

Eastern Canadian
Continental Margin

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Geological Overview

Courtesy of Statoil

Newfoundland and Labrador

Regional Overview

The Province of Newfoundland and Labrador, located on the east coast of North America, is Canada’s offshore oil producing region. Since first oil nineteen years ago the province’s four fields in the Jeanne d’Arc Basin; Hibernia, Terra Nova, White Rose and North Amethyst have produced in excess of 1.5 billion barrels of oil. Discovered reserves/resources now total 3.9 billion barrels of oil and 12.6 trillion cubic feet of natural gas.



Geological Overview

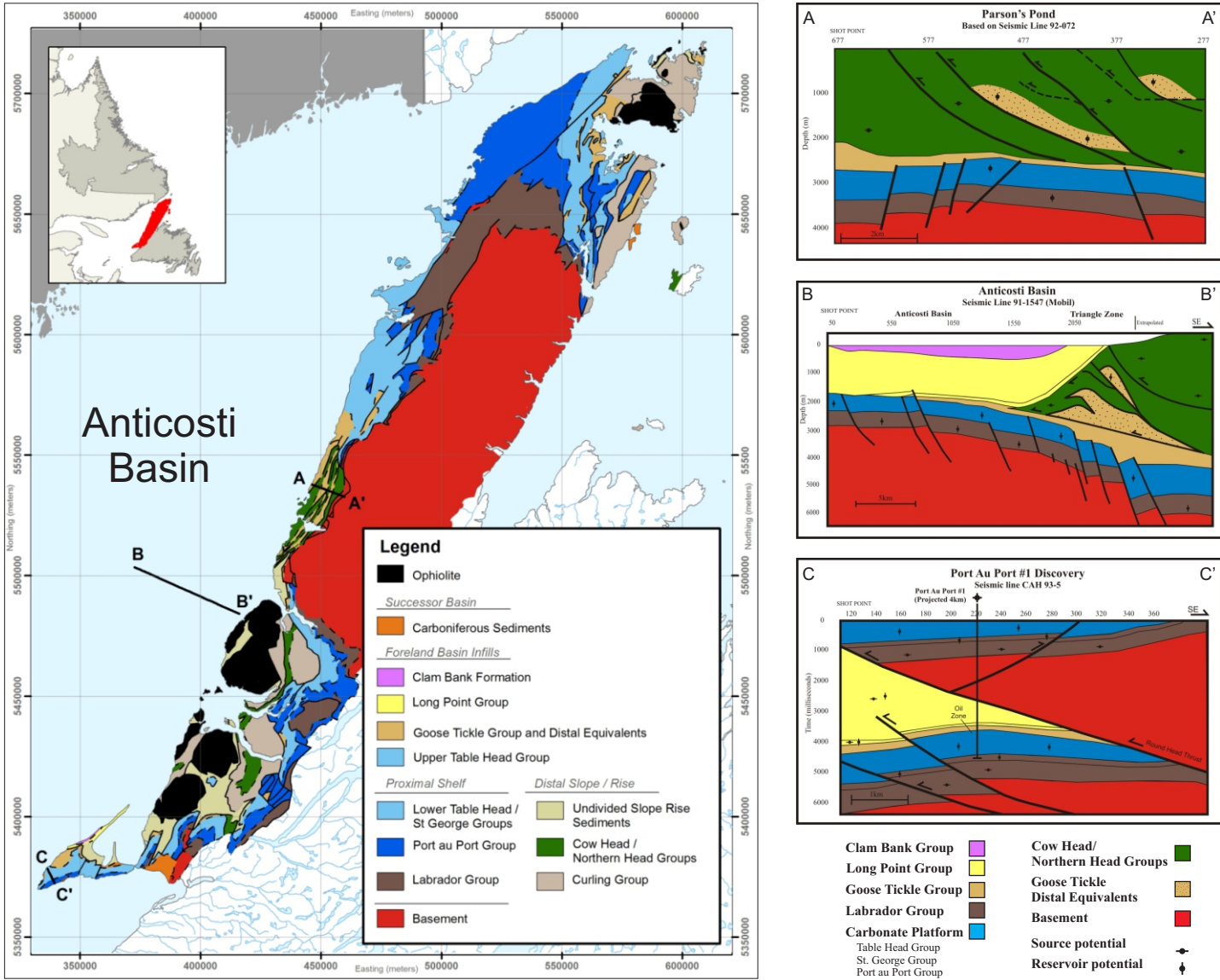
Covering almost 3 million square kilometers, onshore and offshore Newfoundland and Labrador spans the full range of Earth’s history; from Archean basement rocks onshore Labrador, to Appalachian foreland basins in western Newfoundland; to Mesozoic rift basins along the edge of the entire continental shelf, to young Tertiary basins on foundered oceanic crust in the Labrador Sea. With only 6% of its land currently under license there exists a true opportunity to acquire a large acreage position with lots of prospective land available to explore in our region.

This Geological Overview booklet is intended as an introduction to the onshore and offshore basins of Newfoundland and Labrador and is divided into sections based on basin age and region. Stepping back in geological time, the sections are:

- Offshore Labrador Basins
- North Grand Banks Basins
- South Grand Banks Basins
- Onshore Western Newfoundland Basins
 - ✓ Bay St. George Basin
 - ✓ Deer Lake Basin
 - ✓ Anticost Basin



