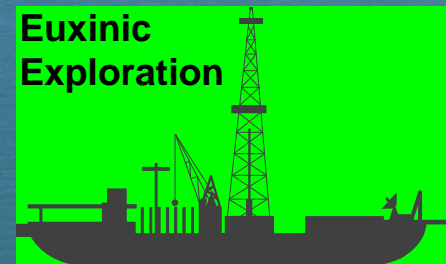


# **Petroleum Exploration Opportunities in Area “C” - Flemish Pass/North Central Ridge Call for Bids NL11-02**

**Dr. Michael E. Enachescu,  
P Geoph, P Geo  
Euxinic Exploration**

**On Behalf of NL DNR  
November 2011**

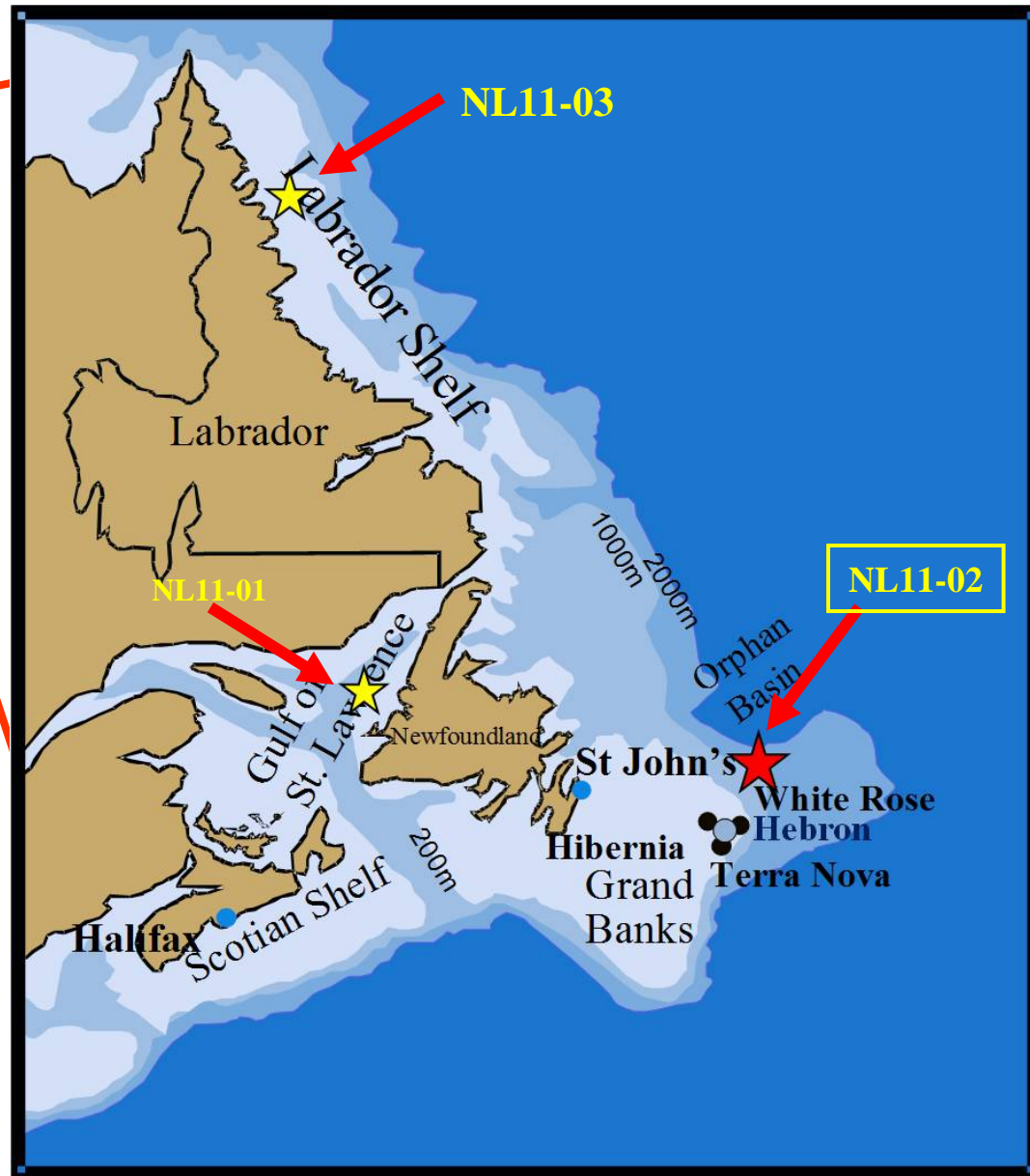




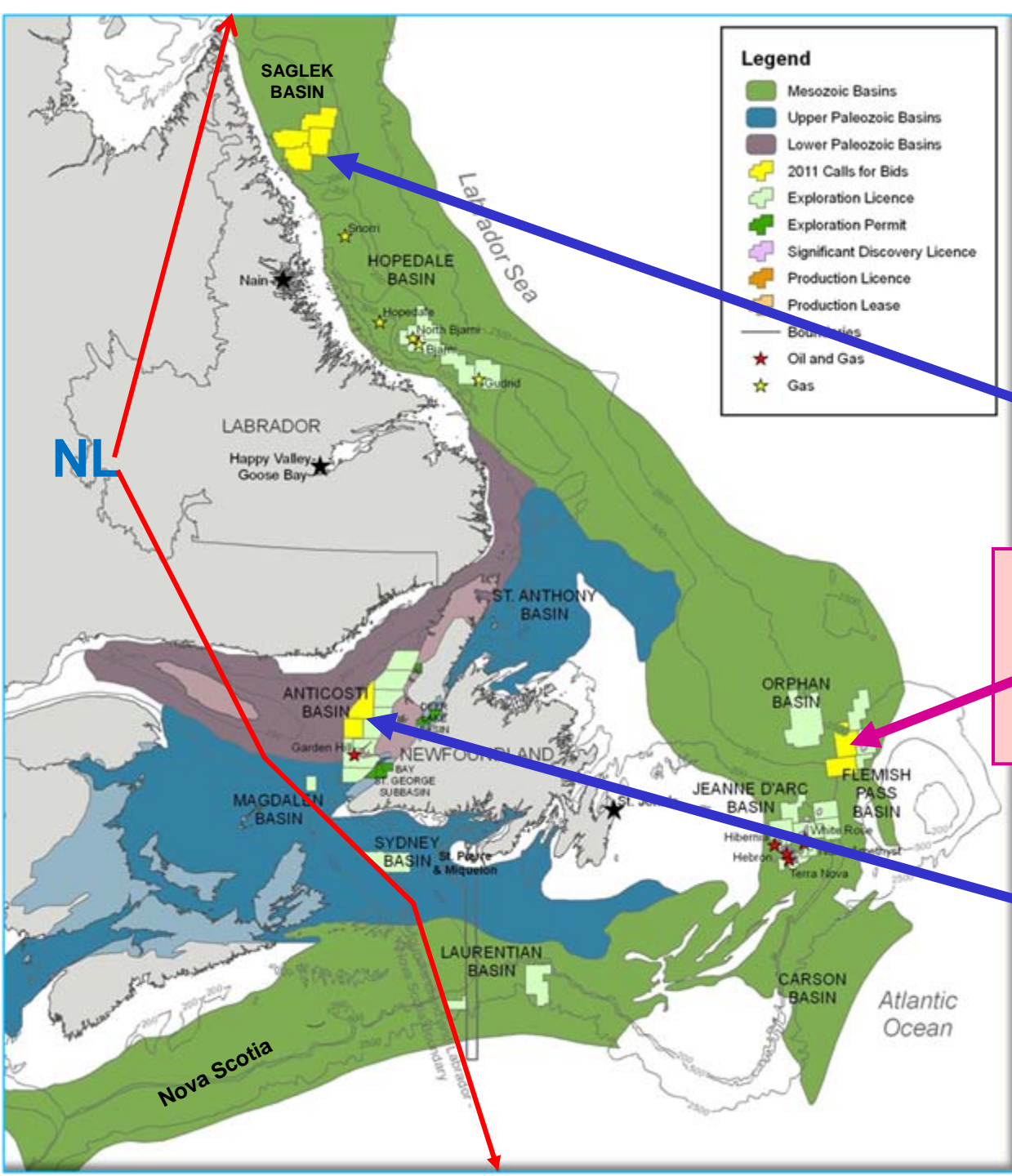


## Acknowledgements

- Wes Foote, David Middleton, Lori Cook, Darrell Spurrell, Brad Kendell, Jillian Owens, Larry Hicks of the NL Department of Natural Resources;
- Ian Atkinson, Phonse Fagan;
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- Memorial University;
- GSC Atlantic;
- This work could not have been performed without valuable information provided by C-NLOPB and Government of Newfoundland and Labrador Department of Natural Resources.



★ = position of CFB NL11-02 Parcels



# NL CFB 2011: Three CFB in four basins

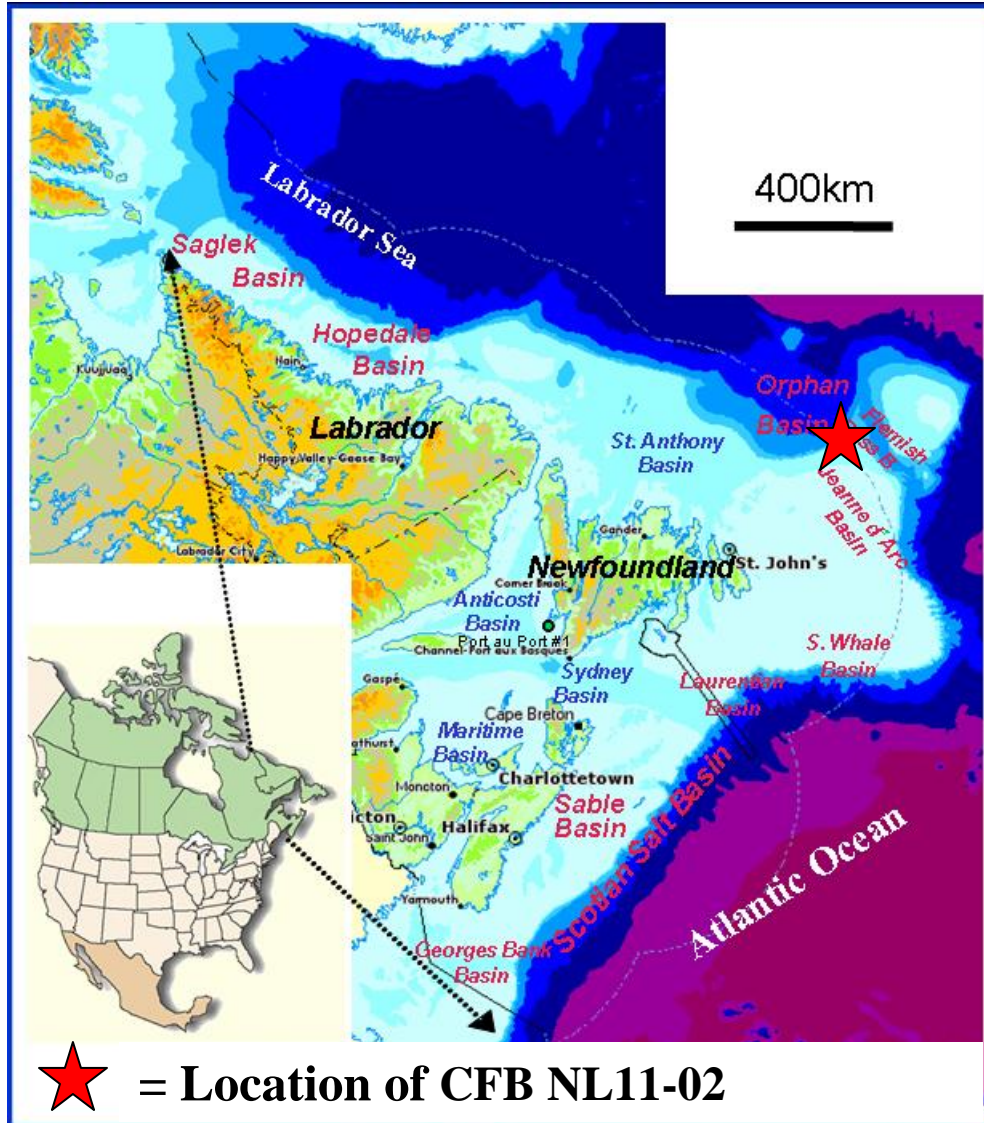
•CFB NL11-03  
Saglek Basin

•CFB NL11-02  
Flemish Pass/  
Orphan/Central Ridge

•CFB NL11-01  
Anticosti Basin



# Atlantic Canada Offshore Basins



Blue Text: Paleozoic Basins

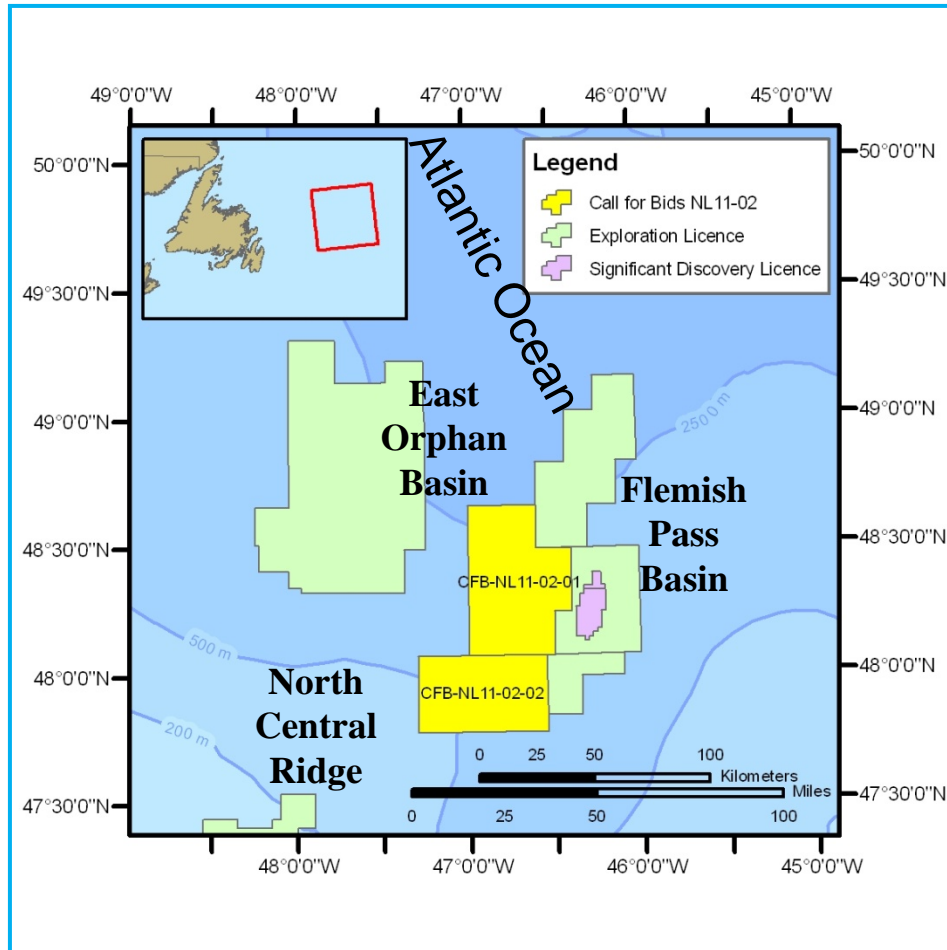
Magenta Text: Mesozoic Basins

## NL Mesozoic Basins

- Laurentian
- South Whale
- Jeanne d'Arc
- Flemish Pass
- East Orphan
- Hopedale
- Saglek

Blue writing above: Mesozoic basins with ongoing exploration

# Area “C” - Flemish Pass/North Central Ridge: Call For Bids



- **CFB NL11-02** consists of two large parcels (each one approximately 200,000 ha), located in the intermediate and deep waters of the North Central Ridge and East Orphan and Flemish Pass basins
- **Call for Bids closes November 15, 2011 at 4 p.m. NL time**

# **Presentation Content**

- 1. Introduction**
- 2. Exploration Background**
- 3. Regional Geology of Call for Bids area**
- 4. Petroleum Geology of Call for Bids area**
- 5. Petroleum Potential Call for Bids**
  - NL11-02 Parcel 1**
  - NL11-02 Parcel 2**
- 6. Conclusions**
- 7. Conclusions**

# 1. Introduction

- Geologically, the CFB NL11-02 Area “C” - Flemish Pass/North Central Ridge includes portions of the North Central Ridge, southern East Orphan Basin and north western Flemish Pass Basin
- The total area covered by the Call for Bids is 433,796 ha
- The two parcels on offer are situated in intermediate to deep water (ranging from 350 to 2,655 m)
- Parcels 1 and 2 are located just northeast of the Jeanne d’Arc Basin where giant oil fields were discovered. Production of oil during the first 8 months of 2011 was recorded at 268,313 bopd
- Parcels 1 and 2 are located immediately west of the 2009 Mizzen O-16 discovery and the 2005 Mizzen L-11 oil show in the Flemish Pass Basin

# NL11-02 Parcels Near Mizzen SDLs

- **CFB NL11-02-01 and -02** parcels offered in the 2011 Call for Bids are two very large blocks located offshore Newfoundland, at the northeast tip of the Grand Banks and on its slope. Noteworthy:
  - The NL11-02-01 parcel is situated less than 20 km west of the Mizzen SDLs 1047 and 1048
  - The NL11-02-02 parcel is situated 40 km southwest of the Mizzen SDL 1047
- In 2010, the SDL 1047 encompassing 22,006 ha was awarded by the C-NLOPB to Statoil (65%) and Husky Oil (35%) based on the results of the Mizzen O-16 well drilled in 2009 in the previous EL 1049. A northern addition, the Mizzen SDL 1048 comprising 3,773 ha, was awarded to Statoil (65%)/Husky (35%) in early 2011



# NL11-02 Parcels Near EL's

- The closest ELs to these parcels are located
  - Immediately south: EL 1112 (Statoil 65%/Husky 35%)
  - Immediately east: EL 1124 (Statoil 65%/Husky 35%)  
surrounding the Mizzen SDLs
  - To the northeast: EL 1123 (Statoil 75%/Repsol 25%)
  - To the northwest, in the East Orphan Basin: EL 1074R  
(Chevron operator 50%, EM/Imperial 30% and Shell 20%)

# Call for Bids NL11-02

- **NL11-02: Two Parcels on Offer**

Call for Bids NL11-02 contains two very large parcels located in Area “C” Flemish Pass Basin (FPB)/Central Ridge offshore Newfoundland and Labrador:

- NL11-02-01 comprised of 247,016 hectares (610,390 acres), located in 635-2655 m water depth
- NL11-02-02 comprised of 186,780 hectares (461,546 acres), located in 350-1165 m water depth

- **Call for Bids Timing:** Bids for these parcels will be accepted up to **November 15, 2011 at 4 p.m. NL time**

- **Minimum Bid:** CAN \$ 1,000,000 (one million) for each of NL11-02 parcels in the Central Ridge/Flemish Pass area

