

Petroleum Resource Potential of the Mackenzie Corridor, Canada: Conceivable Linkages with the Proposed Mackenzie Valley Natural Gas Pipeline*

Peter Hannigan¹, David Morrow¹ and Bernard MacLean¹

Search and Discovery Article #10362 (2011)

Posted October 24, 2011

*Adapted from oral presentation at 3P Arctic - The Polar Petroleum Potential Conference & Exhibition, Halifax, Nova Scotia, Canada, August 30-September 2, 2011, hosted and organized by AAPG and Allworld Exhibitions.

¹Geological Survey of Canada, Calgary, AB, Canada. (Peter.Hannigan@NRCan-RNCan.gc.ca)

Abstract

The Mackenzie Corridor, an area along the proposed route of the Mackenzie Valley pipeline, constitutes a significant petroleum frontier province in Canada's north. The Geological Survey of Canada has recently completed its first comprehensive exploration play-based quantitative petroleum assessment analysis of the region, the results of which are the subject of this presentation.

Objectives

Canada's northern mainland basin is separable into two distinct geological terrane-types: the relatively undeformed platform succession underlying the plains area of Northwest Territories (the Interior Platform) and the deformed fold and thrust belt of the Cordillera in western Northwest Territories and eastern Yukon (the Northern Foreland Belt). A total of 37 oil and gas mature, immature and conceptual exploration plays have been defined and mapped in the study area, which extends from the 60th parallel, northward to, but not including, the Mackenzie Delta.

Procedure

All plays were defined on the basis of reservoir or reservoirs in which oil and/or natural gas were expected to accumulate. All aspects of the hydrocarbon system affecting each play such as source, seal, thermal maturity, trap-style, timing and exploration risks were also defined. Oil and gas play maps were then constructed to define the limits of preserved petroleum accumulations. Once the play maps were completed, compilation of all relevant petroleum data needed to perform volumetric probabilistic analyses for immature and conceptual plays and discovery process techniques for mature plays was undertaken. Probabilistic statistical analyses produced in-place play potential volumes, individual undiscovered pool size estimates, and the

number of pools expected to occur in each play. Matching techniques were used to determine the ranks of discovered pool sizes to individual pool size volumes.

Results

The probabilistic assessment results of total oil and gas potential (produced and remaining) for all sedimentary strata in the Mackenzie Corridor of Canada are in-place mean volumes of 6,624 MMBO of oil and 77 Tcf of gas. Although discovered reserves are substantial in the Mackenzie Corridor region, remaining resource potential is significant as exemplified by the prediction of 8 oil pools greater in size than 100 MMBO and 11 gas pools greater than 250 BCF.

Conclusions

Sufficient data was available in the majority of 37 defined plays established throughout the stratigraphic column from Proterozoic to Cretaceous age to predict their oil and gas endowment. This major study will provide important information for stakeholders involved in the proposed construction of the Mackenzie Valley natural gas pipeline with respect to petroleum potential adjacent or proximal to its proposed route.

ESS Contribution No. 20100470



GEM

Petroleum Resource Potential of the Mackenzie Corridor, Canada: Conceivable Linkages to the Proposed Mackenzie Valley Natural Gas Pipeline

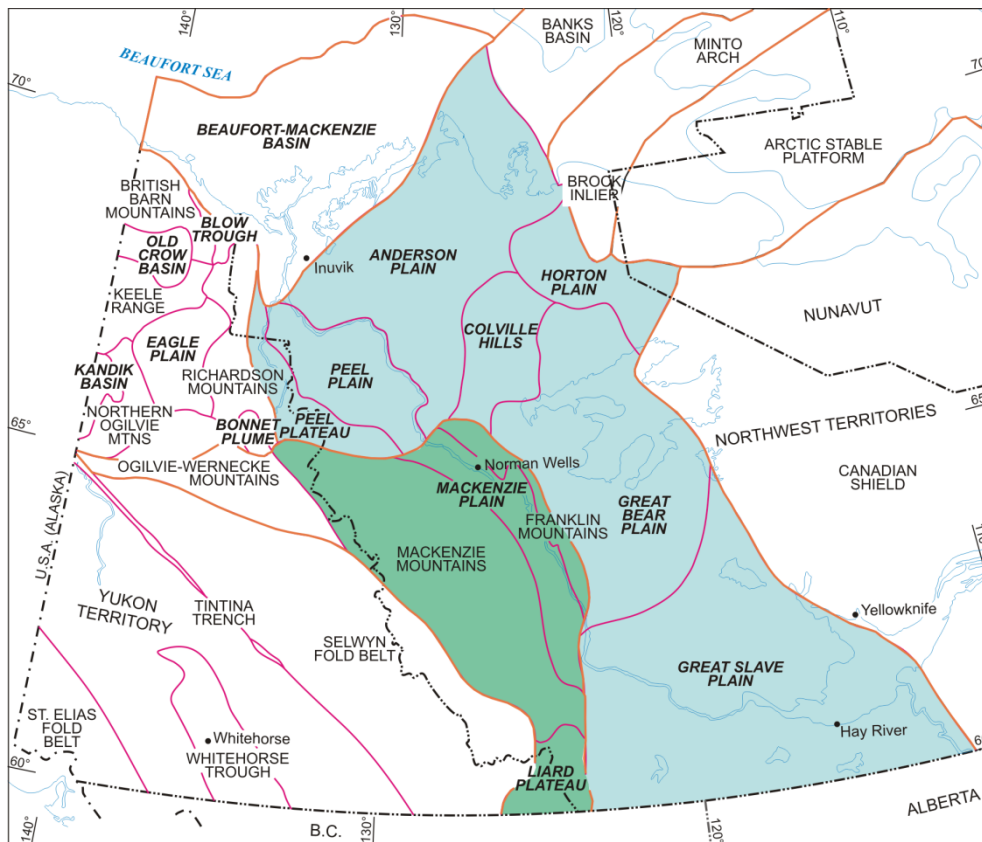
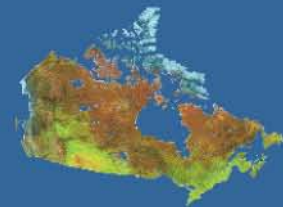
**Peter K. Hannigan*, David W. Morrow
and Bernard C. MacLean
Natural Resources Canada-
Geological Survey of Canada-Calgary**



