Group sandstones. The offset E-47 exploratory well drilled in 1980 to a depth of 2662 m did not encounter hydrocarbons
- The continental origin of the sediments underlying Prince Edward Islands suggests that the region should be considered mostly a natural gas prone area. Green Gables #2 was drilled within the Mabou Group to a total depth of 2293 meters in 1997 by Corridor Resources. The well encountered natural gas in several intervals during drilling and two of these intervals were tested, but flow rates were not considered to be commercial. Presently the well is listed as suspended with plans for re-entry for possible reservoir stimulation
- Prince Edward Island is characterized by structural traps within the Pictou Group which result from folding, faulting or a combination of the two. Traps are commonly associated with salt domes (Windsor salt) and compressional anticlines relating to transcurrent movements on a network of regional faults



Geological cross-correlation of Carboniferous formations and unconformities from onshore and offshore exploration wells of Prince Edward Island and Gulf of St. Lawrence, (from Lavoie, 2006, modified from Giles and Utig, website poster). The section is hang on a Late Carboniferous surface. East Point F-47 and Green Gable No 1 wells are indicated.

Nova Scotia

- Several large Gulf of St. Lawrence seismic programs acquired in the 1970s and early 1980s by companies such as Mobil, Chevron, Texaco, Hudson's Bay Oil and Gas, Shell, Petro-Canada, etc., culminated with the drilling of ten Paleozoic offshore wells, one of which (East Point E-49, drilled in 1970), flow tested at 5 mmcfd of natural gas from Carboniferous sands (Pictou Group). This well was drilled midway between Cape Breton Island and Prince Edward Island, but as previously mentioned, the E-47 delineation well failed to encounter the gas reservoir. The discovery is estimated to contain an in-place gas resource of 77 billion cubic feet
- Two offshore wells (Murphy et al. North Sydney P-05 and Shell et al. North Sydney F-24) were drilled in the 1970s in the Nova Scotia (NS) side of the Sydney Basin. These wells tested a large, seismically defined antiform and encountered gas shows in low porosity/permeability Upper Carboniferous sandstones. The stratigraphically lower Horton and Windsor Group sandstones, which according to Kendell and Harvey (2006) should have better reservoir properties remain untested in the basin. These wells and their relevance to the prospectivity of the Sydney Basin will be discussed in the next section



Geological setting of the Sydney Basin and environs (modified after Pascucci et al., 2000), with locations of the North Sydney F-24 and P-05, East Point E-49, St. Paul P-91 and Hermine E-94 wells, active ELs and Parcels 1, 2 and 3

Newfoundland and Labrador

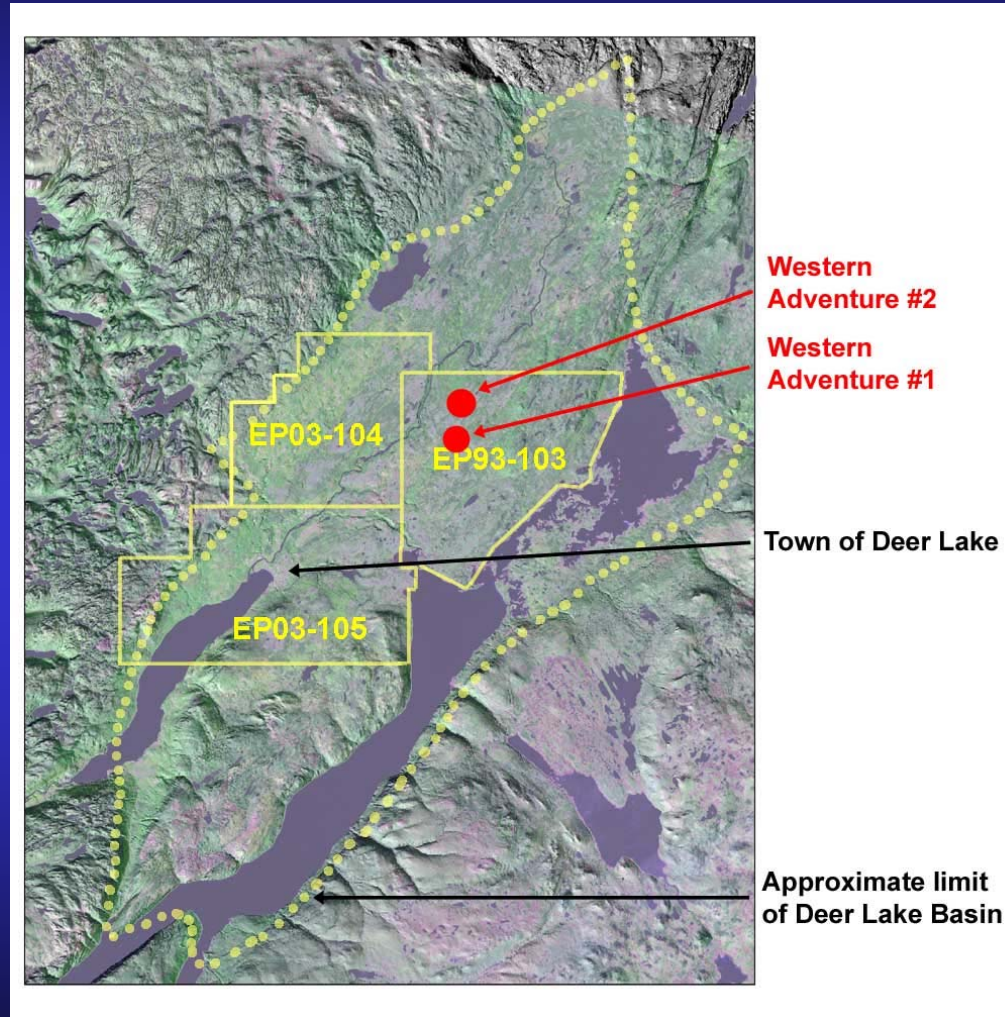
- The offshore Sydney Basin was actively explored by Texaco Canada in the late 1960s to mid 1970s, when several seismic grids were collected within a large area stretching from the east Magdalen Basin, Canso Strait and into the Sydney Basin, where the company held large exploration blocks. About two dozen seismic anomalies representing various types of leads were mapped on about 8000 km of regional (10 by 10 mile grid) along with some denser 2D seismic grids. Texaco estimated an 11 tcf natural gas resource for its licences, which were located mostly on the Newfoundland side of the basin, but did not drill an exploration well. No follow-up exploration has occurred since that time.
- In addition to the Cambrian-Ordovician plays in western Newfoundland (discussed in detail in a sister report (www.gov.nl.ca/mines&en/call_for_bids/nl06_3.pdf), numerous oil and gas shows have also been encountered in the Carboniferous rocks of the Deer Lake Basin and Bay St. George sub-basin. The Deer Lake Basin is an inverted Paleozoic rift basin where the plays involve rotated and inverted blocks containing porous and permeable Carboniferous North Brook sandstone and possibly deeper dolomitized Ordovician carbonates. The source rocks in Deer Lake Basin are Mississippian lacustrine shales and dolostones of the Forty Five Brook and Rocky Brook Formations. Two modern wells (Western Adventure #1 and #2) were recently drilled by Deer Lake Oil and Gas (DLOG) in this basin. Western Adventure #1, drilled in 2000, flow tested 100,000 cu ft of gas per day with some condensate from several sandstone units within the North Brook Formation (<http://www.deerlakeoilandgas.com/npei.pps>)

Deer Lake Basin-onshore



Cores of porous and permeable North Brook fluvial sandstones (Carboniferous) from a well in the Deer Lake Basin, West Newfoundland

www.deerlakeoilandgas.com/npei.pps



Western Adventure #1

DST #4, December 2, 2000

*Natural Gas Maximum Flow Rate
100,000 cubic feet per day
(with condensate)*

*Stimulation to obtain at least
300,000 cfpd to make electric generation
economical*







Newfoundland and Labrador

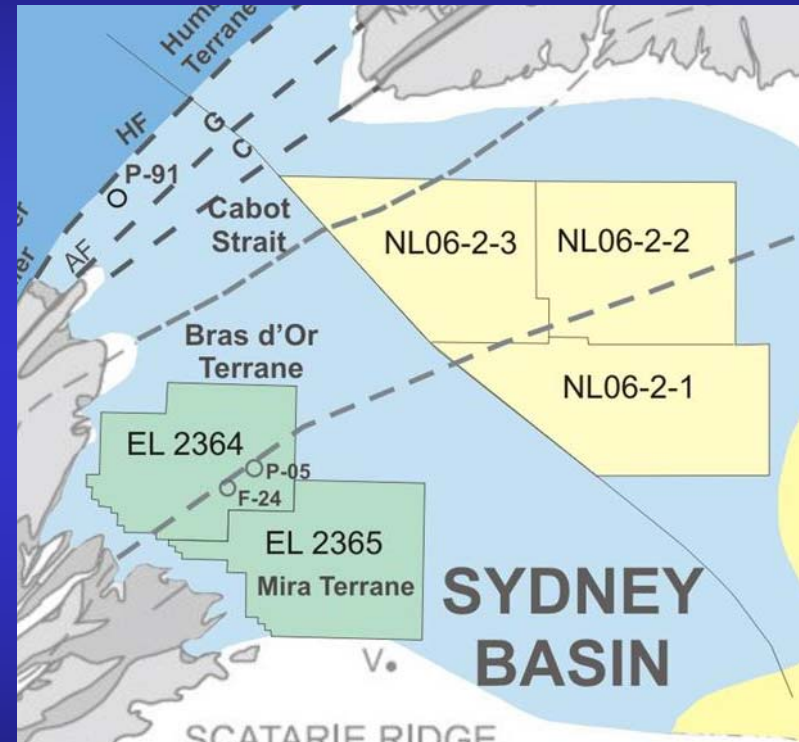
- **Vulcan Minerals of St. John's has drilled seven shallow wells (less than 1,000 m) in the onshore portion of the Bay St. George sub-basin in order to test large structural features mapped on seismic data**
(<http://www.vulcanminerals.ca/properties/onshore.html>)
- **Most of the drilling has been towards the north 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**
- **In the same area, Vulcan has encountered a thick oil zone in a shallow low permeability reservoir (Carboniferous 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 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. Two to three wells are to be drilled to intermediate depth (approximately 1,000 m) during 2006 and additional seismic data acquisition is planned to better define some of the deeper leads** (<http://www.vulcanminerals.ca/images/VulcanMineralsWesternNewfoundlandProspects.pdf>)

Sydney Basin

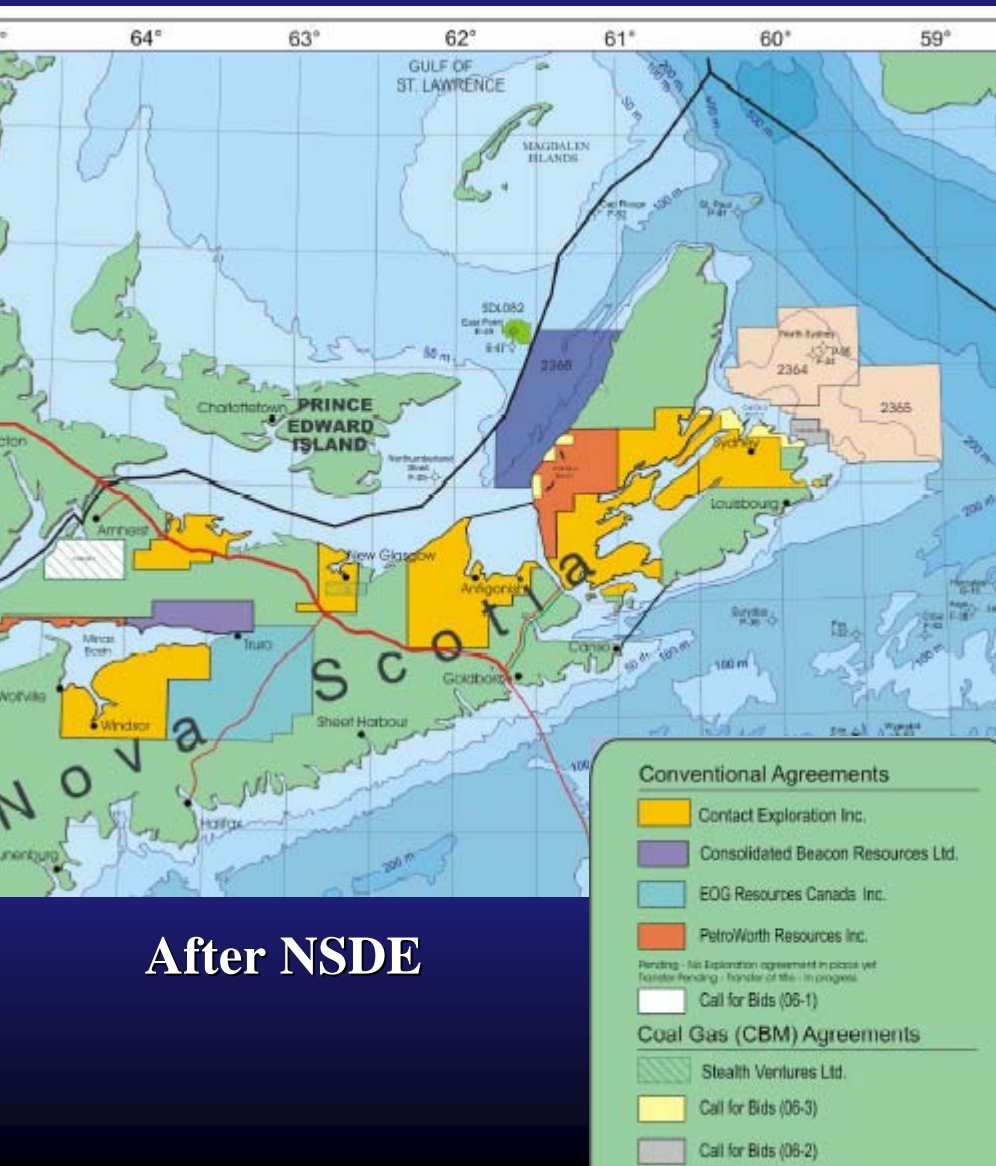
- **The relatively active offshore exploration cycle within the Maritime Basin (Gulf of St. Lawrence and Sydney Basin) that took place during the 1970s ended with the oil price collapse of 1982. Since then, only small seismic programs in the Gulf region (eg., Corridor Resources) and Sydney Basin (eg., Hunt Oil) have helped define several large leads and prospects; for instance the Old Harry structure and West Cape Breton prospects currently held by Corridor Resources:**
http://www.corridor.ns.ca/properties/old_harry/index.xml
- **No seismic acquisition has occurred on the NL side of the Sydney Basin since the 1970s. Past exploration activity in the basin has consisted of the collection of approximately 6464 line km of 2D seismic data, with the most recent seismic program undertaken in 1973. As previously stated, no drilling has occurred on the Newfoundland side of the basin. Due to its spread over two jurisdictions, a downturn in offshore exploration drilling and a lengthy exploration moratorium no basin-wide seismic maps or detailed basinal geologic study has ever been published for the entire Sydney Basin**

Recent Sydney Basin Landsale

- In 1998, Hunt Oil licensed two large blocks EL 2364 (225,406 ha) and EL 2365 (244,315 ha) from the C-NSOPB
- These blocks are located within the Sydney Basin in water depths ranging from 90 to 360 metres
- Work commitments for each ELs was \$2,165,000 suggesting that initial exploration would be directed towards geological studies and seismic acquisition
- Due to delays in receiving approvals for seismic programs on account of environmental concerns the 2 D seismic was not acquired until the year 2005 and this data has only recently been interpreted



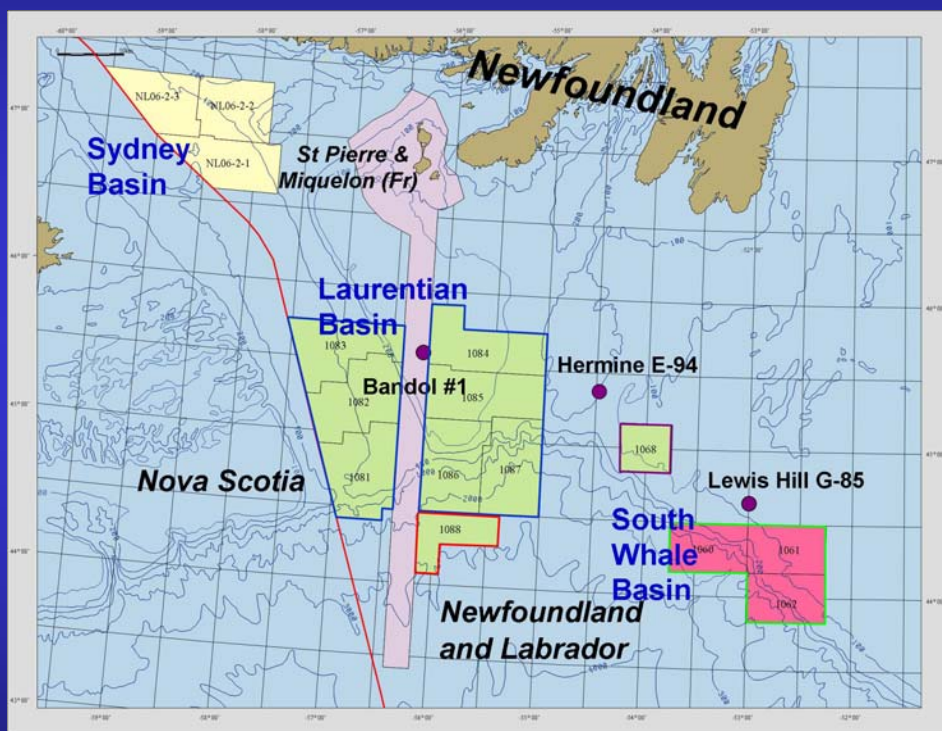
Recent Sydney Basin Landsale



After NSDE

- On the western side of Cape Breton Island, within the neighbouring Carboniferous Magdalen Basin, Corridor Resources owns 100% of EL 2368 (247,020 ha) situated just 8 km from the East Point E-49 gas discovery. Seismic data has been acquired, processed and interpreted over this block and a prospect is drill-ready in a water depth of 60 m - pending rig availability and finding a partner
(http://www.corridor.ns.ca/properties/west_cape_breton/index.xml)
- On Cape Breton Island several Exploration Permits for conventional resources and/or coal bed methane were awarded recently by the Nova Scotia Government in the Cumberland region of the onshore Sydney Basin

