

Petroleum Exploration Opportunities in Laurentian Basin, Call for Bids NL09-2, Parcels 1 and 2

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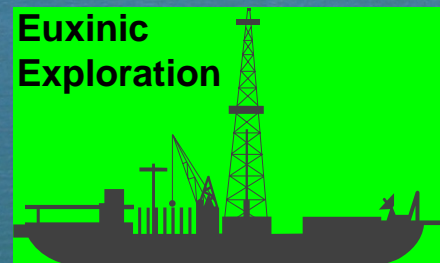
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A.J. Fagan Consulting Inc.

**On Behalf of NL DNR
November 2009**





Acknowledgements

- Wes Foote, David McCallum and Larry Hicks, for edits and suggestions
- Darrell Spurrell, Brad Kendell, Jillian Owens, Anne Lake of the NL Department of Natural Resources
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- GSC Atlantic
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- This work could not have been performed without information kindly provided by GSC Atlantic, Government of Newfoundland and Labrador Department of Natural Resources and C-NLOPB



★ = position of CFB NL09-02 Parcels 1 and 2

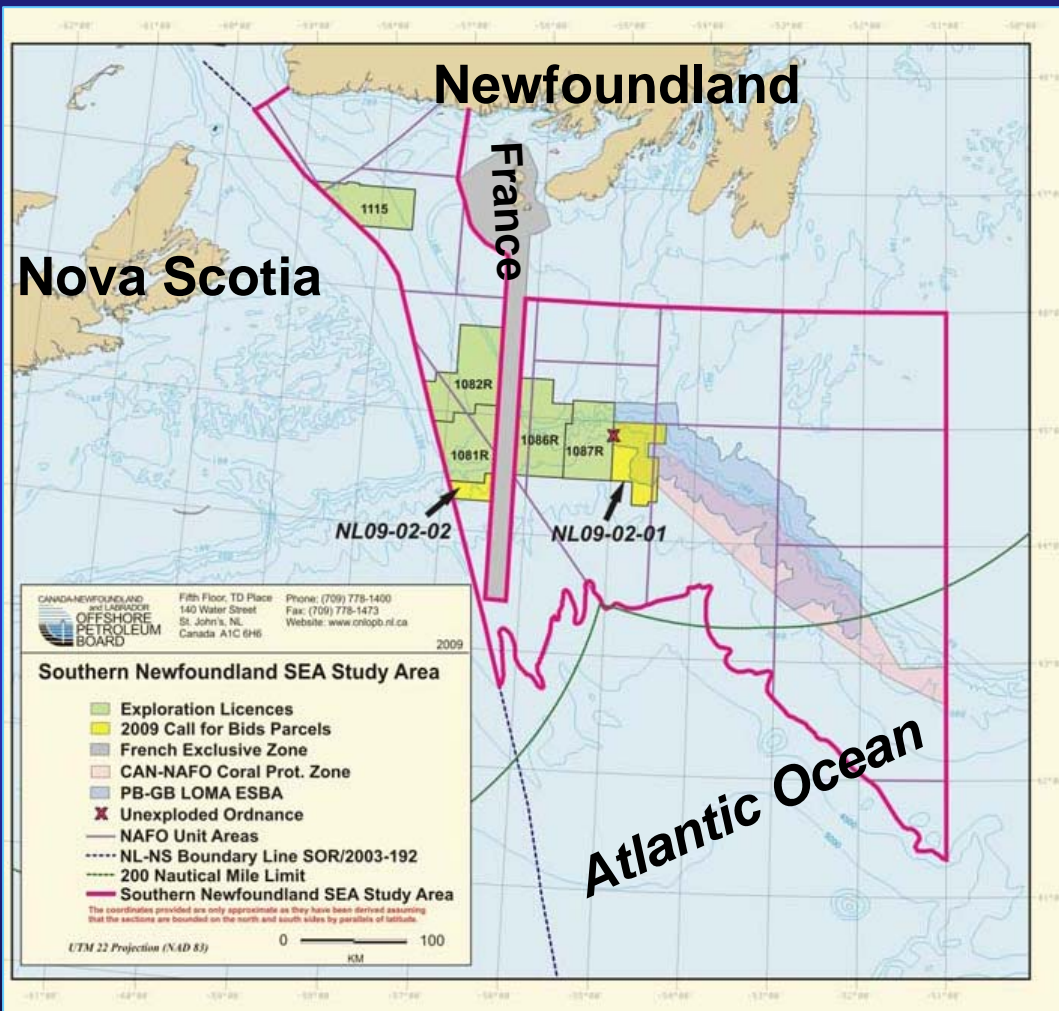
Call for Bids NL09-02

- **Two Parcel Bid.** Call for Bids NL09-02 consists of two parcels totaling 364,001 hectares (899,463 acres), located in intermediate to deep water of Laurentian Basin, south of the island of Newfoundland. Parcel 1 has 290,070 ha (716,776 acres) and Parcel 2 has 73,931 ha (182,687 acres)
- **Laurentian is practically an unexplored basin.** This Mesozoic-Tertiary basin is on trend with the gas producing Sable Basin (approximately 450 MMcfd) and oil producing Grand Banks of Newfoundland (approximately 300,000 bopd from the Hibernia, Terra Nova and White Rose giant oil fields). The subbasin has only one exploration well with results unknown to the public and Canadian geoscientists
- **Exploration and Production activity.** There are 4 active Exploration Licenses (ELs) in the Newfoundland's Laurentian Basin
- **Parcel location.** The parcels offered for bid are located in the western (Parcel 1) and southern (Parcel 2) portions of the Laurentian Basin
- **Call for Bids closure.** The bid for this will be concluded on **November 19, 2009 at 4 p.m. NL time**

More information on this Call for Bids can be found at:

http://www.cnlopb.nl.ca/news/pdfs/cfb09_2.pdf

Strategic Environmental Assessment (SEA)



- The Board has previously conducted a SEA in the active ELs area
- C-NLOPB has also concluded public consultations for the SEA of CFB NF09-02 parcels. A final report is being prepared for public release
- The SEA concludes that petroleum exploration activity generally can proceed in the Southern Newfoundland area with the application of standard mitigation measures currently applied to offshore exploratory activities elsewhere in the NL offshore
- Sensitive Areas within the Southern NL SEA relevant to CFB NL09-02 include: a) **deep water coral communities** and b) **potential unexploded ordinance**

After C-NLOPB

http://www.cnlopb.nl.ca/news/pdfs/noticcecfb09_02env.pdf

Presentation Content

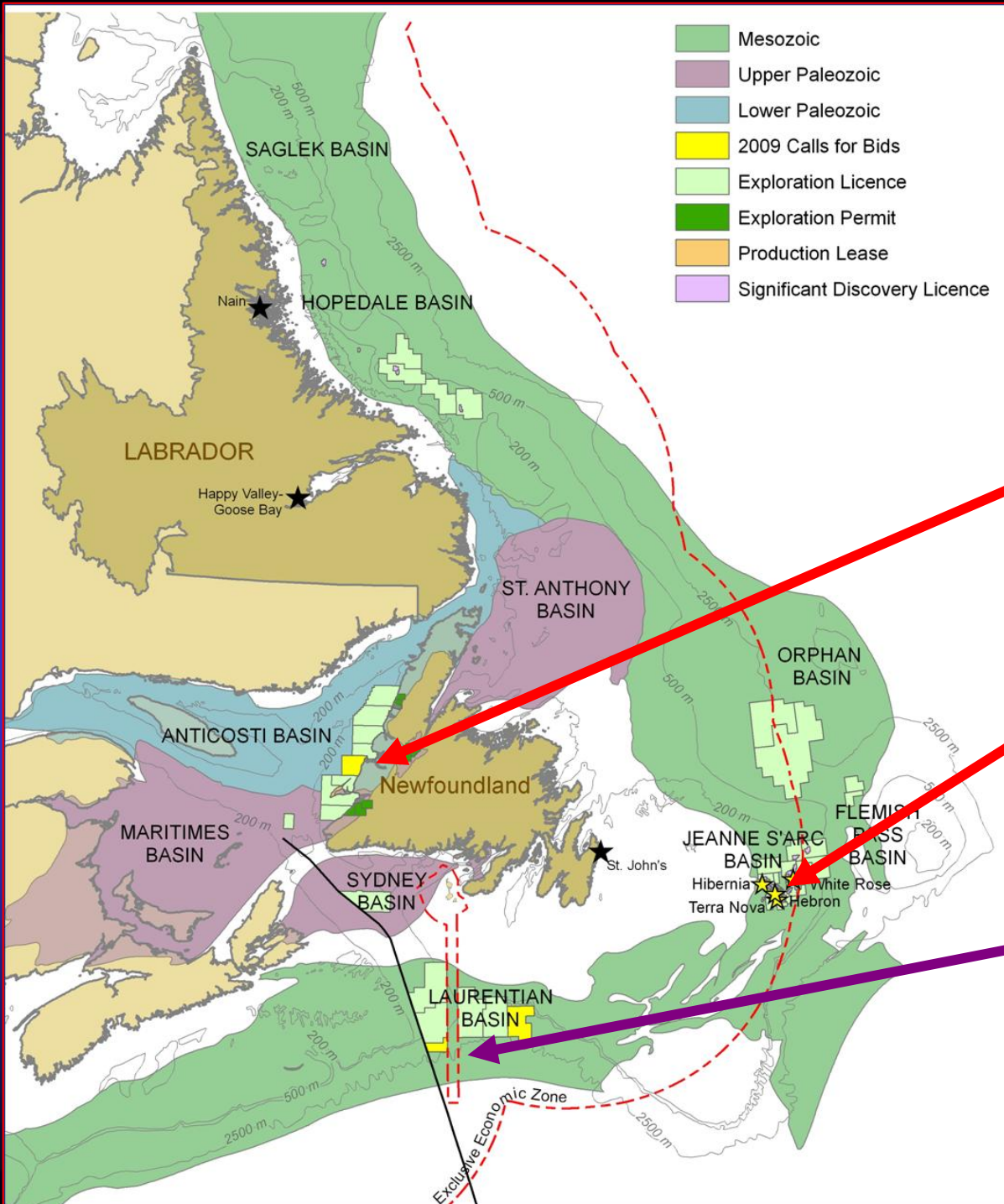
1. Introduction
2. Exploration and Development Background
3. Geology Overview of the Mesozoic Atlantic Basins
4. Geology Summary of Laurentian Basin
5. Petroleum Geology of Laurentian Basin
6. Petroleum Potential Call for Bids
NL09-02 Parcels 1 and 2
6. Discussion
7. Conclusions

Basin vs. Subbasin Nomenclature

- The Laurentian Fan deeper bathymetrical feature and both flanks are part of the Nova Scotia-Newfoundland offshore Mesozoic to Tertiary sedimentary area that is part of the larger Atlantic margin chain of rift basins, subbasins and sedimented ridges
- The area was considered for a long time in continuity of deposition and with similar geodynamic evolution as the Scotian Shelf and Slope and traditionally GSC has considered it a subbasin of the larger Scotian Basin
- Also, as there are no clear geological boundaries (e.g. basin bounding faults, basement ridges) delimitating a separate, disconnected Laurentian basinal area, many Atlantic Margin researchers have considered it a subbasin (of the Scotian Basin)
- According to the traditional nomenclature the C-NLOPB posted the Call for Bid NL09-02 as located in the “Laurentian Subbasin”
- However...

Basin vs. Subbasin Nomenclature

- The authors agree that for Laurentian Basin (LB) the basinal boundaries are loosely defined
- We also acknowledge many similarities with the Scotian Basin, but our and other authors' recent work with new and old seismic reflection, refraction and seamag data (Enachescu and Lines, 2001; Loudon, 2002; Enachescu et al., 2005; Fagan and Enachescu 2007 and 2008, Hogg and Enachescu, 2007; Fagan, 2010 (M Sc thesis, in press) shows the Laurentian area as:
 - A very large sedimentary area of 60,000 square km;
 - A unusual deep depocenter of Jurassic and E. Cretaceous sediments;
 - An environment where transtensional movements along the Cobequid-Chedabucto (CC) Fault and its imbricates as well as on the Newfoundland Transfer Zone has created compressional features;
 - The area is clearly bounded to the North by the CC Fault.
- **In our opinion these clearly distinct features justify the use of “Basin” term rather than “Subbasin” for the Laurentian sedimentary area**
- Consequently the term Laurentian Basin will be used on all maps and discussions in this presentation



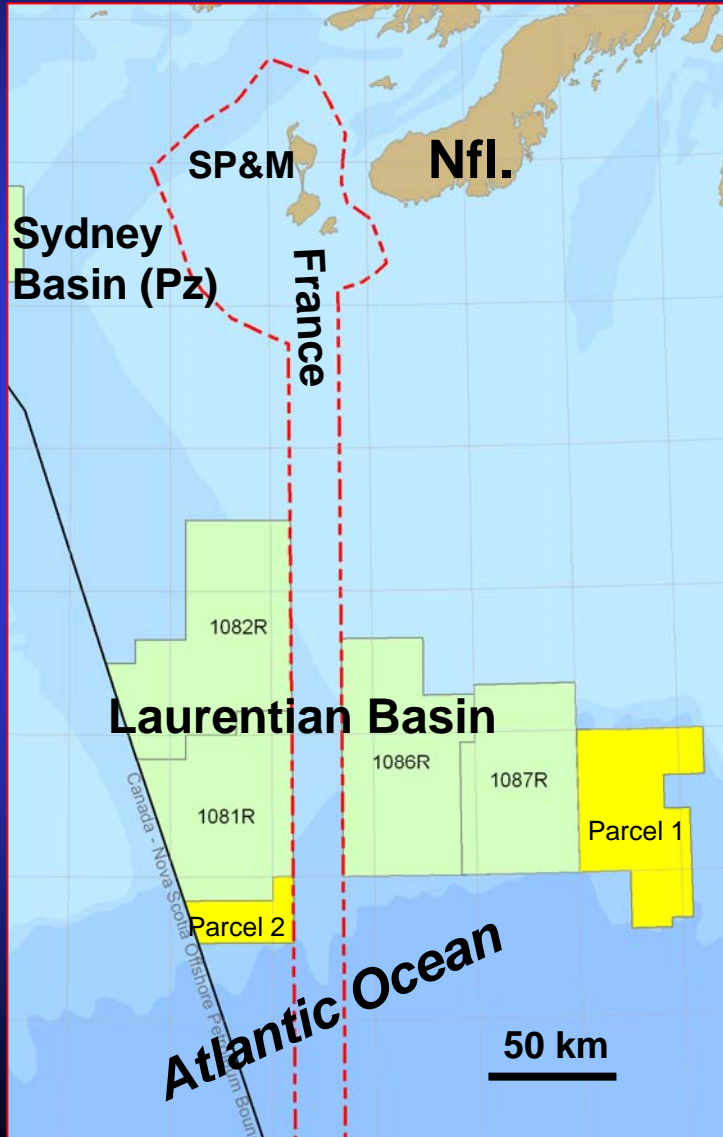
CFB 2009: Three landsales in three basins

•CFB NL09-03
Anticosti Basin

•CFB NL09-01
Jeanne d'Arc Basin

•CFB NL09-02
Laurentian
Subbasin

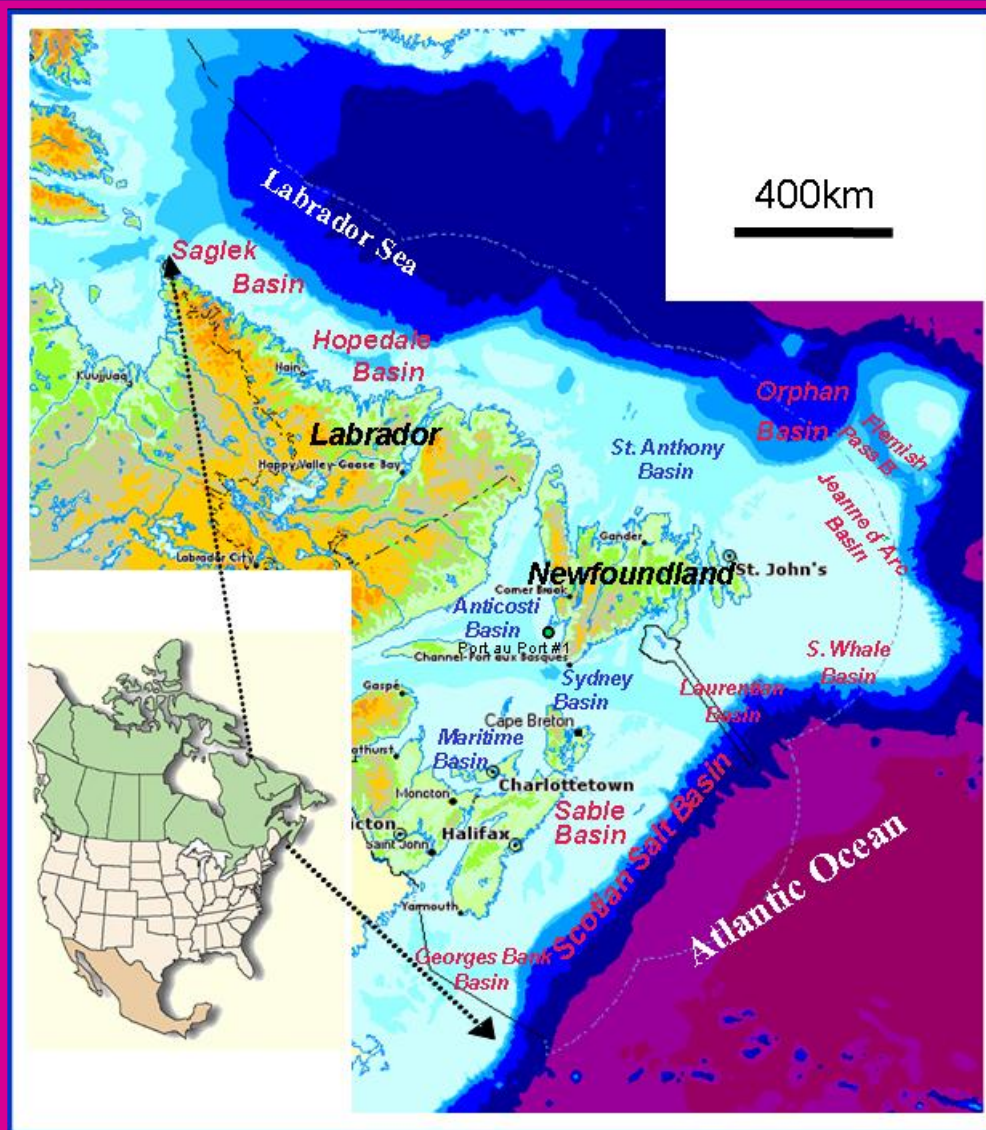
Parcels NL09-02-01 and -02



- This is a presentation of the petroleum potential of Parcels NL09-02-01 (Parcel 1) and -02 (Parcel 2) located in deep and ultra deep water within Laurentian Basin (LB) and offered for bidding at this year's C-NLOPB landsale
- Parcel 1 and 2 are situated on the slope and upper rise of the Mesozoic LB where extensional and salt induced anticlines are visible on seismic data
- Parcel 1 is located just west of the recently consolidated EL 1087R while Parcel 2 is located south of the consolidated EL 1081R
- All four ELs in the basin are explored by a consortium led by ConocoPhillips and including, BHP and until recently Murphy

Nfl = the island of Newfoundland (province of NL, Canada)
SP&M = the islands of St. Pierre and Miquelon (France)

Atlantic Canada Offshore Basins



Text on Map:

Blue = Paleozoic Basins

Magenta = Mesozoic Basins

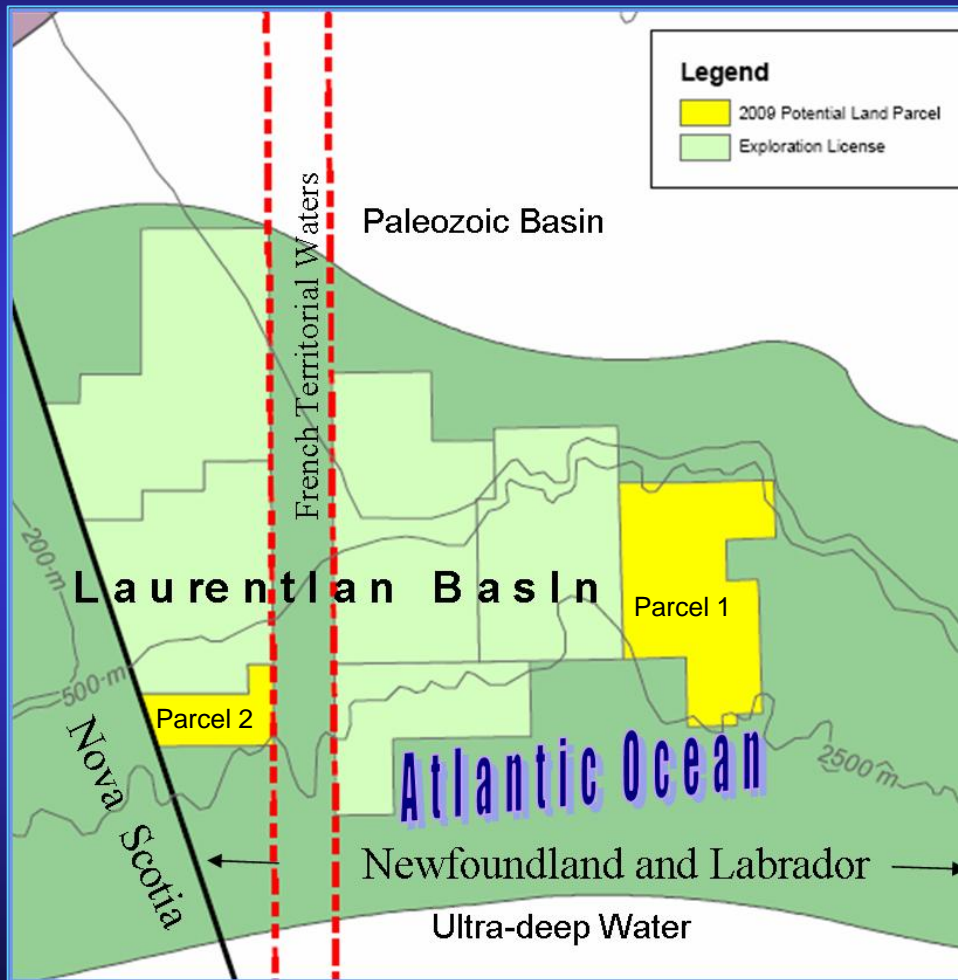
NL Mesozoic Basins

- **Laurentian Basin**
- S. Whale Basin
- Jeanne d'Arc Basin
- Flemish Pass Basin
- Orphan Basin
- Hopedale Basin
- Saglek Basin

1. Introduction

- The CFB NL09-02 parcels 1 and 2 are the first ever parcels offered for direct bid in the Laurentian Basin by the C-NLOPB
- Current LB consolidated ELs are the result of re-issuance of Federal Exploration Permits issued in the 1960s and 1970s and principally owned by Mobil and Gulf Canada
- These permits were frozen for 30 years due to international and provincial jurisdictional moratoria
- Territorial disputes between 1) Canada and France were resolved by arbitration in 1992 and 2) the provinces of Newfoundland and Labrador and Nova Scotia were settled in 2002
- The basin is an high risk-high reward exploration environment and is unique in that it is practically unexplored, close to huge petroleum markets and located in an iceberg-free zone where year round drilling can be performed
- With only one exploration well drilled during 2001 in its shelfal part on French territory, the basin provides a great opportunity for exploration

Laurentian Basin Landsale



- CFB NL09-2 consists of two large parcels
- Parcels are located in deep and very deep waters of Laurentian Basin
- **Landsale closes November 19, 2009 at 4 p.m. NL time**

2. Exploration and Development Background

- **NL Petroleum Production**
- **Emergence of Nalcor Energy**
- **Nova Scotia Petroleum Production**
- **Laurentian Basin History of Exploration**
- **Recommended References**
- **Recent E&P Activity in Laurentian Basin**

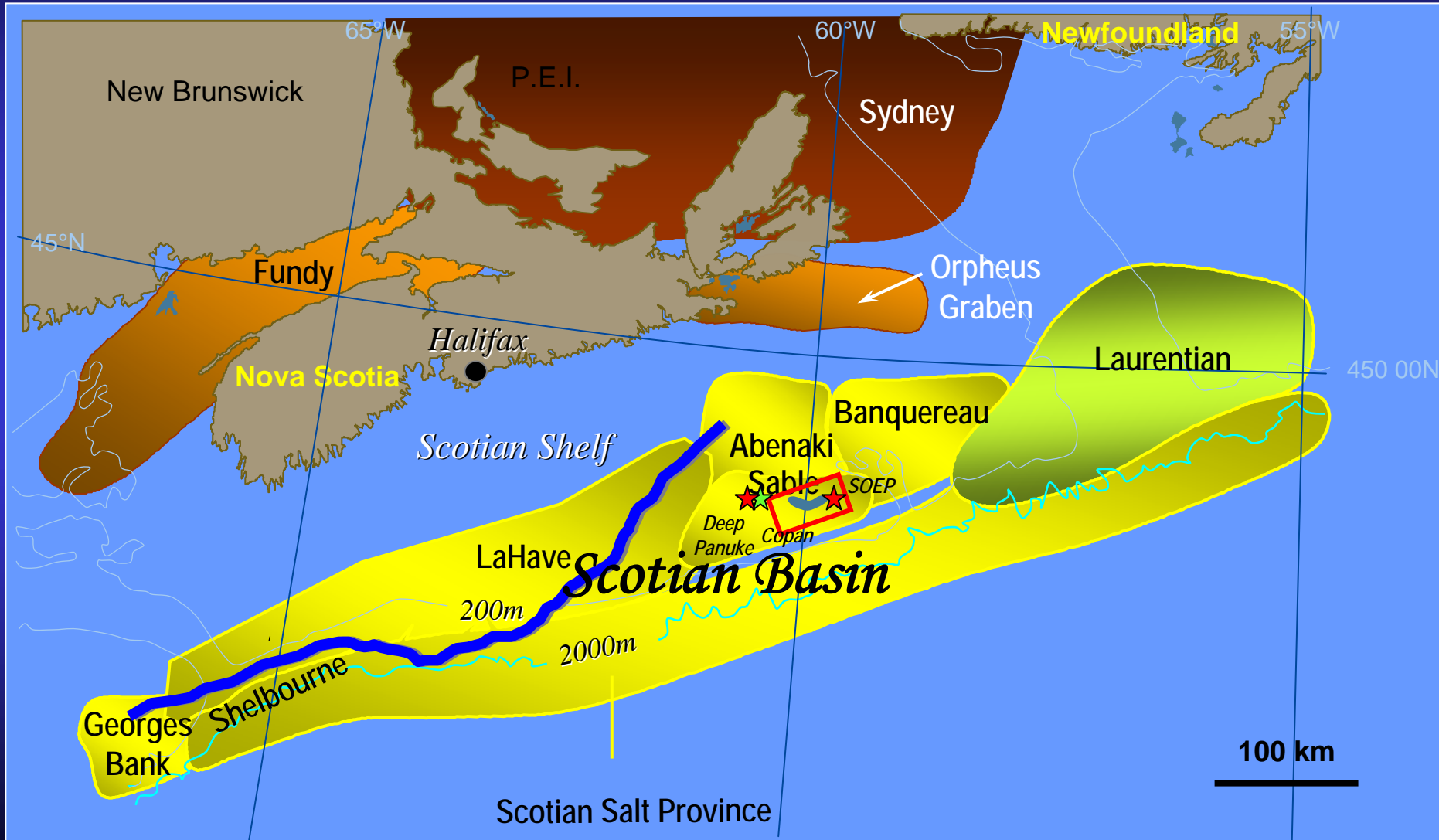
NL Petroleum Production

- NL petroleum production comes from fields developed in 80-110 m water in the Jeanne d'Arc Basin. These fields have produced in each of the past 5 years in the range of 300,000 to 360,000 barrels per day of light crude (30 to 35° API) from Late Jurassic-Early Cretaceous sandstones
- With this output NL is now the second largest hydrocarbon producing province in Canada; over 1 Bbbls were produced to date from the area;
- On the Grand Banks, more than 1.8 billion barrels of proven remaining recoverable reserves/resources exists;
- Approximately 6 tcf of natural gas was discovered on the Grand Banks, but there is no gas production yet
- Jeanne d'Arc Basin developments (see also Call for Bids NL09-01 Power Point Presentation) are the only East Coast North America producing oilfields; the next project Hebron, estimated to contain 731 MMbbls reserves/resources will be developed starting in 2012 with first expected oil in 2017
- Satellites of larger fields are presently being brought on stream
- NL delivers about 37% of the light oil produced in Canada from these fields representing more than 80% of the Atlantic Canada's hydrocarbon production. The rest of Atlantic hydrocarbons are from the Sable Island gas development offshore Nova Scotia

Emergence of Nalcor Energy

- Formation in 2007 of Nalcor Oil and Gas Inc. a subsidiary of Nalcor Energy that presently has interest in several offshore fields: North Amethyst, West White Rose and South White Rose Extension (6.5%), Hebron (4.9%) and Hibernia South (10%)
- In fall 2007, the NL Energy Plan brought implementation of an Offshore Natural Gas Royalty Regime and introduced the concept of a “pioneer project”
- Summer 2009, Nalcor farms into the “Parsons Pond” Exploration Permits located onshore in the Appalachian Paleozoic trend; may be followed by other Nalcor direct involvement with exploration projects
- Presently Nalcor has no involvement in the Laurentian basin exploration.