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

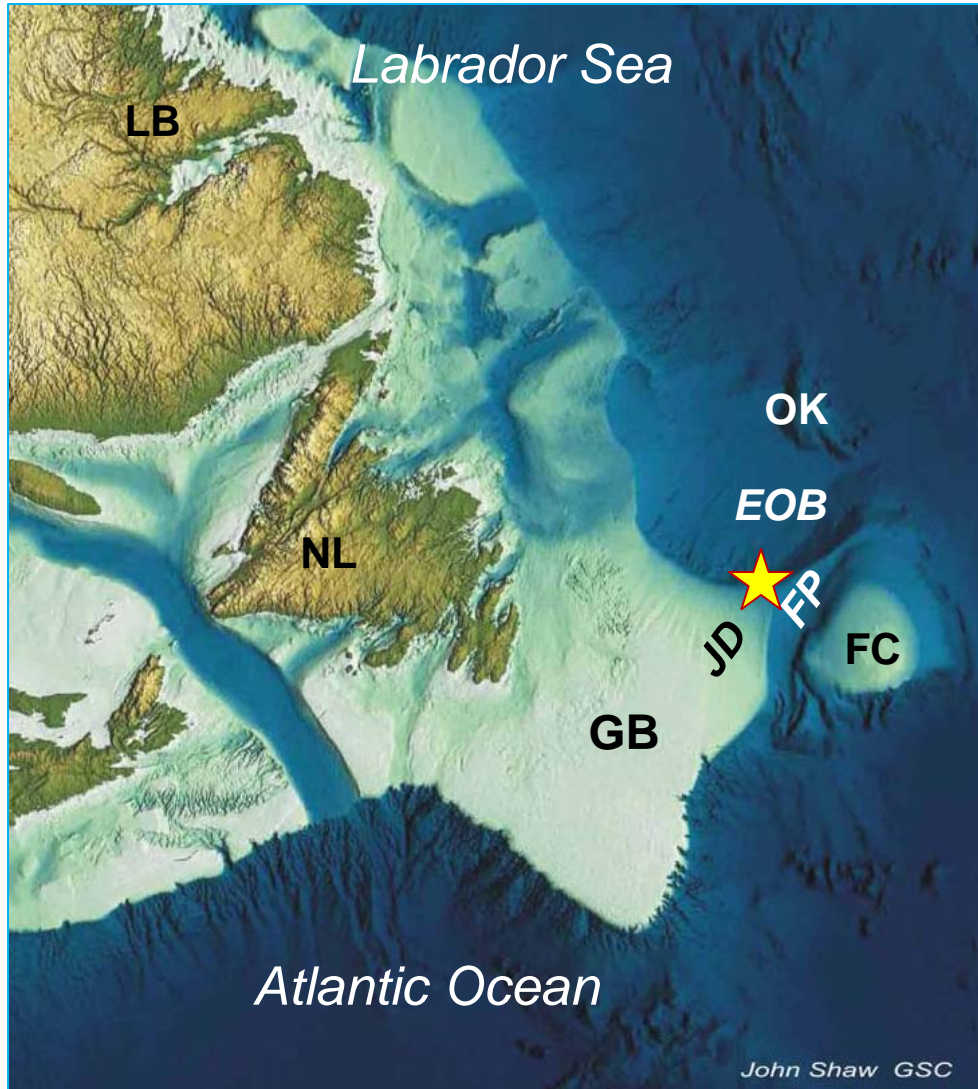
[http://www.cnlopb.nl.ca/news/pdfs/cfb11\\_02.pdf](http://www.cnlopb.nl.ca/news/pdfs/cfb11_02.pdf)

# Comments on Location of Parcels

- C-NLOPB designation for the bid location is: Area “C” - Flemish Pass/North Central Ridge
- Geologically Parcel NL11-02-01 is located mostly inside the East Orphan Basin and partially in the Flemish Pass Basin. Parcel NL11-02-02 is located in the North Central Ridge and Flemish Pass Basin.
- While the posting area was designated by the C-NLOPB as Area “C” - Flemish Pass/North Central Ridge, the parcels are structurally situated in the East Orphan Basin, Flemish Pass Basin and North Central Ridge area (see Enachescu, 1987; Enachescu et al., 2005). These units are continuous as relates to structural setting and stratigraphy but can be separated based on bathymetry
- Thus, the Flemish Pass Basin occupies the area situated in water depths between 500 to about 1500 m, while the East Orphan Basin lies in water depths greater than 1500 m. The North Central Ridge occupies the Grand Banks shelf up to 500 m water depth



# Call For Bids Location



## Location of NL11-02 parcels shown on a bathymetry map of the area

NL = Newfoundland

LB = Labrador

GB = Grand Banks

FC = Flemish Cap

OK = Orphan Knoll

JD = Jeanne d'Arc Basin

FP = Flemish Pass Basin

EOB = East Orphan Basin

★ = Approximate location of NL11-02 Parcels 1 and 2

# Flemish Pass Basin

## A proven petroleum basin.

- This Mesozoic-Tertiary basin contains 1 discovery well (Mizzen O-16), 1 well with a noteworthy oil show (Mizzen L-11) and one delineation well drilled in 2011 (Mizzen F-09 with results not released yet)
- Two Significant Discovery Licences for the Mizzen field were recently awarded (SDLs 1047 and 1048)
- Several other wells in the basin have intersected good reservoir and/or source rocks (e.g. Gabriel C-60 and Baccalieu I-78)

# Central Ridge

## A proven petroleum area.

- The Central Ridge is an intrabasinal high which is separating the Jeanne d'Arc and Flemish Pass basins; it has two subunits the South and the North Central Ridge separated by a transfer zone
- Drilled in only a few locations, the ridge has provided both oil and gas discoveries (oil at South Tempest G-88; gas at North Dana I-43 and Trave E-87)
- Several wells (e.g. North Dana I-43, South Tempest and Panther P-52) intersected thick source rock intervals



# East Orphan Basin

## A basin with petroleum potential.

- East Orphan is an underexplored basin. Only two wells were drilled in this large rift basin, one abandoned (Great Barasway F-66) and one with results not yet in the public domain (Lona O-55)
- A thick Late Jurassic clastic succession was intersected in Great Barasway F-66 well
- Good reservoir intervals and source rocks may have been intersected in Great Barasway F-66 but more studies are needed to confirm their quality
- Seismic correlation using modern seismic data indicates the presence of source rocks west and northwest of the Mizzen SDLs

# Call for Bids NL11-02

- **Exploration and Production Activity.** There are:
  - a) two active Exploration Licences (ELs) in Flemish Pass Basin (EL 1112 and EL 1124-awarded in 2010)
  - b) two ELs in Orphan Basin, one large consolidated (1074R) and most of EL 1123-awarded in 2010
  - c) three ELs on the North Central Ridge: EL 1110 and EL 1111, both awarded in 2009, and the eastern part of the consolidated EL 1190R

**2011 Activity:** Two 3D seismic surveys and several 2D lines were recorded in the East Orphan and Flemish Pass basins and the delineation well Mizzen L-11 was drilled at the border between the two basins
- **Production.** There is no production in either basin or in the Central Ridge area. The closest oil production is from the White Rose oil field situated approximately 200 km to the southwest, in the Jeanne d'Arc Basin
- **Strategic Environmental Assessment (SEA).** The C-NLOPB has previously conducted a SEA for the Call for Bids NL11-02 area. New environmental knowledge has been accumulated during the past 12 years since the Flemish Pass and East Orphan basins ELs were awarded and geophysical, geotechnical and drilling activities were carried out in the basins

# Observations

- References introduced in this presentation are listed in associated reports and presentations posted on the website:

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

- Certain parts of this presentation are repeats or updates of text and illustrations contained in the power points produced by Enachescu, 2010 and available at:

<http://www.nr.gov.nl.ca/nr/invest/energy.html#offshore>

<http://www.nr.gov.nl.ca/nr/invest/enachescuNL100203.pdf>

- Earlier Call for Bids reports and power points concerning Flemish Pass and Orphan Basin areas are available at:

[http://www.nr.gov.nl.ca/nr/invest/cfb\\_nl99\\_1.pdf](http://www.nr.gov.nl.ca/nr/invest/cfb_nl99_1.pdf)

[http://www.nr.gov.nl.ca/nr/invest/cfb\\_nl01\\_1.pdf](http://www.nr.gov.nl.ca/nr/invest/cfb_nl01_1.pdf)

[http://www.nr.gov.nl.ca/nr/invest/cfb\\_nl03\\_1.pdf](http://www.nr.gov.nl.ca/nr/invest/cfb_nl03_1.pdf)

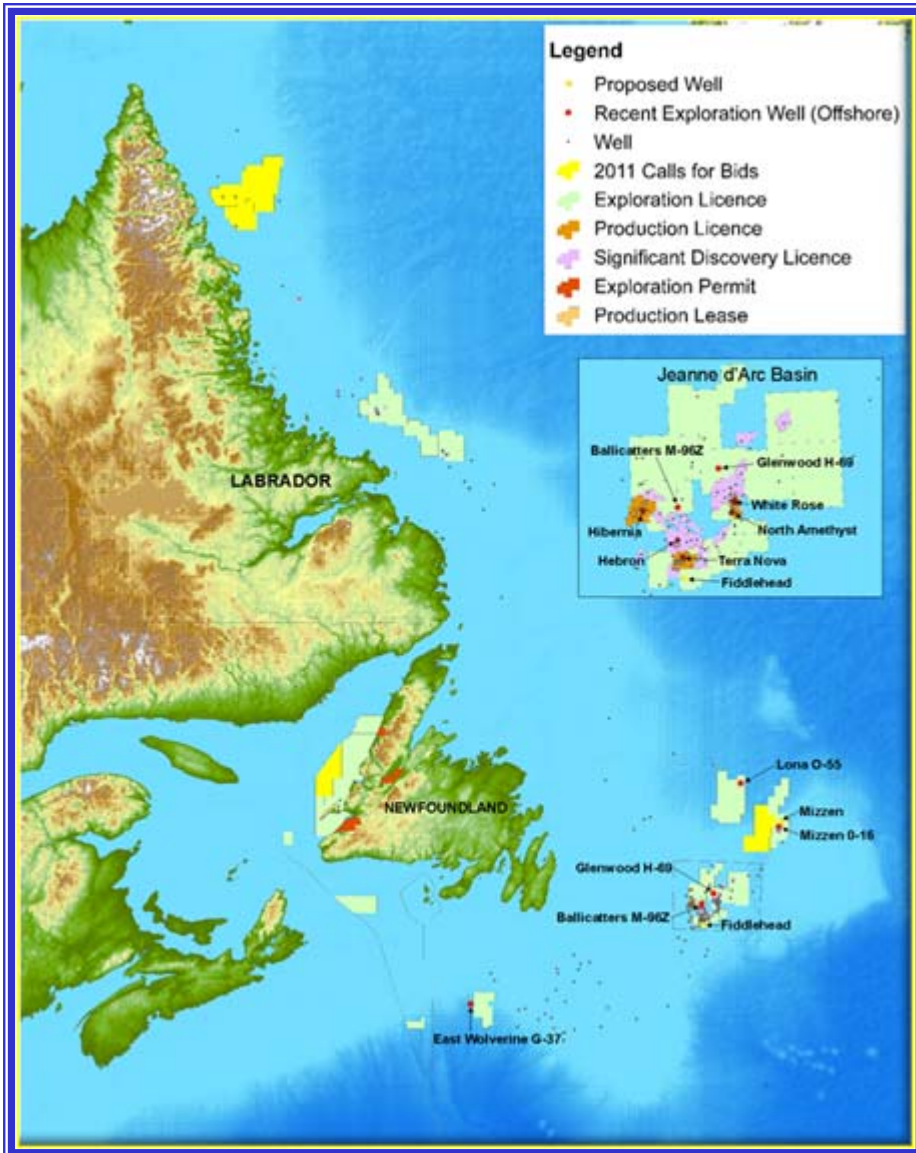
- Other references quoted in this presentation are available from the word wide web scientific publication sites such as: Iyellcollection, searchanddiscovery, sciencedirect, cspg, etc.



# **2. Exploration Background**

- **NL Historic E&P Activity**
- **NL Petroleum Production**
- **Participation of Nalcor Energy**
- **NL Mesozoic Basins Research and Exploration Projects**
- **Large Mesozoic Offshore Under-Explored Basins**
- **Recent E&P Activity in Atlantic Mesozoic Basins**
- **Northeast Newfoundland offshore Land Situation 2011**

# NL Historic E&P Activity



## Wells Drilled

Exploration (Total)	231
Offshore	147
Onshore	84
Delineation	52
Development	170

## Discoveries

Oil	20
Gas	7

## Current Holdings

Exploration Licences (ELs)/Permits (EPs)	42
Significant Discovery Licences (SDLs)	52
Production Licences (PLs)/Leases	11

# NL Petroleum Production

- **1.25 Bbbls** produced to date mainly from three fields - Hibernia, Terra Nova and White Rose developed in the Mesozoic Jeanne d'Arc Basin, on the East Coast of Newfoundland. A fourth field, North Amethyst, started producing in 2010
- These fields have produced in the range of 250,000 to 360,000 barrels per day of light crude (30 to 35° API) from Mesozoic sandstones in each of the past 5 years
- Currently NL produces between **250-300,000 bopd** monthly
- Over 100 MMbbls produced in 2010; daily average of **275, 866 bopd**
- NL production represents 12.5% of Canada's total oil production, 35% of Canada's light oil and more than 80% of Atlantic Canada petroleum output



# NL Petroleum Production (Cont.)

- NL is the second largest hydrocarbon producing province in Canada
- Production to date is from the Jeanne d'Arc Basin only; more than **1.8 Bbbls** proven remaining recoverable reserves/resources exists
- Jeanne d'Arc Basin developments are the only producing offshore oilfields on the Atlantic coast of North America
- A fifth large field, Hebron, estimated to contain 581 MMbbls recoverable reserves/resources (C-NLOPB) will be developed starting in 2012 with first oil expected in 2017. Additional 150 Mbbls recoverable reserves are associated with Ben Nevis/West Ben Nevis fields
- Satellite fields are now adding to production of Hibernia and White Rose oil fields

# Participation of Nalcor Energy

- Legislation to create the province's energy corporation, Nalcor Energy, wholly owned by the Government of NL  
<http://www.nalcorenergy.com>
- Through Nalcor, the Province negotiated equity positions in several offshore fields: White Rose Growth Projects (including North Amethyst, West White Rose, South White Rose Extension) (5%), Hebron (4.9%) and Hibernia Southern Extension (10%)
- On 31 May 2010 Nalcor obtained first oil production from its 5% participation in the North Amethyst field, establishing the company as an emerging provincial-owned upstream oil and gas player in the Atlantic continental margin
- The Energy Plan provided a framework for a price based Offshore Natural Gas Royalty Regime and introduced the concept of a “pioneer project”

# Participation of Nalcor Energy (Cont.)

- During 2009, Nalcor acquired an average of 67 per cent working interest in three onshore exploration permits in the Parsons Pond area on the Great Northern Peninsula
- In 2010, Nalcor completed the drilling of two onshore exploration wells in the Parsons Pond area, Seamus and Finnegan, and completed testing of the Seamus well
- Seamus well drilled to an onshore record depth of 3,160 metres
- Non-commercial natural gas was encountered in both wells
- The results of drilling and testing of these wells and seismic analysis have greatly advanced the understanding of Western NL petroleum geology
- The extensive datasets gathered from the wells can be extrapolated to several of the offshore exploration licences
- Nalcor continues to pursue other investment opportunities and supports the province's efforts to promote exploration

# Offshore NL Research and Exploration (R&E) Projects

- Several large R&E projects are jointly administered by Nalcor and NL Department of Natural Resources through programs such as Petroleum Exploration Enhancement Program (PEEP) and Offshore Geoscience Data Program (OGDP). Details of these programs are given at <http://www.nr.gov.nl.ca/mines&en/oil/>
- Government of NL provided \$20 million to fund the OGDP, including programs such as the offshore Newfoundland and Labrador Seep Mapping and new acquisition of regional reflection data on Labrador shelf and deep water basins
- In 2010-11 an offshore NL regional oil seep mapping and interpretation study was funded by OGDP and awarded to Astrium/Infoterra. Mapping natural oil seeps at sea allows judicious targeting of new seismic data acquisition, minimizing the geologic uncertainty and reducing overall exploration risk. The study results are available for licensing to oil companies

# Offshore NL Research and Exploration (R&E) Projects (Cont.)

- A gas hydrate study involving the NL shelf, slope and deepwater was recently initiated

<http://www.releases.gov.nl.ca/releases/2011/intrd/0818n07.htm>

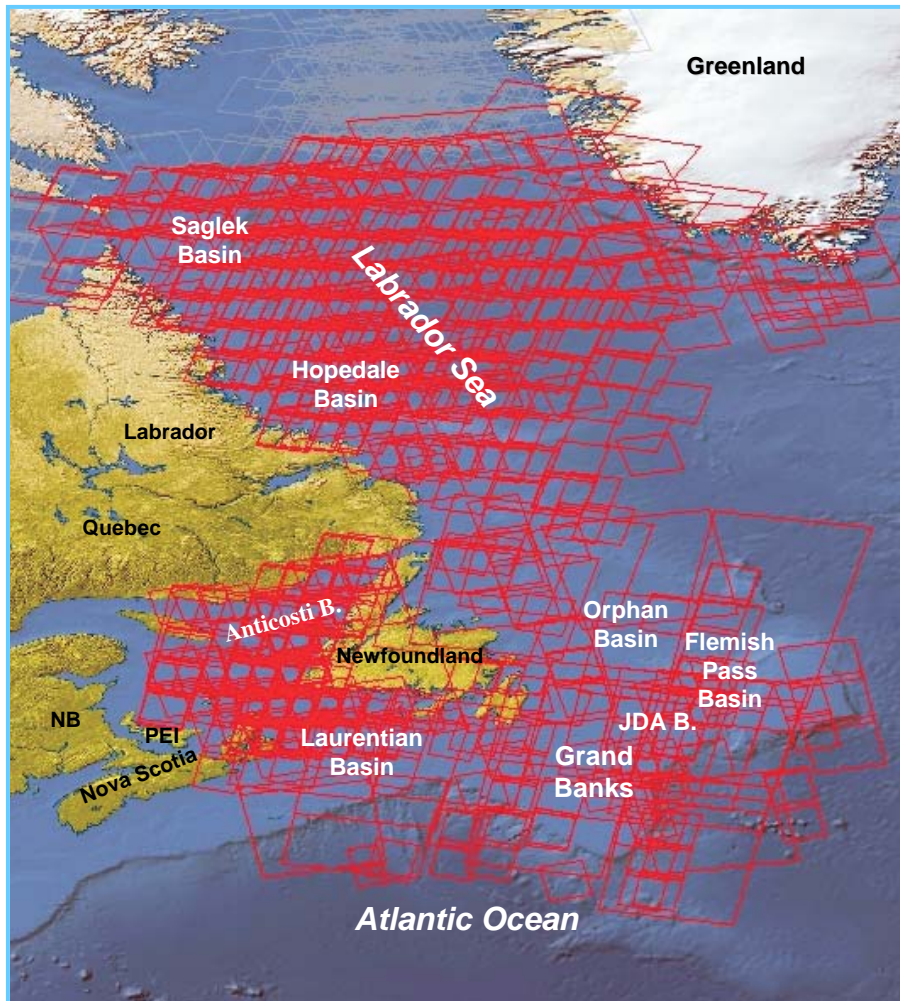
- A Plate Tectonic Kinematic Model for North Atlantic regions project was initiated in 2010 by Nalcor/DNR in collaboration with PIP/PAD of Ireland and awarded to GeoArctic. The model includes the Grand Banks/Western Ireland separation and Grand Banks, Flemish Pass and Orphan basin formation. The resulting study and kinematic animation will be available to funding agencies and also for licensing to oil companies
- A large-scale, multi-client seismic 2D program focused mostly on the Labrador offshore was partially funded by Nalcor through OGDPA and commenced this year by a partnership of experienced global contractors (TGS in collaboration with PGS).



