Petroleum Exploration Opportunities in the Carson Basin, Offshore Newfoundland and Labrador Call for Bids NL13-02

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On Behalf of NL DNR
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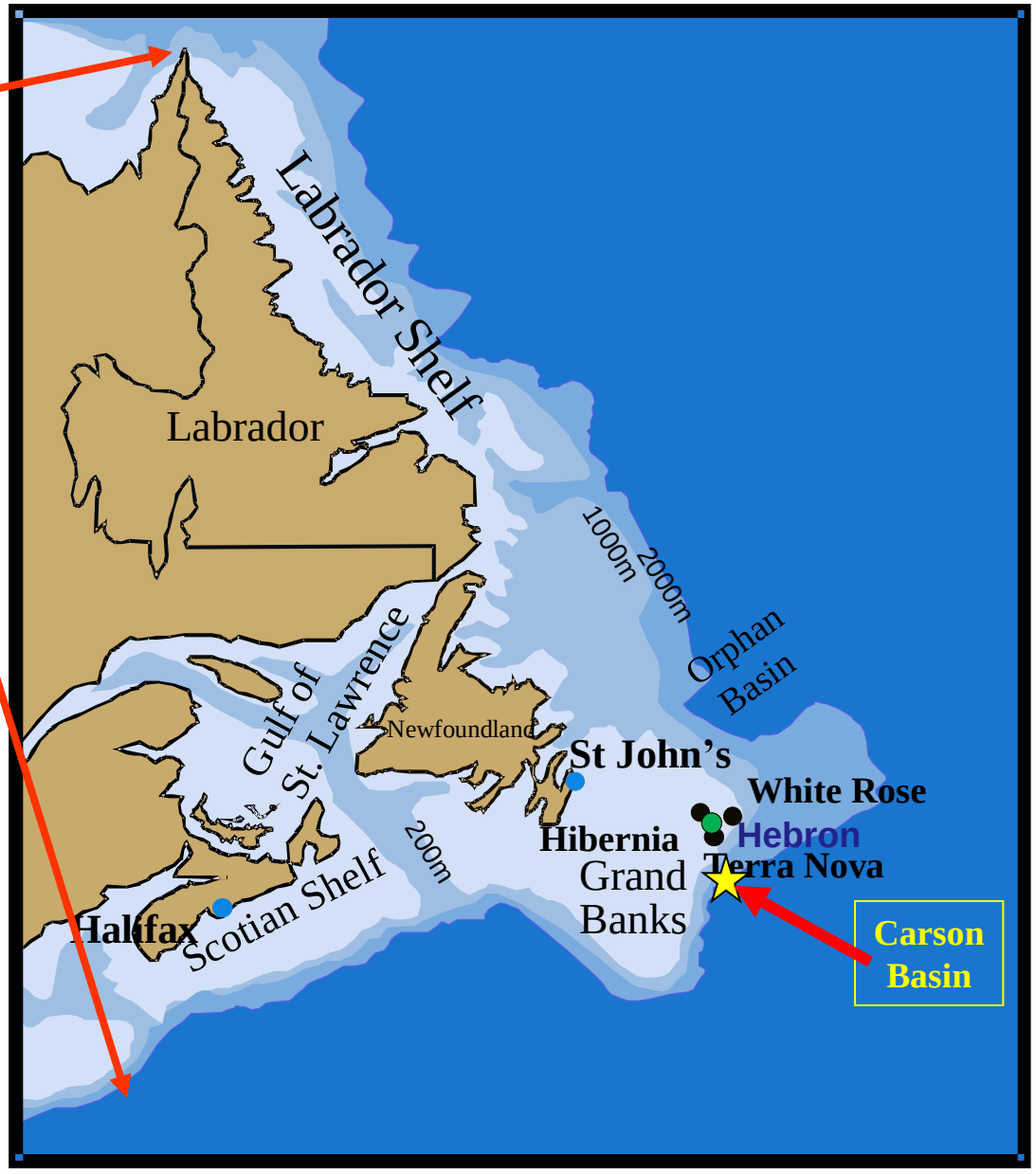
Newfoundland Labrador



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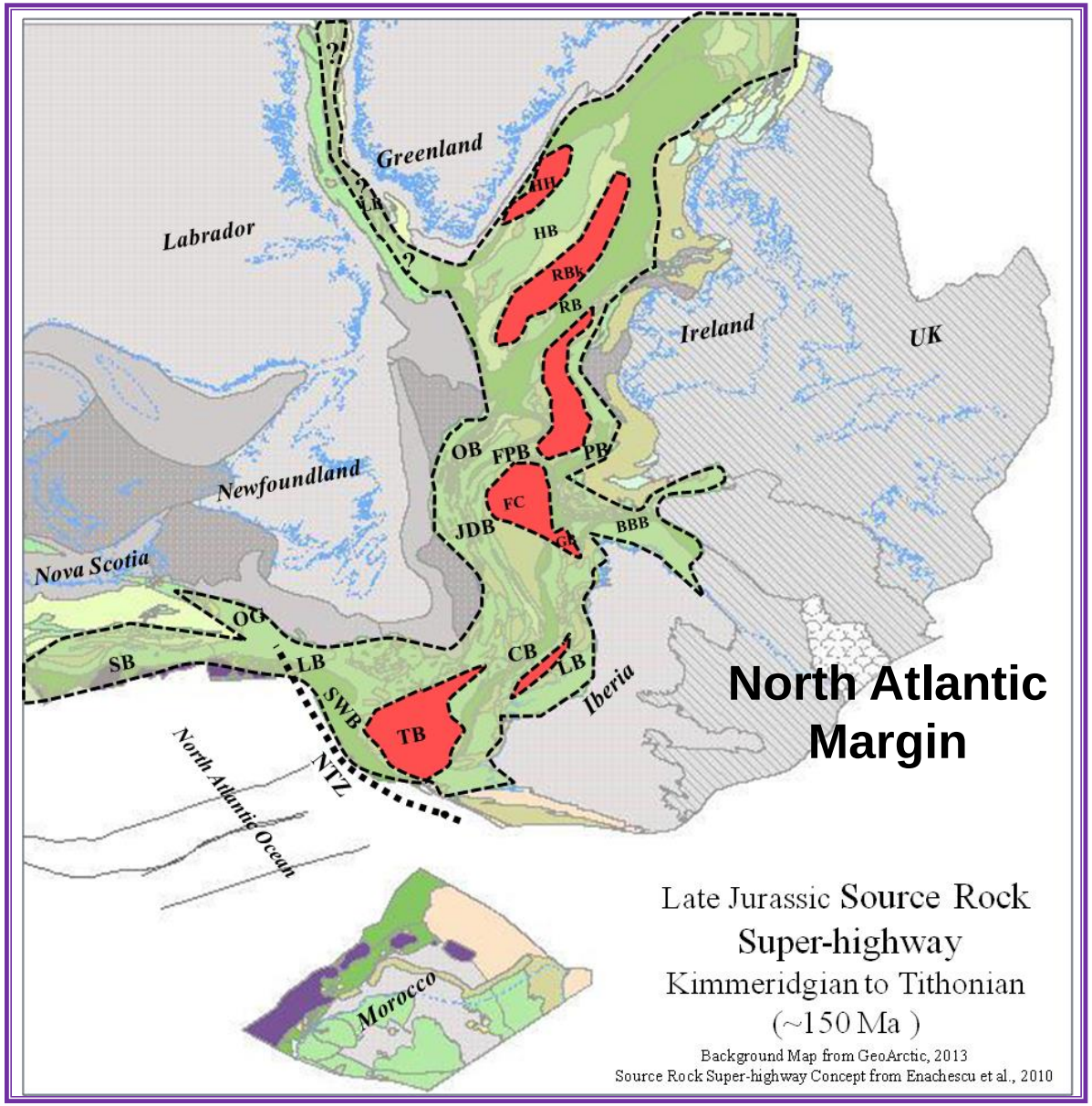
Where Is Carson Basin?



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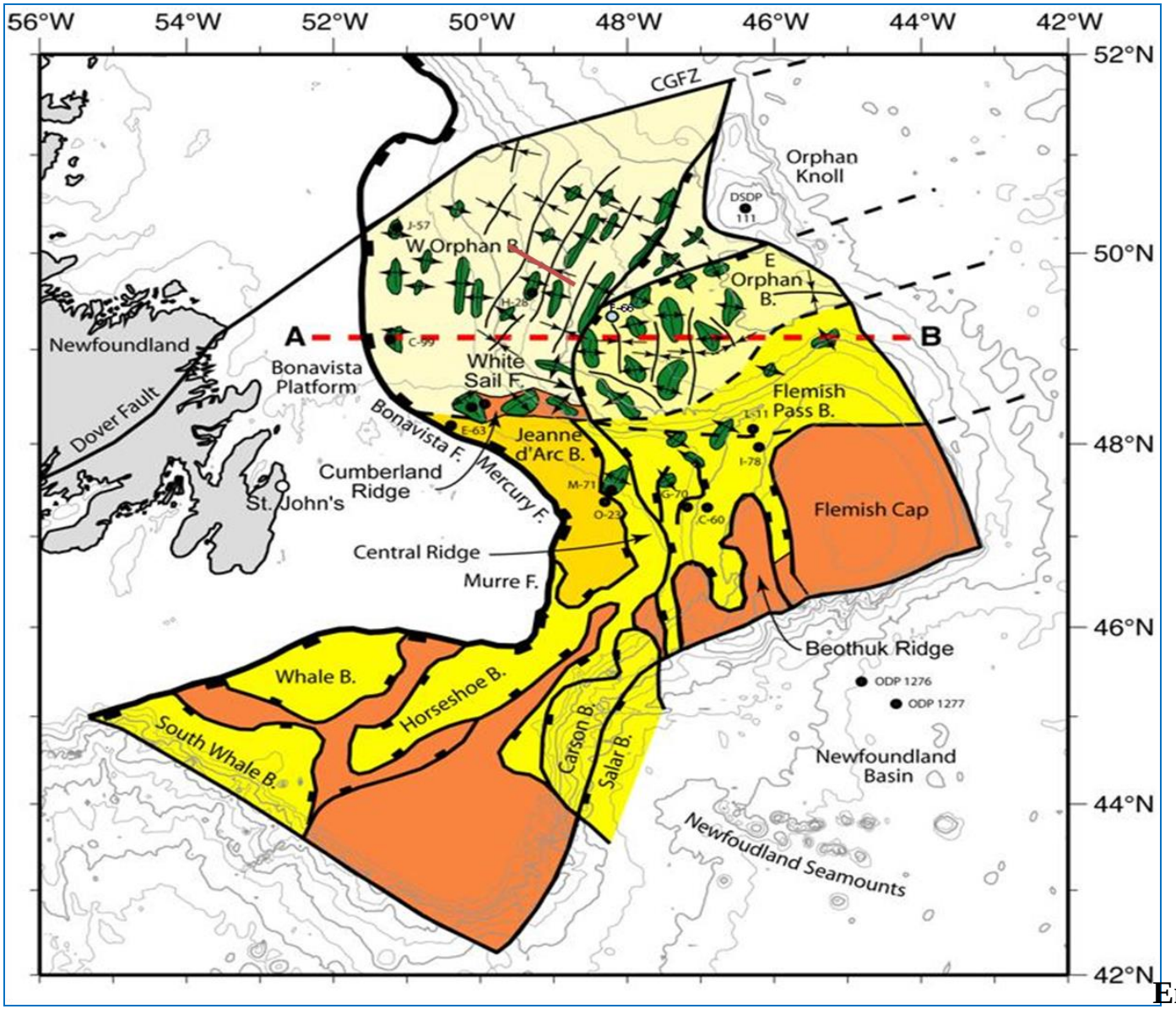
Close up



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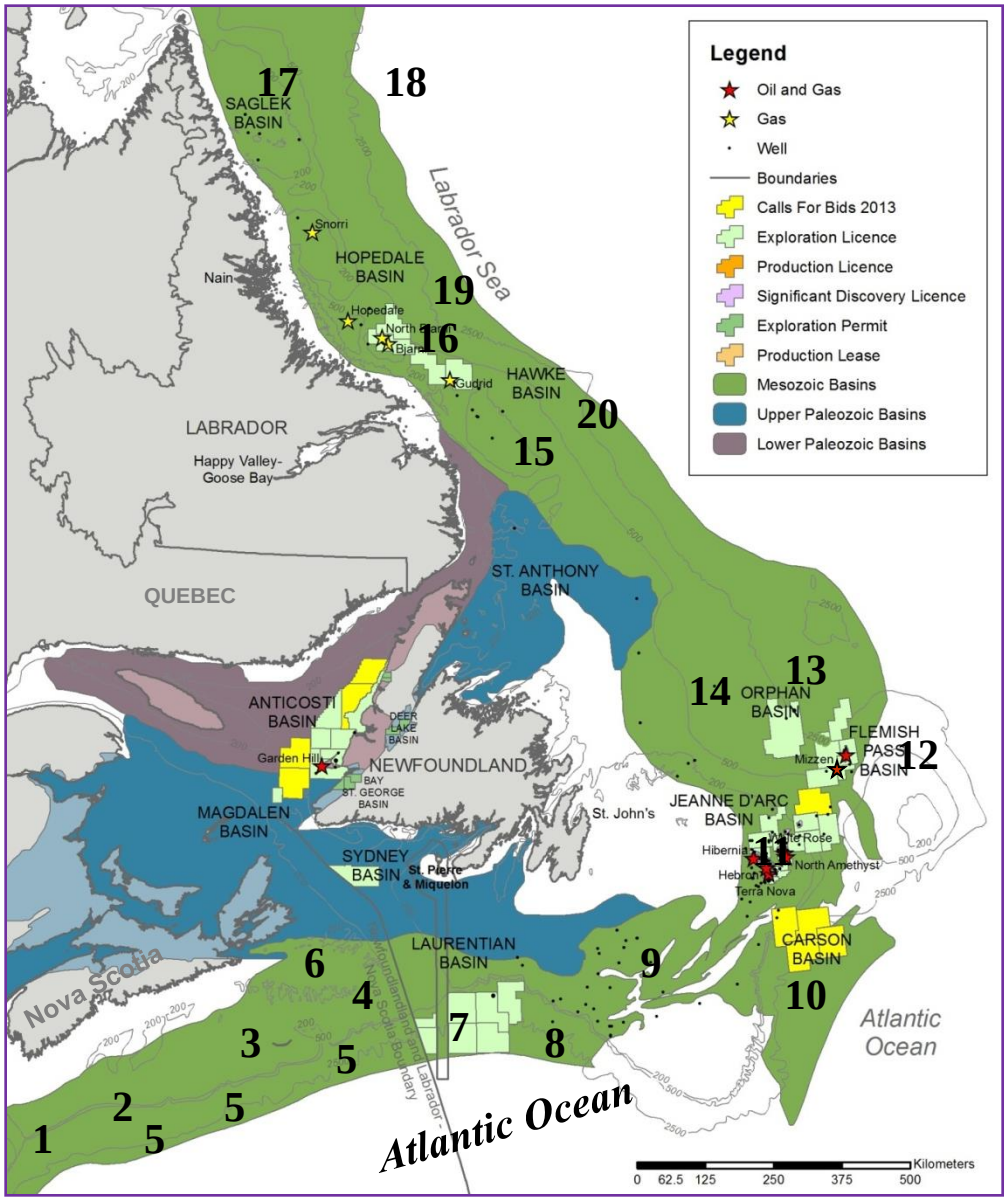
Atlantic Canada Mesozoic Basins



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 (CFB NL13-02)
11. Jeanne d'Arc
12. Flemish Pass (CFB NL13-01)
13. East Orphan
14. West Orphan
15. Hawke
16. Hopedale
17. Saglek
18. Henley
19. Chidley
20. Holton

New Defined Basins

Nova Scotia

Newfoundland and Labrador

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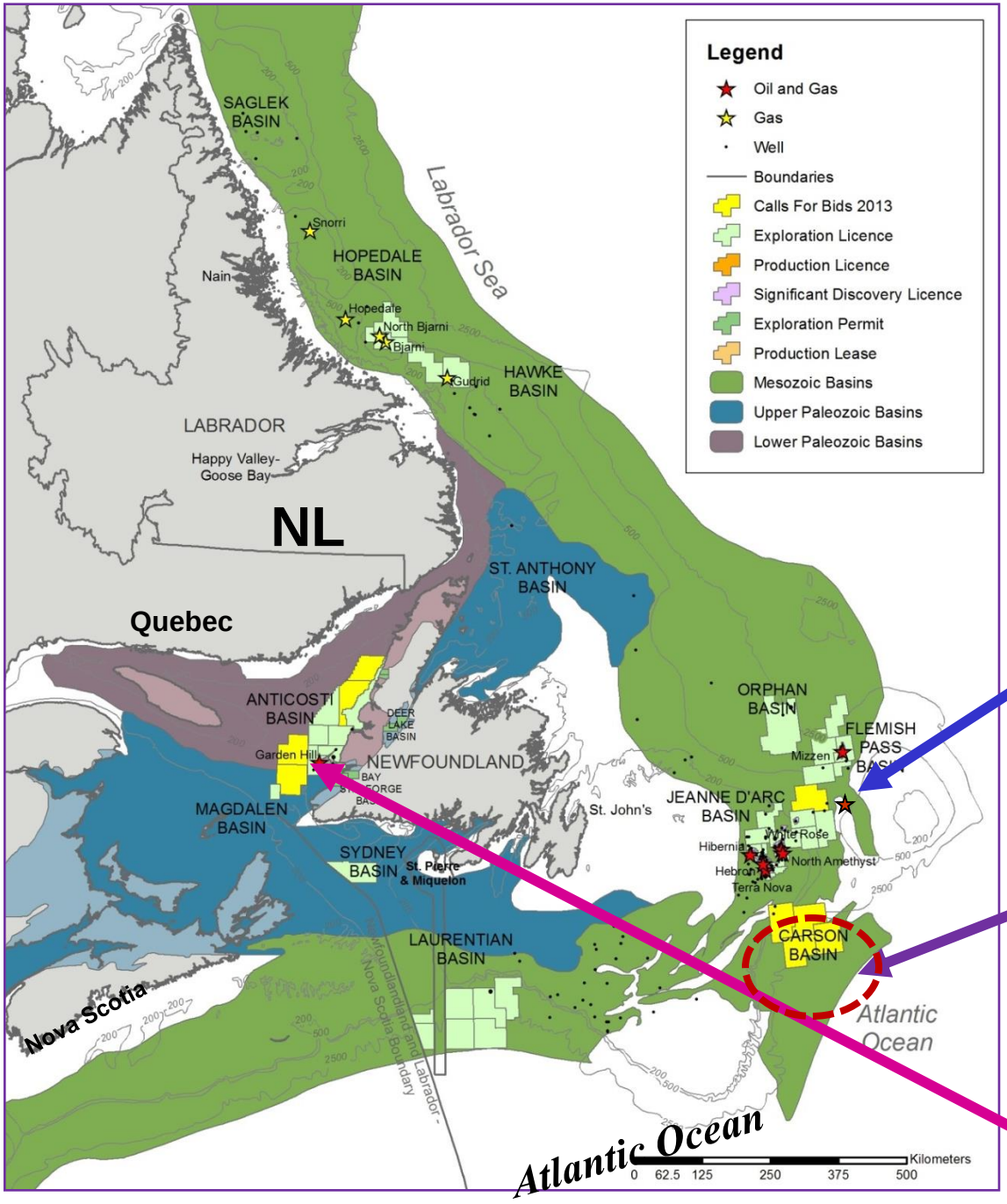

1. Introduction

CFB NL 2013: Three CFB in four basins:

- **CFB NL13-01 Flemish Pass Basin**
- **CFB NL13-02 Carson Basin**
- **CFB NL13-03 Anticosti Basin/ Magdalen Basin**

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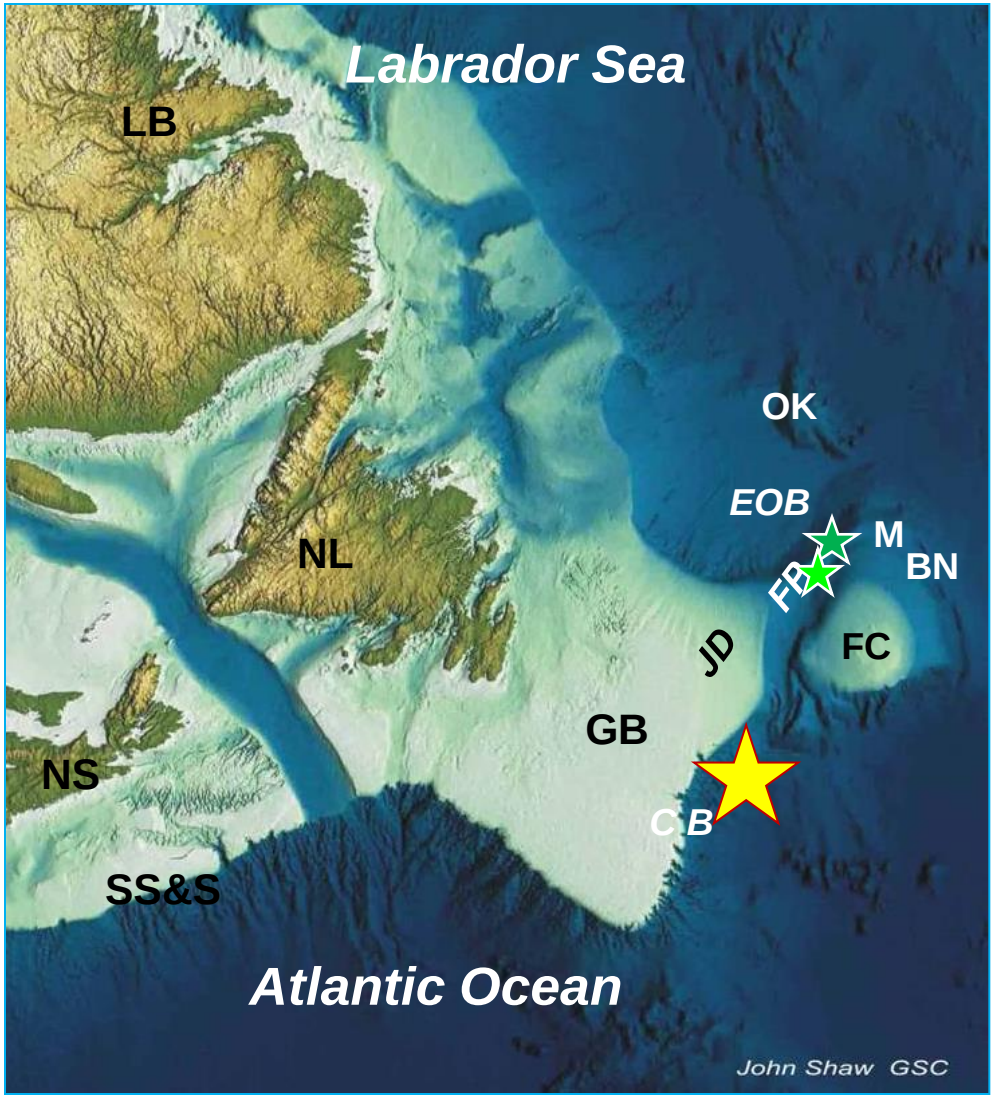
Call For Bids Location



Location of NL13-02 parcels 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
M = Mizzen
BN = Bay du Nord
CB = Carson Basin

★ = Approximate location of NL13-02 Parcels 1 to 4

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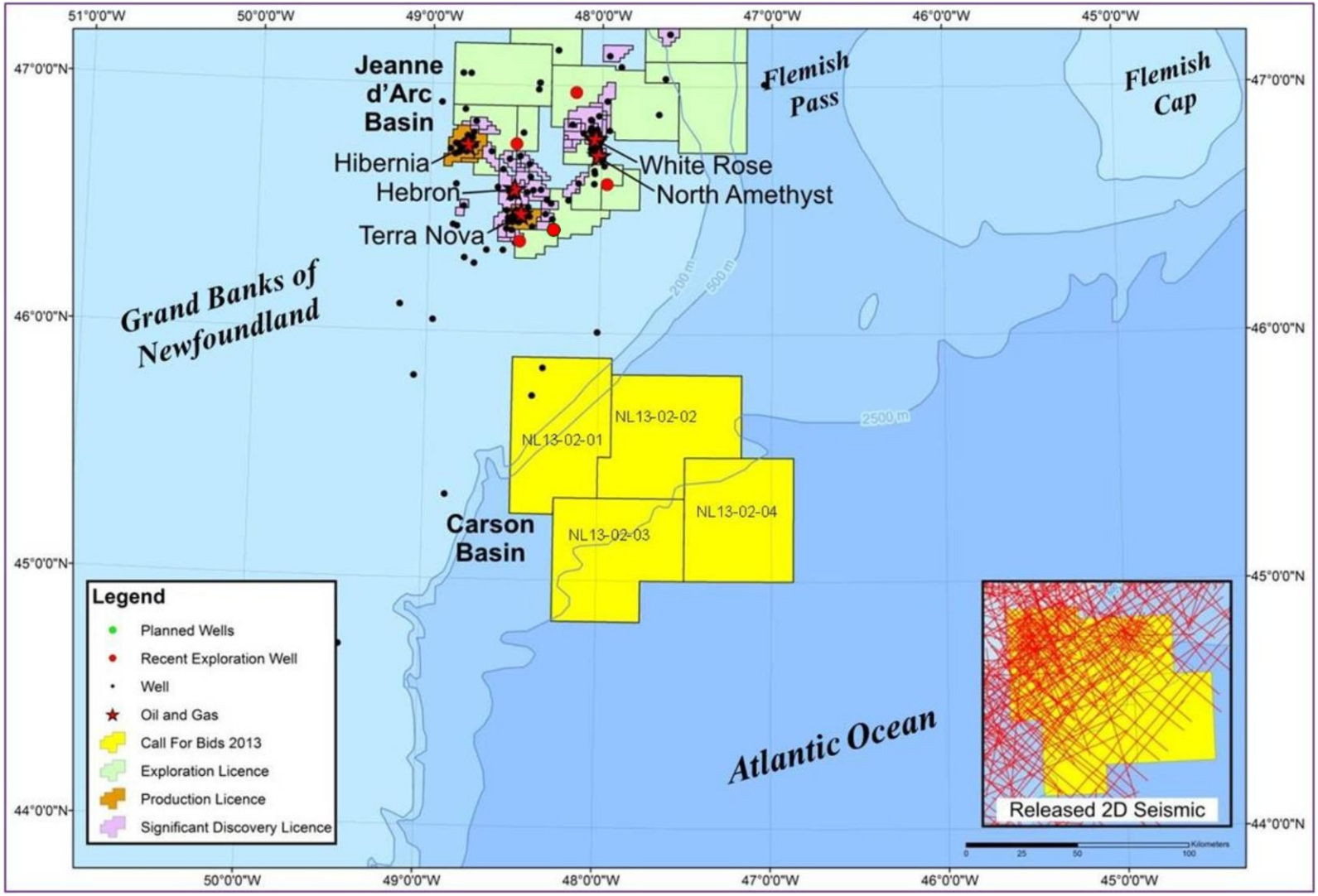
Call for Bids NL13-02