Scotian Shelf and South Newfoundland Basins and Subbasins

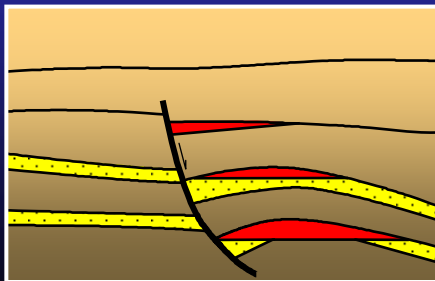


Nova Scotia Petroleum Production

- Offshore Nova Scotia (NS) exploration and production is administered by Canada-Nova Scotia Offshore Petroleum Board (C-NSOPB)
- Offshore NS contains of a very large, Late Triassic to Tertiary synrift and passive margin prism of sedimentary rocks, which has all the ingredients for generation and accumulation of petroleum
- Exploration started in 1960s; several oil and gas discoveries were made in the late 1970s - early 1980s
- First petroleum production was obtained from the Cohasset-Panuke (COPAN) project involving three oil fields – Cohasset, Panuke and Balmoral - contained in small 12-15 m high, four-way closed anticlines (slide 16)
- 27 Logan Canyon good reservoir sands showing continuity were penetrated
- The Cohasset-Panuke Project (COPAN) was the first offshore Canadian energy project. Its oilfields came into production in 1992
- The field was developed in 35 – 40 m of water, 250 km offshore and produced high quality 48⁰ to 53⁰ API crude oil from multiple reservoir sandstones
- The project developed by Lasmo in partnership with Nova Scotia Resources using a modified jack-up platform and 11 producing wells has produced over 37,000 bopd at is peak and a total of 44.5 MMBbls oil before decommissioning
- The operatorship was acquired by PanCanadian (now EnCana) in 1996

Nova Scotia Petroleum Production

- Nova Scotia's first major offshore project, the Sable Offshore Energy Project (SOEP) is a natural gas development consisting of six fields grouped around the Venture discovery, Exxon Mobil is the operator of the field. Production commenced in late 1999
- The project was developed in two tiers. Tier 1 tied in three fields - Thebaud, Venture and North Triumph; Tier 2 tied Alma and South Venture fields (also slide 16)
- The development includes two manned and two un-manned production platforms
- The average daily production is in the range of 400-500 MMcf and 20,000 bbls of liquids
- Production is from listric fault bounded closures and rollover anticlines containing Late Jurassic Mic Mac and Early Cretaceous Mississauga sandstones
- The original estimate of 3.2 trillion cubic feet of recoverable reserves has been downgraded to 1.7 trillion cubic feet because of poor reservoir characteristics encountered during development



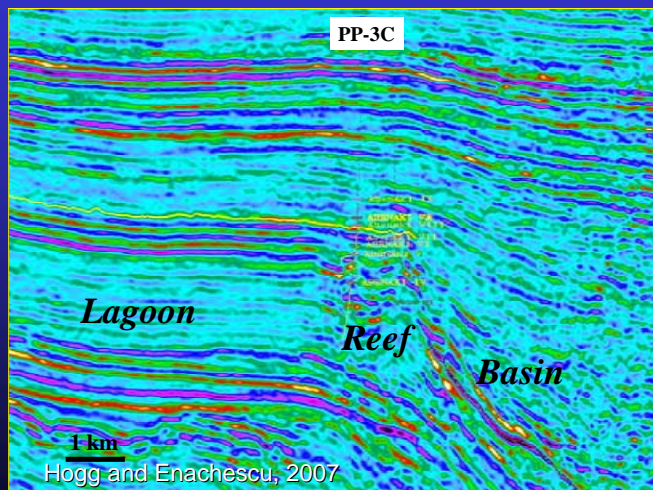
Listric fault and Rollover Anticline - type of trap common in the Sable Subbasin

Nova Scotia Petroleum Production

- Deep Panuke field, located 65 km to the southwest of Sable Island (slide 16) is the last major discovery and the only current petroleum development offshore Nova Scotia
- Deep Panuke was discovered by PanCanadian (now EnCana) in 1998 by drilling under the depleted Panuke oil field into an amplitude anomaly interpreted on 3D seismic data within the Jurassic carbonate platform (Upper Abenaki Formation)
- Reservoir is limestone and dolomite of Late Jurassic age found at the margin of the carbonate platform and includes a melange of reefs, reef rubble and foreslope sediments (Tonn et al., 2004; Hogg and Enachescu 2001); most of the reservoir porosity is in dolostones



Deep Panuke reservoir



Seismic line over Deep Panuke field

- Field was delineated with nine wells, a high quality 3D and expert geophysical attribute work; trap is structural-stratigraphic
- Field development, started in 2007 using a Mobile Offshore Production Unit (MOPU) built for harsh environment and 8 production wells tied back with subsea flowlines;
- Present estimates of field size varies between 0.6 to more than 1 Tcf; first gas production is expected in 2010; average planned production is in the range of 300 MMcfd

Laurentian Basin History of Exploration

- 1930s – Woods Hole Oceanographic Institute dredge and sampling in Atlantic Canada recover Cretaceous and Tertiary sediments
- 1948 - Lamont Doherty Earth Observatory carried out refraction seismic in Atlantic Canada
- 1958 - GSC carried out refraction and magnetic measurements
- Late 1950s – It becomes clear from the work by Canadian and American government agencies and universities that a thick wedge of Mesozoic – Tertiary sedimentary rock was present across the Atlantic shelf and slope
- 1960s - Atlantic Geoscience Centre at Bedford Institute of Oceanography carried out detailed bathymetric studies, dredge and coring programs, gravity and magnetic surveys, shallow seismic (echo sounder) and seismic refraction surveys on Canada's Atlantic margin
- Early 1960s - Industry marine reflection surveys: Amoco and Imperial on the southern Grand Banks and Shell and Mobil on the Scotian Shelf
- 1966 - First well in the Southern Grand Banks PanAm et al. Tors Cove D-52
- 1967 - First well offshore Nova Scotia Mobil et al Sable Island C-67
- Late 1960s - Early 1970s - Federal Exploration Permits were issued to Mobil, Gulf Canada and Texaco for areas covering most of Laurentian Basin
- 1970's - Seismic surveys and exploration reports including parts of the Laurentian Basin area by Elf, Amoco and Petro-Canada
- 1971 - First Sable Island gas discovery: Mobil et al Sable Island E-48
- 1972 - First Sable Island **large** gas discovery: Mobil et al Thebaud P-84 in roll-over anticline associated to down-to-basin listric faults

Laurentian Basin History of Exploration

- Early 1980s-Seismic programs by Petro-Canada and Soquip include some of the area pertinent to Laurentian Basin
- 1984&1985 - GSC acquired 3072 km of reflection seismic data between the southern Grand Banks and the Scotian Shelf. These data were collected to allow a geological assessment of the moratorium area. France carried out its own assessment
- 1992 - Offshore boundary between Canada and France was settled by arbitration with the awarding to France of an elongated offshore area known as “The baguette”
- 1992 - MacLean and Wade published their interpretation of the GSC 1984 &1985 grid. They provides a detailed discussion of the basin’s structure, stratigraphy and petroleum potential; this is the only comprehensive study of the LB in public domain
- Late 1990s - Seismic spec surveys collected in the area by GSI and TGS
- Late 1990s - Early 2000s - Five deep wells were unsuccessfully drilled on Scotian Slope looking for turbidite reservoirs above or under Argo salt
- 2002 -Territorial disputes between the Canadian provinces of NL and NS were settled with most of the Laurentian Basin falling under NL jurisdiction
- 2004 - Federal Exploration Permits in the basin were converted to 8 ELs by CNLOPB
- Post 2004 - Modern exploration in the basin restarted by ConocoPhillips and partners that acquire a large 2D survey in 2004 and then two large 3D surveys in 2005
- 2009/10 - First deepwater well is expected to be drilled

Recommended References and Presentations on Laurentian Basin and Environs

Jansa and Wade, 1975; Powell, 1982; Hubbard et al., 1985; Parson et al., 1985; Piper et al., 1985; Mackenzie et al., 1985; Mason and Miles, 1986; Srivastava and Tapscott, 1986; King et al., 1986; Grant and McAlpine, 1986; Ziegler, 1987; Enachescu 1987, 1988, 1992 and 1993; Enachescu et al., 1993; 2005; 2006; Tankard and Welsink, 1987; Piper and Aksu, 1987; Keen et al., 1987; Fowler and Snowden, 1988; Grant et al., 1988; Ziegler, 1989; Balkwill and Legall, 1989; Tankard et al., 1989; Bell and Howie, 1989; Mukhopadhyay, 1989 and 1990; Williams et al., 1990; Srivastava et al., 1990; Grant and McAlpine, 1990; McAlpine, 1989 and 1991; Keen and Williams, 1990; Wade and MacLean, 1990 and 1992; Allen, 1992; Sinclair et al., 1992; Srivastava and Verhoef, 1992; Enachescu and Dunning, 1994; Langdon and Hall, 1994; Fowler and McAlpine, 1995; Driscoll and Hogg, 1995; Driscoll et al., 1995; Bateman, 1995; Drummond, 1998; Withjack et al., 1998; Hogg et al., 1999; Williams et al., 1999; Srivastava et al., 2000; Mukhopadhyay et al., 2000, 2003 and 2005; Pascucci et al., 2000; Hogg and Enachescu, 2001; Hogg, 2002; Loudon, 2002; Kidston et al., 2002; Deptuck et al., 2003; Pe-Piper and Piper, 2004; Ing et al., 2004; Enachescu and Hogg, 2005; Shimeld, 2004 and 2005; Cummings and Arnott, 2005; Young, 2005 (M Sc Thesis); Young et al., 2005; Kidston et al., 2005; Loudon et al., 2005; Weissenberger et al., 2006; Enachescu, 2006; Cummings et al., 2006; Jenson and Hooper, 2006; Government of Nova Scotia Report, 2006; Hogg and Enachescu, 2007; Negut et al., 2007; Fagan and Enachescu, 2007 and 2008; Brown et al., 2007; Goodway et al., 2008; Fagan, 2010 (M Sc Thesis)

Observation: This list is not exclusive

Enachescu and Fagan, NL DNR 2009

Government of Newfoundland and Labrador Reports and Presentations

- The regional geoscience of Newfoundland and Labrador offshore and specifically the petroleum potential of the Grand Banks as pertinent to the Laurentian Basin were covered in detail in previous Government of Newfoundland and Labrador Government Reports
- Only a summary is contained in this presentation
- More geoscience information is included with reports and presentations available from the :

<http://www.nr.gov.nl.ca/mines&en/publications/offshore/>

and

<http://www.nr.gov.nl.ca/mines&en/oil/>

List of Reports and Presentations Available from Various Government Websites:

- **For offshore Newfoundland:**

Fagan and Hicks, 2003:

<http://www.nr.gov.nl.ca/mines&en/oil/callforbids/flemishpass.pdf>

Enachescu and Fagan, 2004:

http://www.gov.nl.ca/mines&en/oil/call_for_bids_nf04_01.stm

Enachescu and Fagan, 2005:

http://www.nr.gov.nl.ca/mines&en/call_for_bids/NL05.pdf

Enachescu 2006a and b:

http://www.nr.gov.nl.ca/mines%26en/call_for_bids/cfb_nl06-1_%20enachescu_report.pdf

http://www.nr.gov.nl.ca/mines%26en/call_for_bids/CFBNL06-1_presentation.pdf

- **For offshore Nova Scotia:**

NRCAN:

http://gdr.nrcan.gc.ca/seis/lb_e.php

http://gsc.nrcan.gc.ca/marine/scotianmargin/so_e.php?wf=

CNSOPB:

http://www.cnsopb.ns.ca/call_for_bids_08_1/cnsopb/regional_geology.html

Dalhousie University:

<http://cygnus.ocean.dal.ca/public/klouden/Proposals/Muki-GCAGS-Pub-2006-Nov28-2006.pdf>

Government of Nova Scotia:

www.gov.ns.ca/energy/.../RA/.../Executive-Summary-Report-2006-08-26.pdf

More information on Scotian basin is available from the www.gov.ns.ca/energy/ site

Recent E&P Activity in Laurentian Basin

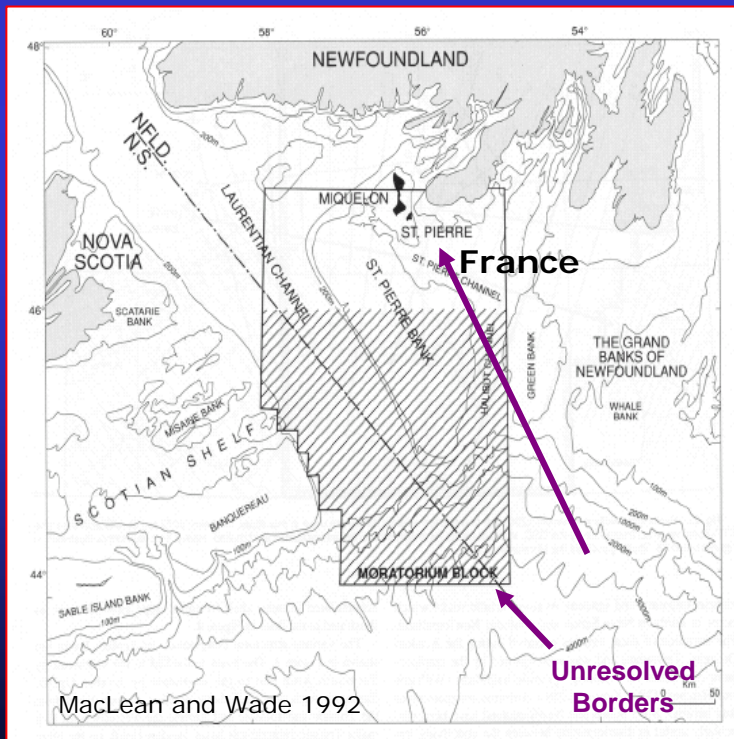
Licensing. Modern exploration starts after lifting of moratoria

1. Arbitration of International Boundaries with France - 1992
2. Settlement of Provincial Boundaries (NL and NS) - 2002
3. Conversion of Federal Permits into Exploration Licences – May 2004

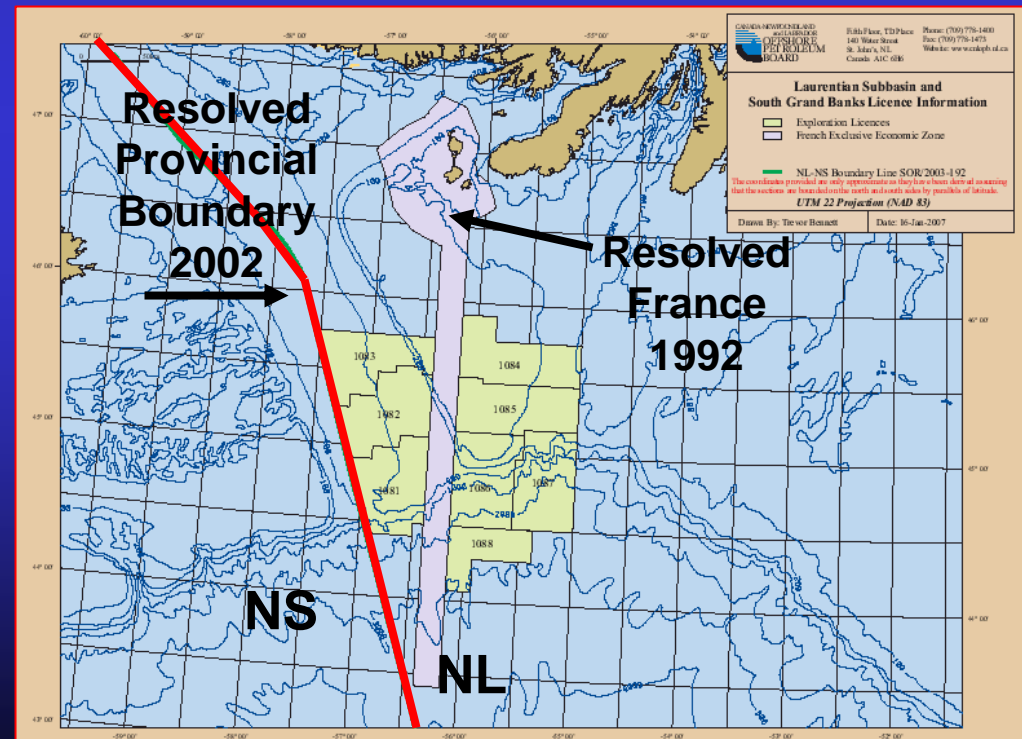
ConocoPhillips (89%)/Murphy (11%) ELs (1081-1087): 2.25 million ha.

Terms: \$18 MM new expenditure additional to \$ 23 MM spent prior to 2004 on the blocks

Imperial Oil (EL 1088): 194,800 ha. Terms: \$1.5 MM expenditure



Pre 1992 Moratorium block

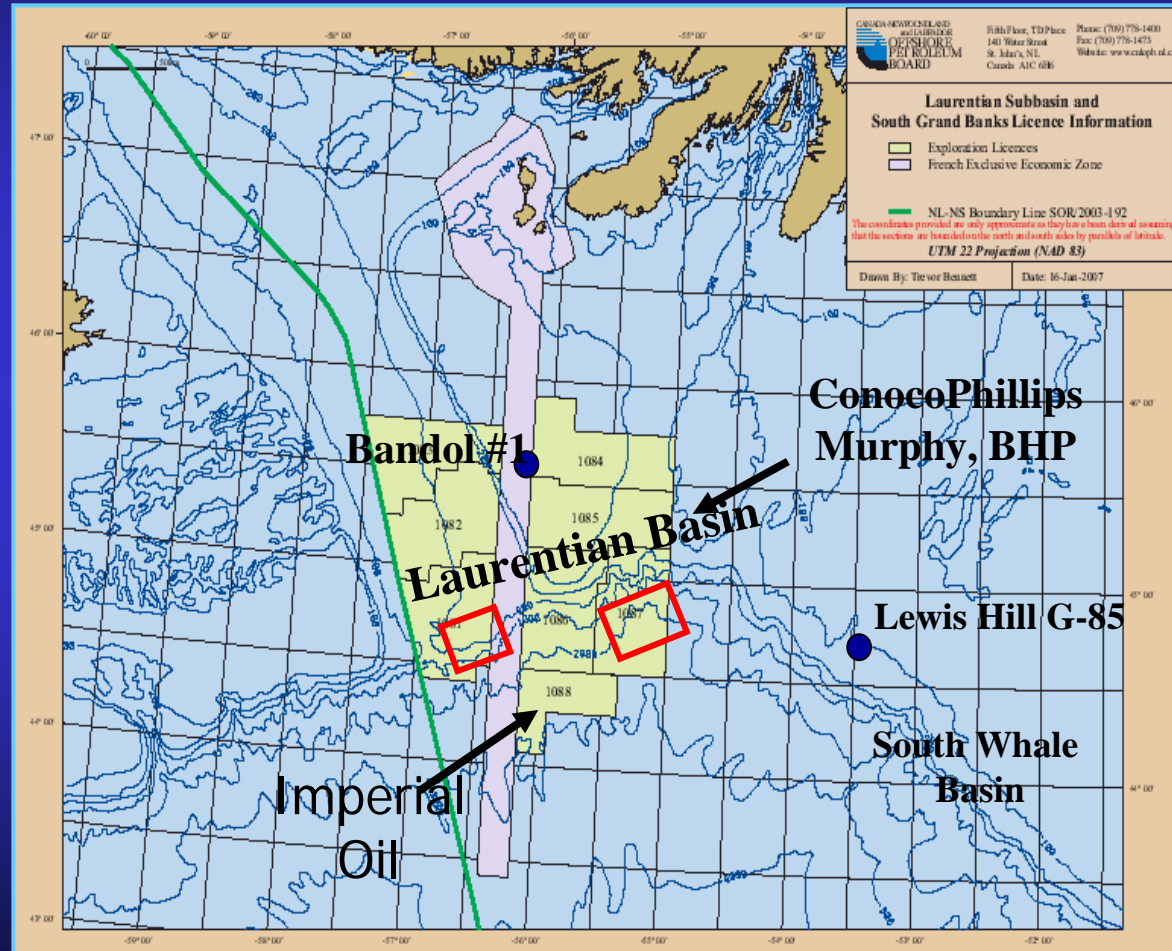


Post Moratorium ELs

Recent E&P Activity in Laurentian Basin

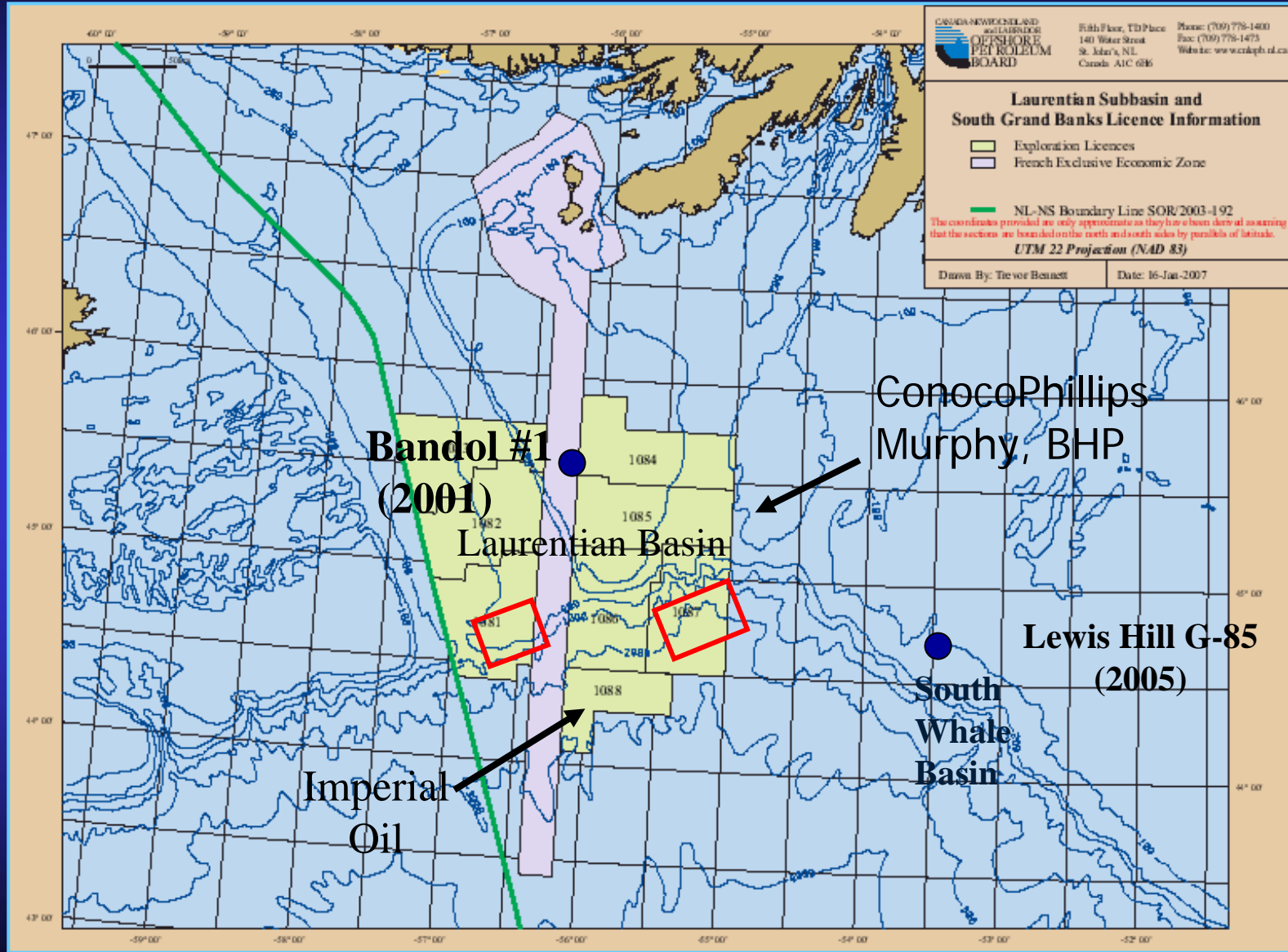
Exploration. Modern seismic surveys

1. TGS and GSI spec surveys - late 1990s early 2000s
2. ConocoPhillips and Murphy collects 3314 km of 2D seismic - 2004
3. Previous 20,000 km 2D data were integrated in a regional interpretation
4. ConocoPhillips et al. upgrade the lands and collects 2 large 3Ds on the slope and rise - 2005
5. 3D Surveys are depth migrated for correct identification of prospects
6. GSC reprocesses the 1984 & 1985 2D survey and makes it available to the public- 2007
7. MUN DES Basin Group performs geoscience research in Laurentian Basin with grants from ConocoPhillips and PPSC