# Regional oil seep mapping and interpretation study offshore NL

## Key Features

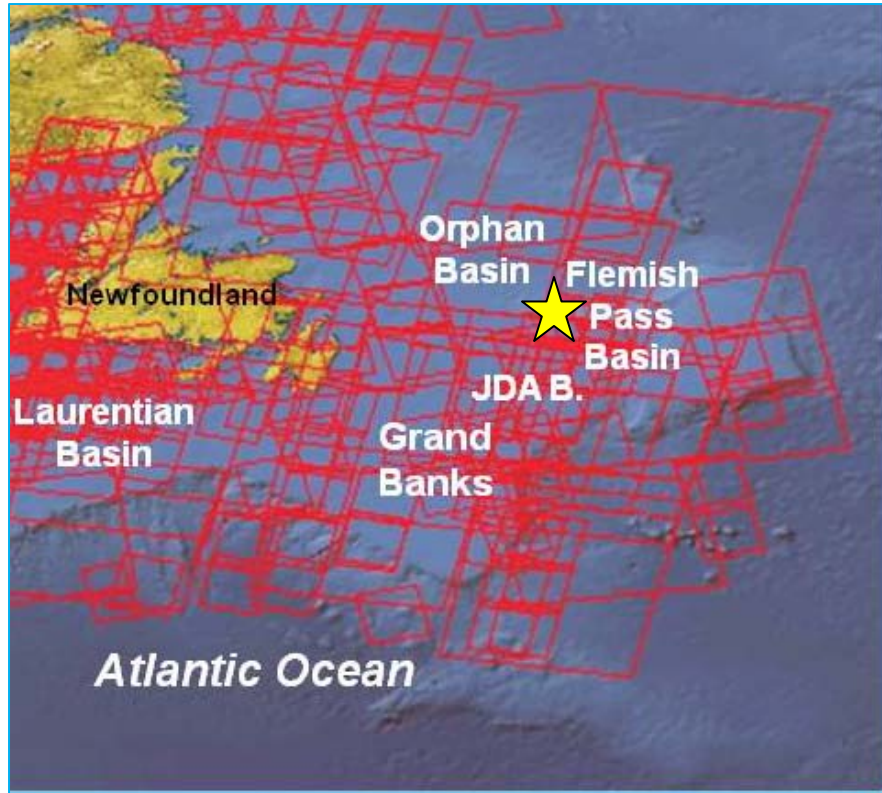
- Part of the OGDG program; Nalcor contracted the GEO-Information division of Astrium Services on a non-exclusive basis
- Cost-effective, de-risking tool used to evaluate exploration potential for both under-explored and mature offshore basins and locate new seismic grids
- Study covered offshore areas of NL totalling approximately 1.5 million km<sup>2</sup> and was linked to SW Greenland
- Mapping and classifying of offshore oil slicks based on satellite data from various providers
- Data can be licensed by oil companies and is delivered as a “plug and go” GIS product



JDA B. = Jeanne d'Arc Basin; PEI = Prince Edward Island; NB = New Brunswick

# Regional oil seep mapping (Cont.)

## Survey Objectives



JDA B. = Jeanne d'Arc Basin

★ = Location of CFB NL11-02 parcels

- Hydrocarbon screening of frontier basins (e.g. Anticosti, Laurentian, East Orphan, Flemish, Hopedale, Saglek basins)
- Risk-ranking of basins and sub-basins prior to new exploration
- Monitoring spatial characteristics of the oil slicks over areas of existing production
- Planning sea surface and sea-bottom geochemical programs
- Designing new 3D and 2D seismic programs and integration with older surveys
- Link geological and geophysical interpretation from onshore to offshore basins
- Environmental monitoring: environmental risk assessment, impact statement or full environmental baseline

# Plate Tectonic Kinematic Model Project for North Atlantic Regions

## Key Features

- A joint research project funded by Nalcor/DNR and Irish Shelf Petroleum Studies Group (ISPSG - this group includes oil companies active in Western Ireland offshore and the Irish Petroleum Affairs Directorate)
- To be managed and carried out by GeoArctic of Calgary
- Academic and technical input from the universities, industry and government scientists from Canada and Ireland
- Based on new acquired data and survey results as well as data donated by TGS and ION
- Final product to be a kinematic animation model of plate movement that will include the Atlantic Ocean and Labrador Sea opening

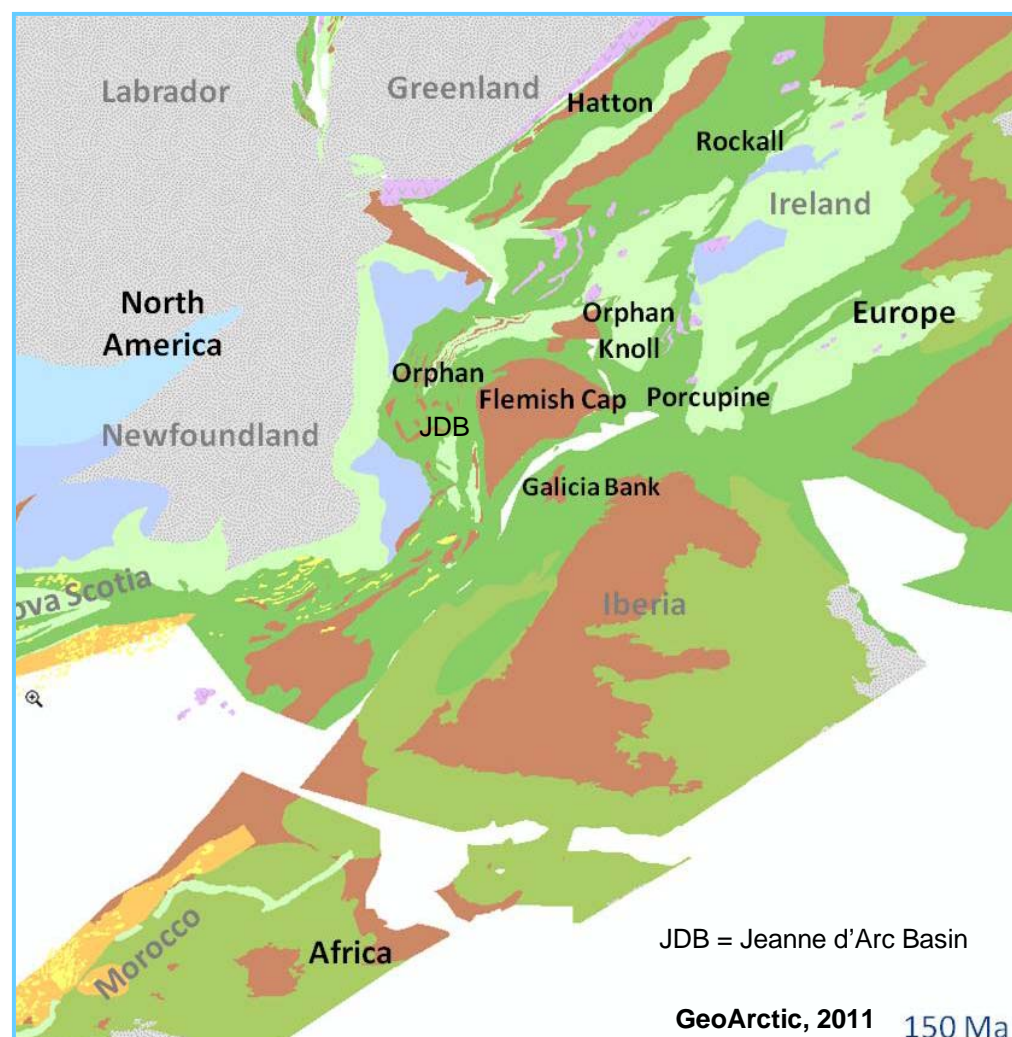
# Plate Tectonic Kinematic Model Project for North Atlantic Regions (Cont.)

## Project Objectives

- Refit the prerift continental margins on both sides of Atlantic minimising overlaps and gaps
- Determine major controls/mechanisms for North Atlantic basin formation and evolution, crustal stretching, rifting and uplift
- Determine relationship of major basins and structural highs between Eastern Canada and Ireland
- Predict Jurassic sedimentation for Orphan, Flemish Pass, southern Rockall, Hatton and southernmost Porcupine basins with greater confidence
- Evaluate prominent highs such as Flemish Cap and Orphan Knoll as possible sediment sources for the southern Porcupine and Rockall basins
- Evaluate potential for Palaeozoic reservoirs and source rocks in the region



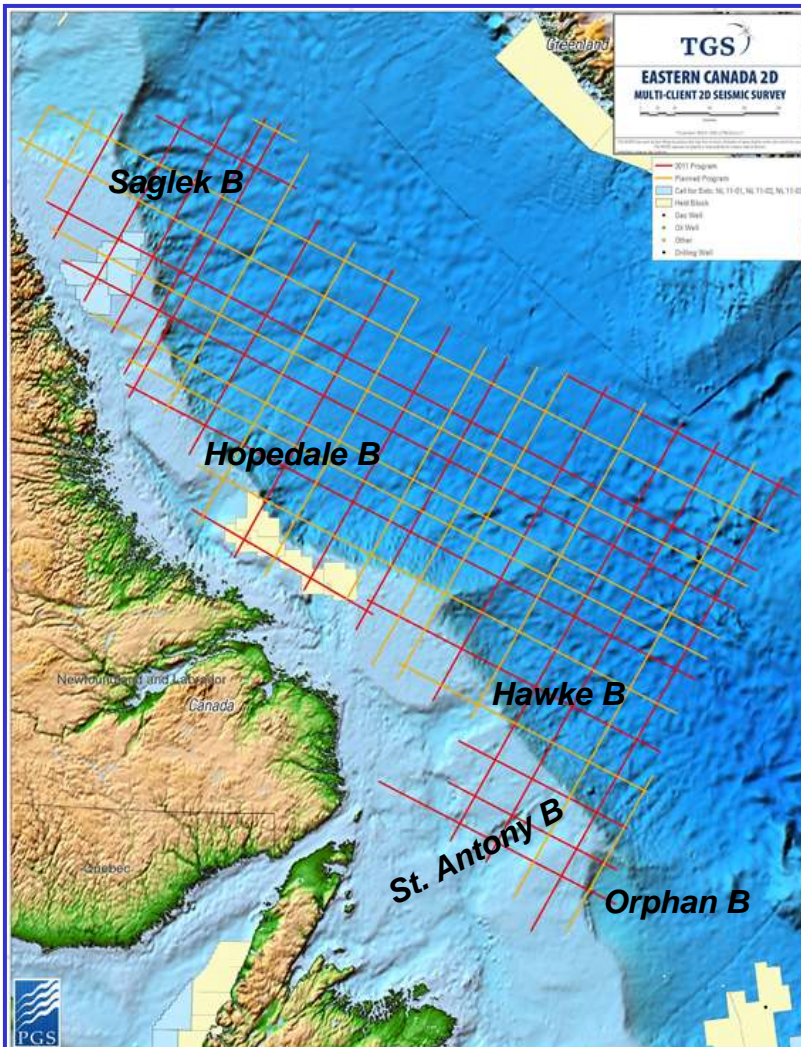
# Plate Tectonic Kinematic Model for North Atlantic Regions (Cont.)



- Reconstructed geological configuration of North Atlantic basins, seaways and continental fragments during Late Jurassic (after GeoArctic, 2011, provisional map)
- During Late Jurassic a rich marine source rock was deposited throughout the intra-continental basins of the North Atlantic region including the Jeanne d'Arc, Flemish Pass and East Orphan basins



# Seismic Survey to Further Exploration Efforts in Offshore NL



Nalcor initiated a large multi-client survey to be recorded north of existing Grand Banks' major oil discoveries. The project is a joint commercial/research project funded 1/5<sup>th</sup> by Nalcor through NL Department of Natural Resources' Offshore Geoscience Data Program (OGDP) and has other industrial funding partners. This Frontier seismic program utilizes advanced seismic acquisition and processing techniques.



M/V Sanco Spirit

<http://subseaworldnews.com/wp-content/uploads/2011/09/TGS-and-PGS-Join-Forces-to-Acquire-2D-Seismic-Survey-Offshore-Canada.jpg>

# Seismic Survey to Further Exploration Efforts in Offshore NL (Cont.)

## Key Features

- Program managed and carried out by TGS in partnership with PGS, both well known global seismic contractors, that have worked several large programs in the East Coast waters of Canada
- Survey builds on regional satellite seeps study carried out by EADS subsidiary Astrium GEO-Information Services and delivered in spring 2011 (see slides 26 and 27)
- Seismic acquisition using the Norwegian seismic ship *M/V Sanco Spirit* built in 2009 and contracted by TGS. This vessel possesses modern S&E, navigation and seismic equipment (see slide 31)
- Vessel will use the advanced PGS GeoStreamer®Technology that has dual-sensors (hydrophones collocated with geosensors), recording both pressure wave and particle motion which allows for better suppression of receiver ghosts and increased frequency bandwidth
- Plans are for 22,000 km multi-client 2D data to be collected during two seasons (2011-2012) with initial data to be available to clients during the fourth quarter of 2011

# Seismic Survey to Further Exploration Efforts in Offshore NL (Cont.)

## Project Objectives

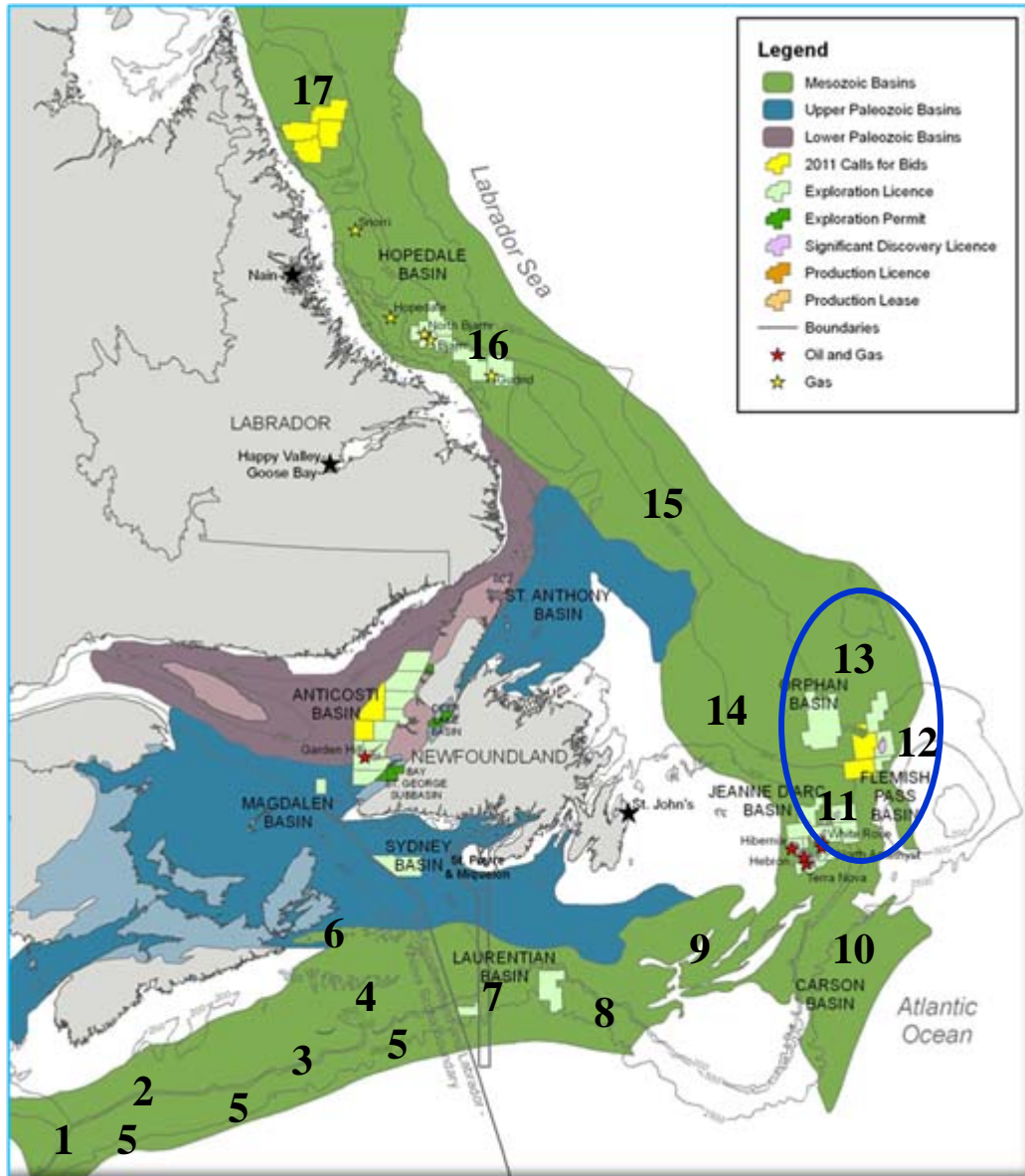
- Understand the frontier region petroleum potential and promote the province's offshore prospectivity in a vast area north of Grand Banks
- Investigate the subsurface structure and stratigraphy on the Labrador shelf, slope and deepwater and extend geological knowledge beyond the present 200 nautical miles exclusive economic zone (EEZ)
- Cover areas nominated in the C-NLOPB Call for Bids NL-11-03 or in vicinity of the offered blocks
- Data collection over the northern Orphan Basin, parts of Paleozoic St. Antony Basin, the poorly known Hawke Basin, Hopedale Basin where 4 ELs are active and Saglek Basins, the object of present Call For Bids offered 4 blocks
- Connect to seismic lines from the West Greenland margin where there is significant drilling activity: three wells were drilled in 2010 and an additional four well program is planned by Cairn and partners

# Large Mesozoic Under-Explored Basins in Atlantic Canada

- Canada's Atlantic Provinces, including Newfoundland and Labrador, were affected by the latest Wilson Cycle that was initiated with continental rifting in Triassic, and culminated with the breakup of Pangea and creation of the Atlantic Ocean
- This process also resulted in the formation of the North American continental margin that on strike, shows a shelf of variable width
- The North American Continental margin includes a series of variable size rift basins, subbasins and troughs separated by ridges starting in Florida, continuing on both onshore and offshore East Coast USA, developing offshore Nova Scotia, then passing through the Grand Banks of Newfoundland and Orphan area, changing direction into the Labrador Sea and Baffin Bay and terminating in the Arctic Ocean
- These basins show an uneven accumulation of synrift sediments and usually exhibit a thick post rift/passive margin prism of clastic and carbonate deposits
- Several northern basins (Sable, Jeanne d'Arc including central Ridge, Flemish Pass and Labrador basins) have working petroleum systems



# Atlantic Canada Mesozoic Basins



1. Georges Bank
2. Shelburne
3. Sable
4. Abenaki
5. Scotian Slope (Deep Water)
6. Orpheus Graben
7. Laurentian
8. South Whale
9. South Grand Banks (Whale, Horseshoe, South Jeanne d'Arc)
10. Carson
11. Jeanne d'Arc/Central Ridge (CFB NL11-02)
12. Flemish Pass (CFB NL11-02)
13. East Orphan (CFB NL11-02)
14. West Orphan
15. Hawke
16. Hopedale
17. Saglek



# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Nova Scotia

- A total of 127 exploration wells have been drilled in the Nova Scotia offshore since 1967 resulting in 23 significant oil and gas discoveries. Since 2003, 20 wells have been drilled: 10 development/delineation and 10 exploration. A comprehensive Geoscience Project was commissioned by Nova Scotia's Offshore Energy Technical Research Association (OETRA) and contracted to RPS Energy of the UK. The **Play Fairway Analysis** was finished this year and indicates a diversity of remaining and new exploration opportunities in the NS offshore and most interesting, points out the existence of an Early Jurassic Type I to II marine source rock ([www.novascotiaoffshore.com](http://www.novascotiaoffshore.com))
- A description of Nova Scotia basins and comments on their petroleum potential is provided by Enachescu (2011) and posted at: <http://www.nr.gov.nl.ca/nr/invest/enachescuNL11-03.pdf>