Anticosti Basin - Geology Map



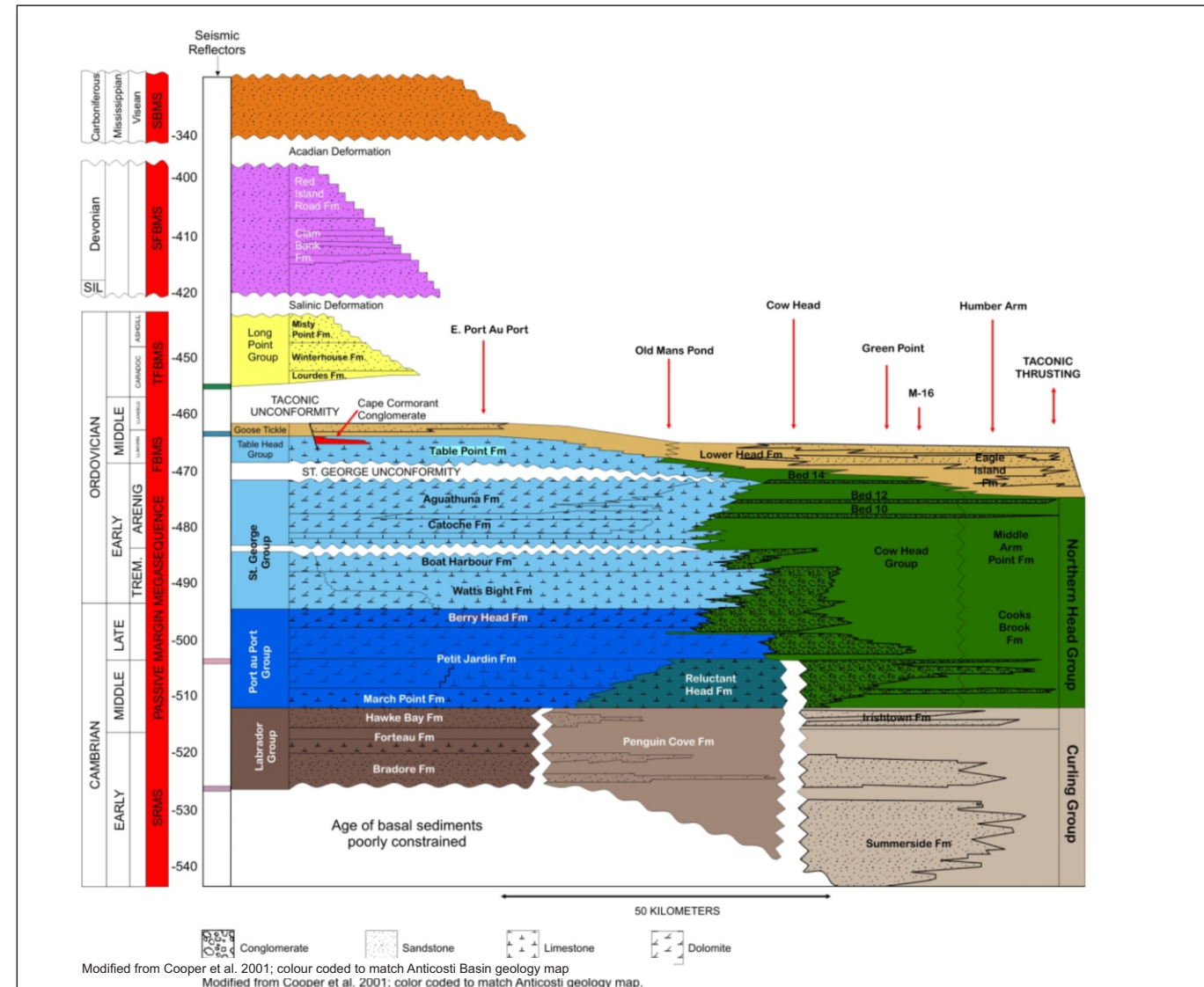
Reservoirs

- Dolomitized (also hydrothermally dolomitized) portions of the Lower Paleozoic carbonate platform (mainly St. George Group).
- Sand dominated sequences within the Hawke Bay Formation Labrador Group.
- Dolomitized carbonate conglomerates and calcarenites, and thin to thick bedded massive turbiditic sandstones within the Goose Tickle Group and the Humber Arm Allochthon.
- Flysch sandstones and marginal marine shoreline sands of Long Point Group and Clam Bank Formation.
- Silurian/Devonian aged reefs (based on seismic anomalies).

Play Concepts

- Thrusted, dolomitized and/or hydrothermally dolomitized platform (as per Port au Port #1 well).
- Horst structures and tilted fault blocks within carbonate platform sediments found beneath foreland basin cover and transported sequences.
- Stratigraphic traps; including diagenetic porosity within platform carbonates, bioherms, unconformity related or pinch-outs.

