

# Petroleum Exploration Opportunities in Jeanne d'Arc Basin, Call for Bids NL09-1

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**On Behalf of NL DNR  
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# Acknowledgements

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★ = position of CFB NL09-01 Parcel

# Call for Bids NL09-01

- **Single Bid Parcel.** Call for Bids NL09-01 consists of a single parcel of 9,558 hectares (23,618 acres), located in 90-110 m water depth within the Jeanne d'Arc Basin on the Northern Grand Banks
- **Jeanne d'Arc is an oil prolific basin.** This Mesozoic-Tertiary basin produced 294,730 bopd from the Hibernia, Terra Nova and White Rose giant oil fields during the first 6 months of 2009
- **Exploration and Production activity.** There are 16 active Exploration Licenses and 45 SDLs (some covering the same field) in the Jeanne d'Arc Basin and environs
- **Parcel location.** The parcel offered for bid is located in the east central portion of the Jeanne d'Arc Basin
- **Strategic Environmental Assessment (SEA).** The Board has previously conducted a SEA in the Call for Bids NL09-01 area
- **Call for Bids closure.** The bid for this will be concluded on **November 19, 2009 at 4 p.m. NL time**

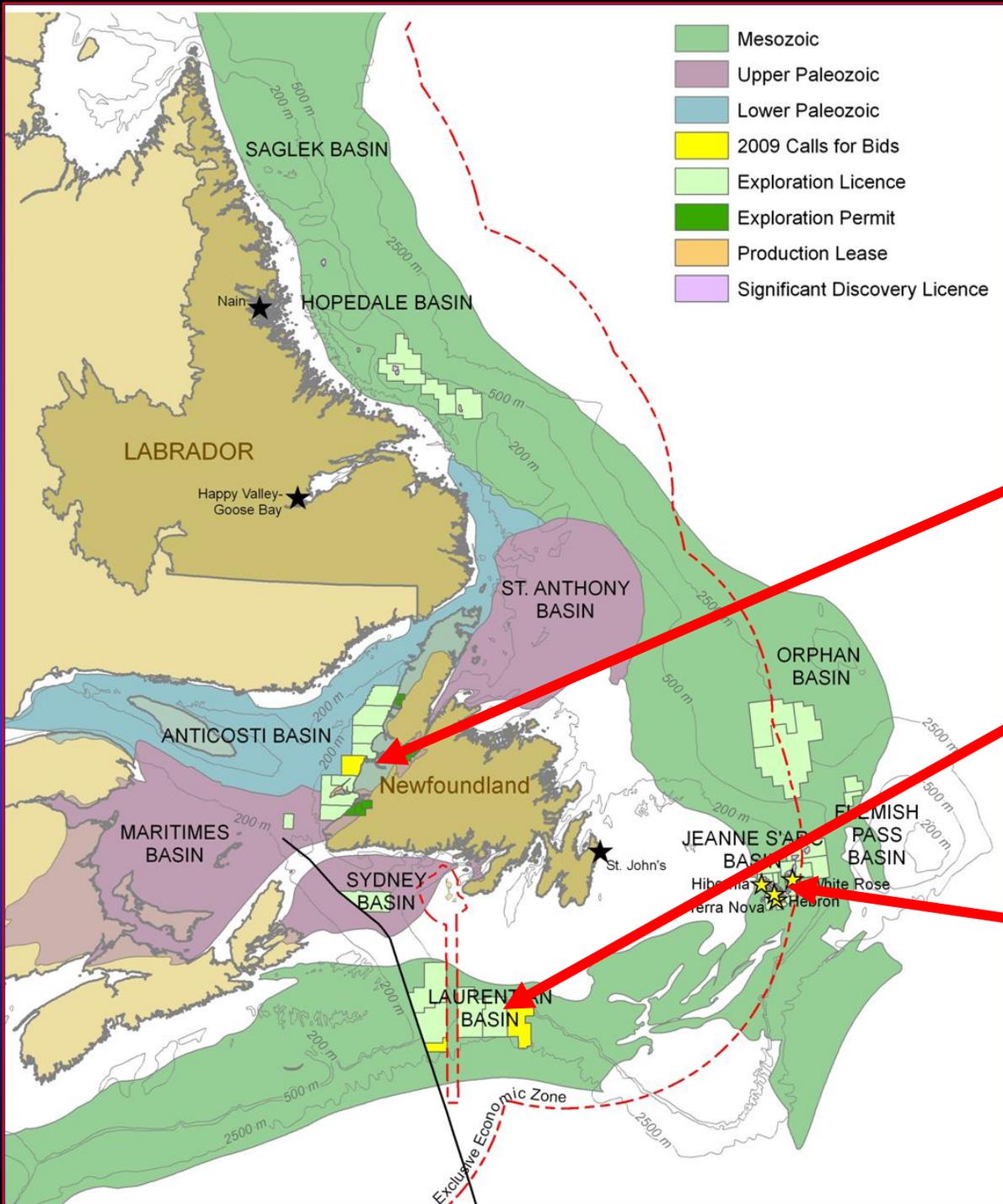
More information on this Call for Bids can be found at:  
[http://www.cnlopb.nl.ca/news/pdfs/cfb09\\_1.pdf](http://www.cnlopb.nl.ca/news/pdfs/cfb09_1.pdf)

# Presentation Content

1. Introduction
2. Exploration and Development Background
3. Geology Overview of the Mesozoic Grand Banks and Environs
4. Geology Summary of the Jeanne d'Arc Basin
5. Petroleum Geology of the JDA Basin
6. Petroleum Potential Call for Bids

NL09-01 Parcel 1

6. Discussion
7. Conclusions



# CFB 2009: Three landsales in three basins

•CFB NL09-03  
Anticosti Basin

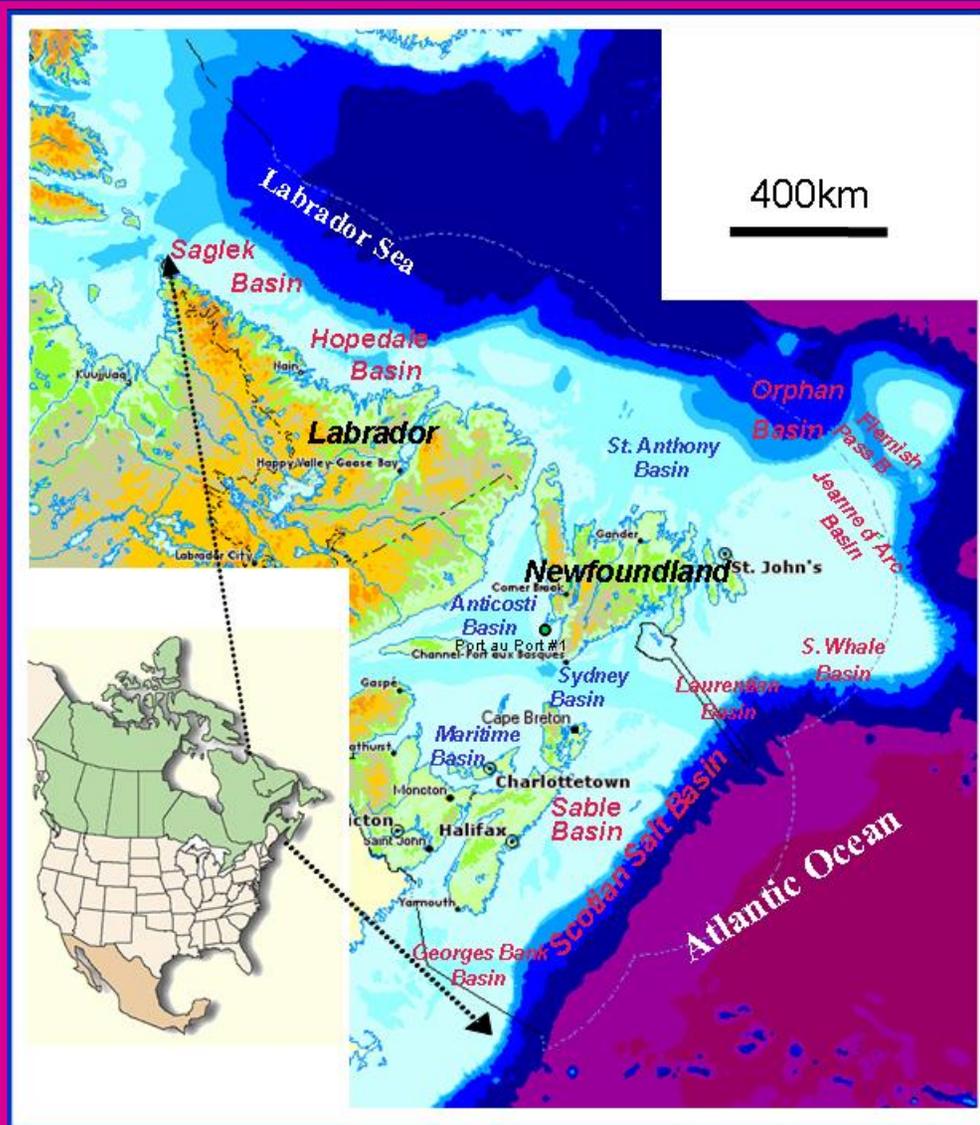
•CFB NL09-02  
Laurentian Basin

•CFB NL09-01  
Jeanne d'Arc Basin

# Parcel NL09-01

- This is a presentation of the petroleum potential of Parcel NL09-01-01 located in shallow water within Jeanne d'Arc Basin (JDA) and offered for bid at this year's C-NLOPB landsale
- Parcel 1 is situated within the Trans-Basin Fault Zone and the "Golden Triangle" formed by the Hibernia-Terra Nova-White Rose oil fields (Enachescu, 1987)
- Parcel 1 is located just south of the White Rose field (PL 1007), west of the North Amethyst oil field (PL 1008), northeast of the North Ben Nevis oil field (SDL 1088) and north of the Fortune discovery (SDLs 1011/12)

# Atlantic Canada Offshore Basins



Blue = Paleozoic Basins

Magenta = Mesozoic Basins

## NL Mesozoic Basins

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

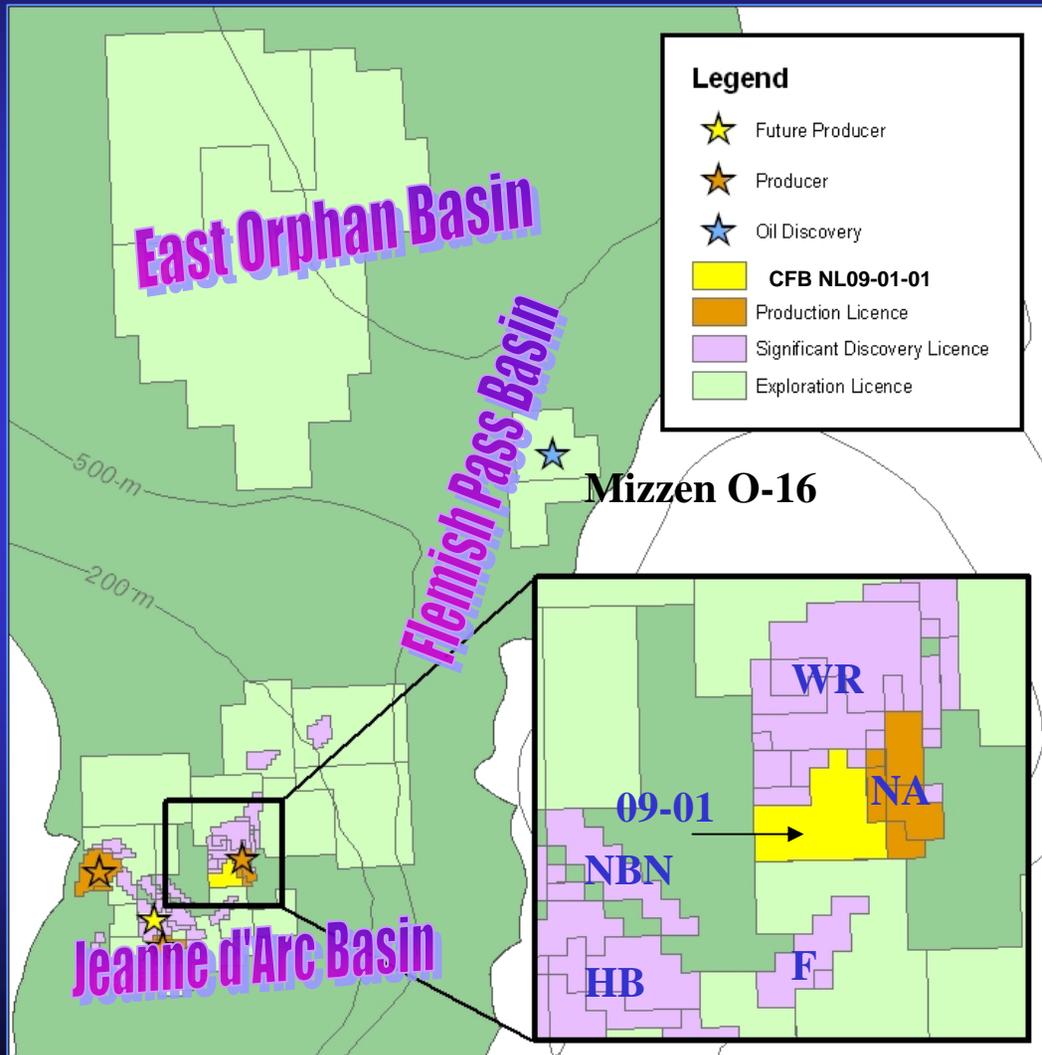
# 1. Introduction

- CFB NL09-01-01 offered parcel is one of the few remaining unlicensed offshore blocks located in the central part of the Jeanne d'Arc Basin
- The parcel is located immediately southwest of the White Rose field Production Licence (PL 1007) and just west of the recent North Amethyst K-15 discovery and Production License (PL 1008)
- The parcel also lies adjacent to several active Exploration Licenses where there is ongoing exploration activity consisting of acquisition of 3D seismic reflection data and exploration drilling

**Observation.** References introduced in this power point are listed in part 2 of this presentation and are also contained in the earlier Jeanne D'Arc landsale reports posted on the website:

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

# Jeanne D'Arc Basin Landsale



- **CFB NL09-1** consists of one large parcel
- Parcel is located in shallow waters of JDB on the Grand Banks of Newfoundland
- **Landsale closes November 19, 2009 at 4 p.m. NL time**

# **2. Exploration and Development Background**

- **NL Petroleum Production**
- **Emergence of Nalcor Energy**
- **Large Mesozoic Under Explored Basins**
- **Grand Banks Exploration History**
- **Recommended References**
- **Newfoundland and Labrador Petroleum Industry**
- **Recent E&P Activity in Atlantic Mesozoic Basins**
- **Recent Jeanne d'Arc Basin and Environs Landsales**

# NL Petroleum Production

- Jeanne d'Arc Basin fields - Hibernia, Terra Nova and White Rose - developed in 80-110 m water are some of the largest offshore producing fields in North America
- These fields have produced in each of the past 5 years in the range of 300,000 to 360,000 barrels per day of light crude (30 to 35° API) from Late Jurassic-Early Cretaceous sandstones
- NL delivers about 37% of the light oil produced in Canada from these fields representing more than 80% of the Atlantic Canada's hydrocarbon production. With this output NL is now the second largest hydrocarbon producing province in Canada
- Over 1 bbls were produced to date from the JDA; more than 1.8 billion barrels proven remaining recoverable reserves/resources exists; approximately 6 tcf of gas was discovered but there is no production
- Jeanne d'Arc Basin developments are the only producing offshore oilfields on the Atlantic coast of North America
- A fourth large field – Hebron - estimated to contain 731 million barrels recoverable reserves/resources will be developed starting in 2012 with first expected oil in 2017
- Satellites of larger fields are presently brought on stream adding to production

# Emergence of Nalcor Energy

- Legislation to create the province's energy corporation, Nalcor Energy, wholly owned by the Province  
<http://www.nalcorenergy.com>
- Through Nalcor, Province negotiated equity positions in the Hebron Project (4.9%) and White Rose Growth Projects (5%)
- Fall 2007, the NL Government released the provincial Energy Plan “Focusing our Energy” that established new policies for oil and gas exploration and production in the Province's large onshore and offshore regions  
<http://www.nr.gov.nl.ca/energyplan/EnergyReport.pdf>
- Energy Plan brought implementation of an Offshore Natural Gas Royalty Regime and introduced the concept of a “pioneer project”

# Emergence of Nalcor Energy

- Formation in 2007 of Nalcor Oil and Gas Inc. subsidiary that acquired interest in several offshore fields: North Amethyst, West White Rose and South White Rose Extension (6.5%), Hebron (4.9%) Hibernia South (10%)
- Summer 2009, Nalcor farms into the “Parson Pond” Exploration Permits located onshore in the Appalachian Paleozoic trend; may be followed by other Nalcor direct involvement with exploration projects
- Petroleum Exploration Enhancement Program (PEEP) financed in 2008-9 a Western Newfoundland onshore aeromagnetic regional survey ; PEEP is a initiative of the Energy Plan and is focused on improving geoscience knowledge of Western Newfoundland onshore
- A further \$20 million was provided to fund the ongoing Offshore Geoscience Data Project

# Large Mesozoic Under Explored Basins

- Atlantic Newfoundland and Labrador were affected by the Wilson cycle initiated during Late Triassic which culminated with the break up of Pangea and opening of the Atlantic Ocean that continues today
- During the initial intercontinental rifting stage and later during the break-up, numerous sedimentary basins were formed on both margins of the Atlantic Ocean
- Some of these basins such as Santos, Gulf of Mexico, Orinoco, Niger Delta, North Sea, etc. are prolific petroleum basins
- Newfoundland and Labrador offshore area contains many underexplored Mesozoic basins including the Laurentian (1 well in French territory), Carson-Bonnyton (4 wells), Flemish Pass (6 wells), East Orphan (1 well), Hopedale (16 significant wells) and Saglek (3 wells) basins

# Grand Banks Exploration History

- 1966 - Mobil Oil conducts first seismic reflection program in Grand Banks
- 1966 - The first Grand Banks well **Pan Am Tors Cove D-52**
- 1967 - First well spudded in the Jeanne d'Arc Basin **Amoco Imperial Murre G-67**
- 1971 - First free flow of oil to surface in the Jeanne d'Arc Basin: 268 bopd, 31<sup>0</sup> API gravity, 0.2 MMcfd gas from **Mobil Gulf Adolphus 2K-41**, the 4th well in Jeanne d'Arc Basin
- 1973 - First penetration of prolific Upper Jurassic source rock: Egret Member of the Rankin Formation drilled at **Amoco Imperial Skelly Egret K-36**, the 5th well in Jeanne d'Arc Basin
- 1979 - First major discovery well: **Chevron et al. Hibernia P-15**; the 45th well drilled in Grand Banks region and 10th well drilled in the Jeanne d'Arc Basin; tested 800 bopd, 32<sup>0</sup> API and 0.2 MMcfd gas on first openhole test of Upper Jurassic sandstones
- 1980 - First oil discovery outside Jeanne d'Arc Basin: **Mobil et al. South Tempest G-88** well on the Central Ridge
- 1981 - First Hibernia 3D seismic survey completed (also first 3D survey offshore Canada)

# Grand Banks Exploration History

- 1981 - **Hebron** field was discovered by Mobil; it is estimated to contain more than 700 million barrels of oil
- 1984 - **Terra Nova** oil field was discovered by Petro-Canada et al.
- 1984 - First **White Rose** oil well (teaser); the major oil and gas field was discovered by Husky et al. with the White Rose E-09 well in 1988
- 1984 - Signing of **Atlantic Accord** by Canadian and NL governments establishing C-NLOPB and regulatory regime for the NL Atlantic offshore area
- 1990 - C-NLOPB declared the giant Hibernia oilfield to be a Commercial Discovery
- 1997 - First oil production from Hibernia, production record for a Canadian well 56,000 bopd
- 2002 - Terra Nova starts producing using the first FPSO offshore NL
- 2004 - White Rose start producing using the second FPSO in the basin
- 2005 - Hibernia more than double its recovery reserves size
- 2007 - First well in East Orphan Basin Chevron et al. Great Barasway F-66
- 2007 - Emergence of **Nalcor Energy**
- **2009 - First billionth barrel produced from the Jeanne d'Arc Basin**
- 2009 - First deep water discovery offshore NL by StatoilHydro: **Mizzen O-16** in the northern Flemish Pass Basin