## Newfoundland and Labrador

- The following slides contain a description of Newfoundland and Labrador Mesozoic basins including East Orphan, Flemish Pass and the Jeanne d'Arc Basins; Central Ridge is a basement high separating the Jeanne d'Arc and Flemish Pass basin (Enachescu, 1987 and 1998)

# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Newfoundland

- **Laurentian** Basin is a typical Atlantic margin deep basin formed by extensional tectonics and influenced by salt movements. The basin has accumulated thick Jurassic and Cretaceous sediments and was strongly canyonized during Tertiary. The basin was under a long lasting exploration moratorium due to international and provincial border disputes, both resolved in early 2000s. A dry hole, Bandol #1, was drilled during 2001 in the French waters by ExxonMobil and partners. The hydrocarbon plays are similar to those encountered on the Scotian shelf and slope and include listric fault blocks, rollover anticlines, salt cored anticlines and slope sedimentary fans. An unsuccessful exploration well, East Wolverine G-37, was drilled in early 2010, by ConocoPhillips and BHP Billiton, to test a deep-water prospect. Two deep water ELs are active in the basin. Numerous leads and prospects remain undrilled in shallow, intermediate and deep water
- **South Whale** Basin was intensively explored during the late 1960s - early 1970, targeting seismically expressed salt diapirs. More than 20 wells were drilled in the basin and its vicinity and all were unsuccessful. Only a noteworthy heavy oil show was encountered in Heron H-73 well. After more than a 20 year pause, exploration was renewed in early-mid 2000s when Lewis Hill G-85 well was drilled in the central part of the basin. The well remained short of Jurassic layers, intersected good Late Cretaceous reservoirs, but failed to encounter hydrocarbons. Some deeper areas in the central and deep water parts of the basin may have preserved the Late Jurassic reservoirs and source rock interval. There is no current exploration in the basin

# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Newfoundland

- **South Grand Banks** was also explored in the earliest Grand Banks exploration phase when about 15 wells were drilled in the Whale, Horseshoe, shelfal Carson and South Jeanne d'Arc Basin. These basins, started along an abandoned arm of the Tethys rift system, contain thick Late Triassic to early Late Jurassic formations, including thick, mobile Argo salt. The basins were elevated during the Early Cretaceous Newfoundland Transfer Zone active stage and the Avalon Uplift episode and most of its Late Jurassic reservoirs and source rocks, as well as Early Cretaceous reservoirs were eroded. These basins have low to no potential for hydrocarbons in Mesozoic rocks, but Paleozoic rocks that form the rifted basement may have potential
- **Carson** Basin has no ongoing exploration but there is significant petroleum potential in the deep water part of the basin. The shelfal part of the basin was severely eroded during the Avalon Uplift emplacement (Avalon Unconformity). Four wells were drilled in the basin and penetrated a section from Triassic to Neogene in age but no hydrocarbons were encountered. A recent 4D petroleum system study by Geological Survey of Canada Atlantic has indicated that hydrocarbons were generated in significant amounts. A 3D survey exists on the slope of this basin. No drilling has been carried out on the slope, where seismic data indicate presence of large structural and stratigraphic features

# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Newfoundland

- **Jeanne d'Arc** Basin is the only North American East Coast basin containing giant producing oil fields. The fields produce light crude (30 to 35°API) from Late Jurassic-Early Cretaceous sandstones. During 2010, the basin's main fields: Hibernia, Terra Nova, White Rose and several satellites, produced at an average of 275,000 bopd rate. A true supergiant, Hibernia has produced 765 MMbbls as of the end of September 2011, with an estimated 630 MMbbls of remaining reserves. The Hebron oil field (17 to 27°API), presently the largest light oil development in Canada, will have first production in 2017. Smaller fields located in the basin wait for innovative development solutions. One exploration well, Statoil's Fiddlehead D-83, located in EL 1101 just south of Terra Nova field, is being drilled this fall. There are 15 current ELs in the basin and vicinity that must be drilled soon. Moreover, numerous deeper structural and stratigraphic features located in the central and northern part of the basin and on its eastern flank remain to be drilled. The Late Jurassic Egret Member is a world-class source rock which may have charged several other major accumulations in this prolific basin
- **Flemish Pass** Basin has become the second NL Mesozoic basin to record a significant oil discovery. Mizzen O-16 well, drilled in 2009 by Statoil, tested at a rate 3774 bopd from a Late Jurassic sandstone interval and proved an oil accumulation (22°API). Only 7 wells were drilled in the basin. Two large ELs adjacent to Mizzen SDLs were awarded at the 2010 Call for Bids. Mizzen F-09 delineation well was drilled in SDL 1047 this summer but results are still confidential. Two 3D surveys were carried out in the basin during 2011 by Chevron (partially in the Orphan Basin) and Statoil. There are several large undrilled structures in this intermediate deep water area where Late Jurassic source rocks were logged by several wells

# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Newfoundland

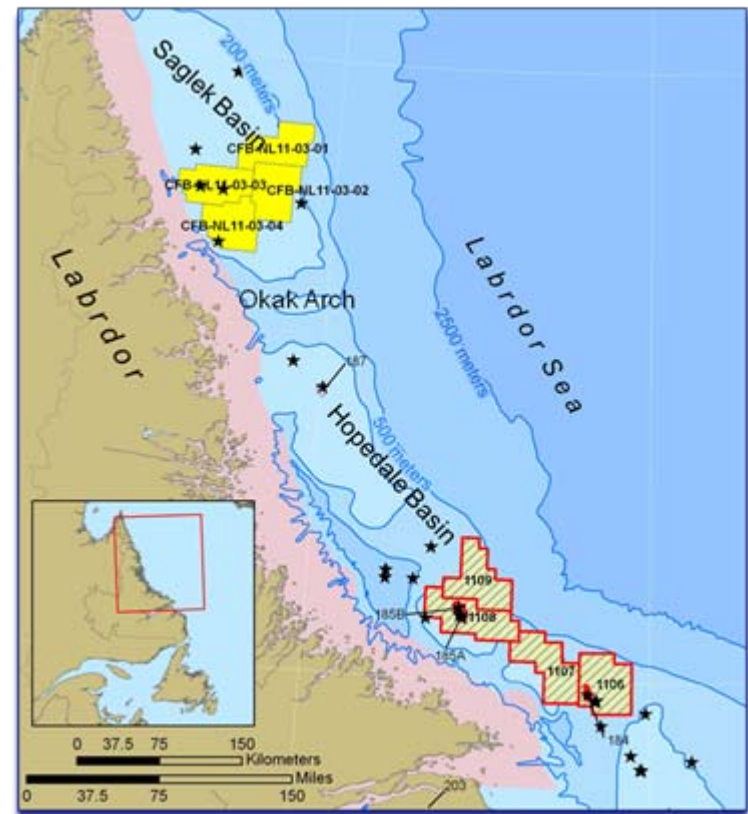
- **East Orphan Basin (EOB)**, is a highly attenuated Mesozoic-Tertiary sedimentary area situated north and northeast of the Grand Banks of Newfoundland in water depths ranging between 1500 and 3500m. This large Mesozoic sedimentary area was the focus of NL deep water exploration for the past 10 years. Large 2D and 3D seismic programs and CSEM surveys were conducted and 2 deep wells were drilled, but they were unsuccessful (Great Barasway F-66 and Lona O-55). A large consolidated EL 1074R, validated by the drilling of these wells and now in its second exploration phase, still contains large undrilled structures. According to several geodynamic models, the Late Jurassic source rocks should be present in some of the elongated troughs, seismically mapped in the basin. One of the CFB NL11-02 blocks, is located close to the Mizzen SDL and extends in the southern East Orphan Basin
- **West Orphan Basin (WOB)** formed during the Late Jurassic-Early Cretaceous extension and is a relatively younger rift basin than East Orphan Basin. The White Sail Fault Zone separates the two basins. The basin had seven dry holes in the early eighties and has not seen drilling since. While good reservoirs and very large structural traps were tested, neither significant hydrocarbon flows nor Kimmeridgian source rocks were encountered. There are thick Cretaceous and Tertiary fine clastic intervals rich in TOC that may be mature in sectors of this basin



# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Labrador

The Labrador margin contains two Mesozoic basins, Hopedale and Saglek, separated by the Okak Arch. The basins were initiated during the continental rifting and oceanic spreading that resulted in the separation of the Canadian north-eastern regions of Labrador and Baffin Island from Greenland, and the formation of the Labrador Sea. The basins contain basement rotated blocks and horsts covered by synrift and postrift sediments and separated by elongated troughs. The basement contains Lower Paleozoic carbonate rocks that have preserved reservoir quality. During Tertiary rift reactivation and passive margin fill, several episodes of transtension led to the formation of compression modified extensional structures



# Large Mesozoic Under-Explored Basins in Atlantic Canada (Cont.)

## Labrador

- **Hopedale** Basin is a mildly explored area which contains several large gas discoveries from the 1970s to early 1980s period. The complex Bjarni-North Bjarni gas field is estimated to contain 3Tcf in Early Cretaceous sandstones. None of the early discoveries have been developed. The basin was the object of a NL Call for Bids issued in 2007 and concluded in 2008 with the licensing of 4 large parcels (ELs 1106 to 1109). Several 2D seismic programs were conducted during 2009-2011 over these ELs but no new exploration well has been drilled yet. A large 2D multi-client seismic survey is being conducted by TGS and partners (including PGS and Nalcor) during 2011-2012 and will cover this basin and its environs. The second basinward lineament of highs, the deep ridge marking on places the slope break and the slope are practically unexplored
- **Saglek** Basin is located in the northern part of the Labrador Sea, the Davis Strait area and on the southeast Baffin Island shelf and slope. The basin contains only 9 exploration wells, all drilled on the shelf during the period 1975 to 1982. One large gas discovery with NGLs (estimated between 2.3 and 3 Tcf resources) was made at Hekja O-71 in the northern part of the basin, offshore Nunavut territory. While 6 wells were drilled in the NL sector of the Saglek Basin, no significant petroleum discovery was made. Unlike the North Saglek Basin that is located within an important transfer zone affected by effusive and intrusive magmatic rocks, the South Saglek Basin is dominated by extensional tectonics and has only minor volcanics. The basin is practically unexplored east of the first lineament of basement highs

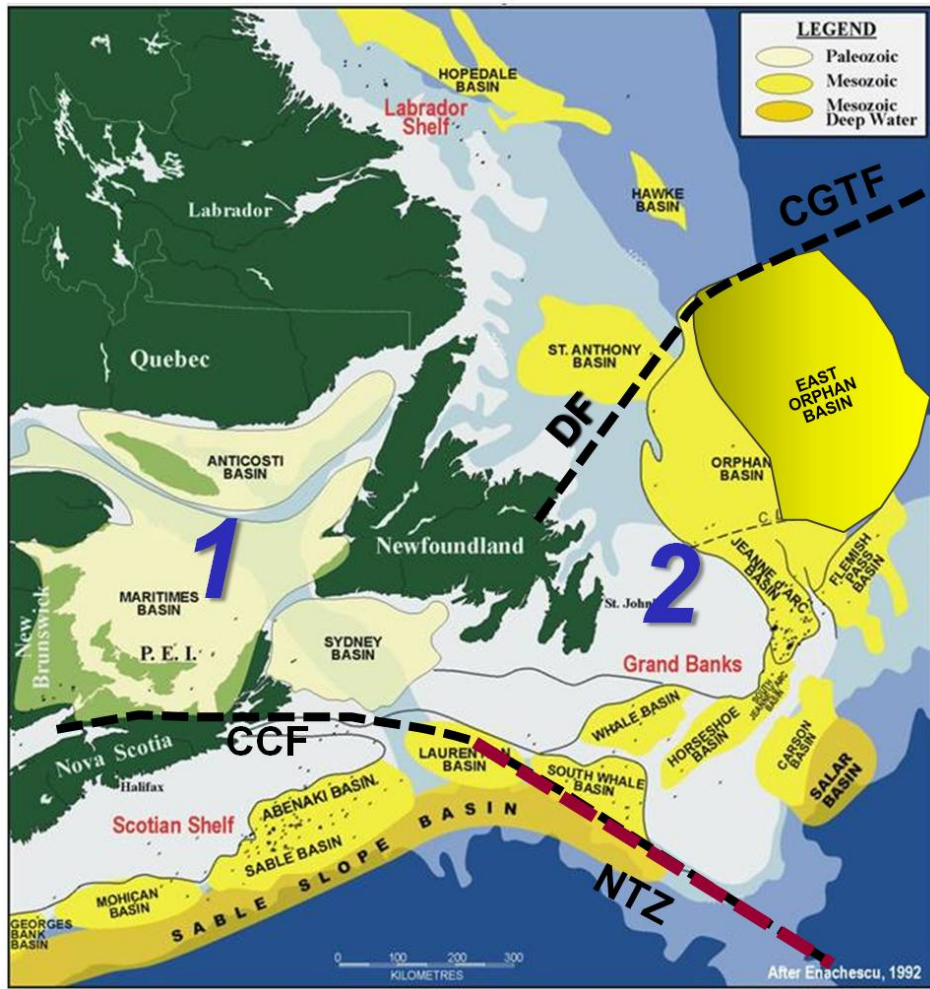
# **3. Regional Geology Of Call For Bids NL11-02 area**

- **Complex Geodynamic Evolution**
- **North Atlantic Rifting**
- **Geologic Evolution of NL Margin  
Sedimentary Basins**
- **Recent Exploration Activity**

*Observation* : More information on Regional and Petroleum Geology of the Call for Bids area is contained in the Enachescu (2010) presentation available from: :

<http://www.nr.gov.nl.ca/nr/invest/enachescuNL100203.pdf>

# 3. Regional Geology of Call for Bids NL11-02 area



- **Two Wilson cycles in the Call for Bids area:**
  - 1. Paleozoic Wilson Cycle - (completed)
  - 2. Mesozoic Wilson Cycle - (incomplete)

- **Both cycles have hydrocarbons discoveries!**

DF = Dover Fault

CGTF = Charlie Gibbs Transform Fault

CCF = Chebucto Cobeqoid Fault

NTZ = Newfoundland Transform Zone

# Complex Geodynamic Evolution

- NL offshore basins have had a complex geodynamic evolution including:
  - Repeated extension and transtension in Mesozoic, block rotation, changes in the direction of rifting, salt tectonism, subsidence, uplift, erosion, volcanism, mantle exhumation and localized inversion (due to various causes but non plate convergence related) have created numerous hydrocarbon traps
- Several rifting stages with changes of direction followed by postrift sedimentation
- Oblique slip is a norm rather than an exception



# North Atlantic Rifting

Offshore NL basins were formed by intra-continental and oceanic rifting. There were four continental rifting phases in the N Atlantic region:

1. Tethys rift phase  
during Late Triassic to Early Jurassic
2. North Atlantic Rift phase  
during Late Jurassic to Berriasian
3. Labrador Sea Rift phase  
during Berriasian to Albian
4. Greenland/Europe rift phase  
during Late Cretaceous-Eocene

**Abbreviations** are GL = Greenland, IB = Iberia, Af = Africa plates; SB = Saglek Basin, HB Hopedale Basin, WOB = West Orphan Basin, EOB = East Orphan Basin, JDB = Jeanne d'Arc Basin, FPB = Flemish Pass Basin, SJDB = South Jeanne d'Arc Basin, CB = Carson Basin, HS = Horseshoe Basin, WB = Whale Basin, SWB = South Whale Basin, SB = Scotian Basin, UFZ = Ungava Fault Zone, CGFZ = Charlie Gibbs Fracture Zone, CBTZ = Cumberland Fault Transform Zone, NTZ = Newfoundland Transform Zone

Enachescu, 2011



# Geologic Evolution of NL Margin Sedimentary Basins

- Intra-continental Rifting; All basins start with an intra-continental lacustrine stage including red beds and “some” lacustrine source rocks
- Later, basins were periodically invaded by the Tethys Sea and then, the newly formed Atlantic Ocean. The oil proven basins - Jeanne D’Arc, Flemish Pass and the little explored East Orphan basins have remained intra-continental throughout their evolution
- Basins are segmented by transfer faults; 2-3 fault systems are present in the basins and ridges, corresponding with repeated changes of extensional vector direction
- Basins are abandoned branches of the Tethys, then North Atlantic rift



# Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- The outer basins initiated as intra-continental, developed as intra-continental (Late Triassic to late Late Cretaceous) and only in Albo-Aptian became divergent margin basins. This is the case for Carson/Salar-Lusitania/Peniche and East Orphan/Flemish Pass/Porcupine pairs
- The outermost basins were then affected by Mantle Exhumation followed by Oceanic Rifting; Transform faults were active during these stages. As a result of transtension, large compression modified, extensional structures were formed
- Only the outermost rifts are successful rifts and they form the Canadian members of the pairs of conjugate margins basins (e.g. East Orphan /Flemish with Porcupine basins)



# Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- Transitional Crust emplacement took place before oceanic rifting. This crust is covered by thick post-exhumation (Mid-Cretaceous-Tertiary) sediments that might contain oil and gas accumulations (undrilled yet)
- Extensional system bounded in the north by the Dover Fault and Charlie Gibbs Transform Zone (CGTF) and in the south by a major Ocean-Continent Transform Zone (NTZ) later becoming an Ocean-Ocean Transform (Newfoundland-Gibraltar Transform)
- Intensive salt halokinetics and halotectonics; Diapirs due to gravity induced flow and salt walls (lineaments) due to extensional faulting and flow into rollover anticline and ridge cores





# Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- There are no or rare allochthonous salt or tow thrusts -unlike offshore Nova Scotia
- Diapiric salt extends to the North Jeanne/central Flemish Pass basins; Only stratified evaporite beds in the northern Flemish Pass/East Orphan basins
- Constrained (e.g. Jeanne d’Arc, Flemish Pass basins) and unconstrained (Laurentian, Salar basins)
- All Grand Banks and West Orphan basins have thick Tertiary cover while East Orphan Basin was a starved basin during most of Tertiary
- Individual basins/subbasins/rifts may be diachronous, with as much as  $\pm 10$  MM years between forming events





# Recent Exploration Activity in Call for Bids Area

- In the past 5 years, industry exploration in NL's Mesozoic basins consisted of 2D and 3D seismic data acquisition, CSEM studies, geotechnical surveys and drilling
- Exploration drilling on the Grand Banks and environs took place in the following basins:
  - Jeanne d'Arc (North Amethyst K-15, Ballicaters M-96 and M-96Z, Glenwood H-69; Fiddlehead D-83 is being drilled at the time of the writing of this presentation),
  - Flemish Pass (Mizzen O-16) and
  - East Orphan (Great Barasway F-66 and Lona O-55)
- The only successful exploration well was drilled on the Mizzen structure that is located in the Flemish Pass at the border with East Orphan Basin, almost perpendicular to a bathymetric feature known as Sackville Spur and close to the Call for Bids parcels

# Recent Exploration Activity in Call for Bids Area (Cont.)

- New exploration licences have been issued and consolidation/relinquishment of older issued ELs has taken place in East Orphan, Jeanne d'Arc/Central Ridge and Laurentian basins
- Large 3D surveys were collected in Jeanne d'Arc, Flemish Pass and East Orphan basins while basin-wide 2D grids were collected in Labrador Sea; two large 3D programs have been conducted in 2011 in the CFB NL11-02 area
- As of the fall of 2011 there are more than \$ 900 million in exploration commitments to be undertaken by interest owners in NL Mesozoic basins
- **The most exciting outcome of the last exploration cycle 2005-2011: A new offshore NL basin, Flemish Pass, has been proven to contain hydrocarbons in significant accumulations**