Onshore Western Newfoundland - Anticosti Basin



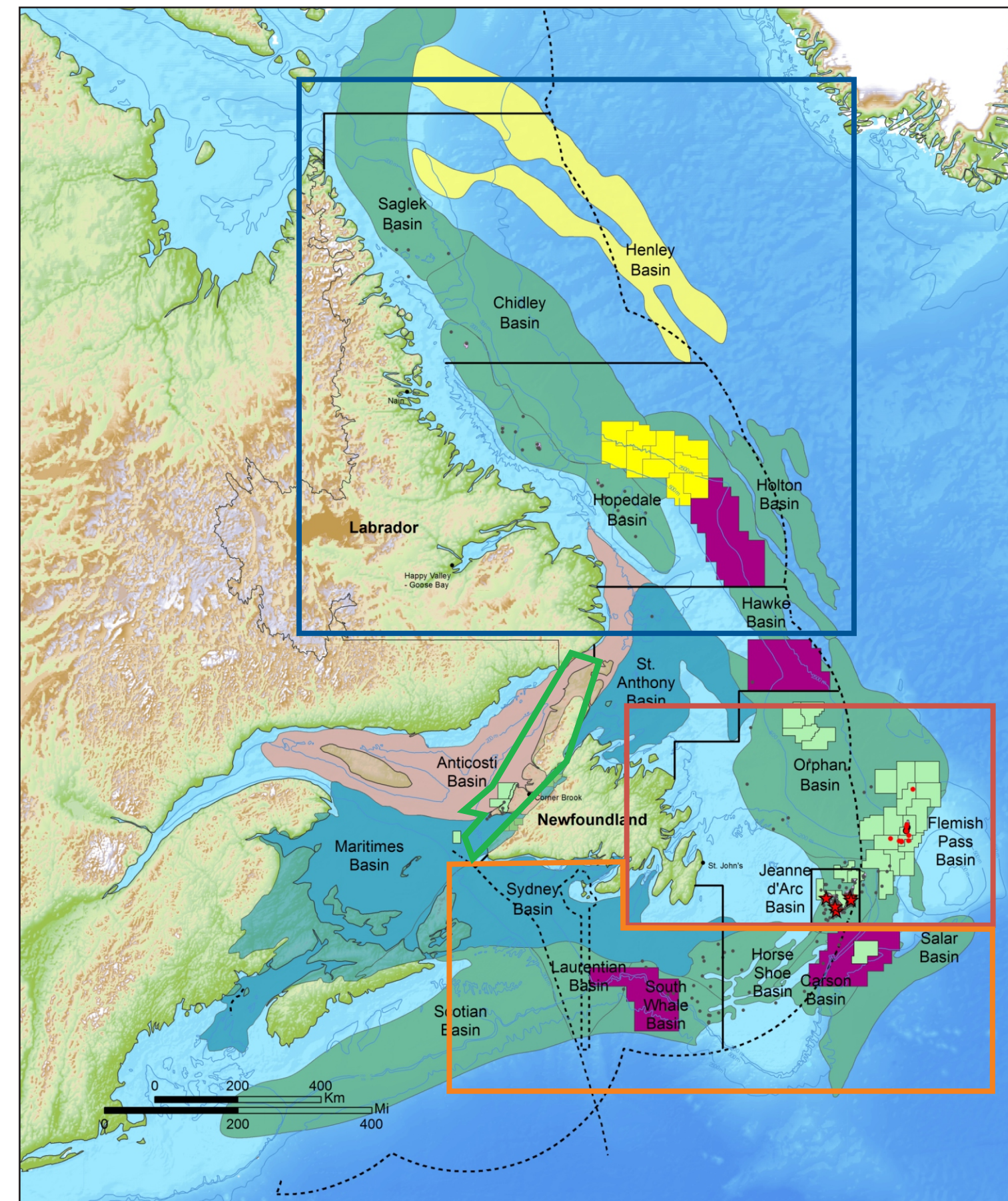
- **Area:** 13,070 km².
- **Age:** Lower Cambrian to Devonian.
- **Type:** Foreland basin developed over deformed continental margin of ancient North America.
- **Thickness:** Up to 6000+ metres, mostly marine sediments.
- **Exploration wells:** 48 (pre -1994*); 14 (recent).
- **Stratigraphic test holes:** 11 (recent).
- **Oil and gas shows:** Numerous oil and gas shows in pre-1994 and recent wells.
- **Oil and gas discoveries:** 1 (recent) Garden Hill South on the Port au Port Peninsula.
- **Production to date:** Approximately 35,000 barrels of oil through pre-production testing at Garden Hill South and unknown quantities (up to 5,000 barrels of oil) from historic (pre-1994) wells at Parson's Pond and Shoal Point.

* Wells prior to 1994 were drilled without seismic data

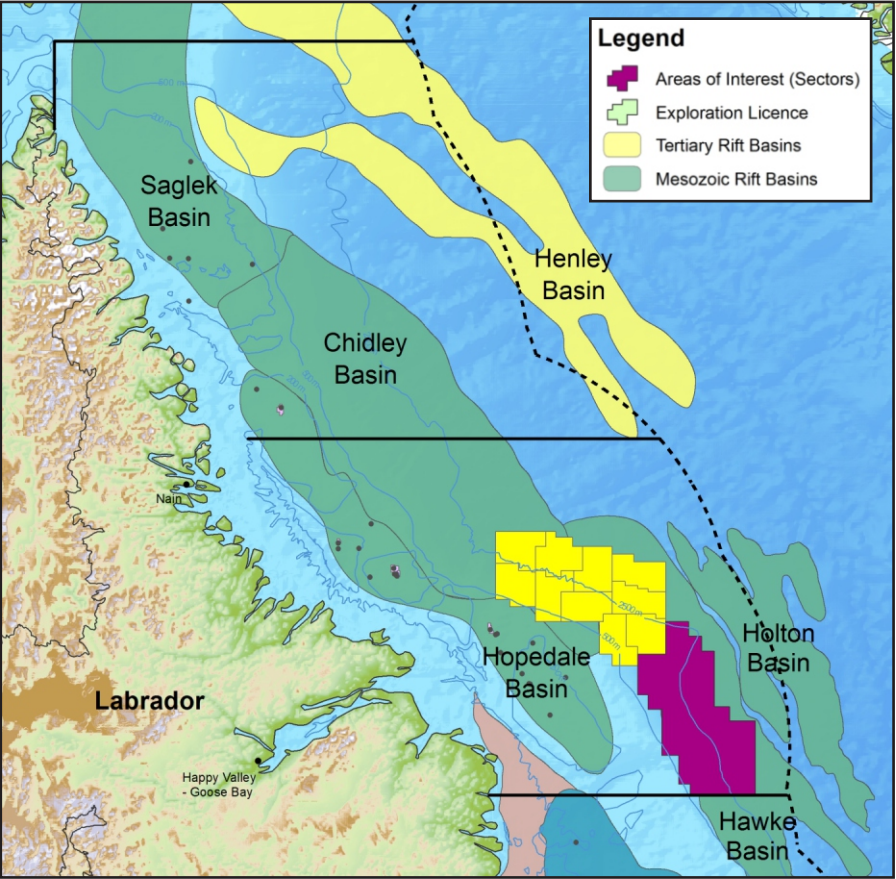
Source Rocks

- **Cow Head Group:** Green Point Formation shales, TOCs up to 10.3% (proven).
- **Goose Tickle Group:** Mainland Formation and Black Cove Fm. shales, TOCs up to 8.1% (proven).
- **Potential Source:** Table Cove Formation, Forteau Formation and Curling Group shales.

Basins Map of Newfoundland and Labrador



Offshore Labrador Basins



Area: ~ 175,000 km² (Hopedale Basin); ~ 70,000 km² (Saglek Basin).

Age: Tertiary to Lower Cretaceous. Possibly underlain by Jurassic and Paleozoic.

Type: Atlantic-type extensional margin.

Thickness: 10+ km (Hopedale Basin); 9+ km (Saglek Basin).