# Recommended Literature on Grand Banks

Jansa and Wade 1975; Hubbard et al., 1985; Parson et al., 1985; Mason and Miles, 1986; Grant and McAlpine, 1986; Srivastava and Tapscott, 1986; King et al., 1986; Grant and McAlpine, 1986; Ziegler, 1987; Enachescu 1987, 1988, 1992, 1993 ; Enachescu et al., 1993; 2005; 2006; Tankard and Welsink, 1987; Keen et al., 1987; Fowler and Snowden, 1988; Grant et al., 1988; Sinclair, 1988; Koning et al., 1988; Ziegler, 1989; Balkwill and Legall, 1989; Tankard et al., 1989; Brown et al., 1989; Bell and Howie, 1989; Tucholke et al., 1989; Hiscott et al., 1990; Srivastava et al., 1990; Wade and MacLean, 1990; Grant and McAlpine, 1990; McAlpine, 1989, 1991; Keen and Williams, 1990; Sinclair et al., 1992; Srivastava and Verhoef, 1992; Foster and Robinson, 1993; DeSilva, 1993, 1994 and 1999; Enachescu and Dunning, 1994; Fowler and McAlpine, 1995; Driscoll and Hogg, 1995; Driscoll et al., 1995; Bateman, 1995; Drummond, 1998; Hubbard, 1998; Williams et al., 1999; Srivastava et al., 2000; Hogg and Enachescu, 2001; Louden, 2002; Deptuck et al., 2003; Smee et al., 2003; Enachescu and Hogg, 2005; Sibuet et al., 2007; Tucholke et al., 2007; Hardy, 2007 (M Sc Thesis); Fagan and Enachescu, 2008; Fagan, 2009 (M Sc Thesis)

**Observation: This list is not exclusive**

# Government of Newfoundland and Labrador Reports and Presentations

- The regional geoscience of Newfoundland and Labrador offshore and specifically the petroleum potential of the Jeanne d'Arc Basin were covered in detail in previous Government of Newfoundland and Labrador Reports
- Only summaries are contained in this presentation
- More geoscience information is included with reports and presentations available from the :

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

and

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

# List of Reports and Presentations Available from the Government of NL Website:

**Atkinson and Fagan, 2000;**

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

**Smee, 2003;**

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

**Fagan and Hicks, 2003;**

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

**Enachescu and Fagan, 2004;**

[http://www.gov.nl.ca/mines&en/oil/call\\_for\\_bids\\_nf04\\_01.stm](http://www.gov.nl.ca/mines&en/oil/call_for_bids_nf04_01.stm)

**Enachescu and Fagan, 2005;**

[http://www.nr.gov.nl.ca/mines&en/call\\_for\\_bids/NL05.pdf](http://www.nr.gov.nl.ca/mines&en/call_for_bids/NL05.pdf)

**Enachescu 2006a and b;**

[http://www.nr.gov.nl.ca/mines%26en/call\\_for\\_bids/cfb\\_nl06-1\\_%20enachescu\\_report.pdf](http://www.nr.gov.nl.ca/mines%26en/call_for_bids/cfb_nl06-1_%20enachescu_report.pdf)

[http://www.nr.gov.nl.ca/mines%26en/call\\_for\\_bids/CFBNL06-1\\_presentation.pdf](http://www.nr.gov.nl.ca/mines%26en/call_for_bids/CFBNL06-1_presentation.pdf)

# Newfoundland and Labrador Petroleum Industry

- Currently NL produces about 330-340,000 bopd
- This represents 12.5% of Canada's total oil production, 37% of Canada's light oil and more than 80% of Atlantic Canada petroleum output
- \$2.5 billion oil royalty paid during 2008-9
- 31% of provincial government revenue
- 7,400 annual average employment
- 36% of NL nominal GDP
- \$ 16 billion spending in E&P since 1995
- Provincial Government encourages offshore exploration with high concerns for environmental protection and safety; strict regulations are in place
- Total estimated Recoverable Reserves of the NL Province stands at 6 Bbbls oil and 60 Tcf natural gas

# Jeanne d'Arc Basin Daily Average and Annual Production 2008

*Modified after C-NLOPB*

Jeanne d'Arc Basin	Total Production Oil (bo)	Daily Average Production oil (bopd)	Total Production Gas (Bcf)	Daily Average Production Gas (MMcfd)
Hibernia	50,732,530	138,613.5	85,0	232.2
Terra Nova	37,550,268	102,596.3	59.7	163.2
White Rose	36,962,453	100,990.3	31,3	85.5
<b>Total</b>	<b>125,245,251</b>	<b>342,200</b>	<b>176,0</b>	<b>480.9</b>

Gross revenue @ US \$97 per barrel (Brent) = **US \$12,148,808,747**

# NL Offshore – Recoverable Reserves/Resources

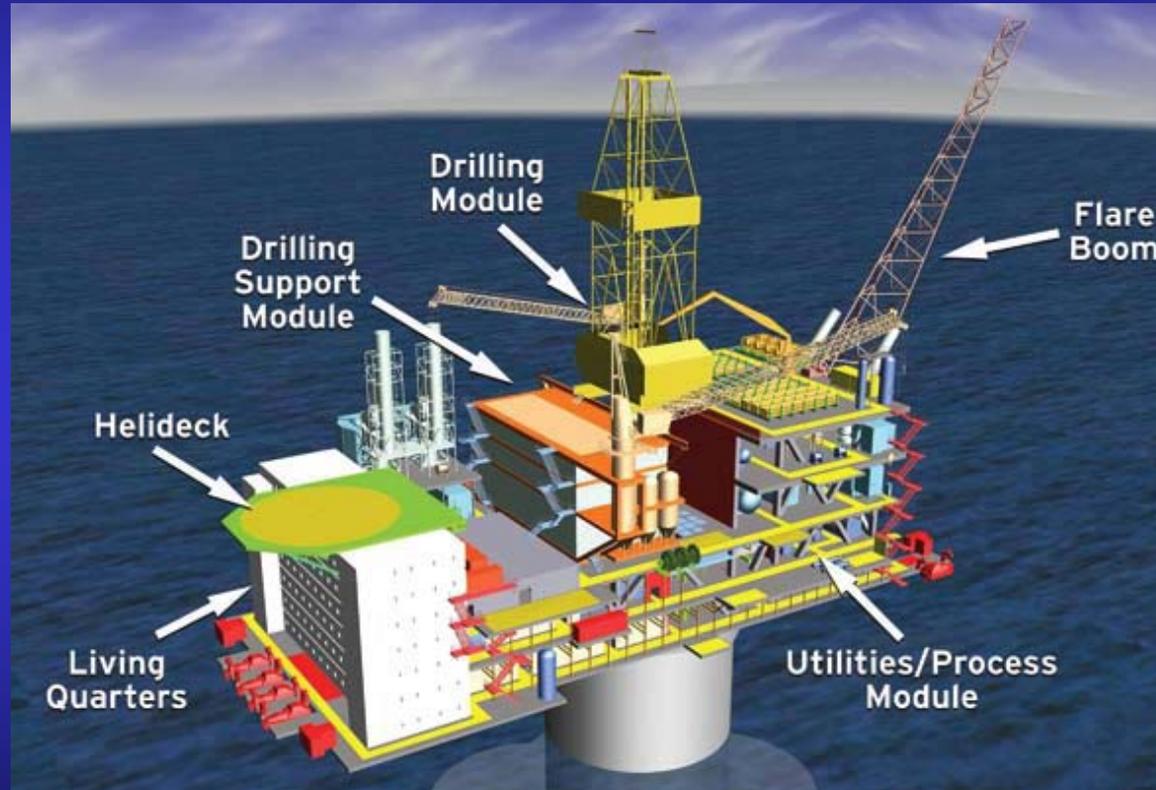
Field	Oil (MMbbl)	Gas (Bcf)	NGL's (MMbbl)
Hibernia	1244	1,794	202
Terra Nova	354	45	3
Hebron/Ben Nevis	581	429	30
White Rose +sat Others	373	2,722	110
<b>Subtotal – Grand Banks</b>	<b>2,840</b>	<b>5,990</b>	<b>355</b>
<b>Labrador Shelf</b>		<b>4,244</b>	<b>123</b>
<b>Total</b>	<b>2,840</b>	<b>10,234</b>	<b>478</b>
<b>Produced</b>	<b>1.068 Bbbls</b>	<b>No Production</b>	

# Recent E&P Activity in Mesozoic Basins

- **Production.** Presently NL production is obtained from **Hibernia, Terra Nova and White Rose** fields in the Jeanne d'Arc Basin. New developments are carried out at the giant and complex **Hebron** oil field and at the smaller satellite fields **North Amethyst, West White Rose and Hibernia South**
- **Exploration.** In the past 5 years, exploration in the Mesozoic basins consisted of 2D and 3D seismic data acquisition, various EMCS surveys and drilling.
  - Exploration Drilling took place in the **Jeanne d'Arc, Flemish Pass and East Orphan basins**. No drilling has yet taking place in the Laurentian and Hopedale basins.
  - The Mesozoic basins have also seen new exploration licensing or consolidation of older issued ELs. As the spring of 2009 there was \$872,756,736 in exploration commitments to be undertaken by interest owners in these basins

# Hebron Field

- Field is situated in Jeanne d'Arc Basin, about 350 km (217 miles) from St. John's in 90 to 100 m (295 to 328 feet) of water
- Development will involve a concrete gravity-based structure to be built in the Province
- Field will yield 120,000 - 176,000 bopd over 30 years



After Hebron Consortium and NL DNR

# Hebron Field

- Hebron is the largest stand alone new field development in Canada
- The Hebron compartmentalized field, consists of the Hebron, Ben Nevis and West Ben Nevis oil accumulations located in several independent fault blocks
- ExxonMobil is operator with a 36% interest, Chevron Canada has 26.7 %, Suncor 22.7%, StatoilHydro Canada 9.7%
- The remaining 4.9% is held by Nalcor Energy. The government paid C\$ 110 million for its stake in the field
- Oil and gas are contained in Ben Nevis, Hibernia and Jeanne d'Arc reservoirs
- Hebron field faces challenges associated with the recovery of heavier oil (~20° API) in the Hebron main pool
- Field is estimated to contain 731 MMbbls recoverable reserves/resources to be developed starting in 2012 with “first oil” production scheduled for 2017

# Laurentian Basin

- The basin is a hybrid Mesozoic basin developed between the Scotian shelf and slope and the Newfoundland Transfer Zone (NTZ); during Late Triassic - Middle Jurassic the Laurentian Basin had affinity with the Scotian Basin
- Large Paleozoic extensional and transtensional structures are mapped in the northern part of the basin. In the south large Mesozoic structural and stratigraphic features are observed
- In the early eighties, several Exploration Permits were held which stretched the unsettled international boundaries of Canada and France and provincial boundaries of Newfoundland and Labrador and Nova Scotia, by Gulf, Mobil, Texaco and Imperial Oil
- The Bandol #1 well was drilled in 2001 on a shelf location and in French territory by Murphy et al.; while it was rumoured to have found good Mesozoic reservoir, the well remains confidential until 2011. This is the only existing well in a 60,000 km<sup>2</sup> area

# Laurentian Basin

- After the jurisdictional boundaries were resolved in 1992 with France and in 2002 between provinces, permits were converted into 7 ELs (1081-1087) awarded in 2004, by C-NLOPB to ConocoPhillips (CP) and EL 1088 awarded to Imperial Oil
- Basin-wide 2D surveys were conducted in late 1990s and early 2000s, followed by 2 large CP et al. 3D surveys conducted in deep water during 2005
- With these surveys several large structural and stratigraphic traps were seismically identified on the slope and in deep water
- A consolidation of the 7 CP operated lands into four ELs (EL1081R, EL1082R, EL1086R, EL1087R) took place in 2008; Imperial's EL 1088 expired in April 2009
- A deep water exploration well is planned by CP et al. for the winter of 2009/10
- Two new deep water exploration parcels are offered by C-NLOPB at the current Call for Bids NL09-02

# East Orphan Basin

- Orphan Basin is a widely stretched Mesozoic rifted area located north of Grand Banks of Newfoundland. The shallow part of the basin was unsuccessfully explored in the late seventies-early eighties when 5 wells were drilled on basement highs
- A deep water well, Blue H-28, drilled a rotated block bald of Late Jurassic-Early Cretaceous, without encountering hydrocarbons
- Based on new 2D seismic data interpretation, the drilled eastern part of the basin is considered more prospective for gas while the East Orphan Basin situated mostly in deep and super deep water has great oil potential as it was an earlier Tethyan rift (Enachescu et al., 2004 and 2005)
- The basin was connected in Late Jurassic to Jeanne d'Arc and Flemish Pass and W. Ireland basins during its Mesozoic evolution
- Eight large ELs (1073 to 1081) covering 21,250 km were awarded to Chevron Canada (50%)/ExxonMobil Canada (EMC) (25%)/Imperial Oil (IO) (25%) in 2003. The partnership later included Shell Canada that took a 20% interest from EMC and IO
- The partnership conducted two large 3D surveys in their licenses

# East Orphan Basin

- Great Barasway F-66 well operated by Chevron was drilled in 2006/7 in EL 1076. This well set a Canadian record for deep water drilling in a water depth of 2338 m; the well TD'd and was abandoned at 6749.9 m
- F-66 well found good Late Jurassic-Early Cretaceous reservoirs and Late Jurassic source rocks. However the reservoirs were wet and only several shows were encountered
- At least a dozen of other large structural and stratigraphic traps were identified in the basin with the two large proprietary 3D surveys and several dense 2D grids existing in the basin. These prospects remain to be drilled
- A consolidation of the Chevron and ExxonMobil operated lands into two ELs (EL1073R and EL1074R) took place in 2008; at the time the EL 1075 and the north-eastern part of EL 1080 were relinquished to the Crown
- An exploration well is planned for the spring/summer of 2010
- A large part of the petroleum prospective East Orphan Basin remain un-licensed and opened for company land posting

# Recent Newfoundland and Labrador Landsales

- During 2008 several successful land rights issuance took place
- In September 2008, C-NLOPB announced that successful bids were received for four CFB NL07-02 parcels located in Labrador Offshore Area totaling \$186,430,680. This was the first land rights issuance in Labrador since early eighties and the third largest land rights issuance in terms of total work expenditure commitment
- In November 2008, successful bids totaling \$129,892,000 were received on all three parcels offered in the Central Ridge/Flemish Pass (CFB NL08-01) area and two parcels in the Jeanne d'Arc Basin (CFB NL08-01)
- A successful bid was received for a large parcel in the Sydney Basin (CFB NL08-03) and another in the Western Newfoundland and Labrador (CFB NL08-04) Offshore Region for an additional work commitment of \$2,400,000

# Results of 2008 Jeanne d'Arc and Environs Landsales

- **NL08-2 Jeanne d'Arc**

Parcel 1 (19 430 ha): Suncor (50%)/StatoilHydro (50%) for \$ 81.90 MM  
Parcel 2 (121 348 ha): Husky (67%)/Repsol (33%) for \$ 9.48 MM

- **NL08-1 Central Ridge**

Parcel 1 (138 200 ha): Husky (40%)/Suncor (40%) Repsol (20%) for \$18.60 MM  
Parcel 2 (134 227 ha): Husky (67%)/Repsol (33%) for \$ 1.19 MM

- **NL08-1 Flemish Pass**

Parcel 3 (55 954 ha): StatoilHydro (65%)/Husky (35%) for \$18.72 MM

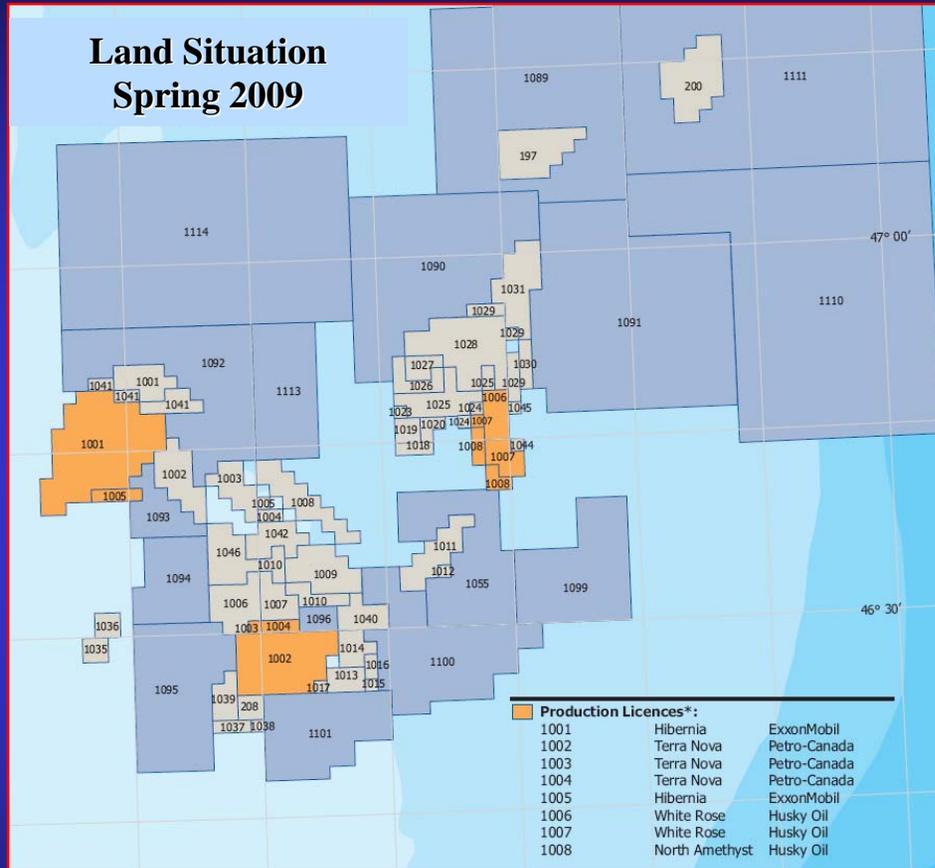
**TOTAL**

**\$129.9MM**

**Observation.** Reports and presentations on the potential of Call for Bids NL07 and NL08 are available from:

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

# Recent Jeanne d'Arc Basin Landsales



## *Observation.*

In the 2008 landsale, Repsol participated for the first time ever and succeeded in an offshore Atlantic Canada landsale. Repsol is a large integrated oil company with assets in many countries.