 = 3D seismic surveys

2004-2008 Land Holdings and Recent Drilling

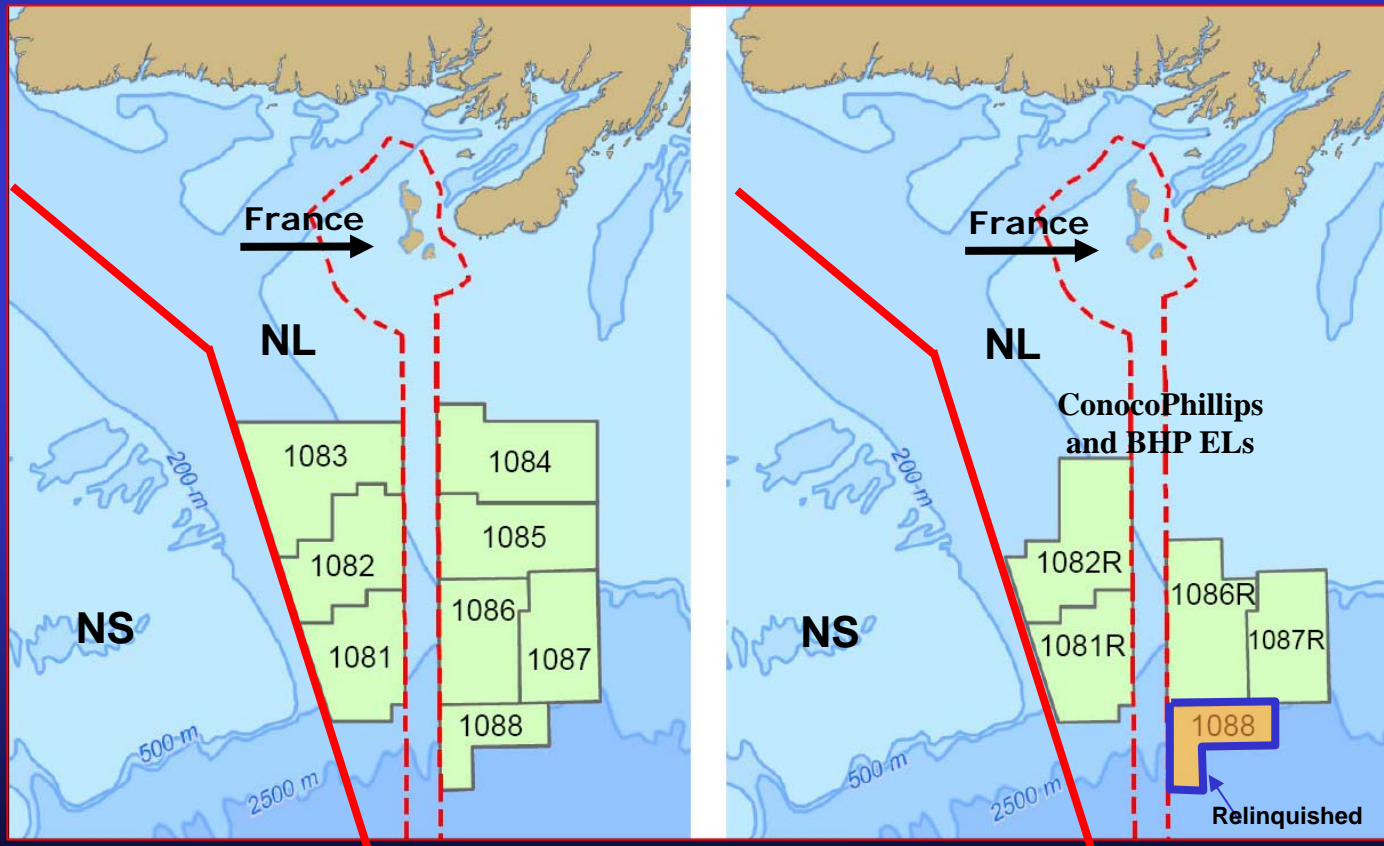


 = 3D seismic surveys

Recent E&P Activity in Laurentian Basin

Other events.

1. BHP farms in CP/Murphy ELs – 2004;
2. Farm out procedure starts in 2007 then stopped in 2008
3. Murphy withdraws from the area in the fall of 2008
4. In fall 2008: consolidation of ELs vs. drilling promissory note and acreage relinquishment



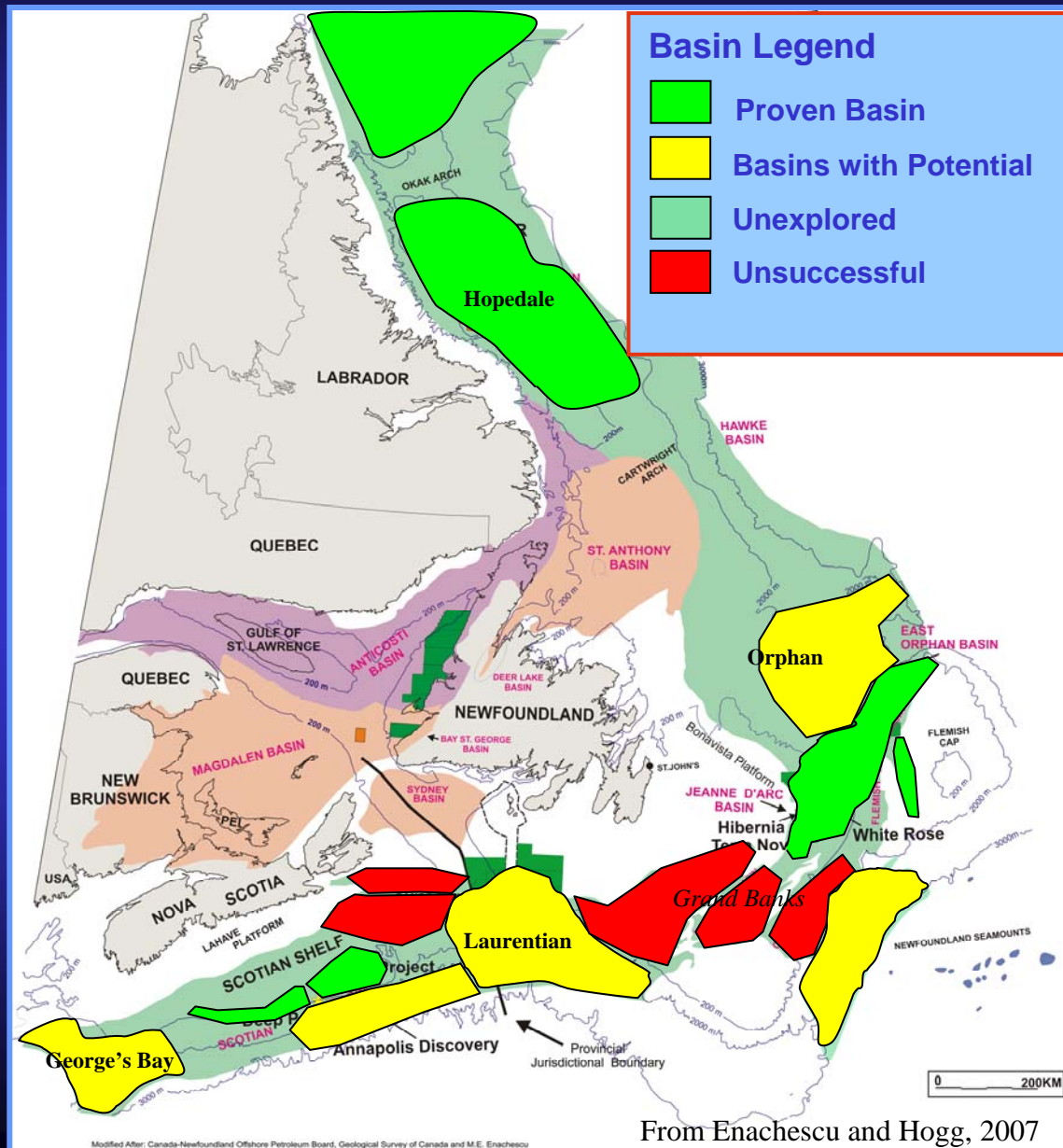
5. EL 1088 is relinquished by Imperial Oil 2009
6. Drilling by the partnership CP/BHP to commence November 2009

Present configuration: ELs 1081R&1082R West and 1086R&1087R East of the French boundary

3. Geology Overview of the Mesozoic Atlantic Basins

- Late Triassic-Early Jurassic rifting of Pangea created a chain of intra-cratonic basins generally oriented NE-SW and extending from Gulf of Mexico to Barents Sea; oblique and perpendicular rift branches (e.g. Bay of Fundy, Orpheus Graben, Aquitaine Basin, Viking Graben, etc.) also formed
- In Canada, the Tethys rift basin chain starts with George's Bay Basin in the south, stretches through Scotian shelf and slope basins and subbasins, continues with the Laurentian Basin, then with the shallow water Grand Banks basins and then extends to the Flemish and Orphan deepwater basins, and probably branches into the Labrador Sea
- Nova Scotia has mostly basins situated on a plate margin setting and directly opened to the North Atlantic Ocean since Middle Jurassic
- Laurentian Basin is located close to and on an important ocean/continent transform margin initiated in Middle Jurassic and active to Middle Cretaceous
- Grand Banks and Orphan Basin are situated on continental crust; only East and Northeast Newfoundland basins are located on a divergent margin
- Nova Scotia has mostly a gas prone petroleum system anchored by a predominantly terrestrial source rock (Verrill Canyon)
- Newfoundland has mostly an oil prone petroleum system anchored by a predominantly marine source rock (Egret Member of the Rankin Formation)

East Coast Mesozoic basins



- Repeated intra-continental Mesozoic rift stages, intermediary rift episodes and thermal sag
- Final rift becomes oceanic in Middle-Jurassic in Nova Scotia and Aptian-Albian in the Grand Banks
- Mostly a non-volcanic margin, with some volcanism present especially on southern Nova Scotia margin
- Thick sediment prism of 10-12 km
- Deformation of sediments mainly due to extension and salt tectonics; inversion is late and only a secondary mechanism for trap formation
- Deepest basins are: Sable, Laurentian and Jeanne d'Arc that can reach 12-20 km in their depocenter
- Late Triassic-Early Jurassic salt is generally thick and pervasive
- Coarse clastics deposition is widespread especially within deltaic episodes during Late Jurassic-Early Cretaceous
- Working petroleum systems exist in both Nova Scotia and Newfoundland and Labrador offshore

Scotian Basin

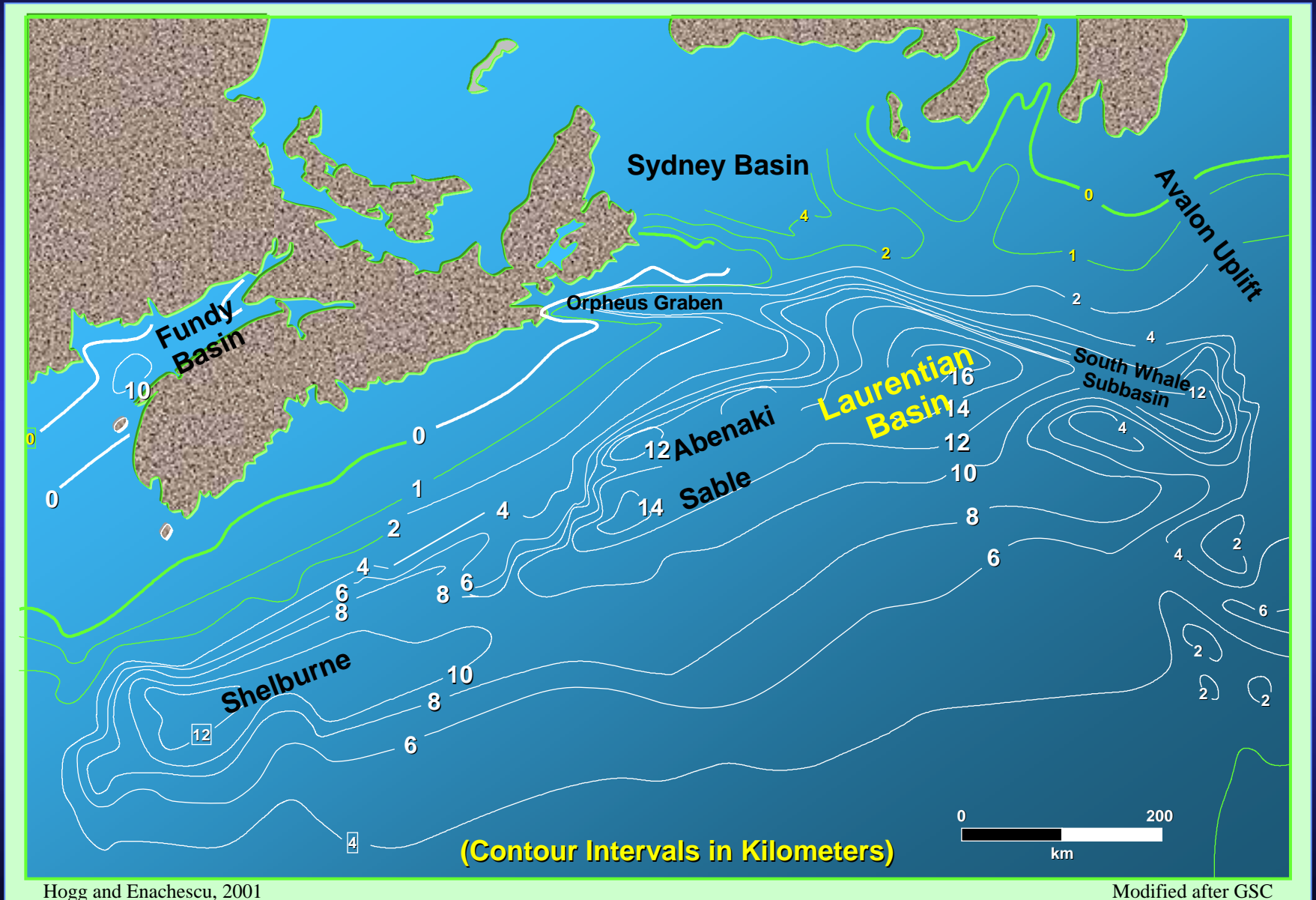


Scotian Shelf and Slope

Including Laurentian Basin

- Geologic evolution, lithostratigraphy, tectonic and structural setting and petroleum potential was recently studied by: Mukhopadhyay et al., 2000, 2003 and 2005; Kidston et al., 2002; Hogg, 2002; Shimeld, 2004 and 2005; Ing et al. 2004, Cummings and Arnott, 2005; Young, 2005 (unpublished MSc thesis) Kidston et al., 2005; Government of Nova Scotia Report, 2006
- Only several illustrative and conclusion slides will be introduced in this CFB presentation

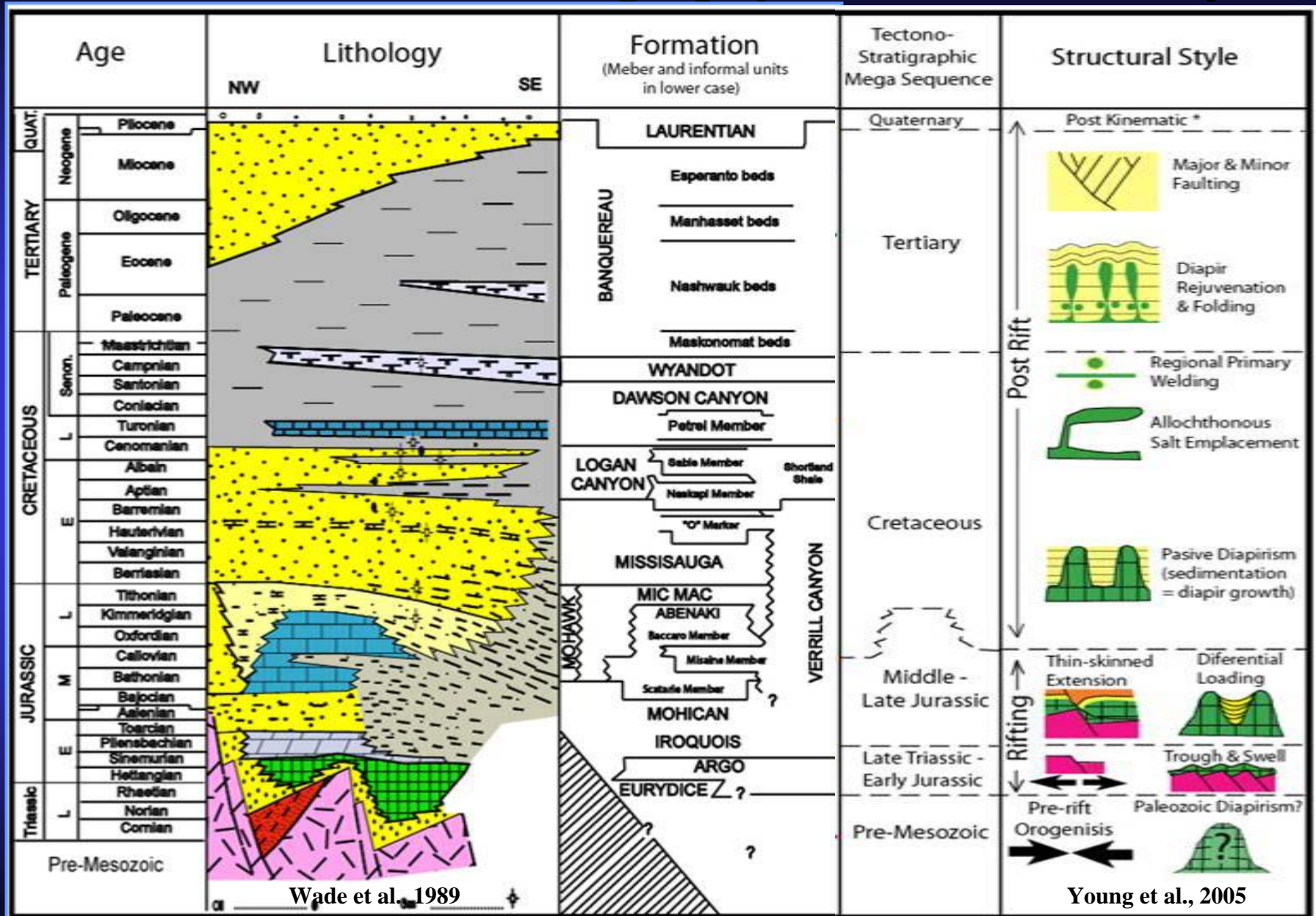
Total Sediment Thickness Scotian Basin



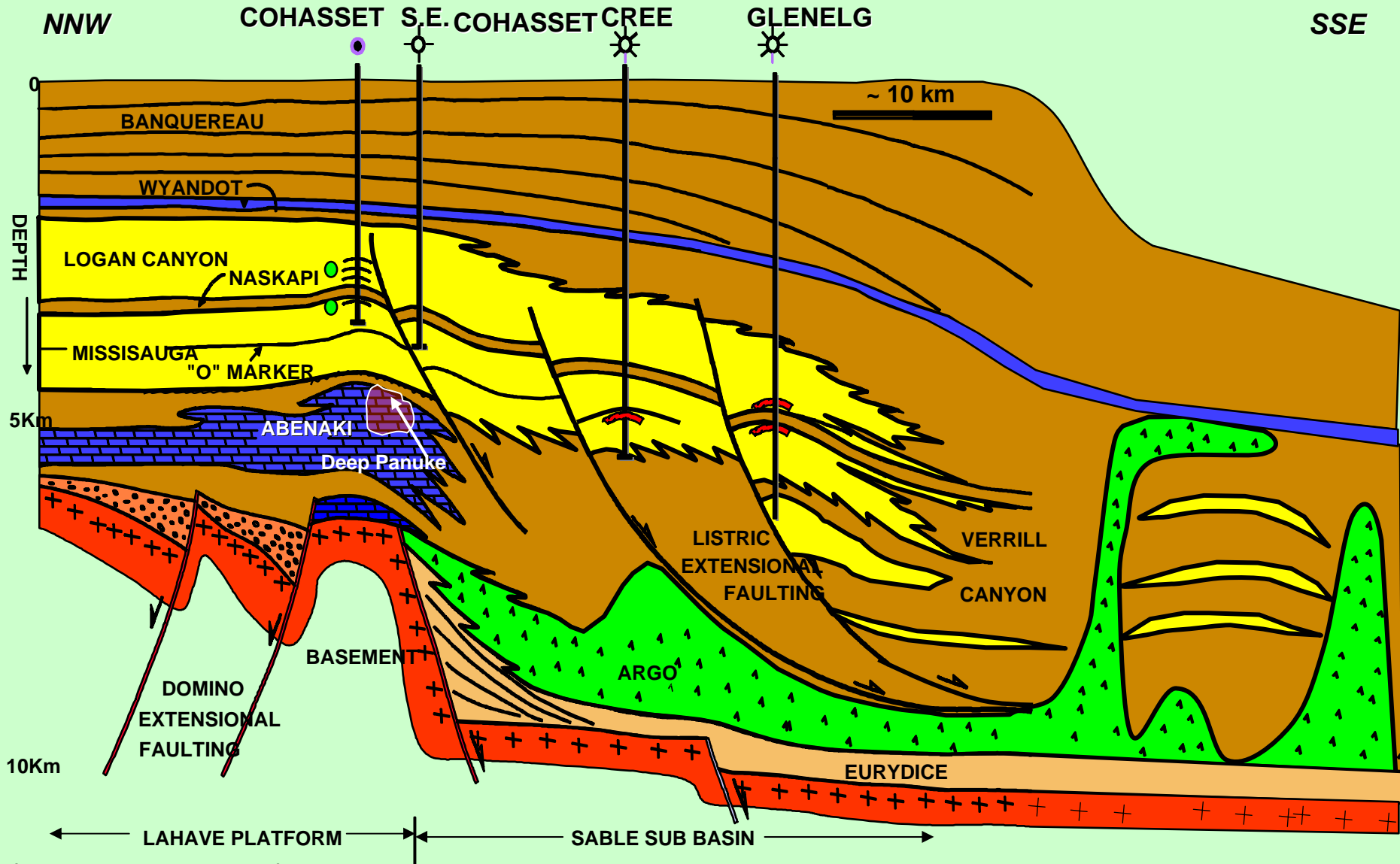
Hogg and Enachescu, 2001

Modified after GSC

Scotian Basin Lithostratigraphy and Structural Styles



Play Types Sable Subbasin and Environs



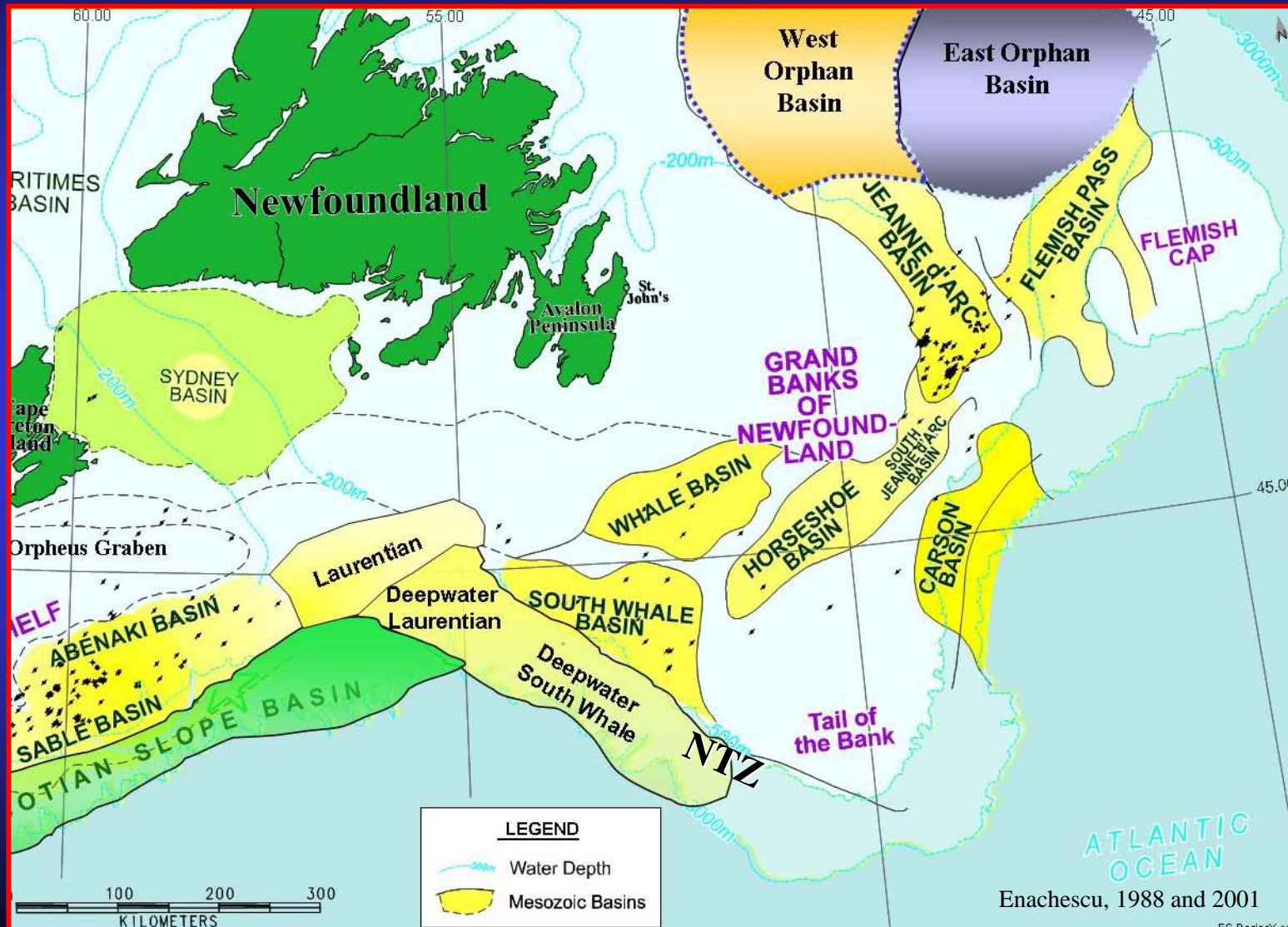
(From Hogg et al., 1999)