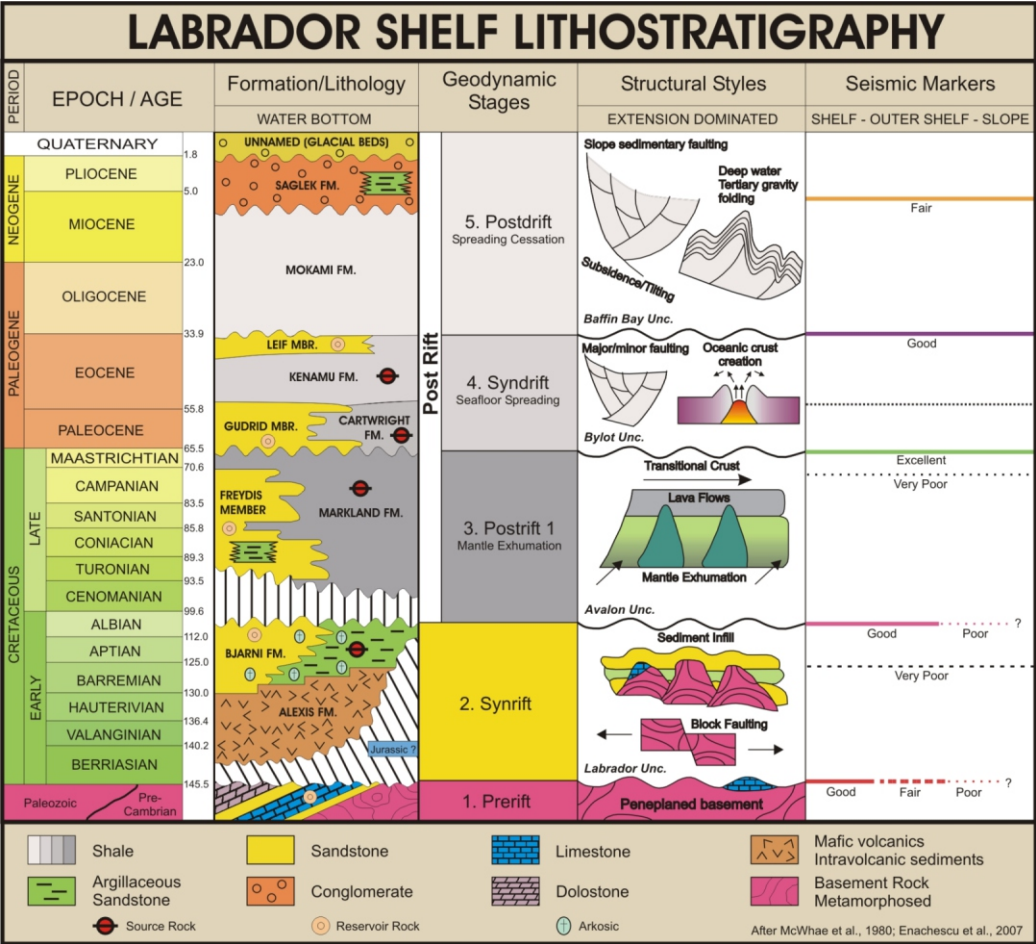
Exploration Wells: Hopedale Basin (21 wells); 16 reached planned target depth; 5 discoveries; Success Ratio ~30%. Saglek Basin (6 wells).

Oil & Gas Discoveries: Hopedale Basin (gas); 4.2 tcf recoverable. Hopedale Basin (oil show) in North Leif I-05 (33° API).

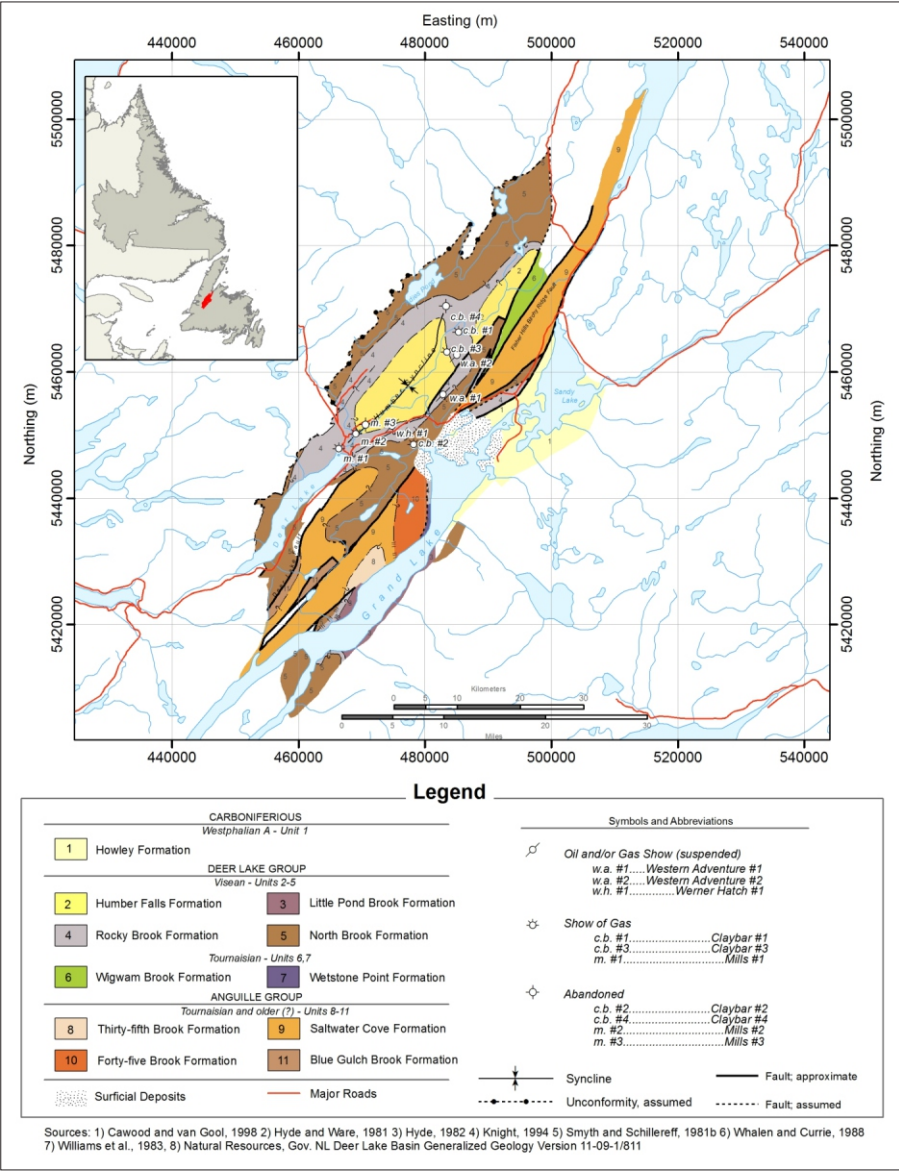
Undiscovered Gas Potential: Estimated at 22 tcf.