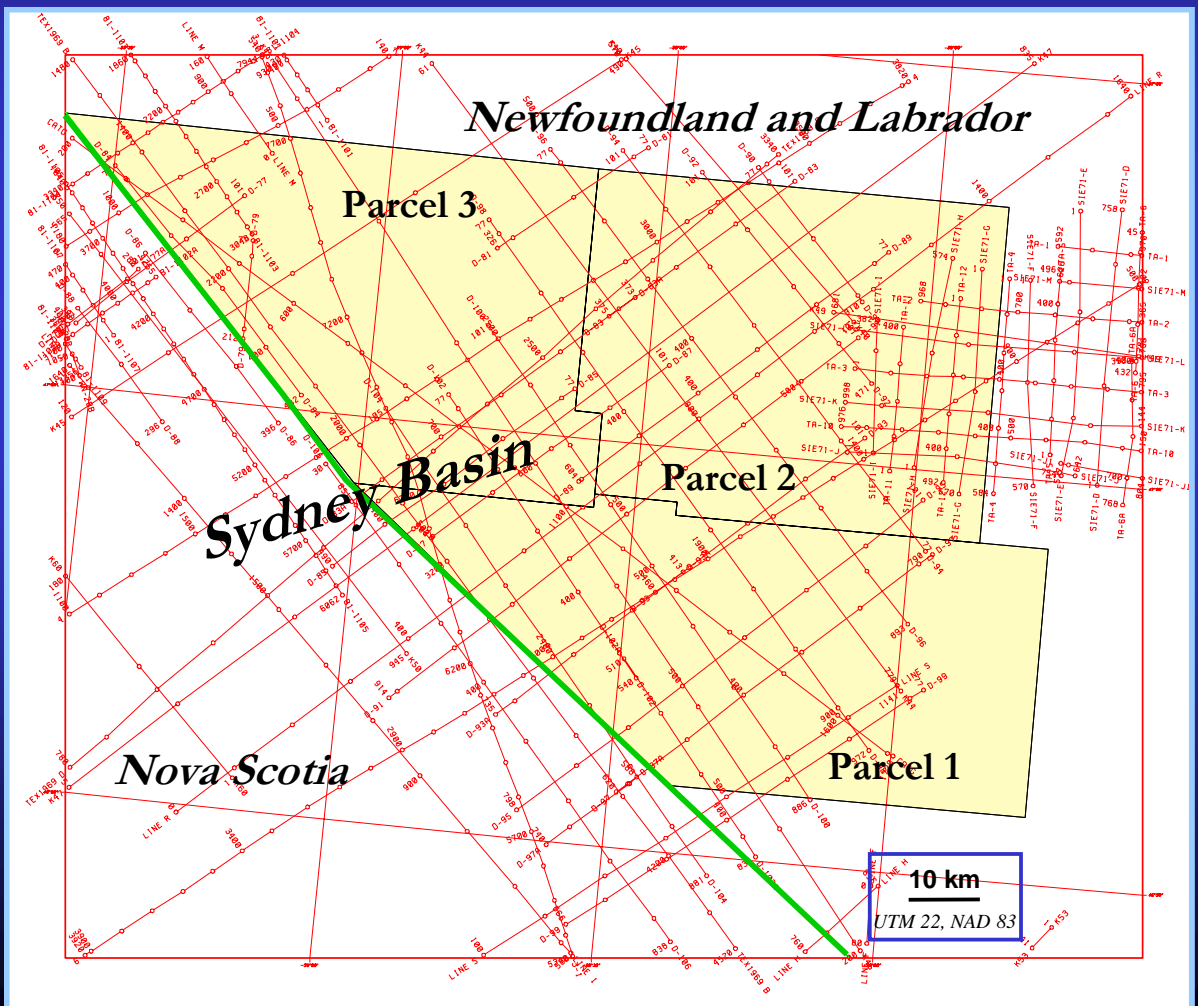
Southwest Newfoundland Exploration



Just South of Sydney Basin, within the Newfoundland and Labrador jurisdiction a total of 2.25 million hectares (2,372,212 acres) are held under seven ELs in the Laurentian Basin by ConocoPhillips and its partners. Imperial Oil has a deepwater EL with an area of 194,800 ha. These 8 licences were awarded in 2004 and it is expected that a well will be drilled in one of the ConocoPhillips operated ELs during the 2007-2008 time frame.

In the Laurentian Basin, Tertiary and Mesozoic sedimentary infill is thick and penetration of Carboniferous rocks which might form the basins pre-rift basement is not expected in any well that may be planned.

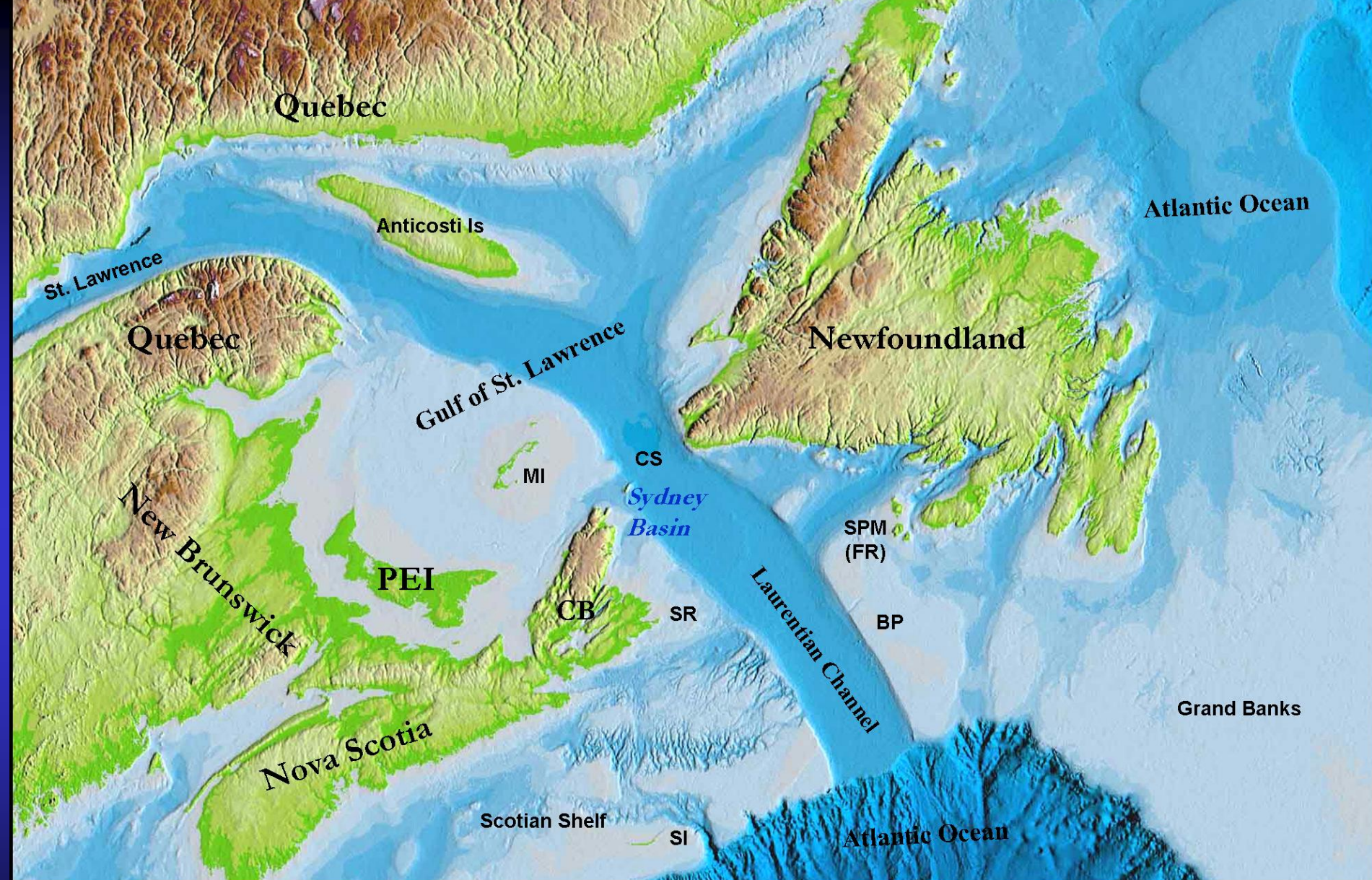
There were no Exploration Licenses awarded on the Newfoundland side of the Sydney Basin during the past three decades. As noted above the last exploration was undertaken by Texaco Canada, who relinquished most of its acreage in 1975, and no new marine seismic data has been acquired on the Newfoundland side of the Sydney Basin since 1974. For reasons stated earlier this is the first Call for Bids in the area in thirty years.



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 bid amount (<http://www.cnlopb.nl.ca/>). The minimum bid for all parcels in the Sydney Basin is \$1,000,000 (approximately US \$900,000) per parcel.

3. Regional Geology of the Sydney Basin

- **3.1. Location**
- **3.2. Basin Overview**
- **3.3. Litho-stratigraphy of Sydney Basin**
- **3.4. Interpretation of South Sydney Basin
Seismic Data**
- **3.5. Basin Evolution**
- **3.6. Offshore Well Results**

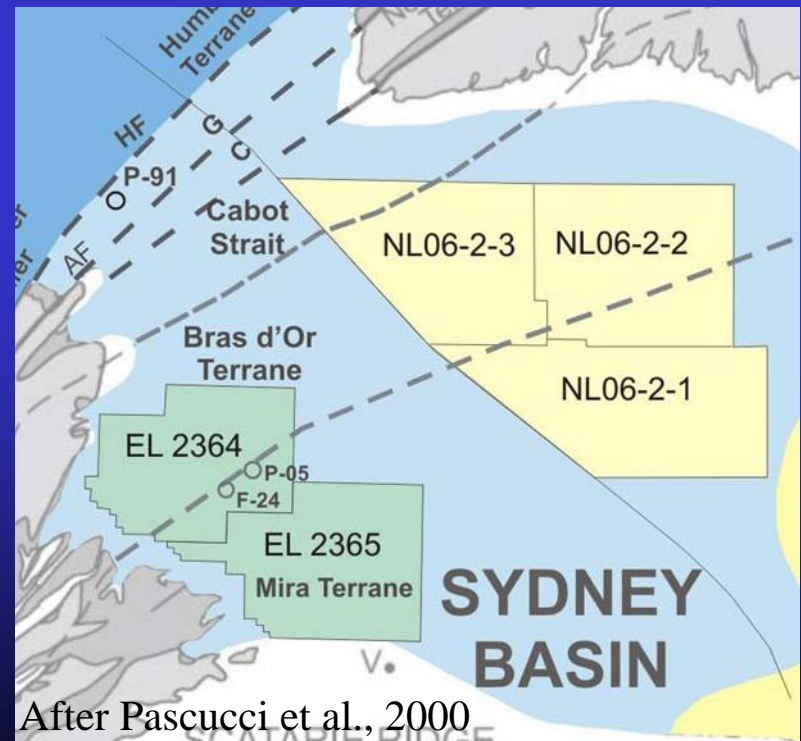


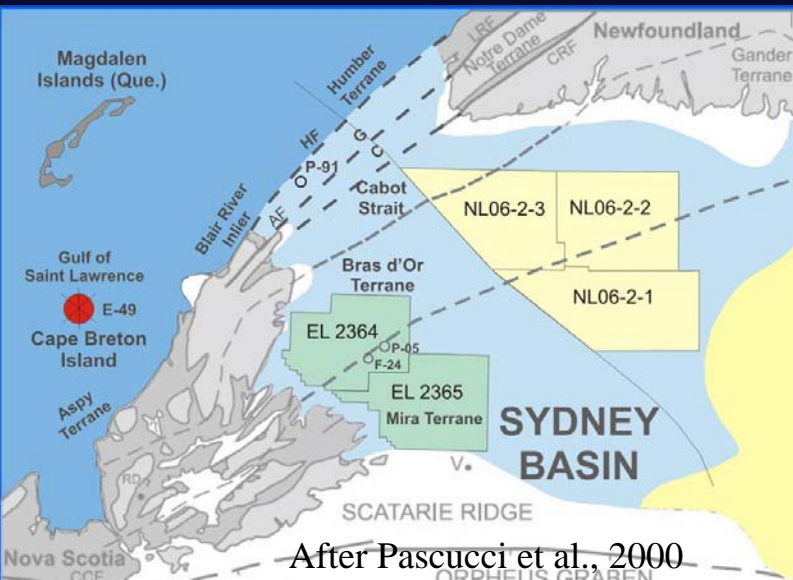
Land topography and bathymetry of the Atlantic Provinces (East Coast Canada) showing main physiographic units and location of the Sydney Basin (modified after NRCan and the Canadian Hydrographic Service)

Sydney Basin Overview

Sydney Basin was formed during 3 orogenic phases: 1). Taconic (late Mid-Ordovician); 2). Salinic (late Silurian), and 3). Acadian (Devonian). These phases were associated with docking and thrusting of several microplates to the Laurentia continental margin. The Acadian orogeny resulted in raising of the Appalachian Mountains along the eastern margin of the North American continent.

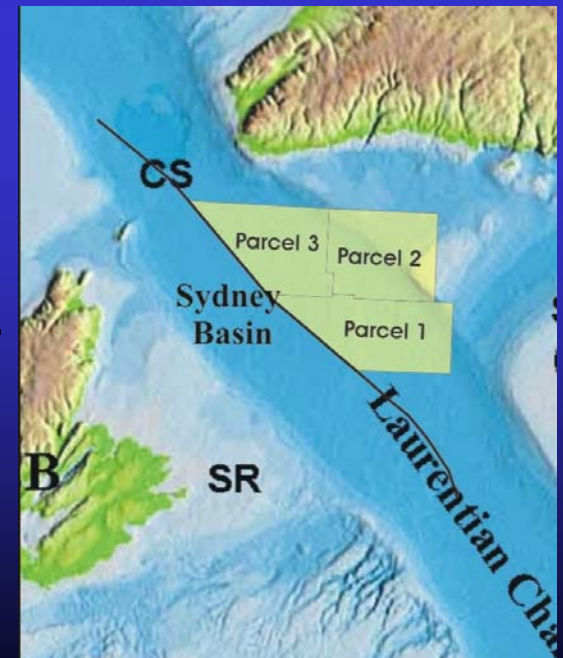
- A fourth orogenic phase—the Alleghenian—during the Carboniferous was manifested by both transtension and transpression, and completed the formation of the supercontinent of Pangea - including the islands of Newfoundland and Cape Breton and the Sydney Basin separating them
- Erosion, which lasted from Late Paleozoic to Tertiary almost peneplained the Appalachian Mts. A regional uplift during the Tertiary, related to the readjustment of plate movements during Atlantic Ocean opening, and selective erosion (including glaciations) shaped the mountain chains and hills now forming the Cape Breton and southwestern Newfoundland landscape. Between both islands, erosion and subsidence lowered the Sydney Basin to as much as 500m below the sea level



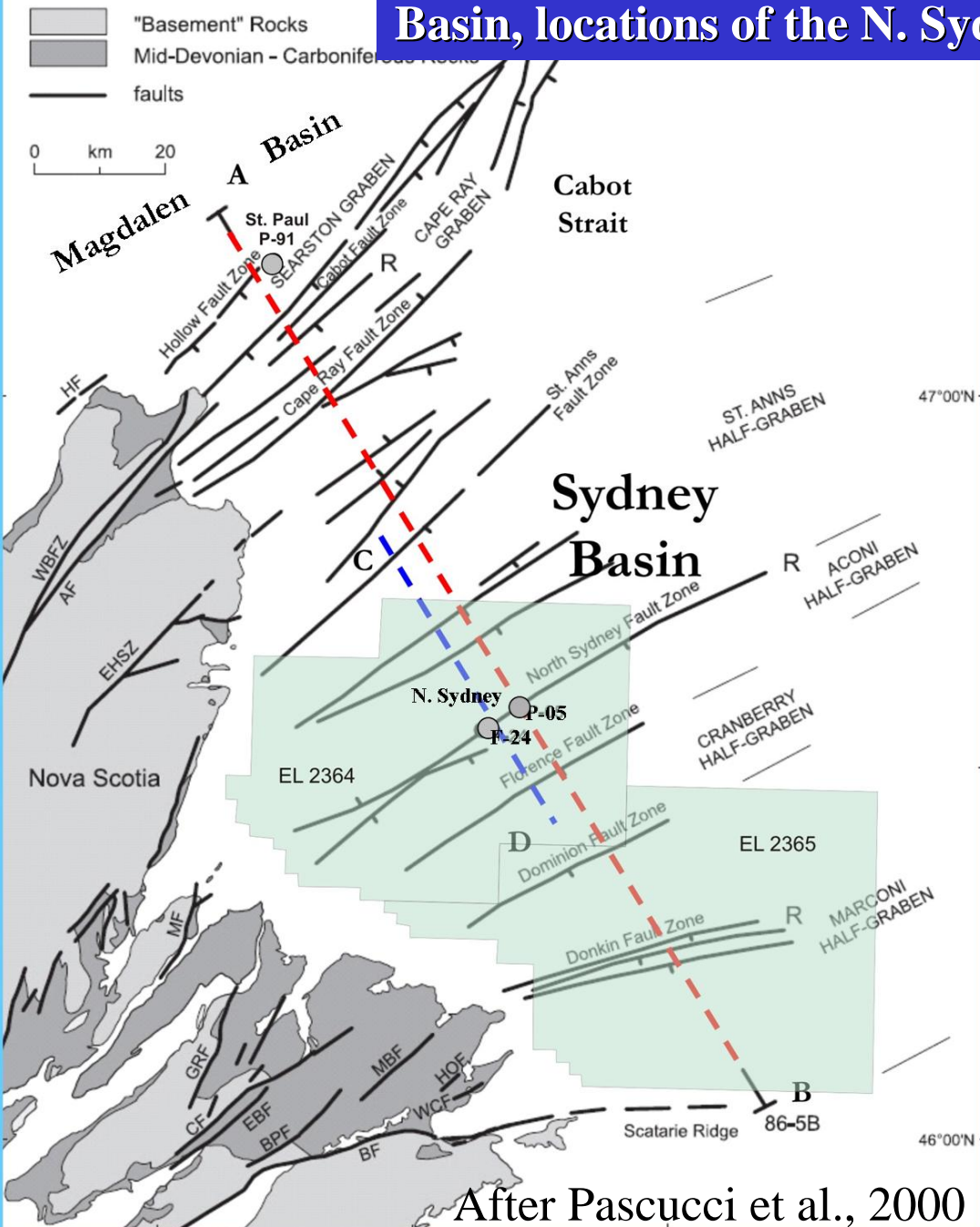


The Sydney Basin is a Carboniferous successor basin situated east of the Cabot Strait in waters shallower than 450 m. The basin covers a large offshore area (35,000 km²) south of the Newfoundland coastline and has a well exposed outcrop belt on Cape Breton Island (NS). The basin extends under the Laurentian Channel and Burin Platform bathymetric features.

The western limit is considered the Hollow Fault and therefore it includes the Cabot Arch and the St Paul High. Its eastern limit is not well defined as basin is gradually overlapped by the Mesozoic sediments of the Laurentian B. The Hermine E-94 well intersected Carboniferous red beds and Windsor evaporites under Cretaceous sediments. Northward, the basin terminates at the Newfoundland coastline and southward extends onshore into Cape Breton county, while seaward it is bordered by the Proterozoic rocks of the Scatarie Ridge.