Enachescu and Fagan, NL DNR 2009

Recent Offshore Nova Scotia Exploration

- **Exploration took place on a number of distinct exploration trends:**
 - 1) On the Jurassic carbonate bank following the 1998 Deep Panuke discovery;
 - 2) In the Sable Basin, exploration continued on the existing, listric fault/rollovers/ geopressured zone around the present Sable Island gas project and
 - 3) Targeting Cretaceous and Tertiary turbidite reservoirs on the present day slope, where high hopes for large finds were placed (11 wells on the slope)
- **No major discovery in the past 10 years**
- **Small gas and condensate discovery at Annapolis G-24 in deep water (30 m pay in multiple zones)**
- **No exploration wells drilled since 2004**

Grand Banks Basins and Laurentian Basin



NTZ = Newfoundland Transform (Fracture) Zone

Enachescu and Fagan, NL DNR 2009

Regional Geology of the Grand Banks of Newfoundland

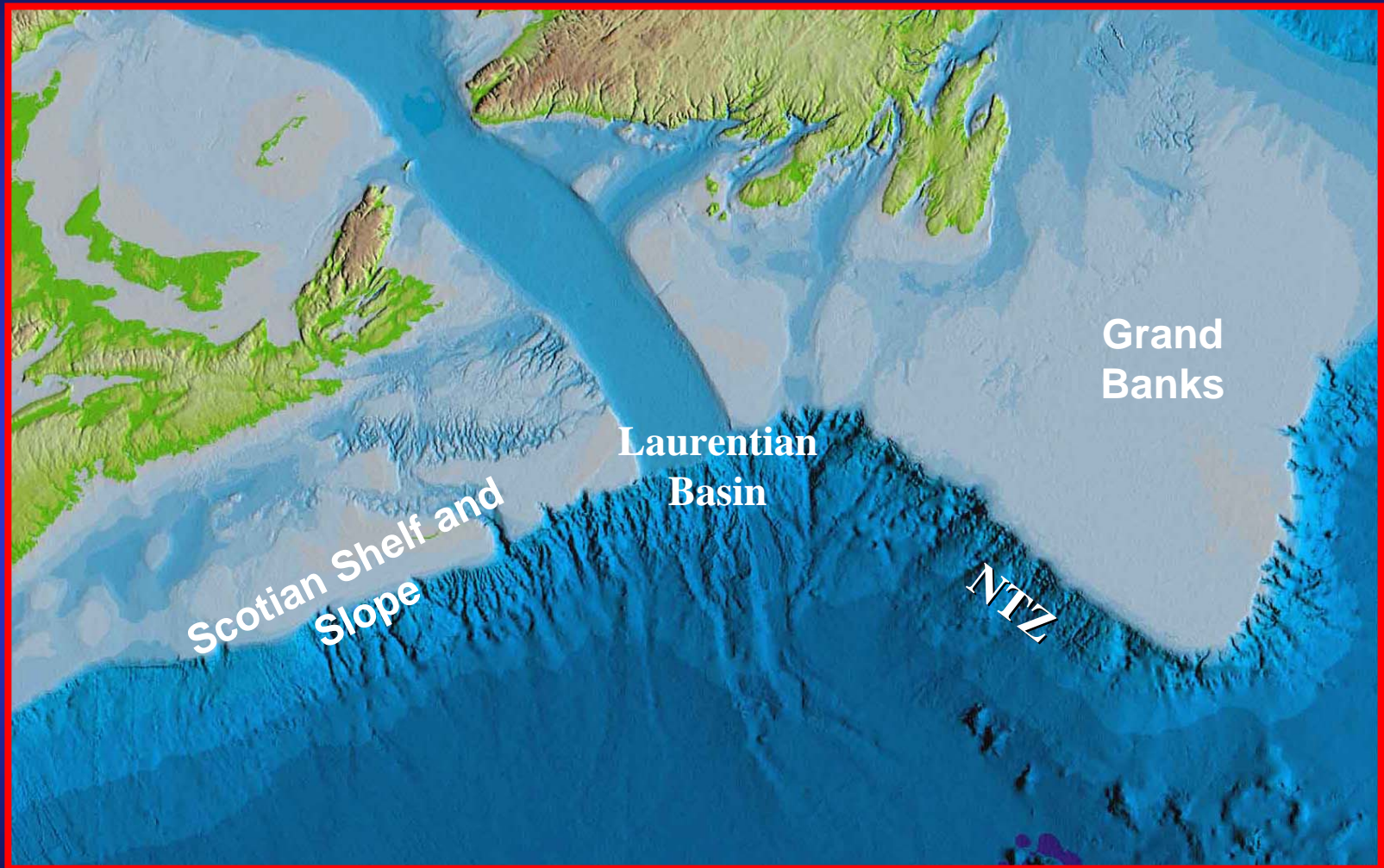
The geologic subdivisions of Grand Banks record the development of the:

- Lower Paleozoic American continental margins;
- Late Triassic intra-continental rifts incised on Grenville, Avalon and Meguma basement;
- Late Triassic - Early Jurassic massive salt and other evaporite deposition;
- Repeated phases of intra-continental extension (Late Jurassic - Early Cretaceous) and intervening subsidence which included source and reservoir rocks deposition;
- Formation of transitional crust;
- The late Early - Cretaceous break-up (oceanic rifting) from Iberia and later from West Ireland;
- Increased thermal subsidence in Late Cretaceous;
- Inversion at the end of Cretaceous - beginning of Tertiary;
- Post - Paleocene widespread subsidence and basin tilting

Grand Banks of Newfoundland

- Grand Banks tectonic-structural framework, geodynamic evolution, stratigraphy and petroleum potential were introduced in several web publications available at:
 - <http://www.nr.gov.nl.ca/mines&en/publications/offshore/>
and
<http://www.nr.gov.nl.ca/mines&en/oil>

4. Geology Summary of Laurentian Basin

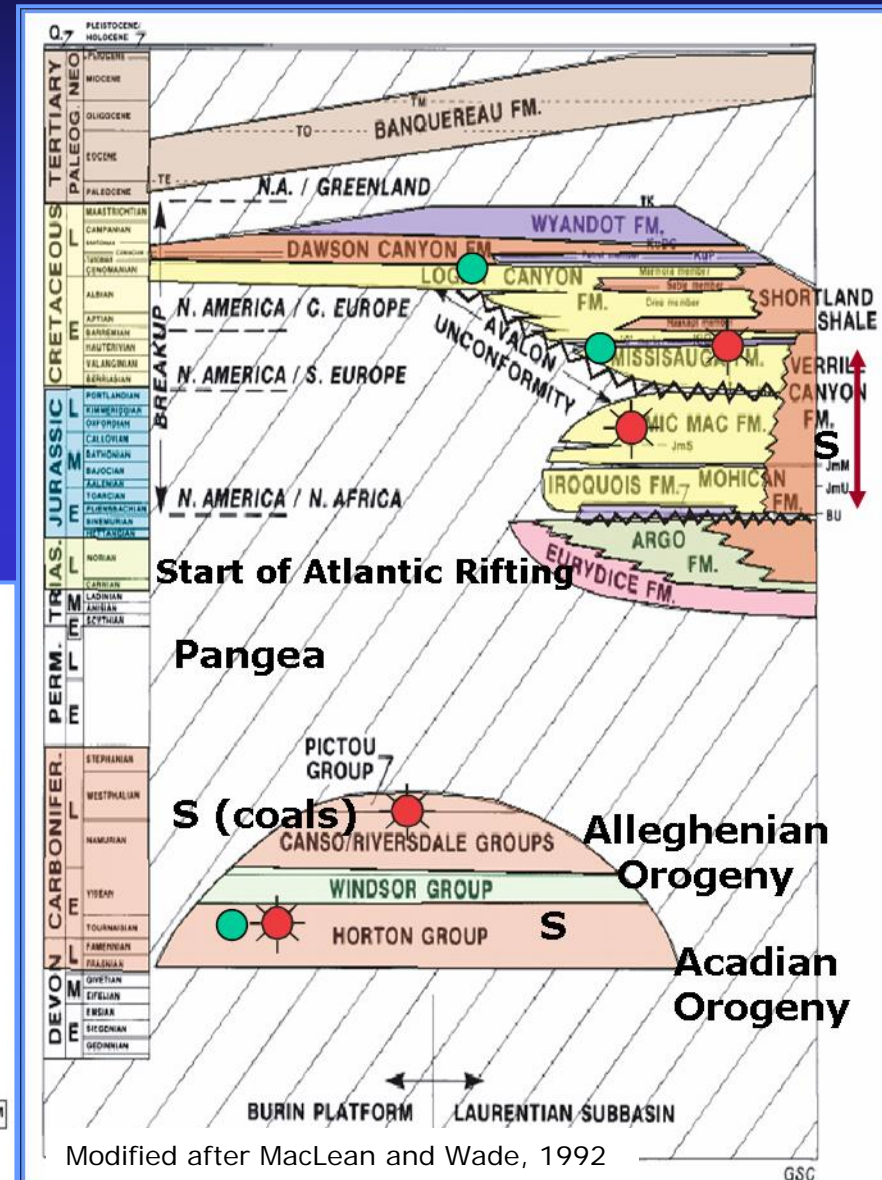
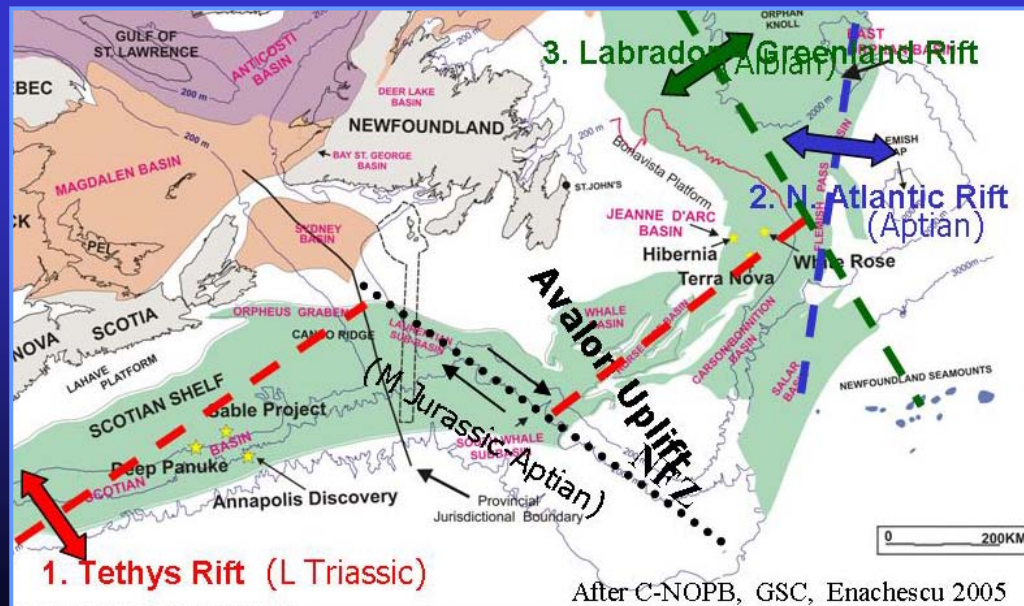


The basin is a hybrid Mesozoic basin developed between the Scotian Shelf and Slope, Grand Banks and along the Newfoundland Transform Zone (NTZ)

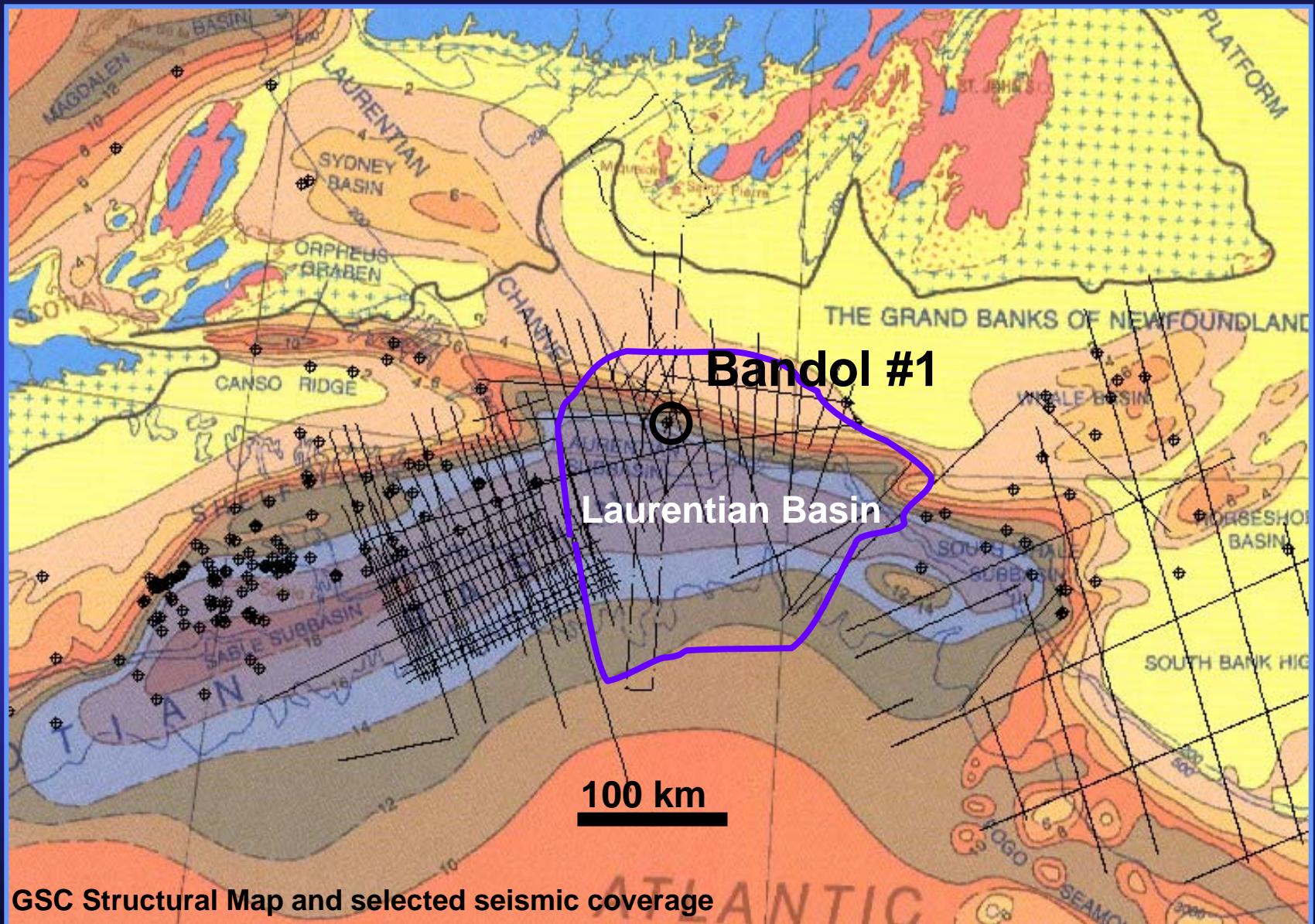
Laurentian Basin

- Laurentian Basin is not set apart from the surrounding offshore Nova Scotia and Newfoundland Mesozoic basins by any obvious geographical or geological features
- A major basin-bounding fault/hinge zone marks the boundary between predominantly Paleozoic Sydney Basin and the Mesozoic Laurentian Basin
- Cobequid-Chedabucto (CC) fault system runs east-west along the northern boundary of the basin and a branch of it along the Newfoundland Transform (Fracture) Zone (NTZ)
- During Late Triassic - Middle Jurassic the Laurentian Basin had common evolution and similar deposition regime with the Scotian Basin
- In Middle Jurassic - Early Cretaceous the Laurentian Basin was situated on a transfer margin being extended, trans-tensed and subsiding at the junction between the Nova Scotia margin transitional/oceanic crust and Grand Banks continental crust
- In Late Cretaceous - Tertiary the basin continue to subside, tilt and receive massive influx of sediment via Paleo-St. Lawrence River

Evolution of Atlantic Canada Margin and Laurentian Basin Lithostratigraphic, Tectonic and Petroleum Geology Chart



Scotian Basin/Laurentian Basin



GSC Structural Map and selected seismic coverage

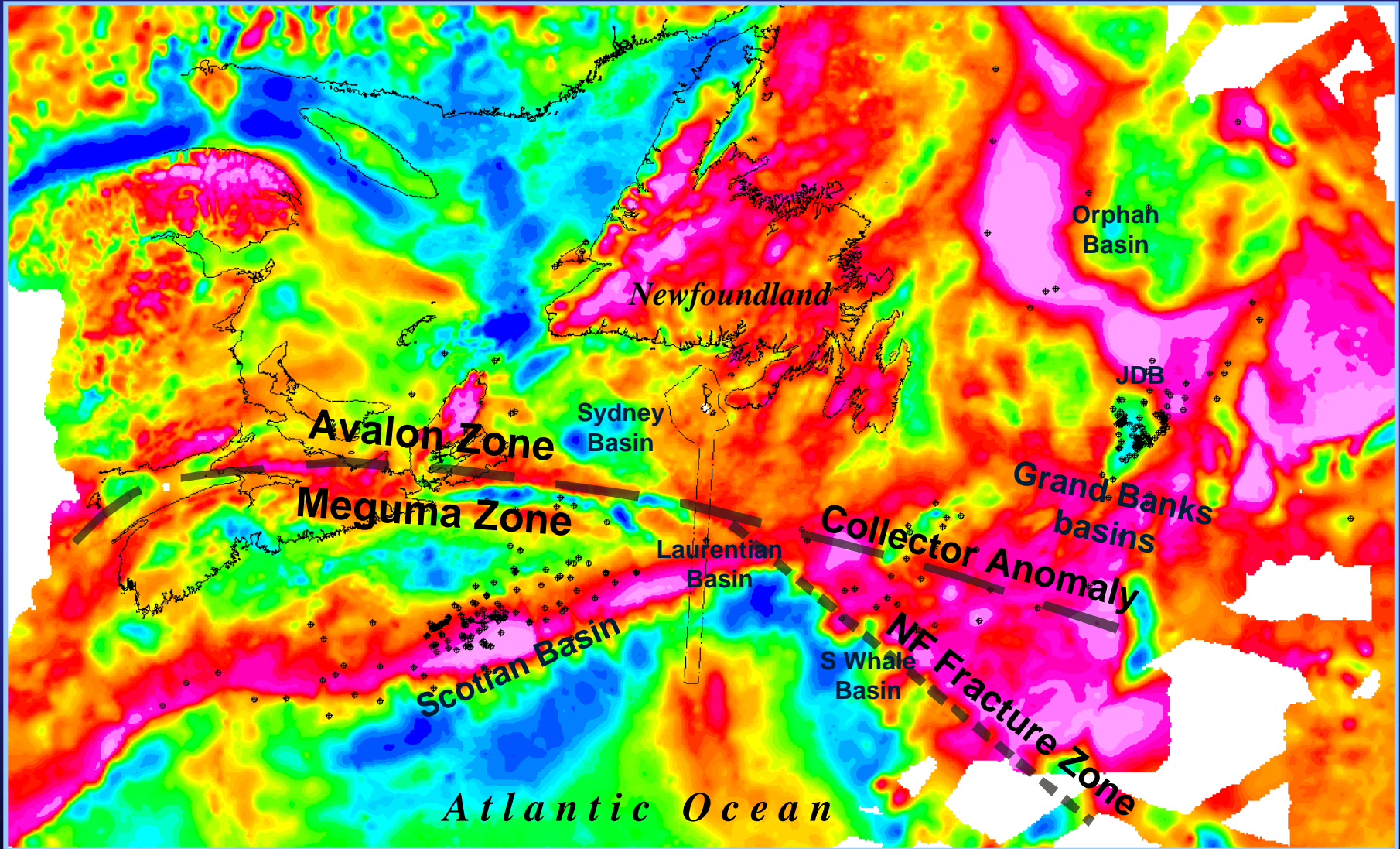
Only one well in the basin thus far!