- **Four Parcels on Offer.** Call for Bids NL13-02 consists of four parcels totaling 1,138,399 hectares (2,813,034 acres), located in shallow to deepwater of the Carson Basin, east of the Grand Banks of Newfoundland. The total land area offered under this licensing round is equivalent to 488 Gulf of Mexico tracts (one GOM tract = 5,760 acres).
- **Carson Basin is an under-explored basin.** This 50,000 km^2 (5405.4 square miles) Mesozoic-Tertiary basin is on trend with the gas producing Sable Subbasin and located just east of oil producing Jeanne d'Arc Basin. The Carson Basin has only four exploration wells drilled on the shelf (first one 40 years ago, last one 27 years ago). No well has been ever drilled on the basin's slope and deepwater.
- **Exploration activity.** There are no Exploration Licences (ELs) in the Carson Basin. ELs are active in Laurentian, Flemish and Jeanne d'Arc basins.
- **Location of Parcels.** The parcels offered for bid are located in the northern portion of the basin.
- **Call for Bids Deadline.** 120 days after the completion of the *Eastern Newfoundland Strategic Environmental Assessment (2013)* (the "Closing Date").
- **More information** on this Call for Bids can be found at:

http://www.cnlopb.nl.ca/pdfs/nl1302.pdf

Location of Parcels



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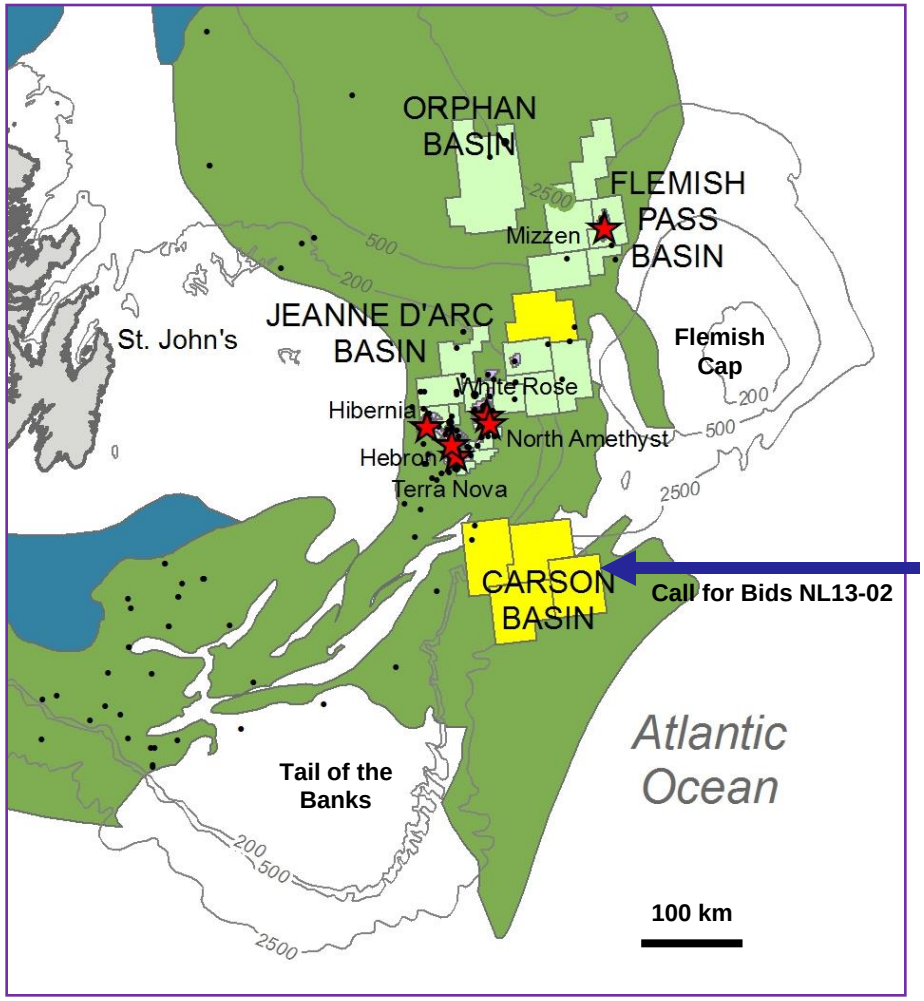
Petroleum Potential of Call for Bids NL13-02 Parcels

- Call for Bids NL13-02 includes four large parcels located in the northern part of the Mesozoic-Tertiary Carson Basin.
- These shallow to intermediate and deep water parcels (90 to 3300 m water depth) are situated in the vicinity of proven oil and gas discoveries in the Jeanne d'Arc Basin, Central Ridge and Flemish Pass Basin.
- Carson Basin is an Atlantic rift basin in which structural, stratigraphic and composite traps are seen on seismic data and the petroleum system should be anchored by Late Jurassic source rocks.



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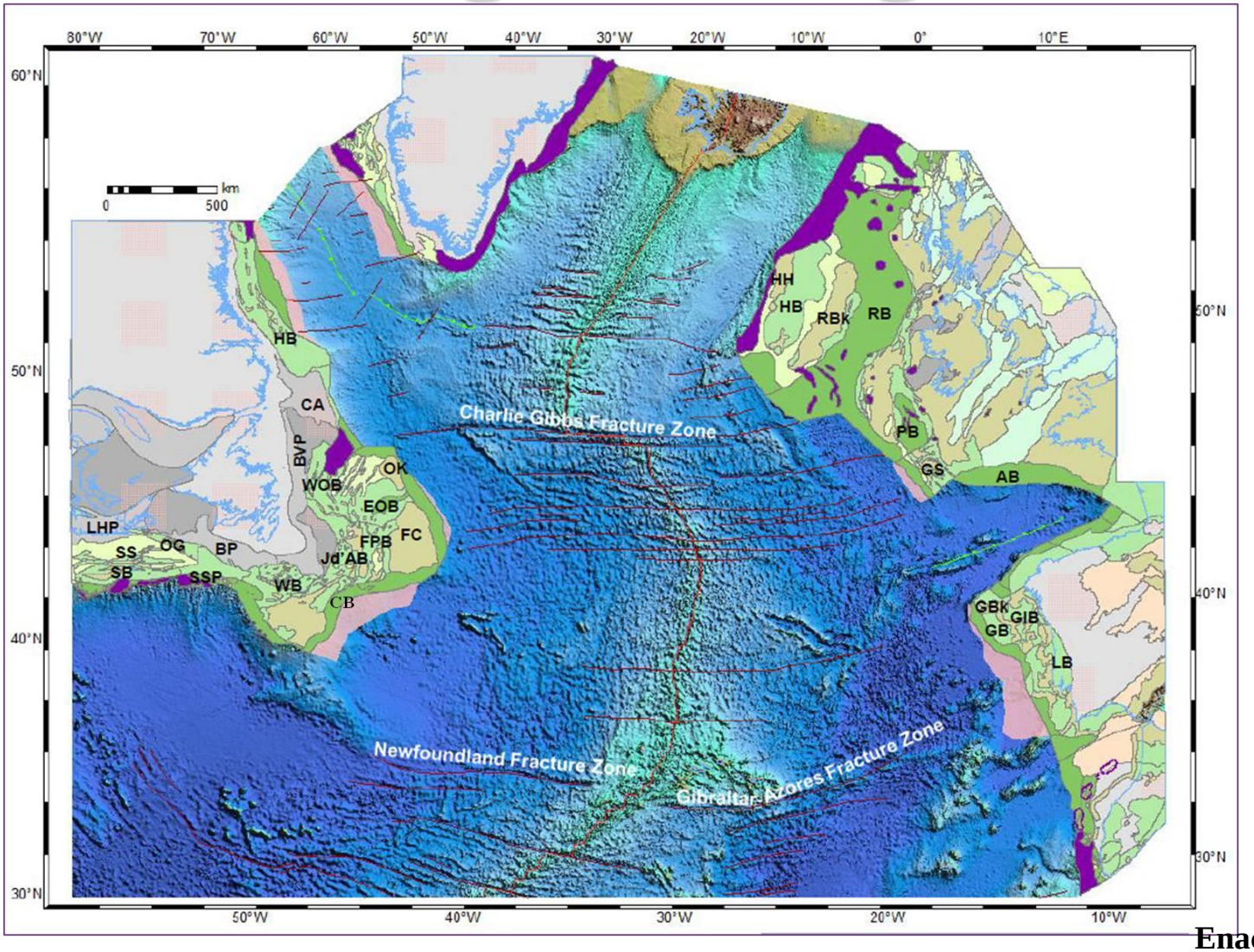
Carson Basin Geological Overview

- **Carson Basin is an under-explored basin.** Only the shelfal sector of the basin has been drilled. The drilling density is 1 well/12,500 km^2.
- **Mesozoic rift basin.** This Atlantic margin, Mesozoic-Tertiary basin is on trend with the oil producing Jeanne d'Arc Basin (approximately 250,000 bopd from the Hibernia, Terra Nova, White Rose giant oil fields and smaller North Amethyst field), the recent oil discoveries at Mizzen, Bay du Nord, and Harpoon in the Flemish Pass Basin and several oil and gas discoveries on the Central Ridge (South Tempest, North Dana).
- **Exploration and Production activity.** There is no active E&P in the basin and the last activity in the early to mid 2000s did not result in drilling. The closest drilling occurred in the southern Jeanne d'Arc and Flemish Pass basins.

Intra-continental and Divergent Margin Settings



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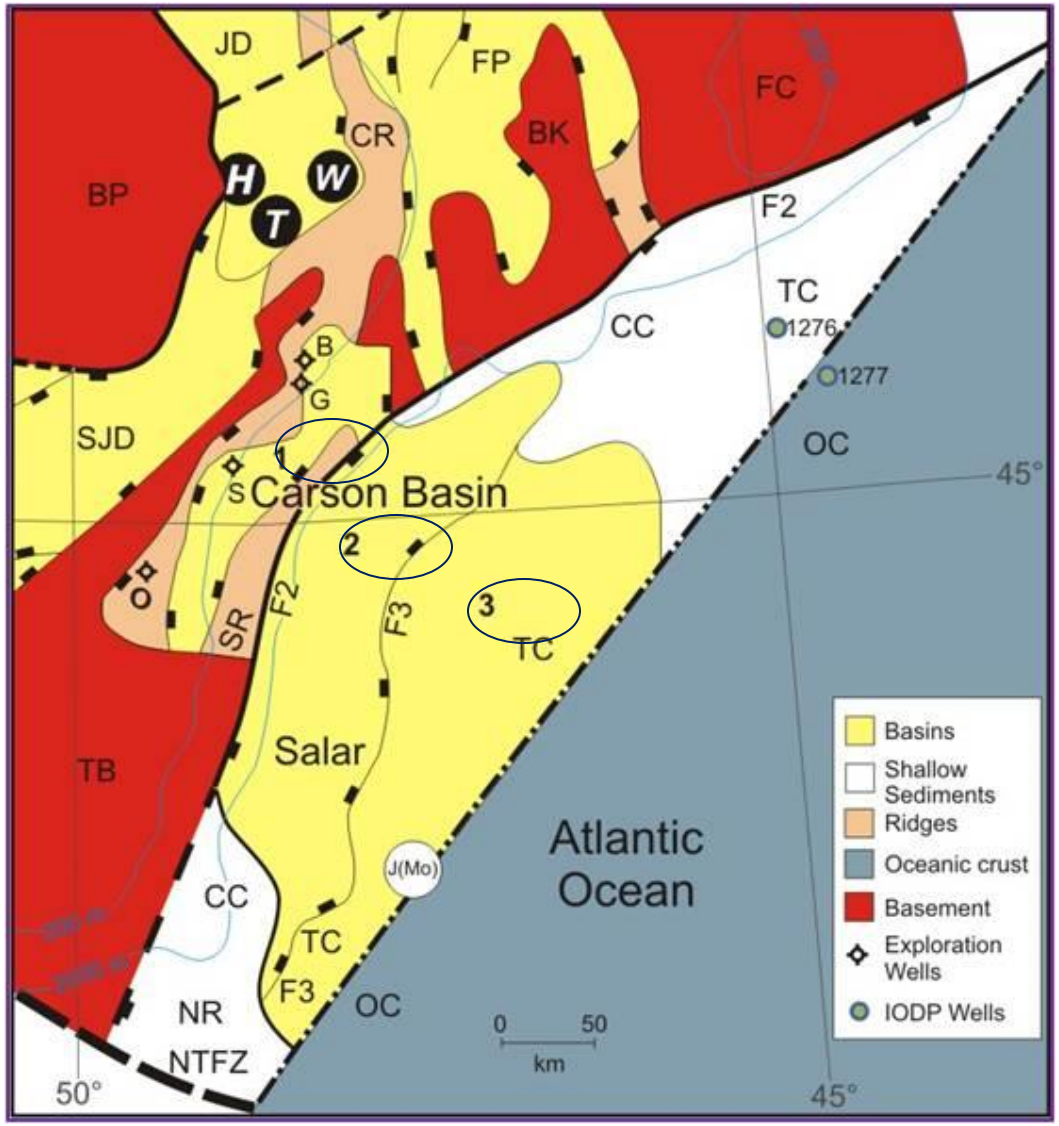
High Reward Exploration Area

- The basin is a high risk-high reward exploration area and is
  - lightly explored,
  - located in shallow to deep water (100-3300 m) and
  - contains very large, undrilled basement induced, tilted blocks, and salt anticlines.
- Only four on-shelf exploration wells were drilled during two earlier exploration phases in the basin (1970-1975; 1980-1987).
- The recent exploration wells, Mizzen O-16 and Bay du Nord C-76 in the Flemish Pass Basin, found oil in intermediate water depths in a structure on trend and similar to structures identified in the Carson Basin.
- The 2013 Call for Bids provides a great opportunity for petroleum exploration in this large potential, petroleum basin that should contain Late Jurassic source rock and Jurassic, Cretaceous and Tertiary reservoirs.
- The basin has a good 2D seismic grid but only limited 3D coverage.
- Exploration blocks in this area are 117-125 times larger than Gulf of Mexico tracts.

Basin Nomenclature



The Carson Basin is a branch of the North Atlantic Mesozoic rift network

1. **On-shelf sector (Carson or Carson Bonnition)**

2. **Slope and Upper Rise (Salar Basin)**

3. **Deepwater (Salar Basin)**

All three subunits are the Carson sedimentary area

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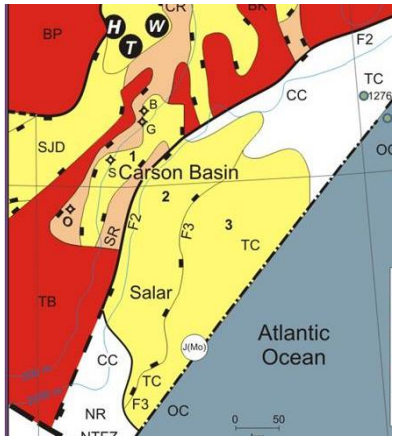
Sector Characteristics



- **On-shelf sector**
  - Easternmost part of the Grand Banks of Newfoundland
  - Separated from the JDB by basement ridge trending approximately NE-SW
  - Separated from slope part of the basin by a basement ridge capped by Argo
  - Late Triassic to Quaternary successions were drilled by 4 wells
  - Late Jurassic source rocks are missing at the well locations, probably due to non-deposition on basement highs or erosion in the proximity of the Avalon Uplift
- **Slope and upper rise sector**
  - Known in the literature as the Salar Basin
  - Separated from the on-shelf part by a basement ridge trending approximately NE-SW (hinge zone)
  - Separated from the deepwater basin by a tortuous fault zone and high ridge
  - Sector contains the entire Mesozoic sedimentary section including Late Triassic -Jurassic beds
  - Large tilted blocks, salt diapirs and complex structures mapped
- **Deepwater sector**
  - Located east of a fault system dividing the deepwater region into sub-regions
  - Mesozoic-dominated area complexly structured
  - In places the Mesozoic section is thin
  - Tilted basement blocks, circular salt structures and transitional zone-like mounds (peridotite mounds?)
  - Mini-basins containing deformed Mesozoic layers are mapped in the deepwater sector
  - Some of the blocks show slight inversion probably due to transtension or isostatic rebound

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2. Exploration and Production Background

- NL offshore oil production
- Carson Basin and Environs Land Situation
- Historical Drilling and Results
- Most Recent Exploration Activity in Carson Basin
- Seismic Coverage
- Recommended References and Presentations

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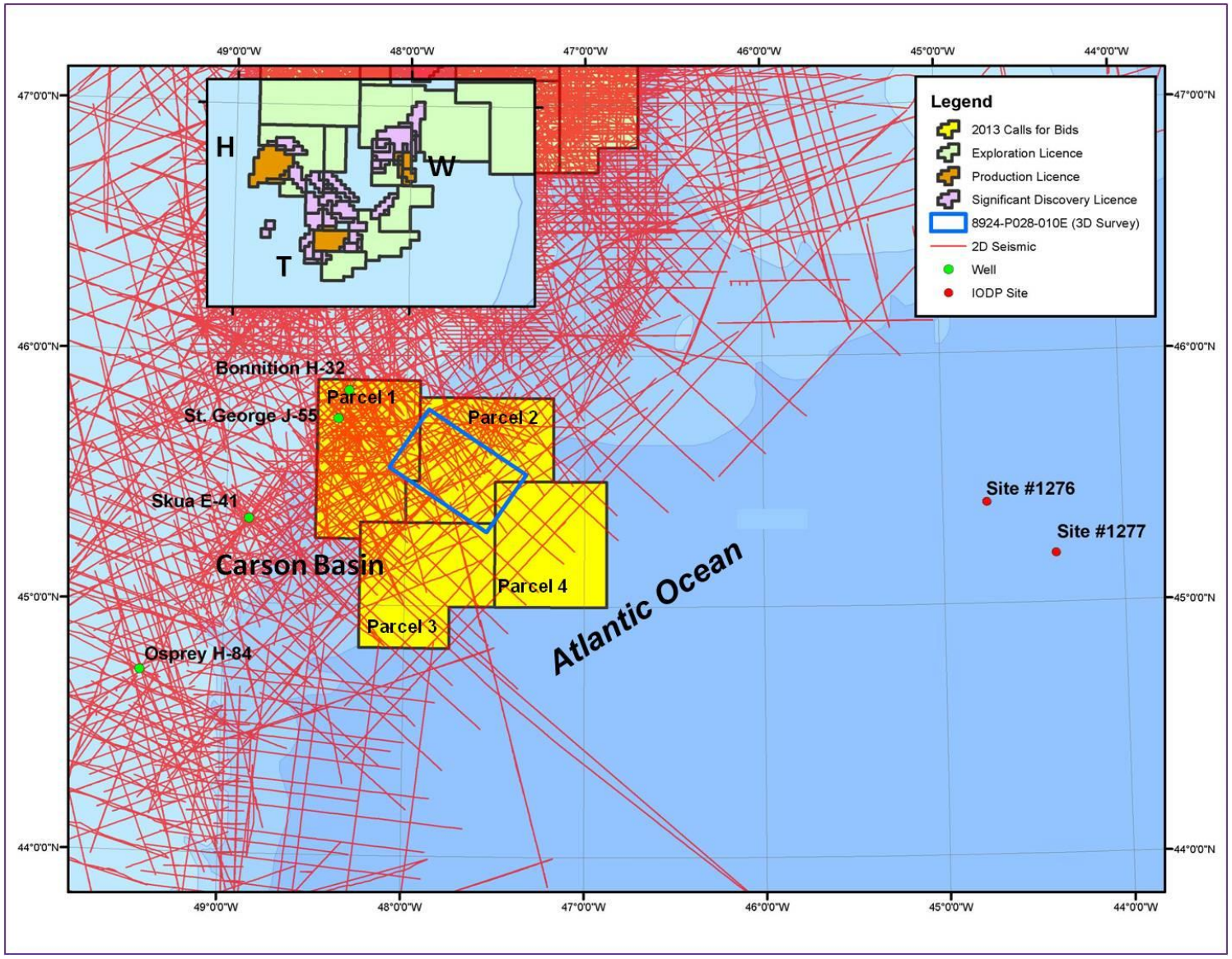
Location Map



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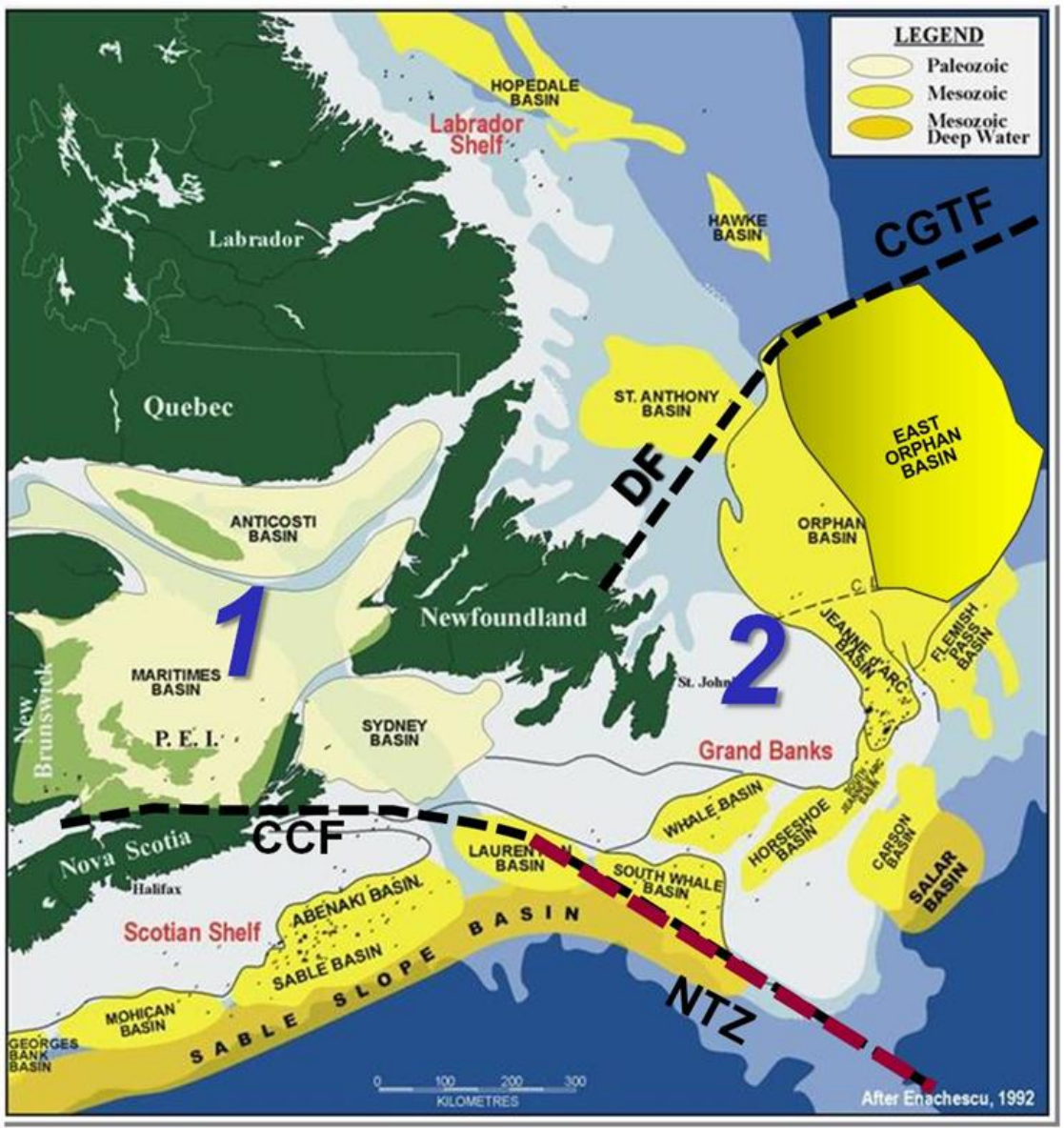
Basin Locations



Large Mesozoic Under-Explored Basin in Atlantic Canada

Newfoundland

- **South Grand Banks** was 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 basins. These basins, starting 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 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 (90 Bbbls generated; 5-6 Bbbls preserved). A 3D survey exists on the slope of this basin. No drilling has been carried out on the slope, where seismic data indicate the presence of large structural and stratigraphic features.