Regional tectonics map of the Nova Scotia side of the Sydney Basin, locations of the N. Sydney F-24 and P-05 wells



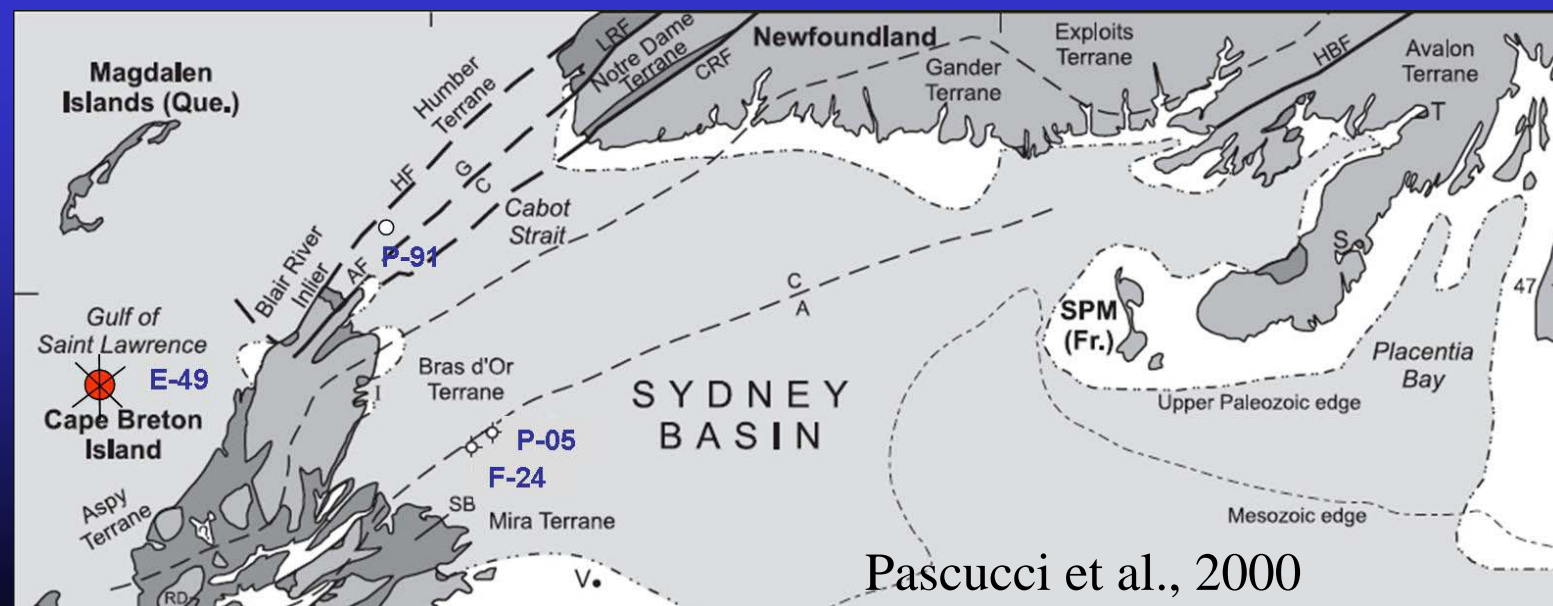
- Pascucci et al. (2000) have interpreted the geological history of this poorly known offshore basin by using an industry seismic grid and the Lithoprobe line 86-5 tied to outcrops, mines and coal drillholes and two offshore wells (N. Sydney F-24 and P-05) located on the Cape Breton side of the basin
- The mid Devonian to Upper Carboniferous/Permian basin fill is generally 6-7 km thick but may reach 12 km in its depocenters, and represents three extensional phases with intervening and succeeding compressive phases
- The basin sedimentary fill comprises grey and red sandstone, siltstone, shale and conglomerate, with one interval of marine limestone and evaporite rocks

Sydney Basin

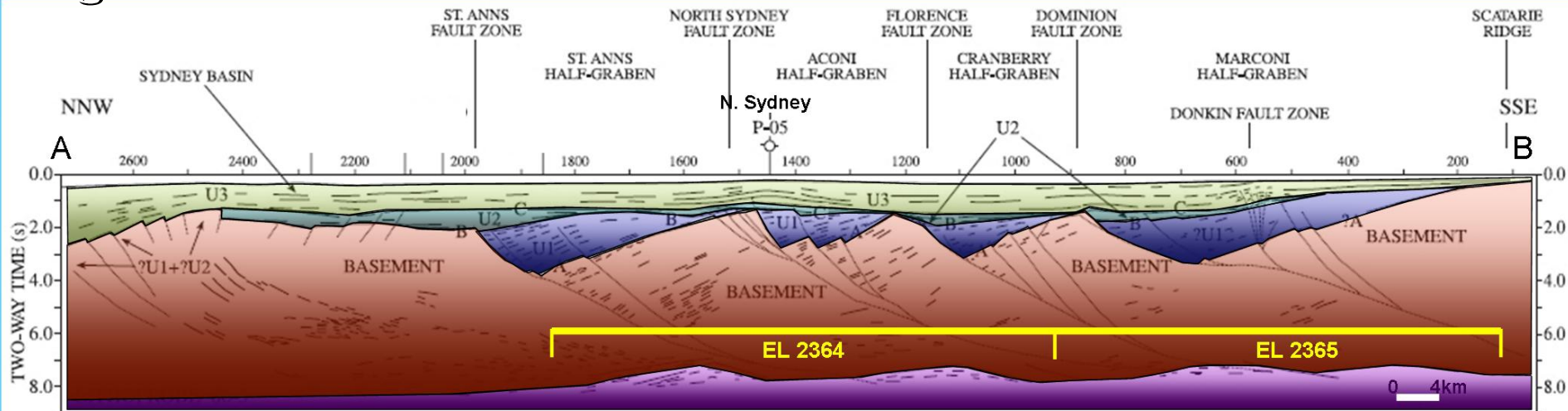
- The basin is saucer-shaped with the deepest part in its central area, but the basin is also characterized by a series of parallel half-grabens and ridges. Some of the ridges and rotated blocks are inverted blocks and deformation is propagated into the Late Carboniferous units
- Major fault lineaments are traceable to the central basin area where correlations are impossible due to lack of data and poor seismic imaging. According to Pascucci et al. (2000) offshore to onshore fault correlations is difficult due to lack of data in the nearshore (transitional) domain
- In spite of poor seismic coverage, the potential field linear trend and the existence of Carboniferous rocks in several locations on the Burin Peninsula, indicate that similar half graben/ridge geometry continues on the Newfoundland side of the basin

The sedimentary rocks were deposited during the Late Devonian to Early Permian in syn-rift, thermal sag and transpressional settings and within an equatorial paleoclimate environment. The deposits were formed in an intra-orogenic setting and are predominantly lacustrine and alluvial deposits but with at least one marine interlude (Windsor evaporites). Coal-bearing strata and hydrocarbon source and reservoir rocks are widespread on land and offshore

- The Horton, Windsor and Mabou strata outcrop along the Eastern Cape Breton Highlands, where a Horton half-graben has been documented
- Near Ingonish the Windsor Group rests on basement rocks, and includes carbonate mounds
- Carboniferous strata, including Windsor diapirs, occupy fault-bounded basins in the Cabot Strait
- Tournaisian (Horton equivalent) alluvial and lacustrine rocks, including dark shales, are present on the Burin Peninsula (“S” and “T”), where they are overlain unconformably by alluvial (Mabou Group?) strata
- Coal-bearing Westphalian B-D strata overlie basement rocks in Placentia Bay and Lower and Upper Carboniferous strata, including Windsor diapirs, underlie the Burin Platform and the eastern Grand Banks possibly within a distinct depocentre
- (above paragraph modified from Pascucci et al., 2000)



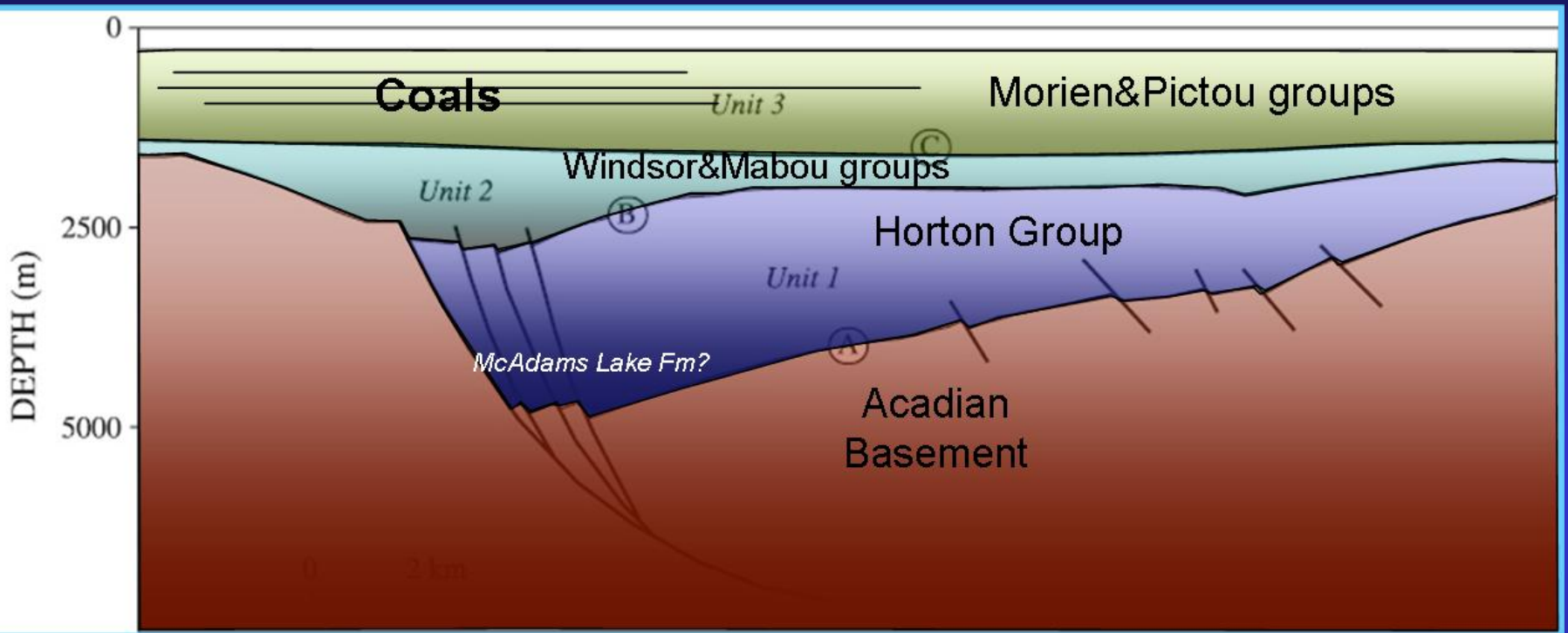
Regional Seismic Line



Interpretation of Lithobrobe seismic line 86-5 that crosses the southern part of the Sydney Basin (modified after Marillier et al., 1989 and Pascucci et al., 2000). The line crosses four half-grabens and several fault zones formally named by Pascucci et al. (2000). The ELs 2364 and 2365 and N. Sydney P-05 well position are indicated. A, B and C are main seismic surfaces representing major unconformities. Annotations are: U1=Horton Group and older; U2=Windsor and Mabou groups and U3=Morien and Pictou group.

The interpreted cross-section indicates the presence of four half grabens bounded by syn-rift normal listric faults detaching to a mid crustal zone. The graben fill thins toward the southeast indicating the major direction of extension being NW-SE. Some of the rotated blocks are slightly inverted bending the youngest sedimentary unit U3 and indicating a final transpressional event in the basin. Four seismic megasequences bounded by angular unconformities are interpreted: the Basement and Units 1, 2 and 3. Faults affect mainly the basement, the Horton Gr and to a lesser extent the Windsor and Mabou Grs. Only reverse faults during transpression affect the U3 unit.

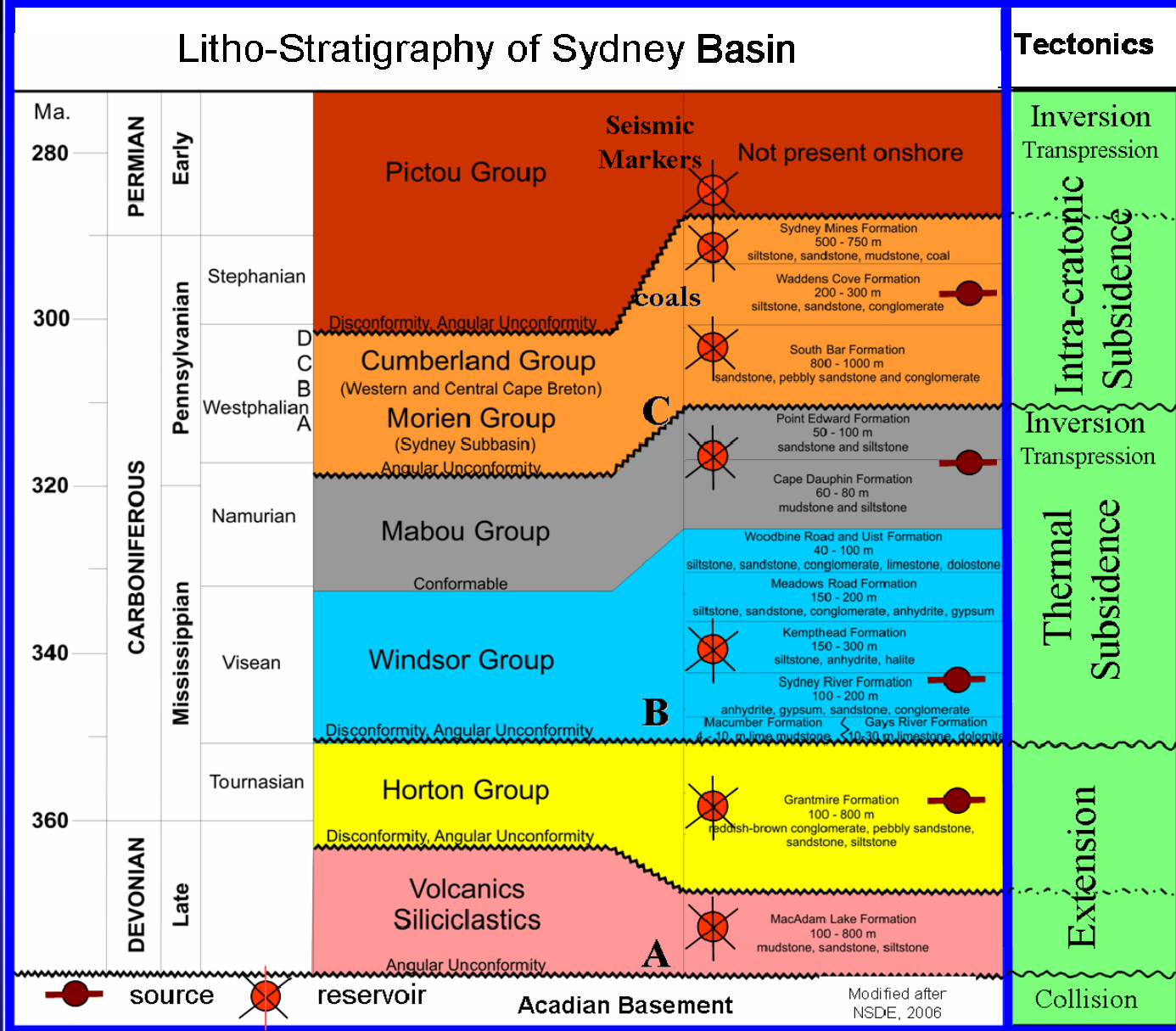
Schematic model of extensional duplex and basin fill applicable to the Sydney Basin structural evolution (after Pascucci et al., 2000)



- Main seismic Markers are: A (pre-rift Unconformity), B (Visean Unconformity) and C (Base Pennsylvanian Unconformity). Other strong seismic amplitude events in the shallow U3 are due to widespread coal seams
- The same structural-stratigraphic model should apply for the central and northern parts of the basin where Parcels 1 to 3 are located
- The interpreted mega sequences correspond respectively to the Acadian basement, Horton Group, Windsor and Mabou groups as well as the Morien and Pictou groups

Litho-stratigraphy of Sydney Basin

- While the main Paleozoic groups have similar names throughout the Maritime Provinces, their subdivisions (formation and members) have diverse local terminology
- For the present report, the litho-stratigraphic sequence compiled by the Nova Scotia Department of Energy (Kendell, pers. comm., 2006) and depicted will be referenced
- The geological units found in the Sydney Basin were interpreted from extrapolation of outcrops, mines and wells in Cape Breton and from the two North Sydney petroleum exploration wells
- A description of these units after Pascucci et al. (2000) follows

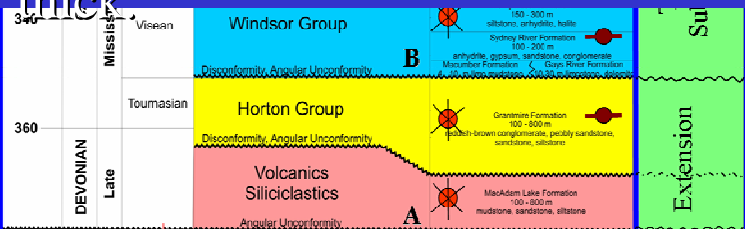


Generalized Litho-stratigraphic column (stratigraphic chart after Gibling, Nova Scotia Department of Energy, modified after Kendell, 2006), depicting main seismic markers, reservoir, source intervals and tectonic evolution for the offshore Sydney Basin

Devonian/Mississippian rocks (Unit 1)

The mid-Devonian *McAdams Lake Fm* is a syn-rift sequence deposited in half-grabens during initial extension. Basin fill of alluvial and lacustrine origin is comprised mainly of coarse siliciclastics, organic-rich shales and coal. The *Horton Group* occupies fault-bounded basins across Atlantic Canada and similar basins with Horton fill are imaged on Lithoprobe line 86-5 and industry lines. The *Grantmire Fm* (Tournaisian) of the Horton Group rests on an angular unconformity and consists mainly of alluvial fan and braided stream conglomerates up to 800 m thick. Volcanic rocks of the *Fisset Brook Fm* underlie the Horton Group in western Cape Breton, while organic-rich shales are prominent at mid-levels within the Horton Group. From seismic data and outcrop measurements, the seismic Unit U1 is estimated to be 3 to 3.5 km

thick.