Available Seismic:

- 165,000 line km 2D data.
- 42,000 line km since 2002.
- Numerous amplitude anomalies and other DHIs observed throughout the Cretaceous- Tertiary section.
- AVO anomalies
- Large unidentified structures.



Onshore Western Newfoundland - Deer Lake Basin



- **Area:** 2,200 km².
 - **Age:** Upper Devonian to Upper Carboniferous.
 - **Type:** Strike-slip basin with central flower structure; lateral basins - Cormack (west), Howley (east).
 - **Thickness:** Up to 3,000 metres, entirely non-marine.
 - **Exploration Wells:** 9 (historic*); 3 (recent).
 - **Oil and Gas Shows:** Oily brines and frequent gas shows in several pre-1994 wells; DST gas flow of 100 Mcf/d and condensate from a recent well
- * Wells prior to 1994 were drilled without seismic data

Source Rocks

- Cormack lateral basin: Viséan aged Rocky Brook Formation lacustrine shales with TOCs up to 15.9% (proven); Upper Devonian to Tournaisian aged Forty-five Brook Formation and Saltwater Cove Formation lacustrine shales (possible).
- Howley lateral basin: Howley Formation shales (possible); Howley Formation coals.

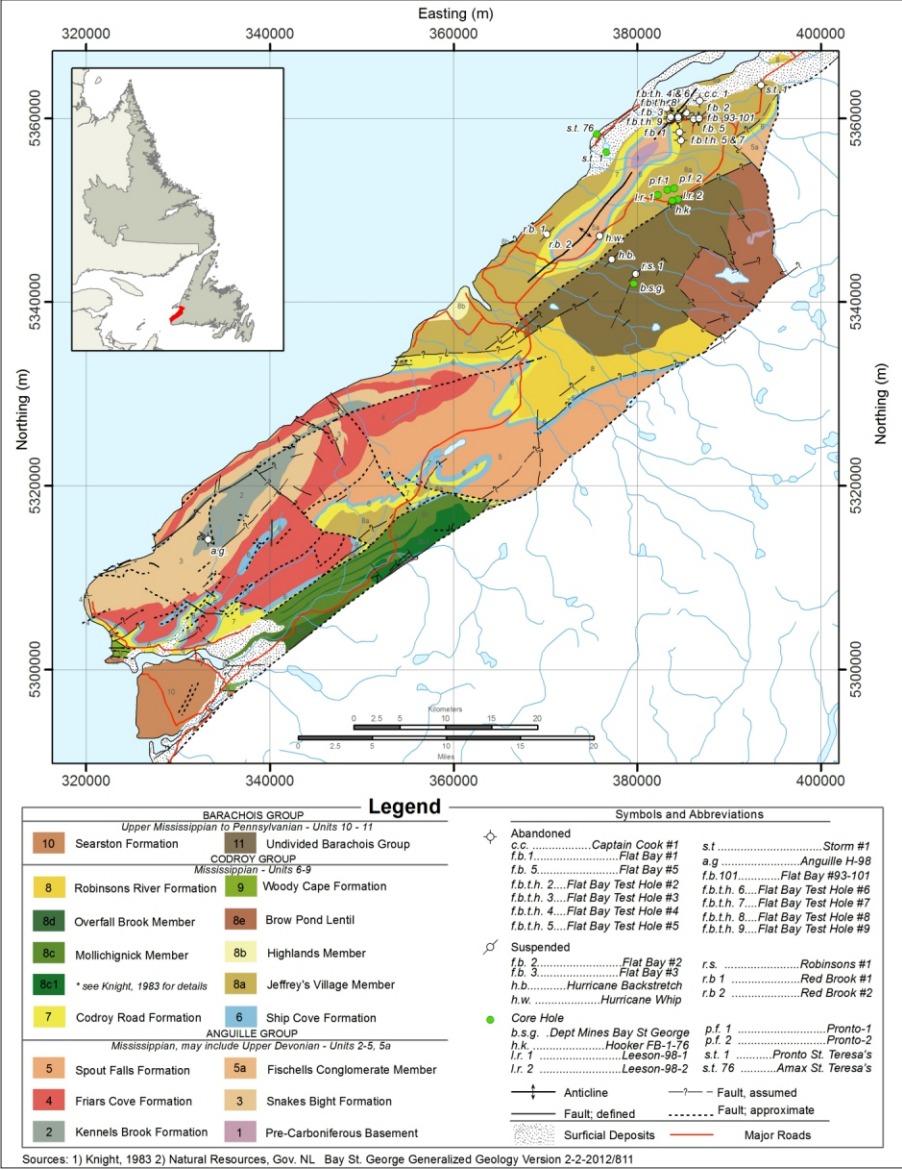
Reservoirs

- Cormack lateral basin: Sandstone and conglomerate of the North Brook Formation (porosities 12-18%) and Humber Falls sandstone (porosities of up to 30%).
- Howley lateral basin (possible): Sandstone and conglomerate of the Howley Formation.
- Lower Paleozoic platform carbonates/clastics located beneath Carboniferous cover.