3. Overview of Regional Geology of the Carson Basin

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

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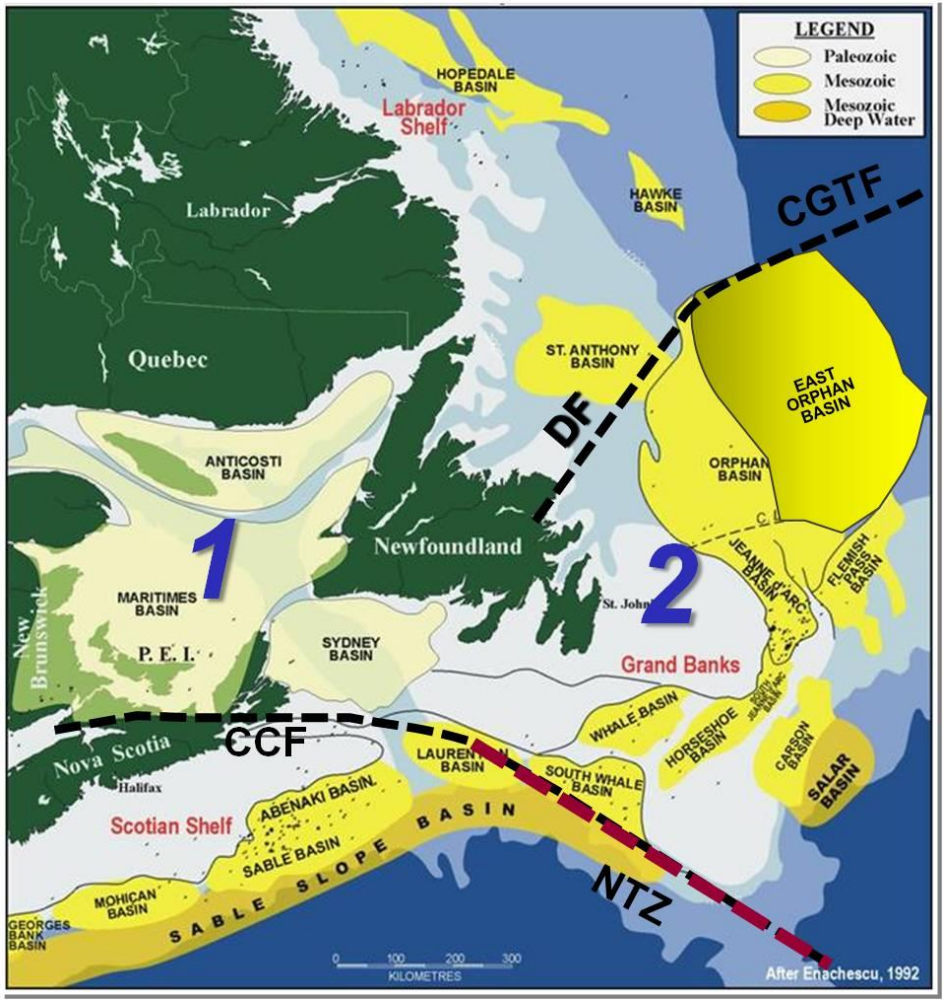
3. Regional Geology of Call for Bids NL13-02 area



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

DF = Dover Fault
CGTF = Charlie Gibbs Transform Fault
CCF = Chebacto Cobeqoid Fault
NTZ = Newfoundland Transform Zone

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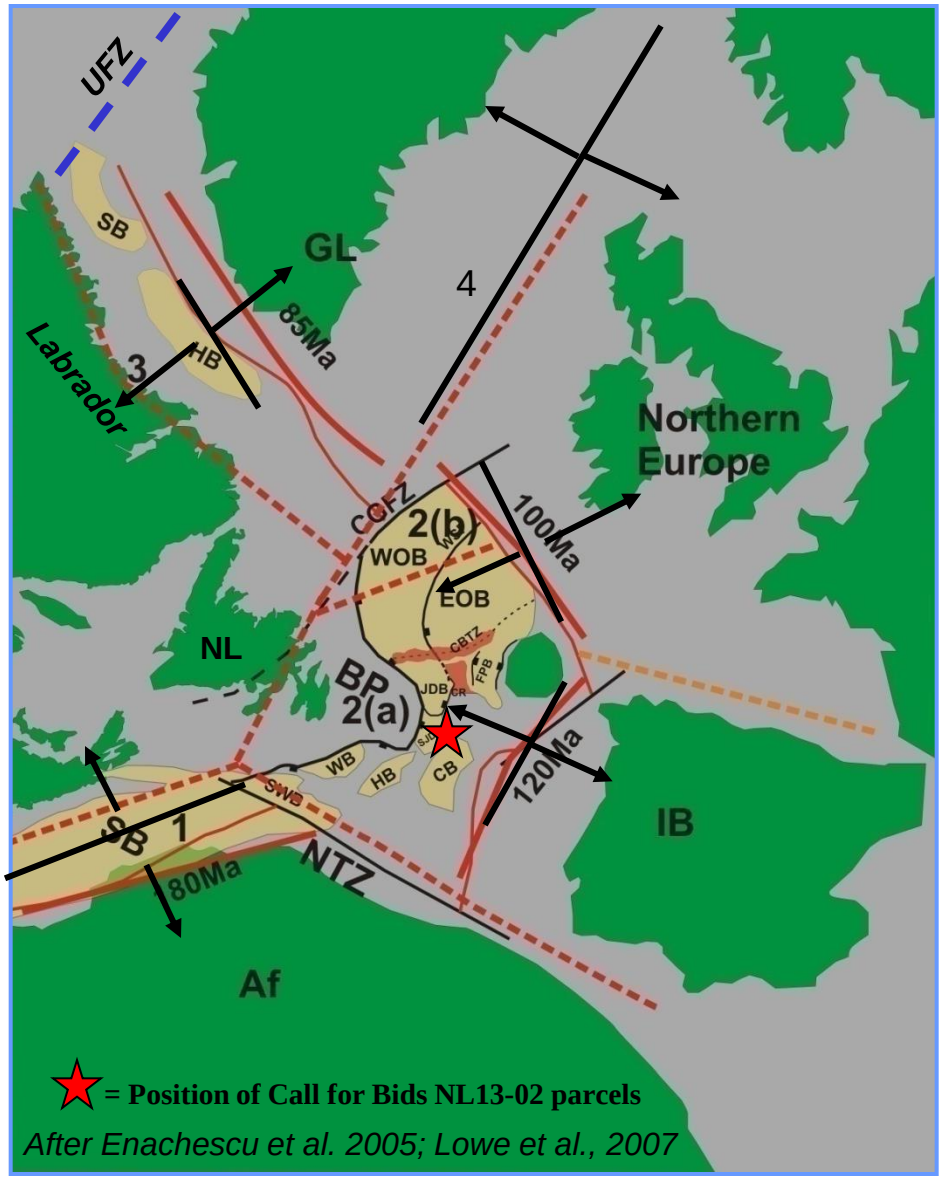
Complex Geodynamic Evolution

- 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). This has 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

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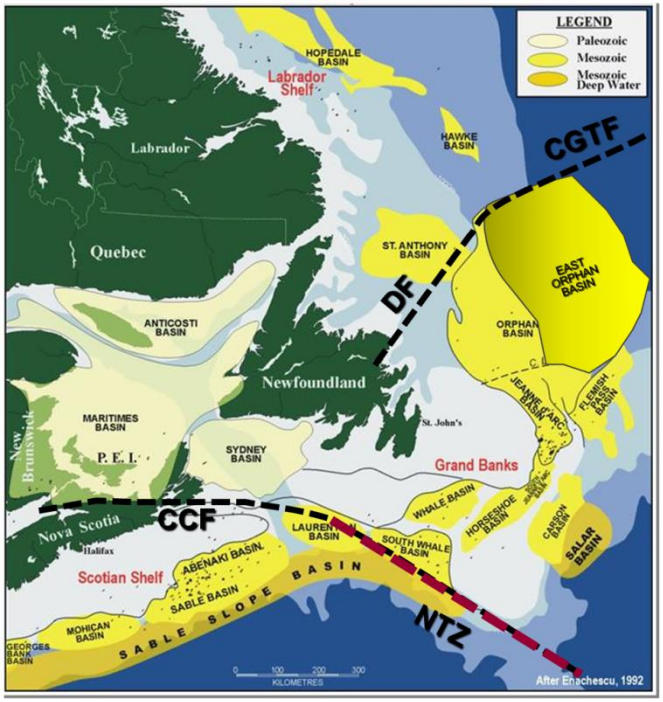
Geologic Evolution of NL Margin Sedimentary Basins

- 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 lightly 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, and then North Atlantic rift.



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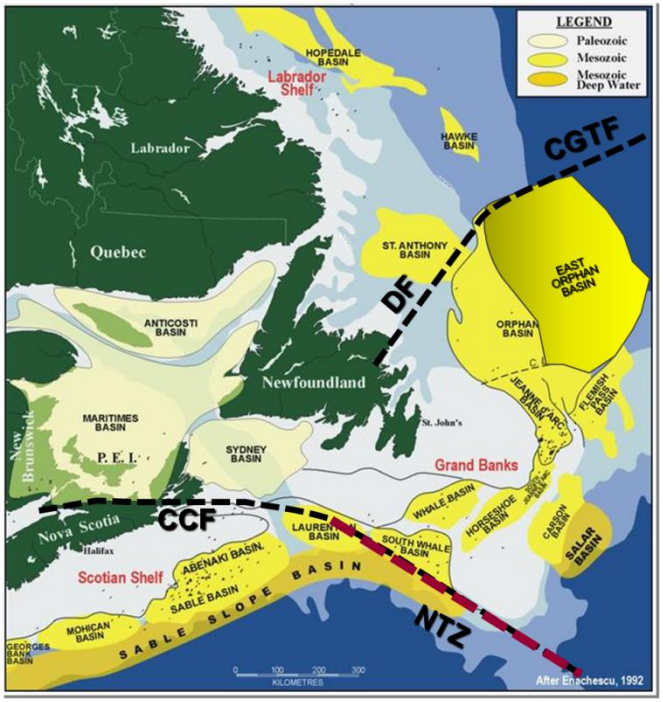
Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- 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-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. Carson /Lusitania).



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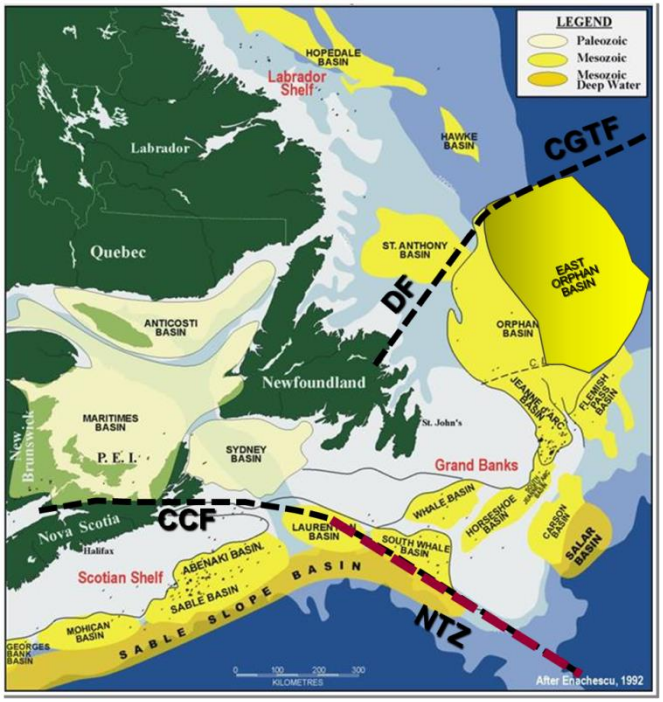
Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- 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 to date).
- 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.



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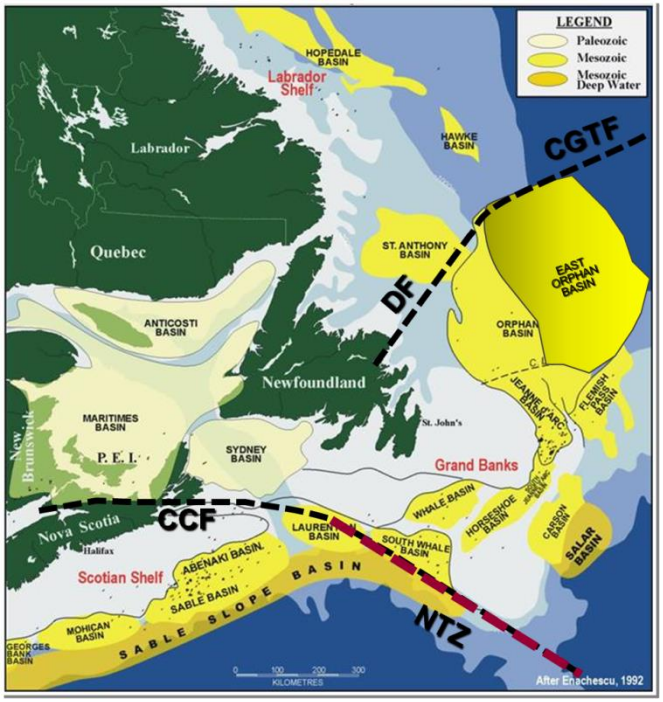
Geologic Evolution of NL Margin Sedimentary Basins (Cont.)

- There are no or at most rare, allochtonous salt or tow thrusts -unlike offshore Nova Scotia.
- Diapiric salt extends to the North Jeanne d'Arc/central Flemish Pass basins; Only stratified evaporite beds are present in the northern Flemish Pass/East Orphan basins.
- Mostly **constrained** basins (e.g. Jeanne d'Arc, Flemish Pass basins) however some become **unconstrained** basins in a later evolutionary stage (Carson Basin, North Flemish Pass Basin).
- All of the Grand Banks has thick Tertiary cover.
- Individual basins/subbasins/rifts may be diachronous, with as much as ±10 MM years between forming events.



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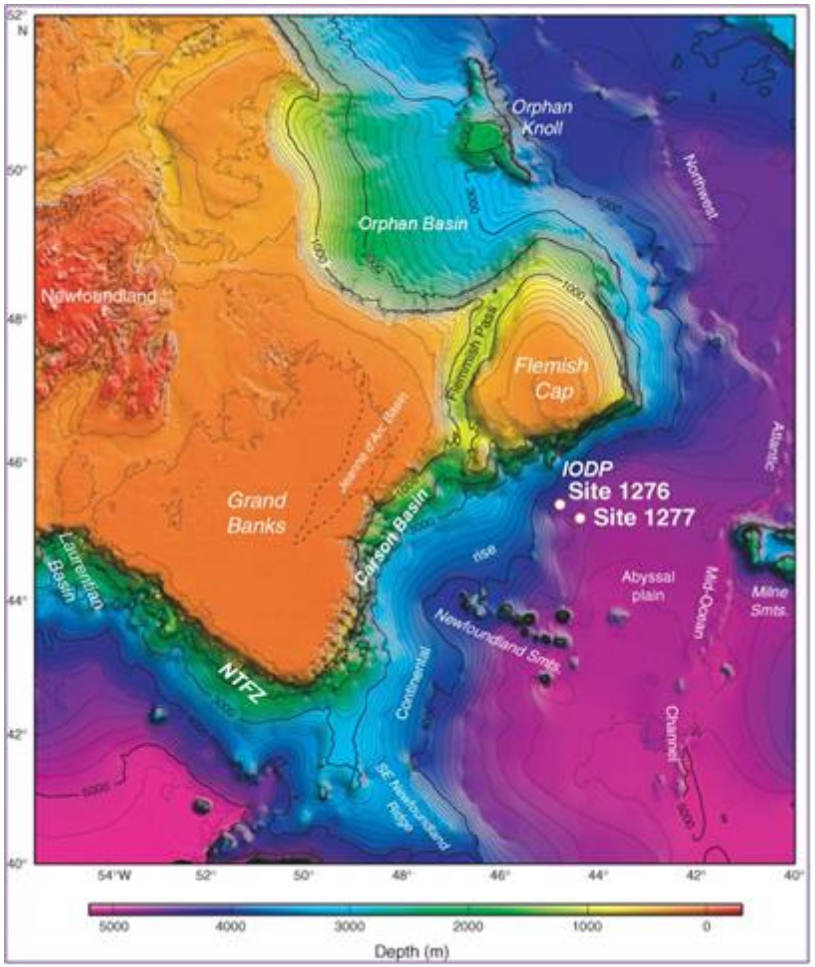
Recent Activity



- The Carson Basin had no active Call for Bids and no new seismic surveys were acquired since the mid 2000's.
- Many international scientific organizations, marine institutes and universities have conducted research studies on the continental margin of NL, focused on the nature of crust in front of the Grand Banks and the timing of continental breakup between NL and Iberia.
- During Leg 210 (2003), the IODP drilled two sites south of Flemish Cap: site 1276 bottomed on transitional crust and site 1277 terminated on ultraslow emplaced oceanic crust.

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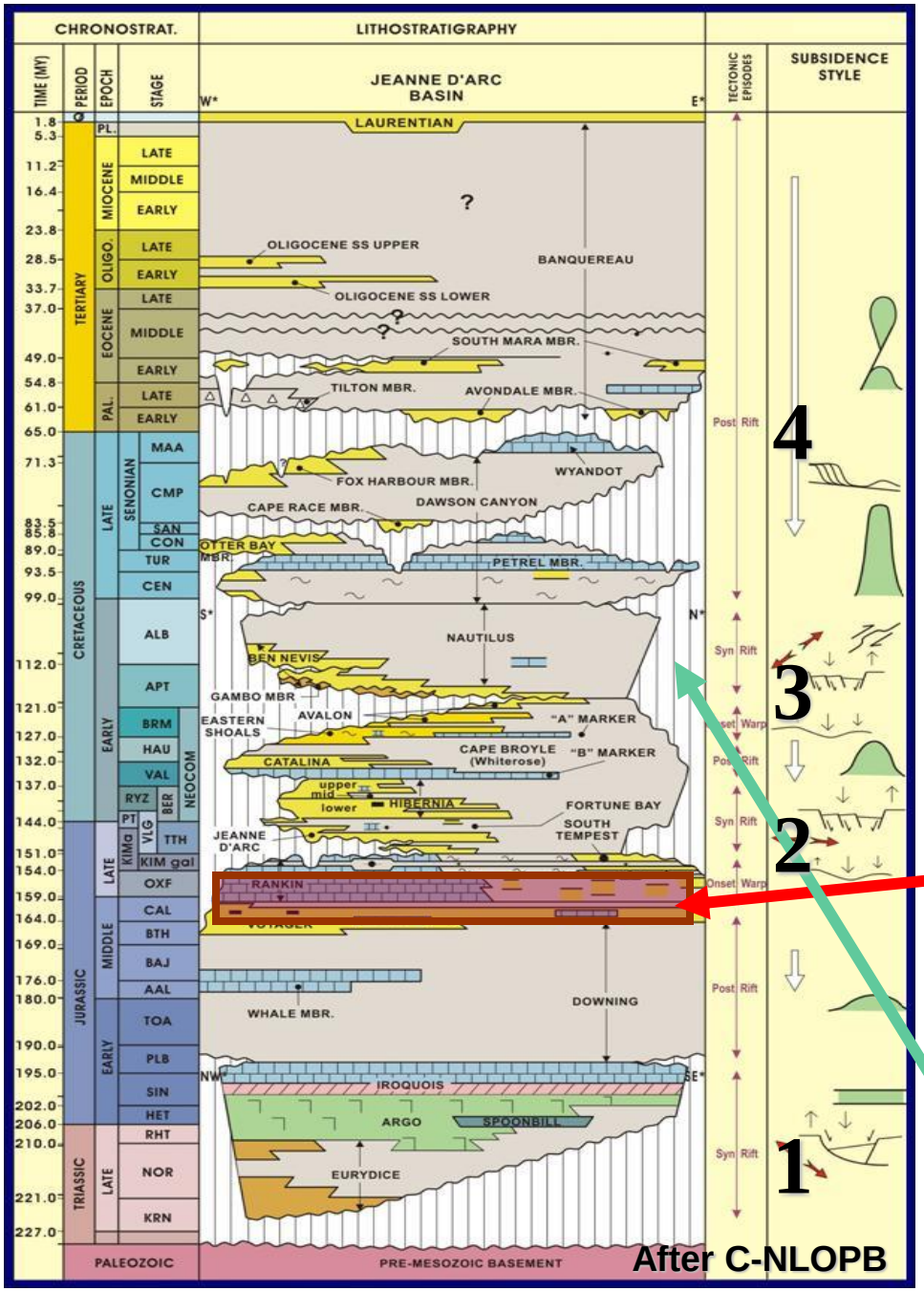

Lithostratigraphy and Tectonic Evolution

- 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 significant period 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 also be a good source rock.
- Albian source rock was identified in IODP drilling but is unproven.

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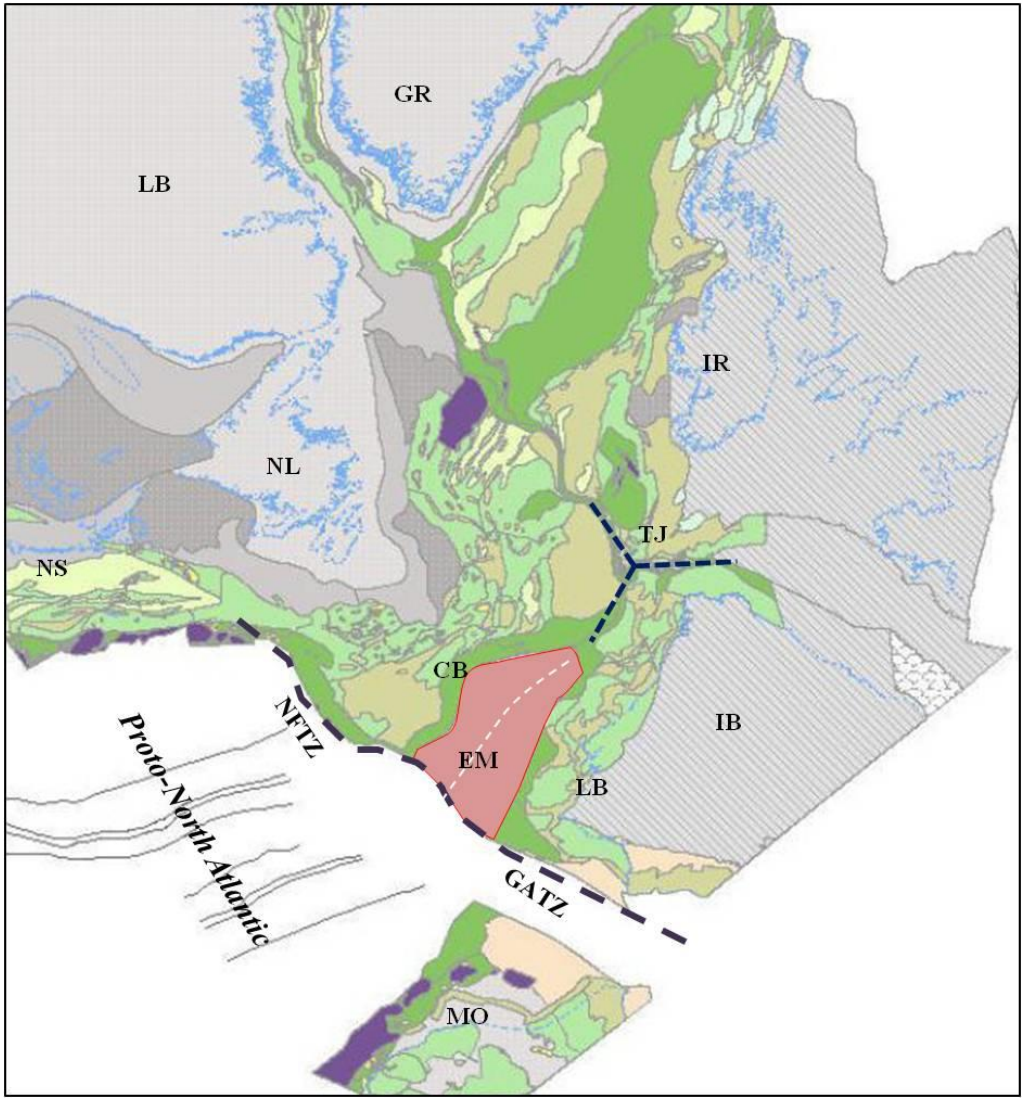
Prerift Basement, Transitional Crust

- Mesozoic basins are floored by Proterozoic metamorphic rocks, and in places by Paleozoic strata and intrusive rocks.
- **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.



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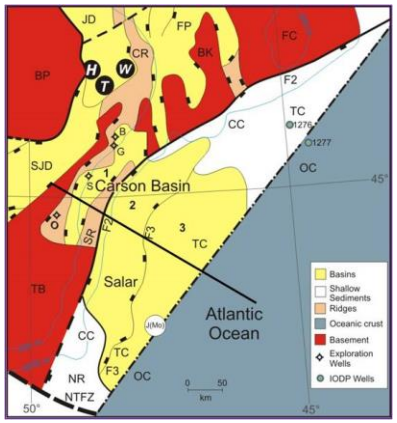
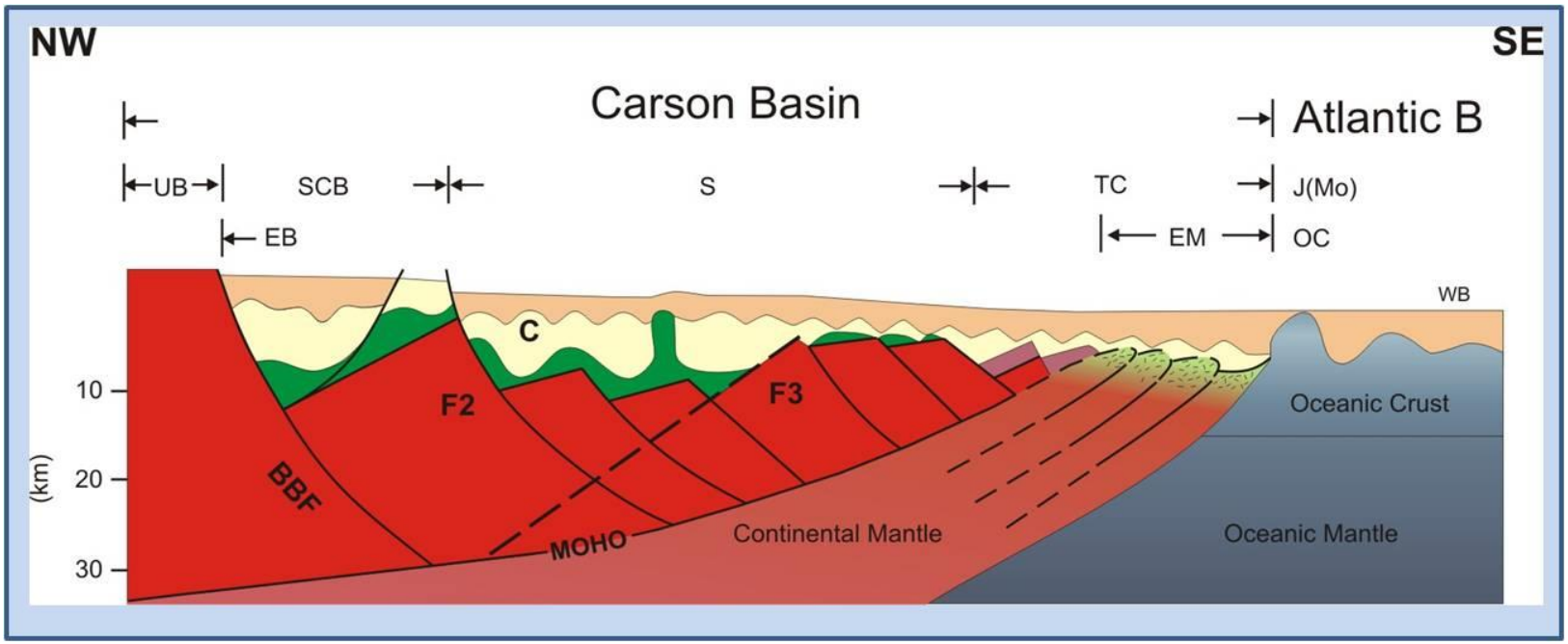
Simplified Crustal Profile



- The early **Synrift** phase deposits filled the incipient basins with lacustrine stage sediments including some reservoir rocks. An incursion of epicontinental Tethys Sea brought deposition of Argo salt. In the CFB area, the Argo salt is thick and preserved as diapirs or a stratified evaporite sequence interbeded with clastics.