It was also the first time in which NL has attracted a new “name” - a large reputable multinational integrated petroleum company to explore the Grand Banks

Presently there are: 16 Exploration Licences (EL), 43 Significant Discovery Licences (SDL) and 8 Production Licences (PL) in the basin

# 3. Geology Overview of the Mesozoic Grand Banks and Environs

- About a dozen Mesozoic basins, subbasins, trough and sedimented ridges are petroleum prospective on the Grand Banks and environs
- They all formed during breakup of Pangea and subsequent Atlantic Ocean opening
- The area is dominated by extensional tectonics and complicated by salt tectonics and transtensional movements
- All ingredients for petroleum formation and accumulation in large structural, stratigraphic and combination traps exists for the basins that preserve the Late Jurassic high TOC/ high HI source rock
- In other Grand Banks basins the existence of a viable petroleum systems remains to be proven
- Areas of petroleum potential extend from the shallow waters of the Banks into the deeper waters of the continental slope, as well as to ultra-deep-water areas such as the Orphan and Laurentian basins
- For now, Jeanne d'Arc is the only oil proven and producing basin in the area

# Regional Geology of the Grand Banks of Newfoundland

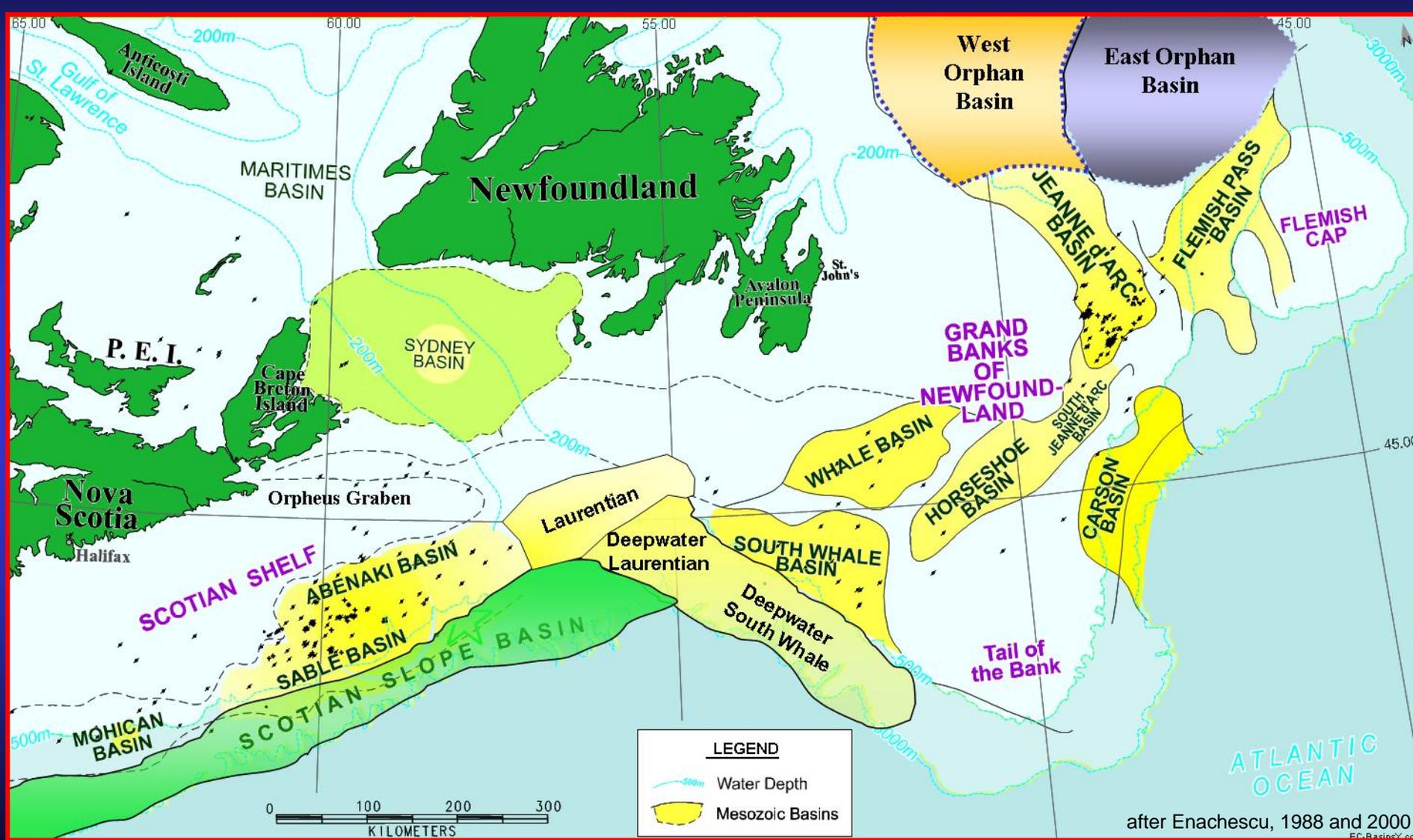
- East Coast Newfoundland and Labrador is a significant part of the eastern N. America to N. Europe extensive, once continuous Gulf of Mexico to Barents Sea, Mesozoic aged rift system developed during the Pangea intra-continental rifting and Atlantic Ocean opening
- The Grand Banks and environs basins evolved through the latest Atlantic Wilson cycle, starting 230 million year ago and continuing today
- Up to now Grand Banks and environs (Central Ridge and Flemish Pass Basin) is the only area along the East Coast North America are with large oil fields that are producing close to world's largest consumer market

# Regional Geology of the Grand Banks of Newfoundland

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

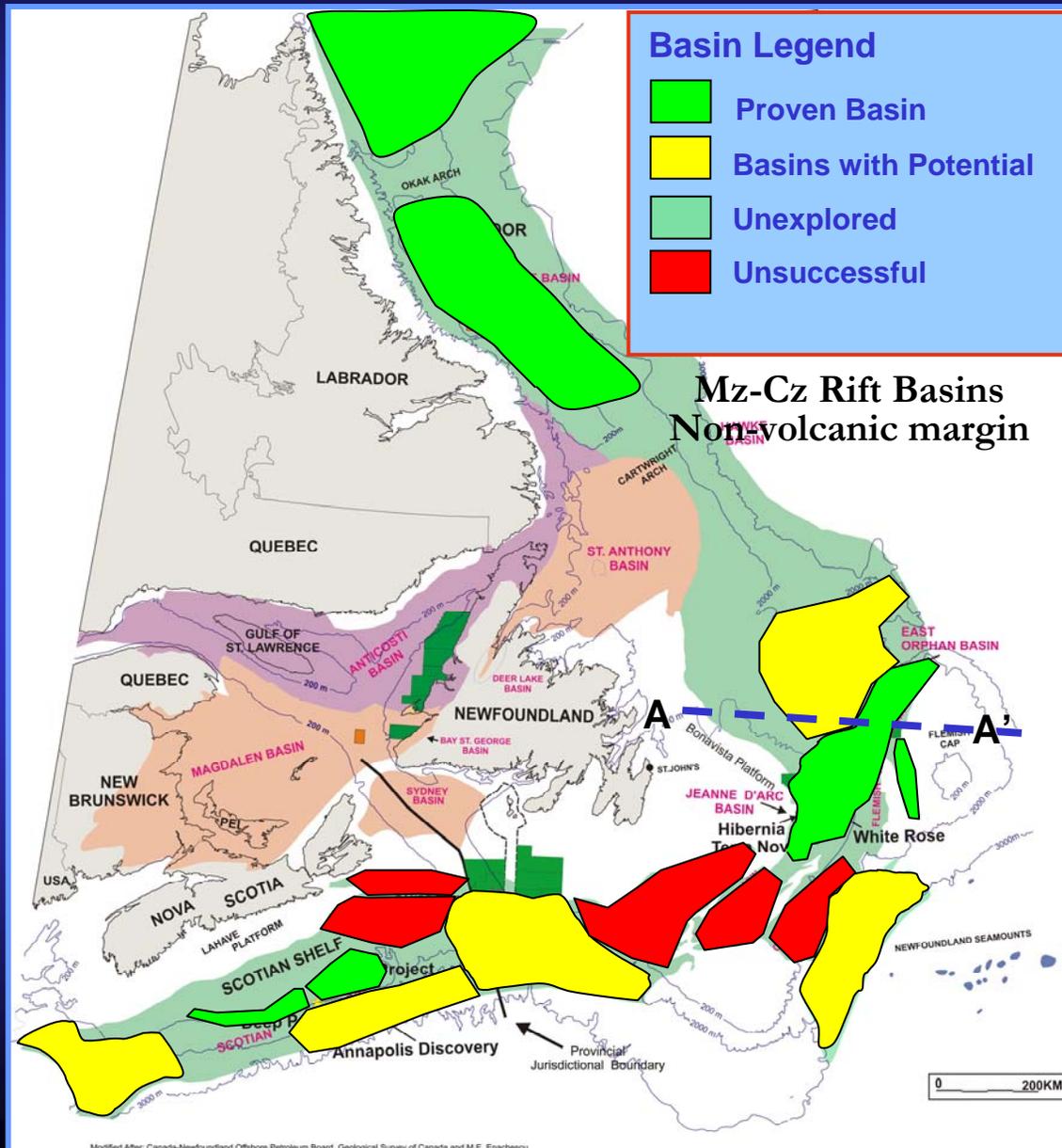
- Lower Paleozoic American continental margins,
- Late Triassic intra-continental rifts incised on Grenville, Avalon and Meguma basement,
- Late Triassic-Early Jurassic massive salt and other evaporite deposition
- Repeated phases of intra-continental extension (Late Jurassic-Early Cretaceous and Albian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

# Atlantic Canada Mesozoic Basins



after Enachescu, 1988 and 2000

# Atlantic Canada Mesozoic Basins



## Petroleum Geology

### Basins with Oil and Gas Discoveries

Sable

Jurassic Carbonate Margin

Jeanne d'Arc

Flemish Pass

Hopedale

Saglek

### Basins with Petroleum Potential

George's Bank

Scotian Salt

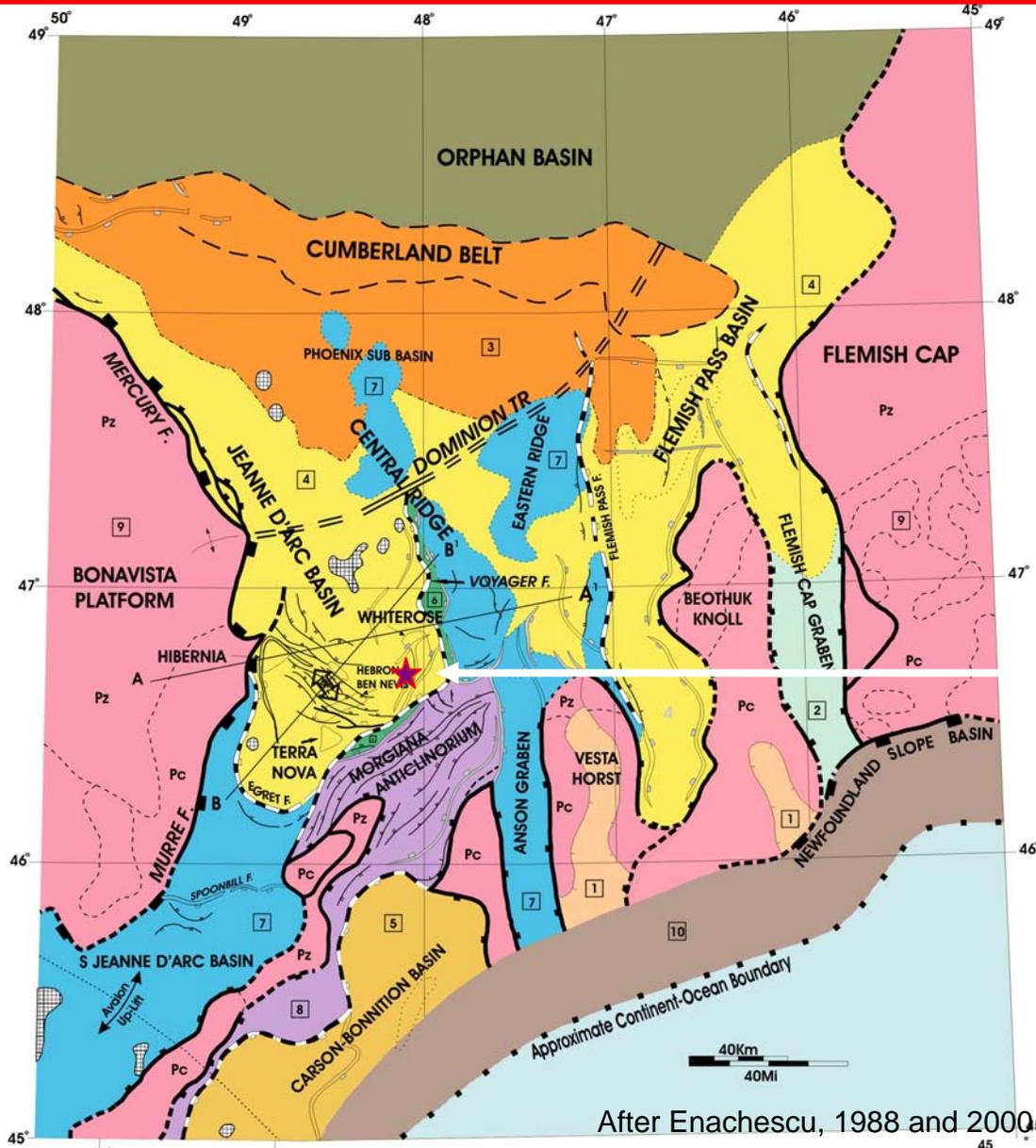
Laurentian

Salar

East Orphan

# Grand Banks Tectono- Structural Units Map

★ Location of CFB  
NL09-01 Parcel 1

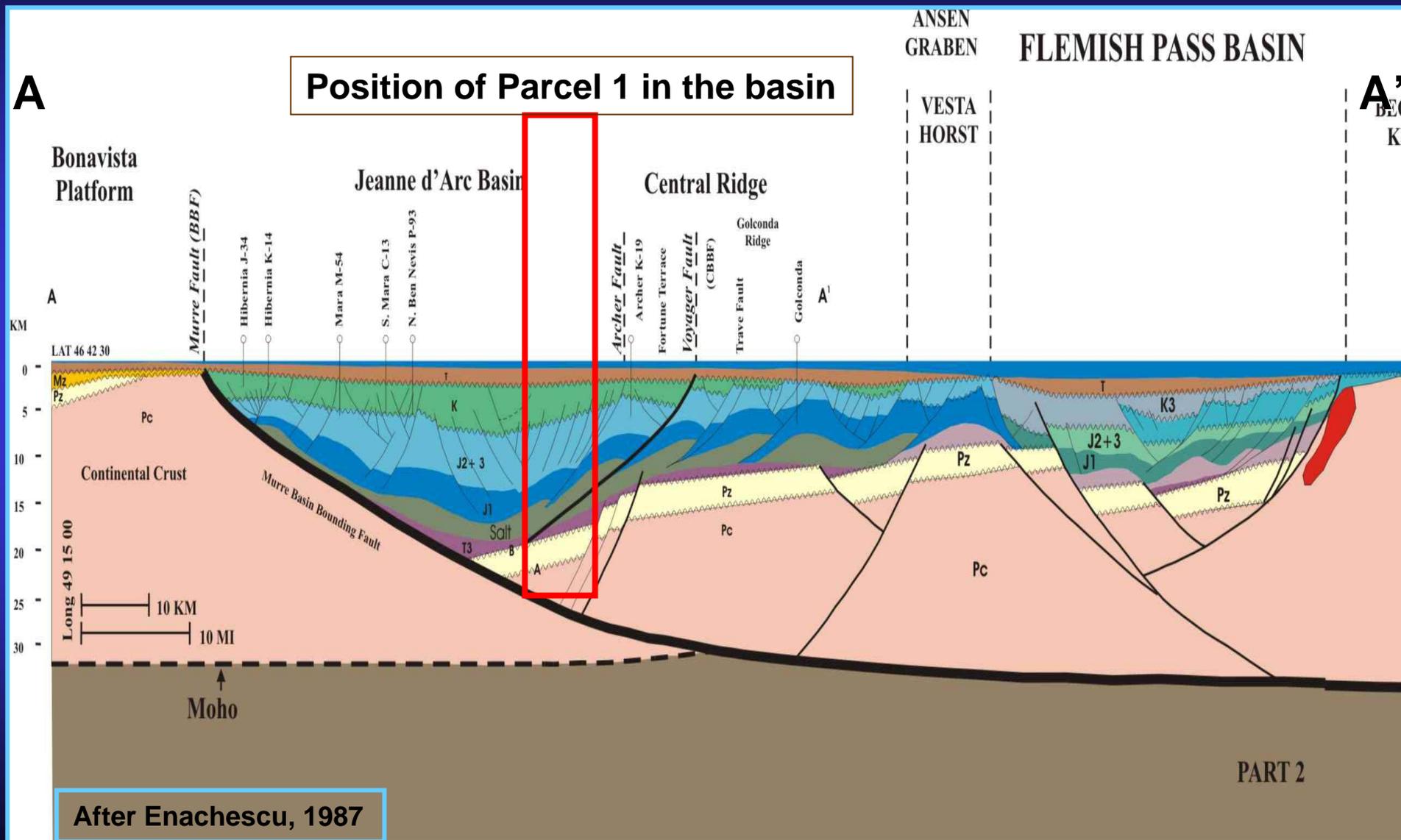


After Enachescu, 1988 and 2000



Observation. A-A' is shown in the next slide and B-B' is a cross-sections shown in CFB NL06-1 report and PP presentation

# W-E Grand Banks Structural Profile



After Enachescu, 1987

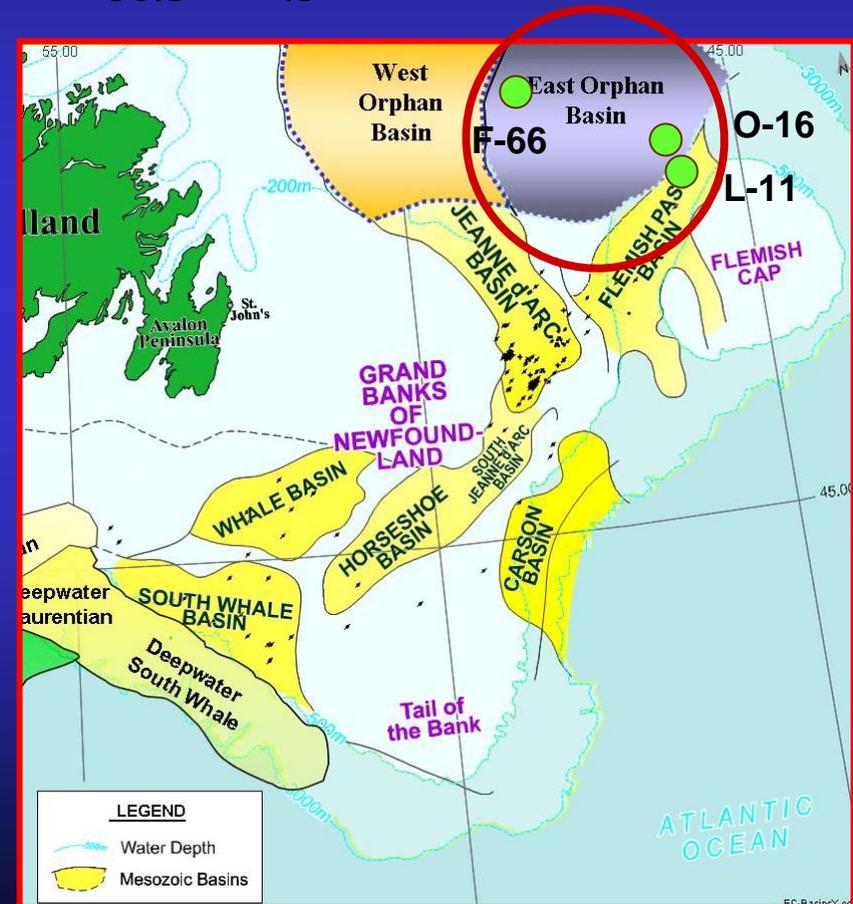
# Significant Exploration Wells Recently Drilled in Grand Banks Mesozoic Basins

## Flemish Pass Basin

- 1. Mizzen L-11 (significant shows)
- 2. Mizzen O-16 (significant discovery)

## East Orphan Basin

- 3. Great Barasway F-66 (source rock and small shows)

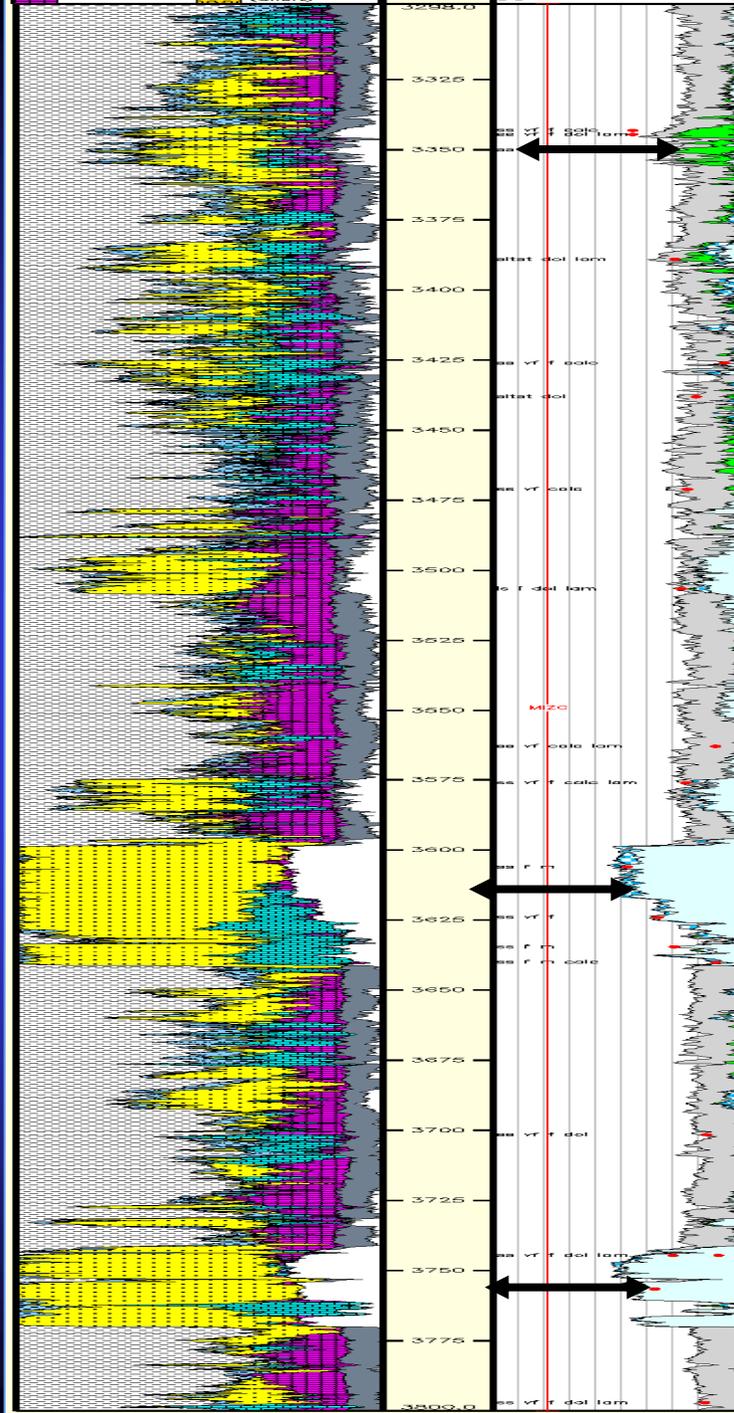


# Mizzen L-11

- Flemish Pass Basin in 1153 m WD
- Drilled in 2003 by EnCana/Norsk Hydro in EL 1069
- Found an oil charged zone and intersected thick source rock
- The Baccalieu sandstone had poor reservoir but included a 6 m oil pay
- Excellent reservoirs in Late Jurassic at 3598 and 3741m
- TD 3820 m