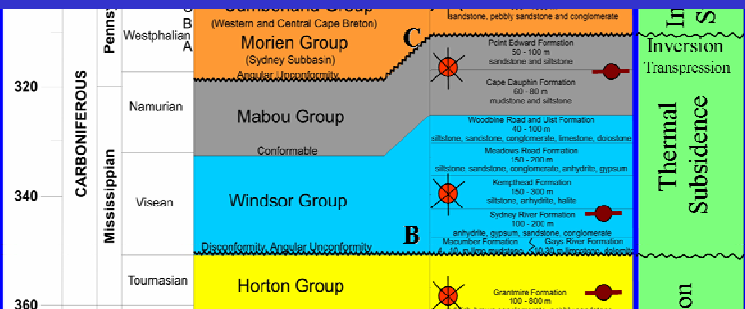


Acadian Basement

Basement consists of Precambrian and Lower Paleozoic (Hadrynian to early Devonian) rocks belonging to several, fault bounded terranes that had merged prior to and during the mid-Devonian Acadian Orogeny (Figures 3 and 10). At various times, these faulted terrane boundaries which extend from Cape Breton over to Newfoundland have been re-activated as either extensional, compressional or strike-slip mega faults.

Devonian/Mississippian rocks (Unit 2).

The *Windsor Group* (Visean) is up to 1000 m thick, but overall, thickness is highly variable. It overlies the Grantmire Fm with apparent concordance, and oversteps it locally to rest on basement rocks. Basal units comprise carbonate buildups of the *Gays River Fm* and dark laminated limestone of the *Macumber Fm*. Overlying strata consists of siliciclastics, carbonates, sulphate evaporites, halite and minor potash salts. The local *Kempt Head Fm* contains a thick halite section (up to 327 m), although evaporites may not be prominent elsewhere in the basin. Overall, there is less salt in the basin if compared to the Magdalen Basin to the west and salt halokinesis is less spectacular than in other Maritime or Grand Banks basins.

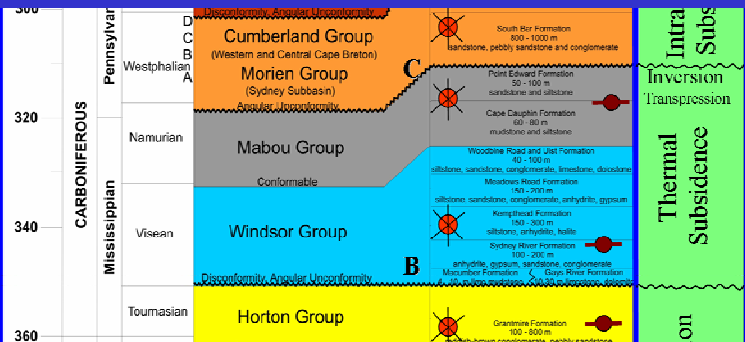


Devonian/Mississippian rocks (Unit 2).

The overlying lacustrine *Mabou Group* consists of sandstone, siltstone, shale, limestone and sulphate evaporites, with some thick dark shales. Unit 2 reflectors normally occupy synformal areas that onlap Unit 1 and overstep onto Acadian basement rocks. Unit 2 is about 1.1 km thick.

Pennsylvanian/Permian (Unit 3)

The *Morien Group* (late Westphalian to Stephanian) is up to 1800 m thick and rests unconformably on the Mabou and Windsor groups. The basal *South Bar Fm* is at least 860 m thick and consists mainly of braided-fluvial sandstones with minor coal. The overlying *Sydney Mines Fm* is about 1000 m thick and consists of sandstone, mudstone, economic coals, dark limestone, and calcrete, deposited in alluvial to restricted marine conditions. It has a distinct seismic signature due to the strongly reflective coal measures. The *Waddens Cove Formation* is a local alluvial-redbed equivalent of these two formations.

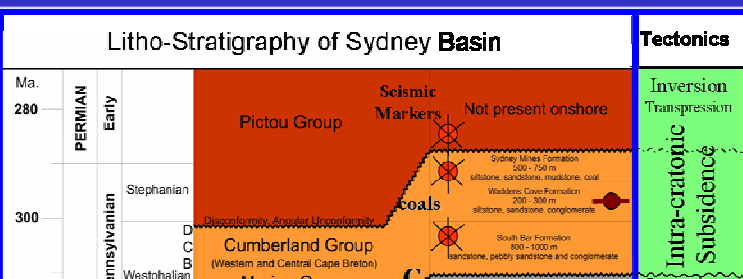


Pennsylvanian/Permian (Unit 3)

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Pennsylvanian/Permian (Unit 3)

The *Pictou Group* (Stephanian to ?Permian) which consists of red mudstone and sandstone underlies the nearshore area and may be 1000 m thick. Unit 3 is bounded by an angular unconformity C, oversteps the other units and may rest directly on the basement. The unit blankets the entire Sydney Basin and can be up to 1.8 km thick in the central part of the saucer-shaped basin. A top Westphalian unconformity between Morien and Pictou groups was recognized in the Cabot Strait. This unconformity (named Barachois Unconformity) may extend throughout the Sydney Basin.

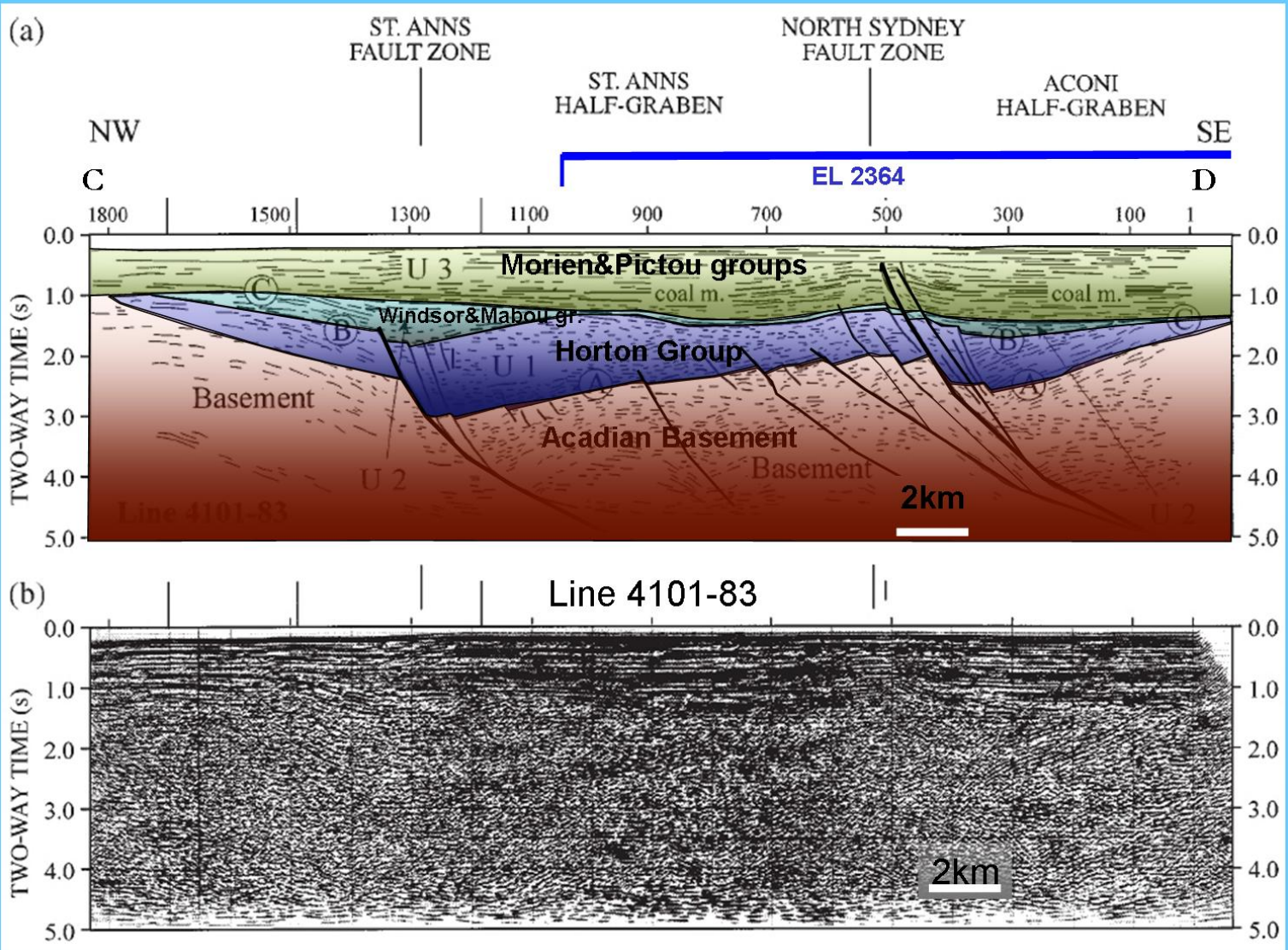


Permian to Quaternary rocks

Post-Carboniferous sediments may be present in parts of the basin. Cretaceous rocks overlie the Upper Paleozoic section on the Burin Platform and the eastern Sydney Basin; while Lower Cretaceous igneous rocks have been dredged from the Scatarie Ridge. Several industry wells have penetrated Carboniferous rocks in the southern Grand Banks (e.g. Hermine E-94), proving that Late Paleozoic successor basins became platform in Mesozoic time, underwent active rifting in the Late Triassic-Early Jurassic and the newly formed grabens were infilled with Mesozoic sediments.

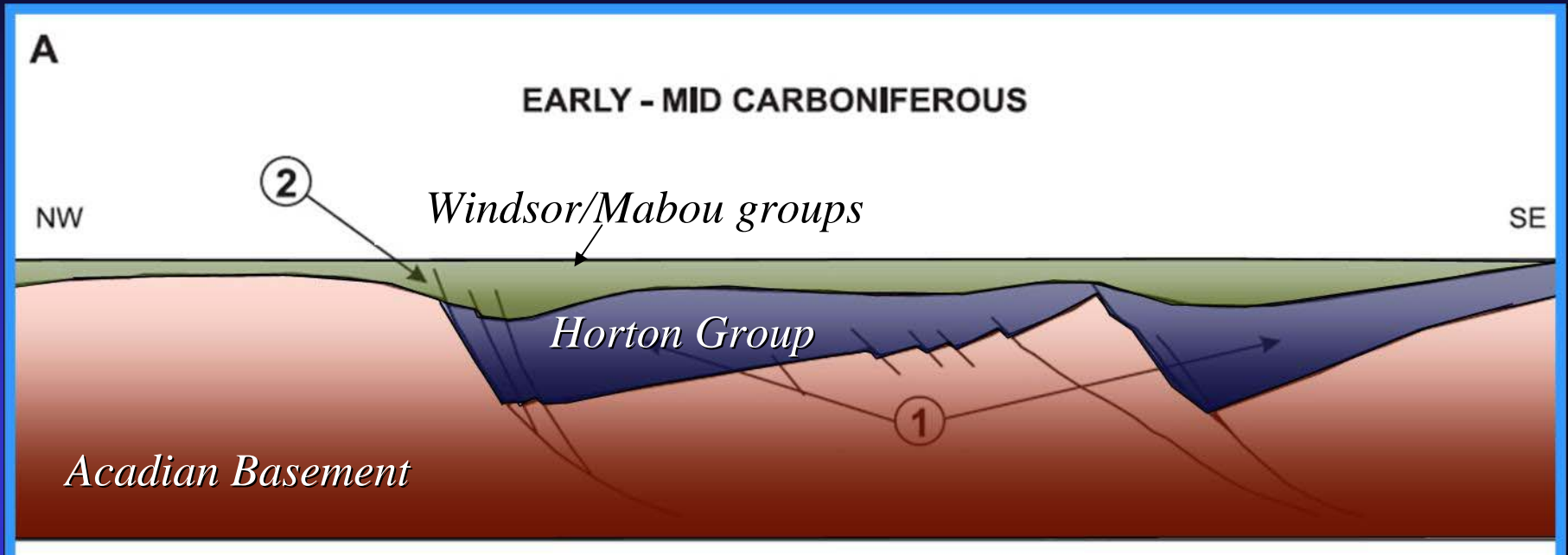
Permian to Quaternary rocks

- Tectonic activity and erosion relating to the Avalon Uplift affected the southern Grand Banks from the Late Jurassic to the Late Cretaceous. Fission-track analysis indicates that the Maritime Basin underwent prolonged exhumation that commenced by the Mid or Upper Triassic, resulting in erosion of several kilometres of the latest Paleozoic to early Mesozoic strata
- Quaternary deposits mostly of glacial origin overlie the older rocks. These deposits are too thin to be correlatable on industry seismic data, without further reprocessing of the data



Interpretation of dip seismic line from the southern part of the Sydney Basin (modified after Pascucci et al., 2000). The line crosses two half-grabens and the North Sydney ridge where industry exploration wells were drilled

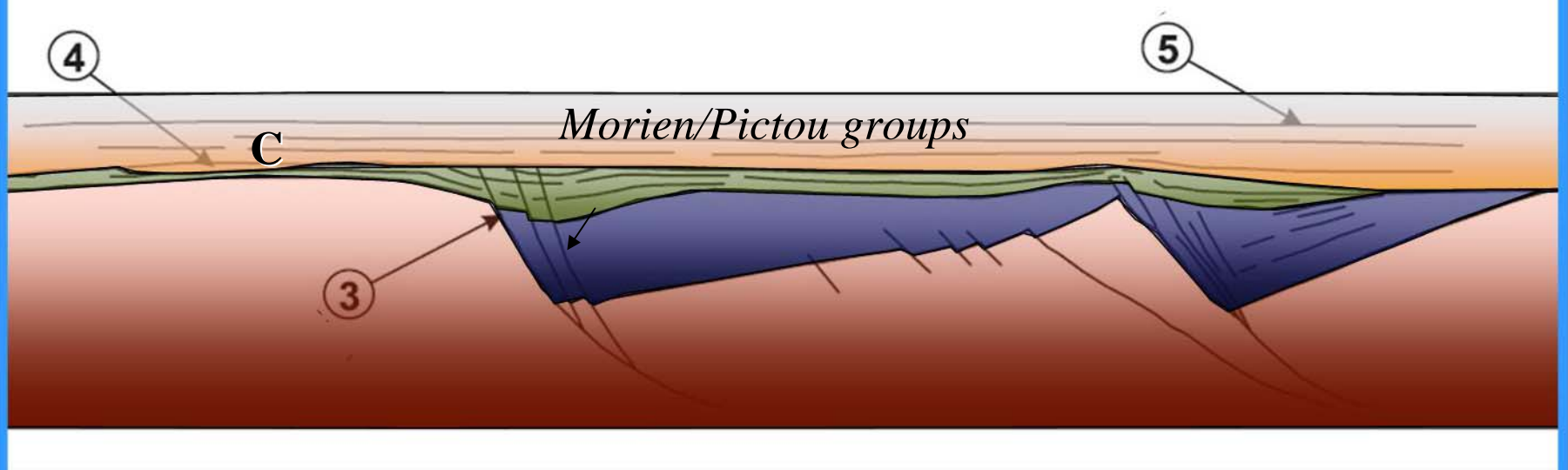
Geological evolution of the Sydney Basin (modified after Pascucci et al., 2003)



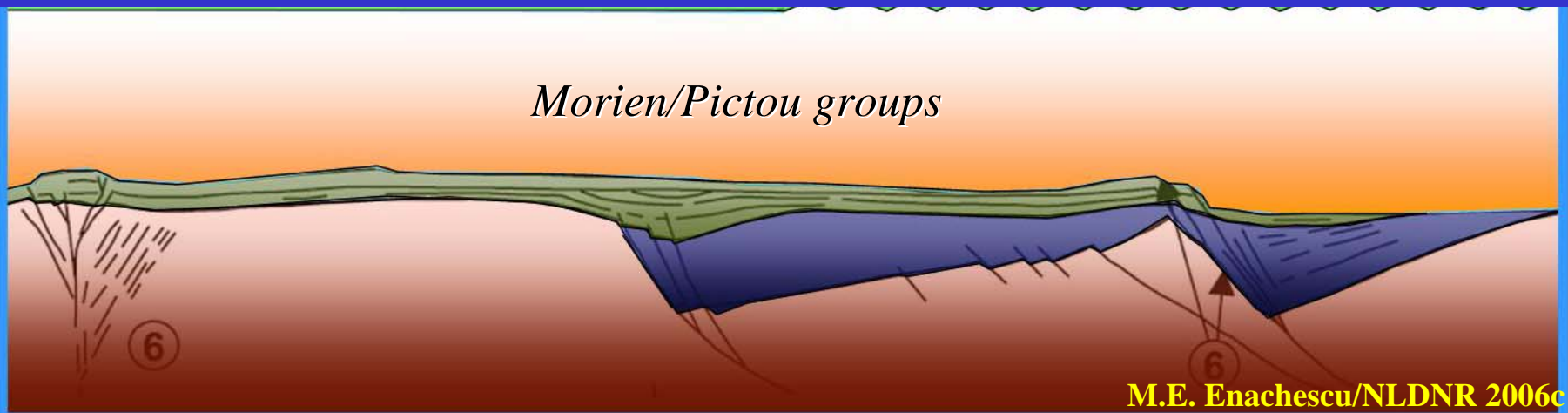
Peneplaning of the Acadian fold belt (pre rift Unconformity A) and formation of extensional half grabens filled with Mississippian Horton Group. The basal Horton Group could be Late Devonian and older deposits (McAdams Lake Formation or equivalent) may exist in deeper grabens. The new extensional area becomes a successor basin to Acadian Orogeny

Erosion and/or nondeposition at the post-rift Unconformity B followed by thermal subsidence when Windsor/Mabou groups are deposited over the entire extended area including the ridges and rift shoulders