Natural Resources
Canada

Ressources naturelles
Canada

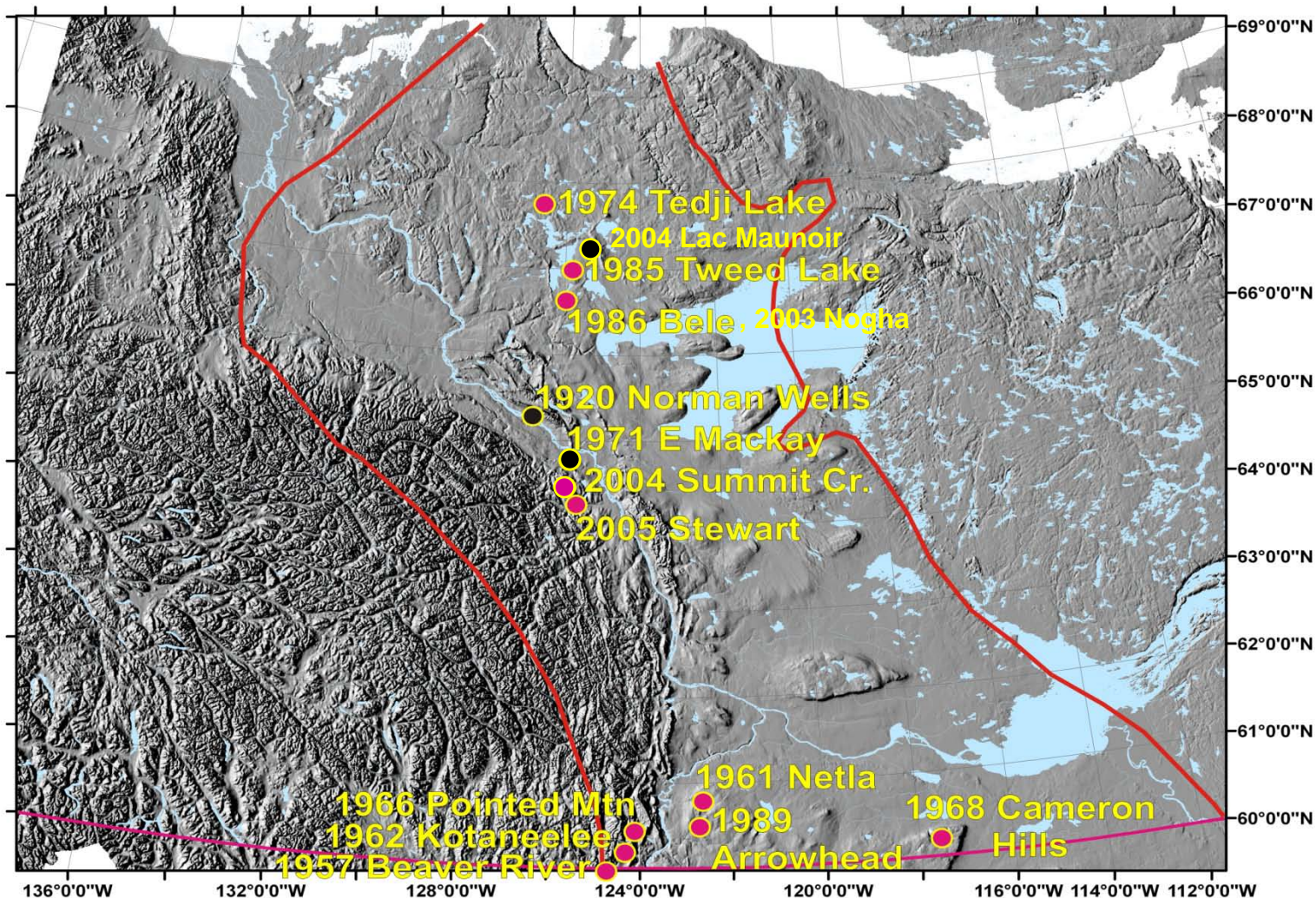
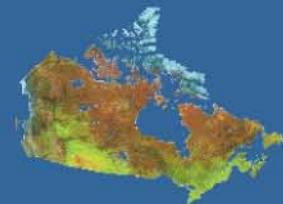
Canada



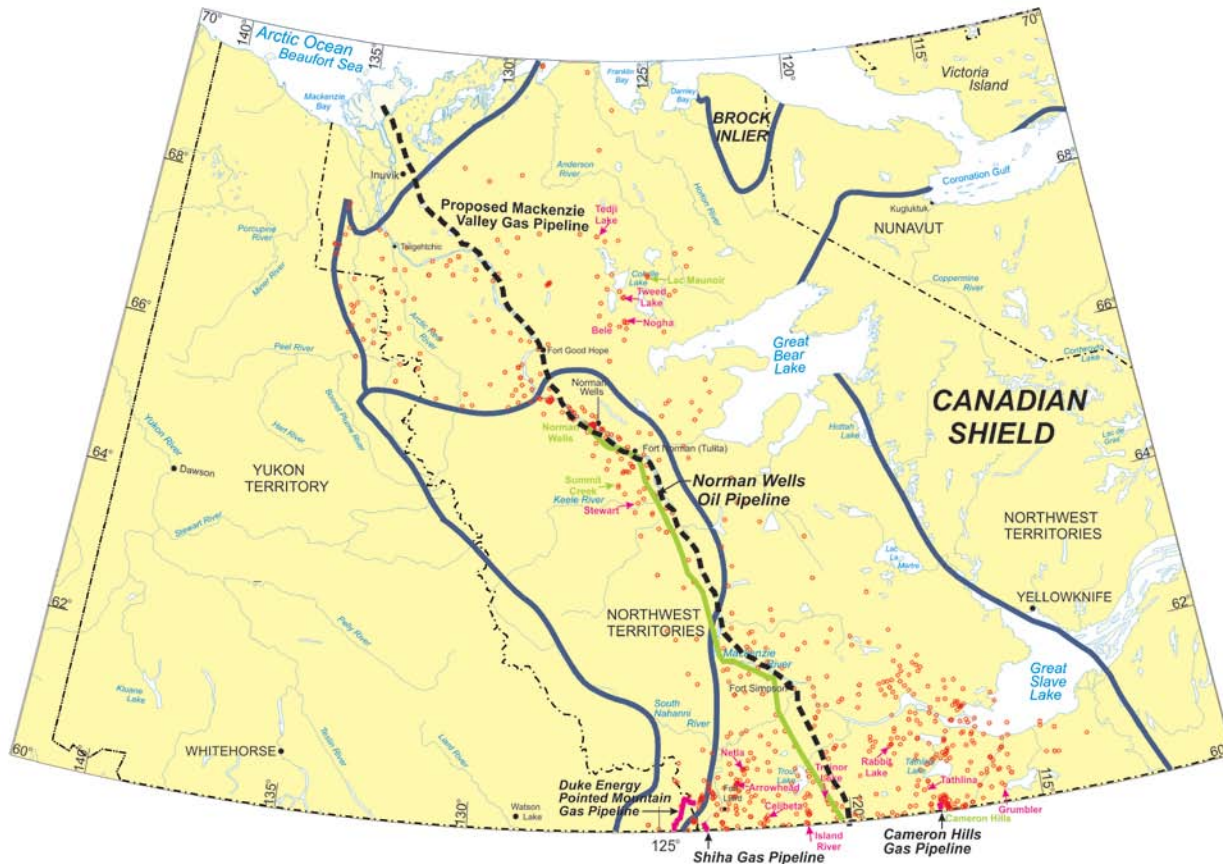
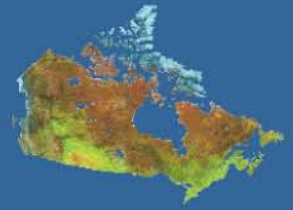
GEOLOGICAL PROVINCES