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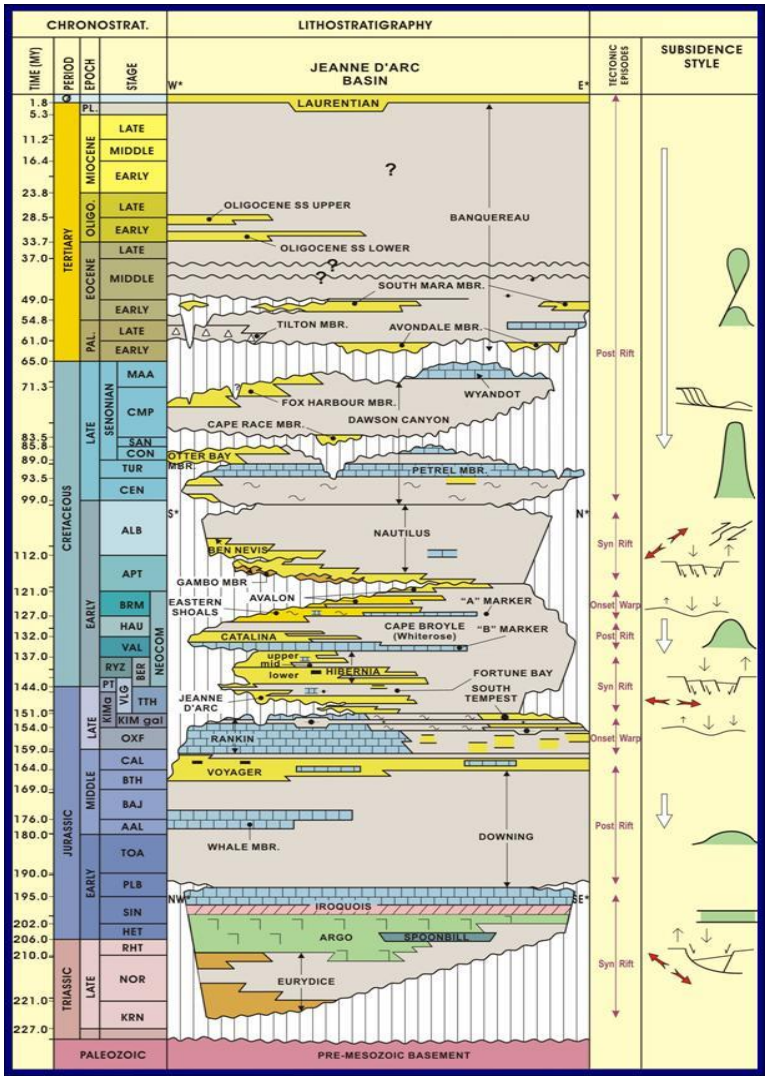
Tectono-Stratigraphic Summary

- 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 was 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.



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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:
  - Late Jurassic reservoirs such as the Voyager, Tempest, Jeanne d'Arc sandstones
  - 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 good source properties.
- A possible source rock is the Albian shale (Nautilus Fm) that showed rich, marine organic content from drilling conducted by the IODP Leg 210, at a location situated just east of Flemish Cap.
- Tertiary shales are yet unproven as source rocks.

Resource Potential: How Much Oil & Gas offshore NL?

- More than **2.2 Bbbls** proven remaining recoverable reserves/resources exists in the Jeanne d'Arc Basin; approximately 12 Tcf of gas has been discovered offshore NL of which **7.9 Tcf** of gas resides 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, Carson and East Orphan region.

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4. Overview of Petroleum Geology of the Carson Basin

- **Land Situation 2013**
- **Exploration Results**
- **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 (2013) DNR Report available from: **http://www.nr.gov.nl.ca/nr/invest/enachescuNL100203.pdf**

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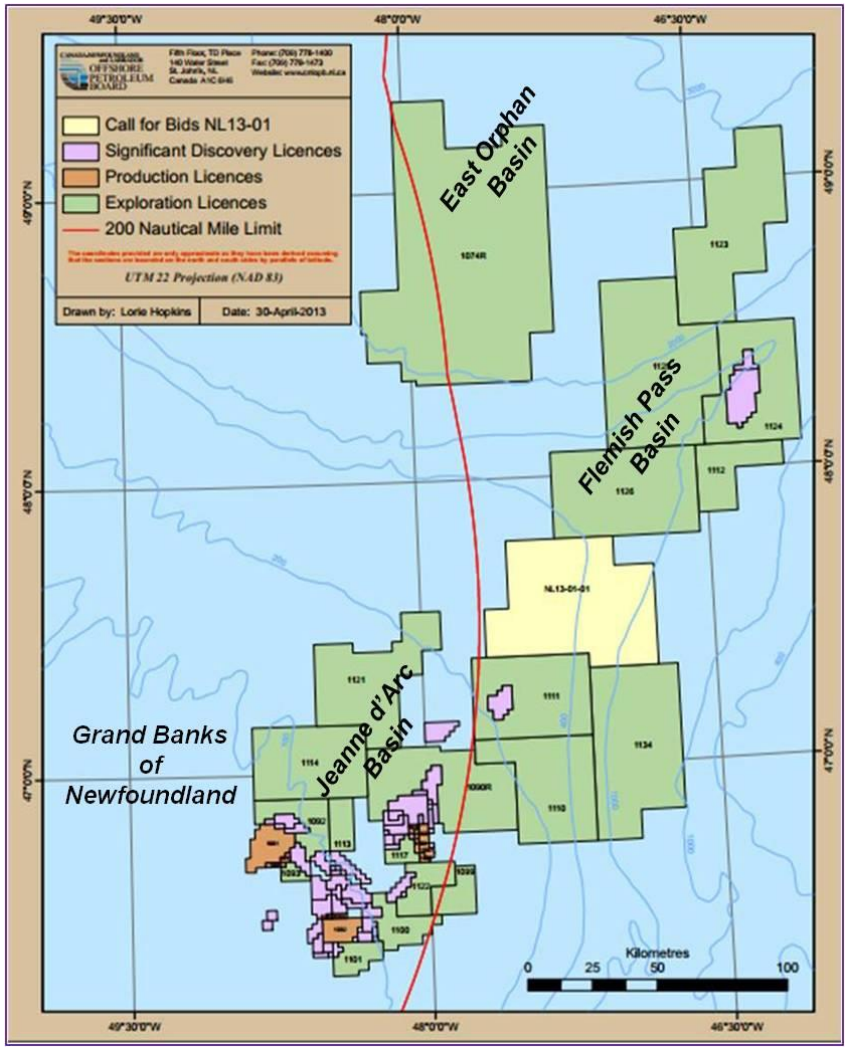
Present Land Situation 2013



- Currently there are 11 Production Licences all awarded in the Mesozoic Jeanne d'Arc Basin.
- A total of 4,312,042 ha (43,120 km^2) are licensed by the C-NLOPB for offshore exploration in three areas: Grand Banks and vicinity, Labrador Sea and Western NL.
- Active Exploration Licences - 38, distributed in three areas covering eight basins.
- 27 active ELs in the Grand Banks and vicinity, distributed in 5 basins.
- Shell is the largest single interest holder (100%) with over 1.3 MM ha. Six other companies: Husky, Statoil, Suncor, ConocoPhillips, Chevron and ExxonMobil are operating ELs in the Grand Banks and vicinity.

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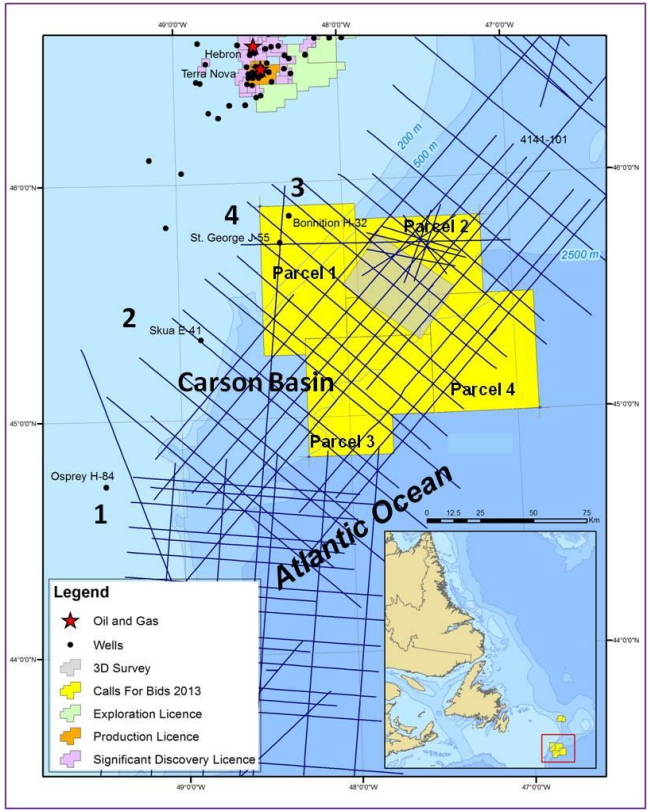
Drilling History

Shelfal part of the Carson Basin underwent two earlier exploration cycles:

1. **Late 1960s to mid-1970s** led by Amoco and Imperial who drilled the Osprey H-84 and Skua E-41 dry wells. These wells were Gulf of Mexico "look-a-like" salt diapirs. Mobil and Gulf drilled the Bonnition H-32 in the northern basin, which was also a dry hole. This well however, proved the existence of Late Jurassic formations in the Carson Basin.
2. **In the early 1980s** led by Canterra and Petro-Canada ended with the drilling of St. George J-55, also a dry hole.



The four shelfal wells drilled indicated that good reservoirs existed, however the wells were too shallow or had no access to a mature source kitchen.

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Significant Wells

Well	Dril-led	WD (m)	Status	Location	TD (m)	Postrift Unc (m)	TD in	Reservoir Interval (m)	Source rock
Osprey H-84	1973	61	Abandoned	Grand Banks shelf	3474	1056	Eurydice Fm		Not present
Bonnition H-32	1973	102	Abandoned	Grand Banks shelf	3048	1291	Rankin Fm	S. Mara Mbr 1268-1291 Hibernia eq. 1458-1640 Jeanne d'Arc eq. 1725-2054	Not present
Skua E-41	1974	83	Abandoned	Grand Banks shelf	3339	1341	Downing Fm	S. Mara Mbr 1077-1117 Eider 1319-1341 Hibernia eq. 1341-1370	Not present
St. George J-55	1986	104	Abandoned	Grand Banks shelf	4100	1840	Rankin Fm	Hibernia eq. 2385-3006 Jeanne d'Arc eq. 3287-3714	Not present

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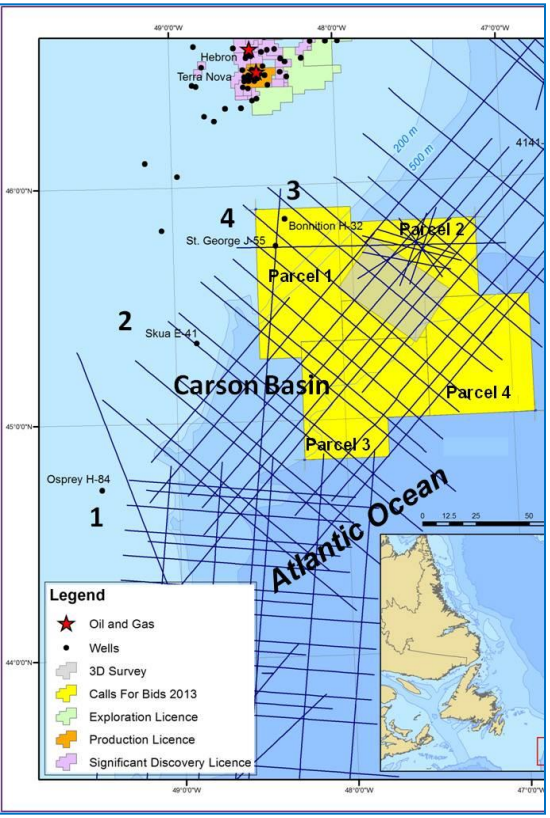
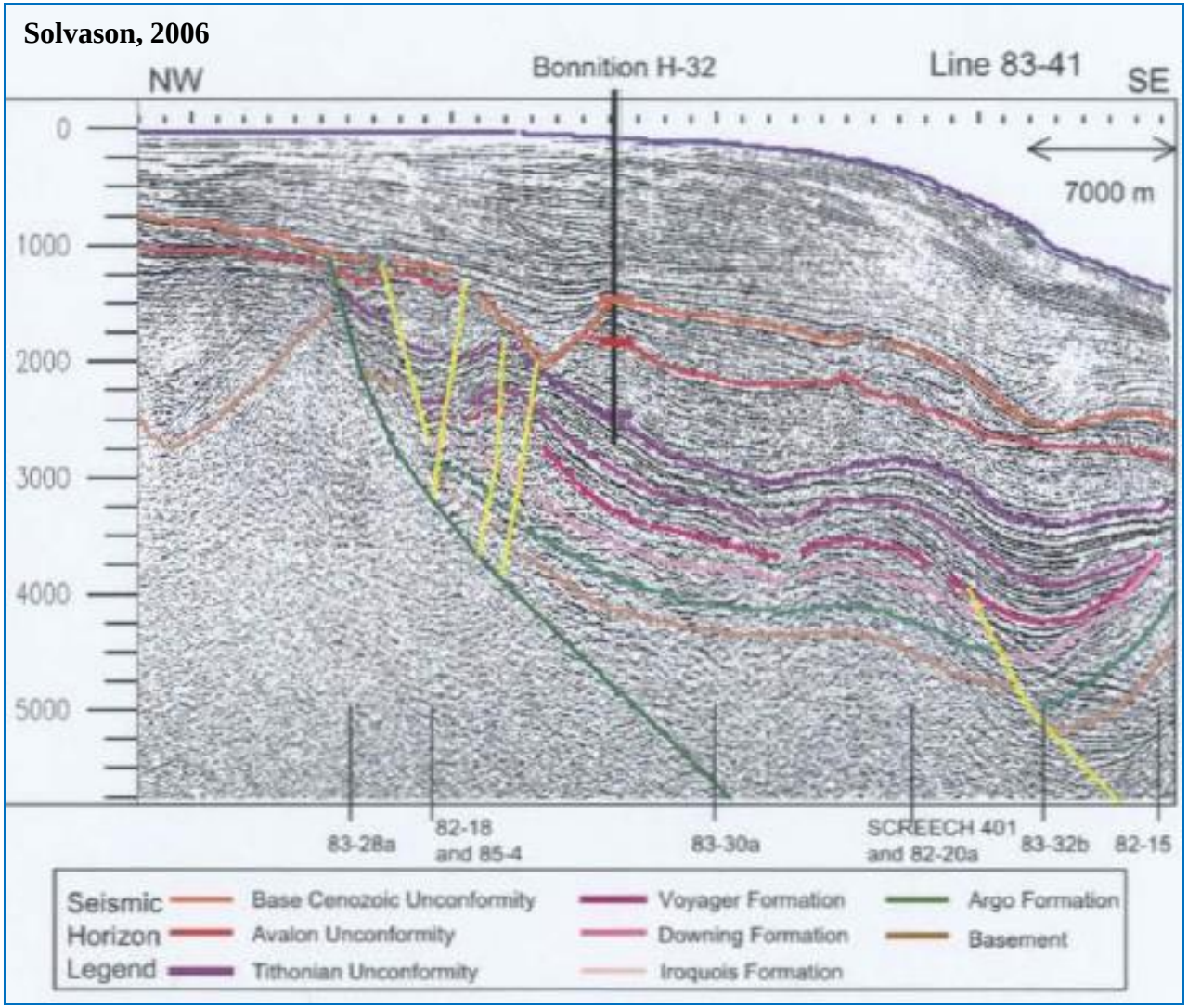
Bonnition H-32



Solvason, 2006



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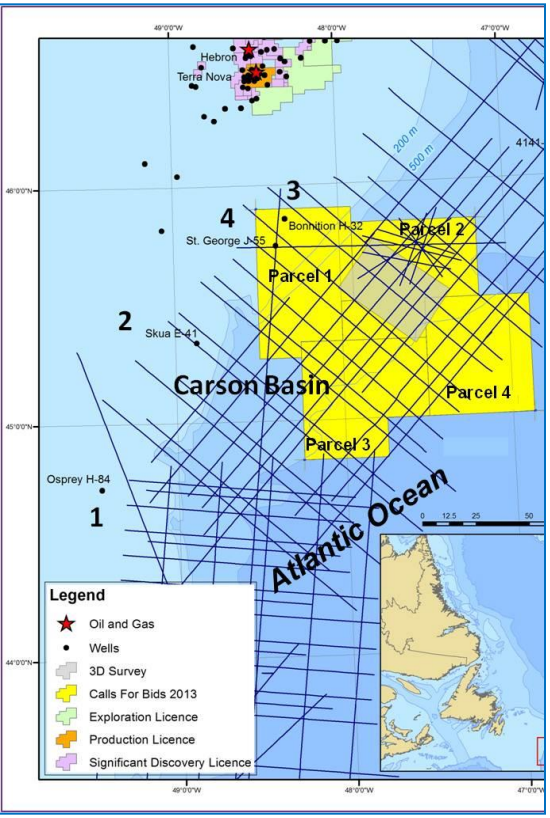
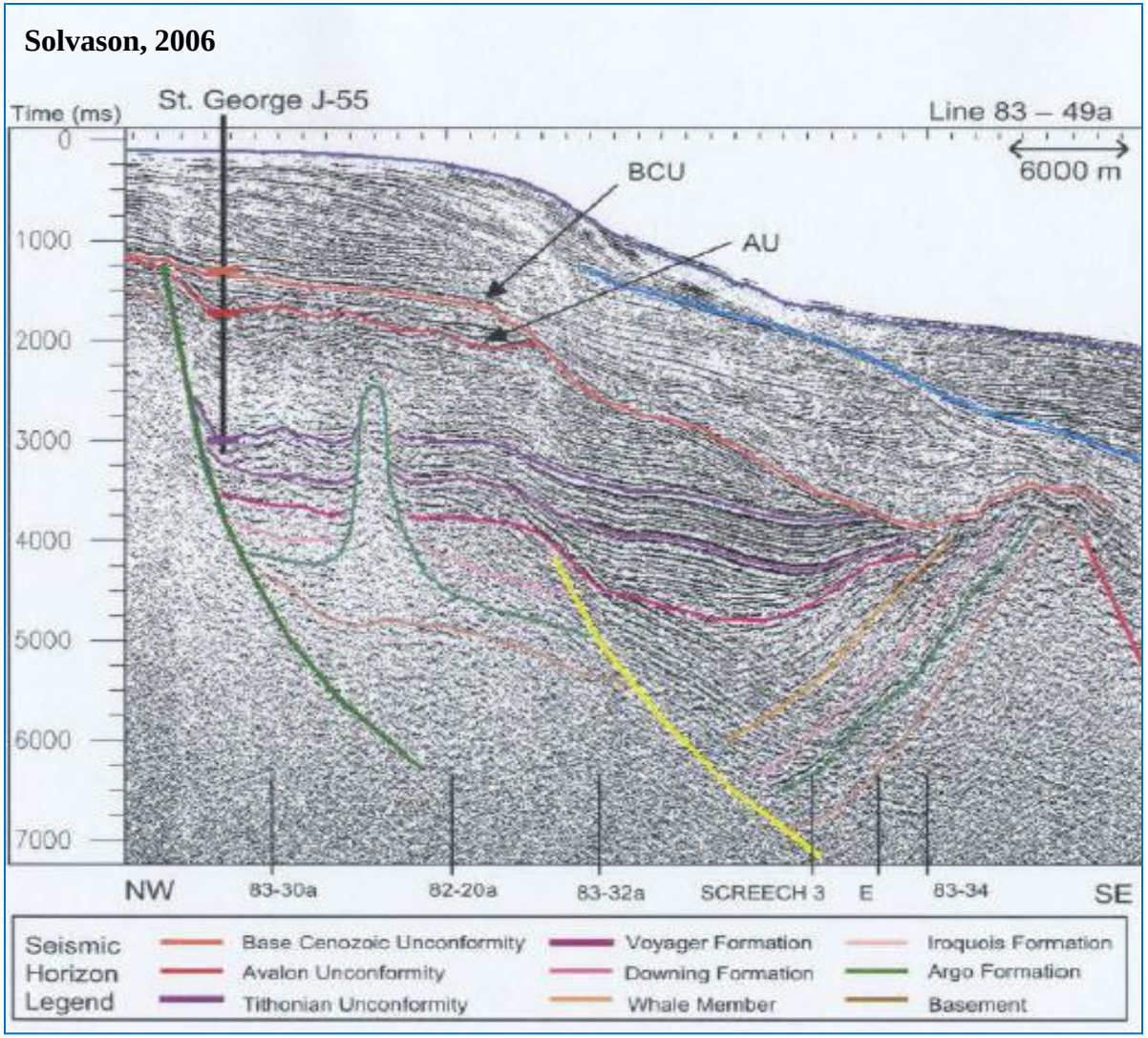
St. George J-55





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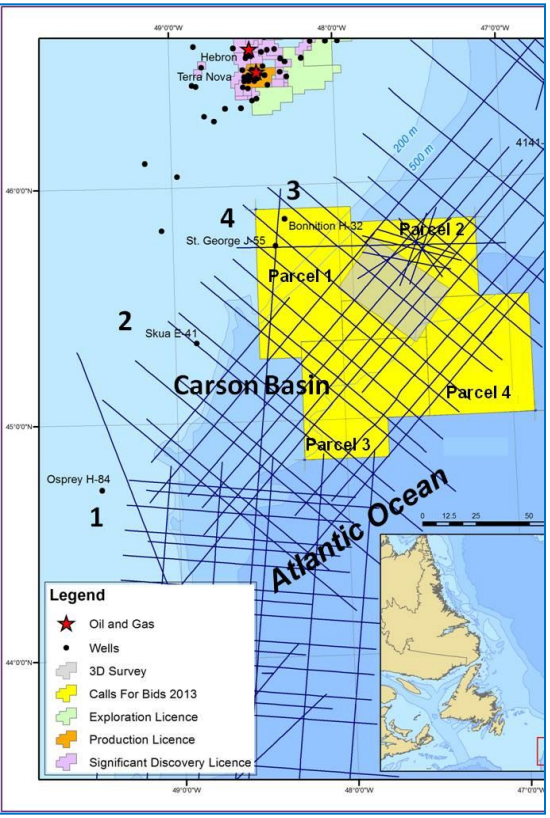
Skua 41



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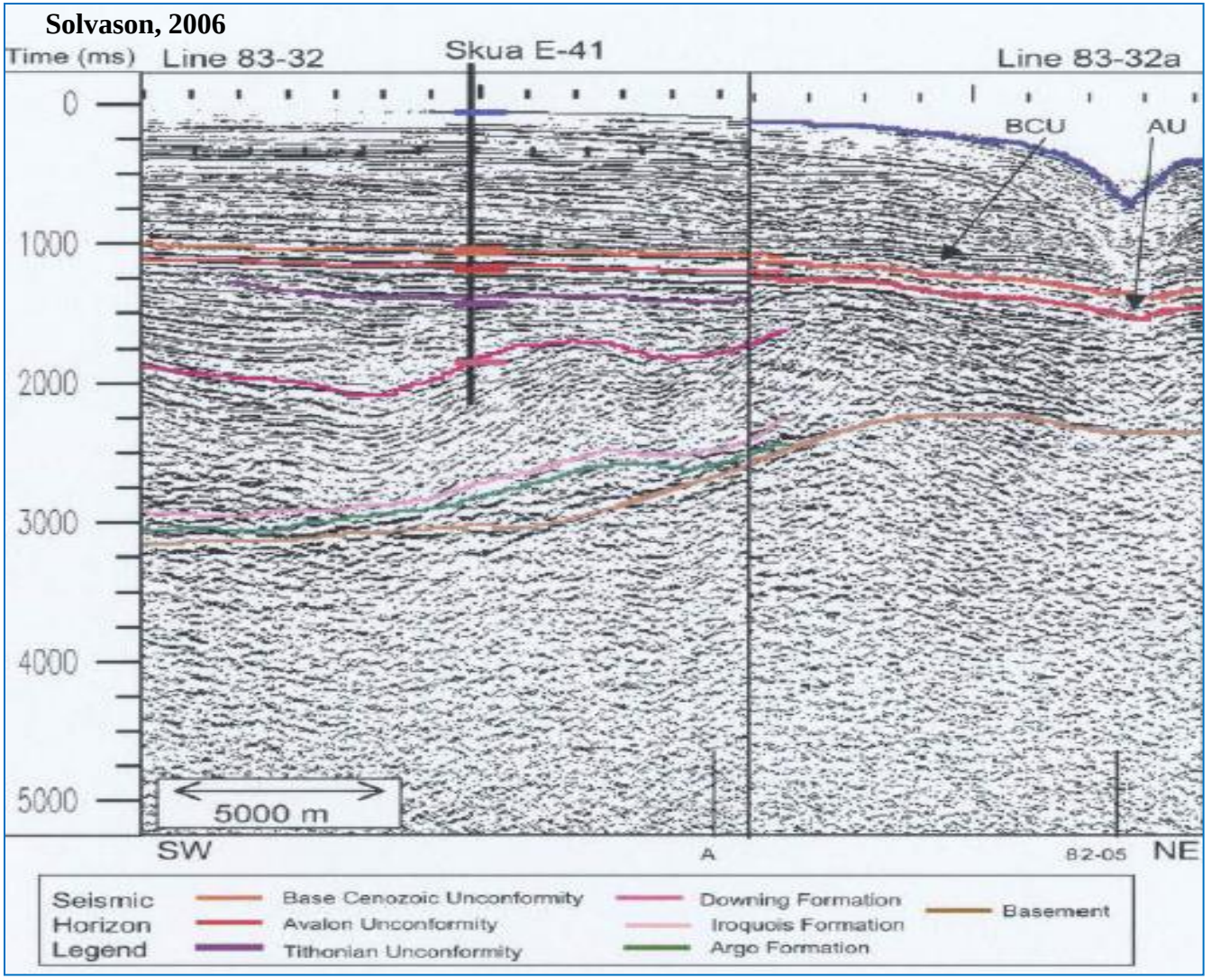

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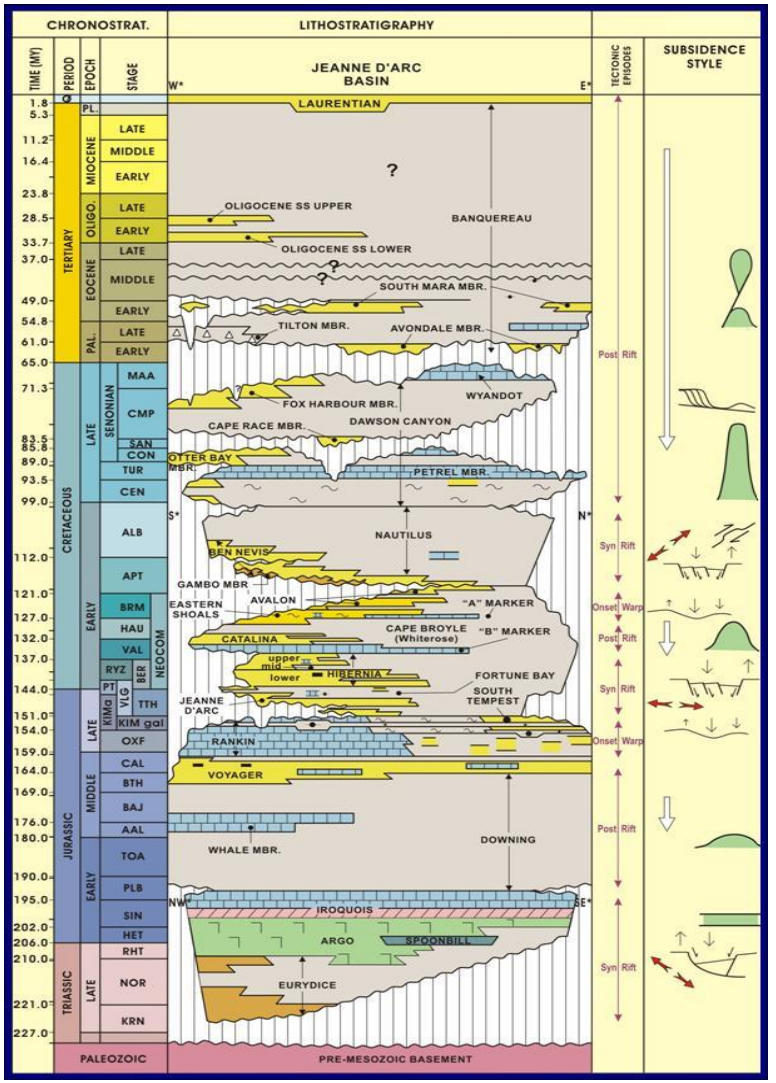
Tectono-Stratigraphic Summary

- During its early evolution, including during the Late Jurassic, the Carson Basin was in communication with the Jeanne d'Arc and Flemish Pass basins as well as with the Lusitania Basin.
- Current knowledge of the stratigraphy of the Carson Basin (based on a low number of close proximity shelfal wells) is in its infancy. However the Lithostratigraphy Chart of the Jeanne d'Arc Basin may be used to identify seismic stratigraphic sequences in the Call for Bids area.
- For simplicity, only geological time is marked on the representative seismic lines used to illustrate this presentation.