Play Concepts

- Anticlinal traps resulting from wrench movements along the Cabot Fault Zone.
- Fault traps related to central flower structure.
- Channel sandstones and sandstone pinchouts in the North Brook Formation and Howley Formation.
- Alluvial fan pinchouts against basin margins and central flower structure.
- Fault traps developed in underlying Lower Paleozoic platform carbonates.
- Carboniferous cover onlapping/sealing karsted Lower Paleozoic carbonates and clastics.
- Hydrothermal dolomitization zones in underlying Lower Paleozoic carbonates.

Onshore Western Newfoundland - Bay St. George Basin



- **Area:** 2,350 km².
- **Age:** Upper Devonian to Upper Carboniferous.
- **Type:** Strike slip ‘pull-apart’ basin.
- **Thickness:** up to ~ 10 km; mainly non-mairine; except lower Codroy Group.
- **Exploration Wells:** 1 (pre-1994*); 12 (recent).
- **Strat Test Holes:** 9 recent.
- **Oil and Gas Shows:** Several in shallow pre-1994 mining holes and recent petroleum drill holes.
- ★ Wells prior to 1994 were drilled without seismic data

Source Rocks

- **Anguille Group** (proven) - Snakes Bight Formation shale (lacustrine); TOCs up to 3%
- **Codroy Group** (possible) - Ship Cove algal laminites
- **Barachois Group** (proven) - Lacustrine derived oil shales and coal beds; TOCs up to 31.9%.

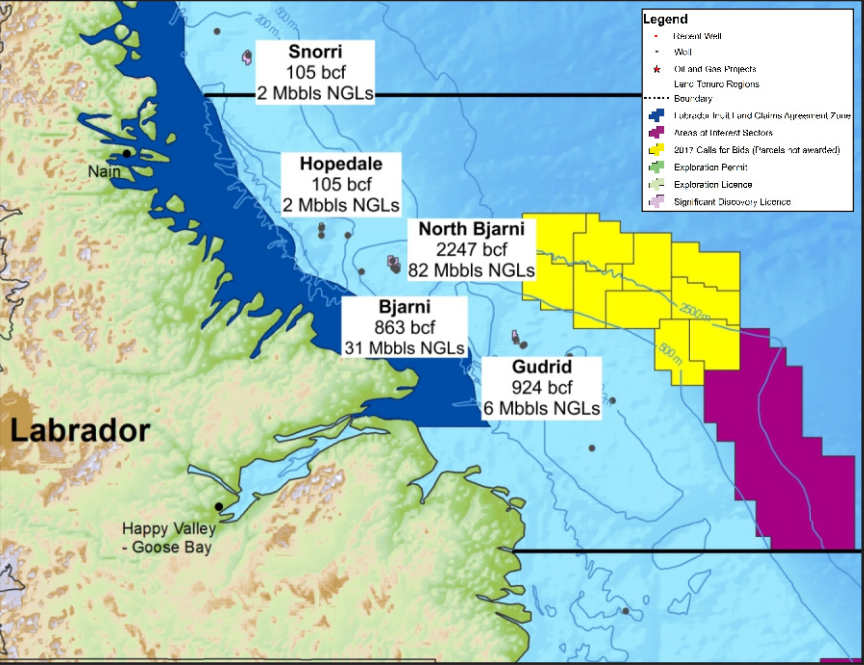
Reservoirs

- Sandstones and conglomerates of the Anguille, Codroy and Barachois Groups.
- Vuggy algal laminites; biohermal limestones and dolostones of the Codroy Group.
- Lower Paleozoic platform carbonates and clastics (if present) beneath Carboniferous cover.

Play Concepts

- Pinchout of Anguille and Codroy sandstones against the Flat Bay anticline.
- Sand drapes over salt swells; pinchout against salt diapirs; salt induced fault structures; sub-salt plays.
- En echelon folded structures related to wrench faulting.
- Bioherm buildups in Ship Cove and Codroy Road Formation, overlain/sealed by evaporites.
- Shale gas from Snakes Bight Formation and other mudstone/lacustrine sequences.
- Oil shale/coal bed methane possibilities in Barachois Group.

Offshore Labrador Petroleum System



Play Concepts

- Early exploration cycle – targeted basement highs, drape anticlines, lateral sand pinchouts, listric fault blocks with rollovers.
- Excellent potential for folded structures; slope turbidites and stratigraphic plays.

Regional Seal

- Markland Formation shale (Upper Cretaceous); Kenamu Formation shale (Eocene); Mokami Formation shale (Oligocene). Numerous potential intraformational seals.

Source Rock

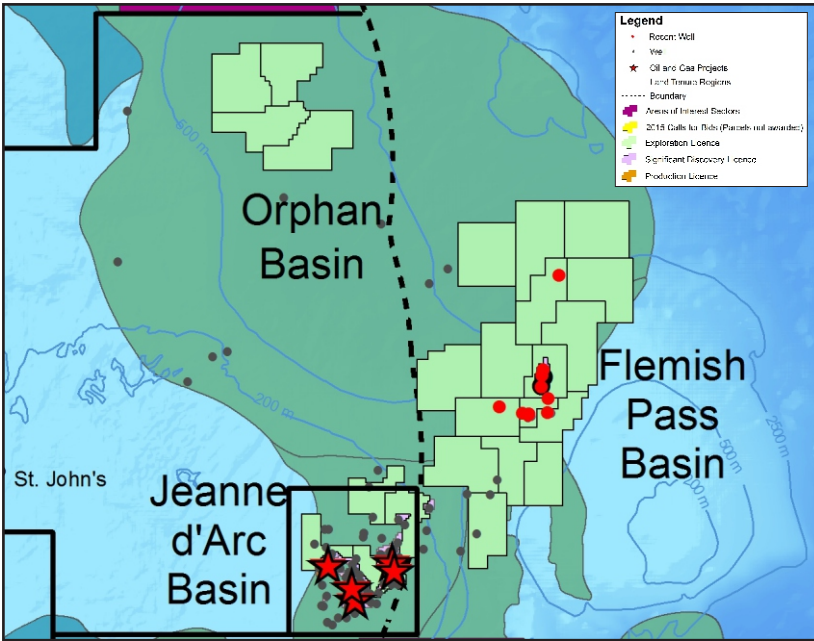
- Mature Upper Cretaceous shales.
- Markland shale; mainly Type III, some marine influence.
- Mature Lower Cretaceous Bjarni Formation shale; mainly Type III, TOCs to 5%; up to 500 m thick.
- Potential Tertiary source rocks.