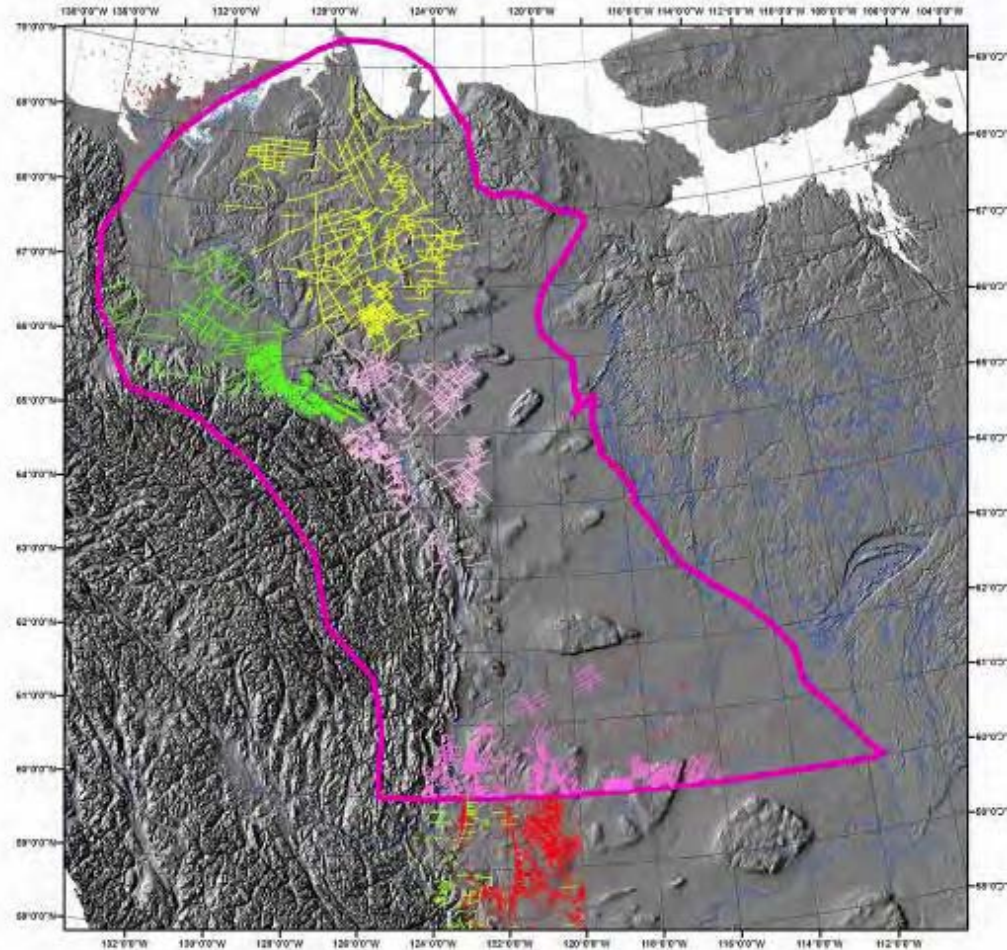
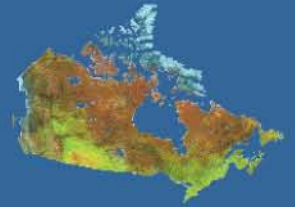
- Interior Platform
- Northern Foreland Belt

Exploration regions

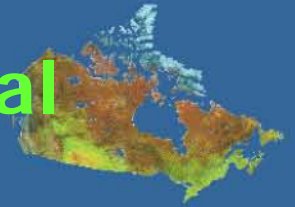


From Lemieux, 2007





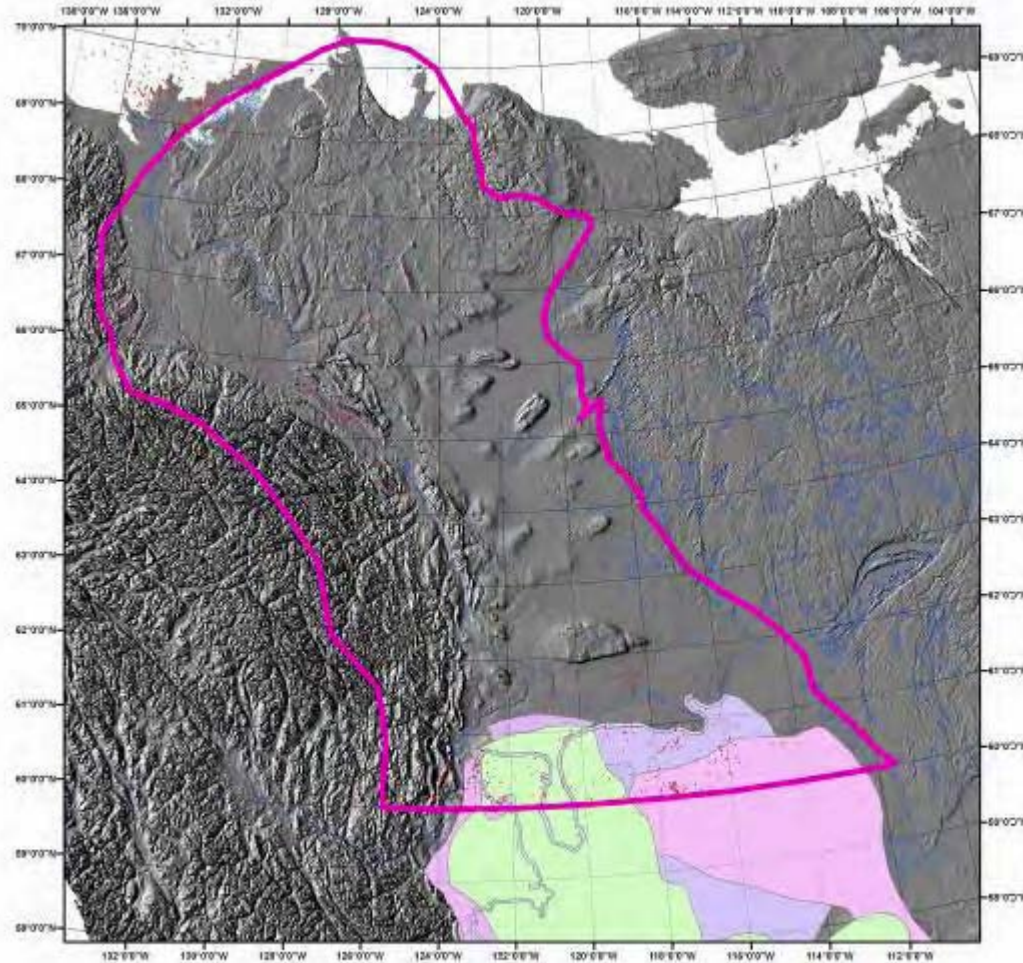
From Lemieux, 2007

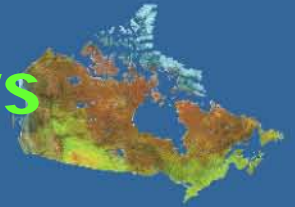


- 37 conventional exploration plays
- **Interior Platform**
- 25 plays (most containing oil & gas)
- 4 mature oil & gas plays
- 6 mature gas plays
- 13 immature or conceptual oil & gas plays
- 3 immature or conceptual oil plays
- 2 conceptual gas plays
- **Northern Foreland Belt**
- 12 plays
- 7 immature or conceptual oil & gas plays
- 5 immature or conceptual gas plays