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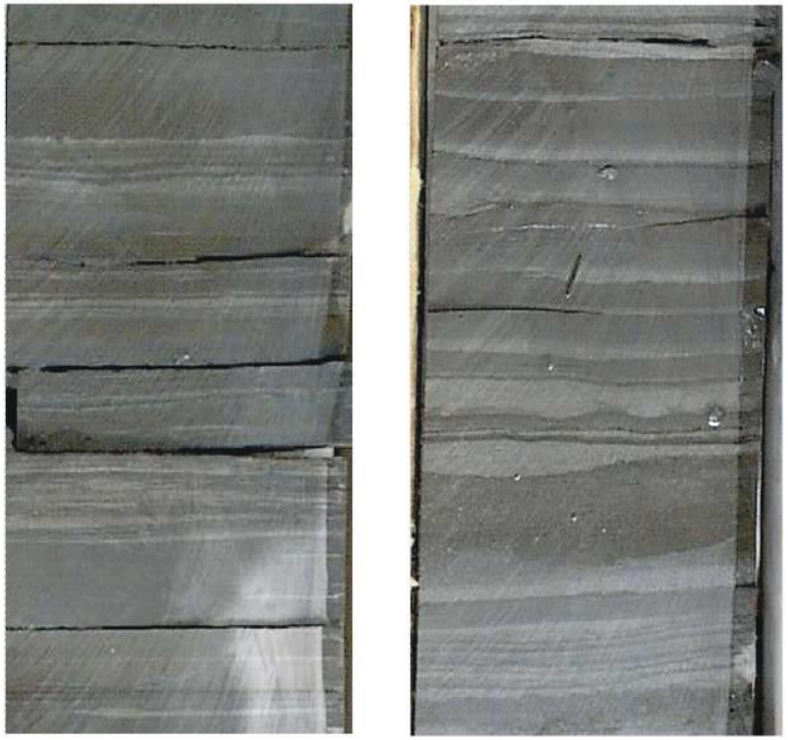
Source Rocks

- The most significant source rock in the Grand Bank's basins is the **Egret Member of the Rankin Formation of Kimmeridgian** age or its equivalent.
- This unit is the prolific source rock that sourced all of the discoveries in the Jeanne d'Arc Basin and probably contributed to the Flemish Pass Basin's discoveries.
- The Egret source rock is an oil prone, marine-derived Type II carbonaceous shale with up to 9% (average 4.5%) Total Organic Carbon (TOC).
- Over 25 exploration wells have penetrated the Egret Member source in the Grand Banks and environs.



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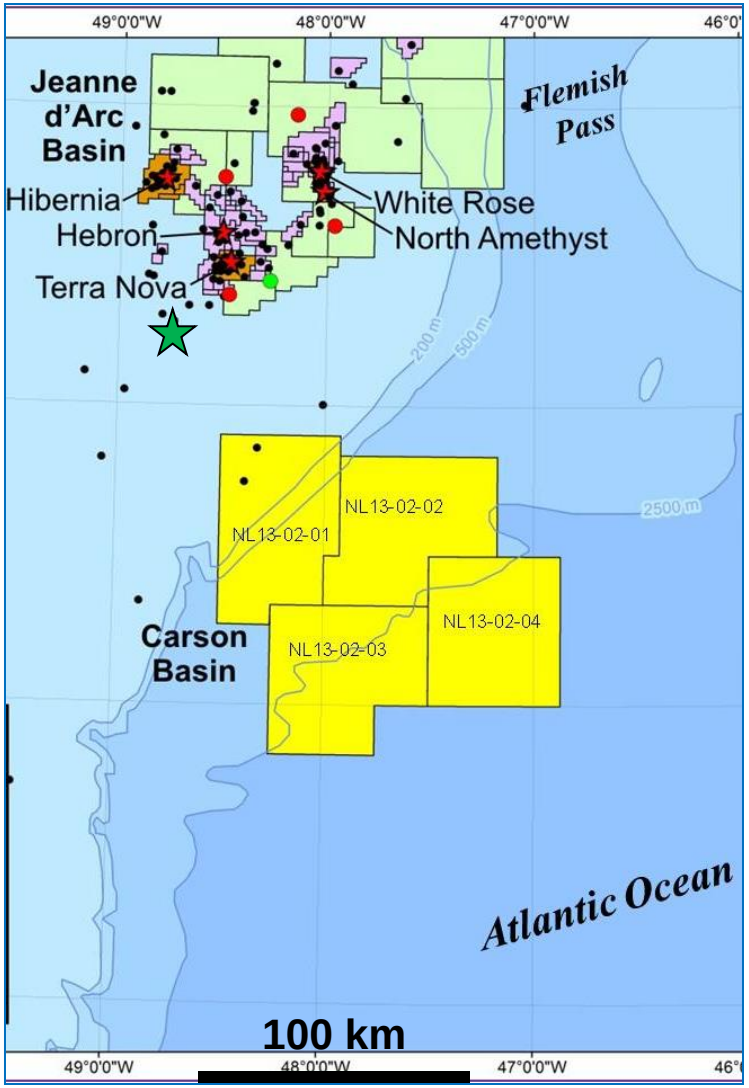
Source Rocks

- The Kimmeridgian Egret shale, deposited in a semi-silled epeiric basin, is the best marine source rock within the North American Atlantic rift system.
- Other source rock intervals have been identified in the Tithonian and Oxfordian shale formations.
- The marine shales that separate the Tithonian reservoirs in the Mizzen oil field have 8 - 12% TOC (Haynes et al., 2012).
- Noteworthy: the Harpoon and Bay du Nord oil finds have been announced as being contained in Jurassic reservoirs and it is presumed that they were generated by a Late Jurassic source rock.



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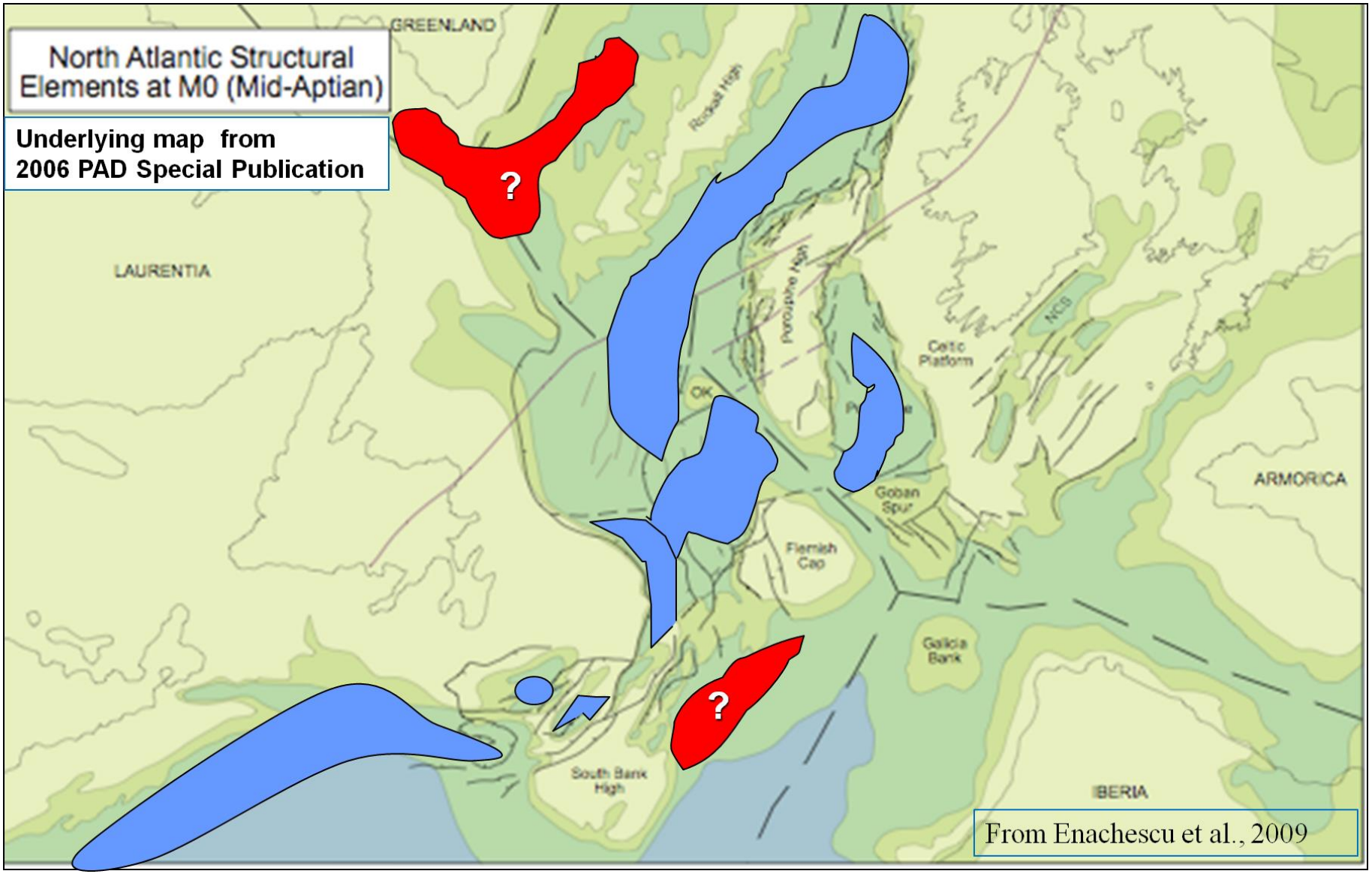
Late Jurassic Preserved Source Rocks



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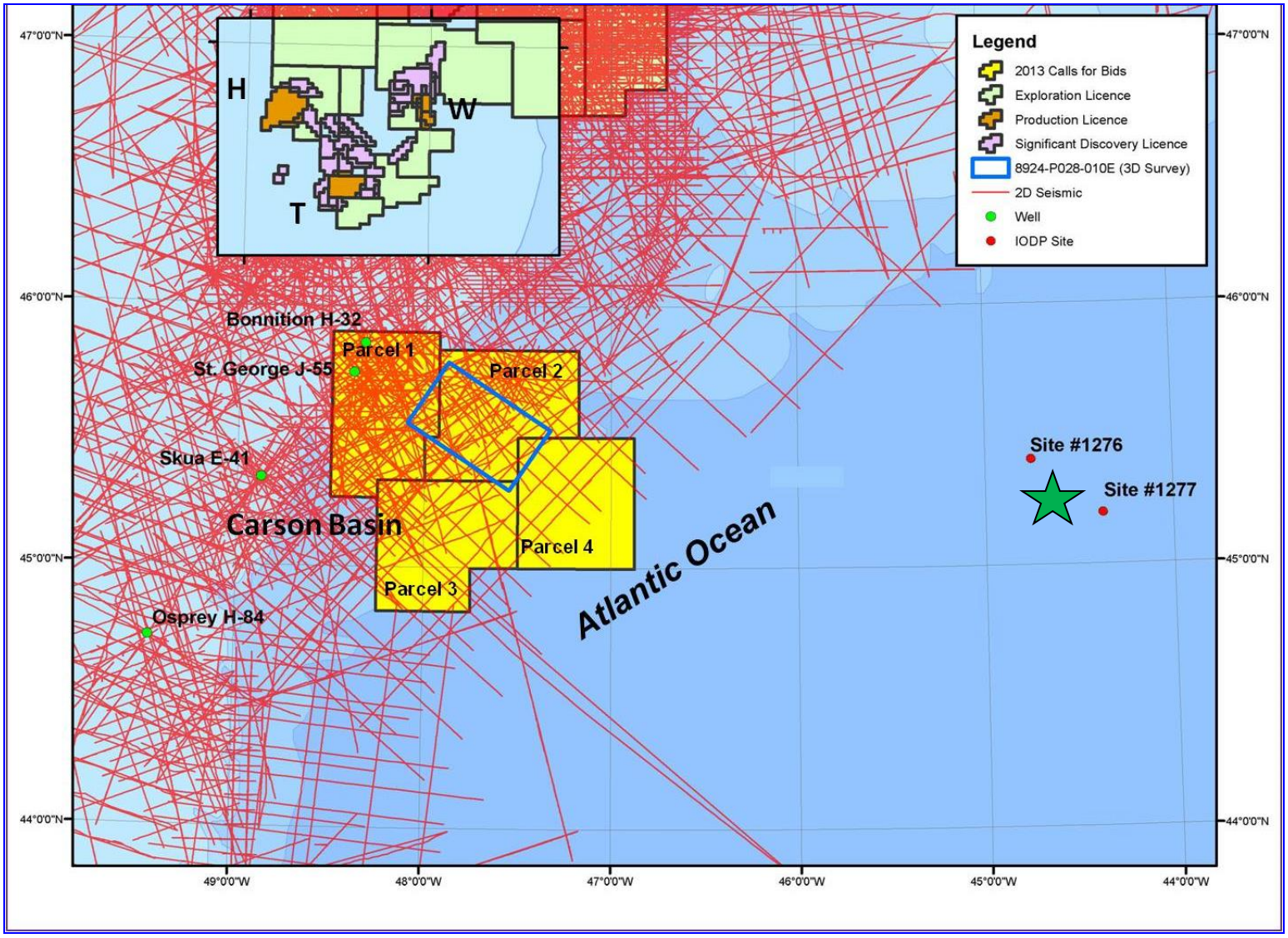
Cretaceous Source Rocks?



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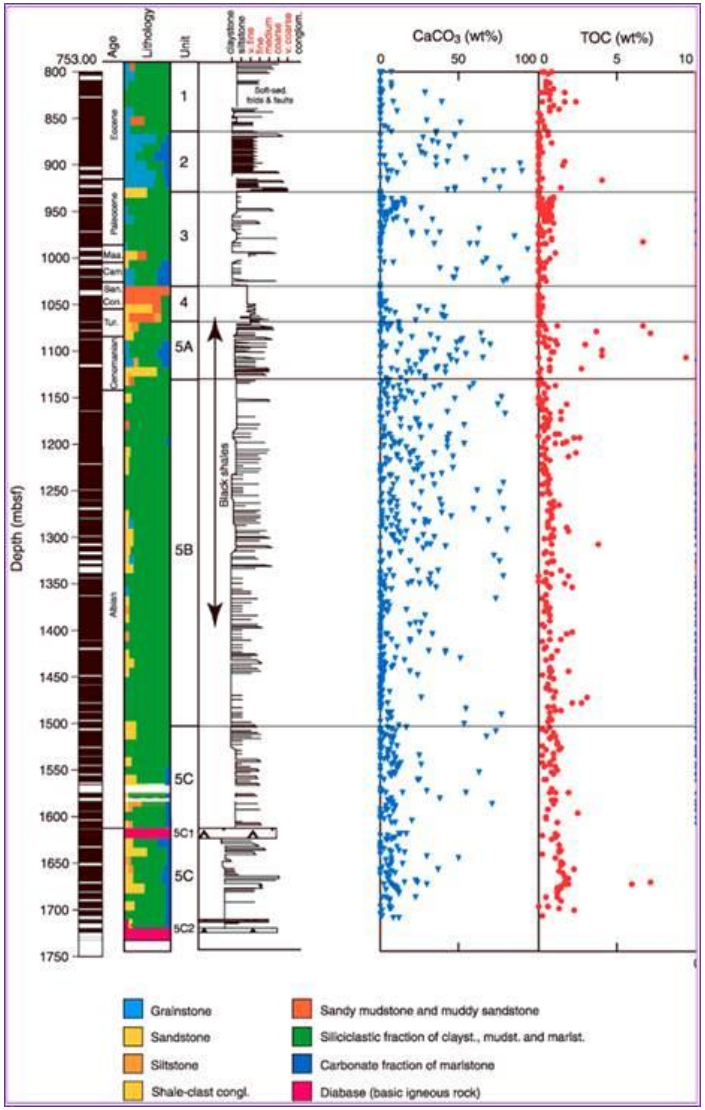
Source Rocks



- Another possible source rock is the Turonian to Albian black shale intervals drilled by IODP during Leg 210 at sites #1276 and #1277 located 60 km northeast of the Carson Basin.
- Five dark-colored intervals that contain up to 13% TOC of both marine and terrestrial provenance were identified in the Site #1276 sequence (Mayers and Arnaboldi, 2011).
- The portions of this interval that had high HI in places may be thicker and mature in the deeper sedimentary troughs of the Carson Basin

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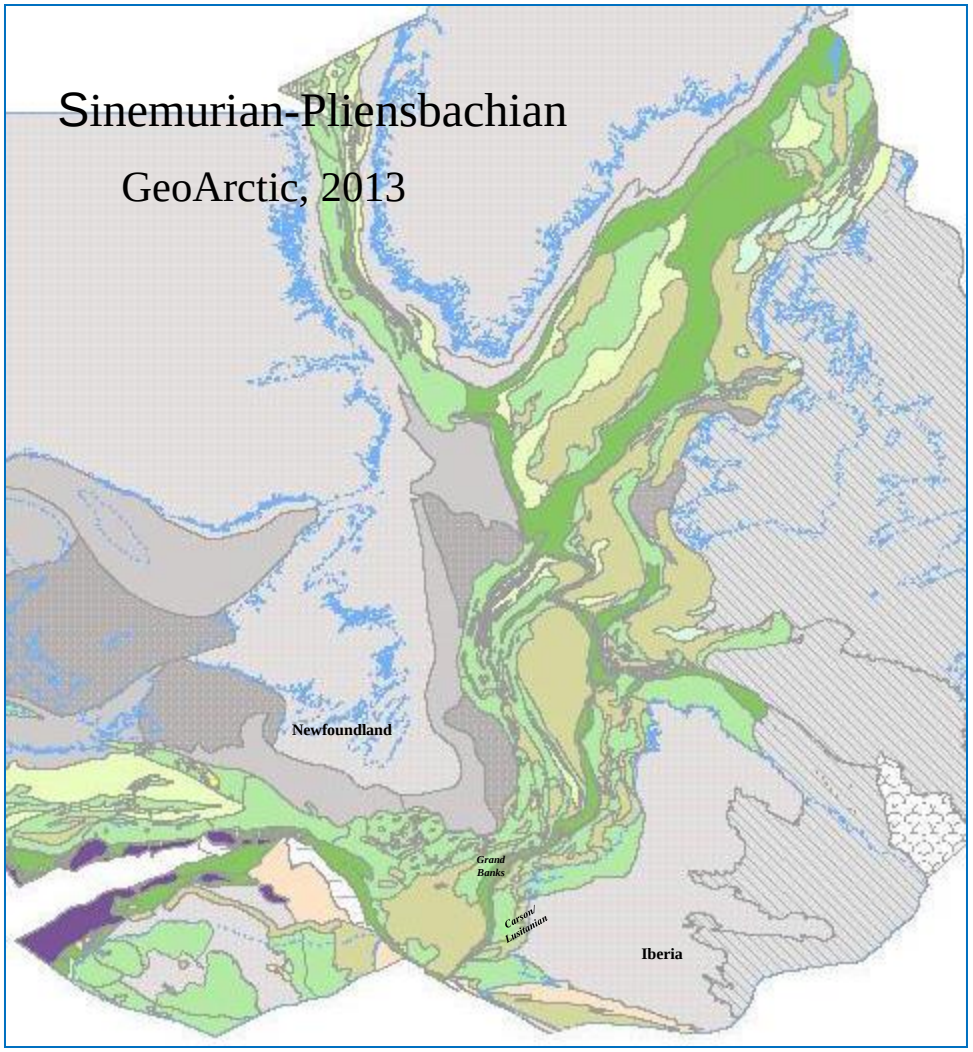
Early Jurassic Source Rocks?

- The Carson Basin has experienced an **early marine incursion** in the Early Jurassic similar to other Atlantic margin basins (e.g. Scotian Basin, Laurentian Basin).
- A **hypersaline shallow sea** occupied the newly formed rift basin, situated in warm latitudes. Massive salt deposits were accumulated during the time.
- It is possible that an **algal, oil potential source rock** was deposited during Sinemurian-Pliensbachian in the hypersaline to carbonate marine environment, in a similar manner as proposed for the Scotian Basin (Nova Scotia Play Fairway Analysis; NSDE, 2011; also in Enachescu, 2012).



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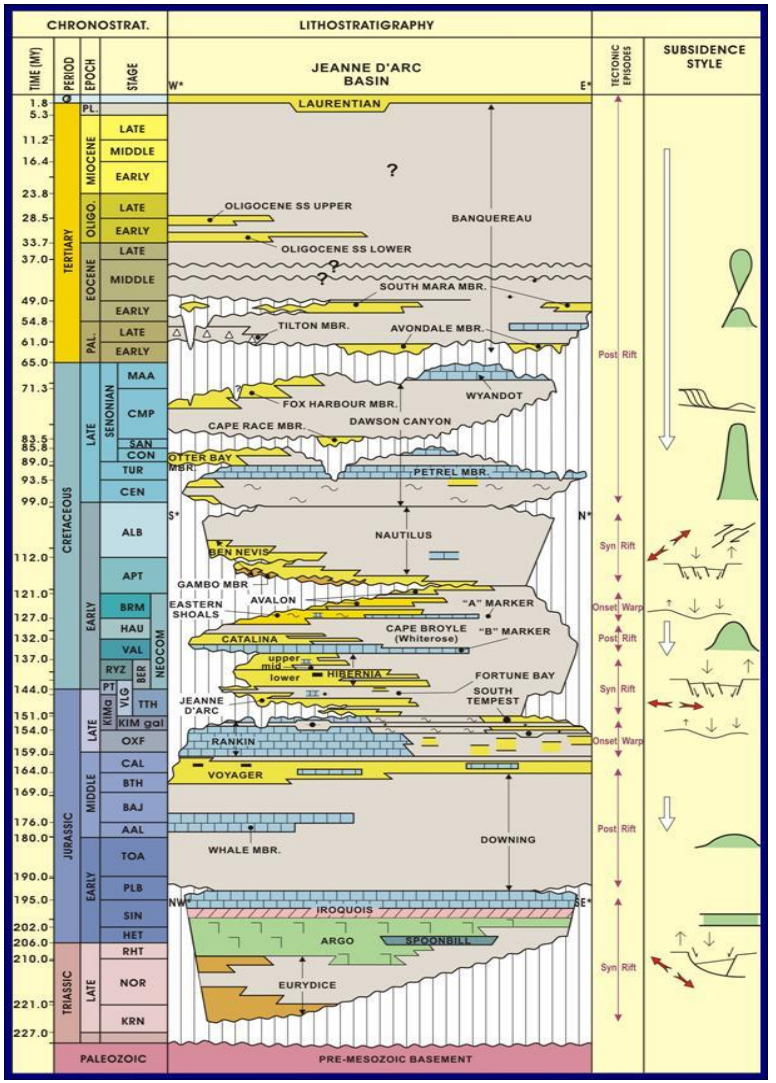
Reservoir Rocks

- Predominantly high porosity - high permeability sandstones of Late Jurassic to late-Early Cretaceous similar to that encountered in the neighbouring basins.
- Additionally, turbidite sands of Late Cretaceous-early Tertiary should be present on the continental slope and deepwater where a major clastics depocenter was mapped.
- Porous matrix or dolomitized carbonates of Jurassic and Early Cretaceous age may develop locally in the Carson Basin. They could be similar to reservoirs encountered at Deep Panuke in the Scotian Basin or the Cretaceous Donquin prospect, recently drilled in the Porcupine Basin.