# Mizzen L-11

- Encountered Egret Source rock
- Encountered reservoir oil
- Encountered other shows



Early  
Cretaceous  
Reservoir

Net Pay  
6 m of oil pay  
Sw 25%

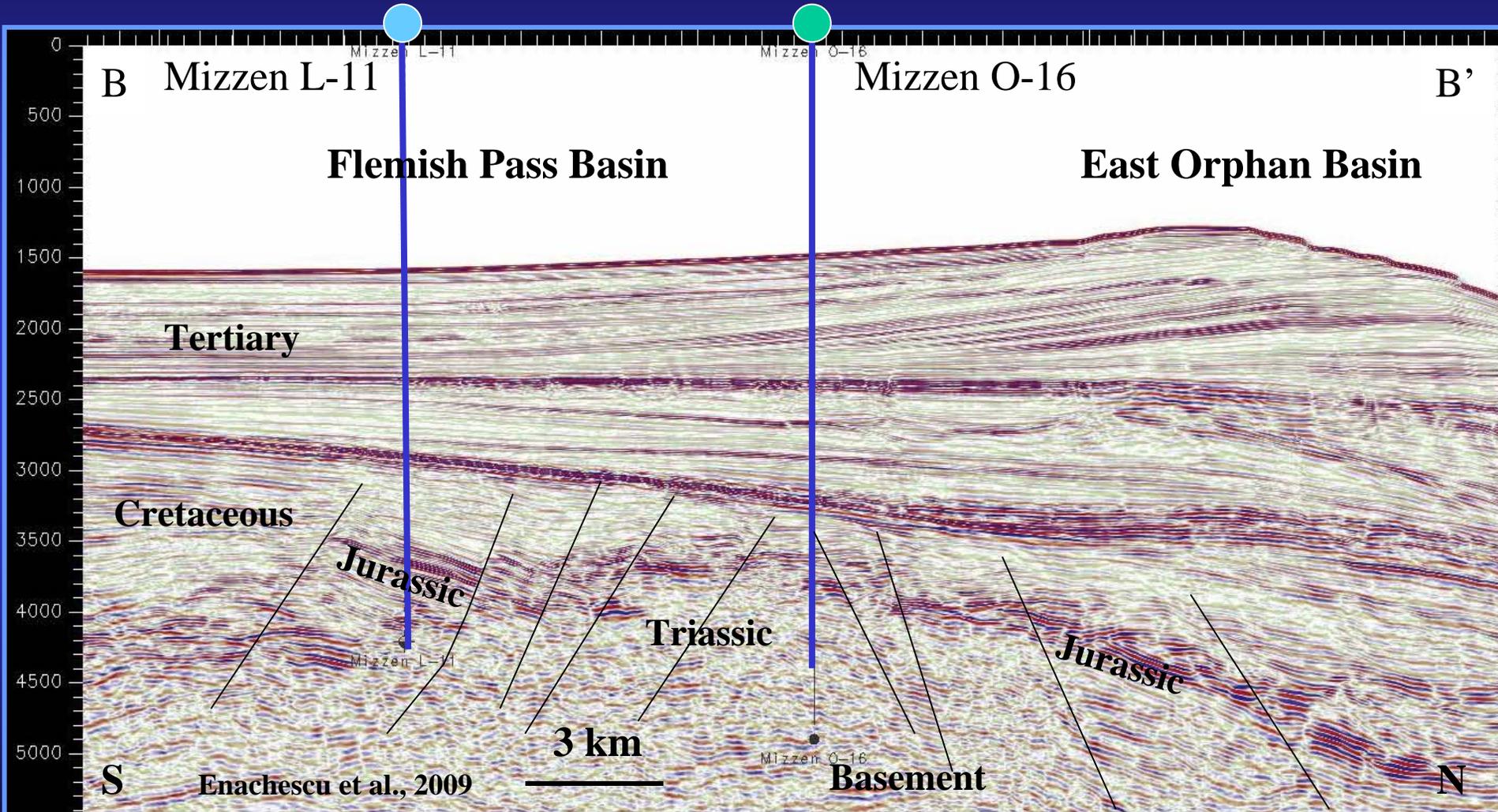
Late Jurassic  
Reservoir

Gross  
Thickness: 70m  
Sw 95%  
Avg Porosity:  
20%

# Mizzen O-16

- Located in Flemish Pass Basin in 1095 m WD
- About 10 km North of the Mizzen L-11 well
- Drilled in 2009 by StatoilHydro (65%)/Husky Energy (35%)
- Located in EL 1049
- Well TD'd at 3756 m
- Declared an oil discovery by the operator
- A Significant Discovery Licence application was submitted in September 2009

# Mizzen Wells Correlation

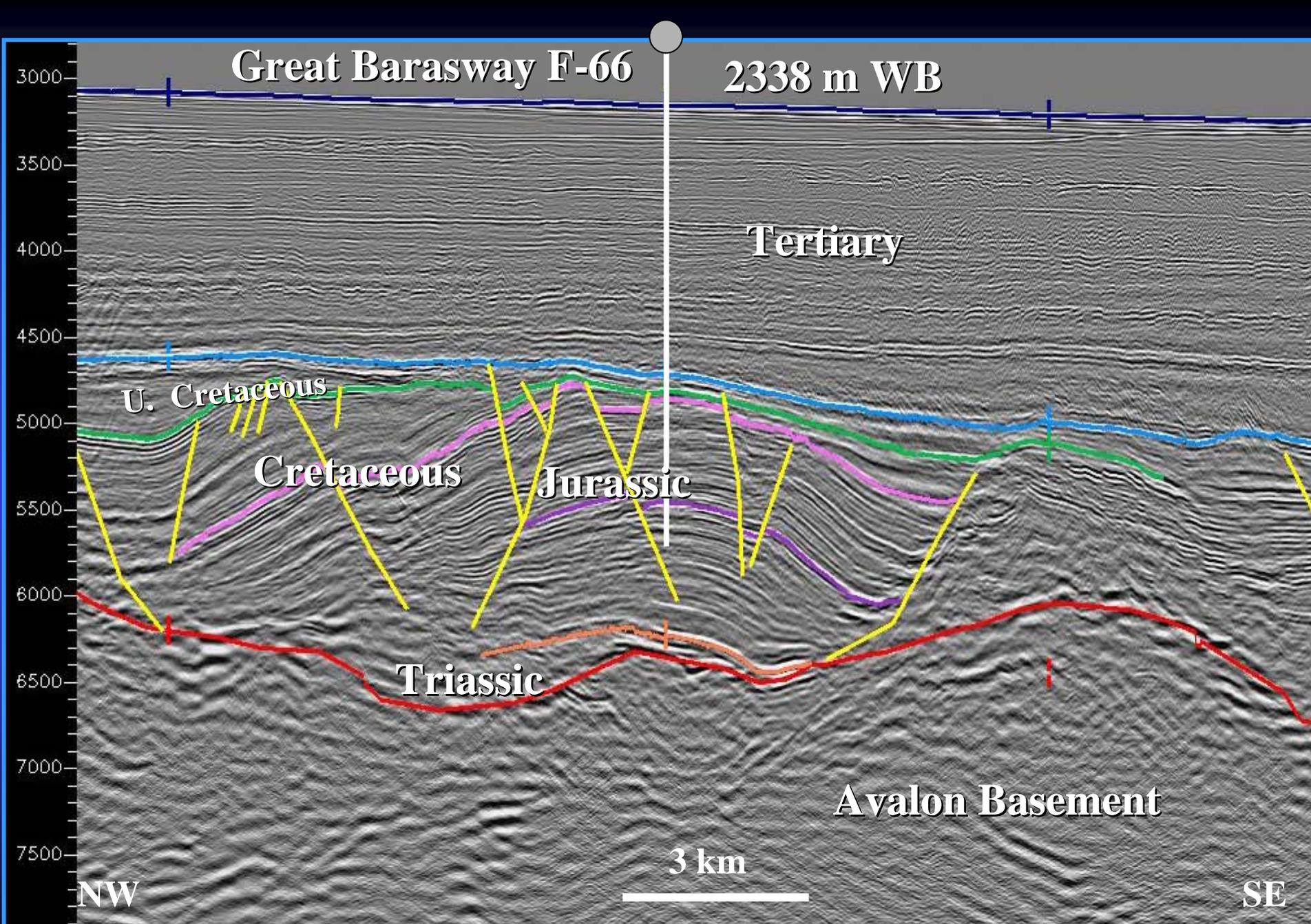


Courtesy of GSI

Enachescu, NL DNR 2009

# Great Barasway F-66

- Located in East Orphan Basin in 2438 m WD
- The most distanced well from the JDB fields
- Drilled in 2003 by Chevron (50%)/ExxonMobil (15%)/Imperial (15%)/Shell (20%) in EL 1076
- Well TD'd at 6751 m; one of the deepest offshore Canada well
- Declared D&A by the operator
- Good reservoirs, Late Jurassic source rocks and encouraging shows were encountered



Great Barasway F-66

2338 m WB

Tertiary

U. Cretaceous

Cretaceous

Jurassic

Triassic

Avalon Basement

3 km

NW

SE

# 4. Geology Summary of the Jeanne d'Arc Basin

- Jeanne d'Arc Basin and adjacent Central Ridge area host most of the significant oil discoveries in the Newfoundland and Labrador offshore area (there are also major gas discoveries off Labrador and an oil discovery in Flemish Pass Basin), including the three currently producing fields; also Hebron and a series of satellites and field extensions which are now developed or planned for development
- The basin forms an elongate, roughly NE trending, large half-graben, encompassing an area of about 14,000 km<sup>2</sup>. It is bounded to the west by the Murre Fault, to the north by the Cumberland Belt Transfer Zone (CBTZ) lineament, to the east by the Voyager Fault and to the south by the Egret Fault. The basin deepens to the north and shallows to the south, and contains over 20 km of Upper Triassic to Cenozoic sedimentary infill in its depocentre, situated to the north of the Trans-Basin Fault Zone (TBFZ) and east of Hibernia
- The sedimentary fill of this area was deposited, structured and fragmented during repeated extensional episodes. Infill includes clastics, salt and carbonates. Minor trans-tensional tectonic movements and several strong erosional interludes have also reshaped the basin and its associated ridges

# Geology Summary of the Jeanne d'Arc Basin

The basin fill can be divided into two major stratigraphic sequences that are clearly recognizable on seismic data:

*1. An extensional stage sedimentary sequence* (Late Triassic to late Early Cretaceous) that is strongly compartmentalised by normal fault systems and contains numerous structures

*2. A thermal subsidence stage sedimentary sequence* (Late Albian to Present) that is tectonically undisturbed (i.e. no extension), but contains remarkable depositional and erosional features, including basin margin and floor fans

Alongside extensional tectonics, prolonged halokinesis and halotectonics played an important role in basin evolution and architecture. Prominent salt-cored structures are presently found throughout the Grand Banks. Salt pillows underlay the Hibernia, Terra Nova and White Rose oil fields and most of the other structural features in the basin and on the Central Ridge

# Jeanne d'Arc Basin Lithostratigraphy and Tectonic Evolution

• 3 stages of extensions

1, 2 and 3

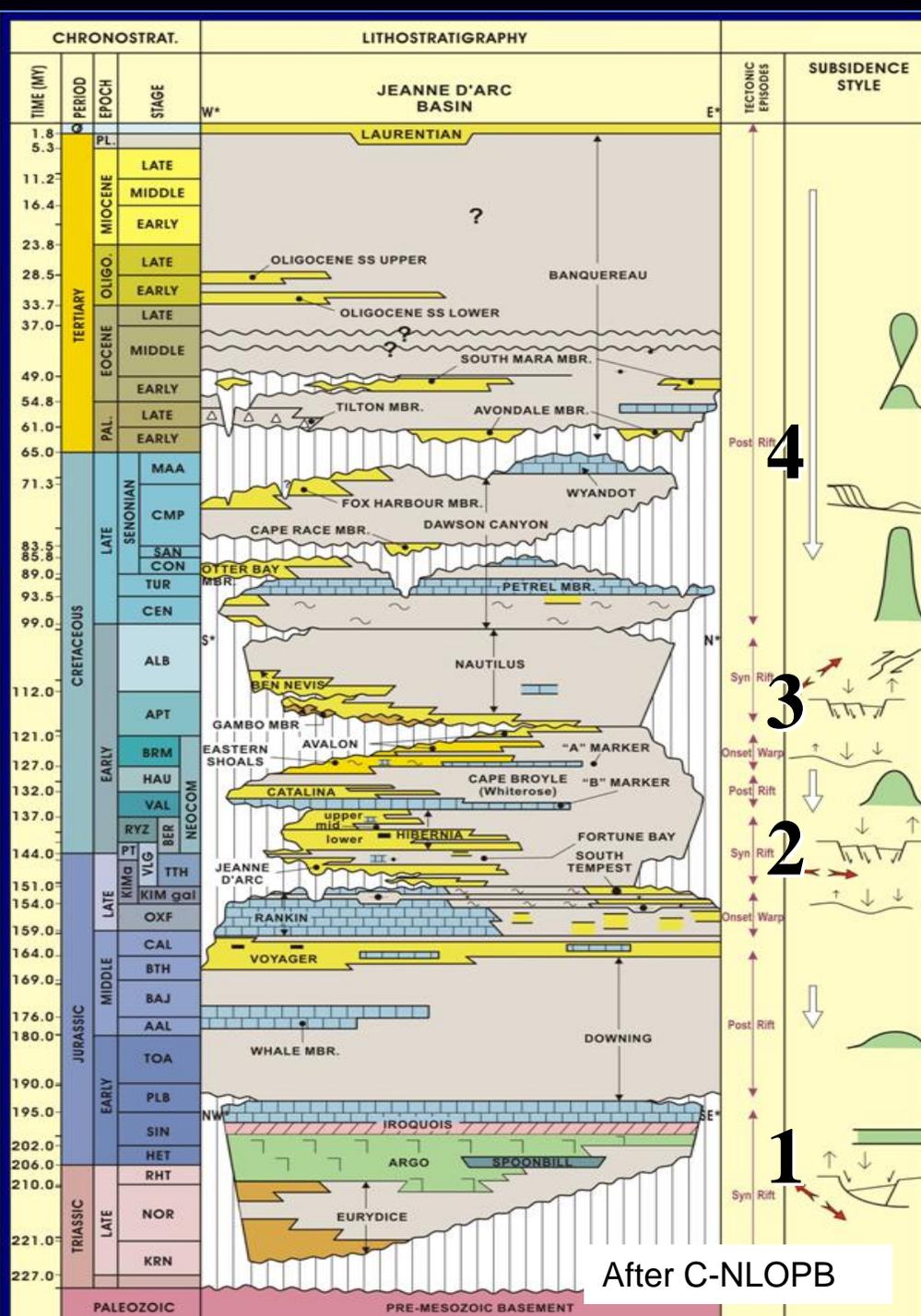
• 2 stages of transtension

2 and 3

• 1 stage of inversion

4

Variations of this chart are applied to other connected NL Mesozoic basins



After C-NLOPB

# Jeanne d'Arc Basin Recent Drilling

## Drilling (since fall 2006):

**Development:** 25 wells in Hibernia (13), Terra Nova (2), White Rose (8) and North Amethyst (2) fields

**Delineation:** 4 wells: Terra Nova I-66; White Rose C-30; North Amethyst E-17; White Rose E-28

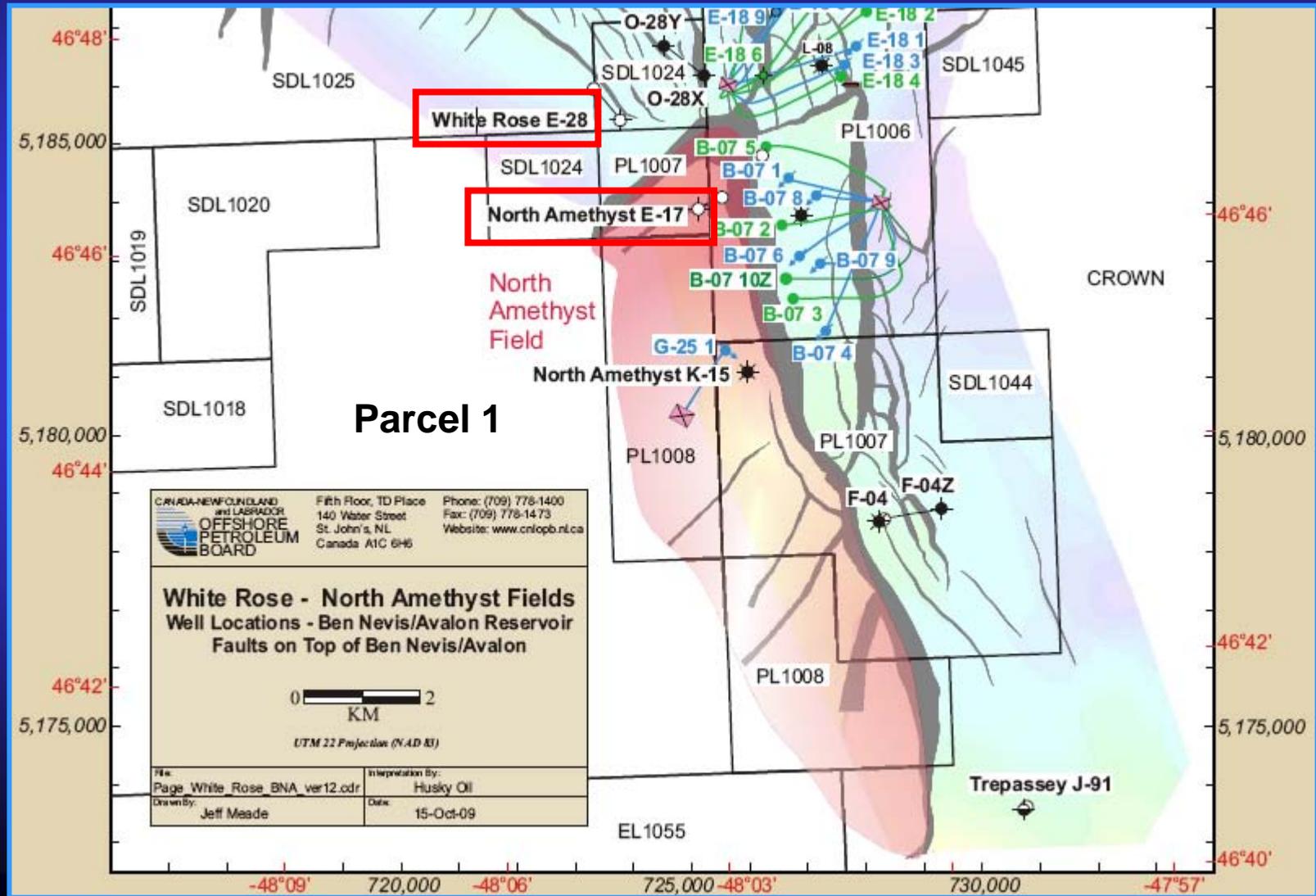
**Exploration:** 2 wells: North Amethyst K-15 (2006) Ballicatters M-96 (2009); no results are yet available for these wells

**Observation.** Rate of exploration drilling in the basin was very low but should pick up in the next few years as: 1) many ELs are getting close to expiry date, 2) development drilling is slowing down in Terra Nova and White Rose fields, 3) 2 semi submersible rigs are in the area under long term contract, and 4) a new operator (StatoilHydro) and a new entrant (Repsol) are looking for NL production