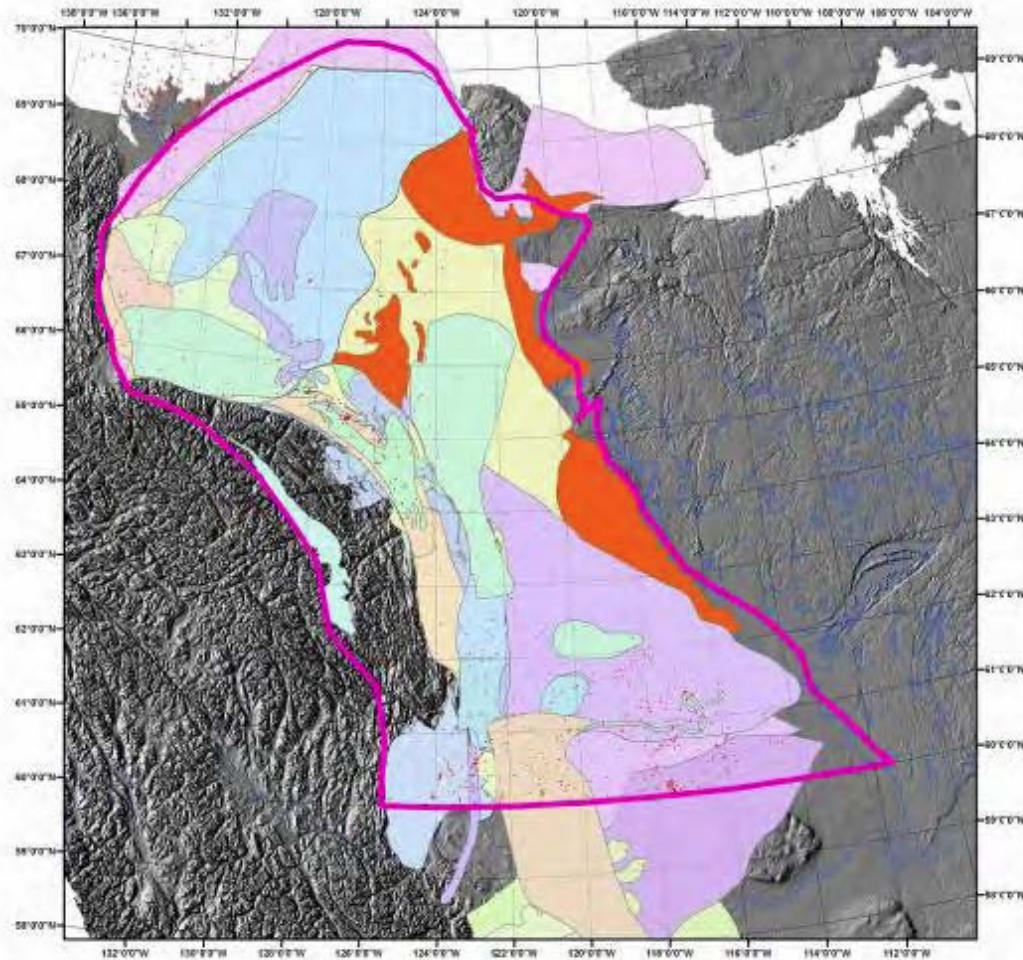


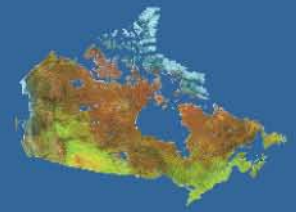
From Lemieux, 2007



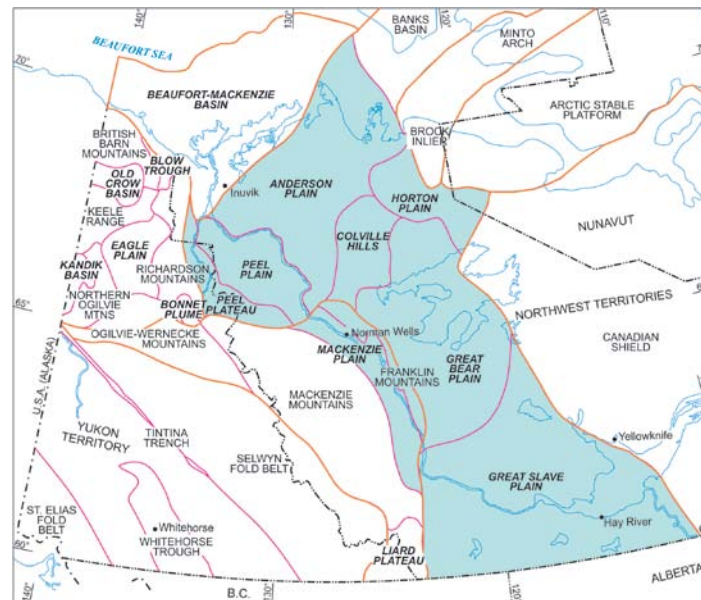


From Lemieux, 2007

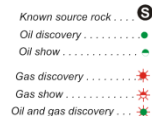
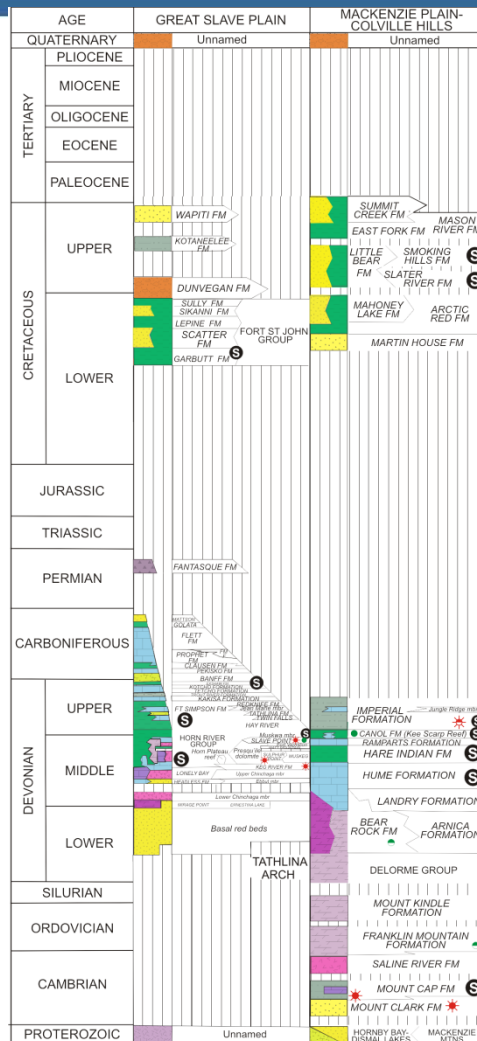
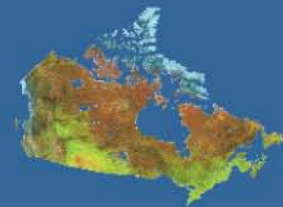


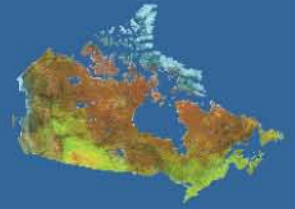


Interior Platform



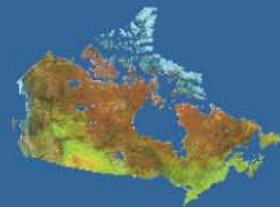
Petroleum Systems (Interior Platform)