Enachescu and Fagan, NL DNR 2009

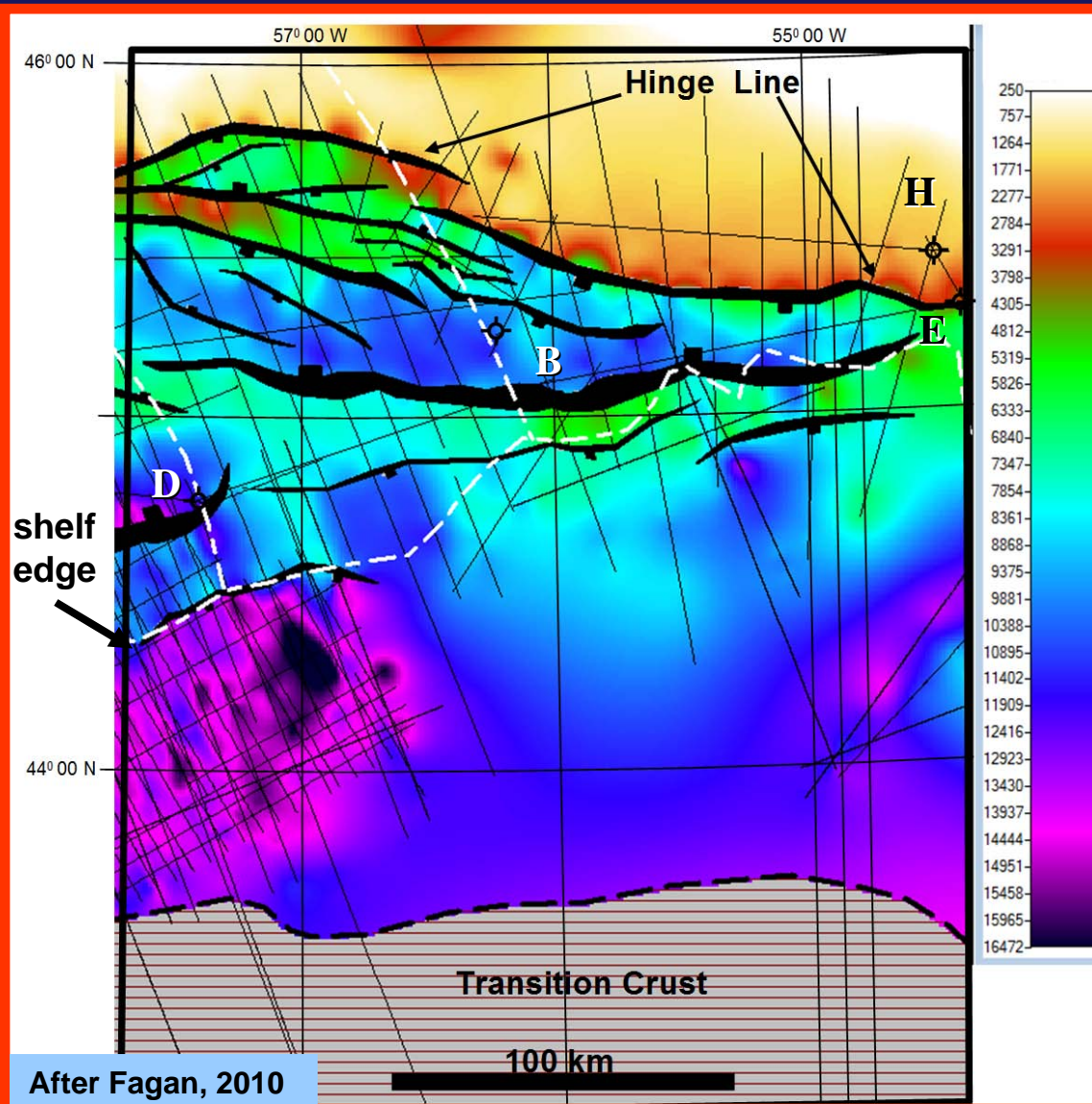
Laurentian Basin

- In the northern part of the basin the Mesozoic - Cenozoic cover is thin; large Paleozoic extensional and transtensional structures can be mapped under the Prerift Unconformity
- The northern basin margin was influenced by strike-slip movements along the Cobequid-Chedabucto Fault and its imbricates; a southeast trending, en echelon ridge and fault system is shown by seismic and potential field data (Fagan and Enachescu, 2007; Fagan, 2010)
- Further south, a large ridge (or perhaps series of coalescing smaller ridges) are running roughly east-west near the modern shelf edge
- Under the slope, the prerift section drops off to greater depths. Large and complex Mesozoic structural and stratigraphic features are observed; a number of structures are salt cored;
- Jurassic sedimentary succession is anomalously thick in this basin when compared to other Atlantic margin basins
- The Bandol #1 well was drilled in 2001 on a shelf location and in French territory; while it was said to have found “hundreds of meters” of reservoir, the well remains confidential until 2011. This is the only existing well in a 60,000 km² area

Atlantic Canada Gravity Map

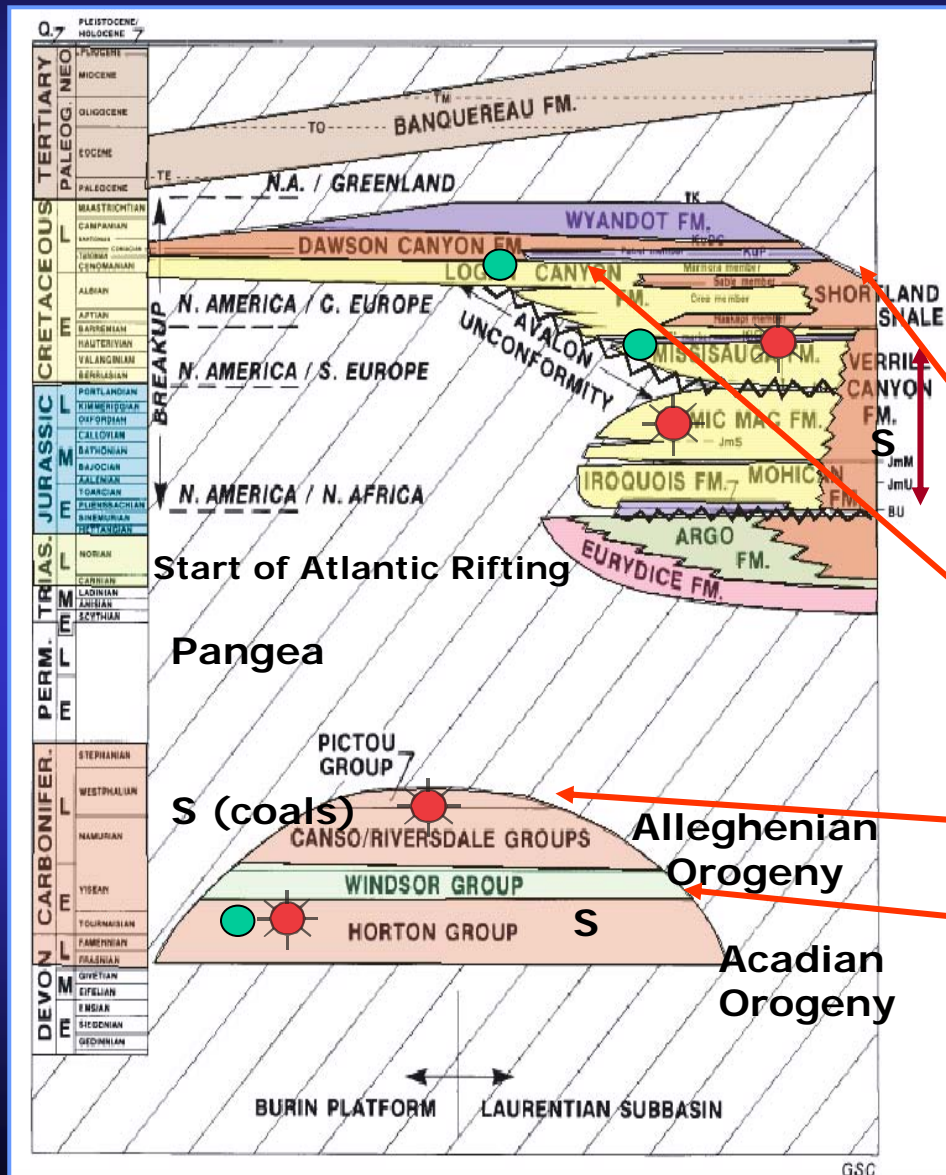


Laurentian Basin

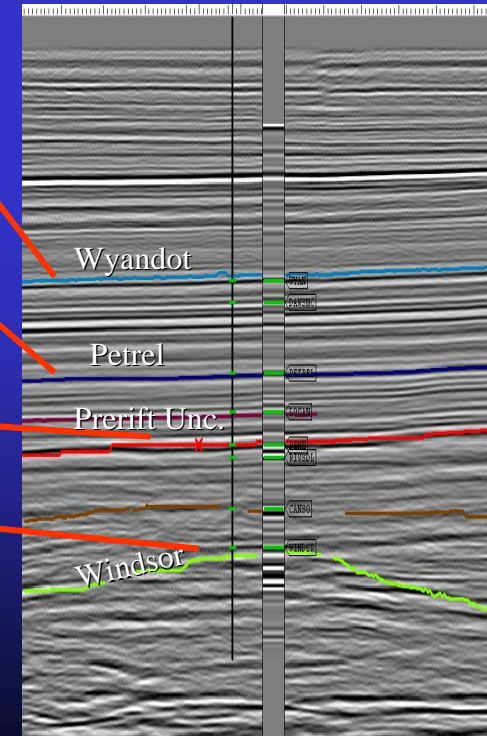


- Major faults are in black
- Shelf edge and Laurentian Channel are dashed white lines
- Colour legend in meters
- Black lines are seismic line tracts from public domain and proprietary grids
- Significant Exploration wells are :
 - B = Bandol #1
 - H = Hermine E-94
 - E = Emerillion C-56
 - D = Dauntless D-35

Laurentian Basin Stratigraphic Chart



- Adapted after MacLean and Wade, 1992
- Other lithostratigraphic charts are in circulation, all adapted from offshore Nova Scotia



Laurentian Basin

The basin can be divided into two sectors:

- 1. Paleozoic Basin.** This sector is located north of a roughly east west trending hinge line (traced by a series of down to the basin faults that coincide with the Cobequid-Chedabucto (CC) fault system (MacLean and Wade, 1992; Fagan and Enachescu, 2008)). North of the hinge zone there is a thin Mesozoic cover over a well imaged Carboniferous sequence. The Mesozoic is in turn overlain by a Cenozoic wedge that thickens basinward from a zero edge. In this sector there are mainly large Paleozoic prospects and leads
- 2. Mesozoic Basin.** This sector is located south of the CC fault system. The Mesozoic section south of the hinge zone is deep and complexly structured. The Mesozoic basin was formed by extensional tectonics during the rifting of the Nova Scotian margin and during transtension along the NTZ. The Mesozoic - Cenozoic extensional structures in this area has been subsequently deformed by localized strike slip movement, inversion, oblique extension and salt tectonism. A Carboniferous sequence may be also be present under the deformed Mesozoic basin. In this sector there are large Jurassic and Cretaceous prospects and leads

5. Petroleum Geology of Laurentian Basin

- **Source Rocks**
- **Reservoir Rocks**
- **Seals**
- **Hydrocarbon Traps**
- **Maturation and Migration**
- **Hydrocarbon Plays and Risks**
- **Verrill Canyon Petroleum System**

Petroleum Geology

- Laurentian Basin can be considered a part of the larger Scotian Basin which is a proven oil and especially a proven gas basin
- In spite of being adjacent to petroleum discoveries on the Scotian Shelf, the Laurentian Basin remained unexplored due to a long lived exploration moratorium that has only recently been lifted
- The basin's infill contains a structured synrift rock successions (includes evaporates, carbonates and coarse and fine clastics) ranging in age from Late Triassic to Middle Jurassic - **Extensional Stage** sedimentary sequence
- The early sedimentary fill contains the Argo Salt that later became mobile and created intrusions and salt induced structures in the overlying sediments
- Late Jurassic to Albian sedimentary succession developed during the basin's **Transtensional Stage** and is also structured and affected by halotectonics
- A multitude of hydrocarbon traps were formed during extension/transtension and prolonged halotectonics

Petroleum Geology

- Late Cretaceous-Tertiary contains a relatively thick, parallel bedding cover of sedimentary rocks (mainly fine clastics and thin chalk and carbonates) that was deformed by gravity sliding and intruded by salt. This constitutes the post-transension (early syndrift) or the early **Thermal Subsidence Stage** sedimentary sequence
- Oil prone source rocks are present in Late Jurassic to Early Cretaceous; the potential for other source rocks is recognized within the Paleozoic basement, Early and Late Cretaceous and Early Tertiary sequences
- Reservoirs are present in all stages but good quality sandstone and carbonates reservoirs are quite localized. Best sandstone reservoirs were encountered on the shelf in the Sable Basin; thick reservoir sands were intersected by Bandol #1 well
- Submarine fans were interpreted on seismic data. A modern, very large turbiditic flow was produced in the Laurentian Basin during the 1929 earthquake. However, up to now no major development of turbidite or basin floor fans were intersected by the deepwater wells drilled on the present day slope of Scotian Basin
- An early petroleum assessment by GSC estimated that the basin could contain recoverable resources of 8-9 Tcf gas and 600 to 700 MMbbls

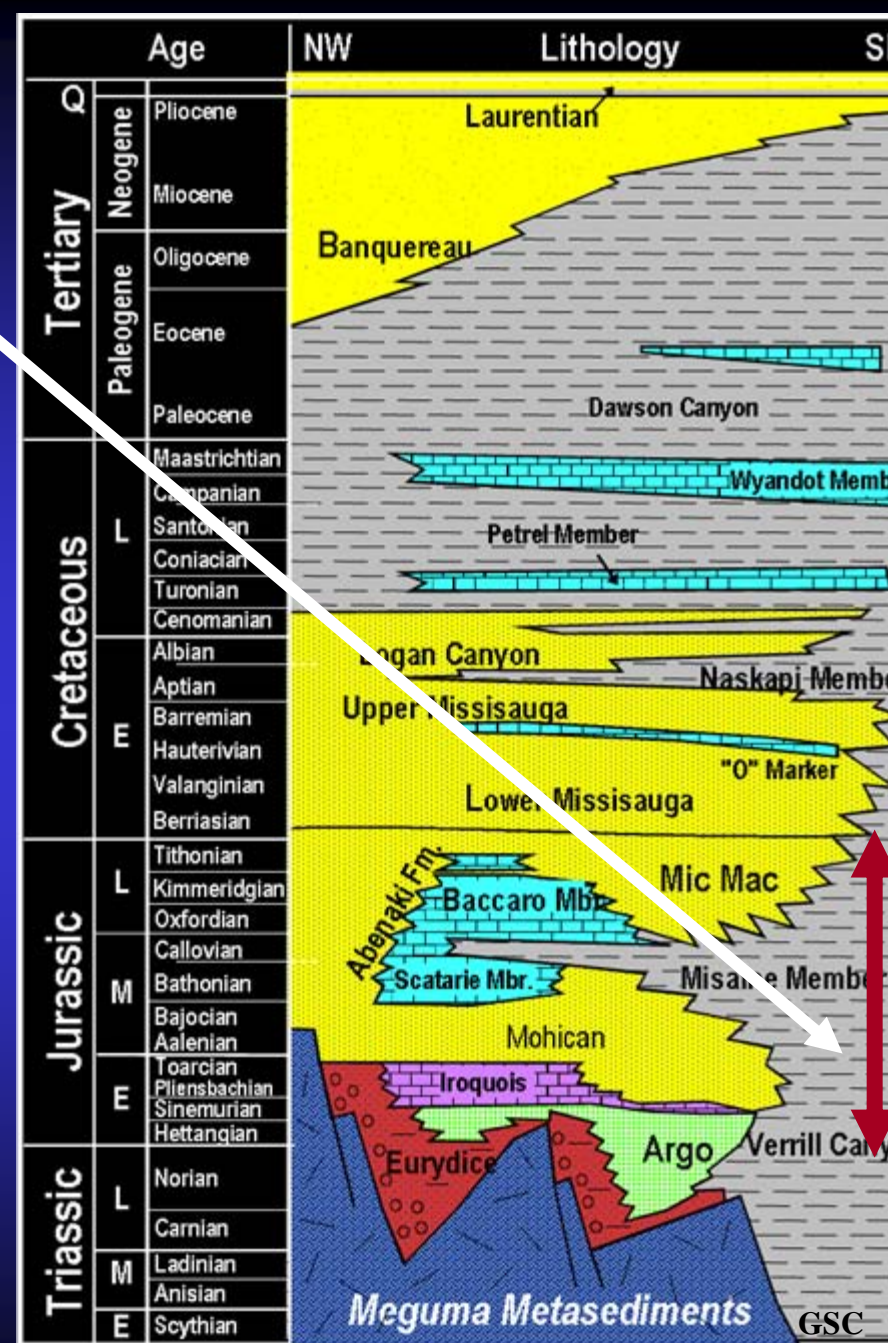
Late Jurassic Aged Verrill Canyon Source Rock

Abundant Type III, gas prone source rock generally with low TOC

- Mostly shales with 2-4 wt% total organic carbon
- May be equivalent to the prolific Kimmeridgian source rock in the Jeanne D'Arc and Flemish Pass basins
- Generated most of the gas, condensate and oil found in the Scotian Basin
- The predominant organic matter in the Verrill Canyon Formation is terrestrial formed Humic Kerogen (Type III) and is gas prone
- There are oil fields and significant oil shows offshore Nova Scotia which indicates that there may be pockets of more marine Liptinic (Type II) organic matter

Verrill Canyon Formation Shales

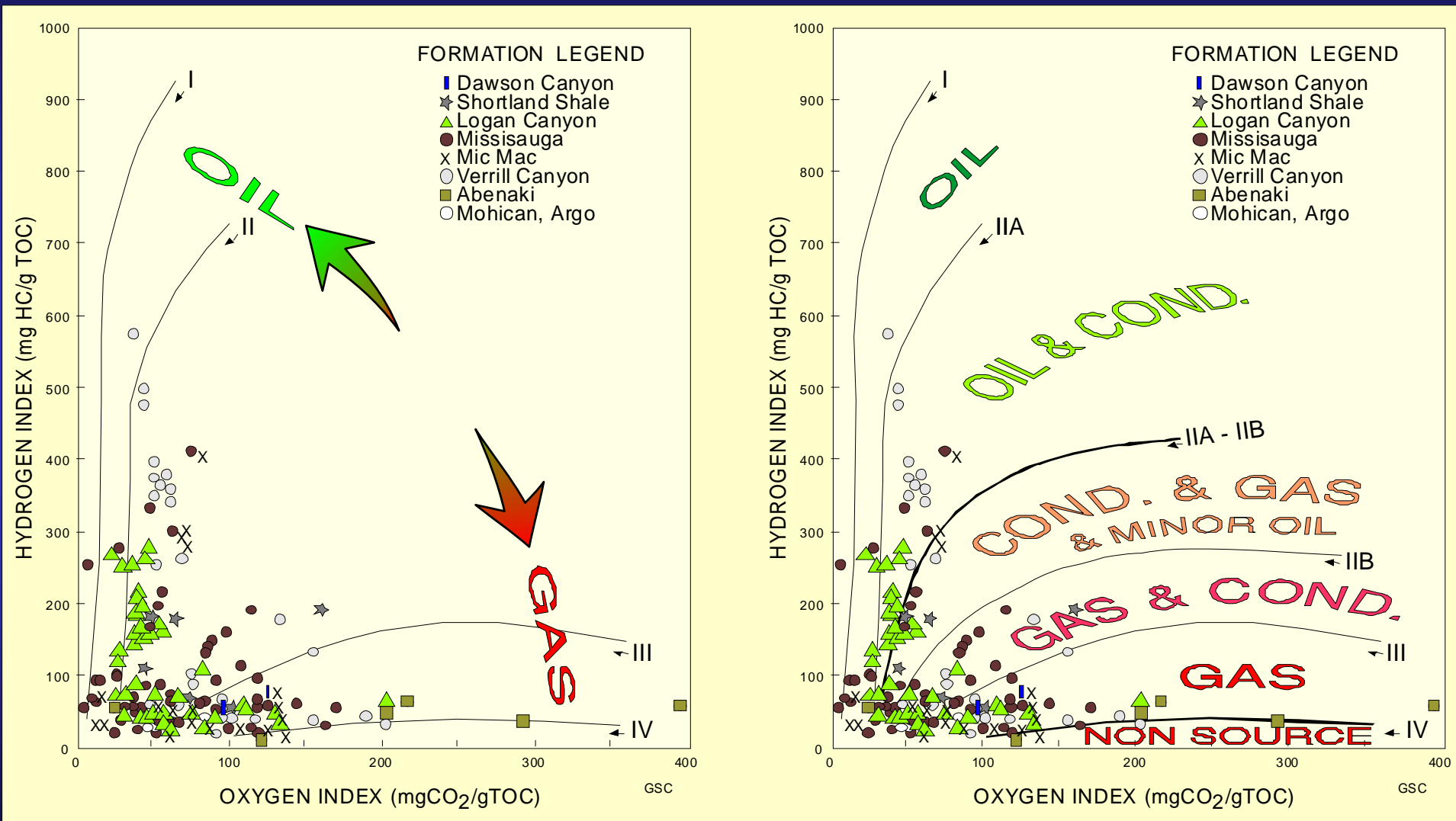
- Deposited in the prodelta, outer shelf, and continental slope settings and ranges in thickness from 360 m in the SW Scotian Basin to more than 915 m in the NE
- Low organic carbon content
- Contains abundant herbaceous, woody, and coaly material
- Terrestrially derived Type III organic matter
- Source rocks for most of the gas and condensate in sandstone reservoirs of the Mic Mac, Missisauga, Logan Canyon, and Dawson Canyon formations



Source Rock

- Within the larger Laurentian Basin there may be Late Jurassic depressions that were isolated from the main ocean and have accumulated a more marine source rock similar to the Egret Member (Type II or Type II – III; see next slide)
- Other intervals including section of Verrill Canyon shale may have more marine derived kerogen and generate oil and condensate
- In some areas a Paleozoic source rock (similar to sources in the adjacent Maritimes Basin) may also be a contributor to gas generation
- Light oil in reservoirs has been previously found on Scotian Shelf wells and produced at COPAN project; other wells have intersected oil filled beds

Scotian Shelf Source Rock



After Mukhopadhyay and Wade, Pers. com.

Reservoirs

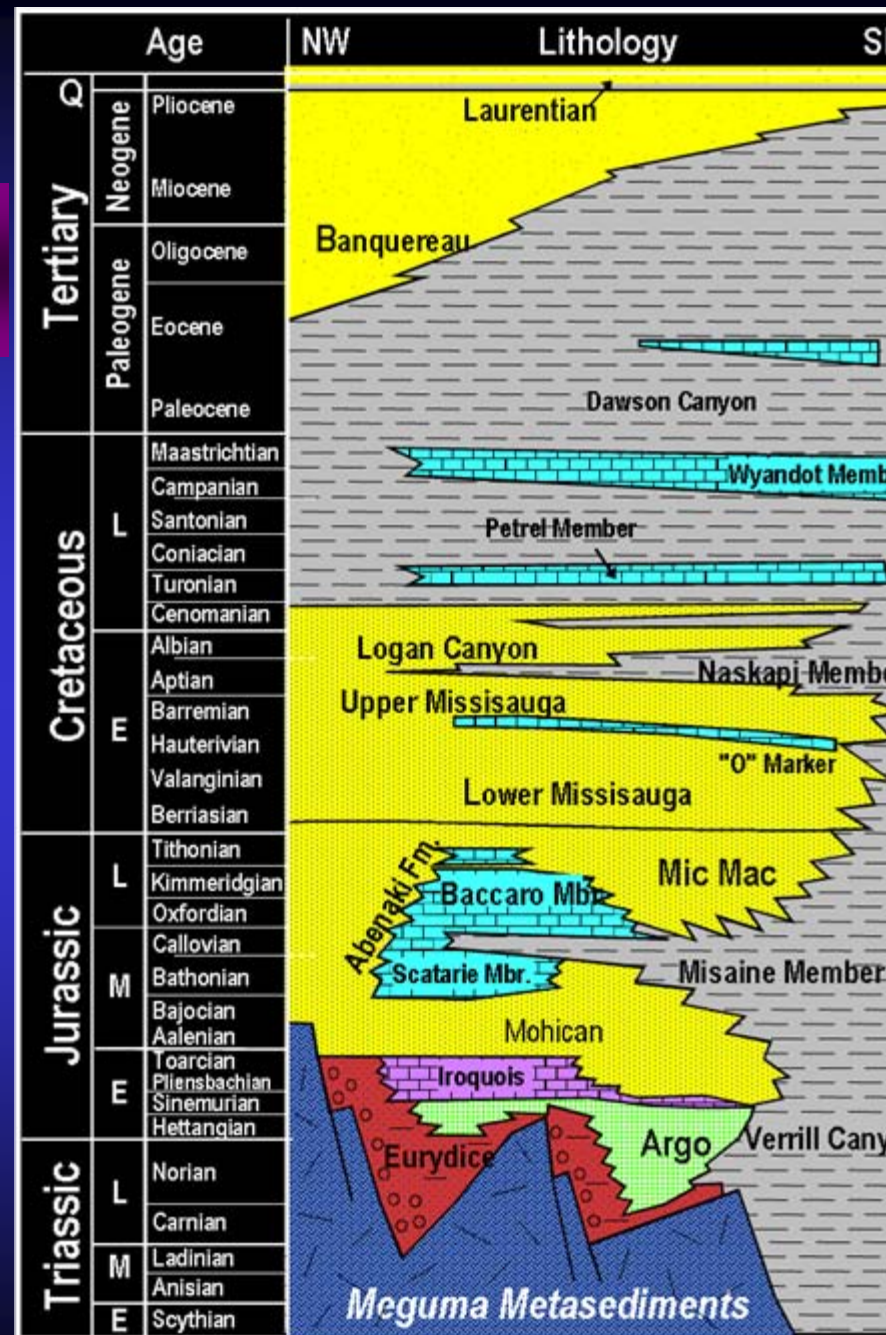
Reservoirs rocks in the Scotian Basin are predominantly high porosity - high permeability sandstones of Late Jurassic to late-Early Cretaceous age. Similar reservoirs and additionally turbidite sands should be present in LB which is a major coarse clastics depocenter. Dolomitized carbonates similar to Deep Panuke reservoir may locally develop in LB.

- Stacked sandstone intervals within the Jurassic Mic Mac and Cretaceous Lower and Upper Missisauga and Logan Canyon formations are proven quality reservoirs. Most of these reservoirs are alluvial or deltaic on the shelf and slope
- The targets in the deepwater are equivalent of these sandstones deposited as turbidites, slope and basin floor fans, minibasins, channels, etc., situated either between salt swells or deformed by later salt movements
- Good reservoirs are found in the Scotian Basin at the carbonate platform margin where reefal development and dolomitization due to solution on deep faults took place. Porosities range from 3 - 40% with permeabilities of one md to several darcies, with net pay values ranging from 30 to 100 m. This “Deep Panuke”-type reservoir should be present on places within the Laurentian Basin
- Early Tertiary sequence has a real and effectively untested potential for large oil and gas pools (especially in deep water)

Seals

Numerous good seal intervals were found in Scotian Basin wells.