# 4. Petroleum Geology of Call For Bids NL11-02 Area

- Land Situation 2011
- Recent Call for Bids Results
- Exploration Results
- Characteristics of Discoveries
- Petroleum System (s)
- Hydrocarbon Traps
- Maturation and Migration
- Resource Potential

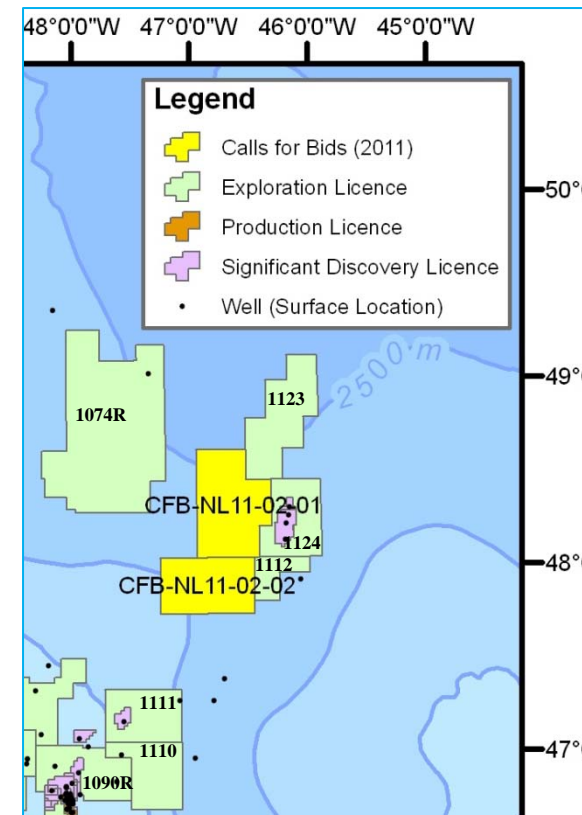
**Observation** : More information on Regional and Petroleum Geology of the Call for Bids area is contained in the Enachescu (2010) presentation available from:

<http://www.nr.gov.nl.ca/nr/invest/enachescuNL100203.pdf>

# CFB NL11-02 Land Situation 2011

## Exploration Licences

No	ELs	Area (ha)	Operator
<b>Flemish Pass</b>			
1	EL 1112	55,954	Statoil
2	EL 1123	201,951	Statoil
3	EL 1124	125,421	Statoil
<b>East Orphan</b>			
1	EL 1074R	604,000	ExxonMobil
<b>Central Ridge</b>			
1	EL 1090R	136,395	Husky Oil
2	EL 1110	138,200	Husky Oil
3	EL 1111	134,227	Husky Oil



# CFB NL11-02 Land Situation 2011

## Significant Discovery Licences

### Flemish Pass

#### SDL

1. Mizzen
2. Mizzen

Area (Ha)

22,006  
3,773

Operator

Statoil  
Statoil

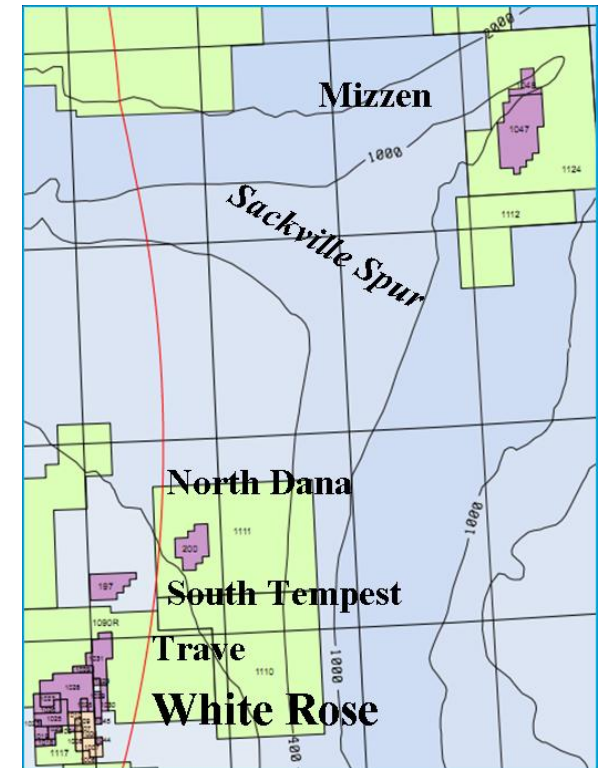
### Central Ridge

#### SDL

1. North Dana
2. South Tempest
3. Trave

8,765  
7,722  
7,045

ExxonMobil  
ExxonMobil  
Husky Oil





# Recent Call for Bids Results in the Vicinity of NL11-02 Area

CFB NL10-02 in Flemish Pass/Orphan Basin area was concluded with the awarding in January 2011 of two deep water parcels as following:

EL No.	Basin	Size (ha)	Date Issued	Bid Size \$	Operator	Other Partners
1123	Flemish Pass	201,951	2011	75 MM	Statoil	Repsol
1124	Flemish Pass	125,421	2010	20 MM	Statoil	Husky

CFB NL08-02 in N. Central Ridge/Flemish Pass Basin area was concluded with the awarding in January 2009 of two shallow to intermediate water parcels as following:

EL No.	Basin	Size (ha)	Date Issued	Bid Size \$	Operator	Other Partners
1110	N. Central Ridge	138,200	2009	18.6 MM	Husky	Suncor/Repsol
1111	N. Central Ridge	134,227	2009	1.2 MM	Husky	Repsol

# CFB NL11-02 Area Exploration Results

No	Discovery	Date	Recoverable Gas (BCF)	Resources Oil (MMbbls)
	<b>Central Ridge</b>	2 gas discoveries while searching for oil		
1	Trave H-81	1973	<b>30</b>	<b>1</b>
2	North Dana H-55	1974	<b>426</b>	<b>11</b>
3	South Tempest G-88	1981		<b>8</b>
	<b>Flemish Pass Basin</b>			
1	Mizzen O-16	2009	<b>Not Disclosed</b>	

**Observation:** No exploration took place in the area between 1983-2003

# Characteristics of Call for Bids Area Hydrocarbon Discoveries

Well	Gas MMcfd	Condensate Bblsd	Oil Bblsd	Source	Reservoir
<b>Trave H-81</b>	<b>17.9</b>	<b>521</b>	<b>-</b>	L. Jurassic Egret Mbr	Hibernia ss
<b>North Dana H-55</b>	<b>12.8</b>	<b>292</b>	<b>-</b>	L. Jurassic Egret Mbr	Tempest ss
<b>South Tempest G-88</b>	<b>5</b>	<b>-</b>	<b>1250</b>	L. Jurassic Egret Mbr	Tempest ss
<b>Mizzen O-16</b>	<b>-</b>	<b>-</b>	<b>3774</b>	L. Jurassic Egret Mbr	Tithonian ss

More information on the characteristics of offshore Newfoundland and Labrador reservoirs and drilling tests are available at:

[http://www.cnlopb.nl.ca/pdfs/oil\\_prop.pdf](http://www.cnlopb.nl.ca/pdfs/oil_prop.pdf)

[http://www.cnlopb.nl.ca/pdfs/gas\\_prop.pdf](http://www.cnlopb.nl.ca/pdfs/gas_prop.pdf)

# Petroleum System(s)

- The only proven petroleum system on the Grand Banks and environs is anchored by the **Egret Member of the Rankin Formation** (Late Jurassic) feeding hydrocarbons into
  - Late Jurassic reservoirs such as the Voyager, Tempest, Jeanne d'Arc sandstones (ss)
  - Early Cretaceous reservoirs such as Hibernia, Catalina Avalon and Ben Nevis ss
  - Late Cretaceous reservoirs such as Fox Harbour and Otter Bay ss
  - Early Tertiary reservoirs such as Avondale and South Mara ss
- Older Late Jurassic shales (Callovian and Oxfordian) have also good source properties
- A possible source rock is the Albian shale (Nautilus Fm) that showed rich, marine organic content when drilled by the IODP leg 210, at a location situated just east of Flemish Cap
- Tertiary shales are yet unproven as source rocks

# Hydrocarbon Traps(s)

- **Structural**
  - Roll-over anticlines in front of basin bounding faults (e.g. Hibernia)
  - Salt core anticlines and ridges (e.g. White Rose, North Amethyst)
  - Rotated blocks (Hebron, Ben Nevis, North Ben Nevis)
- **Combination**
  - Onlapping sandstones on structural highs (e.g. Terra Nova)
- **Stratigraphic**
  - Channel, basin margin or basin floor fans (e.g. Springdale, Mara)

**Observation:** Most of the structural and combination traps on the Grand Banks are salt cored and multi-way bounded by faults. Larger traps are also dissected by several fault systems and may have multiple reservoirs. No salt induced features are in the CFB area. Large basement-cored rotated blocks are present throughout the area. The largest traps can host more than a billion barrels of oil or/and several Tcf of gas



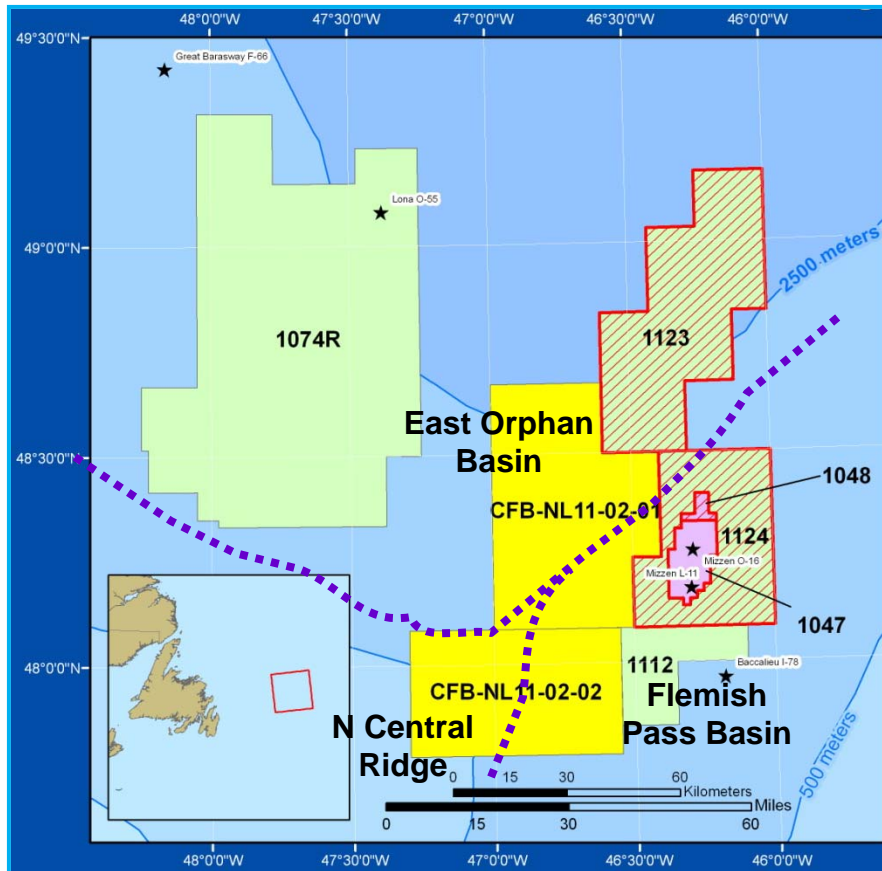
# Resource Potential:

## How Much Oil & Gas offshore NL?


- More than **1.8 Bbbls** proven remaining recoverable reserves/resources exists in the Jeanne d'Arc Basin; approximately 11 Tcf of gas has been discovered offshore NL of which **6.6 Tcf** of gas reside in JDB, however no gas sales to date
- Geoscience data indicate that a further **6 Bbbls** and **60 Tcf** undiscovered resources remain offshore Newfoundland and Labrador
- A large part of the oil resources is expected to be found in the North Jeanne d'Arc, North Central Ridge, Flemish Pass and East Orphan region

# 5. Petroleum Potential of Call for Bids NL11-02 Parcels

- **Call for Bids NL11-02** contains two large, offshore parcels located in the Area “C”-Flemish Pass/North Central Ridge region:

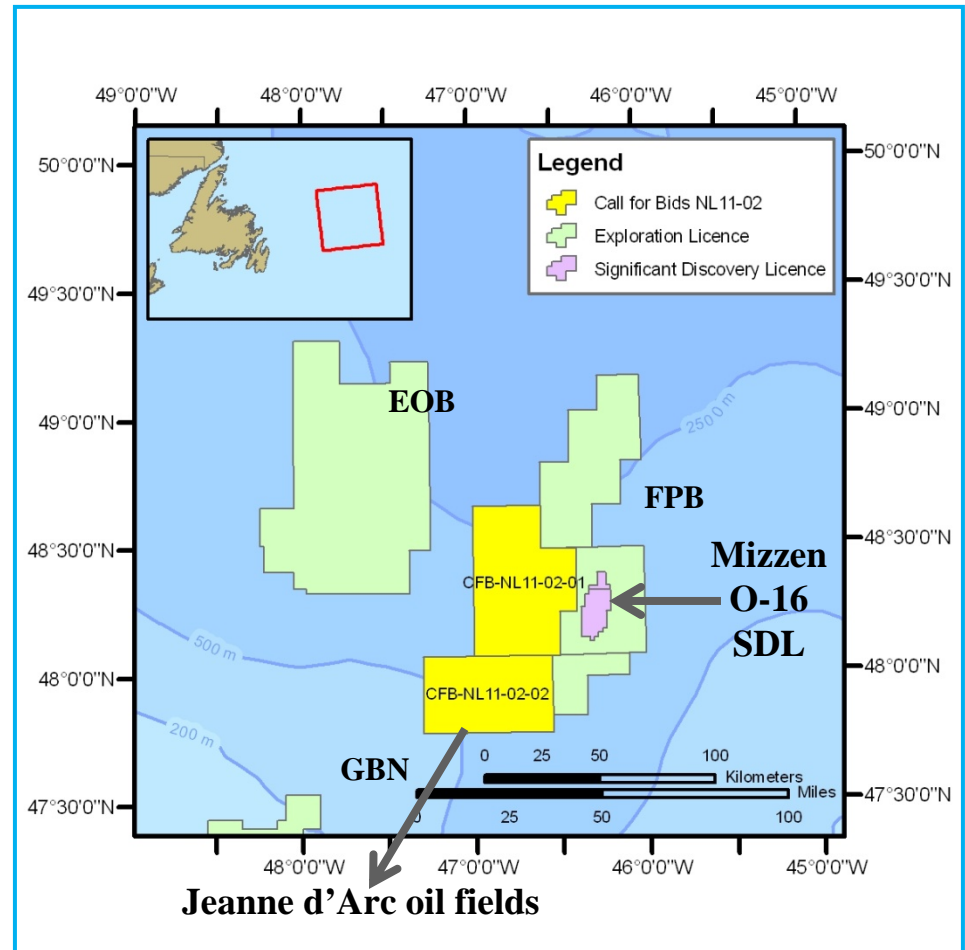


- **NL11-02-01** of 247,016 hectares (610,390 acres), located in 635-2655 m water depth within Flemish Pass/East Orphan basins
- **NL11-02-02** of 186,780 hectares (461,543 acres), located in 350-1165 m water depth within the North Central Ridge/Flemish Pass Basin

 = approximate limit of structural units

# Petroleum Potential of Call for Bids NL11-02 Parcels (Cont.)

- The two large Call for Bids NL11-02 parcels are located on the outer shelf and slope of the Grand Banks of Newfoundland (GBN) and in the intermediate and deeper waters of Flemish Pass (FPB) and East Orphan (EOB) basins
- The parcels are in vicinity of proven hydrocarbon occurrences in the Jeanne d'Arc Basin and North Central Ridge, and just west of a new discovery in the Flemish Pass Basin
- Large structural, stratigraphic and composite traps are seen on seismic data collected in the area



# Call for Bids NL11-02 Flemish Pass/North Central Ridge Region

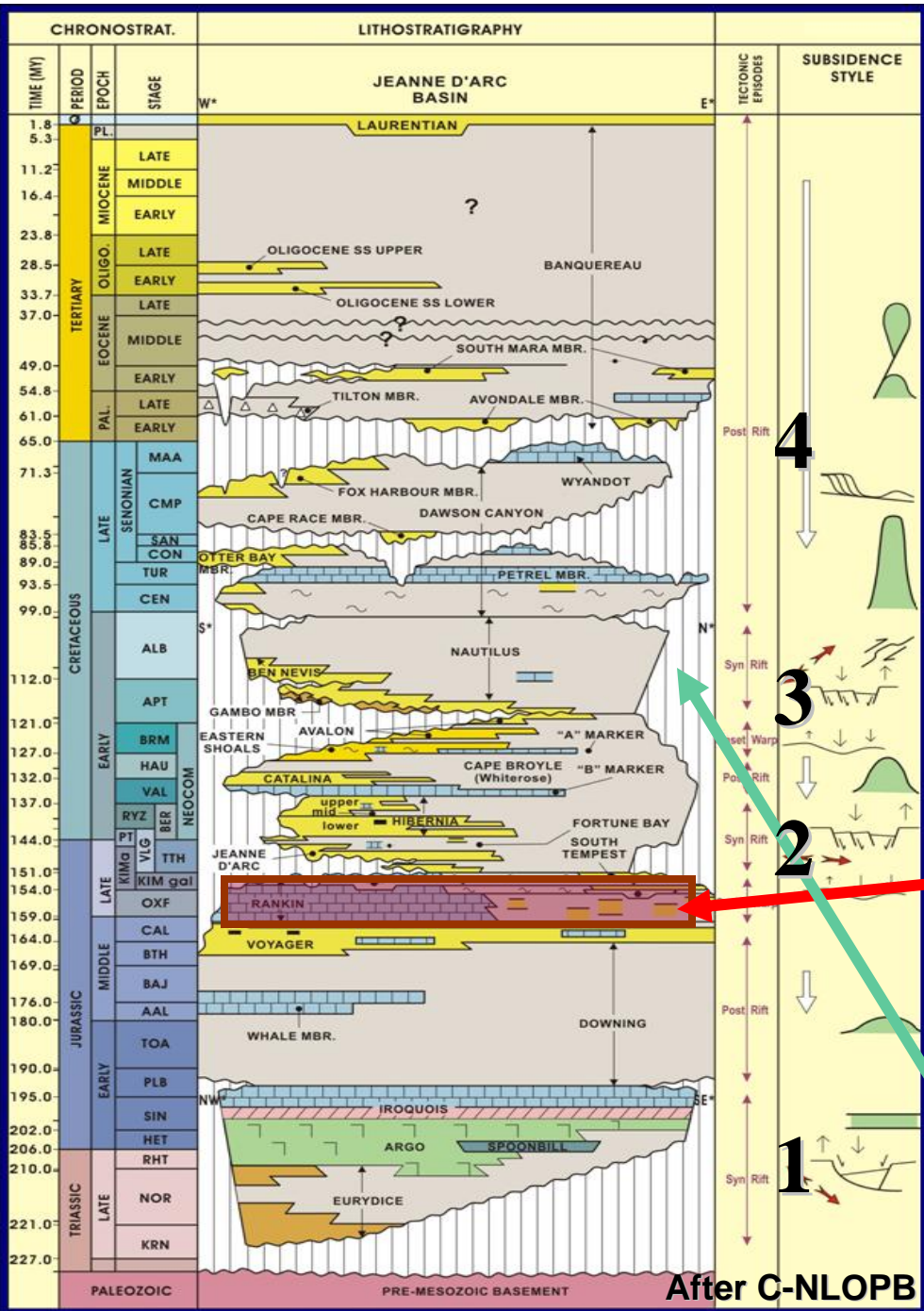
Call for Bids	Area	Area	Area	GOM tract
<b>CFB NL11-02</b>	Hectares	Sq Km	Acres	multiples
<b>Parcel #1</b>	247,016	2,470	610,390	106
<b>Parcel #2</b>	186,780	2,011	461,546	80
<b>TOTAL</b>	<b>433,796</b>	<b>4,338</b>	<b>1,071,936</b>	<b>186</b>