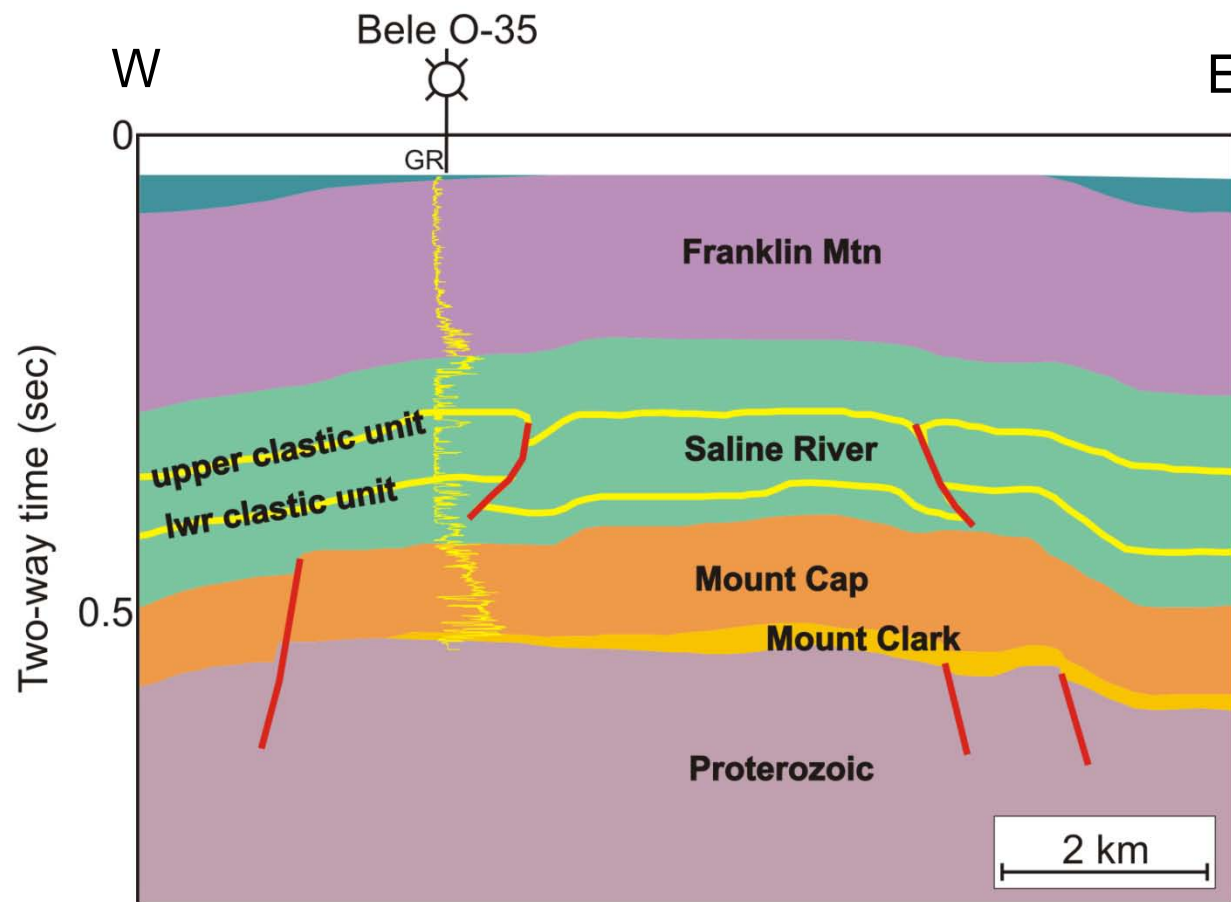
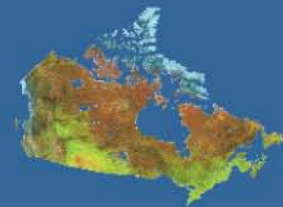


- Established oil & gas play, 5 gas discoveries; 1 oil disc.
- Reservoir: Mt. Clark sandstones
Lower Mt. Cap sandstones & dolomites
- Source: poss. gas source in Proterozoic sediments
oil-prone algal-rich shales in Mt. Cap
- Seal: Saline River evaporites; Mt Cap shales
- Trap-styles: Flower structures; roll-over anticlines;
stratigraphic pinchouts; onlap against basement highs
- Exploration risks: adequate reservoir; source;
communication with source





From Pyle et al., 2007



Gas

P5: $642 \times 10^9 \text{ m}^3$
P50: $247 \times 10^9 \text{ m}^3$
P95: $83 \times 10^9 \text{ m}^3$
(Mean: 10.8 Tcf)

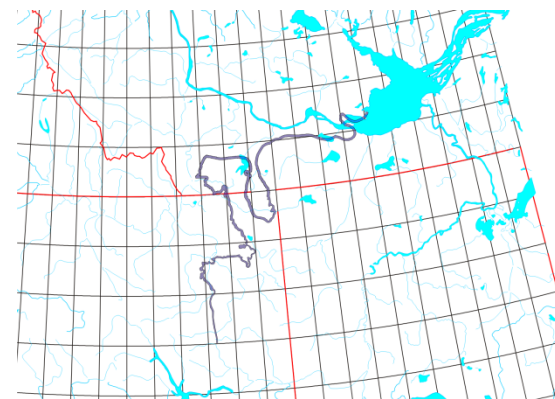
Oil

P5: $402 \times 10^6 \text{ m}^3$
P50: $106 \times 10^6 \text{ m}^3$
P95: $15 \times 10^6 \text{ m}^3$
(Mean: 952 MMBO)

Petro-Canada line 8624 **Largest gas discovery ranks 2nd among 105 pools**



- Established gas play, 61 discoveries; conceptual oil play
- Reservoir: Slave Point/Sulphur Point reefal carbonates
- Source: oil & gas source in organic-rich Devonian shales-
Muskwa & Horn River
- Play area: 7390 sq. km. (gas play); 1800 sq. km. (oil)
- Seal: Horn River shale (lateral); Muskwa shale (top);
tight Slave Point/Sulphur Point limestones (top)
- Trap-styles: dolomitized bioherms or buildups
- Exploration risks: adequate reservoir (dolomite development), adequate long-term seal





Typical, well-developed Presqu'ile-type "facies".

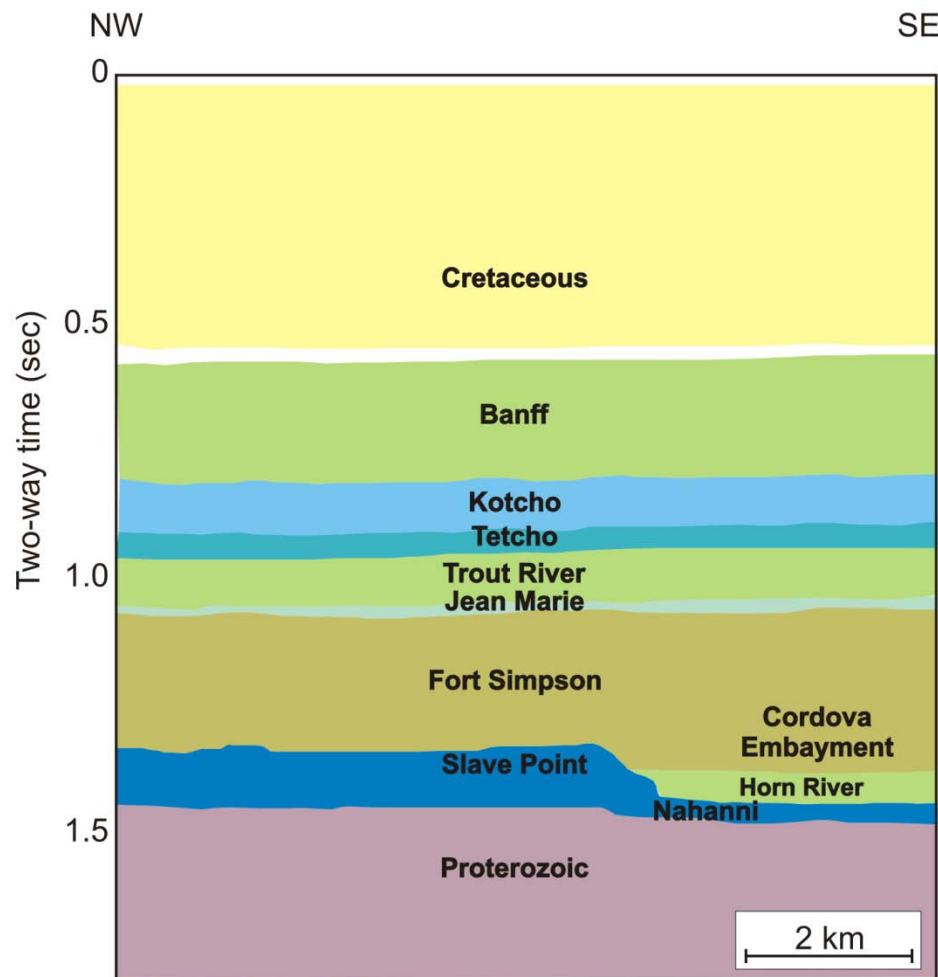
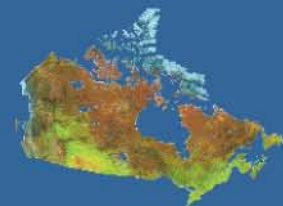


dark grey
replacive saddle dolomite

white, saddle
dolomite cement

grey replacive
saddle dolomite

G-15-919.5



P5: $345 \times 10^9 \text{ m}^3$

Gas P50: $176 \times 10^9 \text{ m}^3$

P95: $77 \times 10^9 \text{ m}^3$

(Mean: 6720 Bcf)