- Seal should not be a problem within the Laurentian Basin as the Extensional, Transtensional and Thermal Subsidence stages contain successions of very fine clastics, tight sandstones and carbonates
- Petroleum accumulations on Nova Scotia margin were sealed by Misaine Mbr, Naskapi Mbr and inter-formational seals
- Dawson Canyon mudstone and clays form an excellent regional seal
- Also Argo Salt is a perfect seal when forms hanging walls and canopies above the younger clastics
- Excellent regional seals are also provided by the “O”, Petrel and Wyandot carbonate intervals

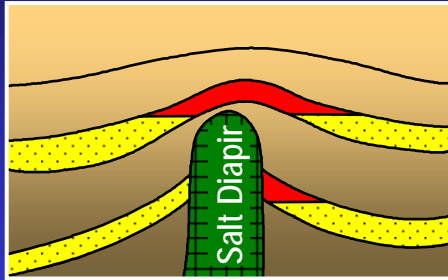


Hydrocarbon Traps

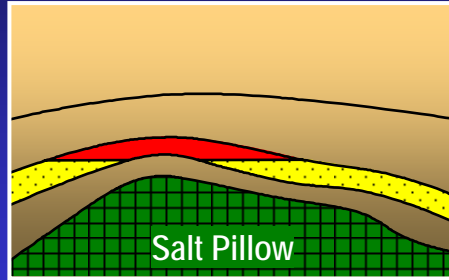
Structural traps in Laurentian Basin are associated with 1) rifting of the Atlantic Margin, 2) transtension and inversion, 3) subsidence and tilting, and 4) movement of the Argo salt

- The main structural trap types are extensional anticlines, roll-overs, faulted anticlines, faulted and tilted blocks and elongated horsts
- Numerous salt induced structures such as pillows, domes, diapirs, ridges, allochthonous teardrops, turtle anticlines and salt canopies are common
- CC Fault and its associates are strike slip faults and serve as northern boundaries for the basin. Several ridges and anticlines are mapped along this major lineament
- The great majority of faults are down-to-basin, listric normal faults, but some transfer faults and antithetic faults form horsts, ridges and trap-door features
- Local inversion due to transtension and halokinesis is also trap forming
- Stratigraphic traps are widespread. Paleo-valleys, basin margin and basin floor fans are abundant in the basin and contain some discovered resources

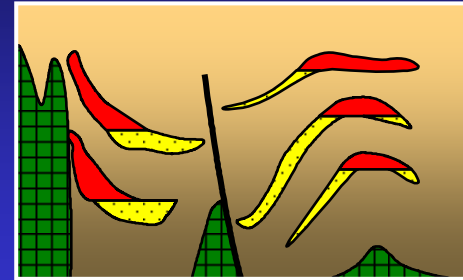
Scotian Basin Trap Styles



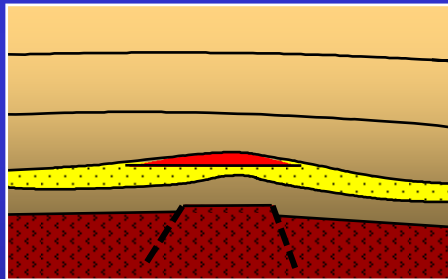
Diapirs Crests & Flanks



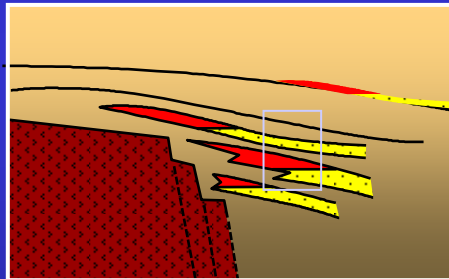
Deep Seated Structures



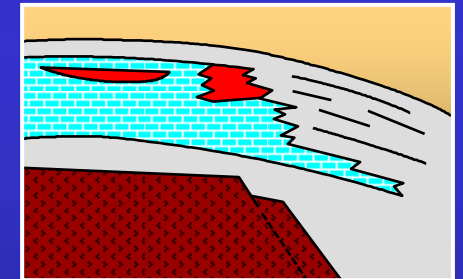
Submarine Fans
(Part Structural, Part Stratigraphic)



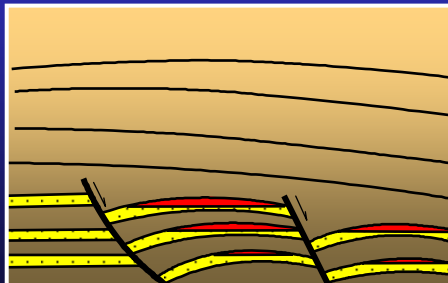
Basement Related Structures



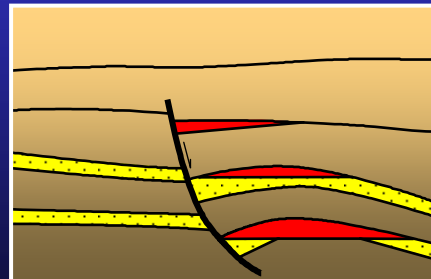
Stratigraphic Traps



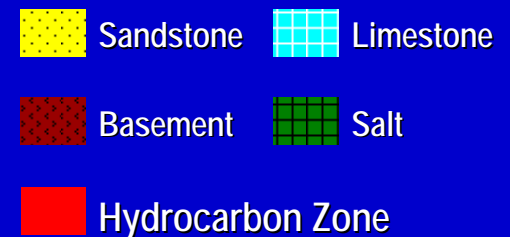
Carbonate Bank



Deep Seated Geopressedured
Structures



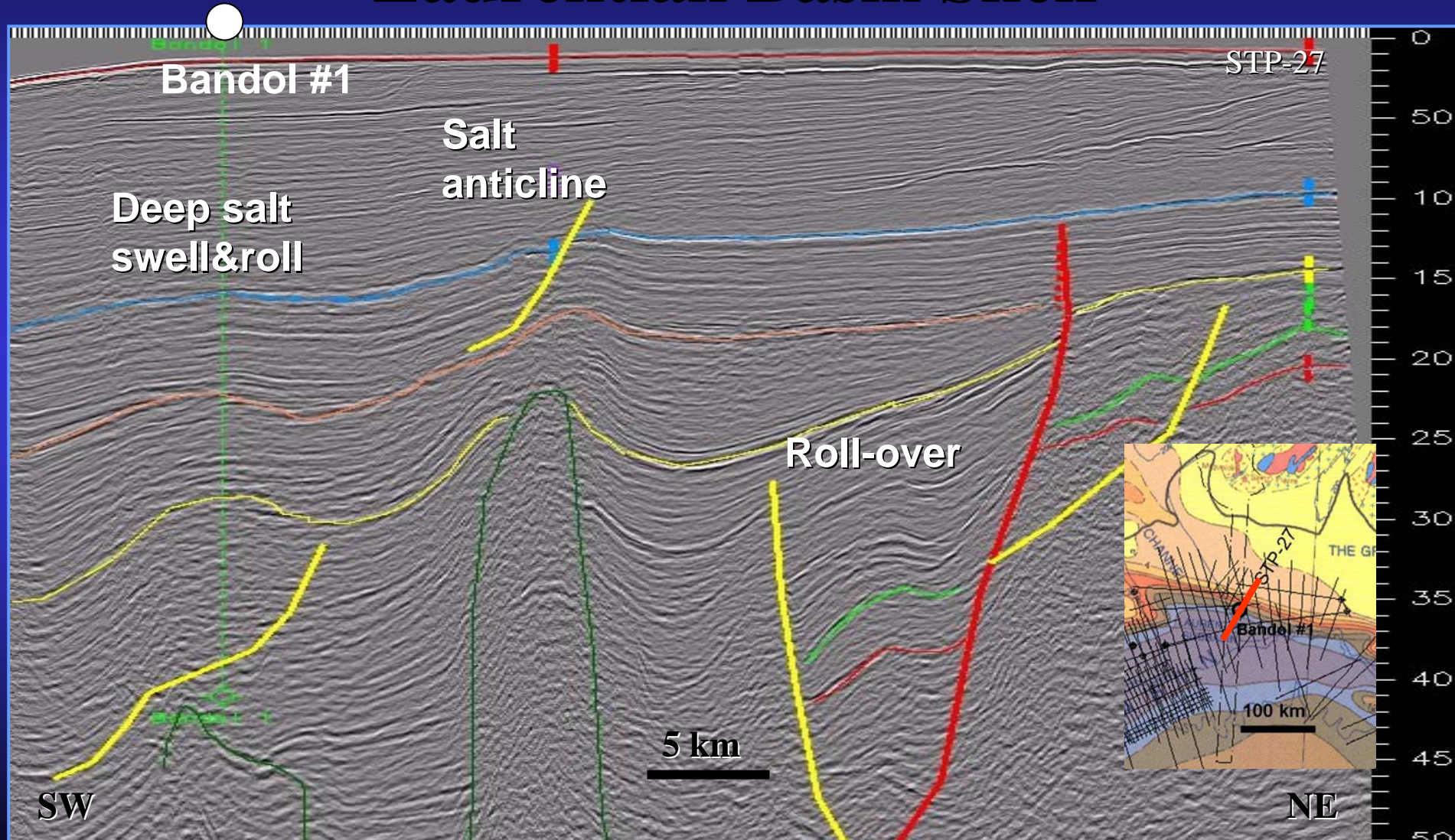
Rollover Anticlines



Hogg et al., 1999; Modified from Wade, 1989

Enachescu and Fagan, NL DNR 2009

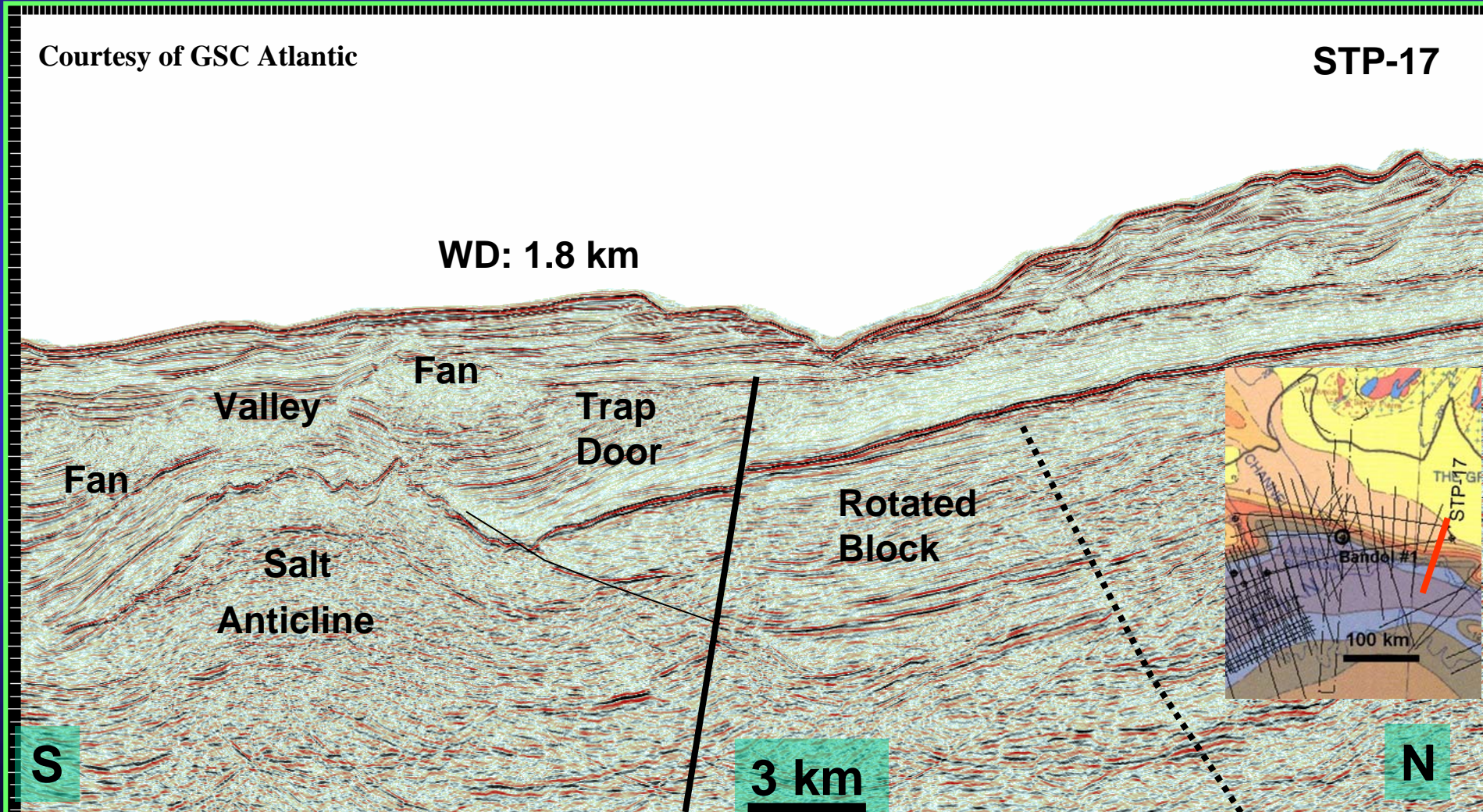
Examples of Hydrocarbon Traps Laurentian Basin Shelf



Examples of Hydrocarbon Traps Laurentian Basin Slope

Courtesy of GSC Atlantic

STP-17



Maturation and Migration

- Verrill Canyon shale maturation starts in mid-Early Cretaceous and continue into Tertiary
- Petroleum expulsion starts at 3000 m and ends at 6000 m
- Top of oil generation zone currently lies 4 km below the shallow regions of the continental shelf and is much deeper on the slope and upper rise
- Expulsed hydrocarbons have migrated mainly vertically, predominantly along the numerous extensional faults and also using sand carrier beds
- The oils found on shelf appear to be generated from a more mature, probably deeper source located on the slope
- Lateral migration occurred locally along basin flanks and on the slope
- Other source rocks, including Paleozoic shales and coals may also be mature and generate hydrocarbons
- Recent studies indicate a much larger variation of composition, quality and degree of maturity of Late Jurassic and Early Cretaceous Verrill Canyon Shales:

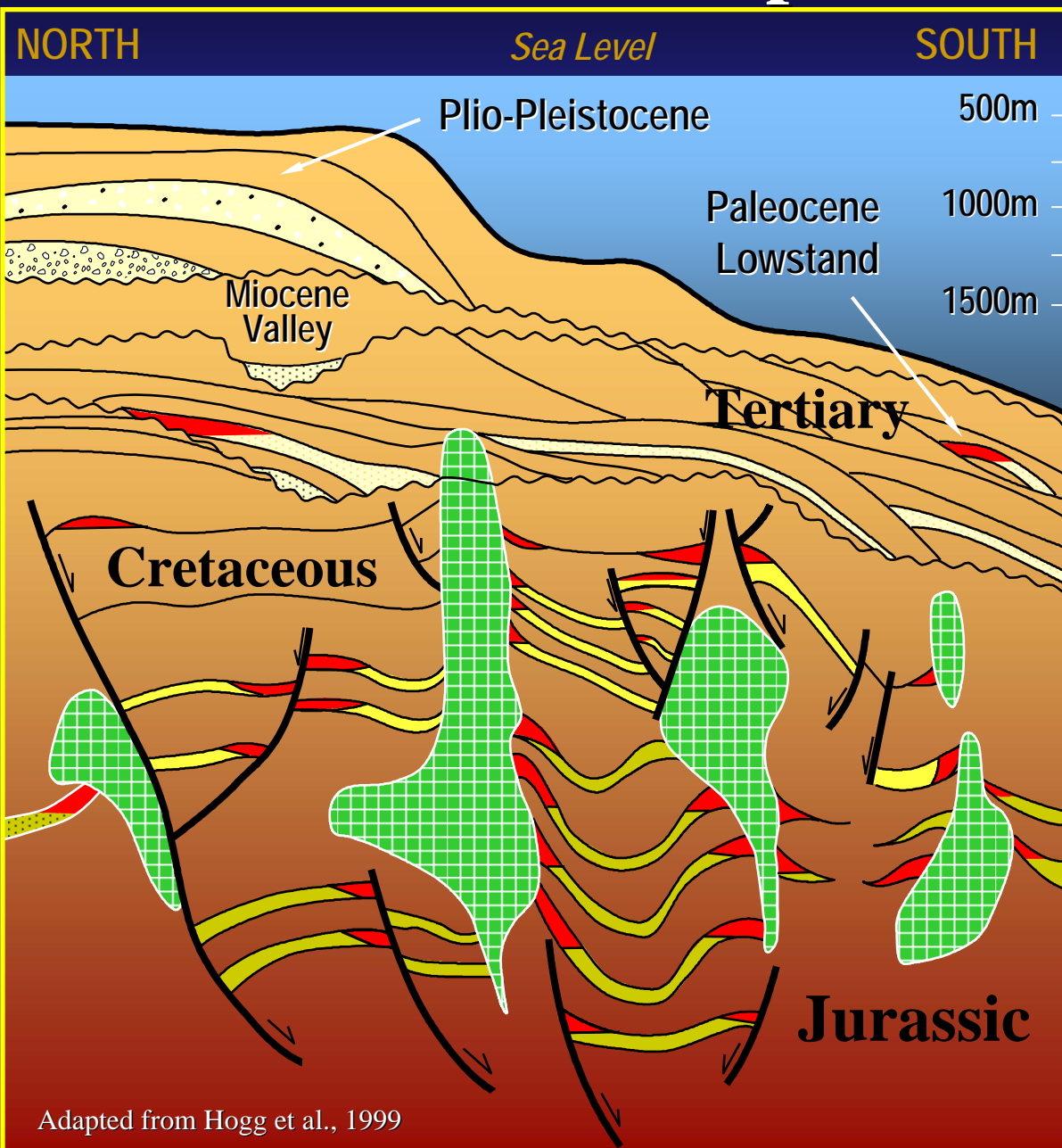
www.gov.ns.ca/energy/.../RA/.../Executive-Summary-Report-2006-08-26.pdf

Hydrocarbon Plays and Risks

- Conventional plays recognized in Scotian Basin and implicitly in Laurentian Basin (e.g. MacLean and Wade, 1992; Kidston et al., 2002; Hogg et al. 1999; Hogg, 2002; Enachescu and Hogg, 2005):
 - 1) Late Jurassic Mic Mac Ss
 - 2) Early Cretaceous Lower and Upper Missisauga Ss
 - 3) late Early Cretaceous Logan Canyon Ss

trapped in roll-over anticlines, listric fault bounded blocks, multi-fault closures, salt cored anticlines or ridges, drape over salt pillow or basement highs
- Late Cretaceous and Early Tertiary Ss (turbidites?) may become important reservoirs on the slope and upper rise
- Overpressure may be also play a significant role in the basin
- Reservoir quality, poor quality or lack of source rock and sealing across faults are the main risks in the basin

Laurentian Basin Deep Water Conceptual Plays



Multiple Play Types:

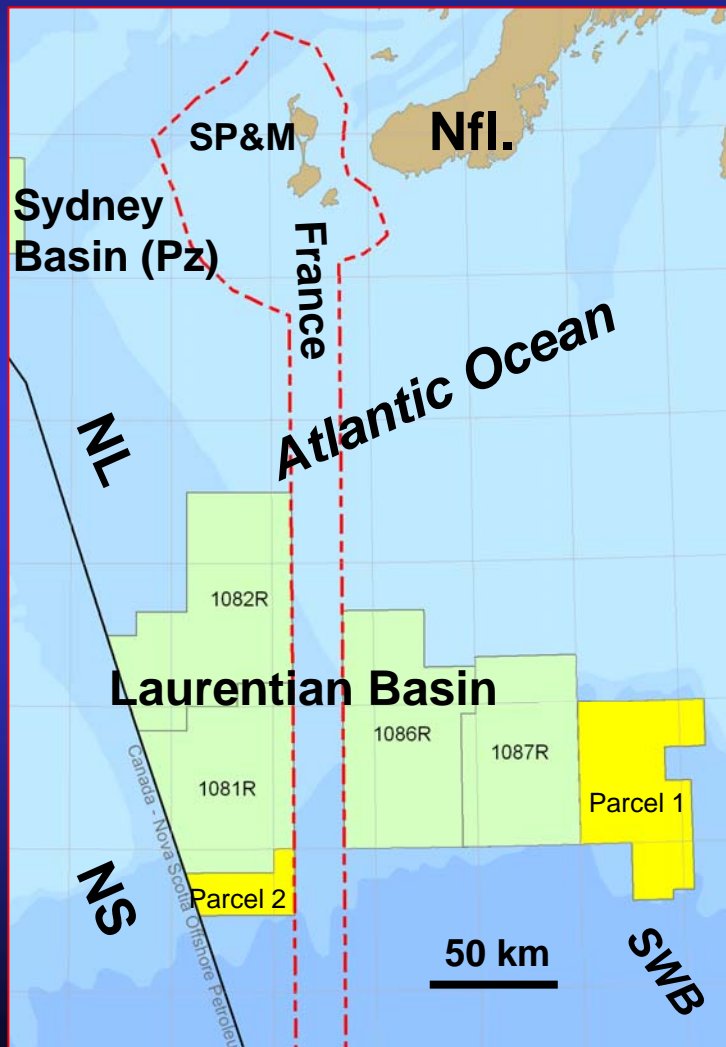
- Large structural fault-bounded closures
- Salt induced anticlines
- Structural\Stratigraphic salt related rollers and mini-basin traps
- Cretaceous fans
- Tertiary lowstand submarine fans & channel complexes
- Salt wall stratigraphic traps and subsalt

Verrill Canyon Petroleum System

- All prerequisites for the formation of large gas/condensate and secondary oil accumulations have been identified and confirmed in the Scotian Basin and implicitly in the Laurentian Basin
- The most sought after drilling targets are structural or combination traps, with plays in the Mic Mac and Missisauga formations
- Rollover anticlines and listric fault blocks have been successful on the shelf and may also work in the deepwater
- Large salt induced anticlines and submarine fans of Late Jurassic and Early Cretaceous age may become important targets in deepwater

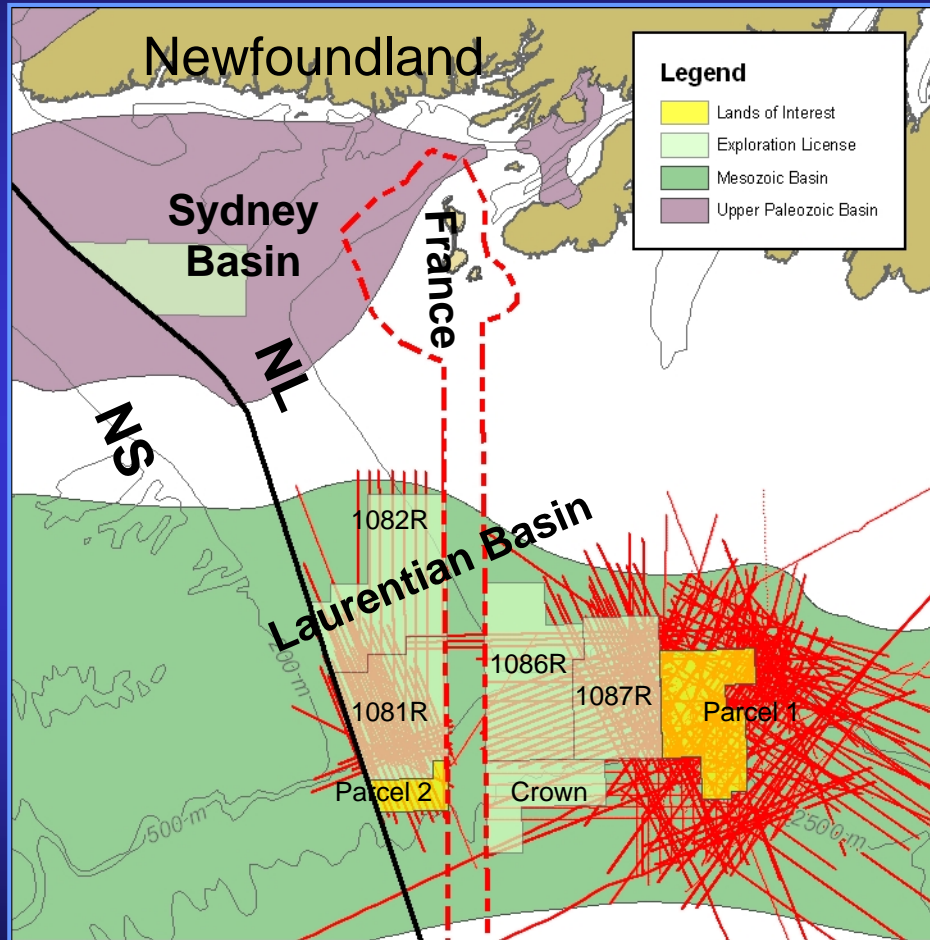
6. Petroleum Potential Call for Bids

NL09-02 Parcels 1 and 2



- Parcel 1 is located west of EL 1087R at the border between Laurentian and South Whale basins (SWB)
- Parcel 2 is located south of EL 1081R, squeezed between the French and Nova Scotia borders
- These parcels were not part of the older 1960s Permits and are first time ever offered at a Call For Bids by C-NLOPB
- Both parcels contain large deepwater petroleum leads

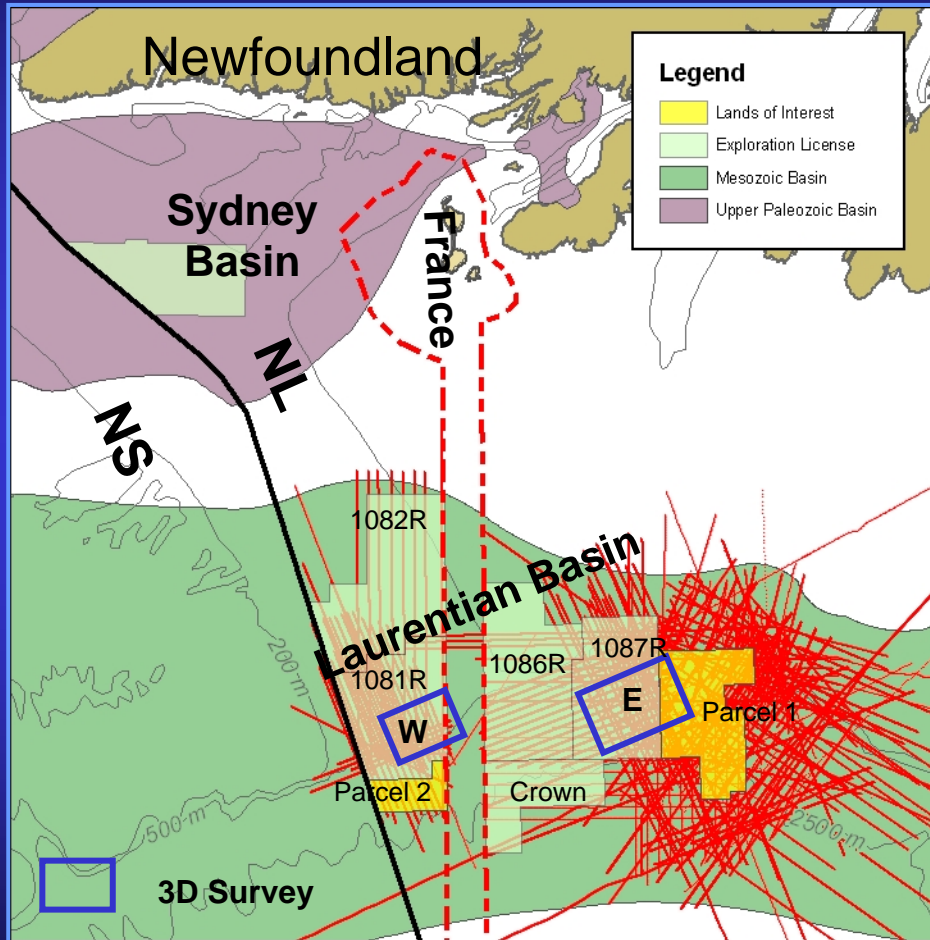
2D Seismic Coverage



- Parcels are very well covered with 2D data
- Majority of 2D lines are post-stack time migrated; most recent data have pre-stack time migration applied
- Marine data was acquired with a 3-4.5 km streamer length during early 1980s and with a 6 to 8 km length during late 1990s-early 2000s when large surveys were acquired by GSI, TGS and GX Technology
- ConocoPhillips et al. collected 3800 km of lines in 2004
- The main regional 2D grid is oriented N-S (dip lines) intersecting E-W tie lines (strike direction)
- A NW-SE/NE-SW 2D intersecting grid also exists
- The grid is much denser in the dip direction, in which the best data quality is obtained

CFB NL09-02 Parcels 1 and 2, adjacent Exploration Licenses and current 2D seismic coverage.