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. More on these parcels and bidding procedure is available at:

[http://www.cnlopb.nl.ca/news/pdfs/cfb11\\_02.pdf](http://www.cnlopb.nl.ca/news/pdfs/cfb11_02.pdf)

# Lithostratigraphy and Tectonic Evolution

- The CFB area was affected by 3 to 4 stages of rifting, 2 stages of transtension and 1 stage of inversion (non-plate related)
- The most important moment for the basins was the deposition of marine source rock: the Egret Member of the Rankin Formation of Kimmeridgian age (154 My)
- The Oxfordian to Tithonian interval may be a good source rock
- Albian source rock was identified in ODP drilling but is unproven





# Tectono-Stratigraphic Summary

- Mesozoic basins are floored by Proterozoic metamorphic rocks, and in places by Paleozoic strata and intrusive rocks. The economic basement in CFB area is the peneplained prerift basement. The **Prerift** basement was significantly stretched during Late Jurassic-Early Jurassic **Synrift** phase forming a succession of basins (grabens) and ridges (horsts). Large rotated basement blocks were successively modified by other rifting phases and became the cores of anticlinal features mapped in the area.
- Separated by uplifted blocks (e.g Central Ridge, Cumberland Belt) several basins were formed. NE-SW elongated horsts and grabens which developed during this phase have produced the structural framework of the margin
- The early **Synrift** phase deposits filled the incipient basins with lacustrine stages sediments including some reservoir rocks. An incursion of epicontinental Tethys Sea brought deposition of Argo salt. In the CFB area Argo salt is either thin or preserved as a stratified evaporite sequence interbedded with clastics as it does not show the intense diapirism present in the southern basins (e.g., Jeanne d'Arc, Southern Grand Banks)

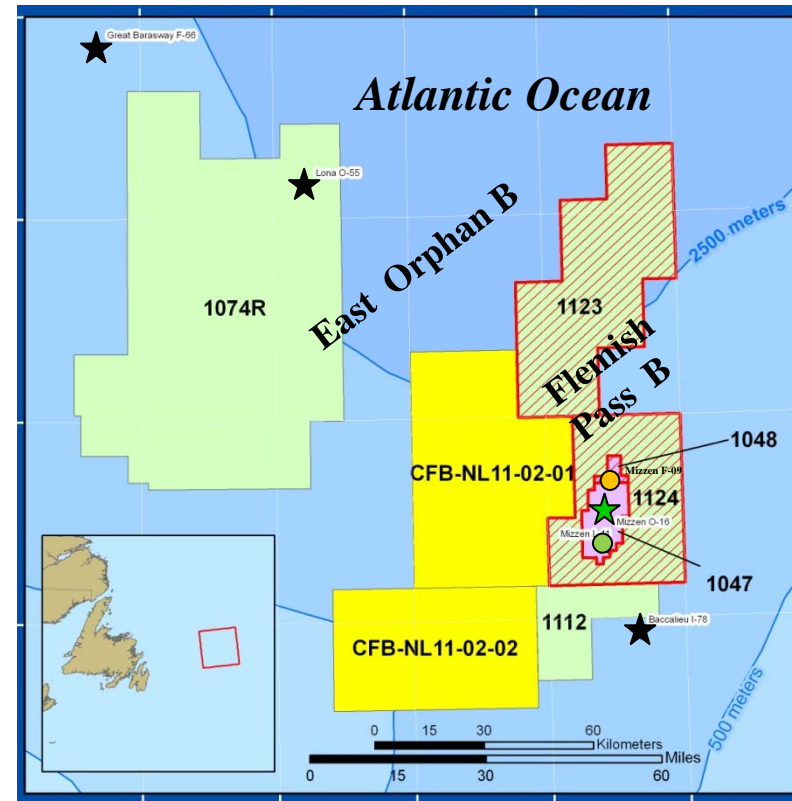
# Tectono-Stratigraphic Summary

- Several rifting stages followed with the direction of extension changing to approximately E-W in Late Jurassic-Early Cretaceous and NW-SE in late Early Cretaceous to Late Cretaceous)
- During the Late Jurassic the Egret source rock has been deposited in a shallow sea filling the interconnected rift valleys. Older (Oxfordian) source rocks were also deposited in some of the basins and troughs
- Quality reservoir rocks were deposited during the Late Jurassic-Early Cretaceous, late Early Cretaceous, late Late Cretaceous and Early Tertiary
- As discussed by Enachescu et al. (2005) and Enachescu (2008 and 2010) the northern Flemish Pass Basin is not a distinct structural unit of the NL margin, but a higher terrace of the larger East Orphan Basin. During its evolution, including during the Late Jurassic, the Flemish Pass Basin was in communication with Jeanne d'Arc Basin and with the East Orphan Basin
- As the East Orphan and North Flemish Pass basins stratigraphy knowledge is in its infancy (due to few wells drilled and unreleased results of latest wells), the Jeanne d'Arc Lithostratigraphy Chart may be used to identify seismic stratigraphic sequences in the Call for Bids area. For simplicity only geological time are marked on the representative seismic lines used to illustrate this presentation

# Significant Exploration Wells

Well No	Well Name	Basin	TD (m)	Status
1	North Dana I-43	N Central Ridge	5304	Gas Well
2	Trave E-87	N Central Ridge	3986	Gas well
3	Panther P-15	N Central Ridge	4203	D&A
4	South Tempest	N Central Ridge	4675	Oil Well
5	Baccalieu I-78	Flemish Pass	5135	D&A
6	Mizzen L-11	Flemish Pass	3823	Oil Show
7	Tuckamore B-27	Flemish Pass	2903	D&A
8	Great Barasway	East Orphan	6751	D&A
9	Mizzen O-16	Flemish Pass	4474	Oil well
10	Lona O-55	East Orphan	5580	D&A
11	Mizzen F-09	Flemish Pass	3759	NR

Yellow = Exploration wells; Red = Delineation well; NR= Not Released  
**Observation:** North Central Ridge wells are not shown on the map



- ★ = Oil Discovery
- ★ = Gas and Condensate Discovery
- = Noteworthy Oil Show
- ★ = D&A
- = Not Released yet

# Significant Wells Near Parcels 1 and 2

Well	Drilled	WD m	Status	Location	TD m	Ben Nevis m	Avalon m	Baccalieu ss m	Late Jurassic ss m	Test	Producer	Source rocks
South Tempest G-88	1981	158	Abandoned Oil well	North Central Ridge	4775	No	No	No	7 intervals 3468 to 4117 Tempest ss	Yes	3 intervals Tempest ss	Yes
Baccalieu I-78	1985	1093	Abandoned	Flemish Pass B	5135	No	2120	3190	4 intervals 3274 to 4550 m	No	No	Yes
Panther P-52	1985	191	Abandoned	North Central Ridge	4203	No	No	No	2 intervals 2969 to 3758 Tempest ss	No	No	Yes
Mizzen L-11	2003	1153	Abandoned Oil Show	SDL 1047	3823	No	No	3335	3598	No	No	Yes
Great Barasway F-66	2007	2338	Abandoned	200 km NW	6751	No	No	Possible	Possible	No	No	Possible
Mizzen O-16	2009	1095	Abandoned oil discovery	SDL 1047	3756	No	No	No	4 intervals 3202 to 3681 Tithonian ss	Yes 3213 to 3224 m	1 interval Tithonian ss	Yes
Lona O-55	2010	2602	Abandoned	100 km NW	5580	Not Released Yet				No	No	Not known yet

**Observation:** Other significant wells for the area Tuckamore, Lancaster and Gabriel in Flemish Pass Basin, North Dana on the Central Ridge have penetrated good reservoirs and source rock intervals. These wells have been discussed in previous Call for Bids presentations available from:

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

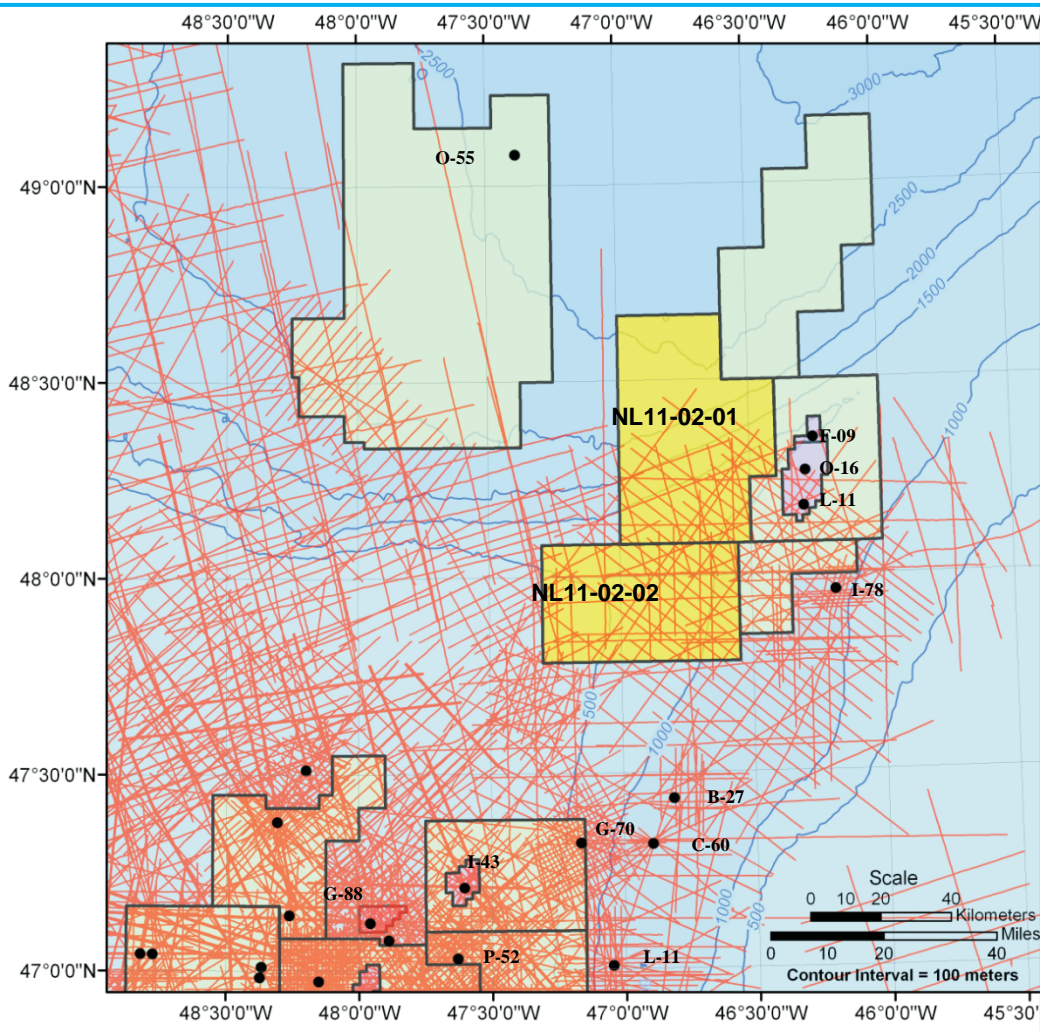
# Significant Wells for CFB NL11-02

- The most significant well for the area-Mizzen O-16, was drilled in 2009 approximately 20 to 50 km west of the two CFB NL11-02 parcels. The well intersected 4 sandstone intervals dated as Tithonian from 3202 to 3681 m (Jeanne d'Arc or Tempest ss equivalents). One interval between 3213 and 3224 tested heavier oil (22° API) at a rate of 3774 bopd. A delineation well Mizzen F-09 was drilled this year a few km north of O-16, but its results are still confidential
- Another important well, Mizzen L-11, drilled in 2003 on the same large synrift faulted anticline, intersected 5 m of oil pay on logs in E. Cretaceous ss (Baccalieu); two excellent reservoirs were intersected in L. Jurassic ss but were wet. Mizzen L-11 has proven that oil was generated in the Flemish Pass Basin and can form accumulation
- South Tempest G-88 is an earlier well (1981) that tested oil and gas from 3 Late Jurassic (Tempest) sandstone intervals. The highest rate was 1250 bopd of 42° API. Two other wells on the Central Ridge were successful: Trave E-87 tested gas from Hibernia reservoir and North Dana I-43 tested gas from Tempest sandstone. Both these wells intersected Egret source rock
- Baccalieu I-78 is the closest dry hole to the CFB parcels. This well has intersected Kimmeridgian source rocks and Tithonian reservoirs



# Seismic Coverage

- The Call for Bids NL11-02 Parcels are well covered by a relatively dense 2D seismic grid. The adjacent map contains only the released data available in analogue format from C-NLOPB. Only a few seismic lines are in public domain for the northern part of Parcel 1
- Substantial more data exists in digital format and is available from oil companies and seismic contractors
- The 2D grid has a 2 to 4 km spacing in the dip direction and 4 to 8 km spacing in the strike direction

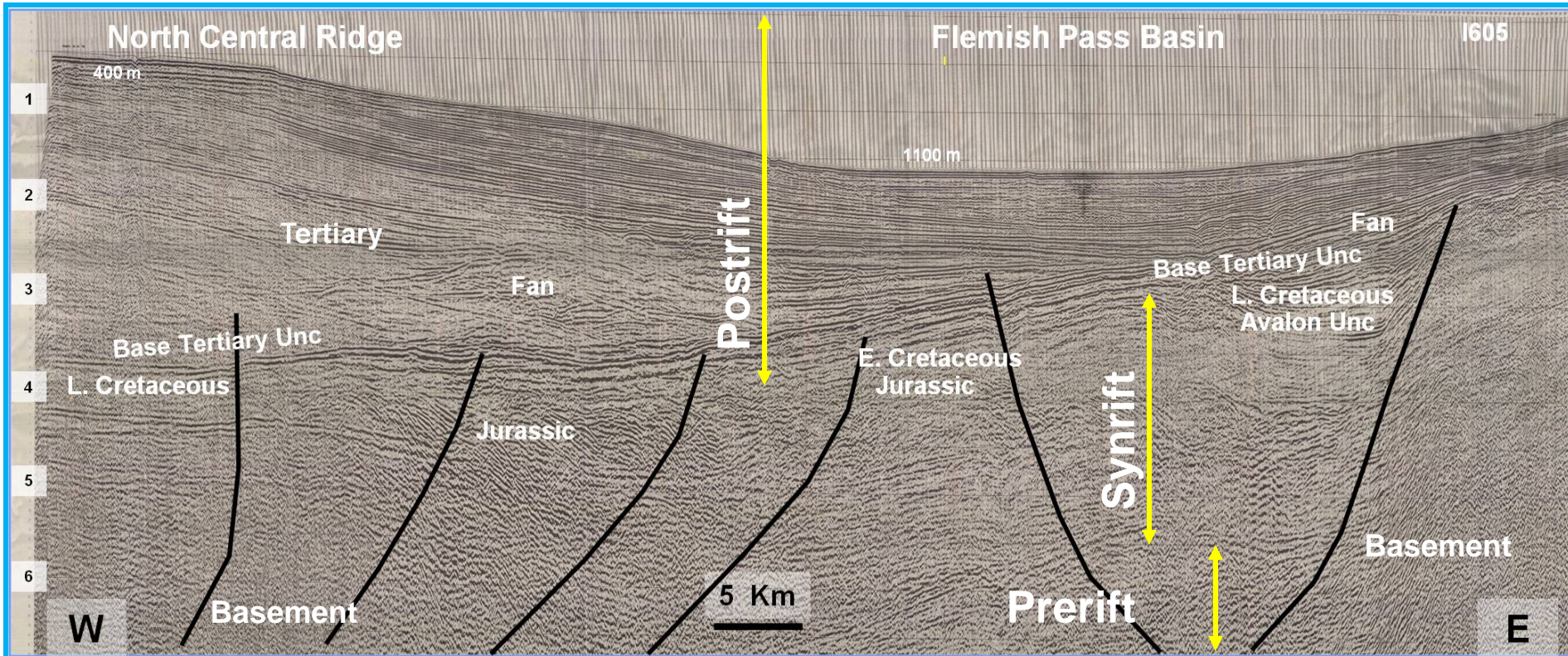


# Representative Seismic Section

- As illustrated by numerous, previously published seismic sections, a thick synrift sequence (Late Triassic to early Late Cretaceous) fills the grabens and overlies the horsts and ridges in the northern part of the Grand Banks, Flemish Pass and Orphan basins (e.g., Smee, 2003; Enachescu et al., 2004 and 2005; Hardy, 2007; Hogg and Enachescu, 2007; Enachescu, 2008)
- Several representative seismic sections from the CFB area, tied to Mizzen wells, are discussed in the presentation by Enachescu (2010) available at:  
<http://www.nr.gov.nl.ca/nr/invest/enachescuNL100203.pdf>
- The synrift sedimentary successions are deformed by extension and transtension, and are segmented by numerous faults; numerous rollover and basement cored anticlines are present
- The postrift sequence generally dips and thins basinward (toward the East Orphan and Flemish Pass basins), and is less deformed
- Considerable deformation of the Early Tertiary postrift sequence occurs on the slope and rise due to gravity or shale detachment tectonics



# Representative Seismic Section



Interpreted dip seismic section C75-8 crossing the Central Ridge and Flemish Pass Basin the CFB NL11-02 area. The line interpretation shows main seismic stratigraphic successions, major faults, geodynamic stages and structural style. Seismic line source: C-NLOPB.