# Wells Drilled in 2008/9 within Jeanne d'Arc Basin

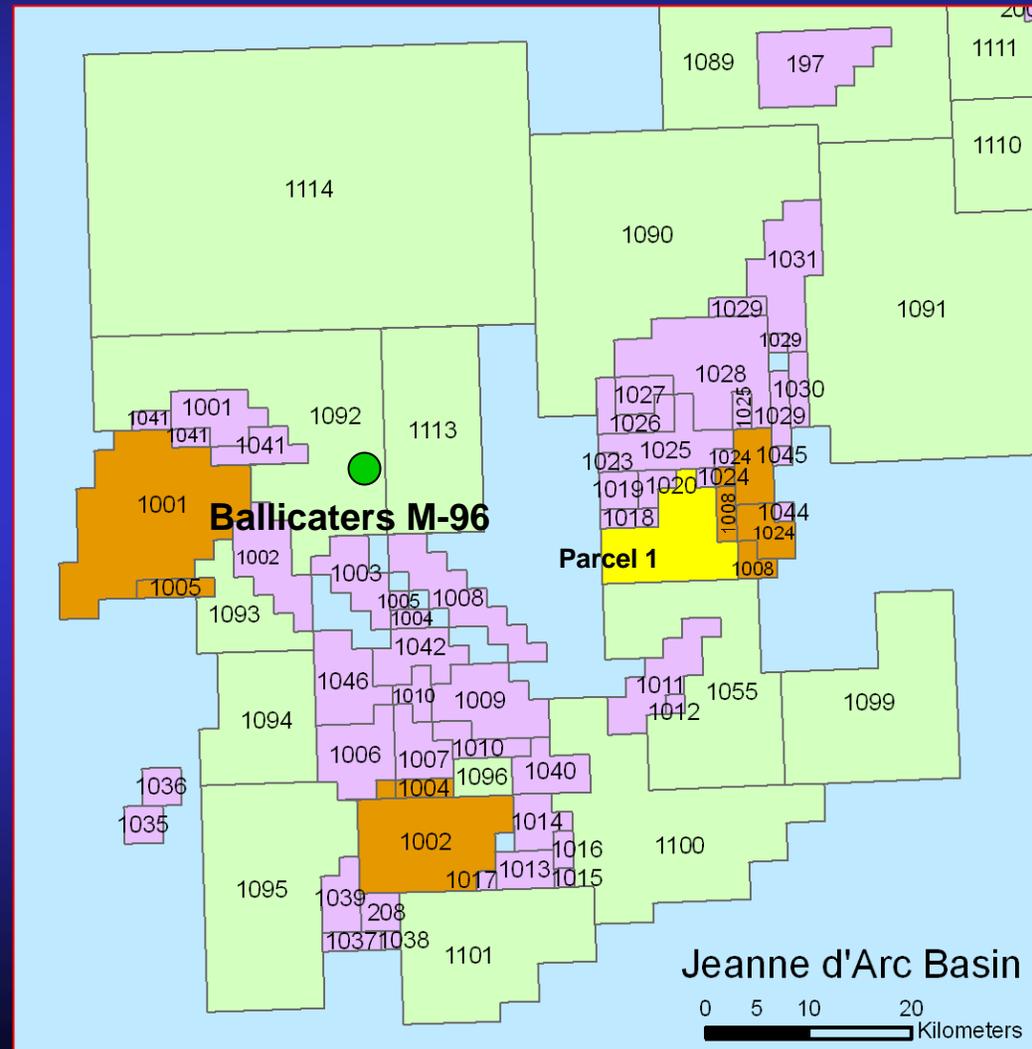
- **1. North Amethyst E-17 (Delineation) TD 2591 m**  
North Amethyst oil field is currently being developed as a White Rose satellite and first oil is expected in 2010 with an estimated production at peak of 37,000 bopd
- **2. West White Rose E-28 ( Delineation) TD 3435 m**  
W. White Rose pool will be also developed as a satellite tie-back to Sea Rose FPSO with first oil expected in 2010/11
- **3. Ballicaters M-96 (Exploration)**  
Spudded end of July 2009 and targeting both EL 1113 and EL 1092; currently being completed at 5655 m. This is a multi reservoir test for a fault-bounded rotated block within the Trans-Basin Fault Zone northeast of Hibernia field

# White Rose/North Amethyst Delineation Wells and Parcel 1



# Jeanne d'Arc Basin and Environs, 2009 ELs, Exploration Drilling and 3D Seismic Surveys

- StatoilHydro collected 738 km<sup>2</sup> 3D seismic data over ELs 1100, 1101 and the Terra Nova Field. The Terra Nova portion of the seismic survey was acquired as a 4D seismic survey over PL 1002
- Husky Energy also carried out an exclusive 3D seismic program of acquired 1437 km<sup>2</sup> over the White Rose Field, North Amethyst Field and ELs 1090, 1091, 1099



# Results of 2006&2008 Jeanne d'Arc and Environs Landsales

- **NL06-1**

- |                        |                    |            |
|------------------------|--------------------|------------|
| 1. EL 1099 (24 838 ha) | Husky              | \$ 15.5 MM |
| 2. EL 1100 (30 572 ha) | StatoilHydro/Husk  | \$ 5.5 MM  |
| 3. EL 1101 (21 009 ha) | StatoilHydro/Husky | \$ 10.4 MM |

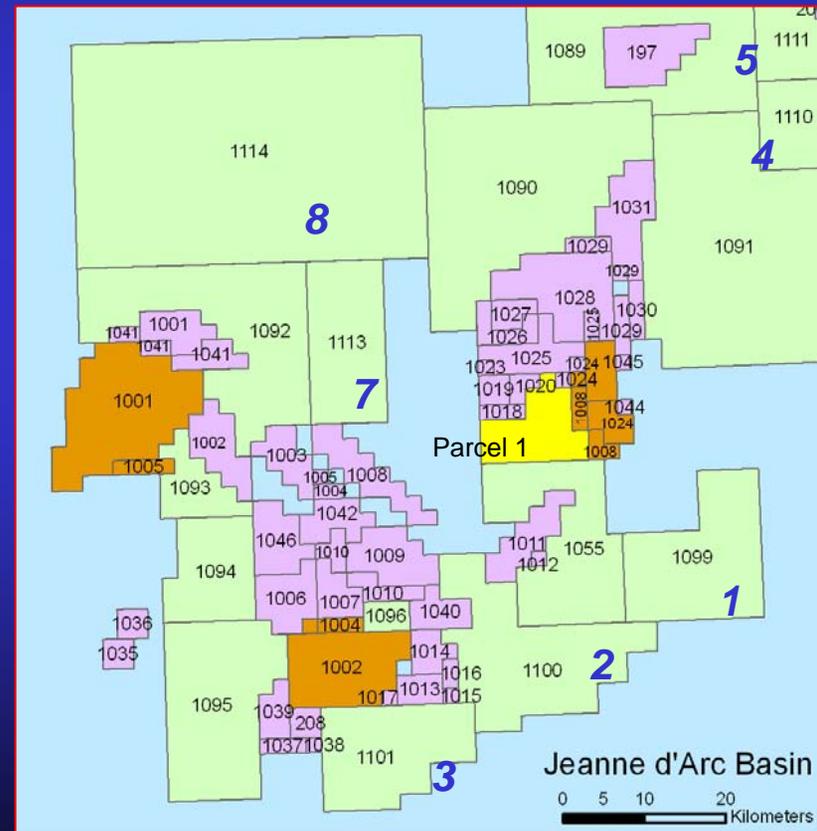
- **NL08-1**

- |                         |                     |            |
|-------------------------|---------------------|------------|
| 4. EL 1110 (138 200 ha) | Husky/Suncor/Repsol | \$ 18.6 MM |
| 5. EL 1111 (134 227 ha) | Husky/Repsol        | \$ 1.2 MM  |
| 6. EL 1112 (55 954 ha)  | StatoilHydro/Husky  | \$ 18.7 MM |

- **NL08-2**

- |                         |                     |            |
|-------------------------|---------------------|------------|
| 7. EL 1113 (19 430 ha)  | Suncor/StatoilHydro | \$ 81.9 MM |
| 8. EL 1114 (121 348 ha) | Husky/Repsol        | \$ 9.5 MM  |

**Total \$161.3**



# 5. Petroleum Geology of the Jeanne d'Arc Basin

**Source Rocks**

**Reservoir Rocks**

**Seals**

**Hydrocarbon Traps**

**Maturation and Migration**

**Hydrocarbon Plays and Risks**

**Egret Petroleum System**



# Petroleum Geology

- Jeanne d'Arc Basin is a hydrocarbon prolific basin that contains almost exclusively all the oil volumes discovered offshore Newfoundland
- The basin's infill contains structured synrift rock successions (includes evaporites, carbonates and coarse and fine clastics) ranging in age from Late Triassic to late Early - Cretaceous (Extensional Stage sedimentary sequence)
- Oil prone source rocks are present in Late Jurassic (Calloviaian, Oxfordian and especially Kimmeridgian); the potential for other source rocks is recognized within the Early and Late Cretaceous and Early Tertiary
- The early sedimentary fill contains the Argo Salt that later became mobile and created salt induced structures in the overlying sediments (e.g. White Rose Diapir, Amethyst Ridge) (Enachescu et al., 2000)
- Post rift sedimentary sequence is represented by parallel, slightly deformed sedimentary layers (mainly fine clastics and thin chalk and carbonates)

# Kimmeridgian Aged Egret Source Rock

**Abundant Type II, oil prone source rock with up to 9% TOC**

- Over 25 exploration wells have penetrated the Egret Mbr. source rock
- Four lithological components have been identified within the Egret Member of Rankin Fm. source interval: 1) a dark-brown laminated shale (most abundant and highest oil generation potential); 2) a grey to grey-brown shale; 3) a light brown marlstone/limestone; and 4) a fine-grained sandstone and siltstone (Bateman, 1995)
- Thickness ranging from 50 m to well over 500 m at Panther P-52
- Best marine source rock within the North Atlantic rift system
- Proven Distribution in Jeanne d'Arc Basin to the South (Hibernia, Terra Nova, White Rose etc.) and to the East (Panther, S. Tempest, Bonanza)
- Proven distribution in northern Flemish Pass Basin (Baccalieu and recently both Mizzen wells)
- Occurs within north-south and/or northeast-southwest trending deep basins

# Reservoirs

**Reservoirs rocks in the Jeanne d'Arc Basin are predominantly high porosity-high permeability sandstone of Late Jurassic to late-Early Cretaceous age. More than 98% of the discovered petroleum resides in these reservoir rock units.**

- Stacked sandstones intervals within the Jeanne d'Arc, Hibernia, Catalina and Avalon/Ben Nevis formations are proven quality reservoirs. Most of these reservoirs are alluvial or deltaic
- Individual wells have tested in excess of 50,000 bopd from the Hibernia Sandstone at Hibernia, and in excess of 40,000 bopd from the Jeanne d'Arc Sandstone at Terra Nova
- Excellent reservoirs are found in Late Jurassic Voyager and Late Cretaceous Dawson Canyon formations (Otter Bay and Fox Harbour members) and the Paleocene Avondale and South Mara members of the Banquereau Formation, but to date only a couple of smaller pools have been encountered at these levels
- Early Tertiary sequence has a real and effectively untested potential for large oil and gas pools (especially in deep water)

# Seals

**Finding good seals should not be a problem in the Jeanne d'Arc Basin as the extensional and thermal subsidence stages contains a succession of very fine clastics, tight sandstones and carbonates**

- Oil and gas accumulations are sealed by thick overlying shales abundant during the Late Jurassic to Late Cretaceous (e.g. Fortune Bay, Cape Broyle (White Rose), and Nautilus shales)
- Also intra-formational shales are widespread within the rift stage clastic sequences
- Excellent regional seals are provided by fine grained Late Cretaceous Dawson Canyon Fm. and the Tertiary fine clastics Banquereau Fm.

# Hydrocarbon Traps

**Structural traps in the Jeanne d'Arc Basin are associated with rifting of the Newfoundland Margin, subsidence and formation of the deep extensional basin and movement of the Argo salt**

- The main structural traps are extensional anticlines, roll-overs, faulted anticlines, faulted and tilted blocks and elongated horsts
- Numerous salt induced structures such as pillows, domes, diapirs, ridges, allochthonous teardrops and turtle anticlines are common
- The great majority of faults are listric normal faults, but some transfer faults, accommodation zones and local inversions due to transtension and halokinesis are also forming traps
- Most of the discovered fields have a stratigraphic trapping component
- Stratigraphic traps are widespread. Paleo-valleys, basin margin and basin floor fans are abundant in the basin and contain some discovered resources

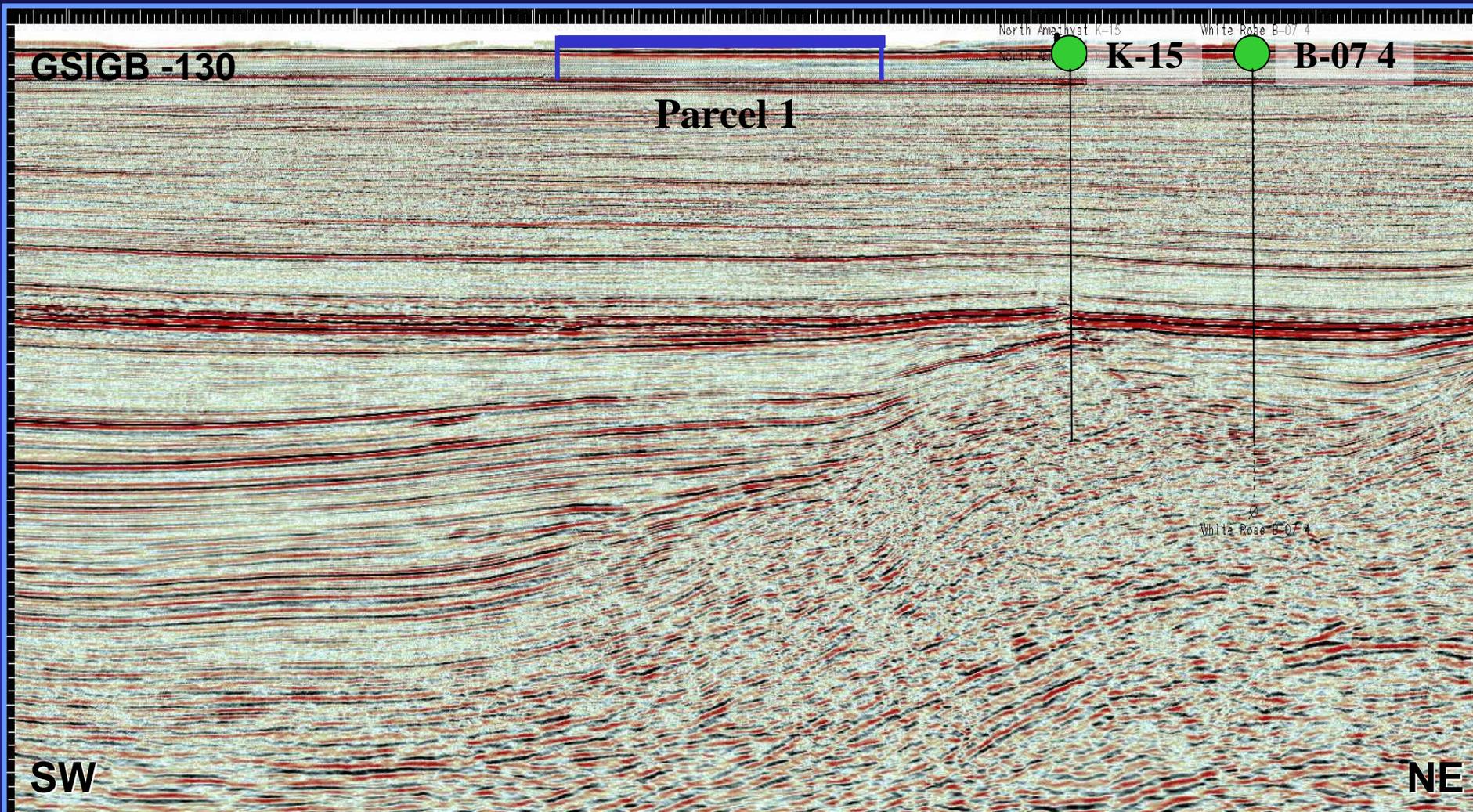
# Hydrocarbon Traps

**Structural traps in the Jeanne d'Arc Basin are associated with rifting of the Newfoundland Margin, subsidence and formation of the deep extensional basins and movement of the Argo salt**

- All major traps were found to have a stratigraphic component as the accumulations are contained in continental, deltaic and shallow marine sandstones onlapping or wrapped over the main structural traps
- Many complex or solely stratigraphic traps remain to be drilled, as well as deeper faulted blocks and rollover structures in the central and northern part of the basin
- The basin margin plays were found to be most successful
- On the east-central part of the basin, where Parcel 1 is located, the deformation of infill is due mainly to the Voyager Fault and its imbricates, and the Amethyst salt cored ridge

# Seismic Strike Line GSIGB-130

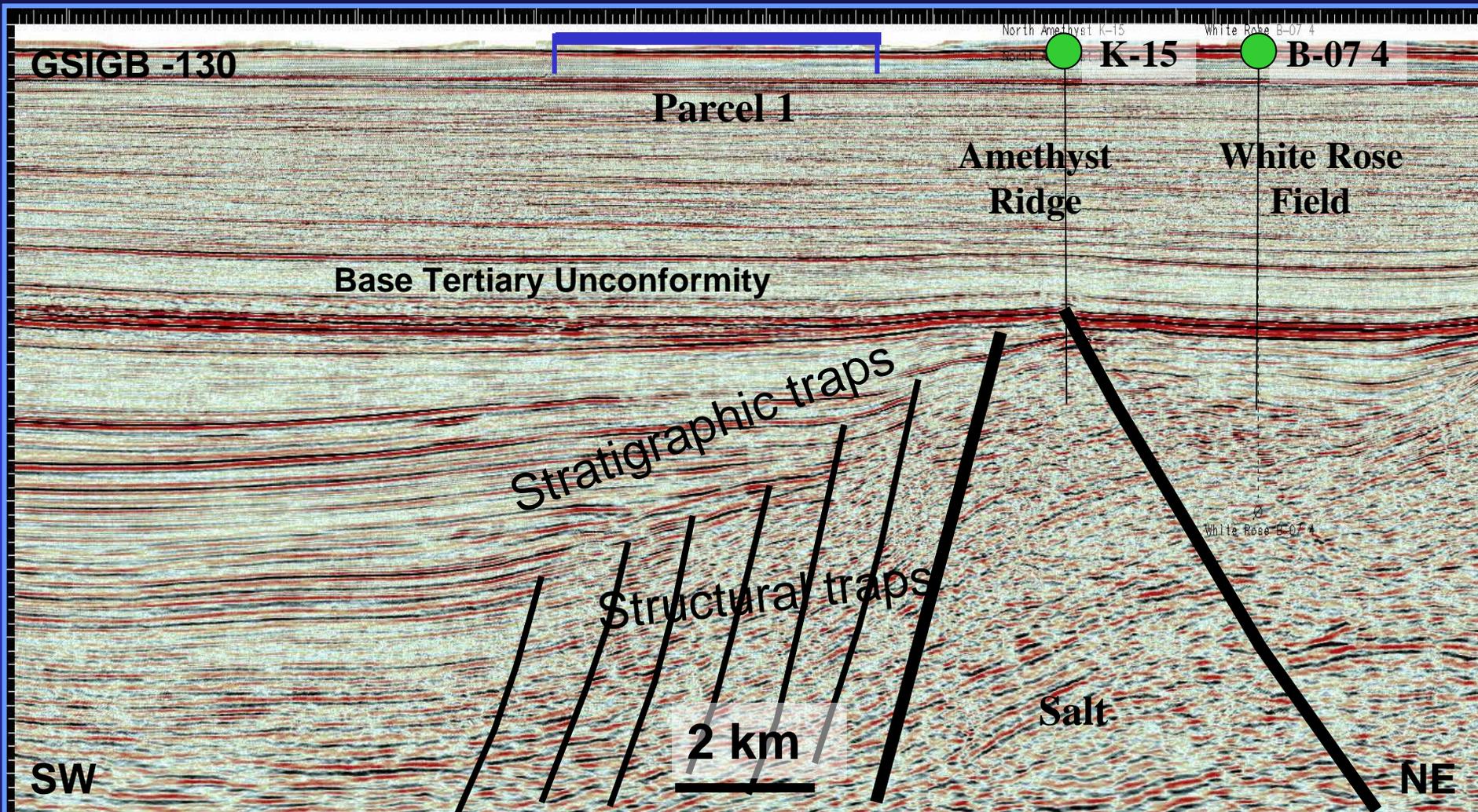
Courtesy of GSI



Uninterpreted SW-NE regional seismic section GSIGB-130 showing possible hydrocarbon traps in Parcel 1