3D Seismic Coverage



- Two large 3D surveys were acquired for ConocoPhillips et al. during 2005
- These WesternGeco state of the art “Q-Technology” proprietary 3D seismic data cover a total area of 1850 km²
- The eastern Laurentian 3D survey (E) covers 1195 km²
- The western (W) Laurentian 3D survey covers 655 km²
- The 3D seismic has quality time processing and also rigorous depth processing
- These 3D surveys were used for the selection of the first Laurentian Basin exploration well locations

CFB NL09-02 Parcels 1 and 2, adjacent Exploration Licenses and current 2D and 3D seismic coverage.

Significant Wells

- No well has been drilled yet within the parcels

Well	Drilled	WD m	Status	Location	TD m	Prerift unc	TD in	Reservoir	Source rock
Hermine E-84	1971	87	Aband	shelf	3267	1636 m	Carboniferous Windsor Salt	no	not penetrated
Emerillon C-56	1974	120	Aband	shelf	3277	3118 m	Carboniferous Windsor Salt	Eider 1786 m Mic Mac 2088 m	not penetrated
Dauntless D-35	1971	119.5	Aband	shelf	4741	No	yes	yes	interpreted
Bandol #1	2001	119	Aband	On shelf in LB	4046	N/A	N/A	yes	N/A
Lewis Hill G-85	2003	100	Aband	In S Whale Basin	3218	2779 m	Missisauga	yes	not penetrated
Narwhal F-99	1987	1577	Aband	Grand Banks South Slope	4585	4491	Basalt	No	yes
Tantallon M-41	1986	1516	Aband	Nova Scotia slope	5602	No	L Missisauga-Verrill Canyon	L Missisauga Gas sands	yes

Significant Wells

- Four wells were drilled in vicinity of Parcel 1: **Hermine**, **Emerillon**, **Lewis Hill** and **Narwhal** (deep water well)
- Two significant wells **Dauntless** and **Tantallon** (deep water well) were drilled in vicinity of Parcel 2
- 2 wells were drilled in deepwater of more than 1500 m
- One well Bandol #1 was drilled on the shelf in central Laurentian Basin. Little was reported on this well except that it found thick reservoir in Late Jurassic - Early Cretaceous formations
- First well Hermine was drilled 1971, last well Lewis Hill was drilled in 2005
- None of the wells encountered significant amounts of oil and gas
- Small shows were encountered; gas sands were present in Tantallon M-41 and confirmed with LMR analysis (Goodway et al., 2008)
- The deep wells encountered Verrill Canyon source rocks that were only marginally mature
- These well results point toward moving exploration in deeper basinal areas, where source rocks may be mature and targeting LMR anomalies that may show sand fairways and/or presence of hydrocarbons

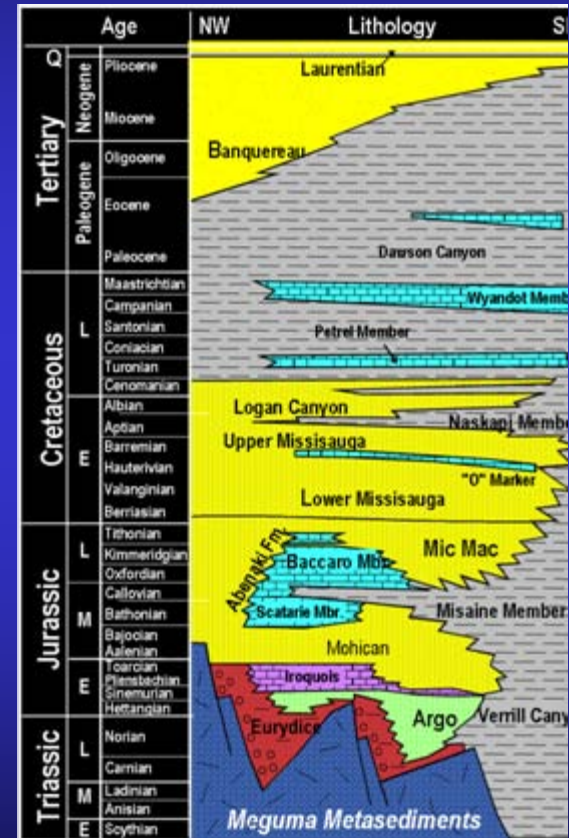
Seismic Data Quality and Availability

- For both parcels, data quality is excellent in Late Jurassic - Tertiary sequences but deteriorates in the Late Triassic - Late Jurassic interval
- There are high quality regional seismic markers such as carbonate intervals within clastics and widespread unconformities (some angular); good local markers are also mappable
- Main and secondary faults are easily traceable
- Salt diapir walls/welds are well imaged in places
- Seismic data can be purchased from vendors (“spec companies”), brokers or oil company owners as SEG-Y files or obtained in hardcopy format from the C-NLOPB, in St John’s NL

Seismic Coverage

Good quality 2D and 3D seismic coverage allows for mapping of several unconformities, formation tops and carbonate, salt and sandstone markers such as:

1. Wyandot (Base Tertiary)
2. Petrel
3. Avalon Unconformity
4. "O" Marker
5. Missisauga
6. Top Jurassic
7. Middle Jurassic
8. Lower Jurassic
9. Argo Salt
10. Basement (when not too deep)

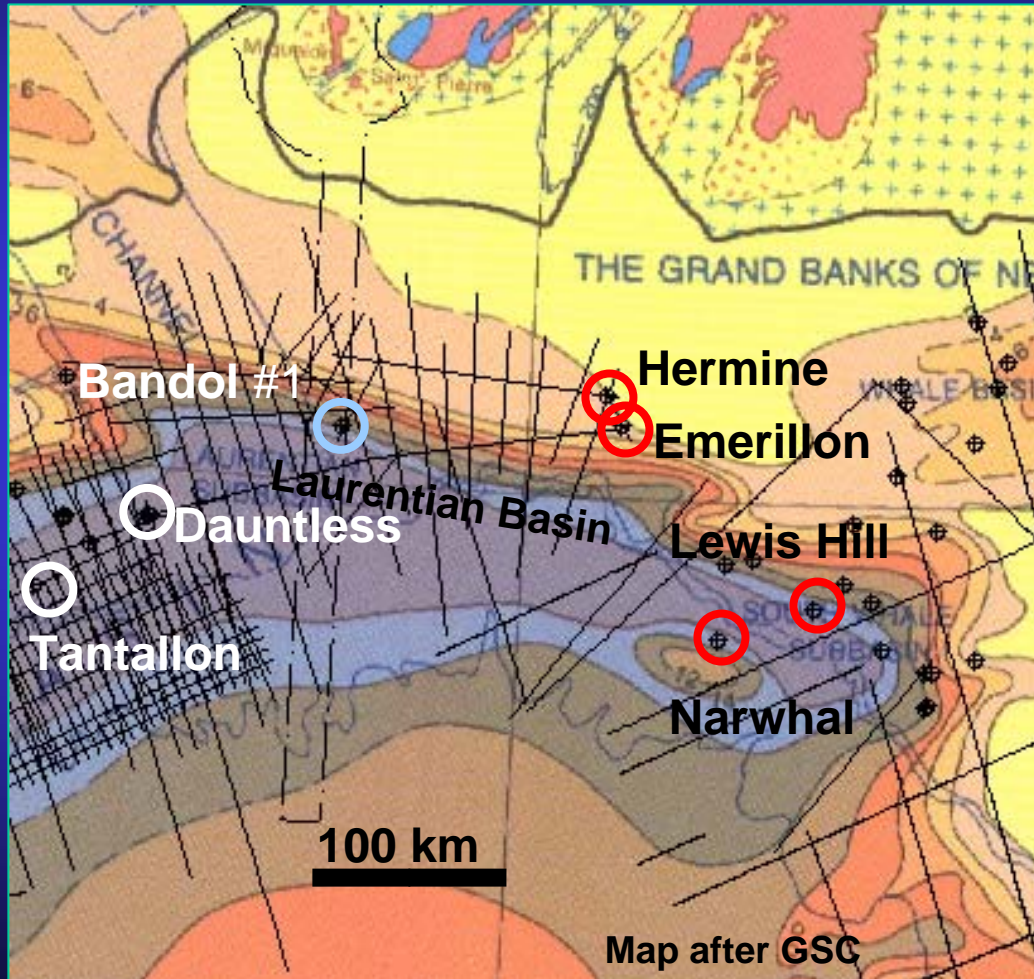


Observation. Data interpretation and economic evaluation of leads and prospects is beyond the scope of this presentation. Only a few markers, faults and leads will be shown on representative seismic lines.

Seismic Interpretation

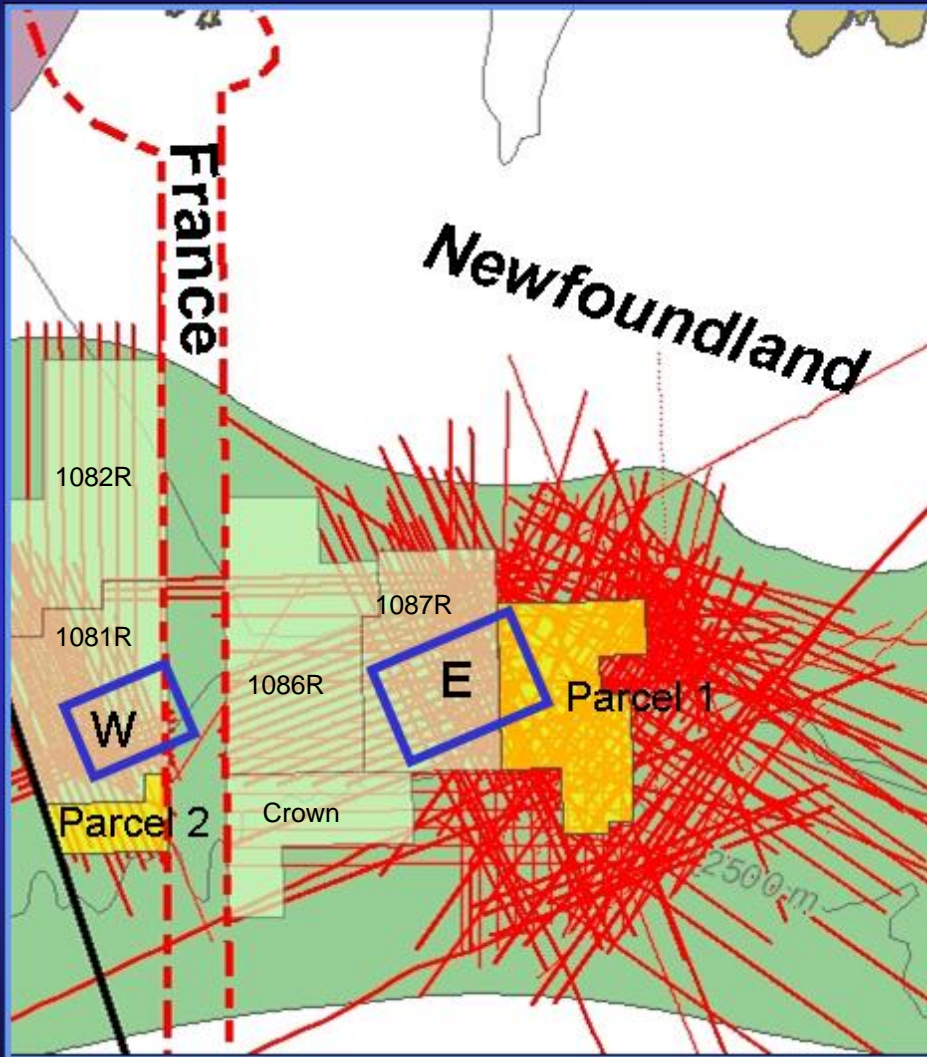
- Regional seismic data was tied with synthetic seismograms to several exploration wells situated outside of the parcels
- Full synrift sequences including Argo Salt and transtensional sequence including reservoir sandstone of Late Jurassic to late Early Cretaceous age exist within the parcels
- On the illustrative seismic sections only a few markers, faults and formation ages are displayed
- Potential reservoirs in the synrift sequence include the proven Mic Mac, Missisauga, Logan Canyon sandstones. These are high producing reservoirs in Nova Scotia gas fields and their age equivalents produce oil on the Grand Banks. Sandstone reservoir beds were encountered in the Bandol #1 well but the well still has a “Confidential” status
- Deep-water equivalents of these sandstones should be present in the deep water parcels 1 and 2

Significant Wells



- Close to Parcel 1:
 - **Hermine E-94** and **Emerillon C-56** drilled on shelf north of the basin's hinge line
 - **Narwhal F-99** drilled in 1577 m water depth encountered source rock
 - **Lewis Hill G-85** last well to be drilled on shelf in parcel's vicinity (in South Whale Basin)
- Close to Parcel 2
 - **Dauntless D-35** drilled on the Nova Scotia shelf on the flank of the Laurentian Channel
 - **Tantallon M-41** drilled on the Nova Scotia slope encountered gas charged sands in Lower Missisauga
- The only well drilled in the LB testing a thick Mesozoic section is **Bandol #1** located in French territory
- All these wells were D&A, but good reservoirs and hydrocarbon shows were observed

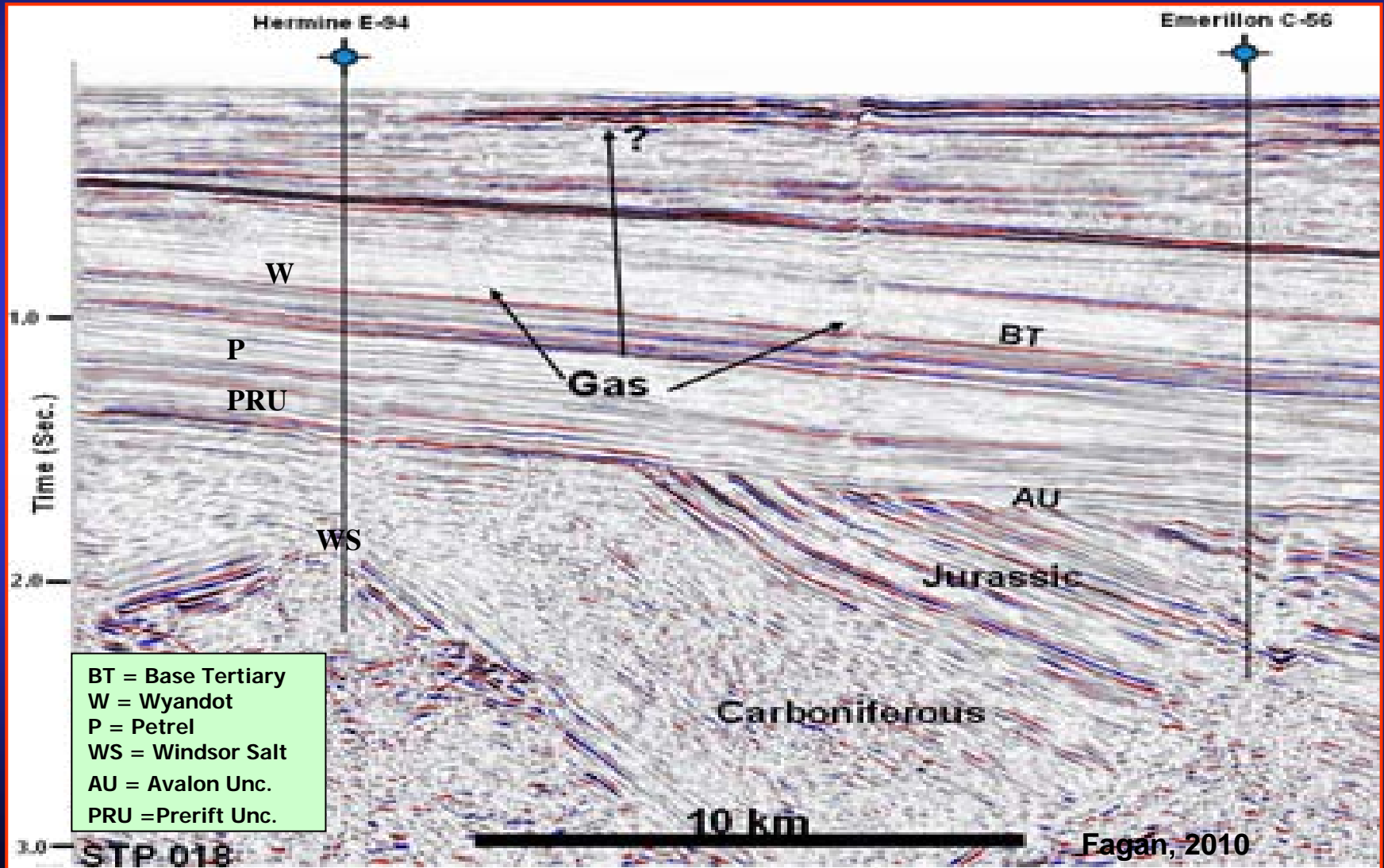
Petroleum Potential Parcel 1



CFB NL09-02 Parcels 1 and locations of illustrative seismic sections.

- Parcel 1 offered for bid has 290,070 hectares (716,776 acres) - this is 124.4 time larger than GOM OCS tract
- It is located in 500 - 2500 m of water in the south-eastern part of the basin
- No well has been drilled in the parcel

Seismic Section through Significant Wells for Parcel 1



Seismic Dip Line GSC STP-17

Courtesy of GSC Atlantic

STP-17

Parcel 1

WD: 1.8 km

Turbidite

Wyandot chalk

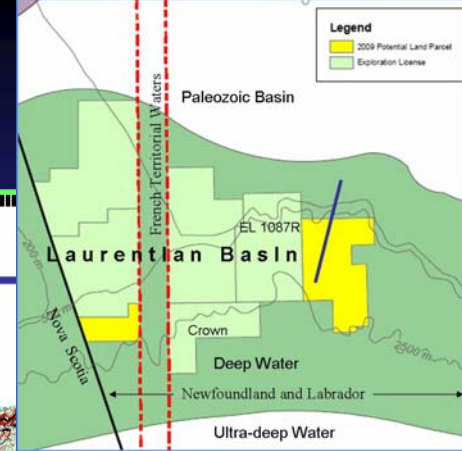
Avalon Unc

Salt
Anticline

3 km

S

N



Interpreted regional dip seismic section GSC STP-17. Note Parcel NL09-02-1.

Enachescu and Fagan, NL DNR 2009

Zoom of Seismic Dip Line GSC STP-17

Courtesy of GSC Atlantic

STP-17

Parcel 1

WD: 1.8 km

Turbidite

Wyandot chalk

Salt
Anticline

3 km

S

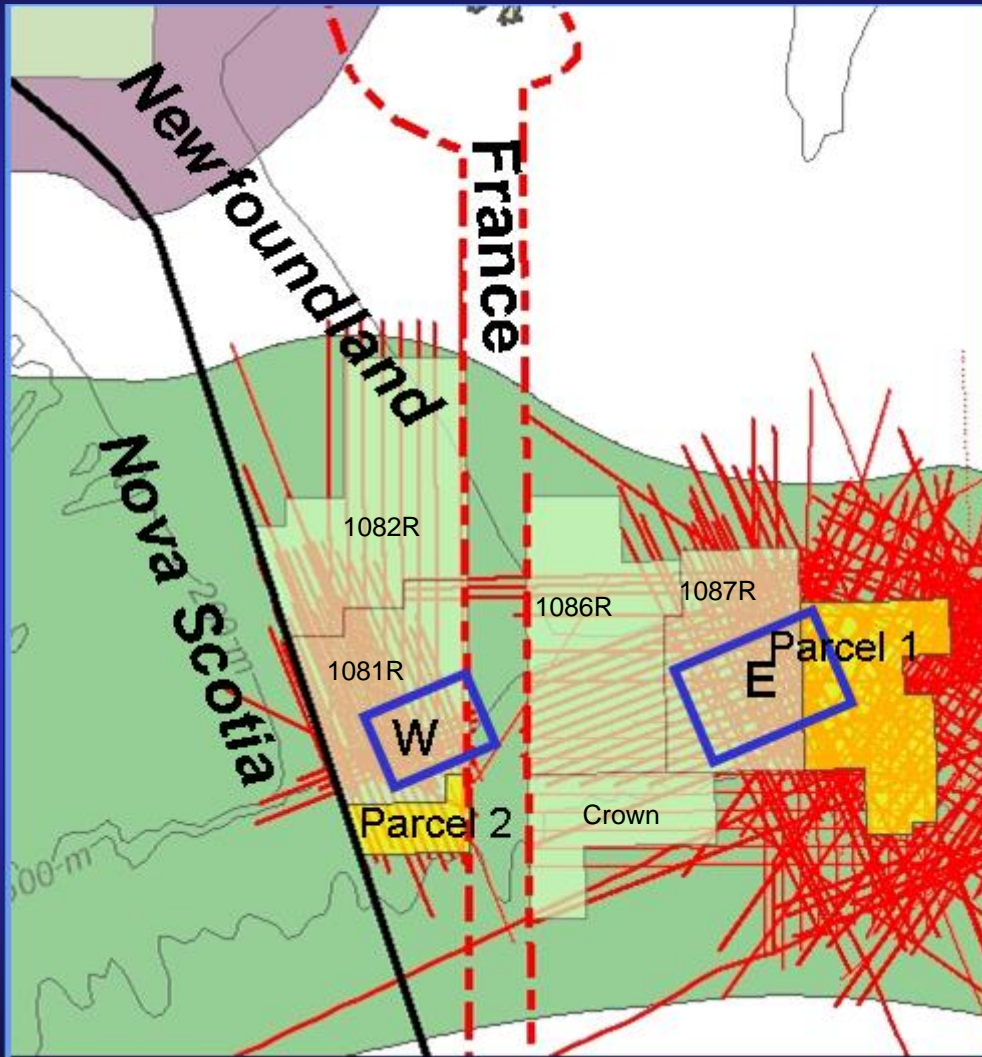
N

Note large salt anticline on Parcel 2.

Seismic Line GSC STP-17

- This regional dip line STP-17 (NNE-SSW) starts on the shelf in Crown land, crosses into Parcel 1 and ends in the southern part of the parcel
- The line starts on the upper slope (400 m WD) and continues into the slope and upper rise (2500 m WD on Parcel 1)
- The line first crosses several rotated blocks triggered by normal faults; several horsts and tilted blocks are formed with Late Jurassic to Early Cretaceous successions; these blocks are 4 to 7 km wide
- In the southern part of the parcel there is a large salt cored anticline with important vertical closure. The anticline deforms Late Jurassic to Tertiary strata. The crestal part of the anticline is incised by 1-2 km wide Late Cretaceous and Early Tertiary paleo-valleys or canyons
- Located in deep water (cca. 2000 m), this anticline is a 7-8 km wide and flanked by large mini-basins. There are patches of high reflectivity associated to this anticline suggesting that hydrocarbons were generated in the area
- Leads interpreted on these lines are 4 to 8 km across and if four-way closure can be demonstrated they can be good drilling candidates

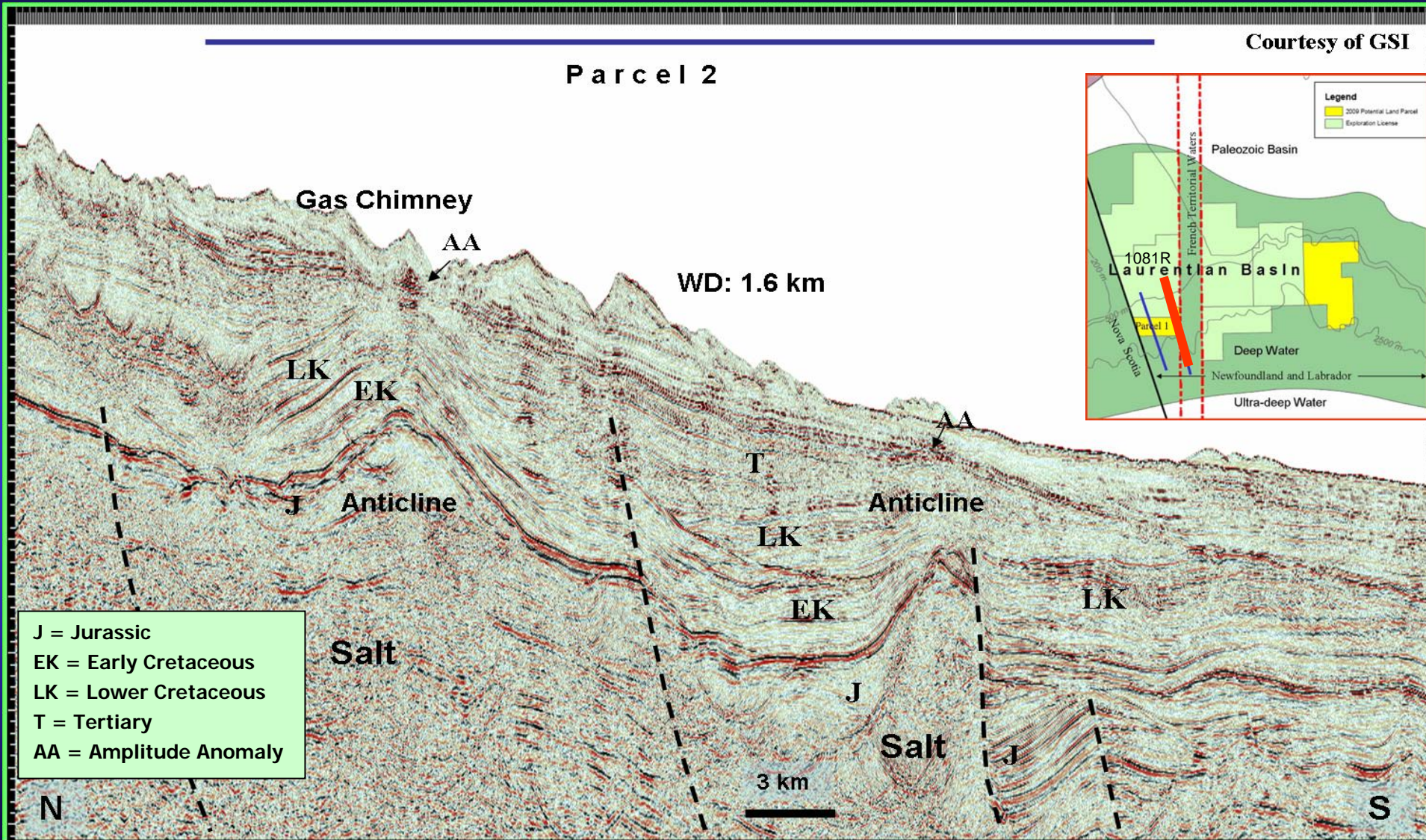
Petroleum Potential Parcel 2



- Parcel 2 offered for bid has 73,931 hectares (182,687 acres) - this is 37.74 times larger than a GOM OCS tract
- It is located in 2000 - 2600 m of water in the south-western part of the basin
- No well has been drilled in the parcel

CFB NL09-02 Parcels 2 and locations of illustrative seismic sections.