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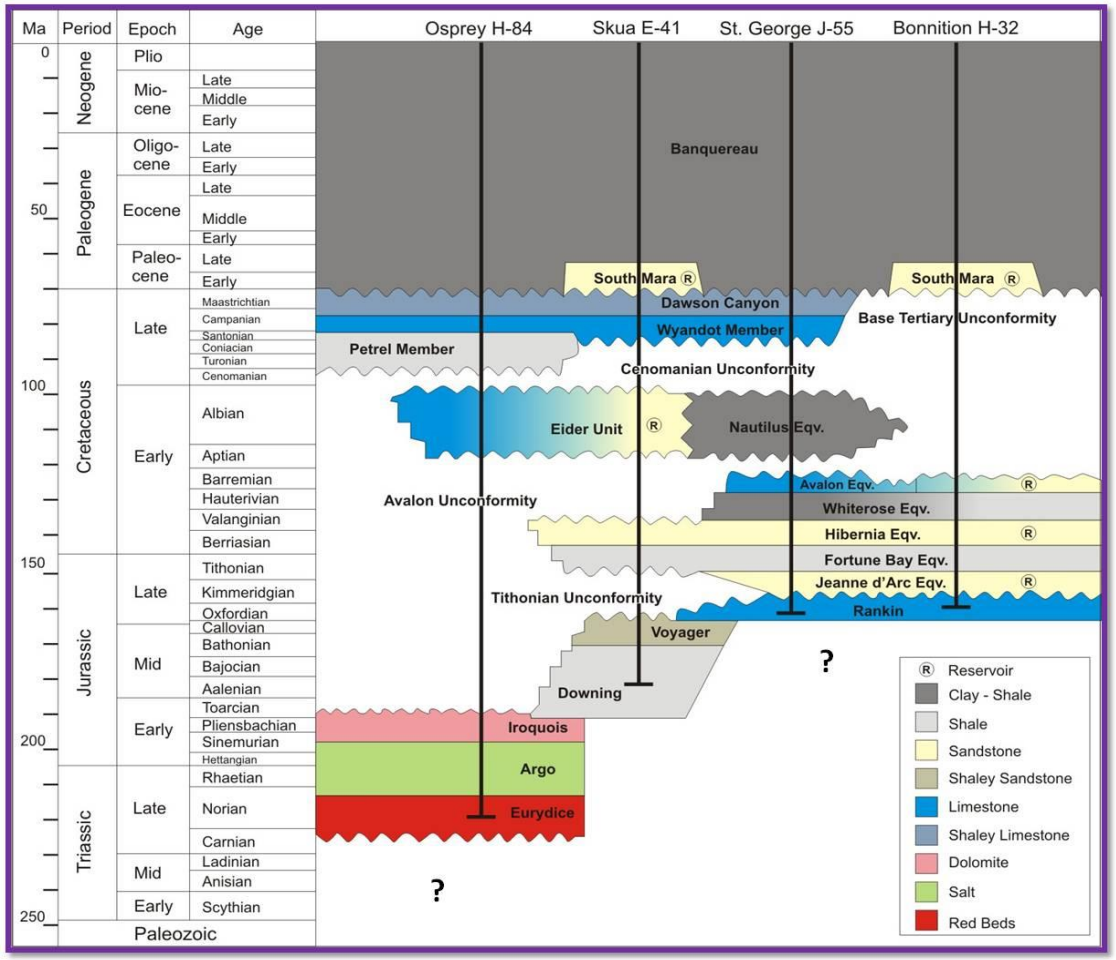
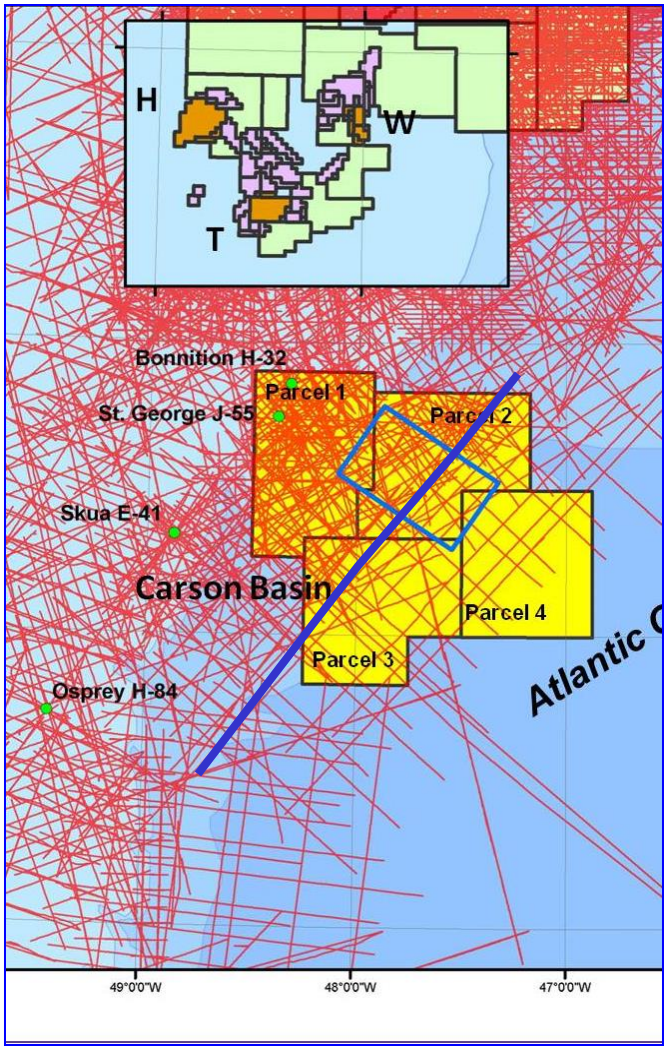
Reservoir Rocks





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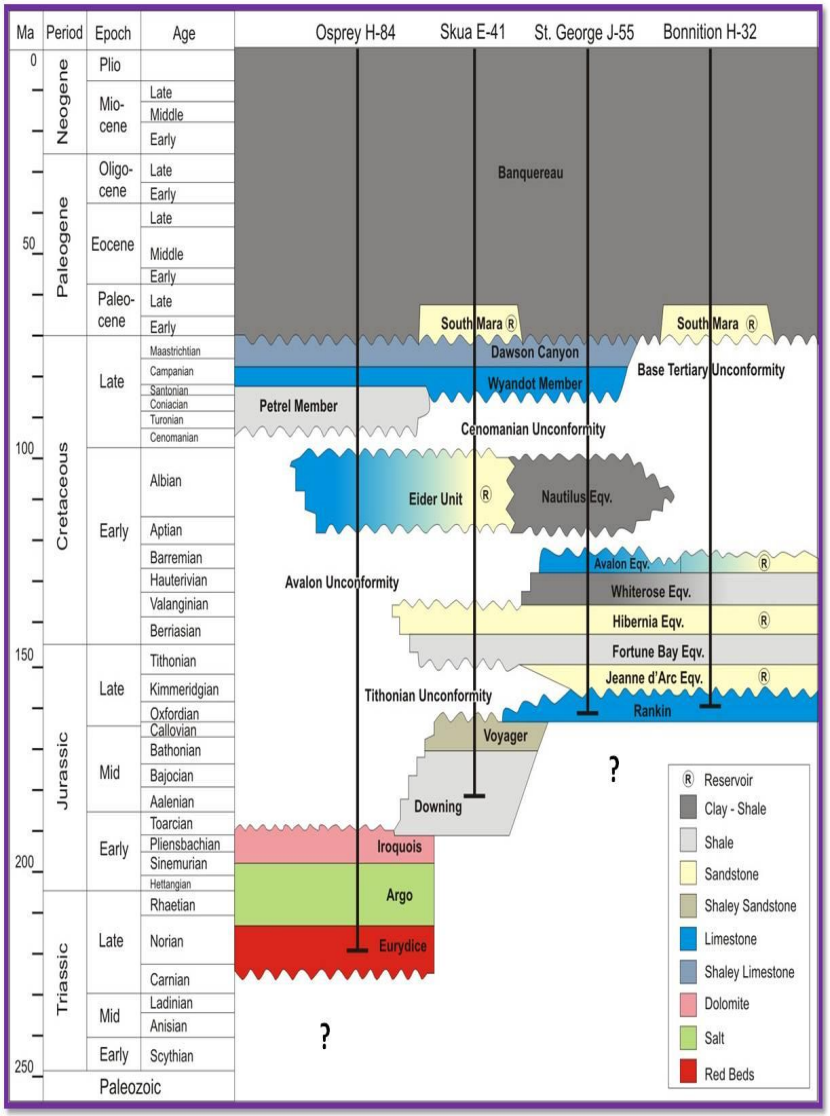
Seals

- Seal should not be a problem for traps within the Carson Basin.
- Extensional and Thermal Subsidence stages contain regionally distributed successions of very fine clastics, tight sandstones and tight carbonate beds.
- Good seal intervals such as the Downing, Rankin, Fortune Bay, Whiterose, and Nautilus formations were found in the four wells drilled in the Carson Basin.
- The postrift Petrel Member (mostly Turonian), Wyandot Limestone (Campanian) and the thick syndrift Tertiary fine clastics of the Banquereau Formation are basin-wide seals.



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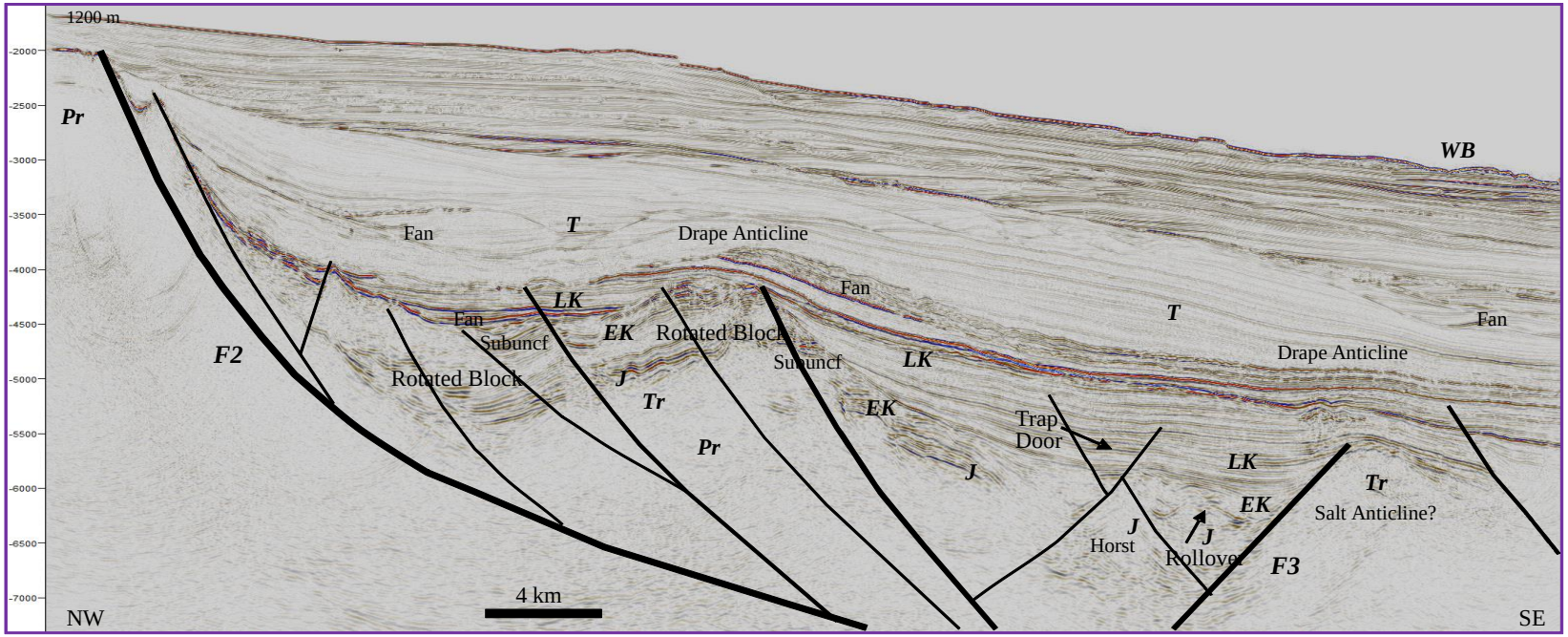
Traps

Numerous structural traps found in Carson Basin are related to:

1) basement highs due to recurring rifting of the Atlantic Margin,
2) gravity faulting,
3) minor transtension and inversion features,
4) differential subsidence and tilting, and
5) movement of the Argo/Osprey evaporites.



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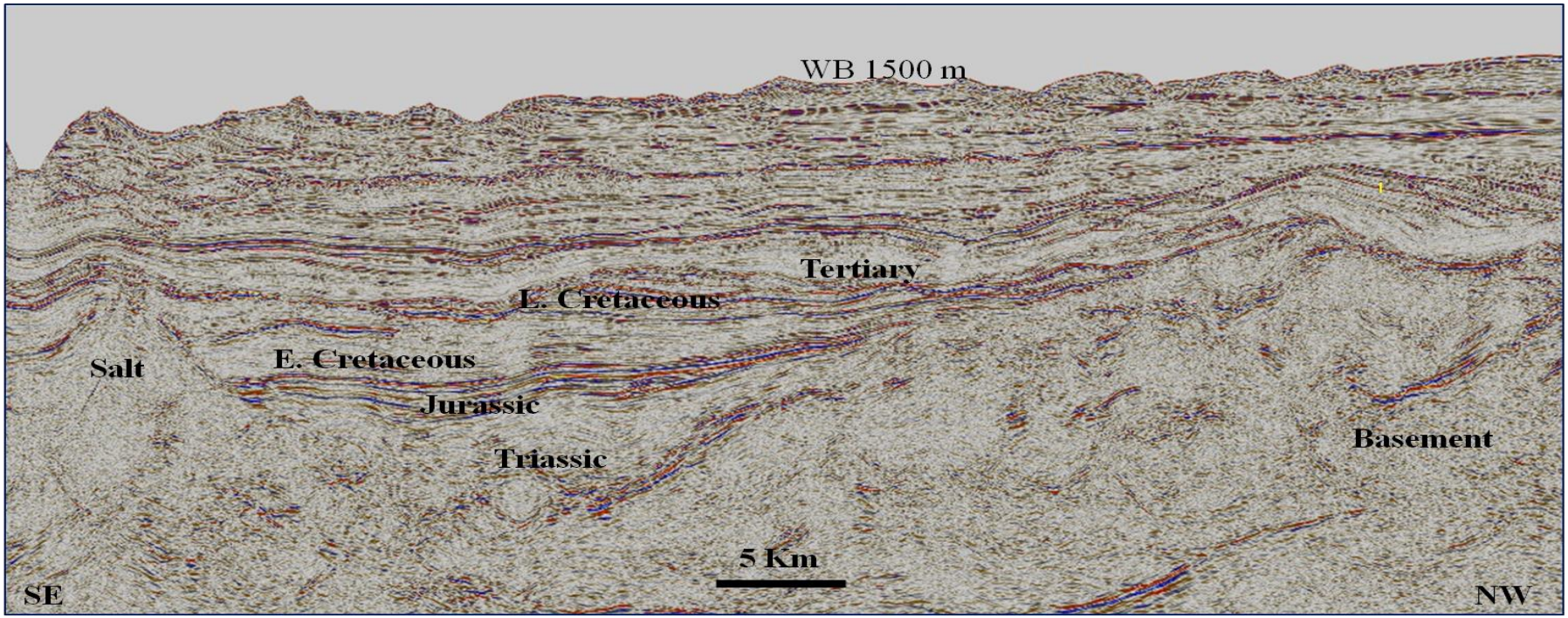
Traps

- Main structural trap types are extensional anticlines, roll-overs, faulted anticlines, faulted and tilted blocks, and elongated horsts that may involve the basement or are restricted to the synrift sequences.
- A large variety of salt induced structures such as pillows, domes, diapirs, ridges, teardrops and turtle anticlines are common in the Carson Basin.
- Drape anticlines are also present and observed from L. Cretaceous to Tertiary.



Line Source: C-NLOPB

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Hydrocarbon Traps(s)

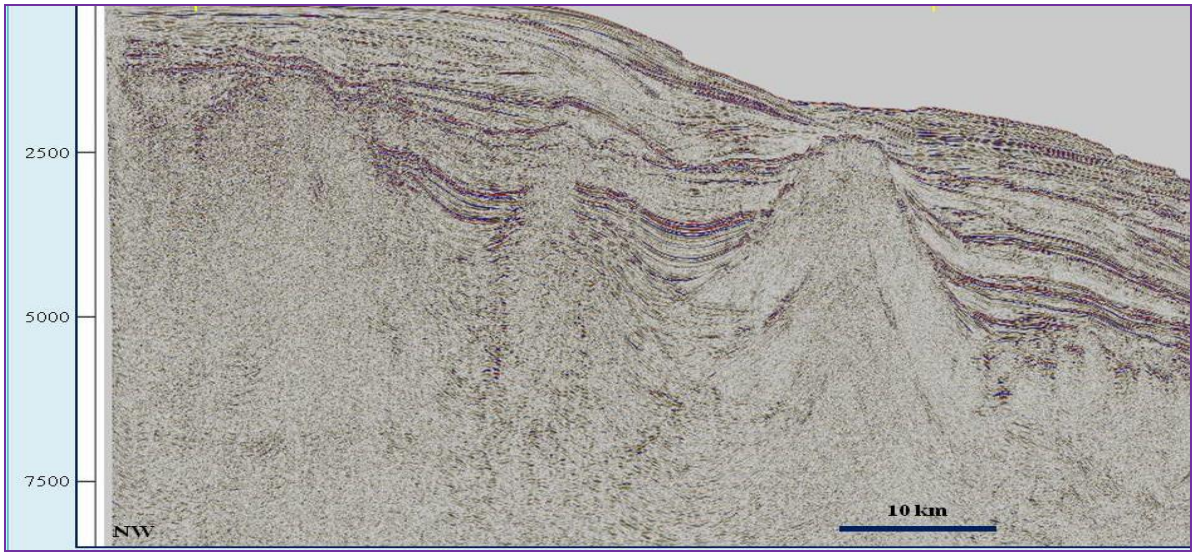
- **Structural**
  - Roll-over anticlines in front of basin bounding faults (e.g. Hibernia)
  - Salt core anticlines and ridges (e.g. White Rose, North Amethyst)
  - Multi- directional faulted anticlines (Mizzen, Terra Nova, Hibernia)
  - Rotated blocks (Hebron, Ben Nevis, North Ben Nevis, Bay du Nord)
- **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-sided bounded by faults. Larger traps are also dissected by several fault systems and may have multiple reservoirs. Salt induced features are in the CFB area, as well as large basement cored rotated blocks. The largest traps can host more than a billion barrels of oil or/and several Tcf of gas.

Hydrocarbon Plays and Risks

The main hydrocarbon play expected to be successful in the Carson Basin will likely be:

- Anchored by a Late Jurassic source rock such as the Egret Member or equivalent; Tithonian, Callovian or Oxfordian organic shales, or a blend of several of these sources,
- Reservoired most likely in synrift Late Jurassic sandstones, or Early Cretaceous sandstone, and
- Trapped in extensional/salt related faulted anticlines with faults provided near source kitchen migration conduits.



Line Source: C-NLOPB

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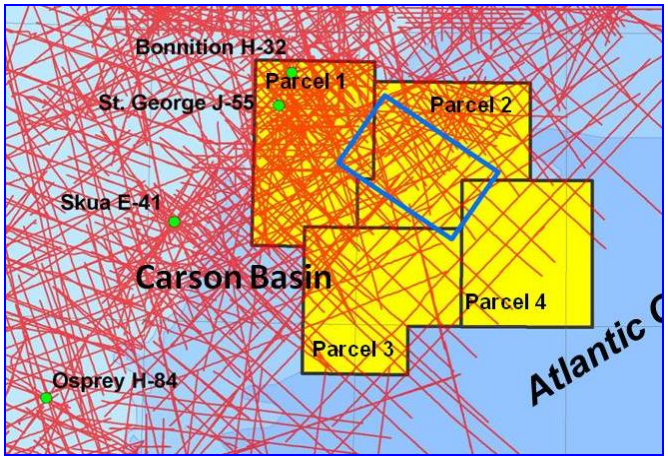
5.0 Call for Bids Parcels

Parcel	Basin	Area ha	Area Acres	GOM tracts
1	Carson	285,864	706,385	122.6
2	Carson	288,800	713, 640	123.9
3	Carson	291,310	719,843	125.0
4	Carson	272,425	673,177	116.9

Carson Basin parcels are licensed by the C-NLOPB to the party submitting the highest bid in the form of work commitments.



These are some of the largest parcels ever offered on the Atlantic Margin!

http://www.cnlopb.nl.ca/pdfs/nl1302.pdf

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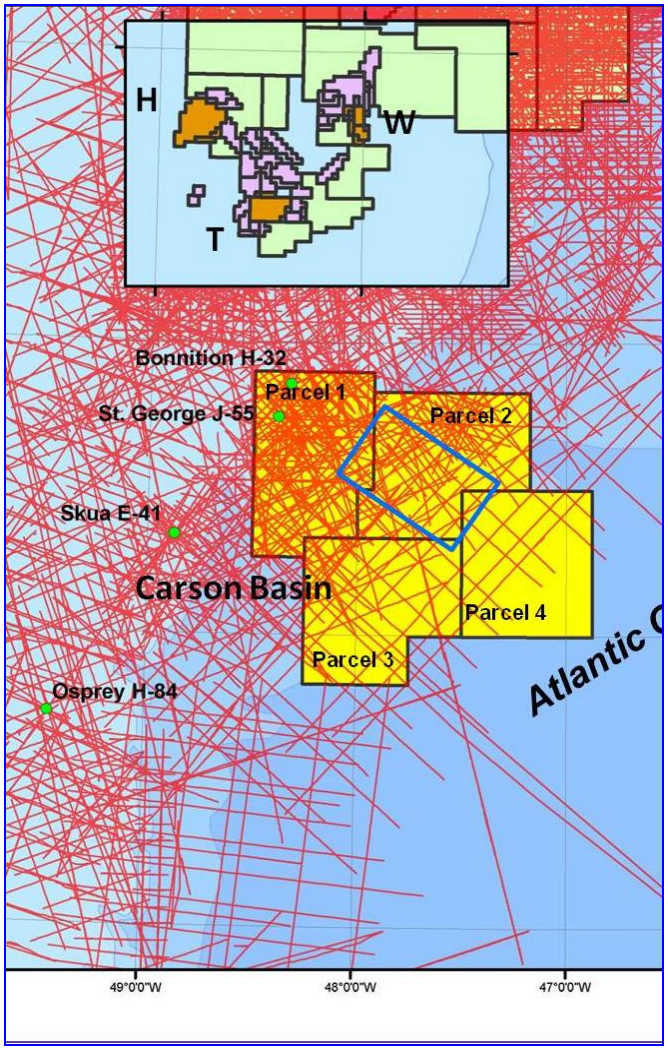
Seismic Coverage



- Two vintage classes of seismic surveys exist in the basin:
  - the pre-modern data acquisition (pre-1998) and
  - the modern data acquisition (post-1998).
- Parcels have good coverage by a relatively dense 2D seismic grid.
- For the deeper part of Parcel 4, only a few seismic lines are in the public domain.
- More data exists in digital format and is available from oil companies and seismic contractors.
- The 2D grid has an average 1 to 3 km spacing in the dip direction and 3 to 5 km spacing in the strike direction.
- The only 3D survey in the basin was collected by Petro-Canada in 2001 and covers 1200 km^2.

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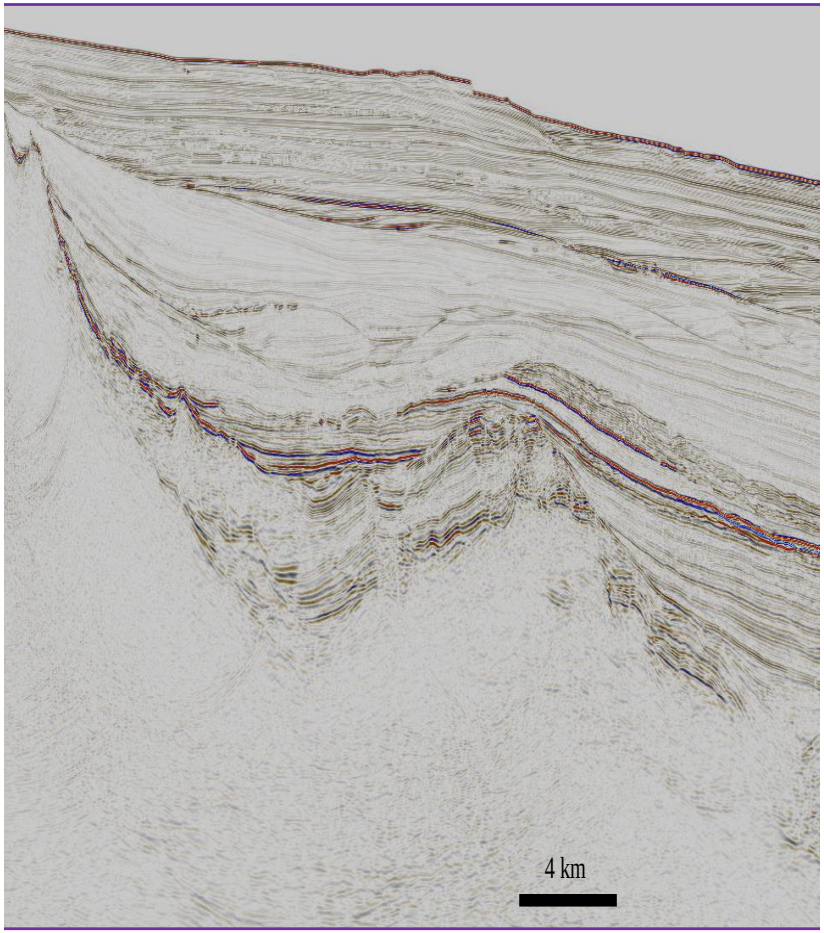
Representative Seismic Section

- A thick synrift sequence (Late Triassic to early Late Cretaceous) fills the grabens and overlies the horsts and ridges in the Carson Basin.
- Several representative seismic sections from the CFB area, tied to wells on shelf wells, are shown next.
- The synrift sedimentary successions are deformed by extension, transtension and salt diapirism and are segmented by numerous faults. Numerous rollover and basement cored anticlines are present.
- The postrift sequence generally dips and thins basinward and shows sedimentary deformation.
- Considerable deformation of the Early Tertiary postrift sequence occurs on the slope and rise due to gravity or shale detachment tectonics.

Seismic Interpretation

- Regional seismic lines shown in this presentation were tied with synthetic seismograms to several exploration wells in the Carson Basin, 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.
- 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. Occasionally 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



Line Source: C-NLOPB

- Using the available seismic grid, several plays can be interpreted within the Late Jurassic to Early Tertiary basin fill in NL13-02 Parcels 1 and 2. The typical play is a 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 all parcels there are locations, where 3.5-5.5 km deep wells can test the synrift and postrift sandstone plays.