Reservoir Rock

- Lower Cretaceous synrift Bjarni Formation sandstone (most important/widespread); porosity to 15%; permeability up to 100 mD.
- Late Cretaceous postrift Freydis Member sandstone.
- Early Tertiary syndrift Gudrid Member and Leif Member sandstones.
- Lower Paleozoic pre-rift limestone and dolostones.

Offshore Labrador/Nunavut			
Discovery	Reservoir	Recoverable Reserves	Date
Hopedale Basin (Offshore Labrador)			
Bjarni H-81	L. Cretaceous Bjarni Sst	0.9 tcf gas; 31 MMbbls NGLs	1973
Gudrid H-55	L. Paleozoic Dolomite	0.9 tcf gas; 6 MMbbls NGLs	1974
Snorri J-90	Paleocene Gudrid Sst	0.1 tcf gas; 2 MMbbls NGLs	1975
Hopedale E-33	L. Cretaceous Bjarni Sst	0.1 tcf gas; 2 MMbbls NGLs	1978
	L. Paleozoic Dolomite		
North Bjarni F-06	L. Cretaceous Bjarni Sst	2.2 tcf gas; 82 MMbbls NGLs	1980
North Saglek Basin (Offshore Nunavut)			
Discovery	Reservoir	Reserves/Flow Rate	Date
Hekja O-71	Paleocene/Eocene Sst	2.3 tcf gas/106.3 bbls/d NGLs	1979

Offshore North Grand Banks Basins



Production: ~ 190,400 bopd, cumulative production 1.65 billion bbls to date.

Play Concepts

- Numerous structural and stratigraphic traps.
- Possible salt-related plays.

Source Rocks

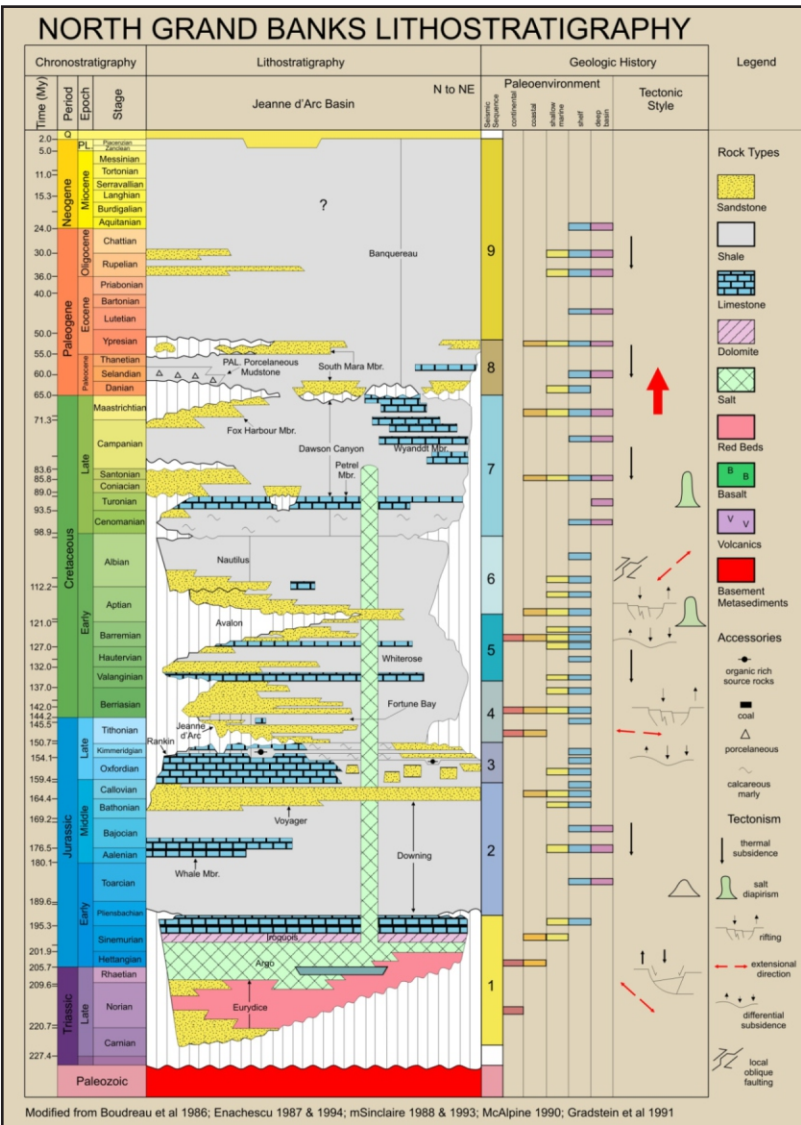
- Proven Upper Jurassic Egret Member and Kimmeridgian equivalents.
- Abundant Type II, oil-prone source rock with TOCs up to 9%.
- Additional source potential in Callovian, Aptian-Albian and Tertiary.

Reservoir Rocks

- Hydrocarbon-bearing reservoirs in Jurassic to Cretaceous Ben Nevis, Avalon, Hibernia and Jeanne d'Arc Formation fluvial and marine sandstones.
- Hibernia Formation typical porosity 16% - 22%, permeability 700 mD - 10 D.
- Additional reservoir potential in Tertiary, Upper Cretaceous and Triassic.

Regional Seal

- Intraformational shallow shelf mudstones, capable of holding a 390 metre oil column (Hibernia Field).



Basins: Jeanne d'Arc, Orphan, Flemish Pass.

Area: >140,000 km².

Age: Triassic to Tertiary.

Basin Type: Atlantic-type extensional margin.

Thickness: 8 to 14+ km of sediment.