B MID CARBONIFEROUS - ? PERMIAN

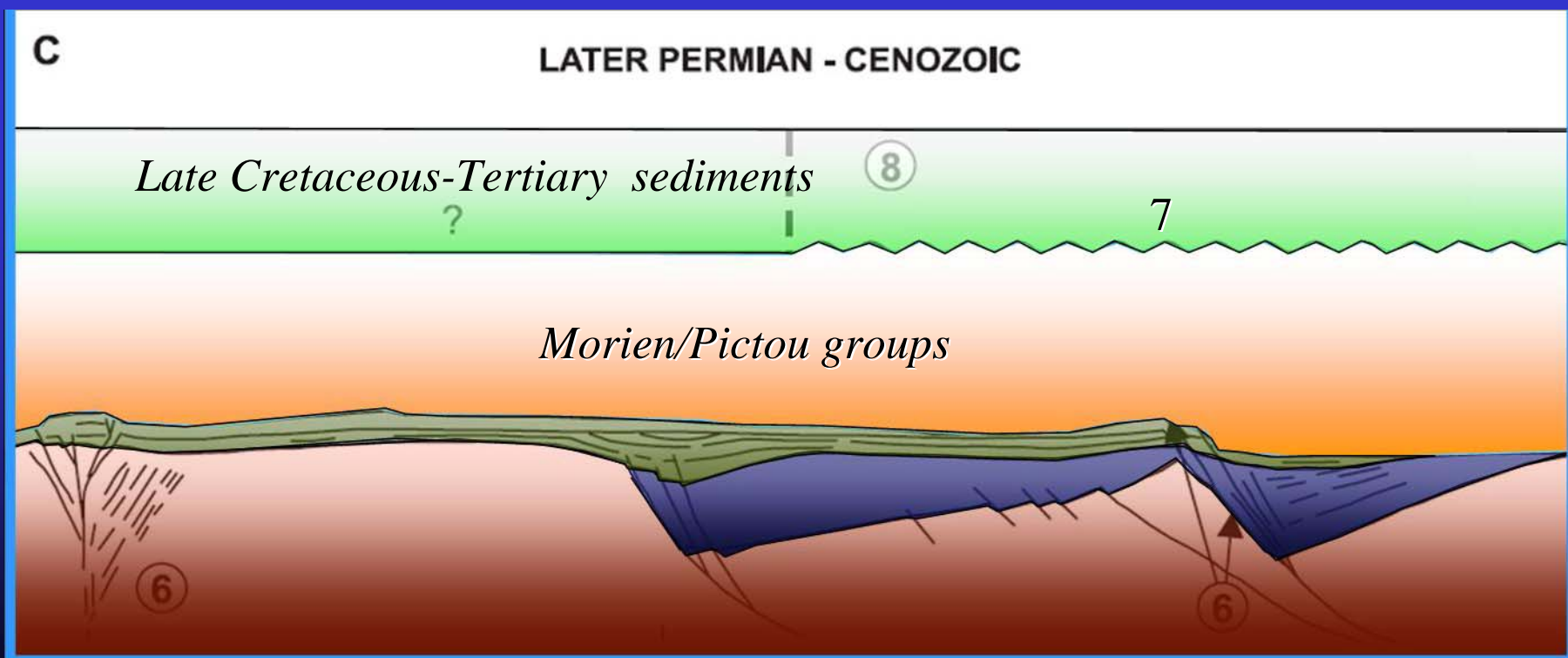


- 3. Fault rejuvenation in mid-Carboniferous due to the Alleghenian orogenic phase
- 4. Mild basin inversion and erosion forming Base Pennsylvanian Unconformity C
- 5. Regional subsidence and deposition of the Morien/Pictou groups in a large lacustrine basin



Geological evolution of the Sydney Basin (modified after Pascucci et al., 2003)

6. Transpressional activity (Permian?) including reactivation of graben bounding faults and deeper crustal fault zones to form flower structures and compressional anticlines
7. Regional exhumation of the basin due to Pangea rifting lasting from Late Triassic to Early Cretaceous (Sydney Basin was part of the Scotian Shelf-South Grand Banks rift shoulder and was also close to the Newfoundland Transfer Zone)
8. Late Cretaceous-Tertiary subsidence and sedimentation along the ancient St. Lawrence Channel and its levies followed by late exhumation and erosion. Recent marine incursion and deposition of glacial beds



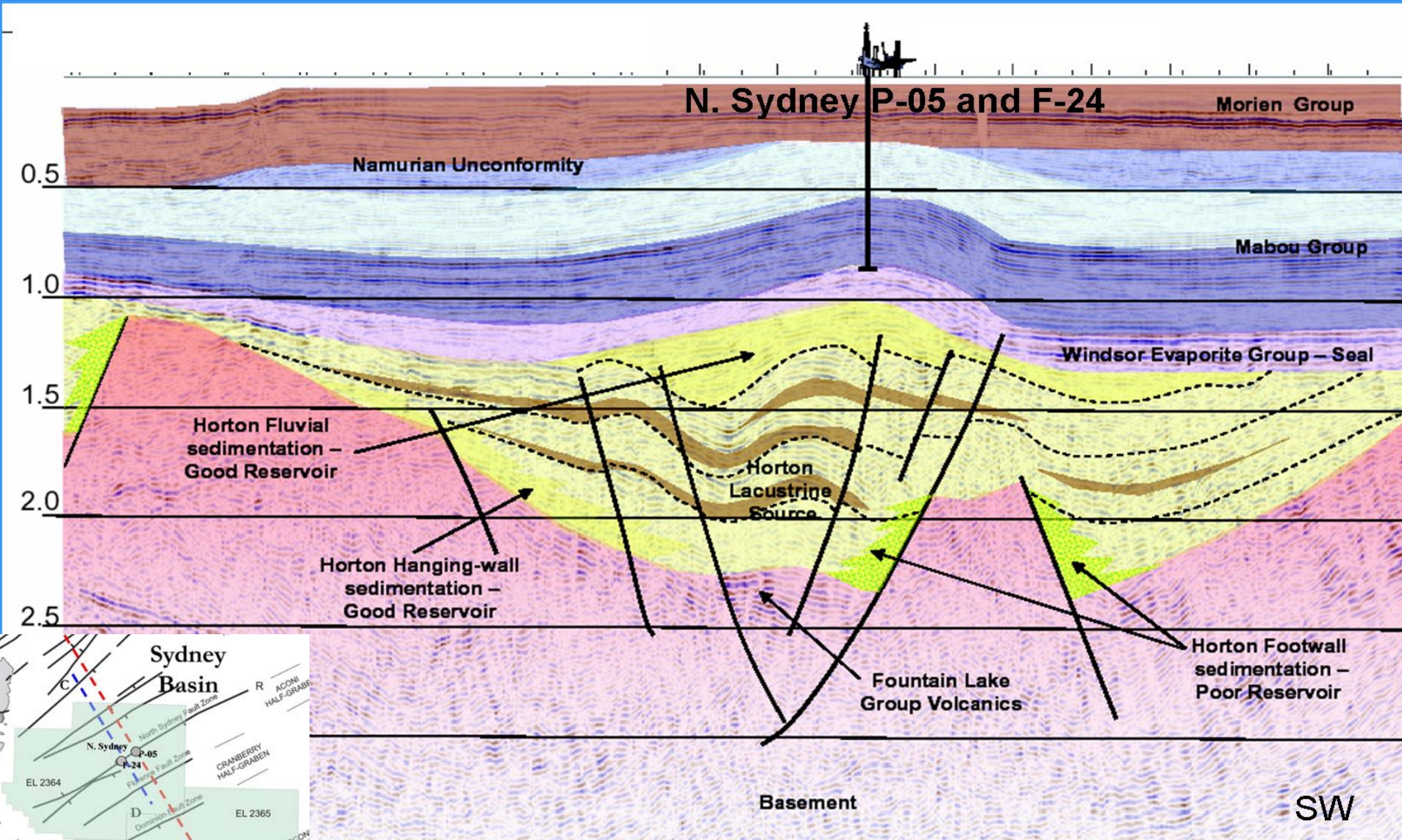
Basin Evolution

1. Peneplaining of the Acadian fold belt (pre rift Unconformity A) and formation of extensional half grabens filled with Mississippian Horton Group. The basal Horton Group could be Late Devonian and older deposits (McAdams Lake Formation or equivalent) may exist in deeper grabens. The new extensional area becomes a successor basin to Acadian Orogeny
2. Erosion and/or nondeposition at the post-rift Unconformity B followed by thermal subsidence when Windsor/Mabou groups are deposited over the entire extended area including the ridges and rift shoulders
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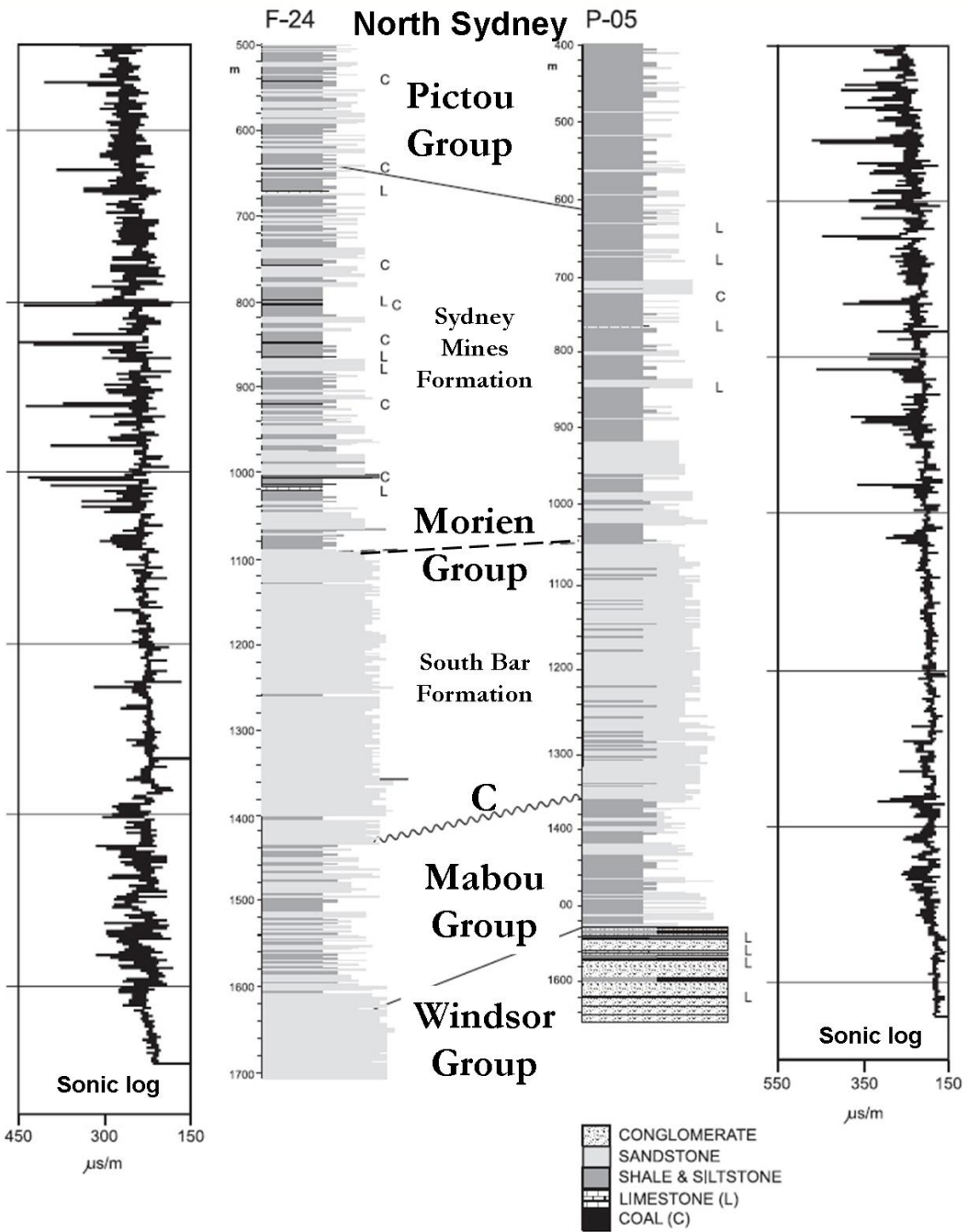
Offshore Well Results

- Three industry wells were drilled on the offshore Cape Breton side of the Sydney Basin during the seventies
- The North Sydney P-05 well (Murphy Oil 1974) and N. Sydney F-24 well (Shell Canada 1976) were located on a basement high identified from seismic mapping. The medium depth wells (1,700 m) TDed in upper Windsor Group, missing the syn-extensional basin fill where according to Kendell and Harvey (2006) rich source and quality reservoir rocks may be present
- Several thick sandstone zones were intersected in the wells but only poor porosities and permeabilities were encountered in the drilled section
- Tectonic and depositional environment modelling for both Windsor and Horton Group clastics suggests better reservoir elsewhere in the Sydney Basin (Kendell and Harvey, 2006). The two wells are essential for any seismic mapping in the basin, providing both stratigraphic ties and velocity information used for depth conversion and estimation of formation thickness

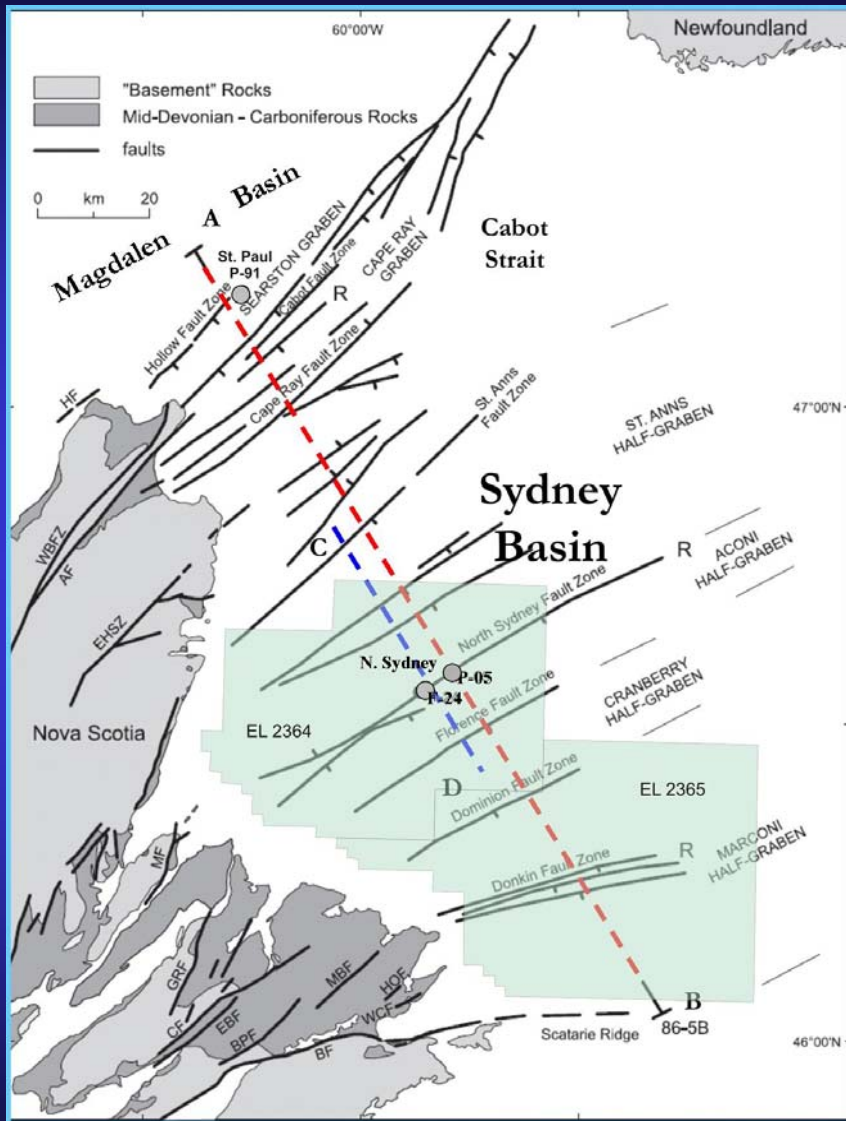
Offshore Well Results



Hunt Oil reprocessed Petro-Canada section, presented by Kendell and Harvey, 2006



- The N. Sydney P-05 well penetrated a Westphalian B/C to Stephanian section of Pictou Group red beds underlain by 740 m of the coal-bearing Morien Group
- A prominent unconformity (seismic marker C) separates the Morien Group from 170 m of underlying red to grey shale, siltstone, sandstone and limestone of the Mabou Group (late Viséan to early Namurian)
- The thickness of these strata is comparable with that of the Mabou Group onshore. The basal conglomerate with minor carbonate is 120 m thick and remains undated but probably belongs to the Windsor Group
- The F-24 well shows a similar succession, although the basal strata are sandstones rather than conglomerates



- Two other wells are significant for the basin. The Birch Grove No. 1 well was drilled in 1968 by Murphy in southeastern Cape Breton Island (Sydney Basin) to a depth of 1,344 metres. The well penetrated the Morien Group (equivalent to Cumberland Group) and Horton Group. There were no significant petroleum shows encountered in this well

- The St. Paul P-91 well drilled by Petro Canada et al., in 1983 to a depth of 2885 m, targeted a plunging, fault bounded ridge structure located between and defining the boundary between the Magdalen and Sydney Basins. The well encountered post-Carboniferous formations, then Mabou and Windsor groups and TDED immediately after intersecting Horton Groups beds. Both wells were dry and abandoned

4. Petroleum Geology of the Sydney Basin

4.1. Source Rock

4.2. Reservoir Rock

4.3. Seals

4.4. Hydrocarbon traps

4.5. Maturation and Migration

4.6. Petroleum Prospect Risks



Petroleum Geology

- This section is written following accounts by Kendell and Harvey (2006), Kendell (2006, pers. comm.), Mukhopadhyay et al., (2002 and 2004); Pascucci et al., (2000); Fowler et al. (1995), and reviewing other petroleum geology documents on the area available from NSDE and NLDNR
- Systematic geochemical investigations and regional geological studies performed mostly on the Nova Scotia side of the basin have shown that for the Sydney Basin all prerequisites for viable hydrocarbon systems are clearly satisfied. Nevertheless this basin and particularly its NL side, is mostly unexplored and contains “high risk-high reward” frontier type plays
- Some seventy oil and gas shows or stains have been found in Carboniferous reservoirs located onshore Nova Scotia. Both North Sydney F-24 and P-05 offshore wells had several gas shows. These seep and gas shows encountered at various levels in the basin indicate the presence of a working petroleum system in the Sydney Basin

Source Rock

Several Carboniferous intervals with medium to rich source rocks have been recognized from drilling and outcrop sampling. According to Pascucci et al. (2000) and Mukhopadhyay et al. (2002 and 2004) the Carboniferous sediments onshore Sydney Basin and environs contain various active and mature oil and gas-prone source rocks that include:

- 1.) *McAdams Lake Formation (late Devonian)* lacustrine and alluvial shales (both oil and gas prone);
- 2.) *Horton Group (mainly Tournaisian)* lacustrine (oil-prone) and fluvio-deltaic shales (gas-prone);
- 3.) *Windsor Group (Visean)* marine shale (oil-prone) and carbonates (oil & gas prone);
- 4.) *Mabou Group (late Viséan – early Namurian)* fluviodeltaic shales (gas prone), and
- 5.) *Cumberland/Morien Group (Wesphalian A through C)* lacustrine (oil prone) and fluviodeltaic shale, widespread coal (oil & gas prone), and coaly shales

Source Rock

- The major oil-prone source rocks in Carboniferous onshore Atlantic Canada are relatively thin and restricted while the gas-prone sources are thicker and dominant in most basins. As proven by the McCully field in NB (1 tcf), this system has produced at least one large scale gas accumulation
- Moreover, source rocks, especially oil prone lacustrine types may thicken in the large half-grabens identified on seismic data in the offshore Sydney Basin. Fingerprinting of oil stained sandstones from the N. Sydney F-24 well (Mabou Group) suggests the presence of both terrestrial and marine source rocks (Mukhopadhyay et al., 2004)
- Maturity profiles of Carboniferous source rock in the Windsor, Mabou, and Cumberland Groups suggest that these sedimentary units are within the "oil window" in most areas of onshore Nova Scotia (Mukhopadhyay et al. (2002), a conclusion that can be logically extrapolated to similar offshore sequences