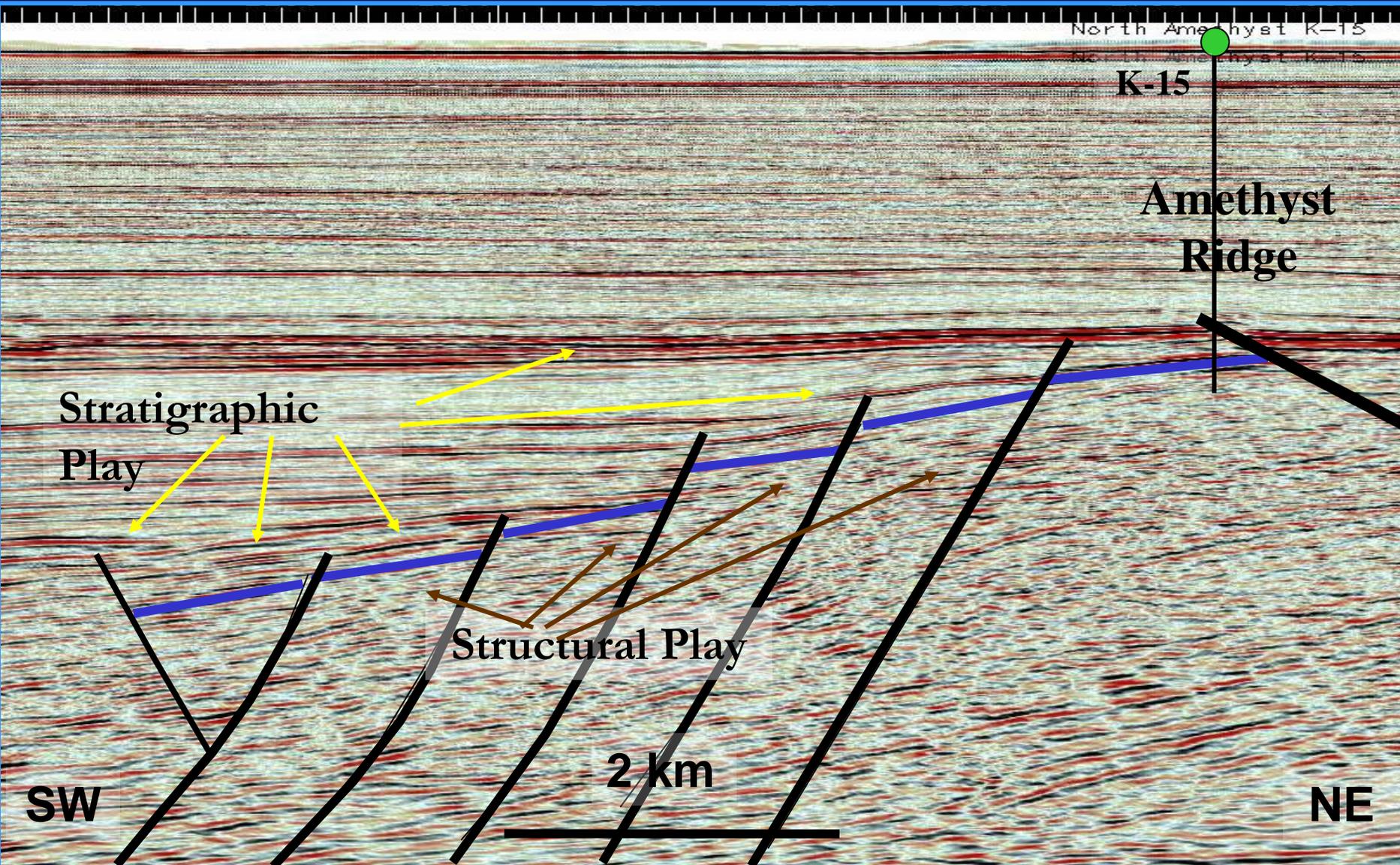
# Seismic Strike Line GSIGB-130

Courtesy of GSI



Interpreted SW-NE regional seismic section GSIGB-130 showing interpreted faults and possible hydrocarbon traps in Parcel 1

# Hydrocarbon Traps



# Maturation and Migration

- Maturation starts in mid-Early Cretaceous and continue into Tertiary
- Petroleum expulsion starts at 3800 m and ends at 5800 m
- Expulsed hydrocarbons have migrated mainly vertically, predominantly along the numerous extensional faults
- Some lateral migration occurred locally along basin flanks
- Late migration of hydrocarbons occurred within the basin marginal fans and sand filled canyons

# Hydrocarbon Plays and Risks

**Three main conventional plays are recognized in Jeanne d'Arc Basin (Enachescu 2007, Grant and McAlpine, 1987):**

- 1) Late Jurassic Jeanne d'Arc SS,
- 2) Early Cretaceous Hibernia SS
- 3) late Early Cretaceous Avalon/Ben Nevis SS

trapped in faulted blocks, parts of large, salt cored anticlines or ridges.

Other Jurassic, Cretaceous and Early Tertiary SS make secondary play

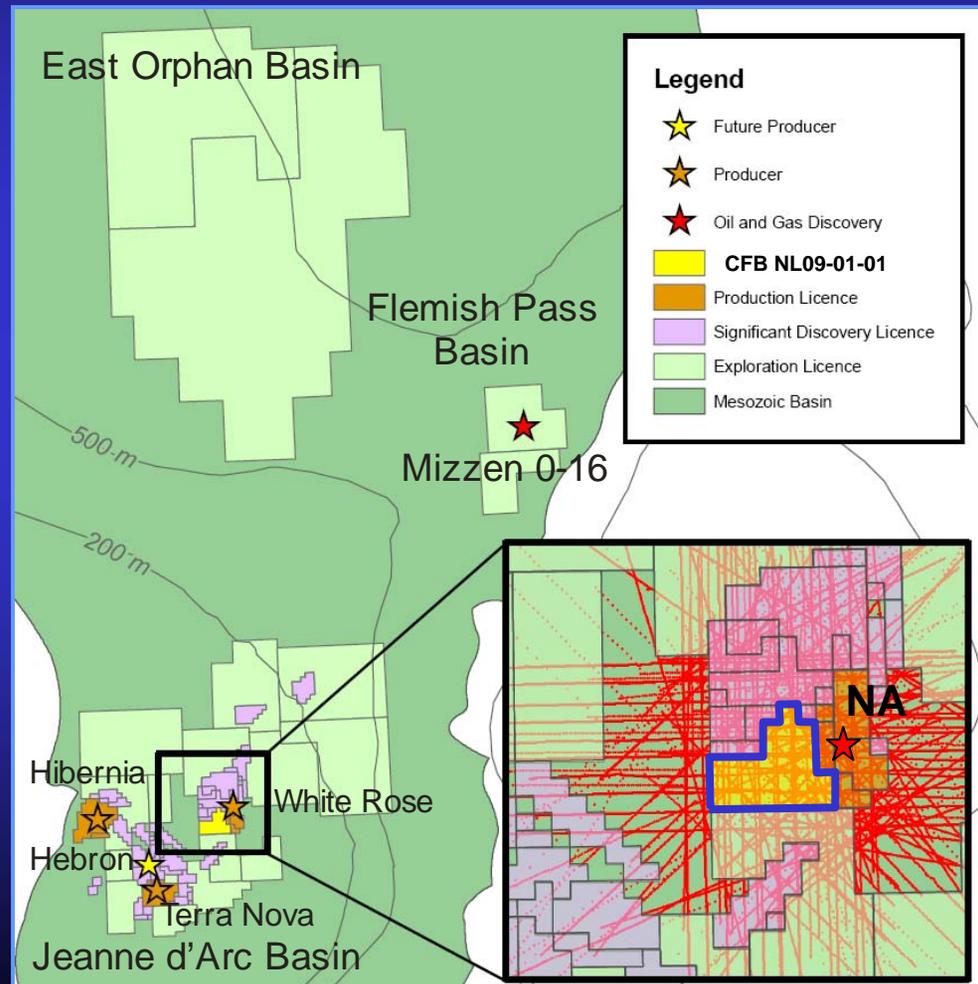
**Risks may exist re quality of reservoir and sealing across faults**

# Egret Petroleum System

- All prerequisites for the formation of large oil and gas accumulations have been identified and confirmed in the Jeanne d'Arc Basin
- The most thought after drilling targets are structural or combination traps, with plays in the Jeanne d'Arc, Hibernia, Avalon and Ben Nevis formations
- Faulted blocks were particularly successful on the eastern flank of Jeanne d'Arc Basin and in the Trans-Basin Fault Zone

# 5. Petroleum Potential of Call for Bids NL09-01 Parcels 1

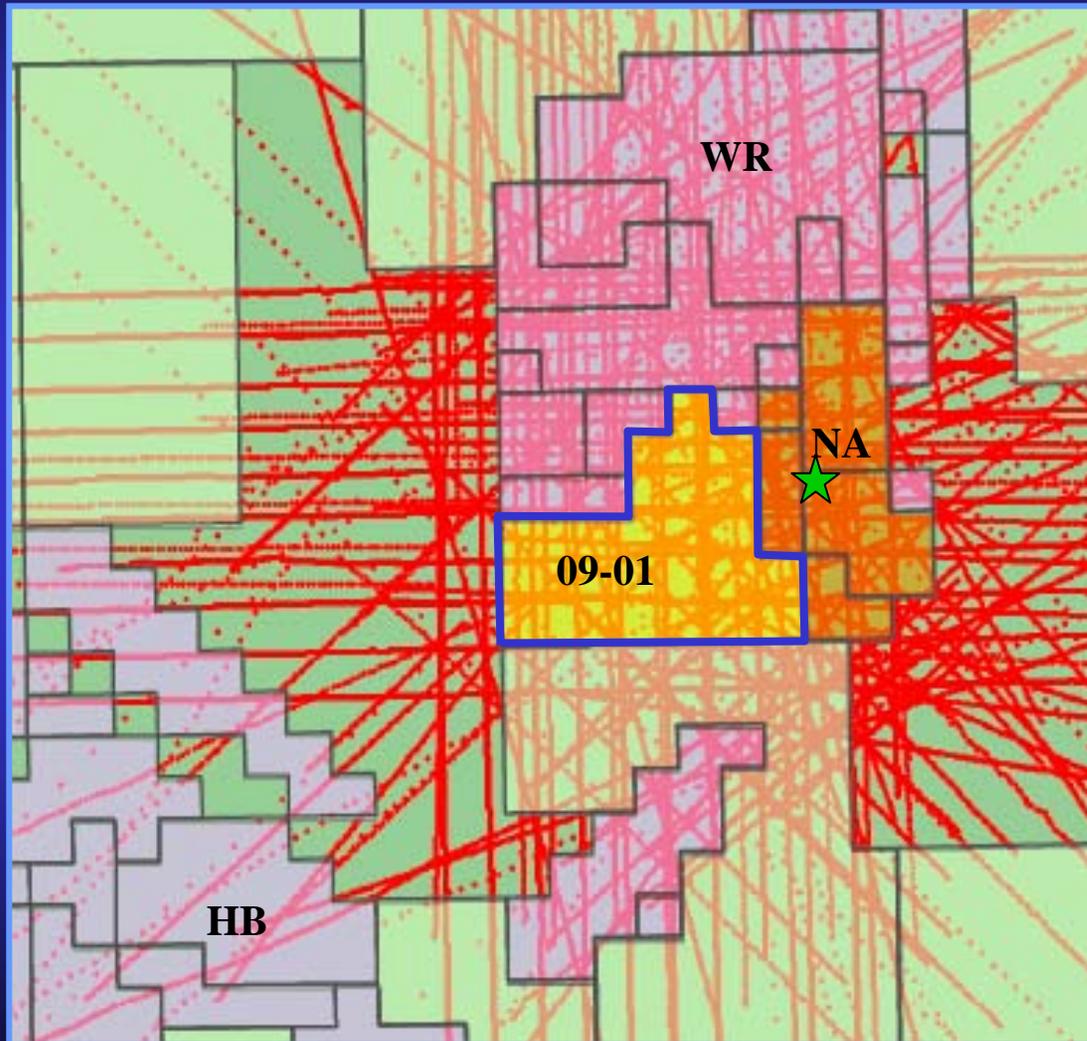
- Parcel 1 covers 9,558 ha (23,618 acres) in the eastern part of the Jeanne d'Arc Basin
- This shallow water parcel (~ 100 m WD) is close to oil producing White Rose field and in vicinity of future production from North Amethyst and Hebron fields
- Parcel is closer to other oil discoveries such as North Ben Nevis and Fortune
- Parcel is located on the south-western plunge of the North Amethyst Ridge and close to the recent North Amethyst K-15 (NA) oil discovery



# Seismic Coverage

- More than 5000 km of high quality 2D and 3D line km is available for petroleum evaluation of this parcel
- The 2D seismic grid has 0.3-1 km spacing in the dip direction and .5-1 km spacing in the strike direction
- Digital data covering the parcel and environs is owned by oil companies that acquired the data (Husky, ExxonMobil, Suncor (Petro-Canada) etc., when they had exploration licenses over the area
- Other seismic sets are available in digital form for licensing from seismic companies (GSI, WesternGeco, CGGVeritas, TGS, etc.)
- GSI has 3D data collected data directly over the parcel; WesternGeco has 3D data in the neighbouring licensed blocks
- 1980s seismic data processing done by HGS and owned now by GSI has designature applied in shot domain, velocity filters, velocity analysis every km, normal moveout and post stack Kircchoff f-k domain migration. Most lines are 40-80 fold

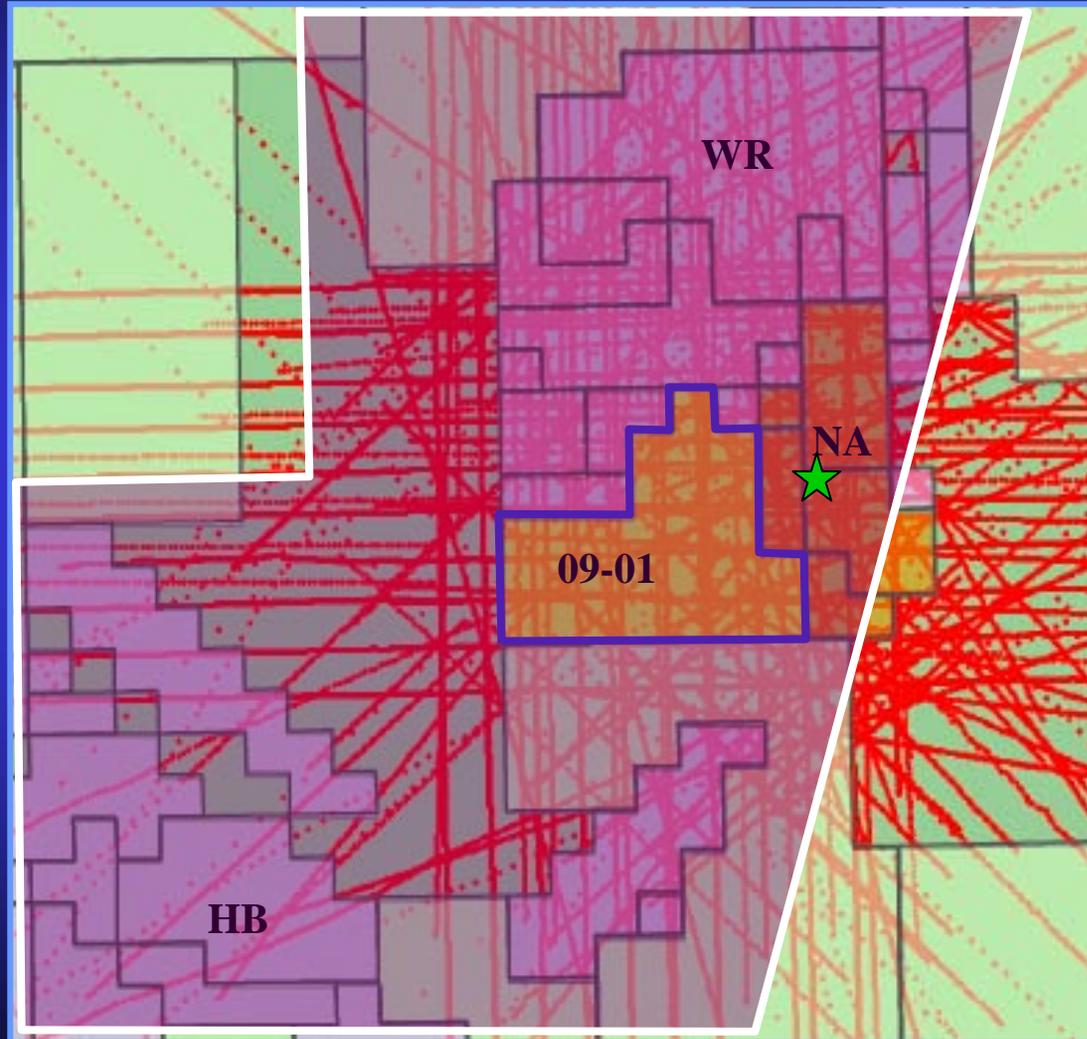
# 2D Seismic Coverage



- Seismic data quality is good to excellent for Parcel 1 and environs
- Majority of lines are post-stack time migrated; most recent data has pre-stack time migration applied
- Marine data was acquired with a 3-4.5 km streamer length during early 1980s and with a 6 km length during late 1990s-early 2000s
- The main regional 2D grid is generally E-W (dip lines) intersecting N-S tie lines (strike direction)
- A NW-SE / NE-SW 2D intersecting grid also exists
- The grid is denser in the dip direction, in which the best data quality is obtained in the synrift sequence

CFB NL09-01 Parcel 1, adjacent Exploration Licenses and current seismic coverage.

# 3D Seismic Coverage



- A large exploration 3D survey was recorded in the eastern part of the JDB in 1985 by GSI
- A one source-one streamer layout was used
- The direction of acquisition was east-west, almost perpendicular on area's major tectonic and structural elements
- Data was recorded to 7 sec and processed with a 4 ms sampling rate to 6 sec display length
- This marine data was acquired with a 200 m line spacing which was interpolated during processing to 50 m

WR = White Rose Field

HB = Hebron Field

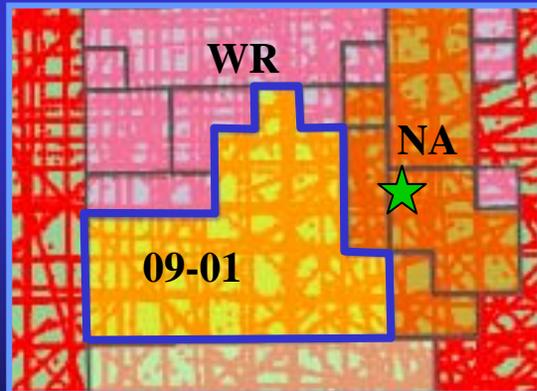
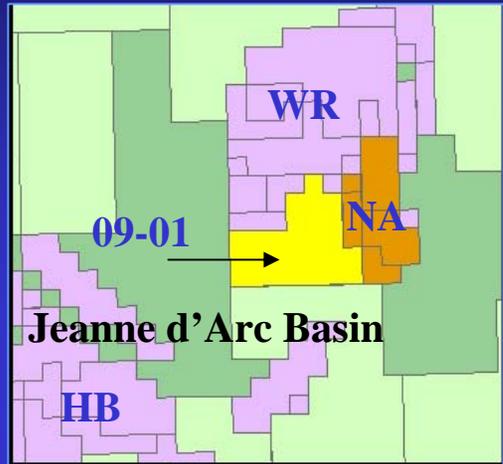
NA = North Amethyst

CFB NL09-01 Parcel 1, adjacent Exploration Licenses and current 2D and 3D seismic coverage.