P5: $115 \times 10^6 \text{ m}^3$

Oil P50: $14 \times 10^6 \text{ m}^3$

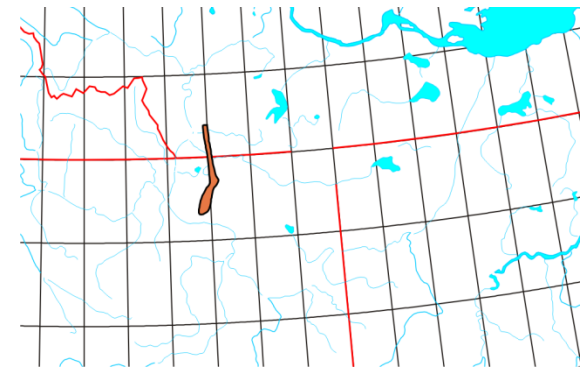
P95: $1 \times 10^6 \text{ m}^3$

(Mean: 225 MMBO)

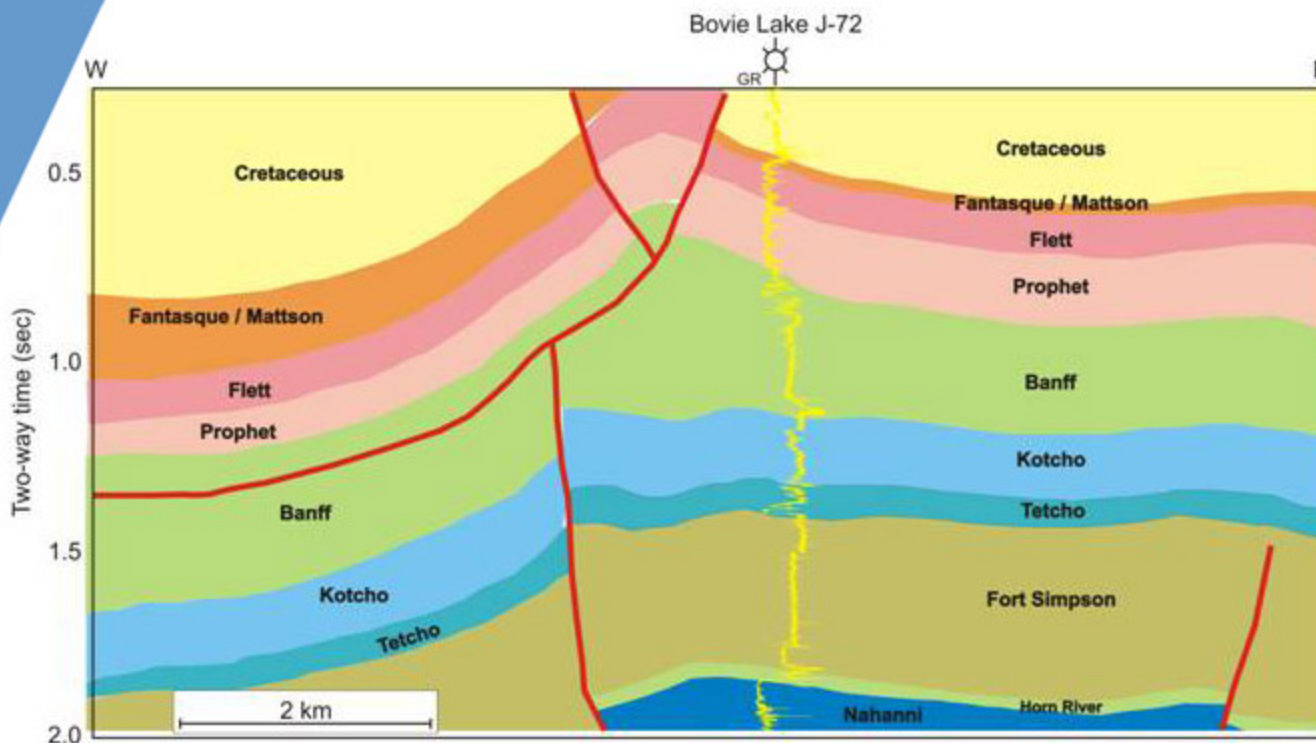
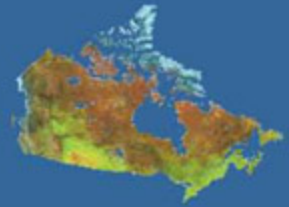
Northcor line 12 Largest undiscovered pool ranks 10th among 159 gas pools



- Established gas play, one discovery; conceptual oil play
- Reservoirs: Paleozoic carbonates & sands; Mesozoic sands
- Source: oil & gas source in organic-rich shales (eg. Besa River, Exshaw, Garbutt)
- Seal: Besa River, Horn River, Banff shales
- Trap-styles: updip fault closures; hangingwall rollover anticlines; secondary dolomitization at structural discontinuities
- Exploration risks: adequate porosity, timing & migration in Mattson & older reservoirs



Bovie structural (Interior Platform)



P5: $6.5 \times 10^9 \text{ m}^3$

Gas P50: $1.6 \times 10^9 \text{ m}^3$

P95: $0.3 \times 10^9 \text{ m}^3$

(Mean: 88 Bcf)

P5: $8 \times 10^6 \text{ m}^3$

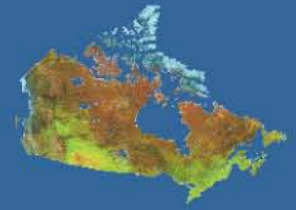
Oil P50: $1.3 \times 10^6 \text{ m}^3$

P95: $0 \times 10^6 \text{ m}^3$

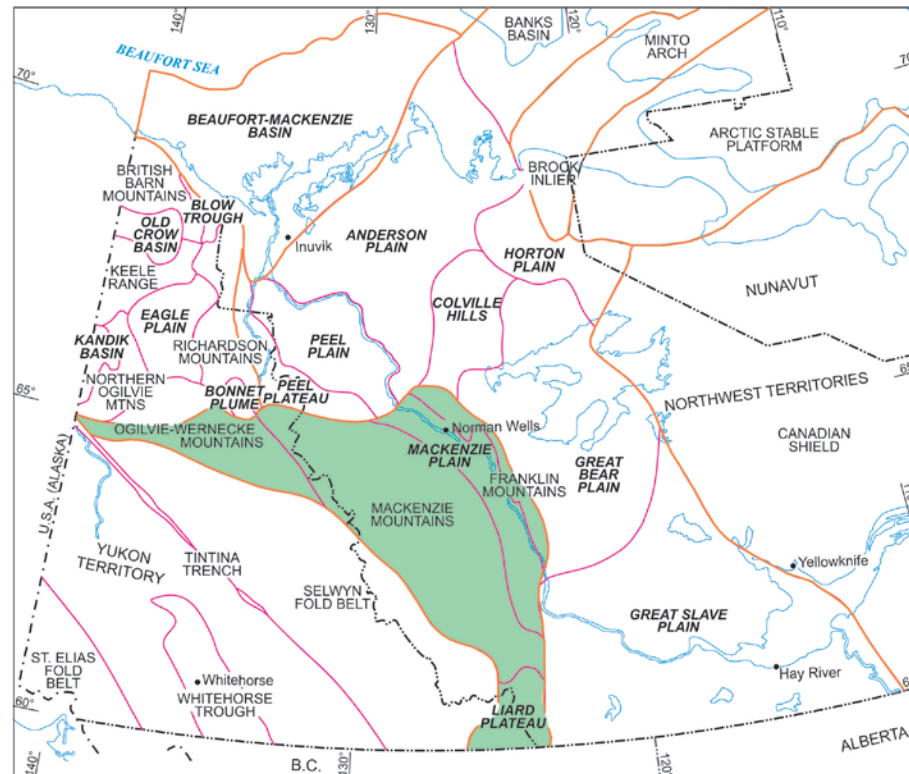
(Mean: 16 MMBO)