# Seismic Coverage

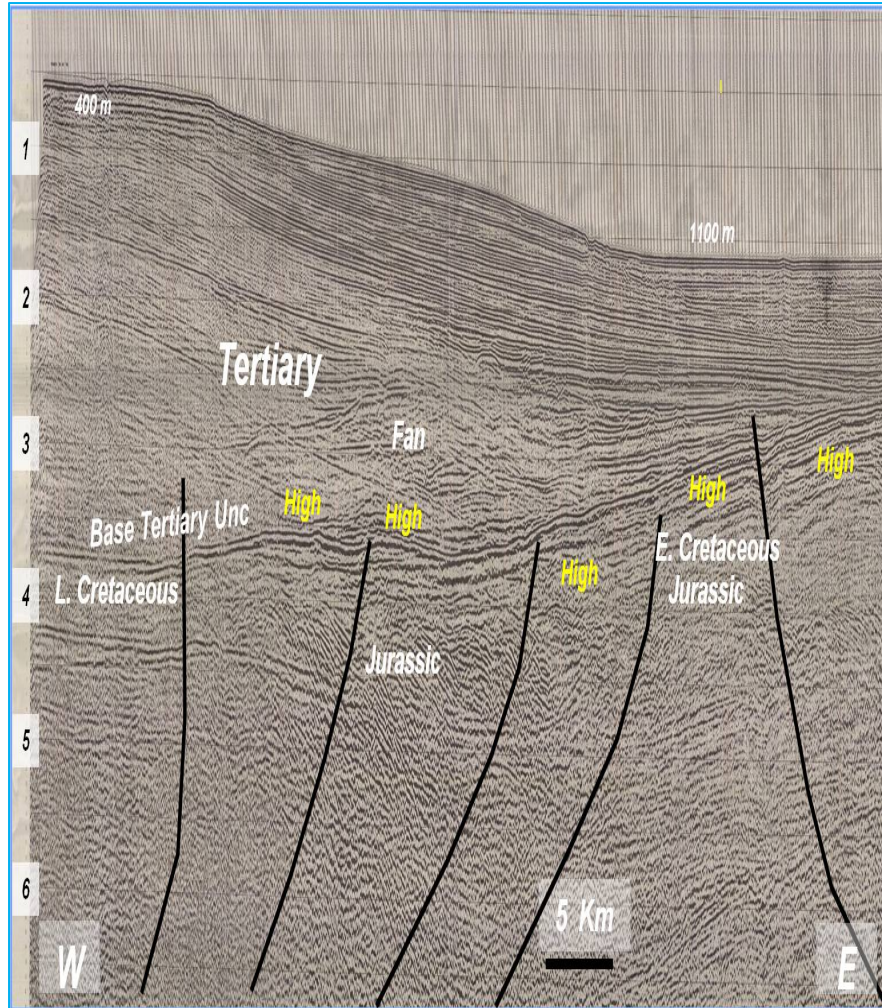
- Oil company 2D digital data in CFB area is owned mainly by Suncor (inheriting Petro-Canada data base) and ExxonMobil (inheriting Mobil data base), Husky and Statoil. The various surveys recorded in the 1970s and early 1980s were used to locate and drill several shallow water wells in the North Central Ridge area and in the southern East Orphan Basin and several intermediate deep water wells in the Flemish Pass Basin
- The seismic grid that covers the CFB parcels (see slide 71) is in the public domain and therefore releasable in analogue format
- Multi-client seismic data from the same era are available from several seismic contractors. GSI of Calgary has a large grid of reprocessed multi-fold seismic data available for licensing in digital format
- GSI has collected modern seismic data in the North Grand Banks, East Orphan and Flemish Pass basins during the 1998-2003 period. Approximately 10,000 km of this data is positioned on or in vicinity of the CFB parcels
- Several large 3D surveys in the vicinity and within the CFB area have been acquired by Statoil and Chevron. Two 3D surveys were recorded during 2011

# Seismic Interpretation

- Regional seismic lines shown in this presentation were tied with synthetic seismograms to several exploration wells in the Flemish Pass Basin and Central Ridge area
- The Prerift basement is hard to interpret on older data (too deep or too sketchy) and as such it was only indicated on the representative seismic sections
- Late Triassic to Quaternary successions are present in the area. Several regional unconformities are prominent (e.g. Base Tertiary, Avalon). On the illustrative seismic sections only a few markers and formations are displayed together with major faults (see slide 73)
- The Avalon Unconformity is a fair marker and allows to discriminate between the synrift and postrift sedimentary sequence
- Based on well intersections and seismic grid, the Jurassic sequence is thick. Now and then, the uppermost Jurassic rocks are eroded by the Avalon Unconformity on top of rotated blocks
- Several thick-skin, listric normal faults affect the synrift sequence. The resulting rotated blocks form anticlinal features that are exploration targets in the area



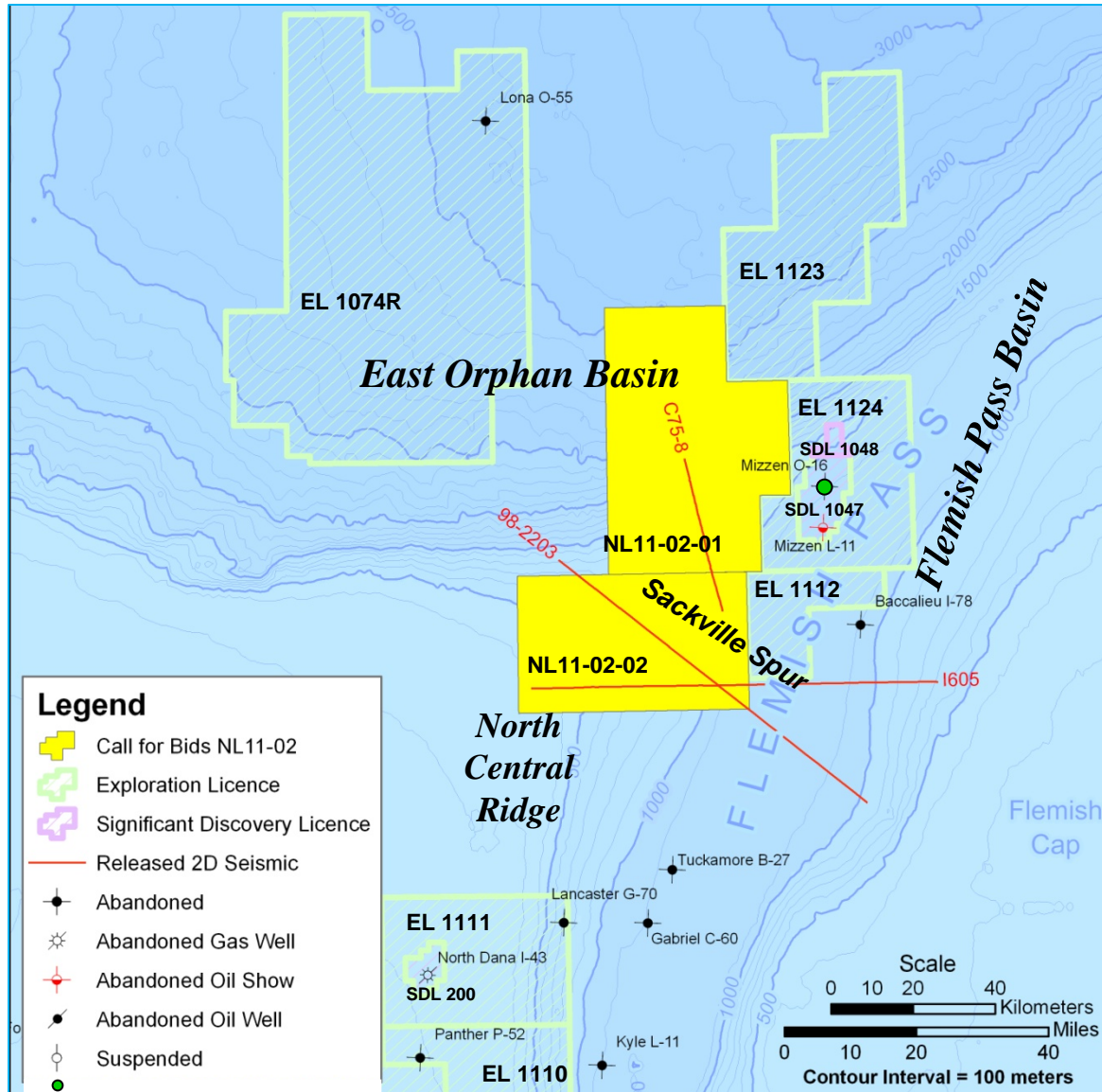
# Seismic Interpretation



- Using the available seismic grid, several plays can be interpreted within the Late Jurassic to Early Tertiary basin fill in the NL11-02 Parcels 1 and 2.
- The typical play is “Structural high (Roll-over Anticline, Horst, Rotated Block, Faulted Anticline), with any of the Jeanne d’Arc, Hibernia, Avalon sandstones (primary target) and/or Paleocene sandstone (secondary target) sourced from Late Jurassic marine source rocks”
- In both parcels there are locations, where 3.5-5.5 Km deep wells can test the synrift and postrift sandstone plays

# Seismic Interpretation (Cont.)

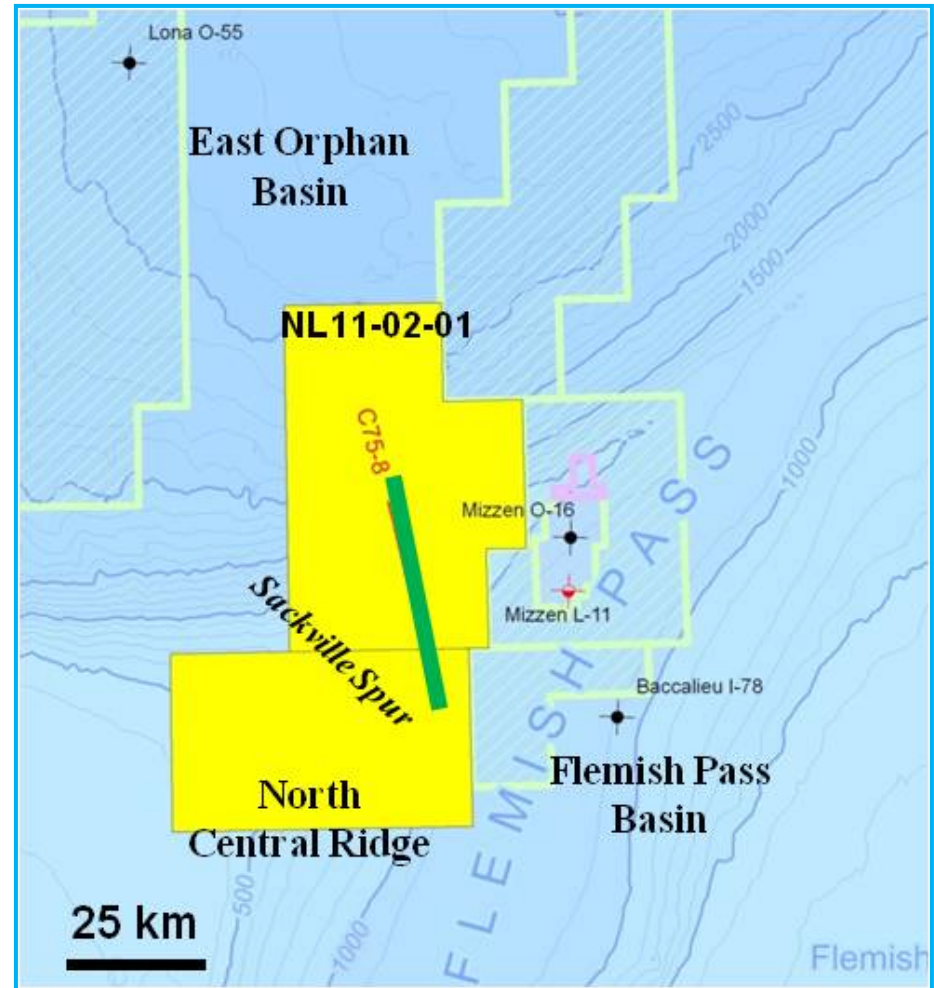
Three seismic lines: C75-8, 98-2203 and I605 are interpreted to illustrate the structural-stratigraphic style of the southern East Orphan Basin, Western Flemish Pass Basin and North Central Ridge and the petroleum potential of the two CFB NL11-02 parcels





# 5.1 Petroleum Potential of Call for Bids NL11-02 Parcel 1

- Parcel 1 covers 247,016 ha (610,390 acres) in the southern Orphan Basin, and northern Flemish Pass Basin just westward from ELs 1023 and 1024
- This is an intermediate to deep water parcel (635-2665 m, 1590 m average water depth) located on the Grand Banks northeastern slope and EOB
- No exploration wells have been drilled in the parcel
- The seismic horizons are interpreted using ties from the Mizzen L-11 and O-16 wells (drilled just 10 to 25 km east of the parcel) and Baccalieu I-78



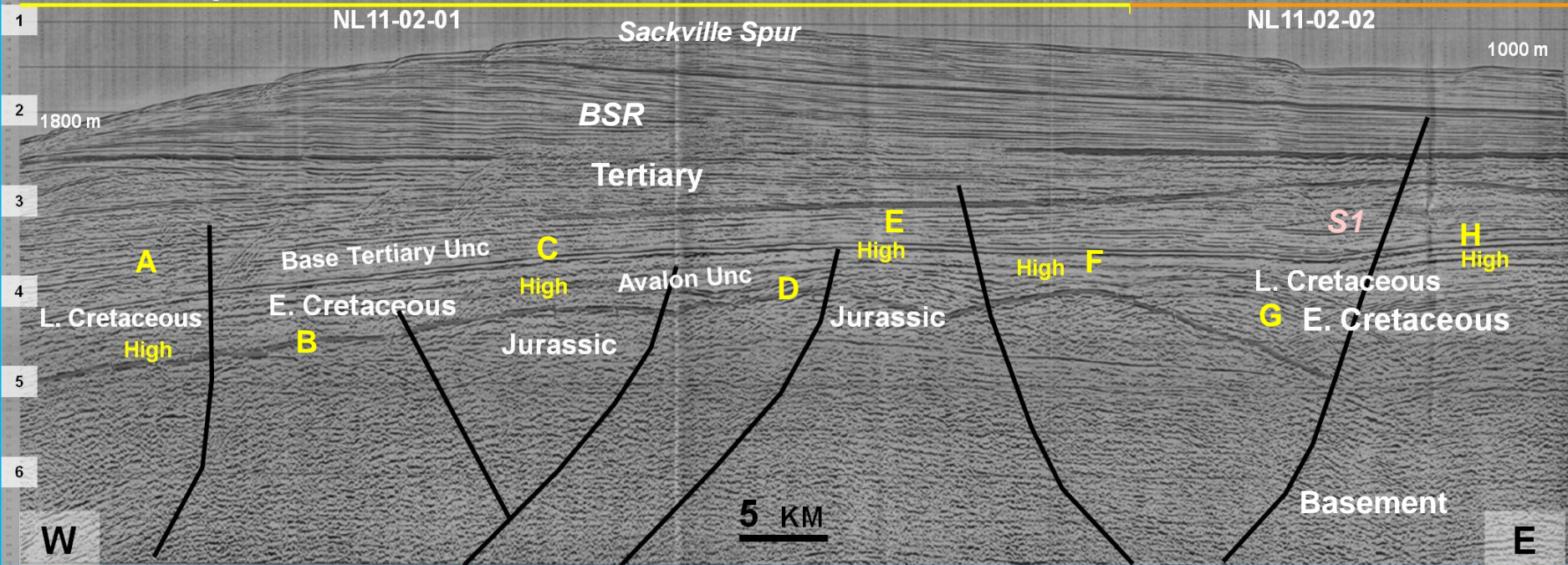
# Seismic Line C75-8



East Orphan Basin

Flemish Pass Basin

C75-8



Interpreted dip seismic section C75-8 crossing Parcel NL11-02-01 and partially NL11-02-02. The Base Tertiary and Avalon Unconformities are prominent. A large regional Jurassic high A is cut by several faults, forming smaller horsts, grabens and rotated blocks. Leads for structural and combination traps exist in both parcels (A through H); a stratigraphic lead denoted *S1* may represent a Tertiary mounded feature (seismic line source: C-NLOPB).

# Seismic Line C75-8

- This dip line C75-8 (approximately NNW-SSE) is located in the central part of Parcel NL11-02-01, exiting the parcel to the south and entering Parcel 2
- The line is positioned over the Sackville Spur bathymetric feature
- The postrift sequences thicken on the Sackville Spur, where Bottom Simulating Reflectors (BSR) indicate presence of gas hydrates in late Tertiary beds
- The basement reflector is deep, sketchy and poor quality on this data vintage
- A large Jurassic regional high probably basement cored, is intersected by this line
- Deep penetrating normal faults compartment the synrift sequence and in places also affect the lower Tertiary beds
- These faults offset the predominantly clastic Late Jurassic-Cretaceous sedimentary successions creating numerous elevated blocks, horsts and downthrown roll-overs trapping possibilities
- These possible structural leads are marked A through F in Parcel 1 and G and H in Parcel 2
- Combination and pure stratigraphic traps may exist as combination between the two major unconformities and truncated or onlapping coarse clastic beds



# Parcel NL11-02-01



**B, E** = Possible closed horst feature in Parcel NL11-02-01

**A, C, D, F** = Possible closed fault block and roll-over in Parcel NL11-02-01

**S1** = Possible stratigraphic trap

## Summary

### Structural leads:

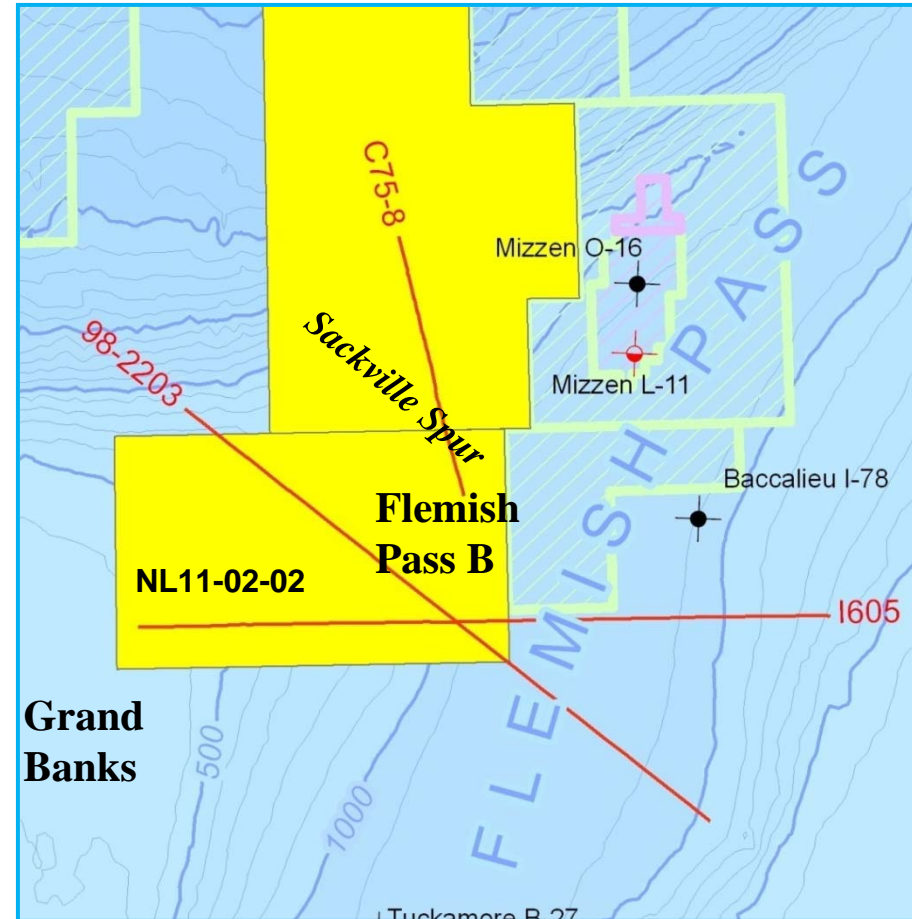
- Large (5-20 km wide) and fault bounded features containing Jurassic and Cretaceous beds that may include reservoirs and source rock
- Two horst-like structures marked B and E
- Two rotated blocks C and D and two roll-overs anticlines A and F
- Strike lines are needed to confirm closure of these leads