# Exploration 3D Seismic Data

- Data quality is excellent in the Late Jurassic-Tertiary sequence but deteriorates in the Late Triassic-Late Jurassic interval
- Best markers are the Base Tertiary Unconformity, A Marker, B Marker and Egret or Kimmeridgian Unconformity Marker
- Main and secondary faults are easy traceable
- Deep penetration is poor due to the smaller streamer length; reprocessing might be needed to improve data quality at depth

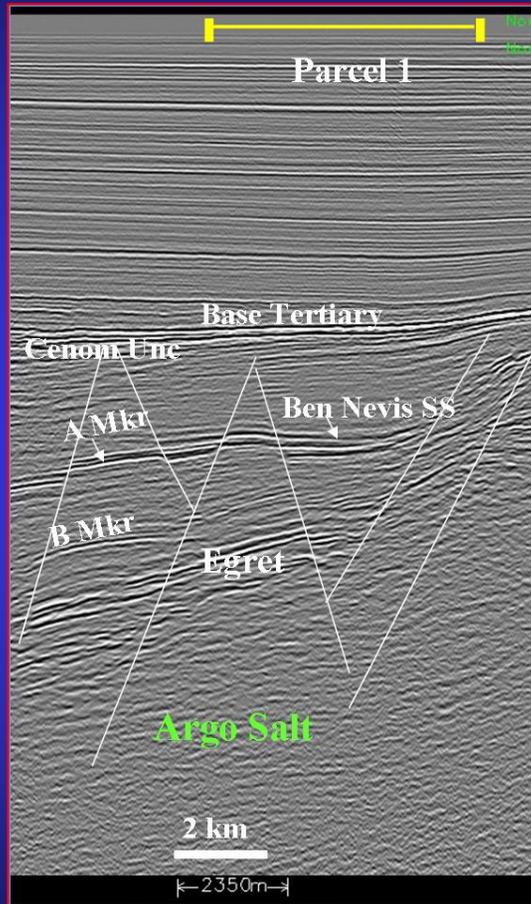
# Seismic Coverage



WR = White Rose Field  
HB = Hebron Field  
NA = North Amethyst

- Parcel NL 09-01 seismic coverage can be purchased as digital data from oil companies owners or data brokers in Calgary
- Hard copies can be obtained for the cost of reproduction from C-NLOPB in St. John's, NL
- Data grids older than 1980s are available from C-NLOPB only as individual seismic line hard copies or in microfiches

# Seismic Coverage



Courtesy of GSI

Good quality 2D and E3D seismic coverage allows for mapping of several unconformities, formation tops and carbonate and sandstone markers

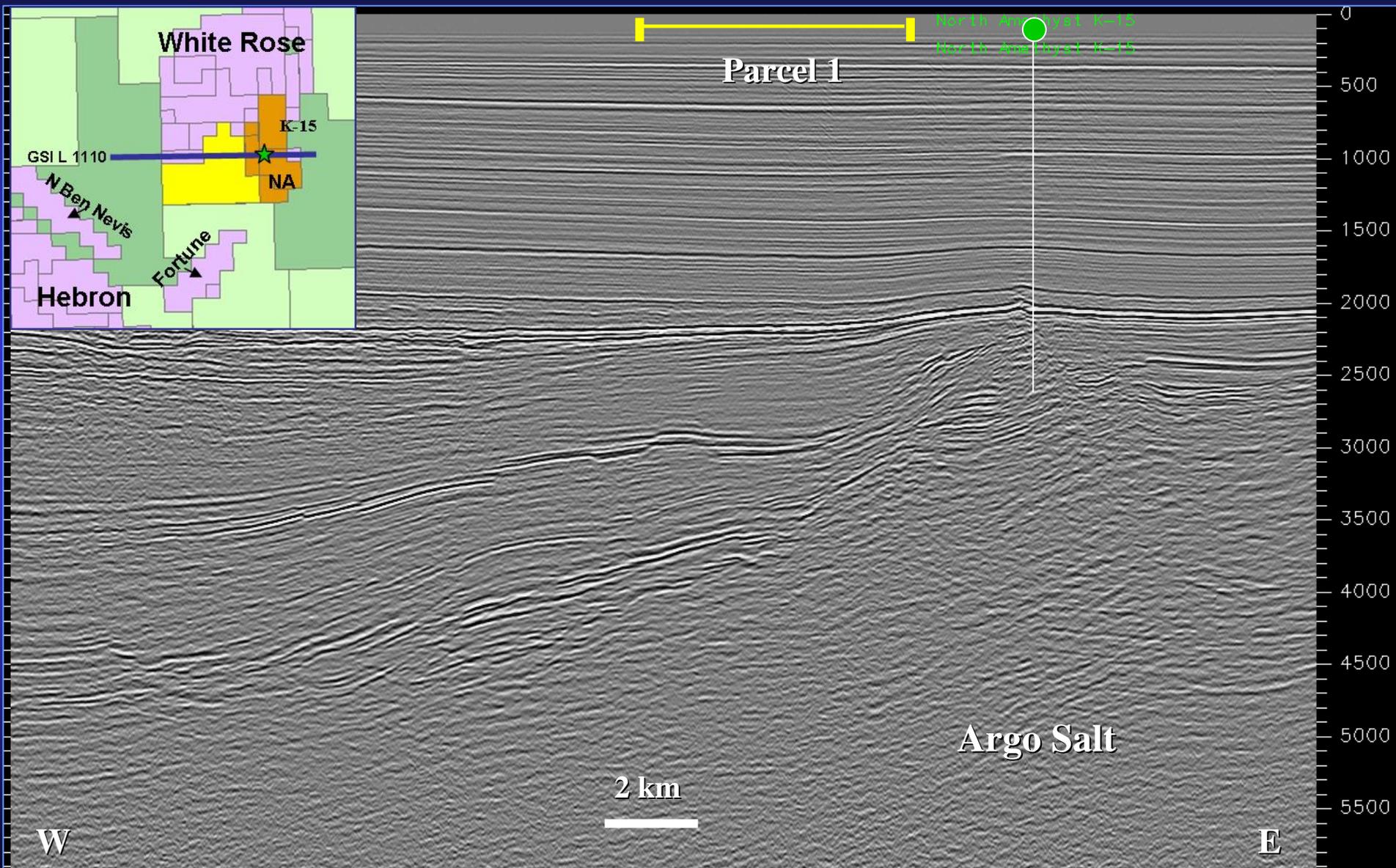
1. Base Tertiary Unconformity
2. Cenomanian Unconformity
3. A Marker
4. Ben Nevis Sandstone
5. B Marker
6. Egret (Top Jurassic) Marker

**Observation. Only a few markers will be shown on representative seismic lines**

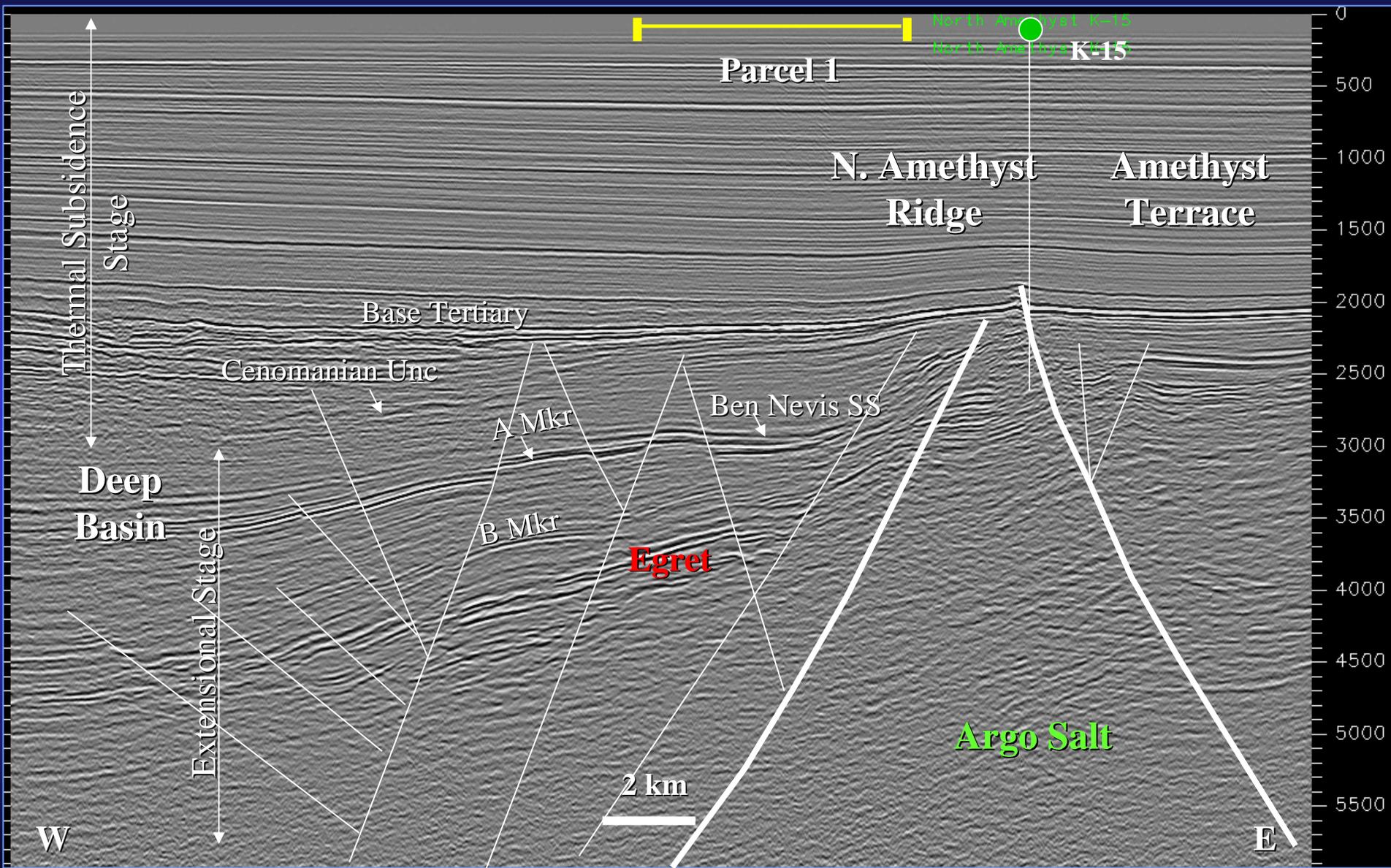
# Hydrocarbon Traps in Parcel 1

- A multitude of traps exists in the parcel. The prerift sequence is rich in structural traps; the postrift sequence contains mostly stratigraphic traps; combination traps may exist on the north-westerly plunge of the salt-cored Amethyst Ridge
- All accumulations found to date are normally pressured in structural traps
- Structural Traps are extensional features such as: horst and rotated blocks; they contain the clastic dominated Late Jurassic to late Early Cretaceous successions
- Stratigraphic traps are of the pinchout, onlap, truncation, lens types containing predominantly Early to Late Cretaceous age and possibly Early Tertiary sandstones

# Regional West-East 3D Seismic Line



# Regional West-East 3D Seismic Line



Courtesy of GSI

Enachescu, NL DNR 2009

# Maturation and Migration in the Parcel 1

- On the south-western flank of the White Rose Diapir and Amethyst Ridge the Late Jurassic Egret source rocks should be mostly in the mature range
- The earlier and most recent wells drilled closed to Parcel 1 prove that mature source rock and migration of hydrocarbons into fault traps took place
- After trap formation there were direct migration routes through porous sandstone beds and numerous normal faults from the Egret Mbr. shale into younger sandstone reservoirs
- Older than Egret source rocks are also mature in the parcel

# Hydrocarbon Plays in Parcel 1

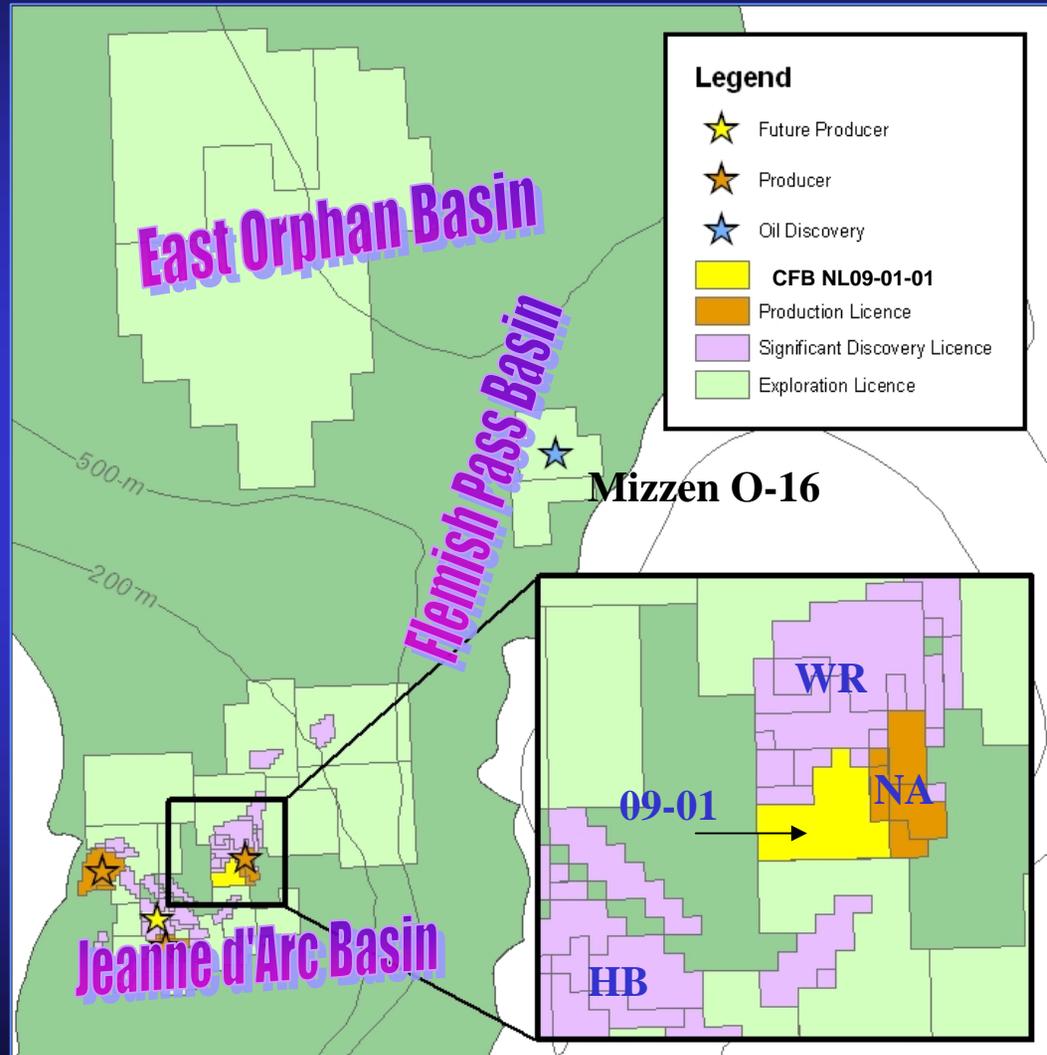
The White Rose and North Amethyst discovery and delineation wells proved that a working petroleum system represented by *the Egret source rock and the Ben Nevis Sandstone extends on the western and south-western sides of the White Rose main pool*

The late rift Ben Nevis sequence deepens south-westward into the basin through numerous steps, creating local horsts and rotated blocks bounded by deep penetrating faults

Older Late Jurassic and Early Cretaceous sandstones are also trapped on the parcel

# Seismic Interpretation

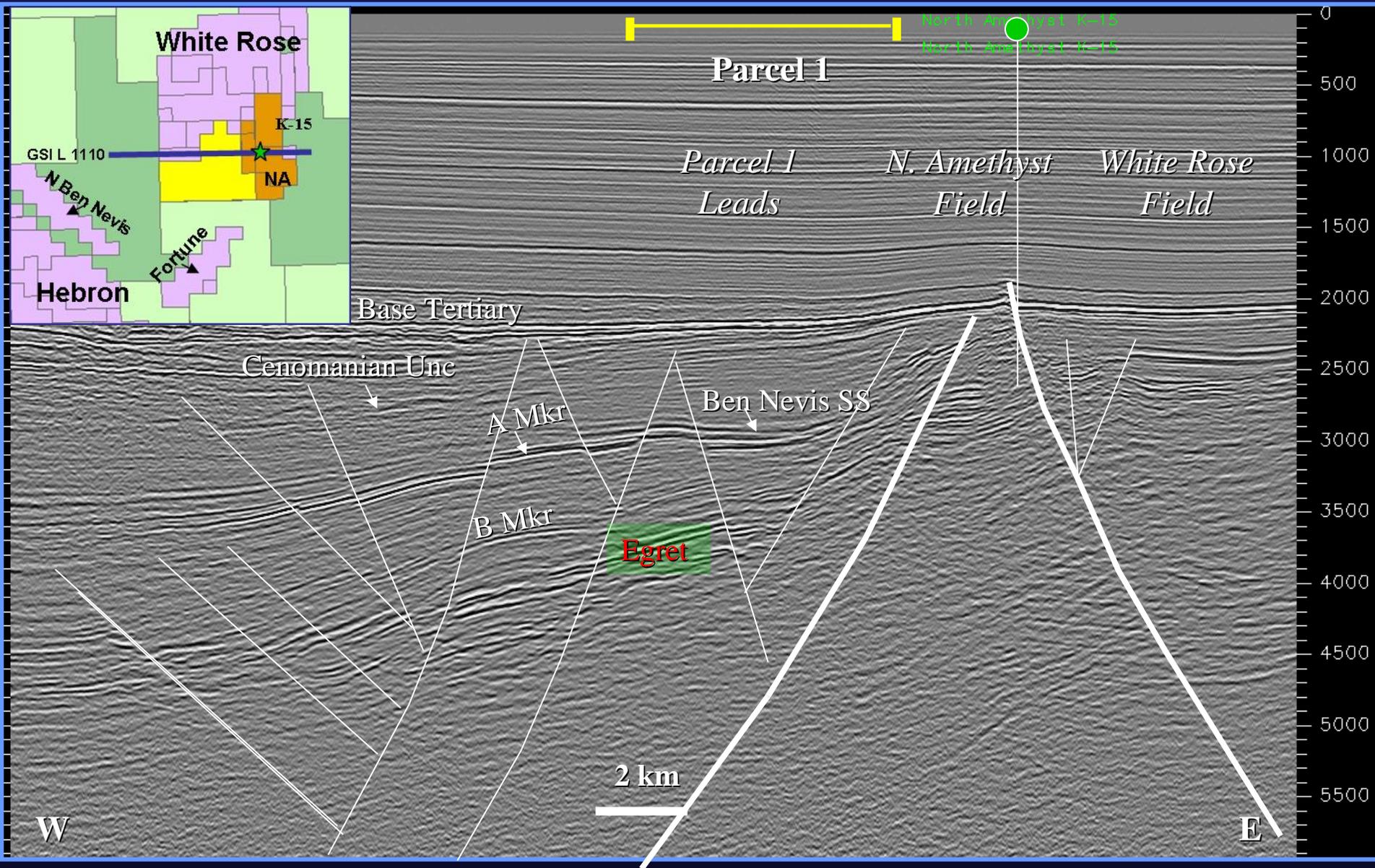
Good quality 2D and E3D seismic coverage allows for mapping of several unconformities, formation tops and carbonate and sandstone markers



WR = White Rose Field  
HB = Hebron Field  
NA = North Amethyst

CFB NL09-03 Parcel 1, adjacent Exploration Licenses, Fields and SDLs

# Regional West-East 3D Seismic Line



# Significant Wells

- No well has been drilled yet within the Parcel 1

Well	Drilled	WD m	Status	Location	TD m	Ben Nevis	Avalon	Hibernia	Test	Producer	Source
White Rose J-49	1985	116	Aband oil and gas	4 km North	4561	2956 m	3131 m	3769 m	1409 bopd	Av/Ben Nevis	not penetrated
White Rose L-08	1999	123	Susp oil and gas	4 km North	3130	2814 m	yes	not pen	2327 bopd	Av/Ben Nevis	not penetrated
White Rose A-17	1999	119.5	Susp oil and gas	3 km East	3200	2867 m	yes	3083	5573 bopd	Av/Ben Nevis	not penetrated
North Amethyst K-15	2006	119	Abandoned oil	2.5 Km East	2506	2312 m		eroded	no	Ben Nevis	not penetrated
White Rose F-04	2003	119.4	Aband oil and gas	2.5 Km East	2994	2779 m	yes	eroded	no	Ben Nevis	yes
Amethyst F-20	1989	118	D&A	4 km SE	3305	2146 m		2306 m	no	no	not penetrated
Fortune G-57	1986	113	Abandoned oil	6.5 km S	4995	2413 m	2695 m	3294 m	6978 bopd; 8.4 MMcfd	Hibernia	Yes
N Ben Nevis M-61	1986	100	Aband oil and gas	20 km SW	3250	2990 m	3093 m	not pen	5000 bopd; 18 MMcfd	Ben Nevis	not penetrated