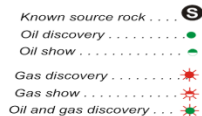
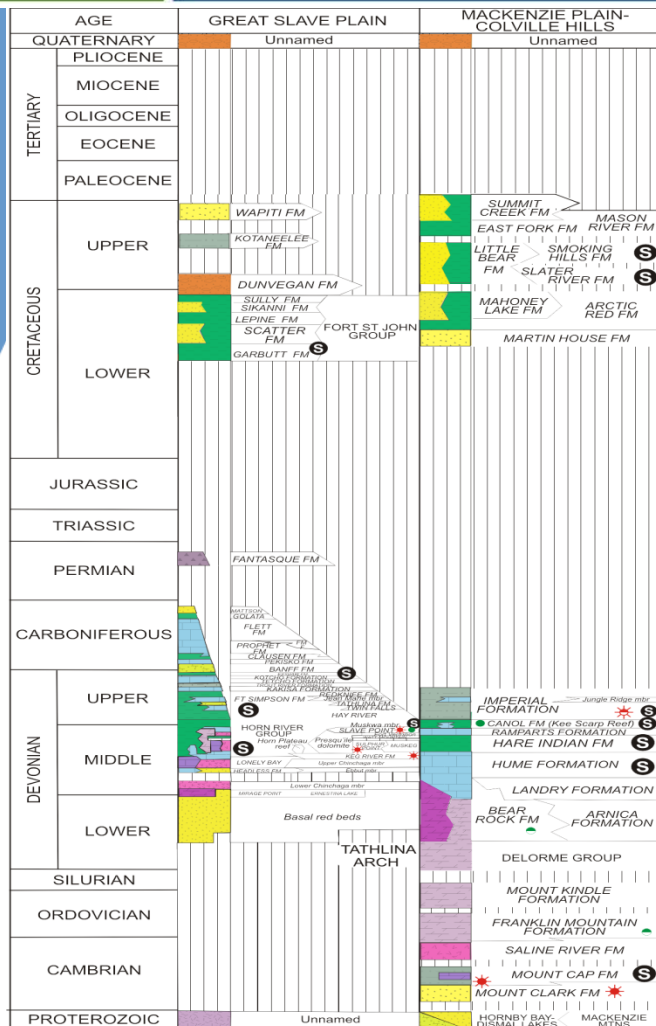
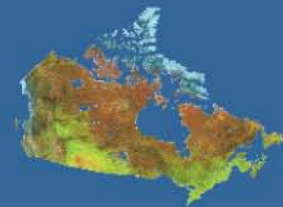
Shell line 91

Largest gas discovery ranks 2nd among 55 pools



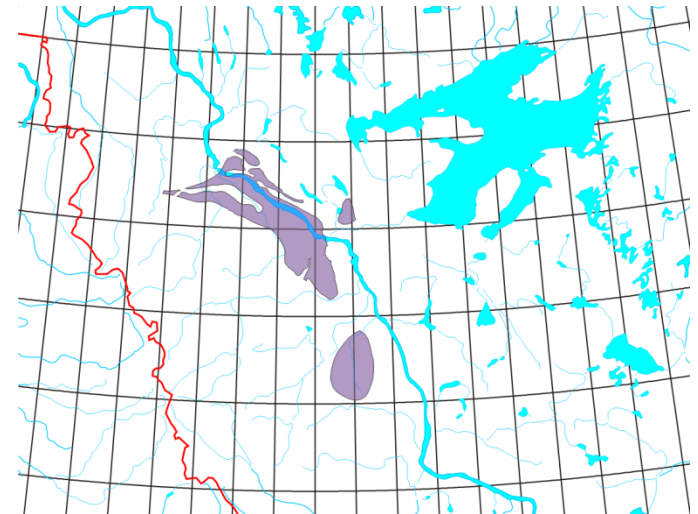
Northern Foreland Belt







- Established oil & gas play, 1 discovery (Norman Wells)
- Reservoir: Kee Scarp & Ramparts limestones
- Source: oil source in Canol black shales
- Seal: Canol shale (lateral & top)
- Trap-styles: isolated reefs; low relief shoals on platform
- Exploration risks: adequate reservoir; preservation



GEM

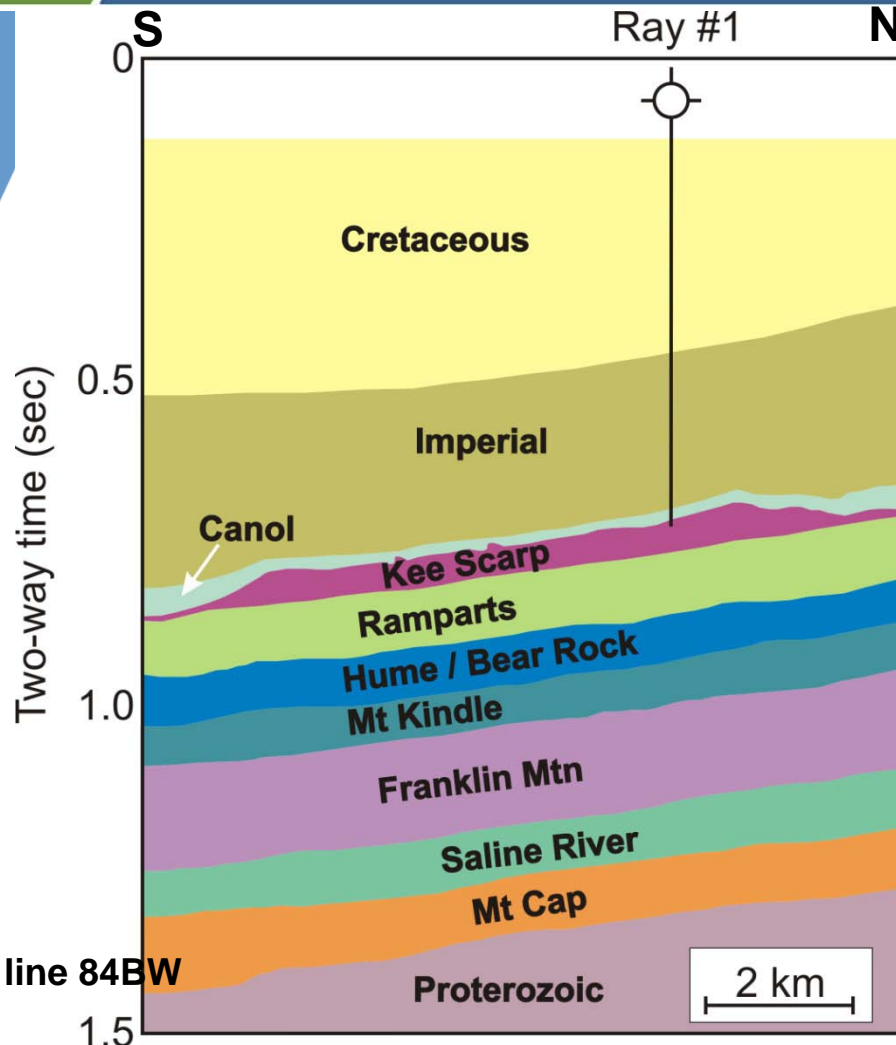
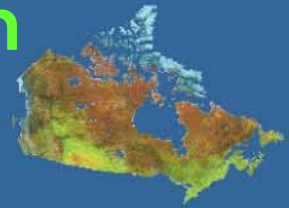
Reservoir- Kee Scarp/Ramparts