Reservoir Rock

- Reservoirs rocks in Sydney Basin are predominantly sandstone that range in facies from lacustrine shoreface to channel fill and alluvial fans. Good to fair reservoirs can be encountered in the below listed Late Devonian to latest Carboniferous stratigraphic intervals:

1. *McAdams Lake Formation and Horton Group* alluvial fans, sandstone and conglomerates
2. *Morien Group (South Bar and Sydney Mines Fm)*
3. Multy-stacked sands within the *Cumberland and Pictou Groups*

- Windsor Group carbonates, although thin, are widespread and exhibit good porosities in onshore exposures in Cape Breton and within reefal build-ups observed in outcrop in western Newfoundland, mainland Nova Scotia and New Brunswick

Seals

- Finding good seals should not be a problem in the Sydney Basin as the Carboniferous succession contains a number of tight shales and carbonates
- Additionally the Windsor evaporites may form a regional seal for the syn-rift McAdams Lake Formation, Horton and Windsor Group reservoirs
- Thick mudrock intervals are seen in the Mabou and Morien groups - which provided the seal for the East Point gas accumulation
- Interbedded shale within the coaly Cumberland/Morien Group can also provide a very effective seal for gas generated within the same succession

Hydrocarbon Traps

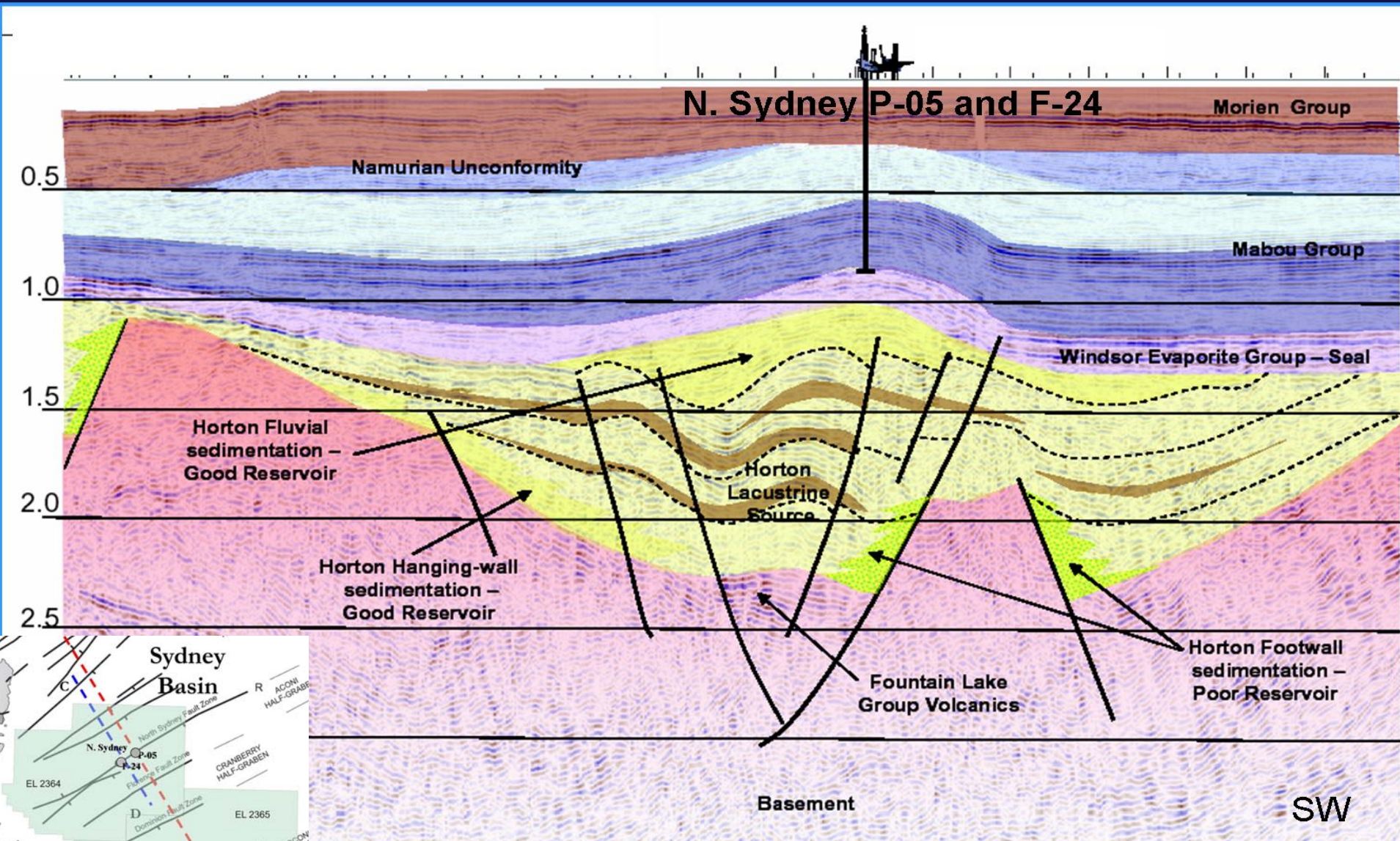
- The plays that have been drilled or traditionally prospected in the southern part of the Sydney Basin are transpressional anticlines
- However a variety of stratigraphic and structural plays are possible including inversion along half graben bounding faults, or large anticlines relating to wrenching along older steeply dipping Acadian faults during the Alleghenian Orogeny or in Early Permian. The observed antiforms are usually elongated and aligned in NNE-SSW direction and they may or may not be faulted. Kendell and Harvey (2006) have described and illustrated on a seismic line several untested Horton Group plays in the inverted North Sydney structure

1. rotated blocks and multi-fault bounded closures, four way closures and pinchouts within the Horton Group (marked 1 on seismic section);
2. structural and stratigraphic traps within the Windsor Group and within Sydney Mines Formation clastics (marked 2 and 3 on seismic section)

Hydrocarbon Traps

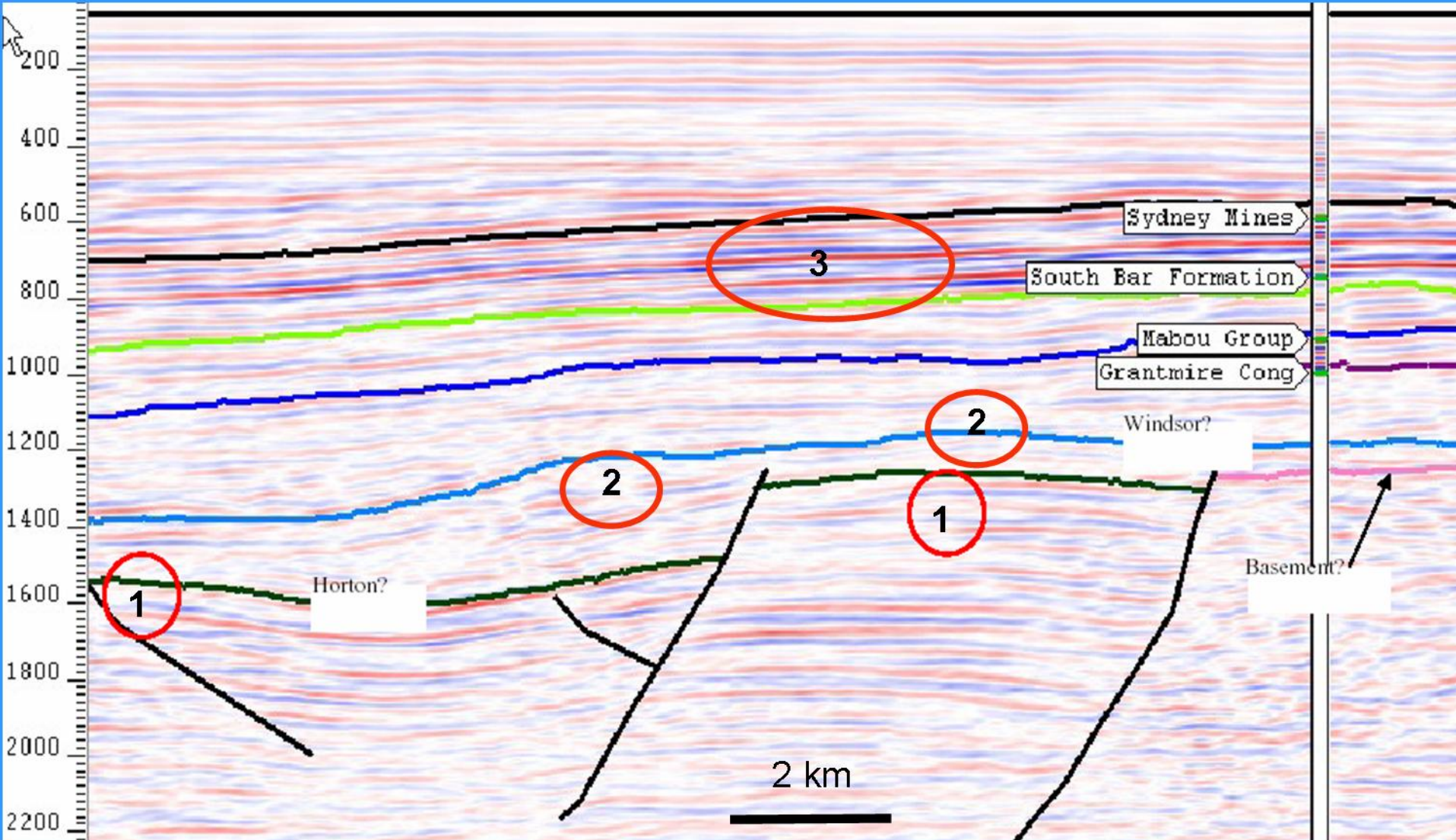
- Certain syn-rift traps such as rotated blocks and extensional roll-over anticlines have only become visible with the newer vintages of seismic data or after expert reprocessing of older data. Elimination of multiples has proven to be essential to imaging the Horton Group and McAdams Lake Formation
- Although diapirism within the Windsor Group is not as pronounced as in some of the other Carboniferous Basins in the area, it does play an important role in the creation of anticlines in the Sydney Basin. A possible analogue for salt induced structures in the Sydney Basin is the East Point E-49 salt structure drilled in 1970 that tested 5.3 MMcfd from Pictou Group sandstones
- The seismic data shows a Windsor salt pillow and large salt anticlines above the salt. The Windsor salt has been intersected by five exploration wells east of the Sydney Basin including the adjacent Hermine E-94
- Stratigraphic traps are also widespread in the basin. The most common are: a) onlap of sandstones beds on basement - either on the margins of the basin or against basement highs; b) unconformity traps; and c) pinchout of sandstones against the flanks of salt pillows. Some of the seismic sequences also show significant amplitude anomalies
- It is worth mentioning that only recently has data reprocessing been effective in preserving the necessary amplitude and frequency range needed for seismic attribute studies and possible reservoir prediction

Offshore Well Results

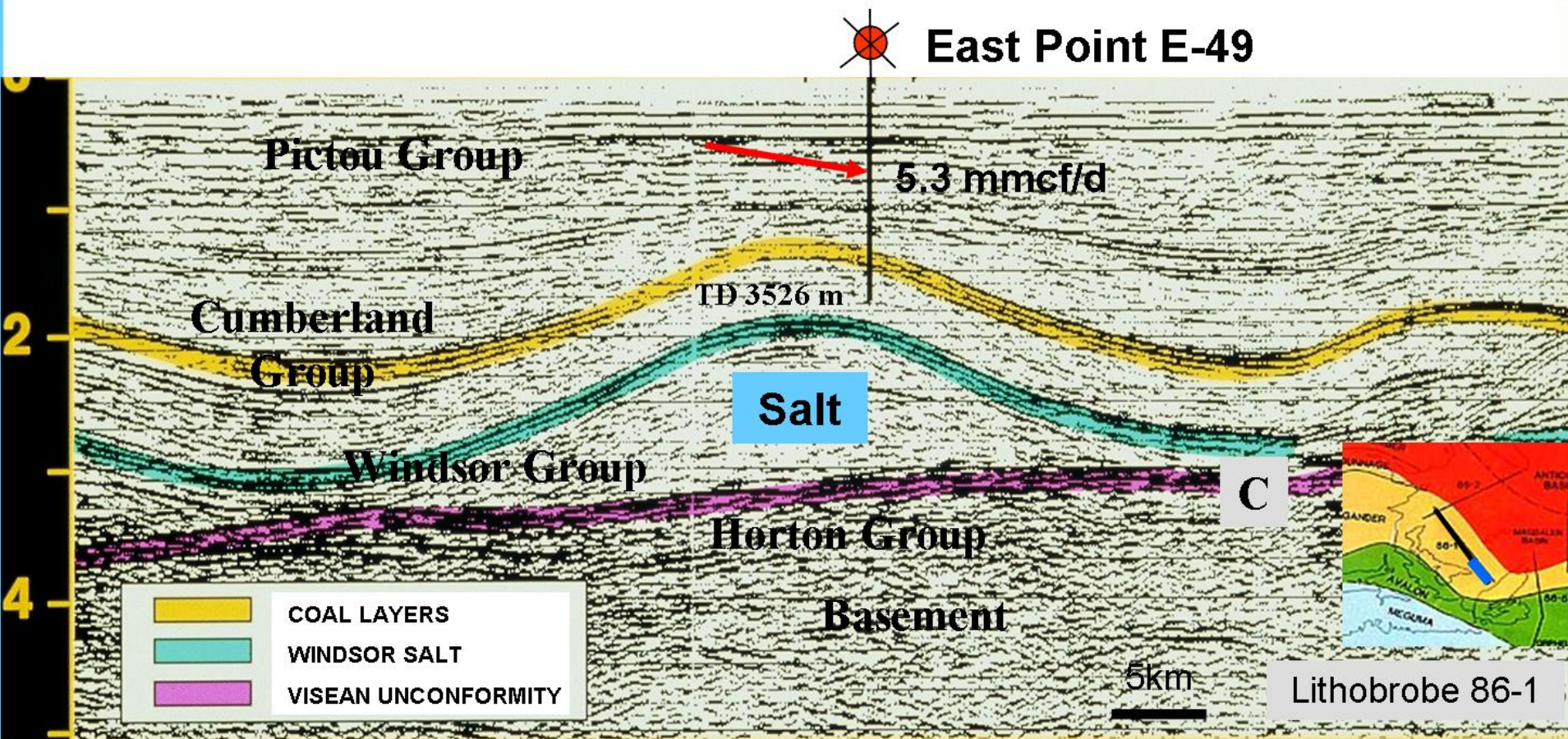


Hunt Oil reprocessed Petro-Canada section, presented by Kendell and Harvey, 2006

M.E. Enachescu/NLDNR 2006c



Interpreted seismic section from southern Sydney Basin indicating possible hydrocarbon plays within the Horton Group (1); Windsor Group (2) and Sydney Mines Formation (3), (modified from Kendell and Harvey, 2006)



Interpreted seismic section (segment of Lithoprobe 86-1) over East Point E-49 gas discovery in Magdalen Basin, showing a possible salt structure that may constitute an analogue for Sydney Basin salt induced leads (modified from Kendell, 2006, pers. comm., original from Grant, 1994). See also Figure 3 and map insert for location (blue segment)

Maturation and Migration

- In both N. Sydney wells, a rapid increase in vitrinite reflectance from 0.0 to 0.85% is observed between 0 and 1000 m depth. This is followed by very little increase in maturity from 1000 to 1700 m, suggesting that sediments at the bottom of these wells are still within the oil window Mukhopadhyay et al. (2004)
- Summarizing older results, Pascucci et al (2000) conclude that maturation levels of Morien Group coals and shales are in the hydrocarbon generation zone as are Horton source rocks in Cape Breton. Vitrinite reflectance for strata at the bottom of the P-05 well approaches 1.8% (Cooper et al. 1974), indicating that these sedimentary units are overmature, but it is not known if these values are representative of these sediments throughout the basin

Maturation and Migration

- Sydney Basin has recorded a complex polycyclic tectonic history from late Paleozoic to Cenozoic, whereby extension and inversion have created numerous structural and stratigraphic traps. Subsidence phases in E. Carboniferous, L. Carboniferous and Cretaceous were followed by phases of deformation. Some stratigraphic units as for example McAdams Lake and Horton source rocks may have undergone several burial periods, each of which could have caused hydrocarbon generation
- The basin probably reached its maximum burial depth during the early Permian
- Cretaceous subsidence and maturation may have been important, and the presence of Cretaceous volcanics on Scatarie Ridge (Figure 1) and other southern Grand Banks wells suggests a local thermal event. Prolonged exhumation of the basin fill commenced in the early Mesozoic or earlier, and has been an important factor in bringing potential reservoirs to relatively shallow depths (Pascucci et al., 2000)

Petroleum Prospect Risks

- While large leads and prospects are observed in the Sydney Basin, the preservation of porosity and permeability in Carboniferous reservoirs must be considered a risk factor. However, quality reservoirs have been encountered in numerous localities around the world where Carboniferous rocks have followed a similar multiphase geodynamic evolution. Similar sands with analogous reservoir characteristics are excellent producers in NE Europe and the North Sea
- The possibility must also be recognized, that intervening deformation events could have breached pre-existing reservoirs or, alternatively, created new structural traps for hydrocarbons and generated later accumulations
- The complexity of the basin's history will require better seismic data and refining of geological and geochemical models to properly evaluate the hydrocarbon potential of the Sydney Basin