# Significant Wells

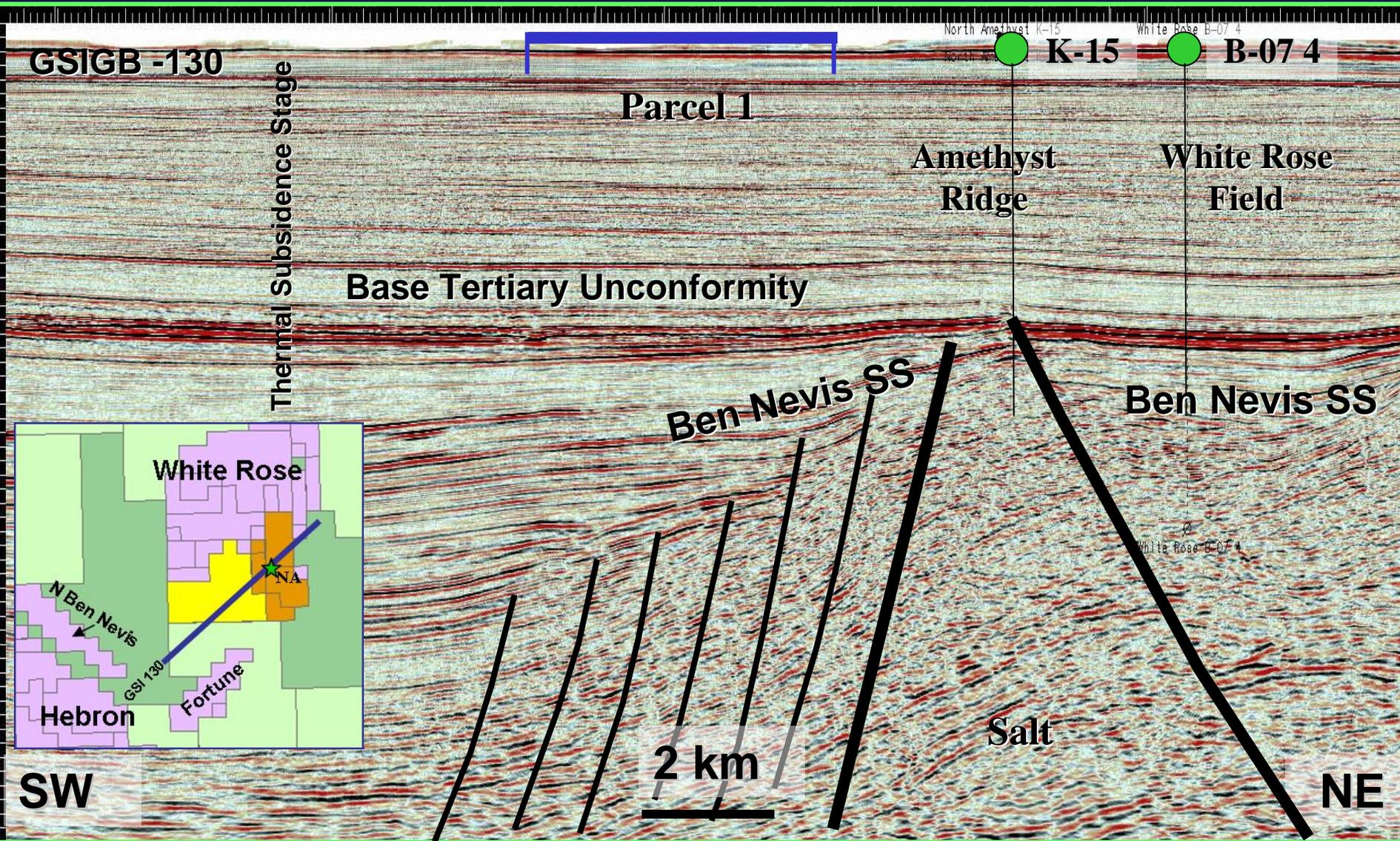
- 8 wells drilled in vicinity of Parcel 1
- First well J-49 drilled 1985 last K-15 in 2006
- 7 out of 8 wells encountered oil and gas
- Several well flow tested between 1400 and 7000 bopd with restrictive equipments; wells in the neighbouring South White Rose pool are capable of producing 25-35,000 bopd
- Oil wells group in the West White Rose, South White Rose, North Amethyst, Fortune and North Ben Nevis pools
- Only Amethyst F-20 drilled down dip on a large anticline to test its upside was dry missing the crestal oil leg on the Amethyst Ridge
- The North Amethyst K-15 and later E-17 intersected the Ben Nevis sandstone that has better reservoir properties than in adjacent area to the north and east
- At least half billion barrels discovered around the Parcel 1

# Seismic Interpretation

- Regional seismic data was tied with synthetic seismograms to several exploration wells situated outside of the Parcel 1 area
- Full synrift sequence including reservoir sandstone of Late Jurassic to late Early Cretaceous exist within the Parcel NL09-01
- On the illustrative seismic sections only a few markers and formations are displayed
- Potential reservoirs in synrift sequence include the proven Hibernia, Avalon-Ben Nevis Sandstones. These are high producing reservoirs in adjacent fields or contain pay zone in undeveloped discoveries
- Ben Nevis sandstone is the producing reservoir in White Rose, North Ben Nevis and North Amethyst fields
- Ben Nevis can be drilled with relatively shallow wells in this Parcel (2500-4000 m)
- Only major faults are affecting the thermal subsidence sequence

# Seismic Strike Line GSIGB-130

Courtesy of GSI



Interpreted regional strike seismic section GSIGB-130. Note Parcel NL09-01.

# *Seismic Line GSIGB-130*

- This regional strike line (NE-SW) starts in Crown Land, crosses the northwestern tip of the EL 1055 , stretches over the offered **Parcel 1**, the N. Amethyst field - close to the K-15 discovery well, and then intersects the southern part of the White Rose oil field and ends on Crown Land
- Structurally, the line starts in the deep basin, crosses the faulted plunge of the Amethyst Ridge, intersects the Ridge's crestal zone and then the White Rose southern terrace, formed in front of the Voyager Fault Zone (outside of this seismic line)

# *Seismic Line GSIGB-130*

- Note the position of Parcel 1 on the southwesterly plunge of the Amethyst Ridge with synrift formations affected by several down-to the basin normal faults
- Potential reservoirs in synrift sequence include the proven Jeanne d'Arc, Hibernia and Avalon-Ben Nevis Sandstones. These are high producing reservoirs in adjacent fields or contain pay zone in undeveloped discoveries

# N-S Seismic E 3D Crossline

J-49



White Rose J-49

Parcel 1

White Rose Field

West Pool

Amethyst Ridge

Plunge

Base Tertiary Unc

Cenomanian Unc

Ben Nevis SS

Egret

Hibernia SS

Fortune Block

Salt

Salt

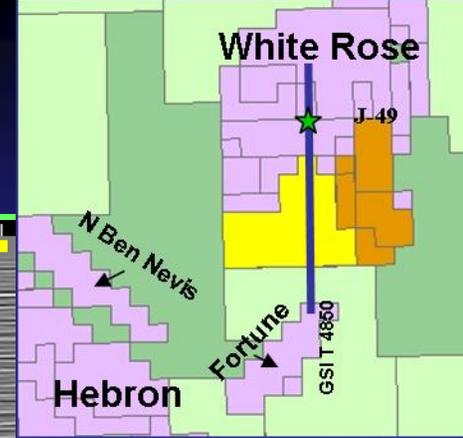
2 km

GSI E 3D

Courtesy of GSI

N

S

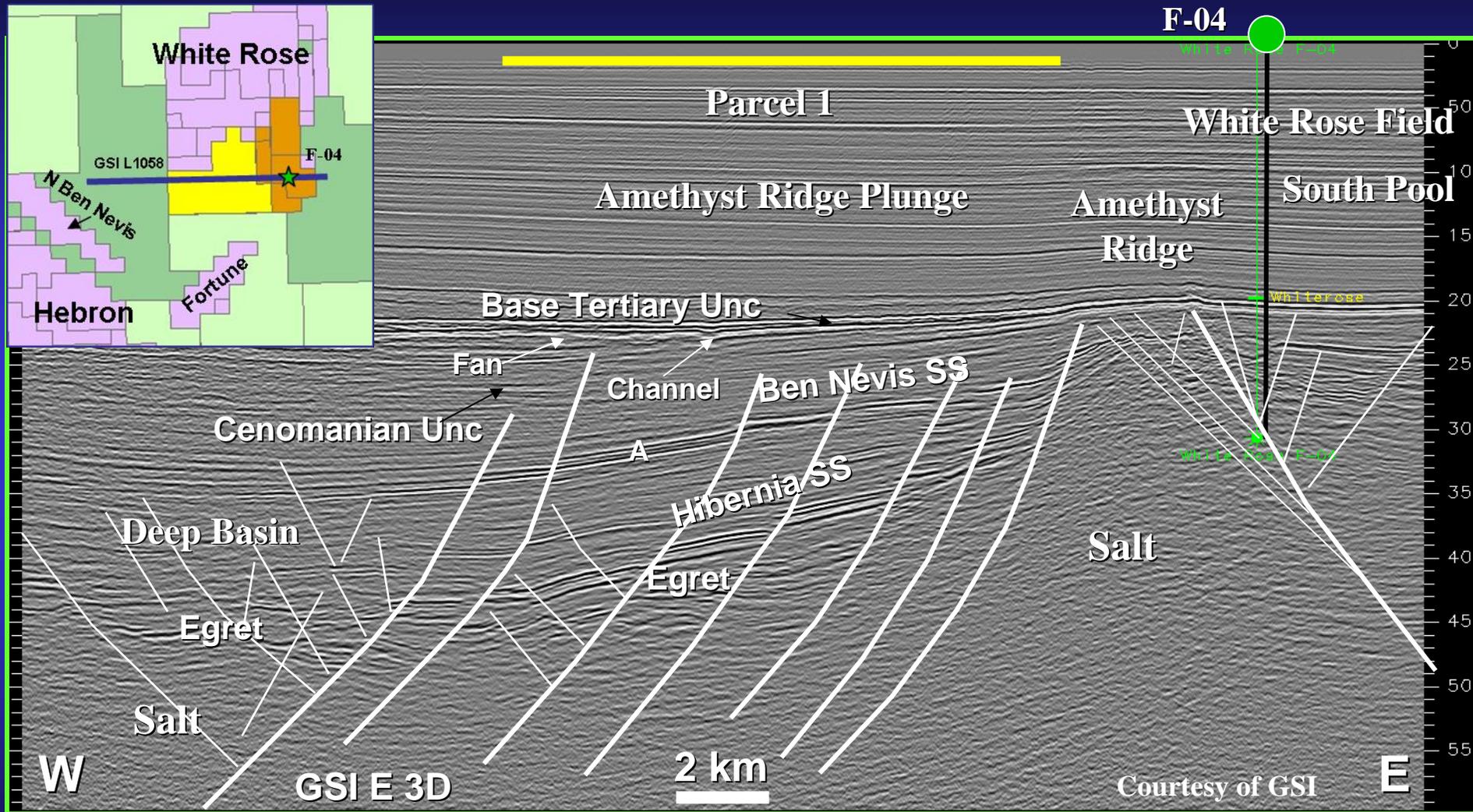


Interpreted N-S E-3D seismic cross-line within parcel NL09-01 and environs (courtesy of GSI). Several rotated blocks bound by normal faults are trapping reservoir beds.

# *N-S Seismic E 3D Crossline*

- This is a E 3D seismic Crossline starting over the White Rose Structure just north of the J-49 well that discovered the West White Rose Pool
- The Crossline continues over the salt withdrawal mini-basin between the White Rose Structure and the Amethyst Ridge; this mini-basin makes a perfect kitchen area for the Egret Mbr source rock
- The line then intersects the fault segmented northwestern plunge of the Amethyst Ridge over Parcel 1, where several rotated blocks traps are identified
- The section then terminate within the fault blocks associated to the Fortune Significant Discovery Licence that has hydrocarbons trapped into a two way fault closure at the level of Hibernia. Fortune G-57 tested 6978 bopd and 8.4 MMcfd
- Within this section, the Egret Source Rock is present as are the traditional reservoirs of the JDB; the Jeanne d'Arc, Hibernia and Avalon-Ben Nevis sandstones that may be trapped in one-way, two-ways and three ways fault closures; some independent closure may also exists
- Stratigraphic trapping of Paleocene sandstones deposited as channel or basin floor fans may also be present

# N-S Seismic E 3D Line



Interpreted W-E E-3D seismic line within parcel NL09-01 and environs (courtesy of GSI). Several rotated blocks bound by normal faults are trapping reservoir beds.

# *W-E Seismic E 3D Line*

- This is a E 3D seismic Line starting over the Deep Basin, within unlicensed land just north of the North Ben Nevis Oil field
- The line crosses over into Parcel 1, intersecting a series of rotated fault blocks bounded by down-to-basin normal faults on the northwesterly plunge of the Amethyst Ridge
- The line then intersects the North Amethyst field located directly on the crestal zone of the Amethyst Ridge. North Amethyst K-15 well has a 51 m oil column and 69 m gas column
- The section then crosses into the southernmost part of the White Rose South Pool intersecting the F-04 well location. Both White Rose F-04 and F-04Z encountered oil and gas in Ben Nevis sandstone extending the South White Rose pool
- To the east, line terminates into Crown land
- Within this section, the Egret Source Rock is present as are the traditional reservoirs of the JDB; the Jeanne d'Arc, Hibernia and Avalon-Ben Nevis sandstones that may be trapped in one-way, two-ways and three ways fault closures; some independent closure may also exist
- Stratigraphic trapping of Paleocene sandstones deposited as channel or basin floor fans may also be present

# Prospects and Leads

- Area's main hydrocarbon play is structural; it involves porous Ben Nevis/Avalon sandstones trapped within multi-sided fault bounded blocks
- Several fault dependent closures can be mapped within the Parcel; closures are capable of each holding 25 to 50 mmbbls oil recoverable depending on trap size and thickness of pay zone
- Multi-pay play is also possible in the area
- Stratigraphic trapping of Ben Nevis sands may also occur within the parcel
- Source rocks are found at expulsion depths of 3800-5800 beneath the individual rotated blocks and within the downdip SW depression
- Seismic amplitude variations are seen in the late Early Cretaceous, Late Cretaceous and Early Tertiary sequences. The variation of seismic amplitude within some of the markers, amplitude anomalies around faults and gas chimneys and curtains may indicate flow of hydrothermal solutions

# 6. Discussions

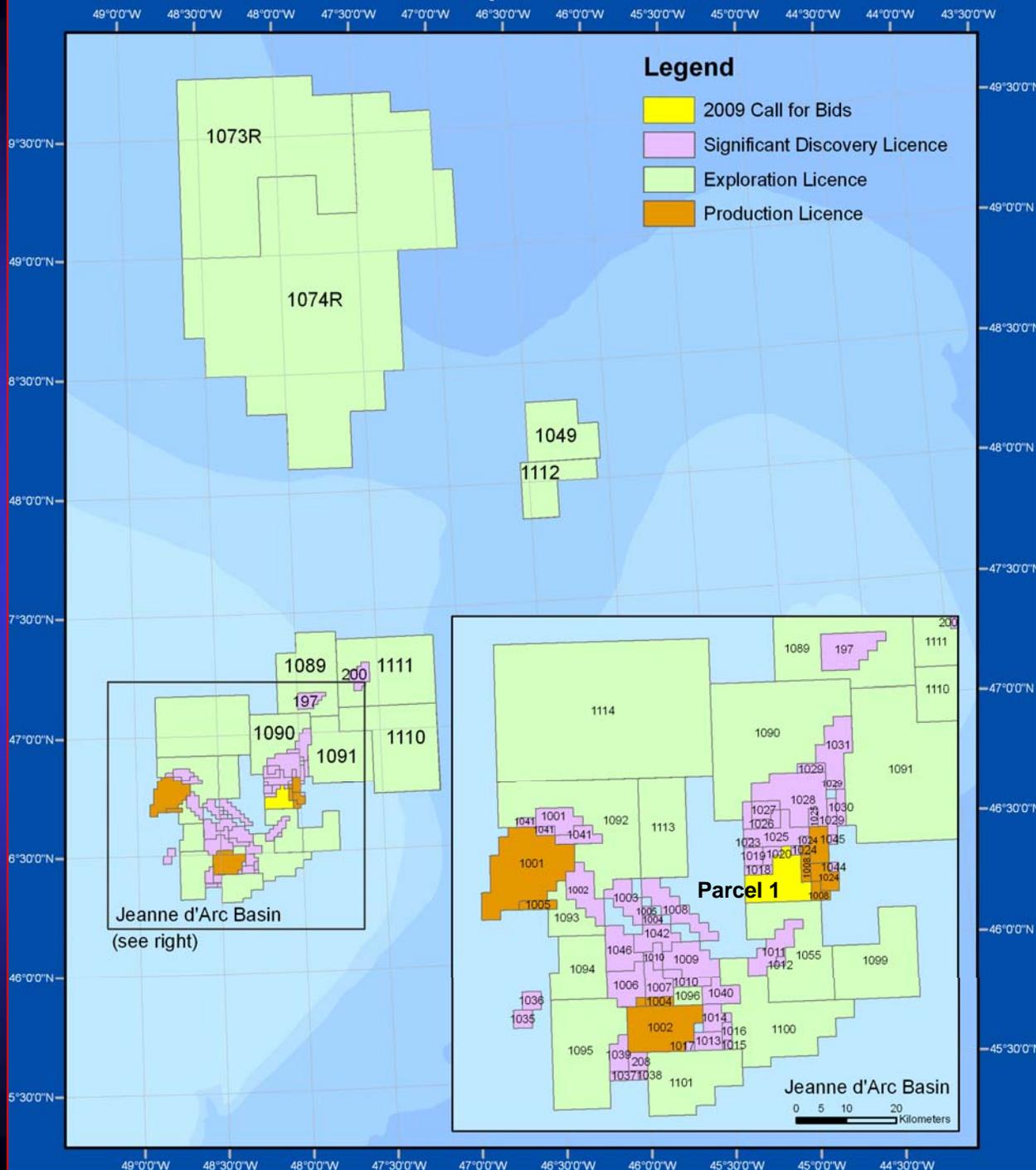
- Production infrastructure exists on this side of the Jeanne d'Arc Basin where three White Rose glory holes exist, sub bottom well completion was executed since 2003 and where tie back to Sea Rose FPSO can easily be done
- A field larger than 100 million barrels recoverable can also be a candidate for a stand alone development
- While exploration in this part of the Jeanne d'Arc Basin approaches the mature stage, there are many medium size blocks with petroleum potential that remain undrilled
- Several oil prospects and leads identified in the parcel with post-1985 seismic data are still waiting to be explored and drilled
- Parcel NL09-01 is well covered by good quality 2D and E 3D seismic data
- These data can be easily reprocessed for better structural and stratigraphic imaging; moreover, prestack and poststack analysis of the data may help reduce drilling risk

# Discussions

- The presence in vicinity of Fortune, West White Rose and North Amethyst fields provides encouragement for the potential of this parcel
- These discovery have flown at rates of 1,400-7,000 bopd in discovery tests neighbouring White Rose producers are capable of up to 35,000 in production tests
- CFB NL09-01 Parcel is larger when compared with a Gulf of Mexico standard block (4.1 times larger) or North Sea offerings
- Parcel is in a region with large extensional traps, known reservoirs, mature source rocks and proven migration paths
- Risks are recognized in regard to reservoir quality and fault sealing
- Parcel contains multiple reservoir targets within synrift sandstones reservoirs at 2500-4500 m depth that can be drilled year round and tested using jack-ups or semi-submersible rigs
- Location of prospects in a shallow water environment certainly lowers the economic risk
- Cost of an offshore well in this Parcel would likely be in the range of Can \$25 - \$45 million depending on the depth to the target

# Conclusions

- One large parcel, within the oil prolific Jeanne d'Arc Basin is available for licensing in the C-NLOPB's **Call for Bids NL09-01** which closes on **November 19, 2009, 4 p.m. NL time**
- Parcel is surrounded by 4 oil fields, some in development some awaiting development or further drilling; **over half billion barrels were discovered around the parcel**
- Parcel contains synrift clastics and carbonates including proven source and reservoir rocks
- Close to the landsale area, Ben Nevis sandstones flow-tested oil and gas at several White Rose wells and also contains oil and gas in the North Amethyst and North Ben Nevis fields
- Similar fault bounded, rotated block trap-type is viable in parcel NL09-01 together with other favourable stratigraphic trapping possibilities for sandstone reservoirs
- Several contiguous hydrocarbon filled tilted blocks, at the Ben Nevis or/and Hibernia levels may form a stand alone field development
- Additional potential may exist in Late Cretaceous and Early Tertiary stratigraphic traps
- Main source rock for the area - the Egret Member - exists in the mature range within the identified tilted blocks or in adjacent depressions
- Good quality and dense 2D and E 3D seismic coverage is available in the parcel to image and adequately map hydrocarbon traps



# 2009 Grand Banks Land Holdings and Position of CFB NL09-1 Parcel 1

# Conclusions

- Recognized risks in regard to reservoir quality and fault seal are mitigated by the presence of relatively large undrilled features and the presence of adjacent oil and gas accumulations
- Geological risk can also be reduce by using pre-stack and post-stack seismic analysis and CSEM methods
- All the prospects and leads in the parcel are located in water depth varying between 90 -110 m and close to existing infrastructure and can be drilled with relatively shallow wells (2500-4000 m)
- The half dozen prospective tilted blocks located in Parcel NL09-01 are undrilled. They can significantly add to the Jeanne d'Arc Basin recoverable reserves in the range of several hundred million barrels
- This parcel constitutes a large exploration block situated in shallow water suitable for jack up rigs in an area with proven oil accumulations
- The parcel will give a new entrant operator in the area an excellent opportunity of participating in a proven oil play located in the most rewarding basin of Canada's East Coast;
- For an existing operator the parcel provides a great occasion to increase its prospective portfolio and add significant oil reserves

# Thank You for your Attention!