Seismic Dip Line GSI NS98-171

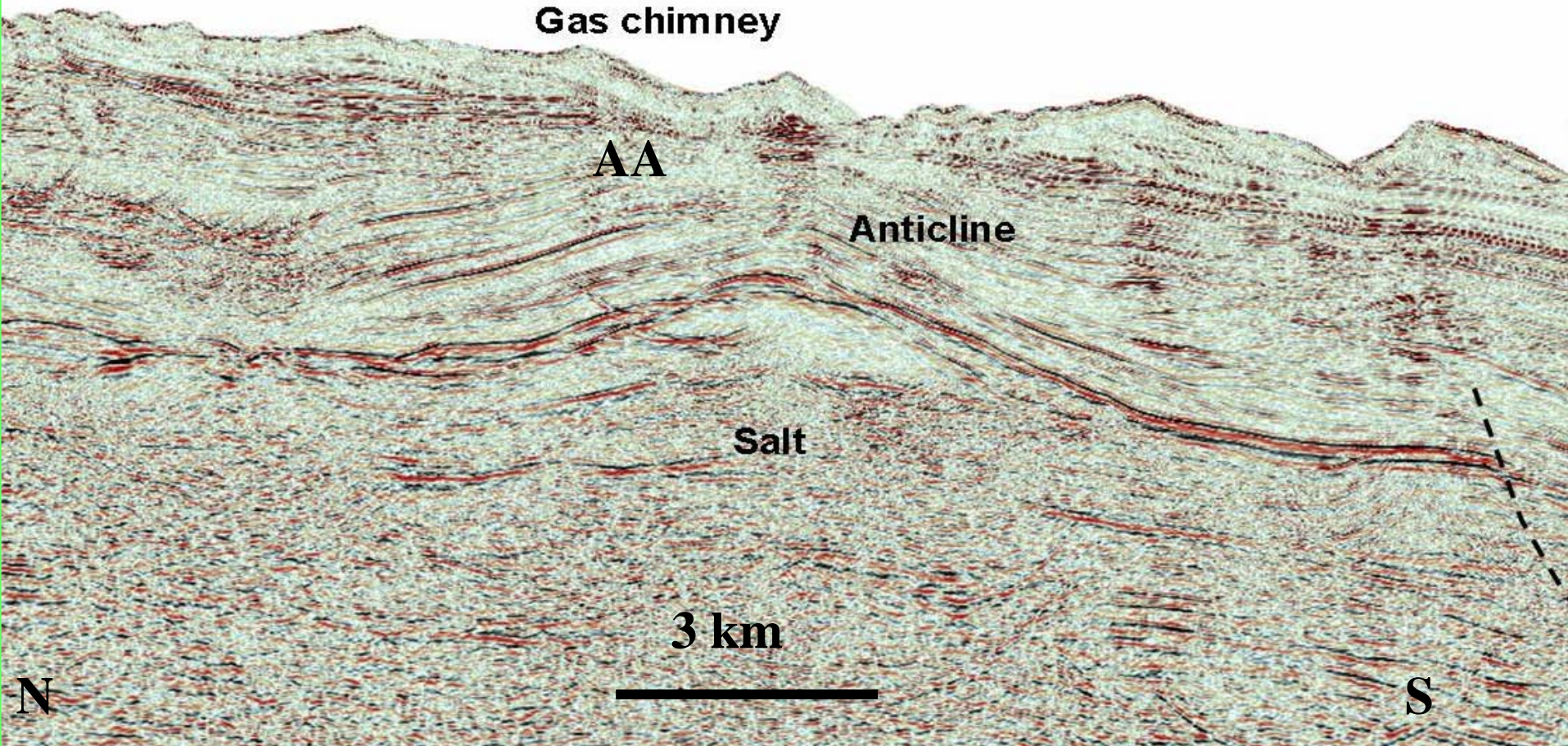


Interpreted regional dip seismic section GSI NS98-171. Note Parcel NL09-02-2.

Enachescu and Fagan, NL DNR 2009

Zoom of Seismic Line GSI NB98-171

Parcel 2

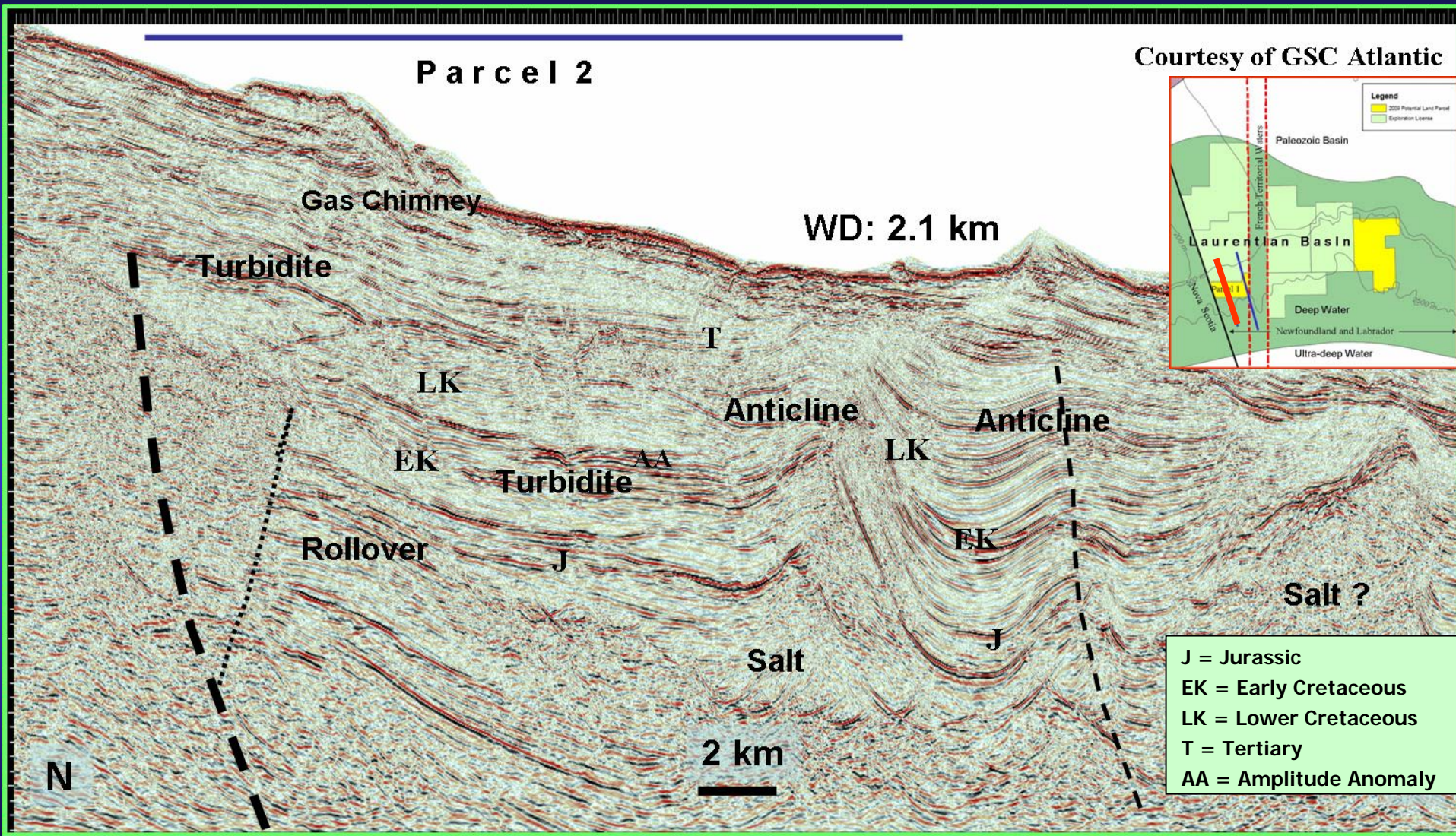


Note large salt anticline on Parcel 2.

Seismic Line GSI NB98-171

- This regional dip line NB98-171 (NNE-SSW) starts in the southeastern corner of EL 1081R, crosses into Parcel 2 and stretches in the French territory
- The line starts in the upper slope (500 m WD) and continues into the slope and upper rise (2500 m WD)
- The line crosses first a large salt anticline (10 km across; significant vertical closure) located in about 1 km of water and including Late Jurassic to Late Cretaceous beds. The anticline has an associated gas chimney and a large Amplitude Anomaly in shallow Tertiary strata
- The line also intersects a series of down-to-basin major listric faults, some creating 4-6 km rotated blocks in the downthrown
- In deep water (cca. 2000 m) the line crosses a large mini-basin followed by steep (4 km across) salt cored anticline that also shows a gas cloud and a shallow Amplitude Anomaly
- Line ends in deepwater where high amplitude rotated blocks are truncated by a major unconformity (Avalon U.?)
- Leads on this line are 4-10 km across and if four-way closure can be mapped they can hold significant amounts of hydrocarbons

Seismic Dip Line GSC STP-05



Interpreted regional dip seismic section GSC STP-05. Note Parcel NL09-02-2.
 Enachescu and Fagan, NL DNR 2009

Zoom of Seismic Dip Line GSC STP-05

Parcel 2

STP-05

WD: 2.1 km

Turbidite

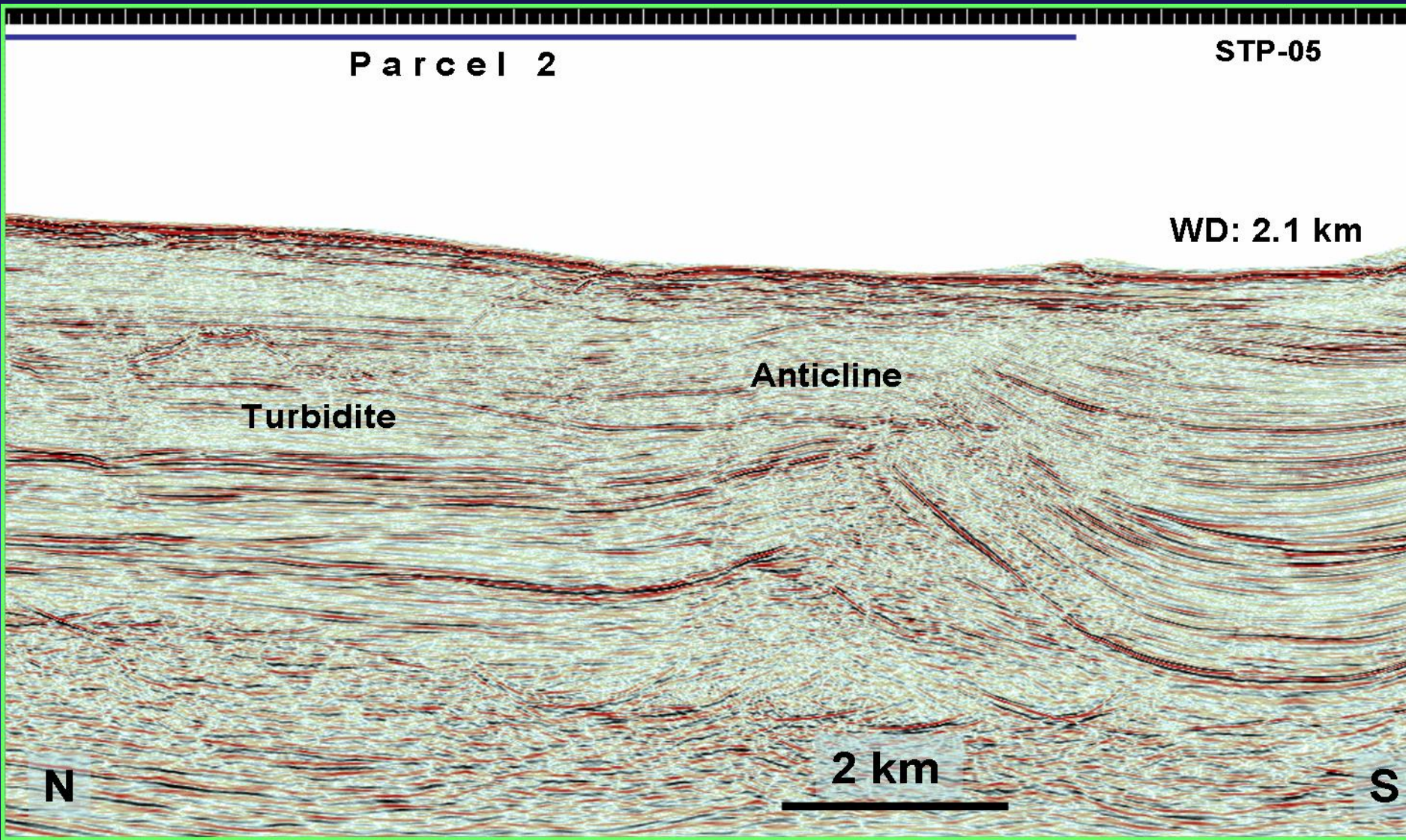
Anticline

N

2 km

S

Note asymmetric salt induced anticline on Parcel 2.



Seismic Line GSC STP-05

- This regional line STP-05 (NNE-SSW) starts in the southwestern corner of EL 1081R, crosses into Parcel 2 and stretches into the Crown land
- The dip line starts in the upper slope (500 m WD) and continues into the slope and upper rise (2500 m WD)
- In the shallower part of Parcel 2 there is a major down-to-basin listric fault that creates a large rollover. The rollover is about 8-10 km wide and is affected by at least one antithetic fault. The rollover contains layers from Late Triassic to Early Cretaceous
- Late Cretaceous turbidite flows (or Mass Transport Deposits) may cap this rollover and a gas chimney is also visible above the structure
- An asymmetrical salt cored diapir affecting Jurassic to Tertiary strata is imaged in the deeper part of the parcel. This anticline is about 5 km wide and is faulted in its shallower part. The anticline has significant vertical closure
- A large Early Cretaceous fan is visible on the northern flank of the anticline. Bright amplitude reflectors are contained in this fan and there are indications of feeders and lobes presence
- Leads on this lines are 5 to 10 km wide and if they are closed in the east-west direction they can contain large amounts of hydrocarbons

Prospects and Leads

- Area's main hydrocarbon play is structural; it involves porous Late Jurassic - Early Cretaceous sandstones trapped by salt induced anticlines, listric fault triggered roll-over anticlines and large rotated blocks
- With the limited 2D grid available to us only leads were identified
- Several such leads with significant lateral and vertical dimensions were imaged by the seismic lines crossing Parcel 1 and 2;
- As indicated by seismic data multi-pay play is also possible for these leads
- Late Cretaceous and Tertiary sequences are not affected by extensional faults but are deformed by salt diapirism
- Source rocks are found at expulsion depths of 3000-6000 m beneath the mud line in several mini-basins and deep rotated blocks
- Seismic amplitude variations and large gas chimneys are seen in the late Early Cretaceous, Late Cretaceous and Early Tertiary sequences
- MacLean and Wade (1992) carried out a probabilistic analysis of the Laurentian Basin petroleum potential based on a variety of play concepts; they have identified numerous prospects and leads in the basin and concluded that, at an average expectation, the basin contained 8-9 tcf of recoverable gas and 600-700 million barrels of oil

Discussions

- Only one well has been drilled in the basin - Bandol #1 that was reported to have encountered hundreds of meters of good reservoir, but was D&A and it is not yet in the public domain
- Main source rock for the area - the Verrill Canyon Shale - exists in the mature range within the identified anticlines, tilted blocks or in adjacent depressions
- CFB NL09-02 parcels are larger when compared with a Gulf of Mexico standard tract (124.4 and respectively 37.7 times larger)
- Good quality and dense 2D seismic coverage is available in the parcels to image and adequately map hydrocarbon traps
- Parcels are in a region with large extensional traps, known reservoirs, mature source rocks and proven migration paths
- Risks are recognized in regard to reservoir quality, source rock quality, overpressure and fault sealing
- Parcels contain multiple reservoir targets within synrift/syndrift sandstones reservoirs at 2500-4500 m depth that can be drilled year round and tested using semi-submersible rigs
- Cost of an offshore well in these parcels would likely be in the range of Can \$60 to \$70 million depending on the depth to the target

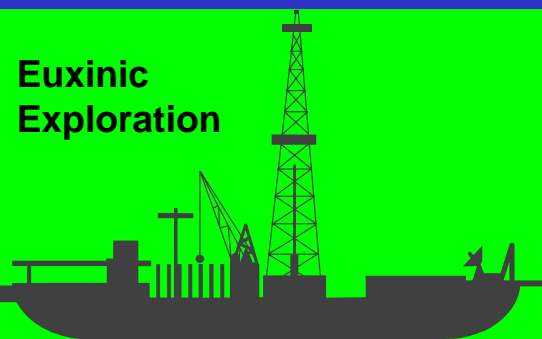
Conclusions

- Two large parcels, within the practically unexplored Laurentian Basin are available for licensing in the C-NLOPB's **Call for Bids NL09-02** which closes on **November 19, 2009, 4 p.m. NL time**
- Parcels are adjacent to large exploration blocks that are mature for drilling. One well is planned for the 2009/2010 winter in a large structure adjacent to Parcel 1
- Parcels contain synrift and syndrift Mesozoic clastics and carbonates including proven source and reservoir rocks
- Similar reservoirs have tested high amounts of natural gas, condensate and oil in the Sable Basin located cca. 300 km southwest of Laurentian Basin; excellent oil flows were obtained from the Jeanne d'Arc Basin oil fields located cca. 550 km to the northeast
- Large fault bounded rollovers, salt cored anticline and rotated block trap-type with Late Jurassic and Early Cretaceous reservoirs that were successful in the aforementioned basins are viable in NL09-02 Parcels 1 and 2; some traps have clearly expressed DHIs

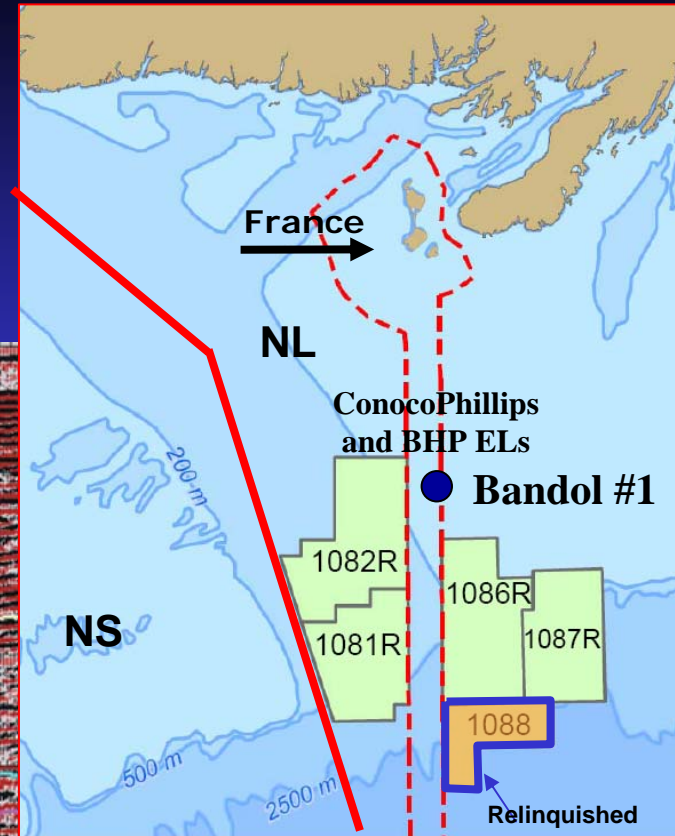
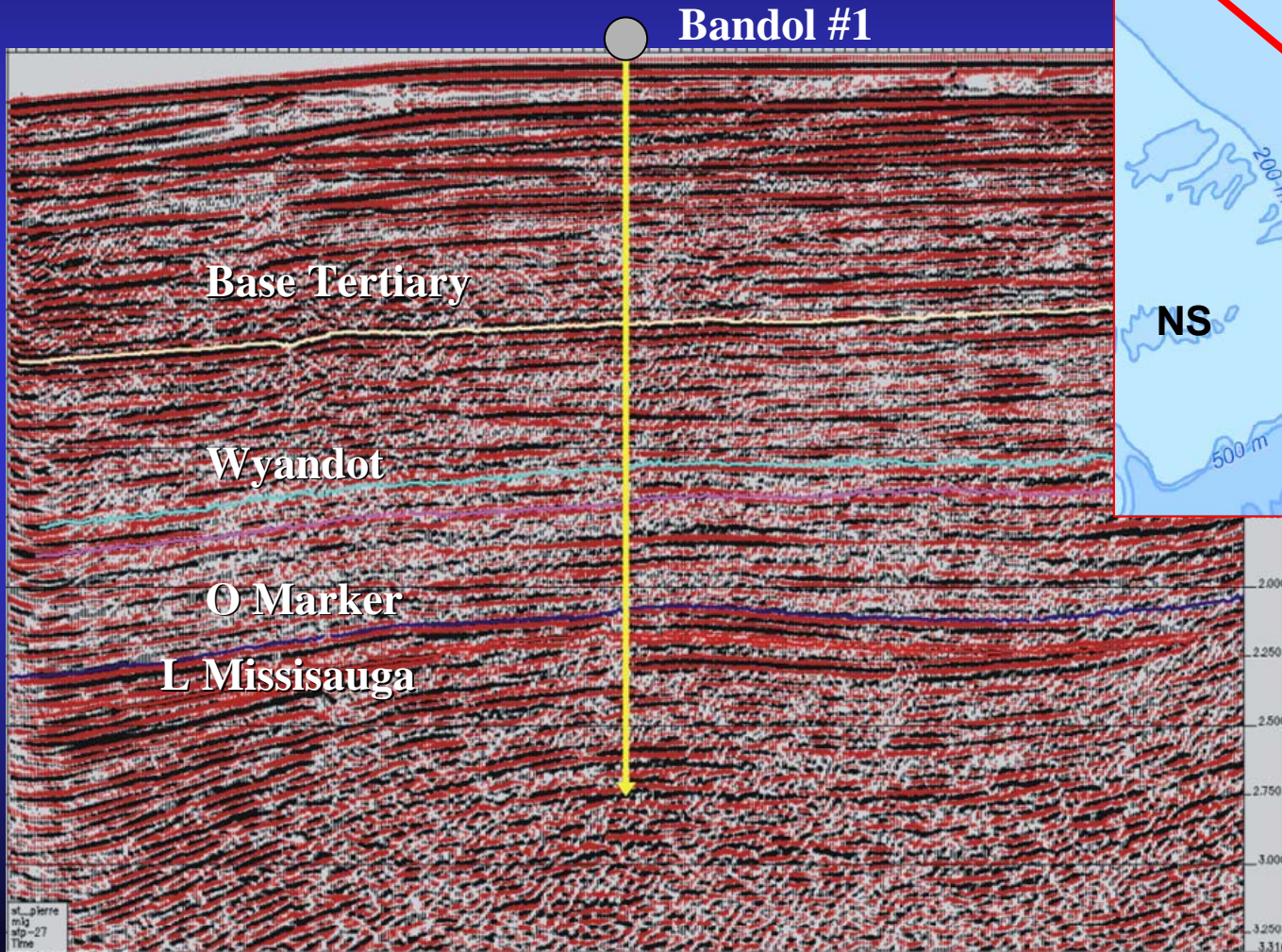
Conclusions

- Additional potential may exist in Late Cretaceous and Early Tertiary stratigraphic traps
- Recognized risks in regard to reservoir quality and fault seal are mitigated by the presence of relatively large undrilled features and the presence of clear DHIs structurally conformable amplitude anomalies and also gas chimneys
- Geological risk can also be reduced by using depth migration, pre-stack and post-stack seismic analysis and CSEM methods; risks are mitigated by the large size of the interpreted leads that can contain several tcf of natural gas or more than 1 Bbbls of oil
- The leads in the parcels are located in water depths varying between 500 -2500 m and require modern, harsh environment drilling units. These parcels constitute large exploration blocks situated in a deep water Mesozoic basin, in a geologic setting similar to other prolific Atlantic margin basins; leads in Parcels 1 and 2 can add value to the existing prospect inventory in the basin
- The parcels will give a new entrant operator in the area an excellent opportunity of participating in a high risk-high reward petroleum play off Canada's East Coast; for an existing operator the parcel provides a great occasion to increase its prospective portfolio of leads and prospects

Thank You for your Attention!



Bandol #1



- Encountered excellent reservoirs
- Not in public domain