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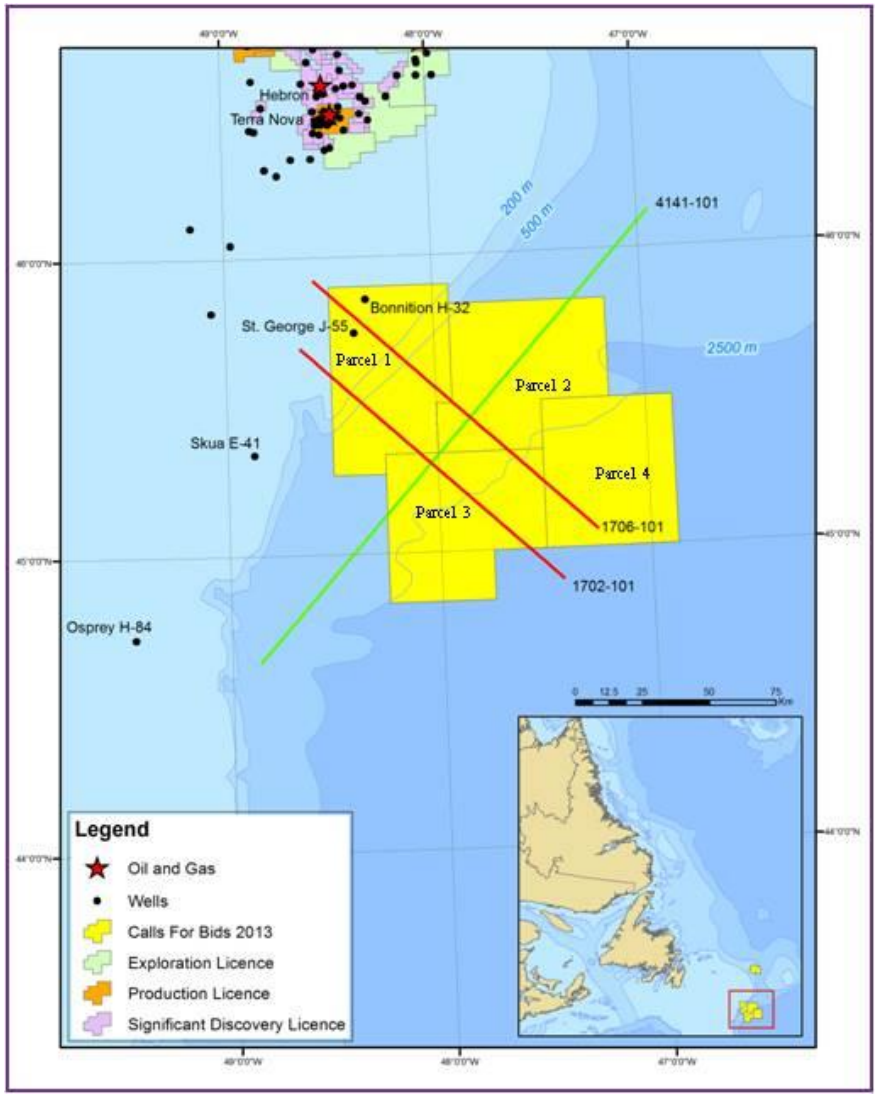
Seismic Interpretation (Cont.)



Parcel	Area ha	Area Acres	GOM tracts
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2	288,800	713, 640	123.9
3	291,310	719,843	125.0
4	272,425	673,177	116.9

Three, early 2000s 2D seismic lines are interpreted to illustrate the structural and stratigraphic style of the Carson Basin and the petroleum potential of the four parcels on offer.

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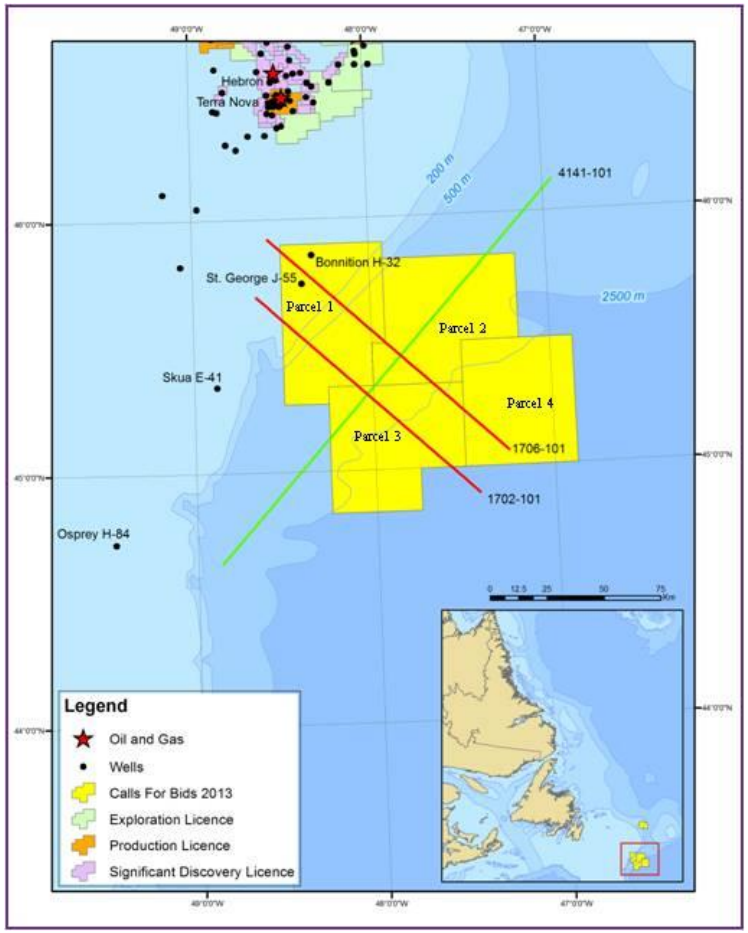
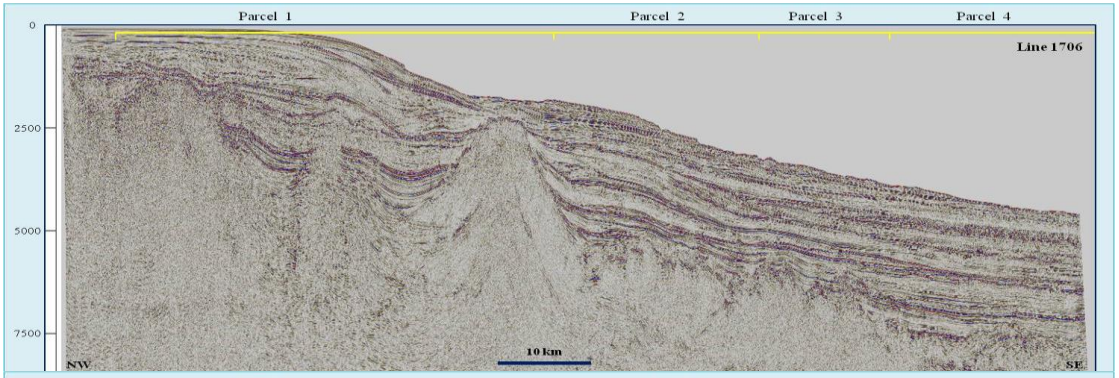
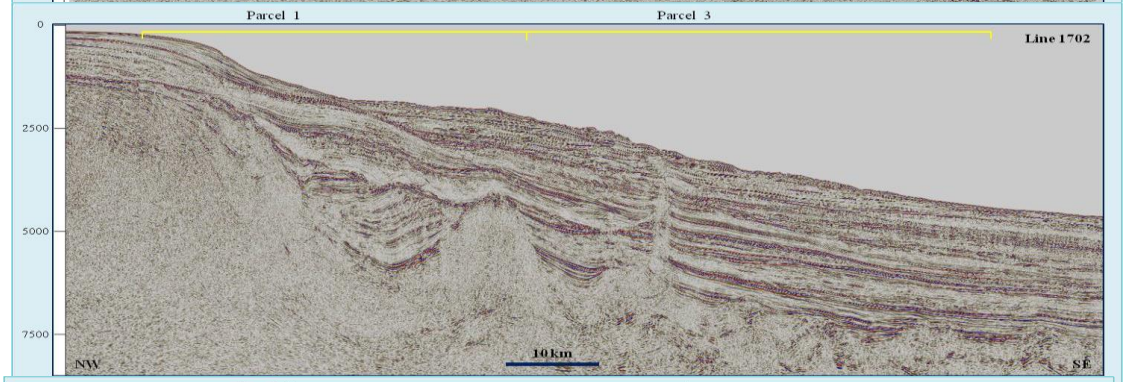
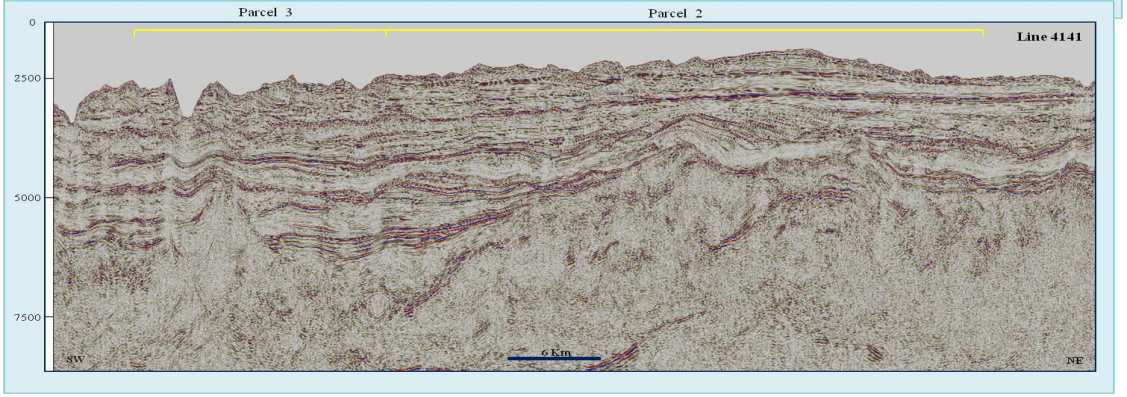
Representative Sections









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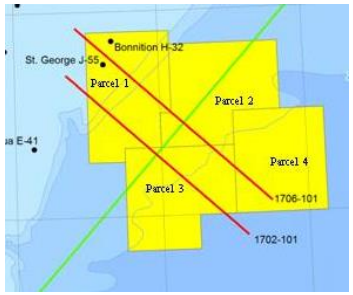
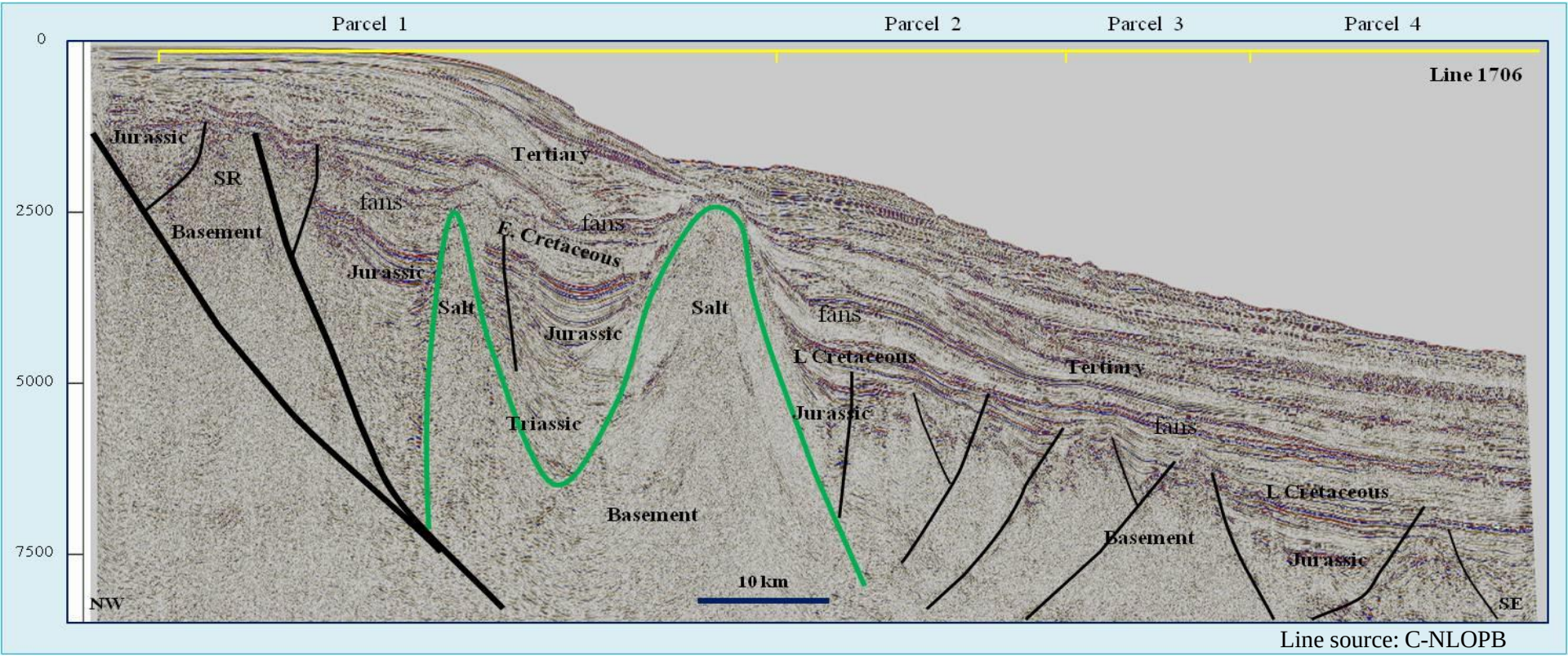


Seismic Line 1706



Line source: C-NLOPB

Interpreted regional 2D seismic line 1706 crossing all CFB NL13-02 parcels. The line shows the presence of several horsts, salt anticlines and rotated blocks in the synrift and large postrift sedimentary sequences.

SR = Salar Ridge. Line source: C-NLOPB

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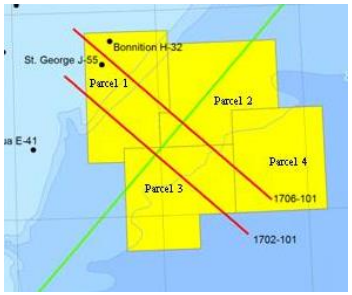
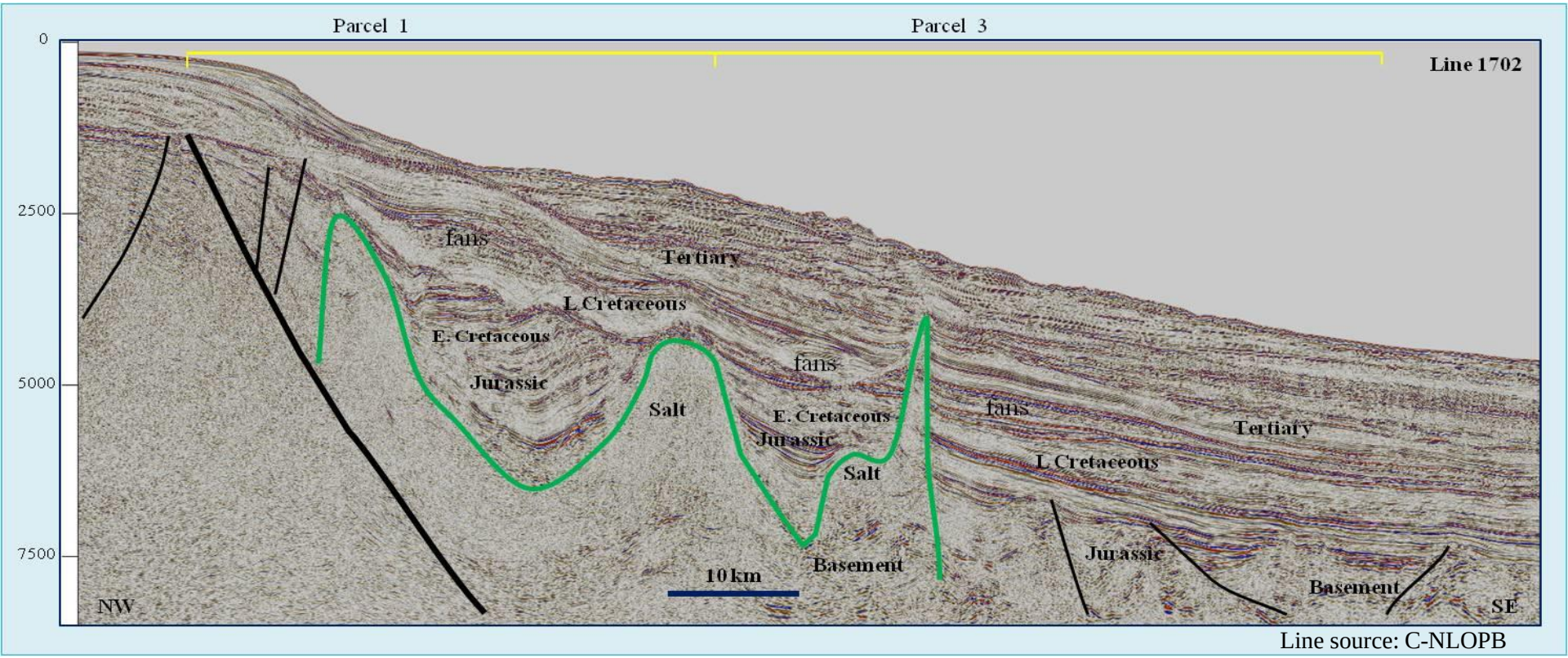


Seismic Line 1702



Line source: C-NLOPB

Interpreted 2D seismic line 1702 crossing the central part of Parcel 1 and 3 in a dip direction. Deep penetrating faults, a large rotated block, and two large half grabens containing synrift sedimentary successions are imaged in the section. Late Triassic salt may be involved in the three anticlinal features seen on this line.

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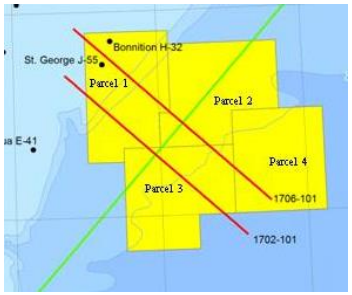
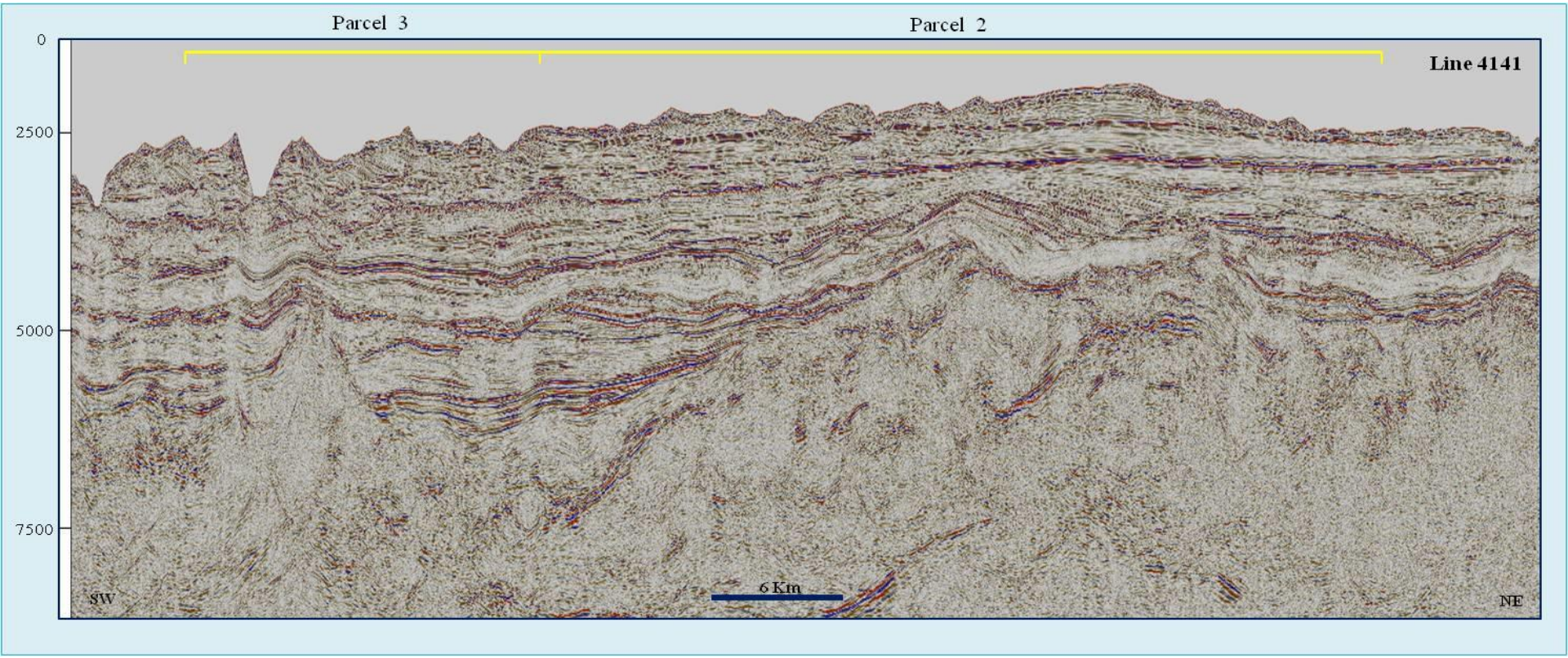


Seismic Line 1706



Interpreted regional 2D seismic line 4141 crossing parcels 2 and 3 in a strike direction. The line shows the presence of numerous complex basement and salt involved structures. A large local depocenter where a thick Jurassic sequence has accumulated lies between the two salt features. Several large sedimentary fans can also be interpreted on this strike line.

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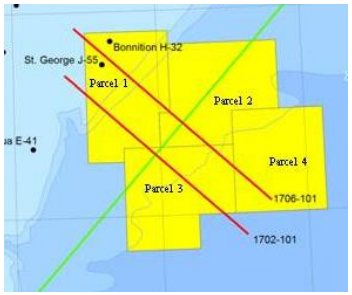
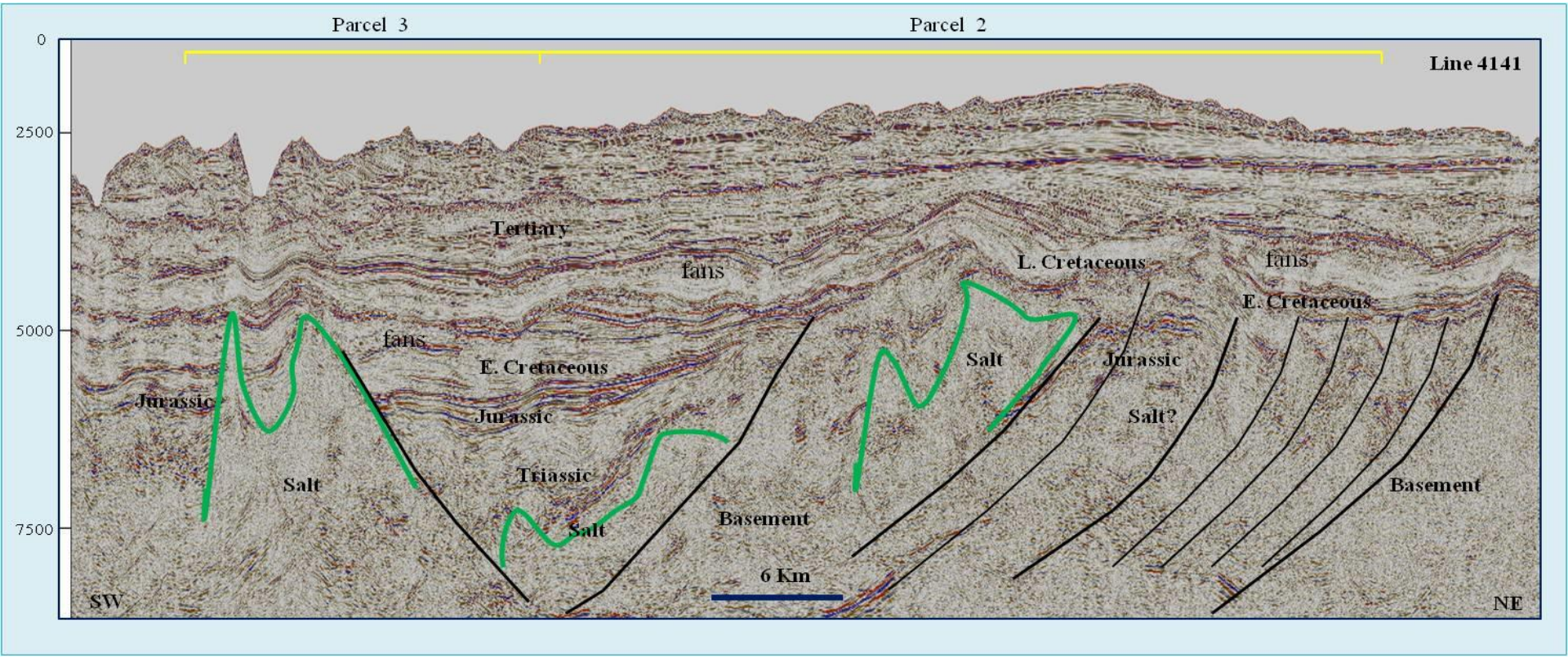
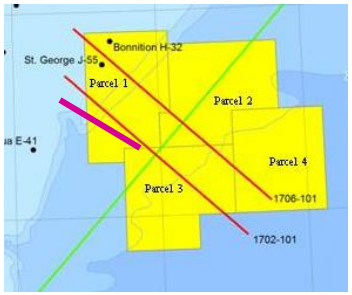


Seismic Line 1706

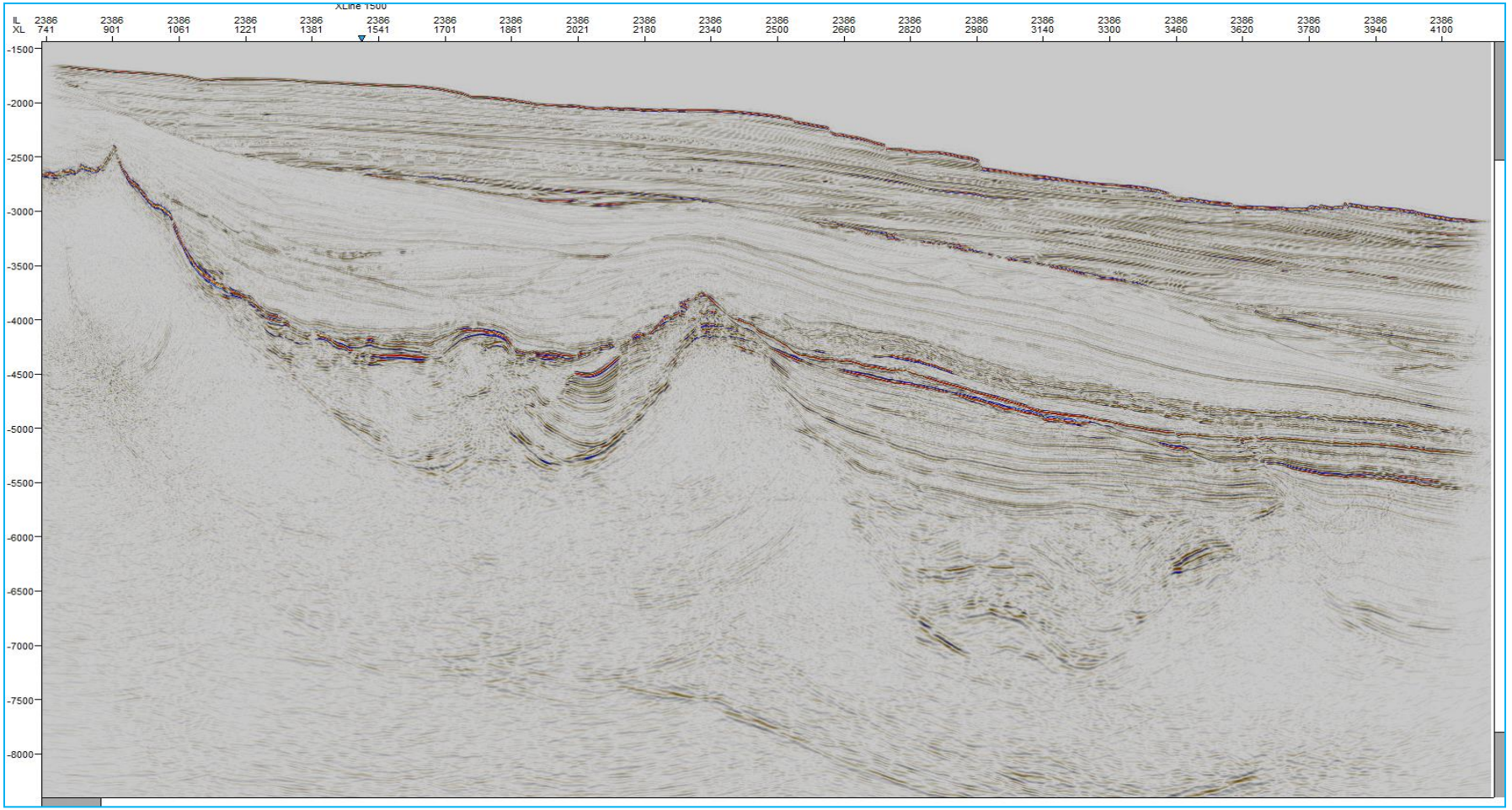


Interpreted regional 2D seismic line 4141 crossing parcels 2 and 3 in a strike direction. The line shows the presence of numerous complex basement and salt involved structures. A large local depocenter where a thick Jurassic sequence has accumulated lies between the two salt features. Several large sedimentary fans can also be interpreted on this strike line.