Petroleum Potential of Call for Bids NL06-2 Parcels 1 to 3



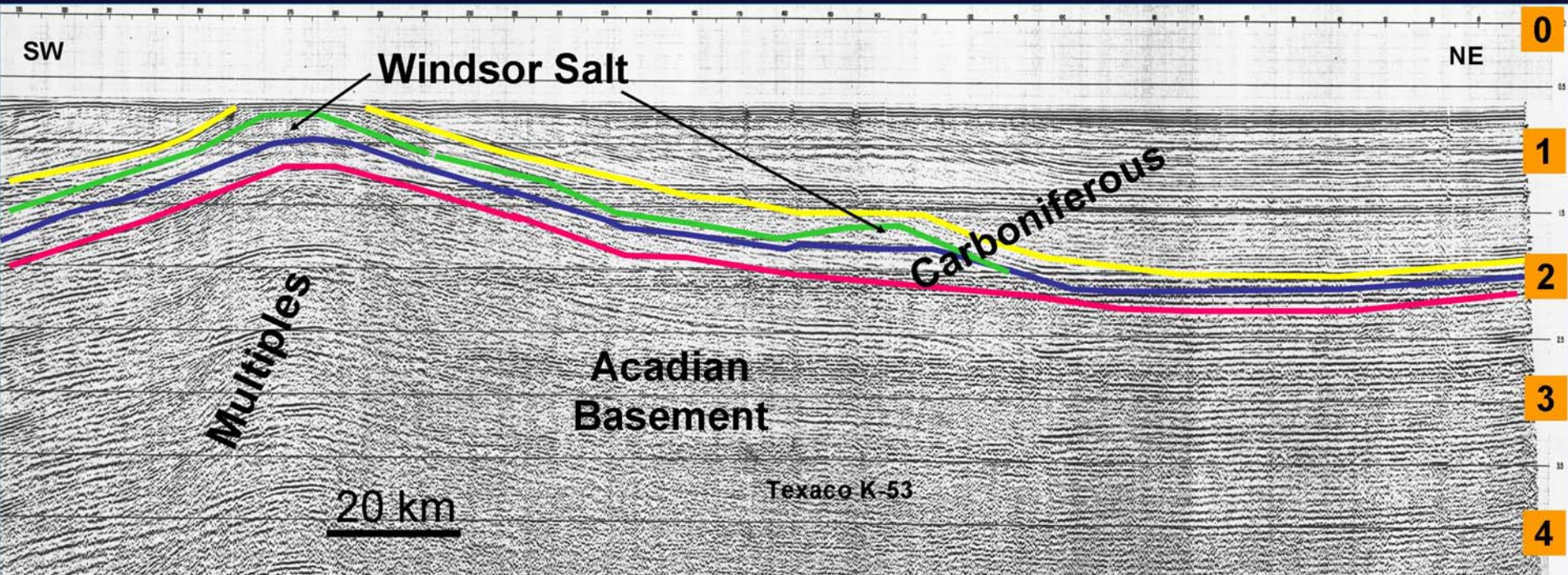
The Call for Bids NF06-2 Parcels 1, 2, 3 covers a total area of 768,768 hectares (1,899,667 acres) within the Newfoundland and Labrador jurisdictional part of the Paleozoic Sydney Basin

Petroleum Potential of Call for Bids NL06-2 Parcels 1 to 3

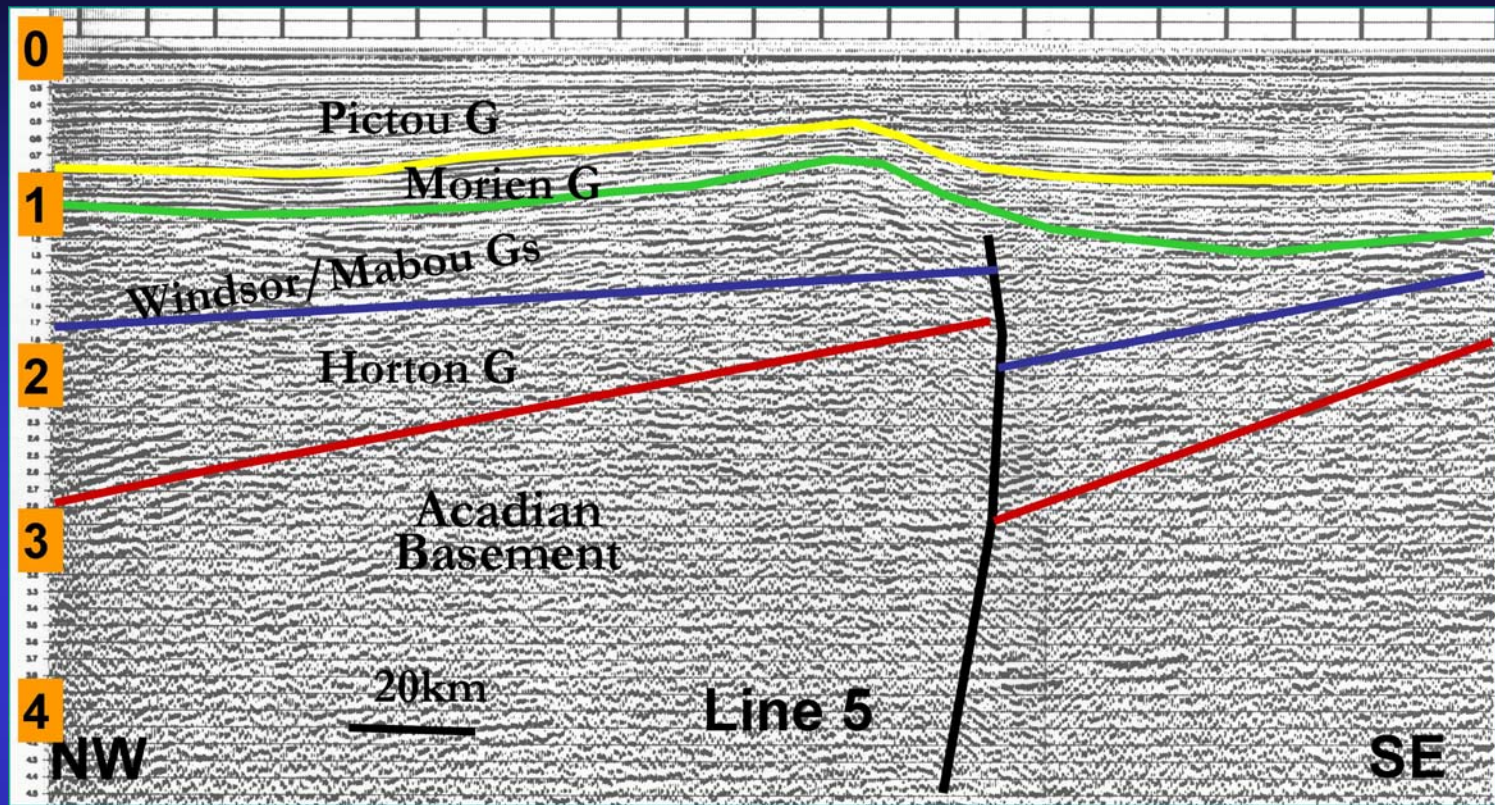
- The parcels are situated in water depths ranging from 80 to 450 metres, over an area including the Laurentian Channel and the southwest Newfoundland shelf
- No wells have been drilled in these parcels. The closest offshore wells situated at a distance of about 200 km are the pair North Sydney F-24 and P-05 and the St Paul P-91 discussed in a previous sections Other significant wells for the exploration in Parcels 1 to 3, are the East Point E-49 located offshore East Cape Breton in the coeval Magdalen Basin and the wells drilled onshore Newfoundland in the St. George sub-basin
- The East Point E-49 well has tested a significant gas flow from a Late Carboniferous reservoir

Petroleum Potential of Call for Bids NL06-2 Parcels 1 to 3

- Structurally, Parcels 1 to 3 are located entirely within the Sydney Basin, a Carboniferous intra-montane successor basin, described in detail in section 3
- The Carboniferous source rocks are mature throughout the area covered by the three parcels and most likely to generate gas. There is also a possibility of oil generation from lacustrine (Horton Group) and marine sources (Windsor Group)
- When Texaco specialists interpreted the available seismic data in the Sydney Basin, they mapped about a dozen of large and medium size seismic anomalies of the four-way closure type in the area where the three parcels are located (Texaco, 1974).
- About half dozen four way closures were also recognized by Pascucci et al. using a scarce grid but their finding has not been reported in their paper (Gibling, pers. com). These features were either transpressional anticlines formed along major transcurrent faults or salt induced.
- Several examples of structural traps from the Sydney Basin are shown in the following slides. Regrettably, due to the absence of adequate archiving procedures at the time the data was submitted to the then regulators, the author could not find a map for precise position of these lines. Therefore these lines should be used only as an indicator for the type of structures that may be found in the area and not to evaluate the landsale.



NE-SW on strike representative seismic section through the Sydney Basin. A large post carboniferous fault that involves the Acadian Basement is observed. Sat pillow within the Windsor group are also seen. This in an example of a large anticlinal feature present in the basin that may exist in Parcel 1 to 3

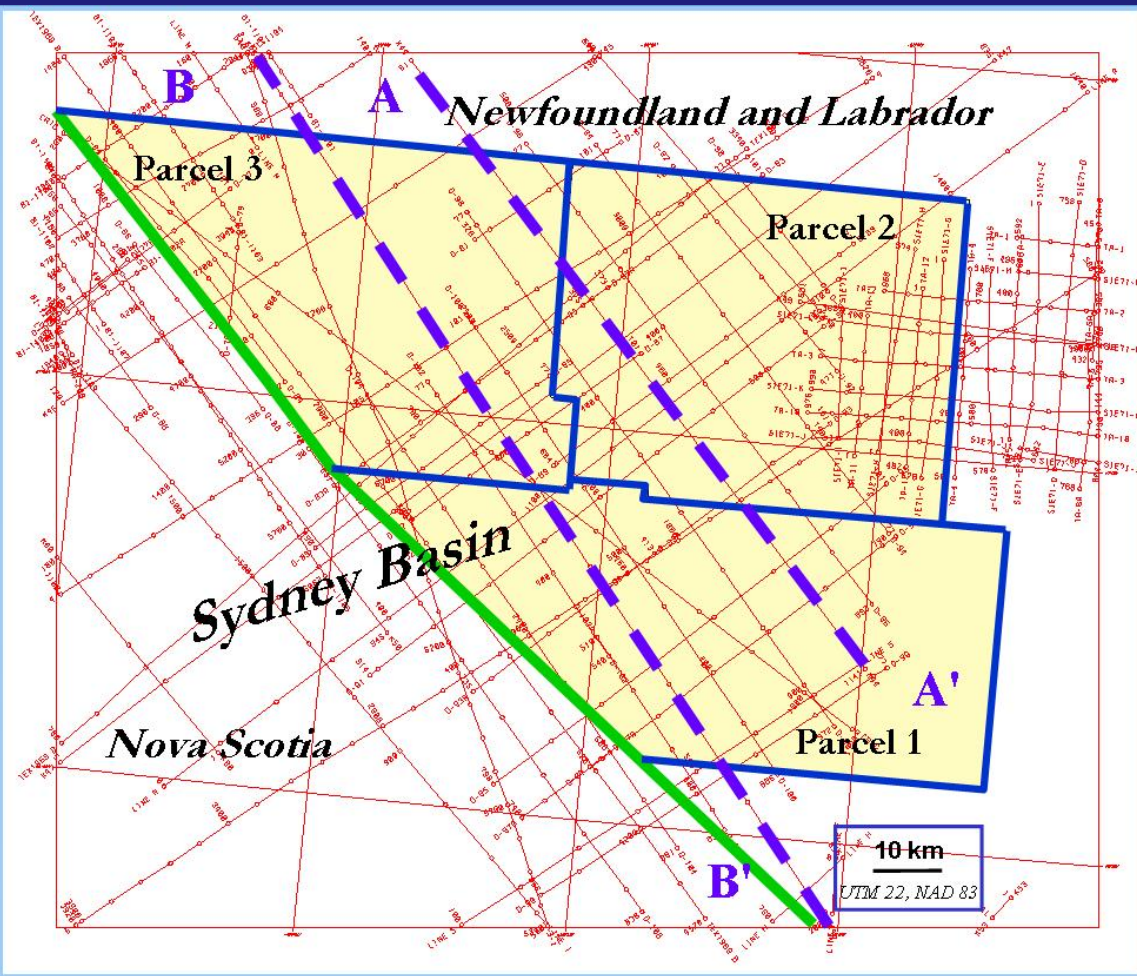


NW-SE dip representative seismic section through the Sydney Basin. The line shows a large post-Carboniferous reactivated fault that involves the Acadian Basement. An inversion fold is observed on the upthrown block of the fault. Windsor salt may also create pillows. This is another example of a large anticlinal feature present in the basin that may exist in Parcel 1 to 3

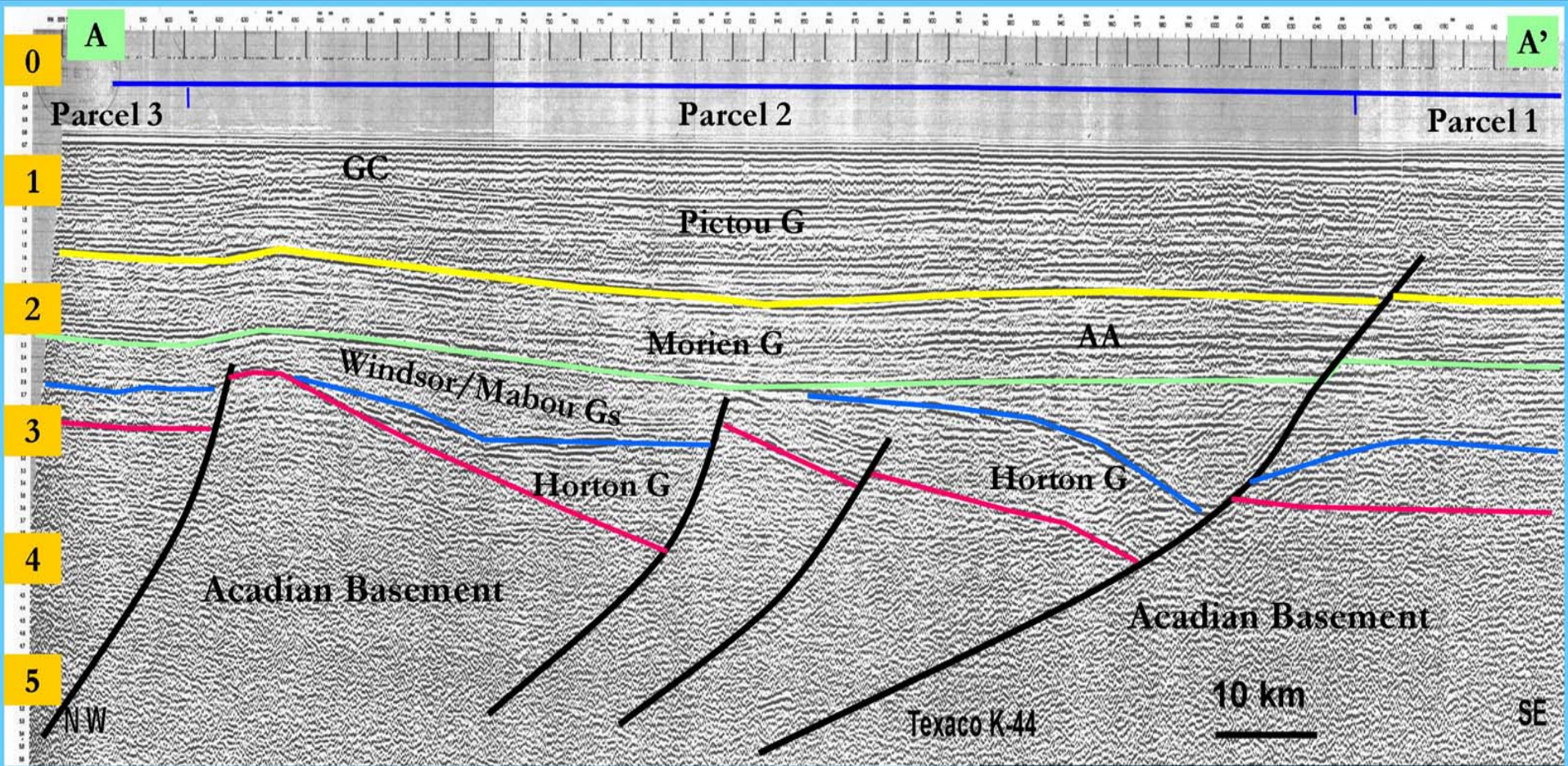
Seismic Coverage

- More than 6000 km of late sixties 1960s to early 1970s seismic data is available in the parcels. Seismic data quality varies from good to poor. These lines were recorded with a short 2400 m streamer and this is detrimental for imaging deeper sedimentary layers and for the efficacy of multiple elimination routine used at the time. During the recording at sea, there was poor navigation control and some lines do not tie properly. The lines were recorded using different sources available at the time such as: explosive, marine vibrator, vaporchoke or airguns
- The data is 2400% or 4800% and is not migrated. As the water bottom is quite hard in the area and under the thin Quaternary deposits there are Carboniferous rocks with high velocities, a large number of lines are severely contaminated by strong multiples (water bottom multiples, peg-legs and reflected refractions type)
- Most of the area is covered by a 17 by 17 km grid (10 by 10 miles), directed in the dip (NW-SE) and strike (NE-SW) direction. Certain areas have a denser coverage and some have no coverage at all
- Some lines are no more retrievable either from tapes, films or paper copies and only microfiches are available. Unfortunately no data was reprocessed since the initial mid 1970s

Seismic Coverage



- Only a limited volume of paper copies or tiff files of originally processed lines submitted to the C-NLOPB were available for the evaluation of the Call for Bids NL06-02 parcels
- A small selection of the best available data—the K series—acquired by Texaco in 1973 and processed in 1974 is used to show the petroleum potential of these parcels
- Due to lack of well ties or correlation to the newly reprocessed southern set of data, the interpretation of the data and the identifications of main seismic reflectors is based only on regional seismic structural and stratigraphic correlations and comparisons with data from other Paleozoic onshore and offshore basins



Parcel 1 Potential

- This is the southernmost parcel offered for bid in the Sydney Basin and has the largest area of the three landsale parcels
- The Parcel 1 occupies an area of 271,891 hectares (671,857 acres) and is located almost entirely in the Laurentian Channel in water depths ranging from 460 m to 220 m, with most of the parcel in the 430 m depth range. To the north the parcel borders with Parcels 2 and 3 and to the west it extends all the way to the jurisdictional border. East of the parcel there is only open exploration acreage
- The parcel lies entirely within the Carboniferous Sydney Basin. Overlying the Acadian Basement are the Horton (and probably Mac Adam Lake Fm), Windsor, Mabou and Pictou sedimentary sequences that include excellent source and quality reservoir rocks as described in sections 3 and 4 of this report
- No wells have been drilled in the parcel, but based on structural and stratigraphic information, similar lithologies with those drilled in North Sydney and East Point wells will be encountered when drilling in structural traps in this parcel

Parcel 1 Potential

- The description of geological setting, petroleum geology and hydrocarbon potential of this parcel applies to the remaining two parcels located to the north. Seismic line A-A' is a dip line diagonally crossing all three Sydney Basin parcels in their north-eastern part. Above a fractured and segmented basement, the Horton Group shows structural deformation. In Parcel 1 the rotated block in the up thrown of a major thick-skinned fault shows a slight south-easterly dip and may create a large fault dependent closure for the MacAdam Lake (possibly), Windsor/Mabou and Morien successions

The pre-1974 2D seismic data is available in paper copies from the C-NLOPB. With the exception of the 1973-74 lines, seismic data is of very poor quality. Lines are unmigrated and heavily contaminated by multiple. The usable seismic grid is insufficient for prospect mapping.