### Stratigraphic leads:

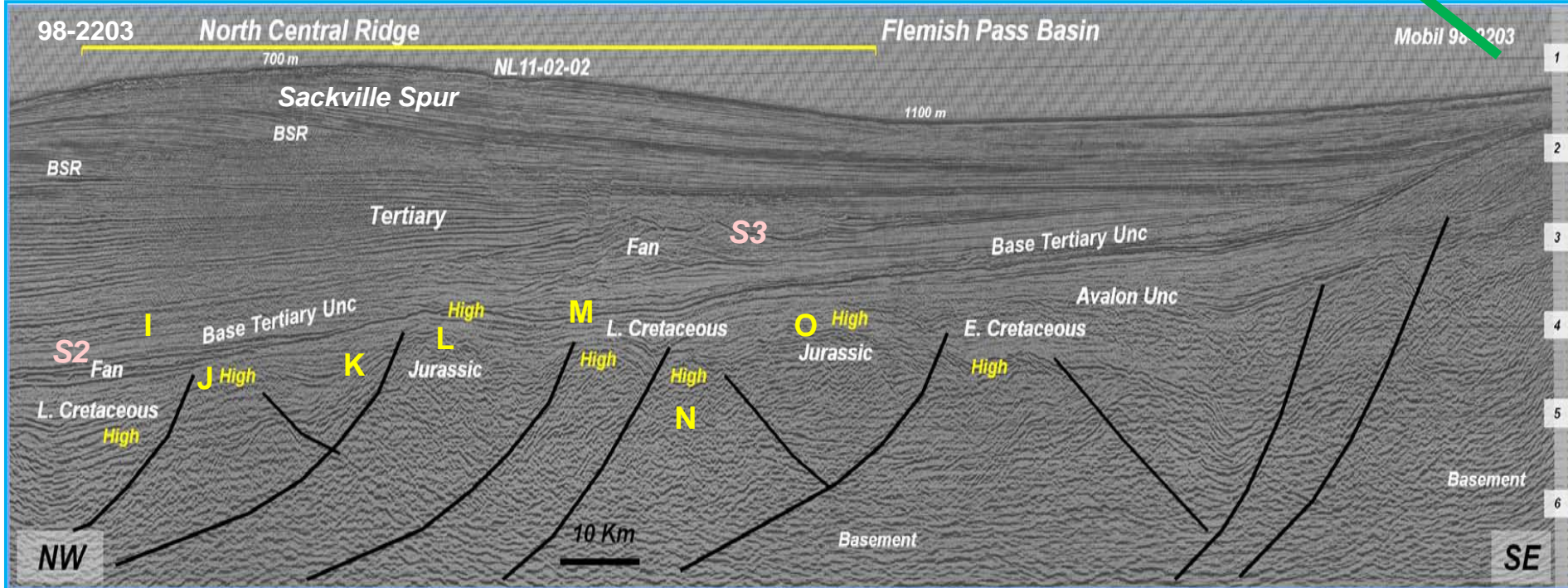
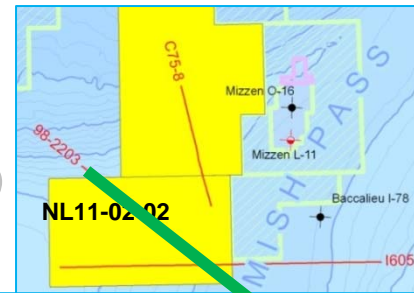
- Avalon and Base Tertiary sub-unconformity or onlap type traps

# 5.2 Petroleum Potential of Call for Bids NL11-02 Parcel 2

- Parcel 2 covers 186,780 ha (461,546 acres) in the south western part of the North Central Ridge and eastern Flemish Pass Basin, south of Parcel 1 and SW from the Mizzen SDLs
- This shallow to intermediate deep water parcel (350 -1165 m, 760 m average water depth) is located on the outer shelf and slope of Grand Banks. The parcel lies over the Sackville Spur bathymetric feature
- No exploration wells have been drilled in the parcel
- The seismic horizons are interpreted using ties the Mizzen L-11 and O-16 wells (drilled just 25 to 50 km east of the parcel) and Baccalieu I-78



# Seismic Line 98-2203



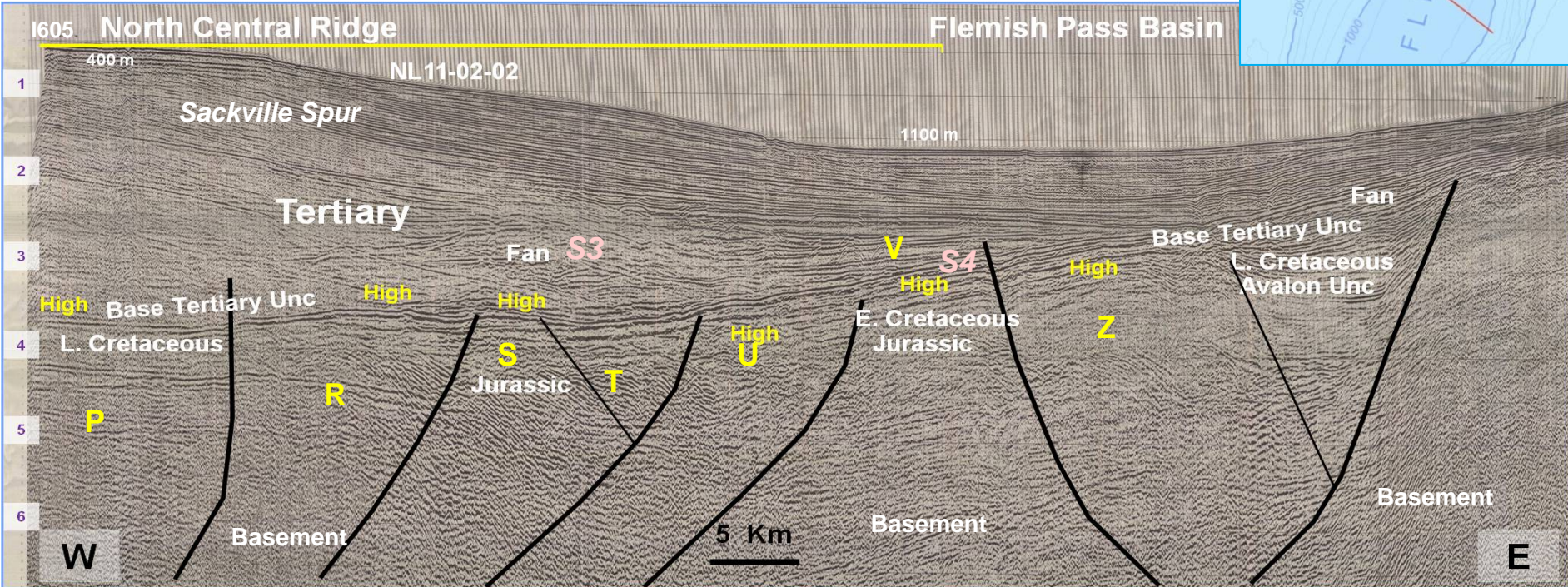
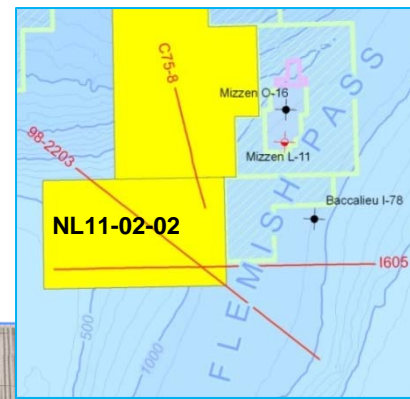
Interpreted dip seismic section 98-2203 crossing Parcel NL11-02-02 and un-licensed land in Flemish Pass Basin. The postrift sedimentary formations considerably thicken towards northwest over the Sackville Spur. A highly disturbed synrift sequence is segmented by several deep-penetrating faults. Drilling opportunities for structural and combination traps exist on rotated blocks, horsts and fault bounded roll-overs (I through O). Stratigraphic traps S2 and S3 are present in the postrift sequence (seismic line source: C-NLOPB).

# Seismic Line 98-2203

- This dip line 98-2203 (NW-SE) is located in the central part of Parcel NL11-02-02, extending southeasterly into unlicensed land
- The line is positioned over the outer shelf and slope of the Grand Banks in an area known as the Sackville Spur and Flemish Pass
- The postrift sequence is thick over the Central Ridge and is thinner in the Flemish Pass Basin. The Base Tertiary unconformity is a strong marker that plunges from the eastern boarder of the Flemish Pass Basin (one second) to the northwest into East Orphan Basin (4 seconds)
- The economic basement marker is not evident on this seismic line due to poor signal penetration
- The synrift sequence is thick. North-westerly dipping listric normal faults segment the synrift sequence into several horsts and rotated blocks in the parcel marked I through O
- The larger highs are 15 to 25 km wide but these leads need supplementary lines to be properly defined
- As the seismic line is of poor quality, no major faults are interpreted in the Late Cretaceous basin fill above the rotated blocks. However the interpreted faults may continue to the Base Tertiary extending upward the interpreted traps
- Numerous sub-unconformity traps and a two possible Tertiary fans **S2** and **S3** can be interpreted on this seismic line



# Seismic Line I605



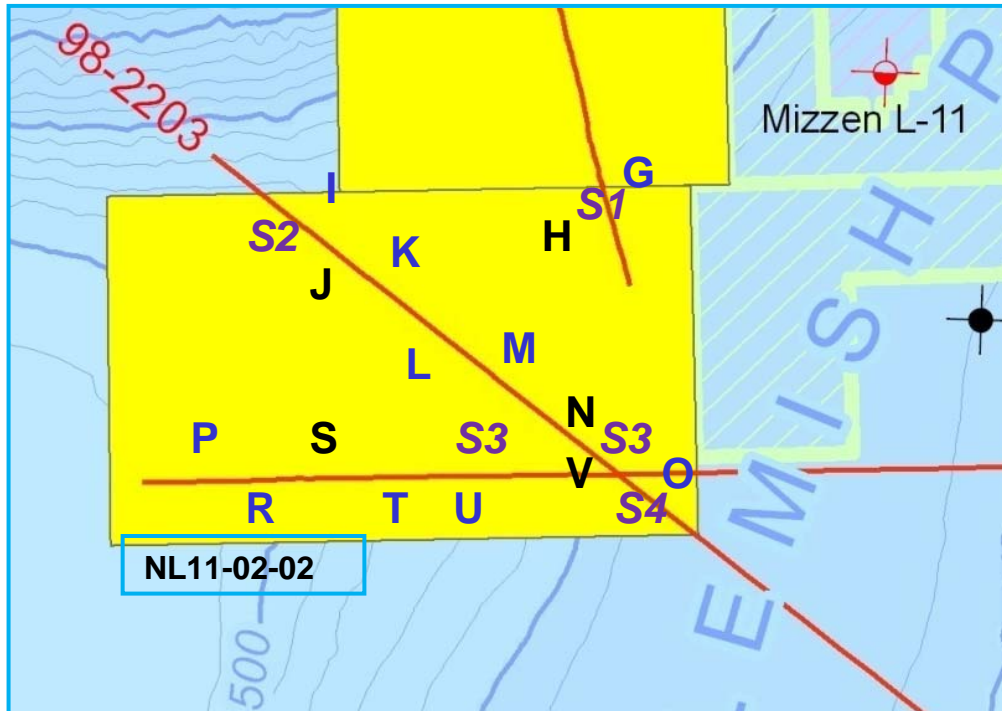
Interpreted dip seismic section I605 crossing Parcel NL11-02-02 and un-licensed land in Flemish Pass Basin. The postrift sedimentary formations considerably thicken towards the west over the Sackville Spur. The deformed synrift sequence is segmented by several deep-penetrating faults. Drilling opportunities for structural and combination traps exist on rotated blocks, horsts and fault bounded roll-overs (P through V). Stratigraphic traps S3 and S4 are present in the postrift sequence (seismic line source: C-NLOPB).



# Seismic Line I605

- The seismic line I605 (W-E) is located in the southern part of Parcel NL11-02-02, eastward into unlicensed land in Flemish Pass Basin
- The line is positioned over the outer shelf and slope of the Grand Banks in an area known Sackville Spur and Flemish Pass
- The postrift sequence is thick over the Central Ridge and is thinner in the Flemish Pass Basin. The Base Tertiary Unconformity is a strong marker that plunges from the eastern boarder of the Flemish Pass Basin (two seconds) to the northwest into East Orphan Basin (4 seconds)
- Data quality does not allow interpreting a continuous basement marker
- The synrift sequence deepens towards the west
- Westerly dipping listric normal faults divide the synrift sequence into several horsts and rotated blocks that are marked P through V in Parcel 2
- The larger highs are 10 to 20 km wide. All the leads shown on this line need additional crossing lines to be confirmed
- Several major faults extend into the Late Cretaceous and Tertiary successions and can create multi-pay traps
- Tertiary fans can be interpreted on the seismic line, S3 that is also visible on line seismic 98-2203, and S4. Other stratigraphic traps may be formed at the Avalon and Base Tertiary unconformity levels

# Parcel NL11-02-02



## Summary

### Structural leads:

- Numerous fault bounded traps are present in the three representative seismic lines
- Several large size rotated basement blocks and roll-overs denoted I, K, L, M, O, P, R, T, U are seen on the three lines
- H, J, N, S and V are horst type leads interpreted on the seismic lines
- Faults may extend into the postrift sequence creating trapping opportunities in L. Cretaceous and Tertiary beds
- Additional lines and mapping are needed to confirm all leads closure

### Stratigraphic leads:

- **S2, S3** and **S4** are possible basin floor fans

**H, J, N, S, V** = Possible closed horst feature in Parcel NL11-02-02

**I, K, L, M, O, P, R, T, U** = Possible closed fault block and roll-over in Parcel NL11-02-02

**S2, S3, S4** = Possible stratigraphic traps

# Comments on Seismic Data

- Seismic coverage for the two CFB NL11-02 parcels can be purchased as digital data from vendors such as GSI, TGS, CGG or data brokers
- Older seismic data can be obtained as hard copies for inspection, for the nominal cost of reproduction, from C-NLOPB in St. John's, NL
- Older than mid-1990s data has poor quality and was recorded with shorter than 4 km cables. Retrieving the original field data and reprocessing old lines to pre-stack depth migration is needed to better image leads in the two parcels and environs
- Access to modern digital data recorded during the past decade by GSI and TGS is necessary to confirm the identified leads (slides 81 and 87) and define drillable prospects
- 3D data may be now or become available from companies such as Chevron, Statoil and ExxonMobil that acquired data in the Flemish Pass and Orphan basins

# Prospects and Leads

- The area's main hydrocarbon play is structural; it involves porous synrift Late Jurassic (e.g. Tempest, Jeanne d'Arc) and/or Early Cretaceous (e.g. Hibernia, Baccalieu) sandstone reservoirs trapped in large, faulted anticlines
- More than a dozen structural leads such as horsts, rotated blocks and rollover anticlines have been identified on the public domain seismic lines (slides 79, 83 and 85) crossing Parcels NL11-02-01 and -02. These leads are probably multi-way fault bounded (Mizzen-like anticline) and therefore they need to be mapped using denser, high quality, modern grids available from seismic vendors
- Several large stratigraphic plays were identified. They reside mostly in Parcel 2. These leads are Tertiary basin floor fans that also need better coverage to be adequately mapped
- There are several possible locations where a well will intersect both the potential synrift reservoirs and the stratigraphic leads

# Prospects and Leads (Cont.)

- Good seals such as regional Fortune Bay, Nautilus, Dawson Canyon and Banquereau shales are present in all parcels
- The leads located in CFB Parcels 1 and 2 were mapped by companies active in the area in the 1970s and early 1980s (Mobil, Petro-Canada, Esso, Shell, Husky, etc.). Their regional seismic interpretation reports and annexed time structural maps for the area parcels are available from the C-NLOPB archive and can be inspected and copied for bid evaluation
- Main geological risks of the area's leads and prospects are: the possibility of fault leaking, quality of the reservoir and access to quality source rock. The large size of the structural leads identified in these parcels should mitigate these risks
- If firm closures can be proven by mapping the area's 2D and or 3D seismic coverage, each of the interpreted structural leads is capable of holding large oil and gas resources (hundreds of million to a billion barrels of oil or several Tcf of gas)



# 6. Discussions

- The North Grand Banks/East Orphan Basin/Flemish Pass Basin area where the NL11-02 parcels are located, is a marine exploration frontier in which only a handful of wells have been drilled. The earlier wells were drilled based on poor quality, low penetration seismic data
- Numerous hydrocarbon leads identified with old seismic data in this highly deformed area, remain to be mapped and confirmed by modern data
- No exploration has been carried out in these parcels since the early 1980s
- Two gas fields and an oil field have been discovered in the North Central Ridge in an earlier exploration phase
- A significant oil discovery (size unpublished) was recorded in 2009 at the nearby Mizzen O-16 location and delineated by the Mizzen F-09 well
- Significant exploration activity is taking place on the same structural trend in ELs 1023 and 1024
- CFB NL11-02 parcels are very large when compared with a Gulf of Mexico standard section (more than 80 times larger)
- Parcels may contain multiple targets within Late Jurassic, Early Cretaceous, Late Cretaceous and Early Tertiary sandstone reservoirs at depths between 3500-5500 m which can be tested by using drill ships

# Discussions (Cont.)

- Risks exist as to fault closure, reservoir quality and source rock quality; new mapping with reprocessed and modern 2D and 3D seismic data may lower the geological risk
- The area's structural traps can host resource estimates of hundred of million barrels of oil and/or several Tcf natural gas
- A 6-year (Period 1) +3-year (Period 2) = 9-year term Exploration Licence is set by C-NLOPB for North Central Ridge/Flemish Pass Basin (Area "C"). Licence awards are based on highest work commitment bid
- Royalty regime is well established and places offshore NL in the middle to-upper tier of world's favorable areas for petroleum exploration and production
- Canada is one of the countries with the most stable political and financial system and has a long tradition in oil and gas exploration
- The NL Province obtains 27.5% of the nominal GDP from the oil and gas industry and is actively encouraging offshore exploration
- There is a robust regulatory regime in the offshore area including HS&E. Provincial Government encourages offshore exploration, however safety of workers and protection of environment are paramount

# 7. Conclusions

- Two large parcels located offshore Newfoundland in the Area “C” - Flemish Pass/North Central Ridge are available for licensing in the C-NLOPB’s Call for Bids NL11-02 which closes on November 15, 2011, 4 p.m. NL time
- The parcels are in a region with large extensional and transtensional traps, where previous drilling has proven good reservoirs, mature source rocks, proven migration paths and several oil and gas accumulations
- This is the second Call for Bids in the area. The first CFB in 2003, while successful, left unlicensed the presently offered parcels. Therefore the parcels have not been explored since early 1980s
- The basin contains excellent Late Jurassic source rocks which are known to generate large oil accumulations
- Parcels are located within the “Late Jurassic Source Rock Super Highway” indicated by wells and seismic correlations that connects the Grand Banks to Flemish/East Orphan basin and across the Atlantic to Porcupine Basin
- Large structural leads such as horsts, tilted blocks and rollover anticlines interpreted in the parcels 1 and 2 may have closure at several synrift reservoir levels. Closures may vary in size from 40 to 140 sq km

# Conclusions (Cont.)

- Relatively dense 2D seismic coverage is available in Parcels 1 and 2 to image and map petroleum traps in the synrift and postrift sequences. Exclusive 3D surveys may exist on portion of Parcels 1 and 2
- Parcels are situated in water depth varying between 350 m and 2665 m (average 1590 in Parcel 1 and 760m in Parcel 2). The leads are located at distances of 40 to 120 km from the shore line
- The A to V leads (see slides 81 and 87) defined in parcels NL11-02-01 and -02, are situated in an underexplored basin, close to oil production in Jeanne d'Arc Basin and to NE American and Canadian markets
- Recognized risks in regard to fault seal, reservoir quality and source rock quality are mitigated by the presence of very large undrilled features
- Estimated sizes of unrisks reserves that may be contained in the identified leads are up to a billion barrels of oil or several Tcf of natural gas
- These parcels provide excellent petroleum resource prospects to any new, seasoned operator that desire an entry position in an underexplored basin with high upside, or to an existing operator willing to consolidate its leadership position in the NL hydrocarbon exploration and production industry