Enachescu, 2013



3D Dip Line



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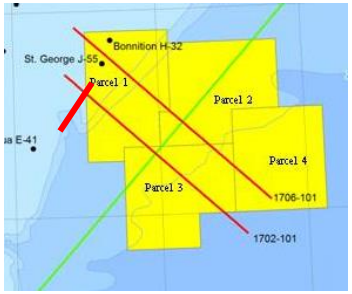
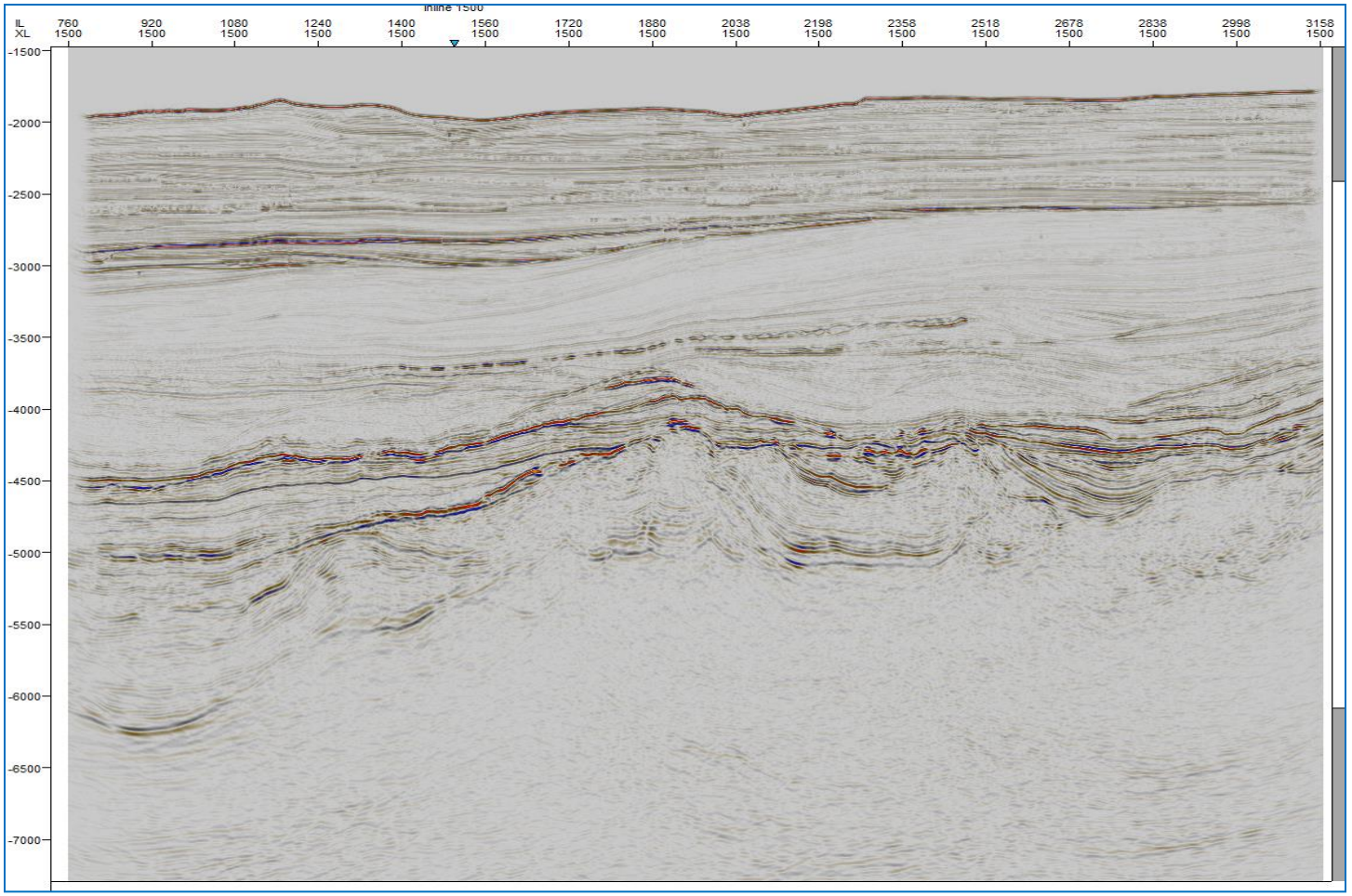


3D Strike Line



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Representative Seismic Sections

- A thick synrift sequence (L. Triassic to early L. Cretaceous) fills the grabens and overlies the horsts and ridges in the Carson Basin.
- The synrift sedimentary successions are deformed by extension, transtension and salt diapirism and are segmented by numerous faults. Numerous rollover, salt cored and basement cored anticlines are present.
- The postrift sequence generally dips and thins basinward and shows sedimentary deformation.
- Considerable deformation of the Early Tertiary postrift sequence occurs on the slope and rise due to gravity or shale detachment tectonics.

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, Avalon) sandstone reservoirs trapped in large, faulted anticlines.
- A total of 5 Billion barrels of oil was estimated to be present in the slope and deep water of the Carson Basin (Wielens et al. 2004 and 2006; Baur et al., 2009).
- More than a dozen structural leads such as horsts, rotated blocks and rollover anticlines have been identified on the public domain seismic lines crossing the parcels. These leads are probably multi-side fault bounded (Mizzen-like anticline).
- Several large stratigraphic plays were identified. These leads are Late Cretaceous Tertiary slope and 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 early 2000s (Petro-Canada, Encana). Their regional seismic interpretation reports and annexed time structural maps for the area's parcels may be 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 mitigated 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 millions to a billion barrels of oil or several Tcf of gas).

6. Discussion

- The Carson Basin area where the NL13-02 parcels are located, is a marine exploration frontier in which only four wells have been drilled. The earlier wells were drilled on shelf based on poor quality 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 drilling has been carried out in the basin since the early 1980s.
- A significant oil discovery was recorded in 2009 at the nearby Mizzen O-16 location and the Bay du Nord and Harpoon discoveries were announced in 2013 just 100 km north of the CFB parcels
- Significant exploration activity is taking place on the same structural trend in the Flemish Pass and Laurentian basins.
- CFB NL13-02 parcels are very large when compared with a Gulf of Mexico standard section (more than 100 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 or semi-submersibles.

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Discussion (Cont.)

- Risks exist as to fault closure, reservoir quality and source rock quality. New mapping with modern 3D seismic data may lower the geological risk.
- The area's structural traps can host resource estimates of many hundreds of million barrels of oil and/or several Tcf of natural gas.
- Licence awards are based on highest work commitment bid.
- A 6-year (Period 1) +3-year (Period 2) = 9-year term Exploration Licence is set by C-NLOPB for the Carson Basin (Area "C"). A one year term extension through the submission of a drilling deposit is available.
- The royalty regime is well established and modelled.
- Canada boasts a stable political and financial system and has a long tradition in oil and gas exploration.
- The Province obtains 33% of the nominal GDP from the oil and gas industry and is actively promoting offshore exploration.
- There is a robust regulatory regime in the offshore area including HS&E. The Provincial Government encourages offshore exploration, however the safety of workers and protection of the environment are paramount.

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7. Conclusions

- The Carson Basin, a divergent margin basin in our day, had a similar tectonic and structural evolution with adjacent Jeanne d'Arc and Flemish Pass basins, including basement extension, synrift sediment deformation and salt diapirism.
- Basin fill and stratigraphic divisions are also similar to the neighbouring Jeanne d'Arc and Flemish Pass basins and include equivalent reservoir and source rock formations.
- Deep basement penetrating faults, synthetic and antithetic intra-basement faults, highly rotated fault blocks, deep half-grabens and asymmetric horsts, mantle exhumation at the continental margins and high beta factors (3-5) provide strong evidence for the deepwater Carson Basin hyperextension.
- Numerous structural traps are interpreted in the Carson Basin associated with
  1) basement fragmentation and rotation due to recurring rifting of the Atlantic Margin,
  2) gravity detachment faulting,
  3) minor transtension and inversion features,
  4) differential subsidence and tilting, and
  5) movement of the Argo/Osprey evaporites.

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7. Conclusions

- Stratigraphic trap types such as slope and basin floor fan, sub-unconformity truncation and canyon fill, abound on the continental slope and in the deeper basin.
- If quality reservoirs are discovered, these structural, stratigraphic and combination traps can hold reserves in the range of several billion barrels.
- Based on the relation and continuity of sedimentation with the Grand Banks' basins, the Egret Member equivalent and/or other Late Jurassic source rocks should be present in the basin and when below 3000 m mud line depth, generate significant quantities of oil.
- The basin represents a lateral, parallel belt of the Late Jurassic source rock superhighway connecting the Canadian East Coast with Ireland and Northwest Europe offshore.
- Amplitude anomalies in the Cretaceous and Tertiary successions are related to several of the identified structural or stratigraphic traps.
- The oil of the Grand Banks is generally light sweet crude, with a density of 30-37° API, high percentage aromatics and low sulphur content.

Conclusions (Cont.)

- Cretaceous high TOC, source rocks of Albian and Cenomanian to Touronian age which were drilled in 2003 during the IODP Leg 210 (known as Cretaceous black shale, or Hatteras Formation) should be present in the basin and be mature in its deeper grabens.
- A structural high (roll-over anticline, horst, rotated block, faulted anticline, salt anticline or drape over anticline), with any of the Jeanne d'Arc, Hibernia, Avalon equivalent sandstones (primary target) and/or Paleocene sandstone (secondary target) sourced from Late Jurassic marine source rocks (mainly Egret Member equivalent) is the main hydrocarbon play in the basin.
- Modern and older 2D and 3D seismic coverage exists in the basin for evaluating potential drilling targets with the opportunity for new modern multi-client data to be acquired.
- GSC Atlantic researchers performed a basin modeling exercise based on seismic mapping during early 2000s to add to the exploration in this basin and assigned a potential resource of 5 Billion barrels oil to the deeper part of the basin.

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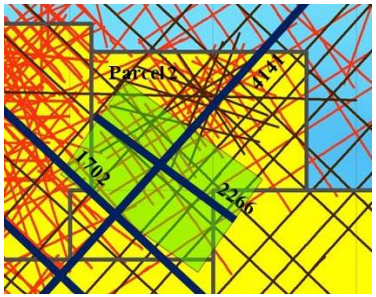
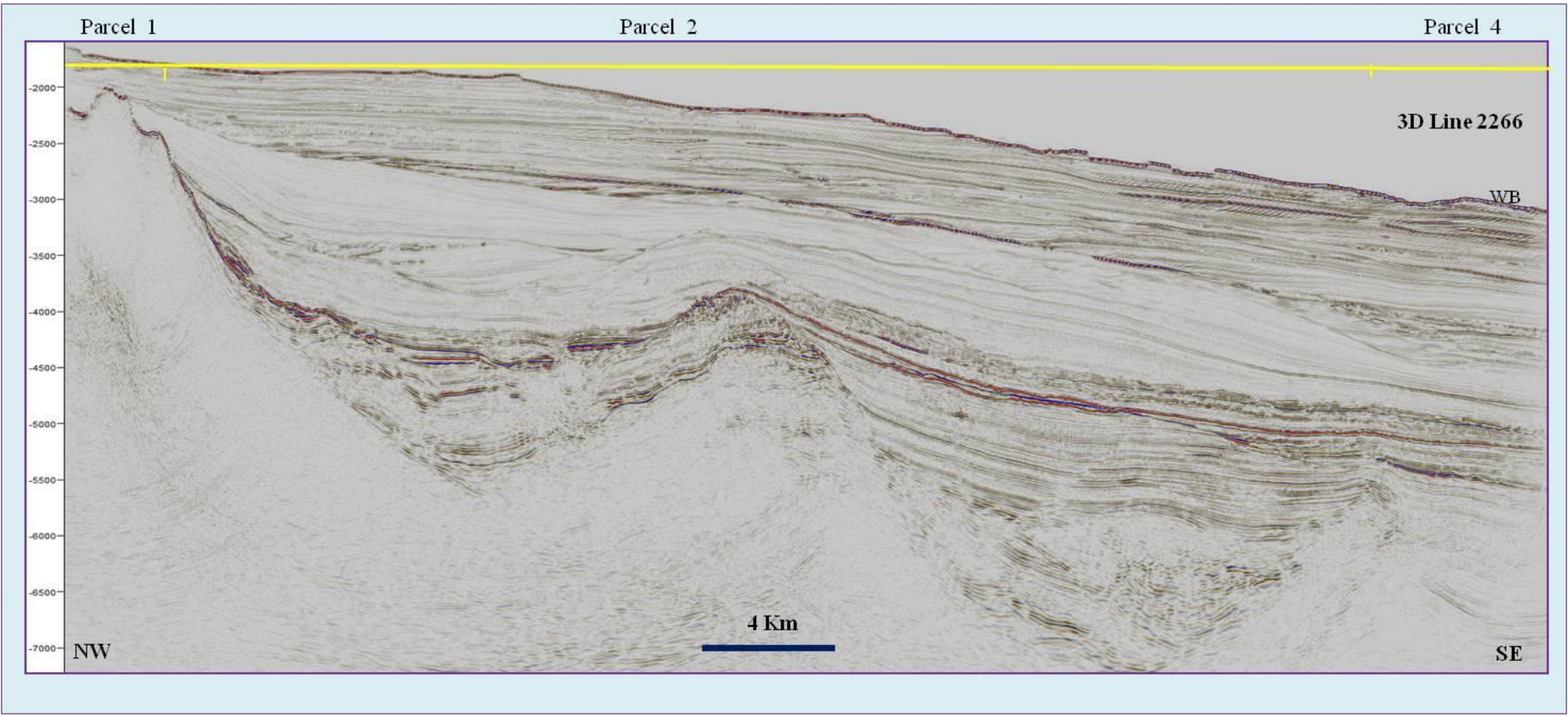
Conclusions (Cont.)

- Interpretation of 2D and 3D seismic data in the parcels suggests that several undrilled leads as large as 50 to 150 km^2 (~ 12,350 to 37,000 acres) are present.
- Large parcels approximately 120 times bigger than the Gulf of Mexico standard block are offered allowing oil companies to enter an unexplored Atlantic margin basin, close to large producing fields and huge North American and European oil markets.
- This is a high-risk high-reward, frontier type of exploration not unlike the acreage already licensed in the Scotian and Laurentian deepwater basins and elsewhere on the Atlantic margins - the right type of play that can produce high impact, billion barrels - size discoveries.
- Call for Bids NL13-02 Parcels 1 to 4 contain a variety of large and very large oil prospects and leads that can improve any Canadian or multinational oil company's portfolio of highly prospective drilling targets



3D Seismic Line



Uninterpreted dip 3D seismic line showing structural, tectonic and stratigraphic characteristics and possible drilling leads. Deep penetrating faults, a large rotated block with possible salt involvement and two large half grabens are interpreted in the section.

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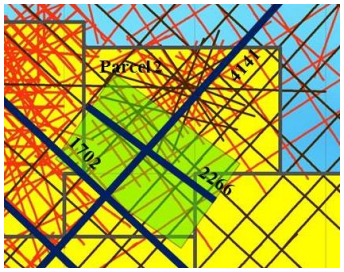
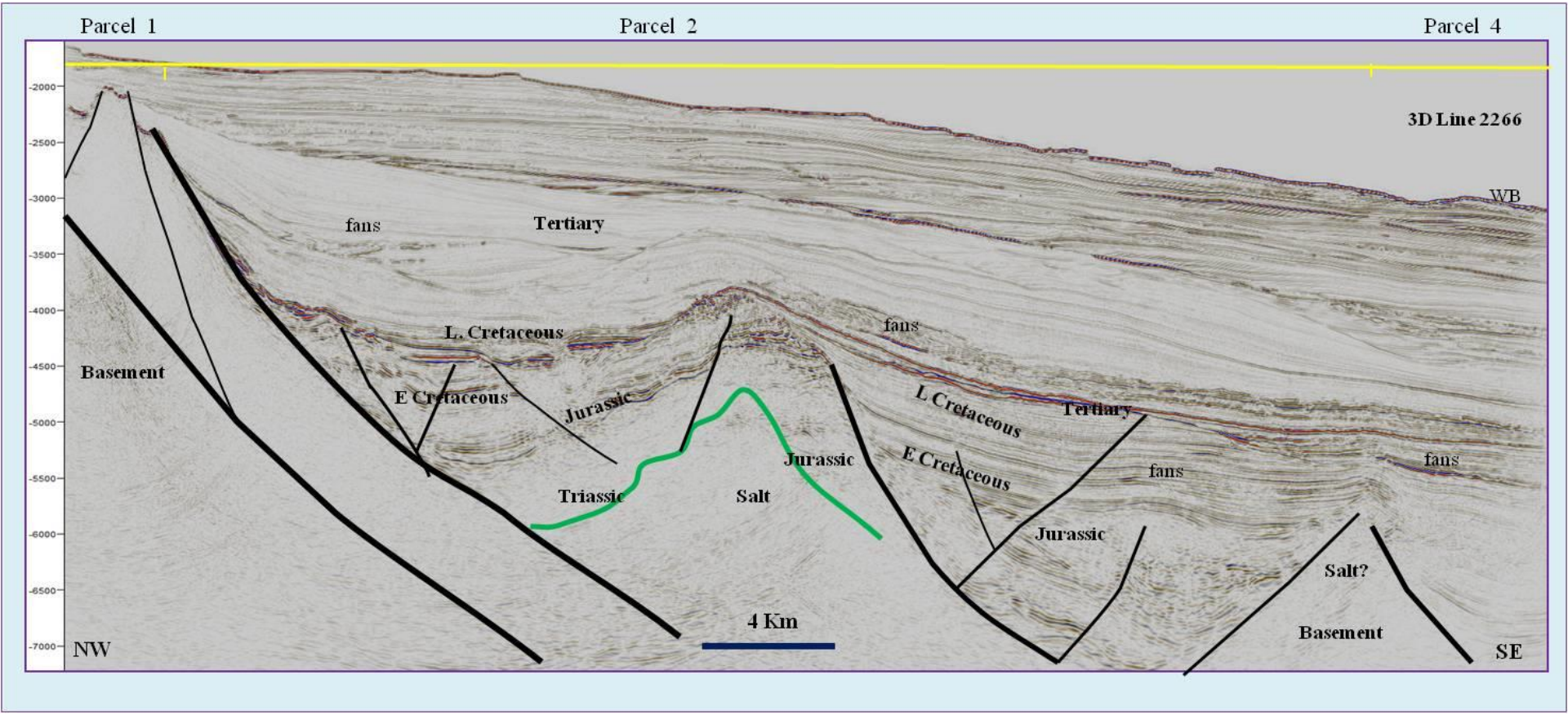


3D Seismic Line



Uninterpreted dip 3D seismic line showing structural, tectonic and stratigraphic characteristics and possible drilling leads. Deep penetrating faults, a large rotated block with possible salt involvement and two large half grabens are interpreted in the section.

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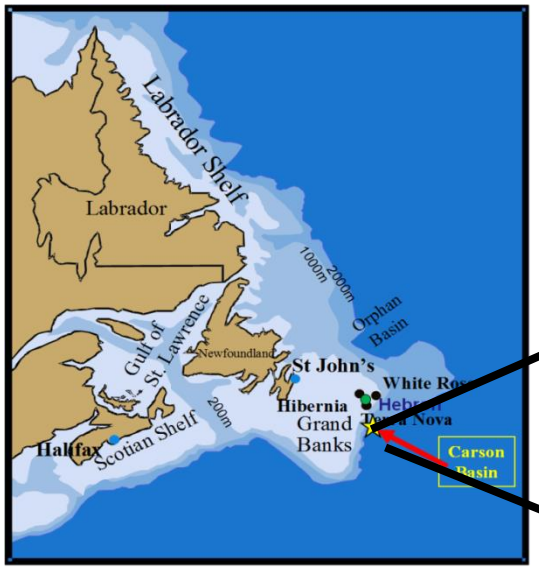
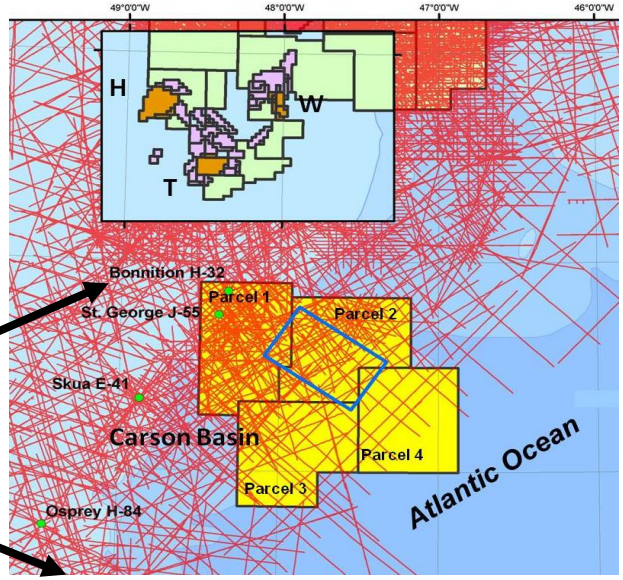
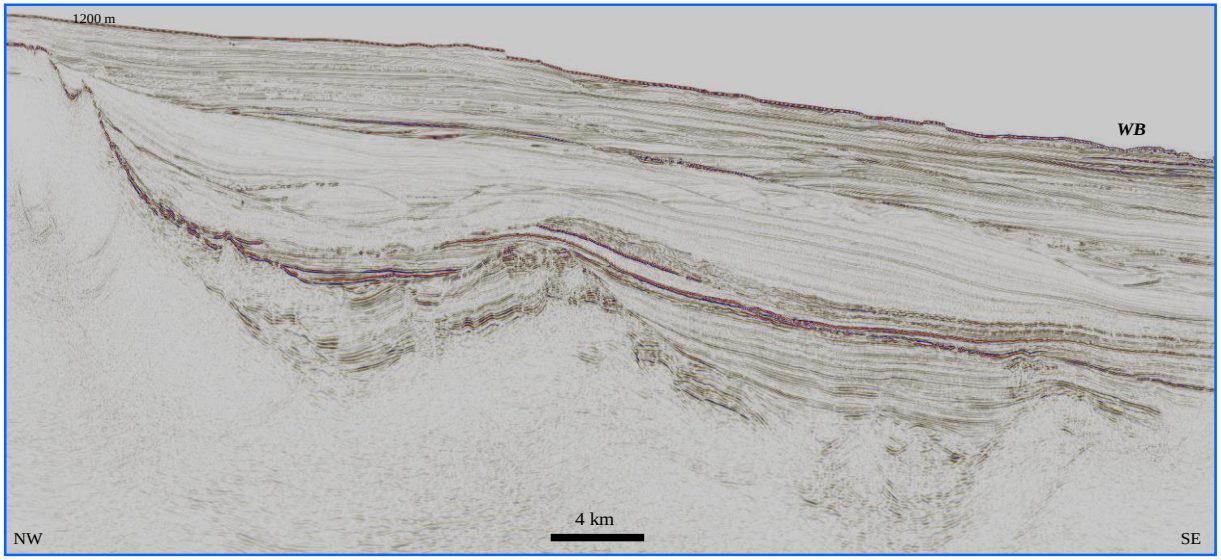
Summary







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