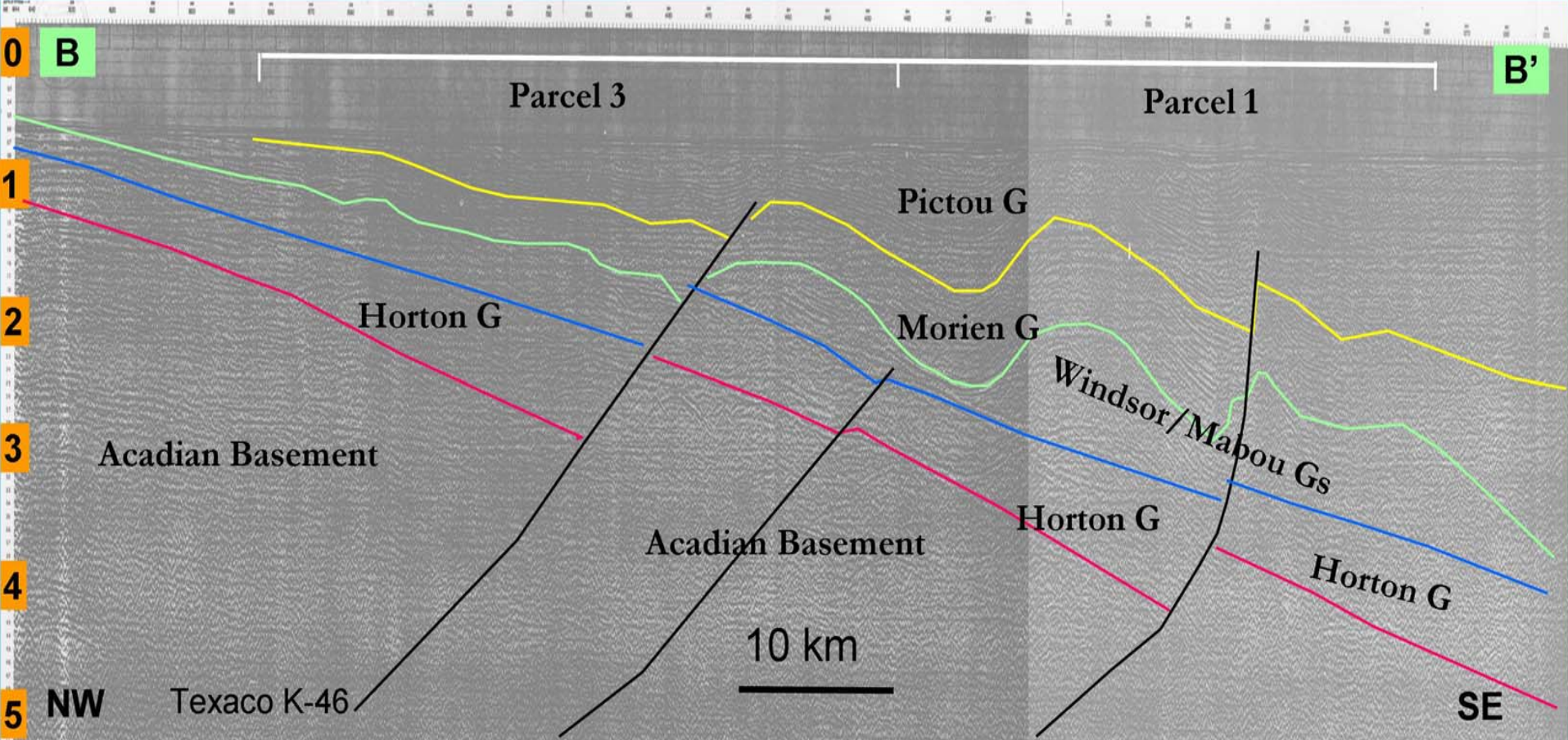
- By using the few lines that are interpretable and properly positioned and with help from the potential field data one can define significant size leads in this parcel
- The traps are 1) rift related, fault bounded structures formed in Late Devonian-Early Carboniferous; 2) later inversion features of Early Pennsylvanian and/or early Permian age, and 3) salt diapirism features
- Other types of traps never drilled in the Maritime basins put prolific in the Gulf of Mexico area, are mini-basins between salt induced highs where coarse clastics may be accumulated and coarse intervals located sub-salt or at the edges of salt diapirs
- Sandstones of the MacAdam Lake Formation, Horton, Windsor/Mabou, Morien and Pictou group are possible reservoirs. Other reservoirs are limestones and dolomites of the Windsor Group
- The source rocks expected to be mature in the parcel are the lacustrine shales of the synrift sequence, marine shales of the Windsor Group, shales of the Mabou Group and coals of the Morien Group. Windsor evaporites form an excellent seal for syn-rift reservoirs while numerous tight intervals are present at all levels. Migration is along the regional fault zones that affect the extensional stage sequences and extends upward to Mississippian and Pennsylvanian levels. The key risk on this parcel is finding quality reservoirs and trap preservation since Late Paleozoic

Parcel 2 Potential

- This Sydney Basin Parcel 2 occupies an area of 256,352 hectares (633,460 acres) and is partially located in the Laurentian Channel and partially on the shelf. Water depth in the parcel ranges from 460 m within the Laurentian Channel to 80 m on the Burgeo Bank, with about two-thirds of the parcel situated in water depth less than 200 m.
- No wells have been drilled in the parcel or in its immediate vicinity. To the south the parcel borders with Parcels 2, to the west with Parcel 3 while to the east it borders with open exploration acreage
- The regional setting, petroleum geology and exploration potential are similar to those described for Parcel 1. The potential hydrocarbon plays includes reservoirs and sources described above while possible traps are shown in seismic section. Rotated blocks that may contain syn-rift reservoirs in their higher flank and transtensional anticlines that contain Mid and Late Carboniferous reservoirs are indicated in the seismic section A-A'

Parcel 2 Potential

- In this parcel located toward the northern margin of the Sydney Basin, the syn-rift sequence is easier to reach as it generally lies at a lower depth than in Parcel 1
- The stacked reservoirs of the synrift and post rift Carboniferous successions trapped in four way or fault bounded closures are the main targets in this parcels
- An interval with strong amplitude anomalies (AA) is visible within the Morien Group close to a major fault zone, indicating probably the presence of reservoir gas
- On the northwestern portion of the parcel a clear gas chimney (GC) is present within the Pictou Group just above a large anticline expressed in the basement and sedimentary cover all the way to the basement
- Lack of quality reservoirs is also the main risk in this parcel. Similar petroleum systems affirmations and unrisks size of possible accumulations made for Parcel 1 are valid for this parcel. Analogue comments regarding data quality and scarcity of coverage can also be made for this parcel. The leads visible on the old 2D seismic data have impressive sizes but undoubtedly the parcel needs modern seismic acquisition and processing to map drilling prospects

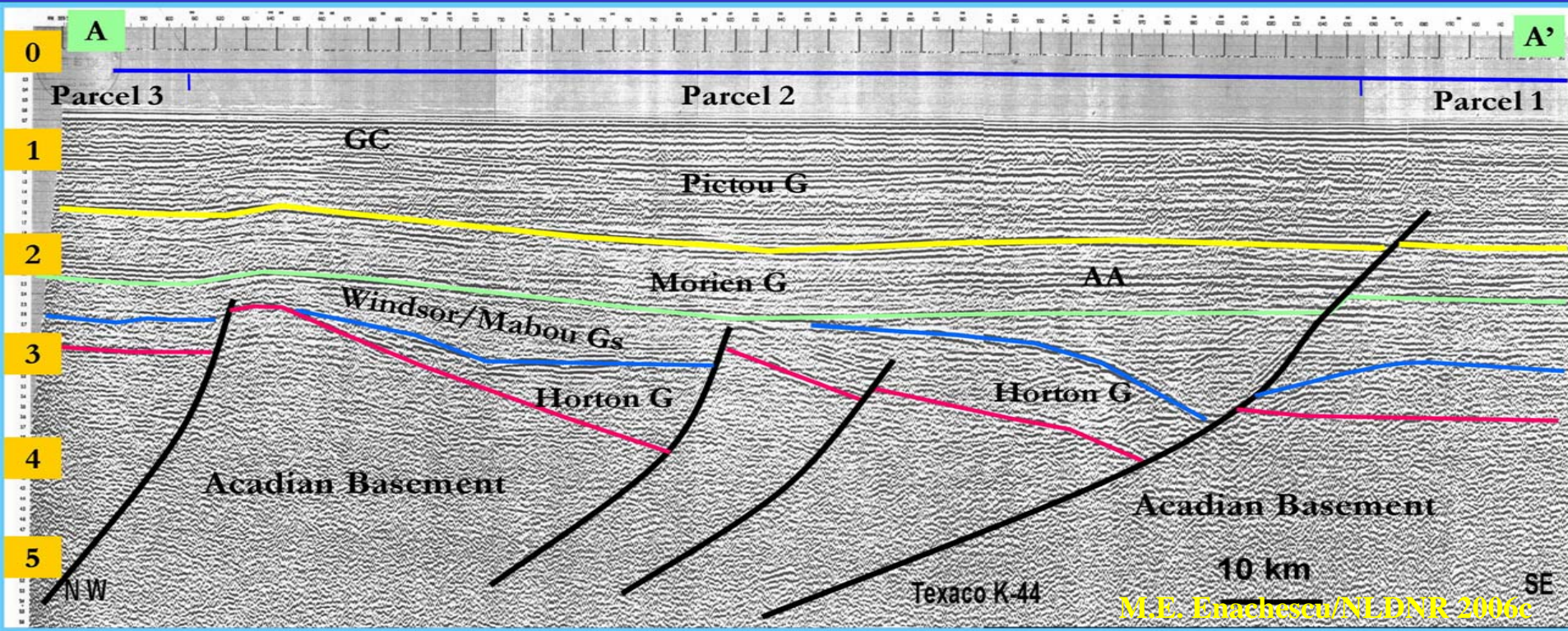


•On the dip section B-B' the MacAdam Lake (possibly), Windsor/Mabou, Morien and the lower Pictou successions are deformed due to transpressional movements on major NE-SW trending faults. Several anticlines in Parcel 1 are propagating all the way to the mid-Pictou Group where they are eroded at the water bottom. Windsor salt movement is also responsible for some of the anticlinal features seen in Parcel 1

Parcel 3 Potential

- Parcel 3 is situated near the north-western margin of the Sydney Basin. The parcel occupies an area of 240,525 hectares (594,350 acres) and is located in the Laurentian Channel in water depths ranging from 460 m to 200 m, with most of the parcel in the 425 m depth range
- No wells have been drilled in the parcel. To the north the parcel borders with open acreage, to the east with Parcel 2, to the southeast with Parcel 1 and to the southwest it extends all the way to the jurisdictional border
- Geologically, the parcel is located in the Sydney Basin, toward its north western margin, where extensional and transpressional deformation on long faults connecting the offshore to onshore structural trends is more pronounced. The basin shallows toward the north bringing the syn-rift successions (MacAdam Lake Formation and Horton Group) closer to surface
- The main hydrocarbon play in this parcel is drilling for multiple stacked Carboniferous reservoirs (Windsor/Mabou, Morien and Pictou sandstones) trapped in salt induced or transpressional or salt induced anticlines
- Stratigraphic trapping configurations are also present near the margin of the basin. Sandstone layers onlapping the Acadian Basement or sandwiched between impermeable clastics or evaporite members, subuncorformity traps, etc., can be interpreted on the north-western portion of seismic lines B-B'
- Similar statements made for Parcel 1 regarding the presence of seal, source maturation migration of hydrocarbon and size of accumulation can be made for this parcel

- Due to lack of seismic coverage these features cannot be properly evaluated regarding their total area or vertical closure, but their amplitude on individual lines is impressive. Some anticlines are as wide as 10-20 km and this suggests that if they are symmetrical they can be as large as 400 km² and therefore ranking them among the largest undrilled features in North America. These large features can hold between 300 and 1 billion barrels of oil (unrisked) or several Tcf of gas if adequate reservoir is found



Discussions

- Notwithstanding its proximity to the industrially developed regions of central Canada and to the vast markets of the eastern United States and existence of analogue Paleozoic fields to the south and across the ocean, exploration in the Sydney Basin is in an incipient stage
 - Numerous large oil and gas leads are identified with very old seismic data but the Newfoundland part of the basin has never seen exploration drilling and awaits modern data acquisition and systematic exploration for both oil and gas
 - The three parcels offered in this landsale are located within the western and central part of the Sydney Basin a virtually unexplored basin of Late Devonian to early Permian age (approximately 400-280 million years old), in which for way closures and fault bounded anticlines formed by extension, structural inversion or salt diapirism
- The size of the three parcels contained in Call for Bids NL06-2 is very large when compared with Gulf of Mexico block size (100 to 120 times larger) or Grand Banks offerings

Discussions

- All parcels are located in areas with known reservoirs, mature source rocks and proven migration paths, but risks exist related to quality of reservoir sandstones and the preservation of trap since Paleozoic time
- The three parcels contain multiple reservoir targets within Paleozoic sandstones reservoirs and limited potential for reefal carbonates also exists. These multiple target zones can be tested by drilling relatively shallow offshore wells using jack-ups or semi-submersible rigs (2000-3500 m drilling depth)

Only leads can be tentatively mapped with the scarce, old vintage, nonmigrated, low quality seismic grid available in the area. New mapping with modern data may lower the geological risk, and location of prospects in a shallow water environment with less severe climate lowers the economic risk. Numerous seismic amplitude or other attribute anomalies are observed on the few quality seismic lines that are available which may indicate hydrocarbons presence in reservoirs. Systematic mapping and post-stack analysis of seismic attributes extracted from newly acquired and processed data may further reduce the geological risks associated with reservoir and trap integrity

Discussions

- In the Sydney Basin offshore well in water depth between 80 and 450m may cost from Can \$15 MM to \$ 25 MM, depending on total depth
- Metocean conditions are fair to good. Sea ice is infrequent and iceberg presence is very low and very sparse (from one iceberg every 8 years to one iceberg every 25 years) (C-NLOPB, 2006). The ocean has some one-year ice cover or ice flows only for approximately 3 months (February to early May)
- Fields can be developed using tie back to shore processing facility, gravity based structures, bottom founded caisson, sub-bottom completion with FPSO

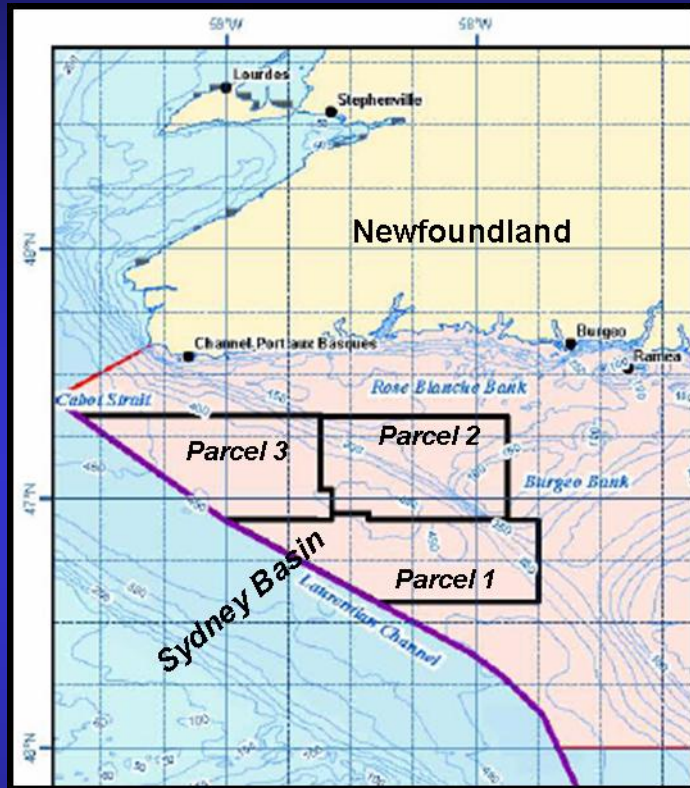
Conclusions

- **Three large parcels, located offshore to the southwest of the island of Newfoundland are available for licensing in the C-NLOPB's Call for Bids NL06-2 which closes on November 30, 2006. These parcels are more than 100 times larger in size than Gulf of Mexico blocks. All three parcels contain late Devonian to early Permian mostly clastics sequences that has produced oil and gas elsewhere in the Appalachian fold and thrust belt including in the neighbouring New Brunswick province**
- **The licensing of these parcels represents a rare opportunity for oil and gas companies to lock into a new exploration area with large and very large leads, that has not been yet subjected to a proper exploration program and remain undrilled**
- **The Sydney Basin is a successor basin, formed during the final assembly of Pangea from mid Devonian to early Permian. The basin was tectonically active for about 120 Ma and was subjected to rifting, thermal subsidence and inversion and experienced both lacustrine and marine interludes. Salt diapirism and movements on the Cobequid-Chedabucto transcurrent fault and its subsidiaries has created numerous structural highs in the Sydney Basin**

Conclusions

- **The basin has all the prerequisites to become an important petroleum province**
- **Successive thick clastic sequences underlying the basin contain both multiple reservoirs and various source rock levels. Carboniferous marine and lacustrine shales and numerous coals are proven source rocks throughout Atlantic Canada. Seismic amplitude anomalies pointing toward gas accumulations are present in much of the inspected old seismic lines. Additionally, marine episodes during Windsor Group deposition and other marine restricted incursions throughout Late Paleozoic may provide oil prone source rocks**
- **Large rotated fault bounded blocks, inversion anticlines and salt diapirs, most of these showing simple or fault bounded closures, provide sizable targets on all three Sydney Basin parcels available for bid. High quality dense 2D or 3D seismic data is needed to properly image such targets and ascertain the geological risks. Exploration risks are the presence of quality reservoirs and the preservation of traps since late Paleozoic. New seismic acquisition is also absolutely necessary to identify more complex composite traps and investigate the areal distribution and quantify the seismic attributes**

Conclusions

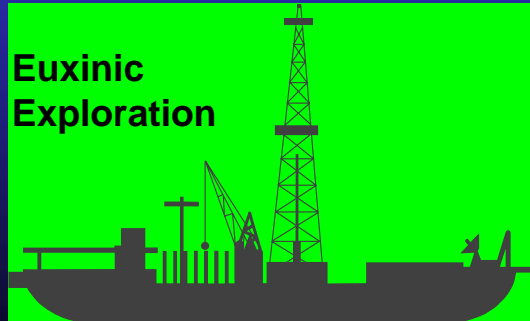


All these parcels are very large size exploration blocks situated in shallow water, some in the territory of jack up rigs, in an area where drilling can be performed year-round. The Sydney Basin parcels are located in a practical unexplored basins but close to NE American and Canadian markets in an area with low political risk. Acquiring these parcels present a unique Frontier opportunity for companies looking for large oil and gas reserves within the North American continent and willing to take a long term view to exploration and production

Thank You for the Attention!



Euxinic
Exploration



Newfoundland
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