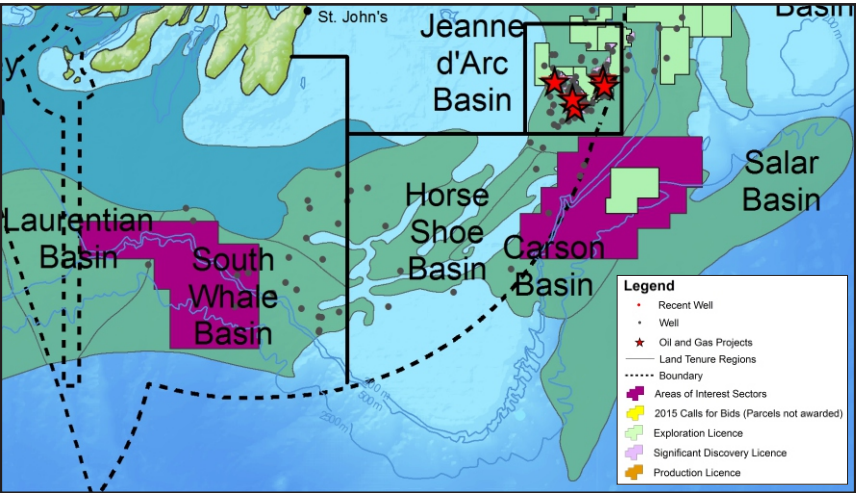
Seismic: >316,000 line km 2D;
>1,283,634 CMP 3D.

Exploration Wells: 78.

Discoveries: 5 producing fields, numerous other discoveries.

Reserves: Discovered 3.336 Bbbls of light oil and 8.322 tcf of gas with 397 MMbbls of associated liquids.

Offshore South Grand Banks Basins



Resources: Undiscovered potential estimated at 700 MMbbls oil and 9 tcf gas.

Play Concepts

- Numerous structural and stratigraphic traps.
- Possible salt-related plays.

Source Rocks

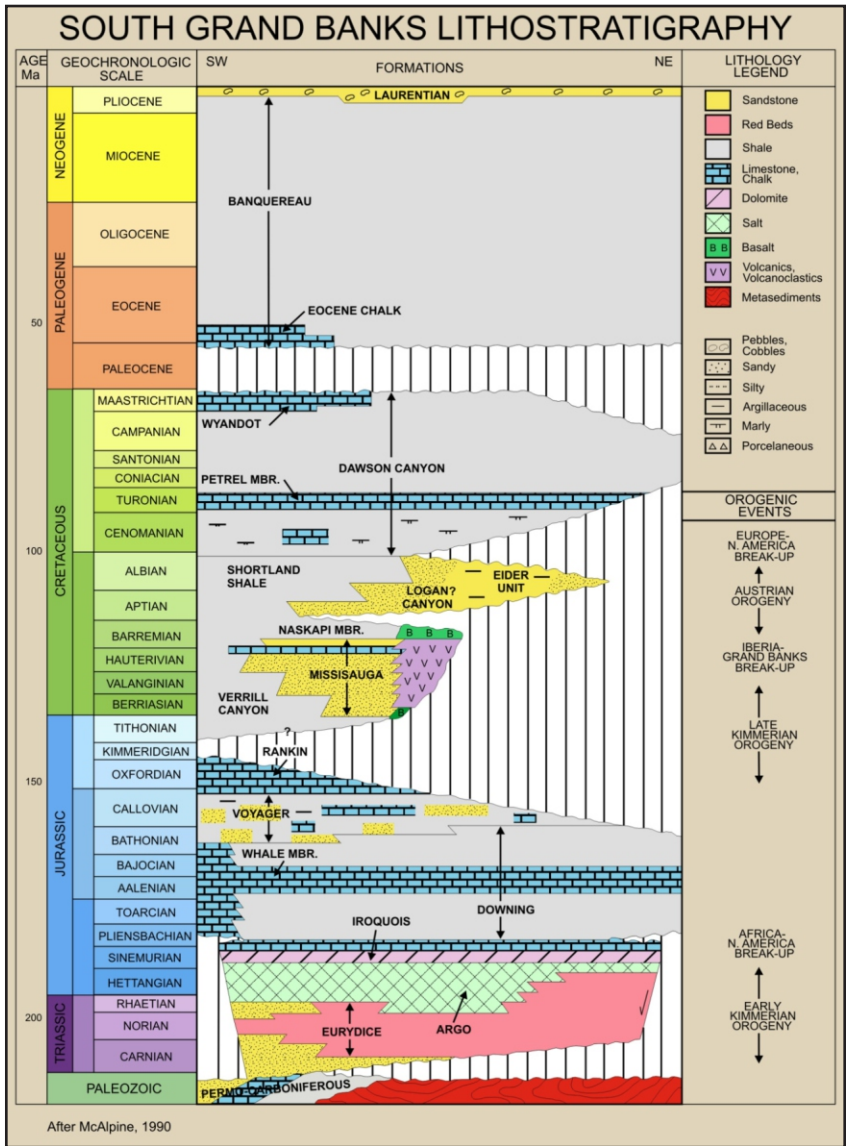
- Probable Upper Jurassic Egret Member and/or Kimmeridgian equivalents – Proven in Northern Grand Banks and to south on Scotian Shelf.
- Additional source potential in Missisauga and Verrill Canyon Formations (Upper Jurassic-Lower Cretaceous).

Reservoir Rocks

- Lower Cretaceous Missisauga Formation (equivalent to hydrocarbon-bearing reservoirs North Grand Banks) and Upper Jurassic MicMac Formation fluvio-deltaic sandstones.
- Upper Jurassic Abenaki carbonate reefs, equivalent to Deep Panuke discovery on Scotian Shelf.

Regional Seal

- Intraformational shallow shelf mudstones and cemented oolitic limestones.



Basins: Laurentian, Carson, South Whale, Sydney.

Area: >170,000 km².

Age: Carboniferous to Tertiary

Basin Types: Atlantic-type extensional margin and strike-slip pull-apart.

Thickness: 10 to 15+ km of sediment.

Seismic: >157,000 line km 2D;
>155,000 CMP 3D.

Exploration Wells: 35.

Oil and Gas Shows: Shows and DHIs on seismic.