Natural Resources
Canada

Ressources naturelles
Canada

Canada



P5: $546 \times 10^6 \text{ m}^3$

Oil

P50: $166 \times 10^6 \text{ m}^3$

P95: $21 \times 10^6 \text{ m}^3$

(Mean: 1337 MMBO)

P5: $24 \times 10^9 \text{ m}^3$

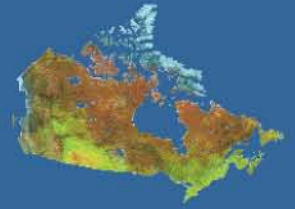
Gas

P50: $7 \times 10^9 \text{ m}^3$

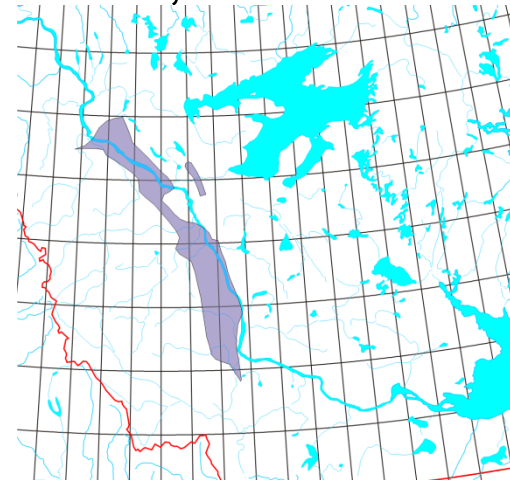
P95: $0.2 \times 10^9 \text{ m}^3$

(Mean: 328 Bcf)

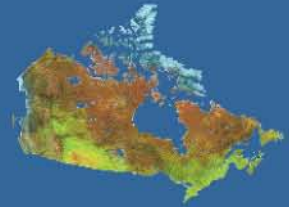
**Largest oil discovery ranks
1st among 10 pools**



- Established oil & gas play, 1 discovery (Summit Creek)
- Reservoir: Arnica/Landry/Bear Rock carbonates
- Source: Bluefish, Canol shales; shale interbeds in Ramparts Formation
- Seal: Bluefish & Canol shales (lateral & top); tight Hume argillaceous limestones (top)
- Trap-styles: overthrust & faulted anticlines; fault closures; post-depositional leaching & dissolution traps
- Exploration risks: adequate reservoir, seal, timing



Arnica/Landry platform (Foreland Belt)

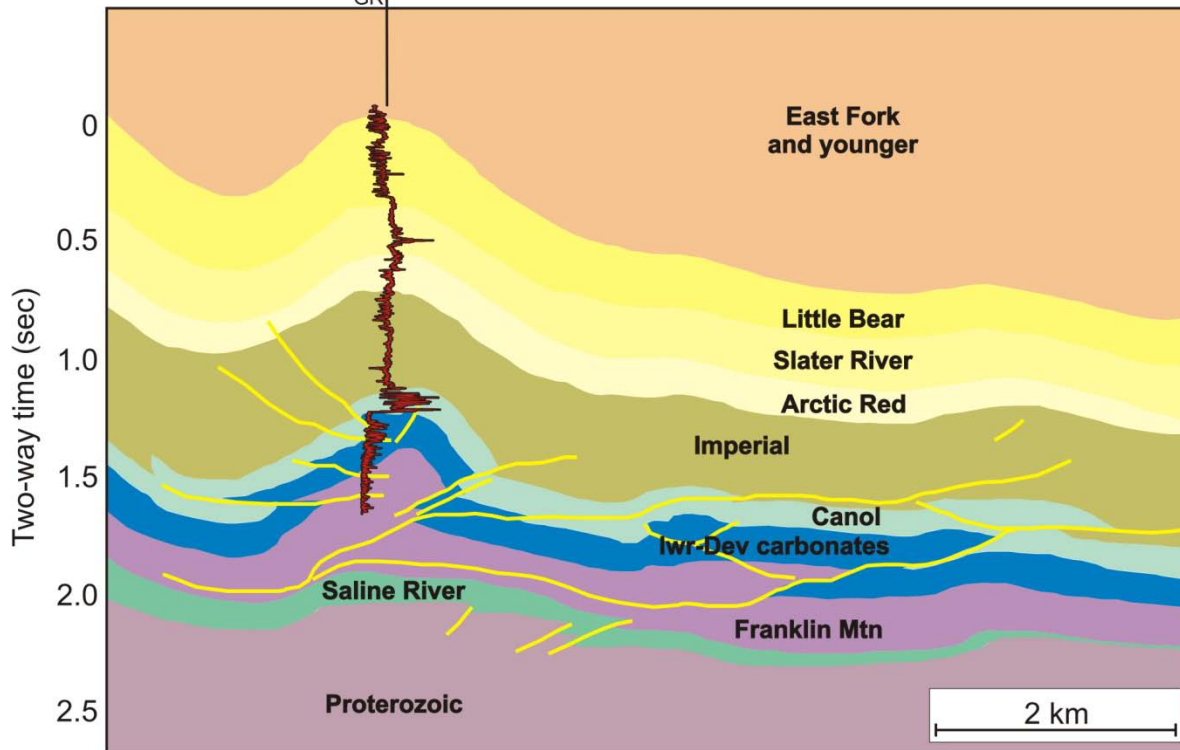


SW

NE

Summit Creek B-44

GR



P5: $100 \times 10^9 \text{ m}^3$

Gas P50: $41 \times 10^9 \text{ m}^3$

P95: $2 \times 10^9 \text{ m}^3$

(Mean: 1610 Bcf)

P5: $303 \times 10^6 \text{ m}^3$

Oil P50: $120 \times 10^6 \text{ m}^3$

P95: $7 \times 10^6 \text{ m}^3$

(Mean: 854 MMBO)

Northrock line 293

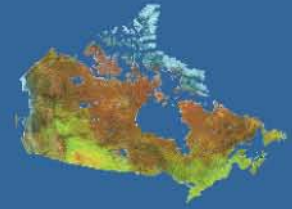
Largest gas discovery ranks 10th among 33 pools



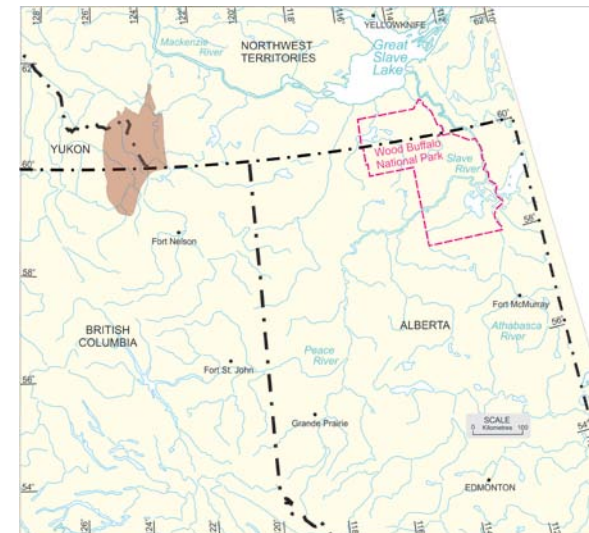
Natural Resources
Canada

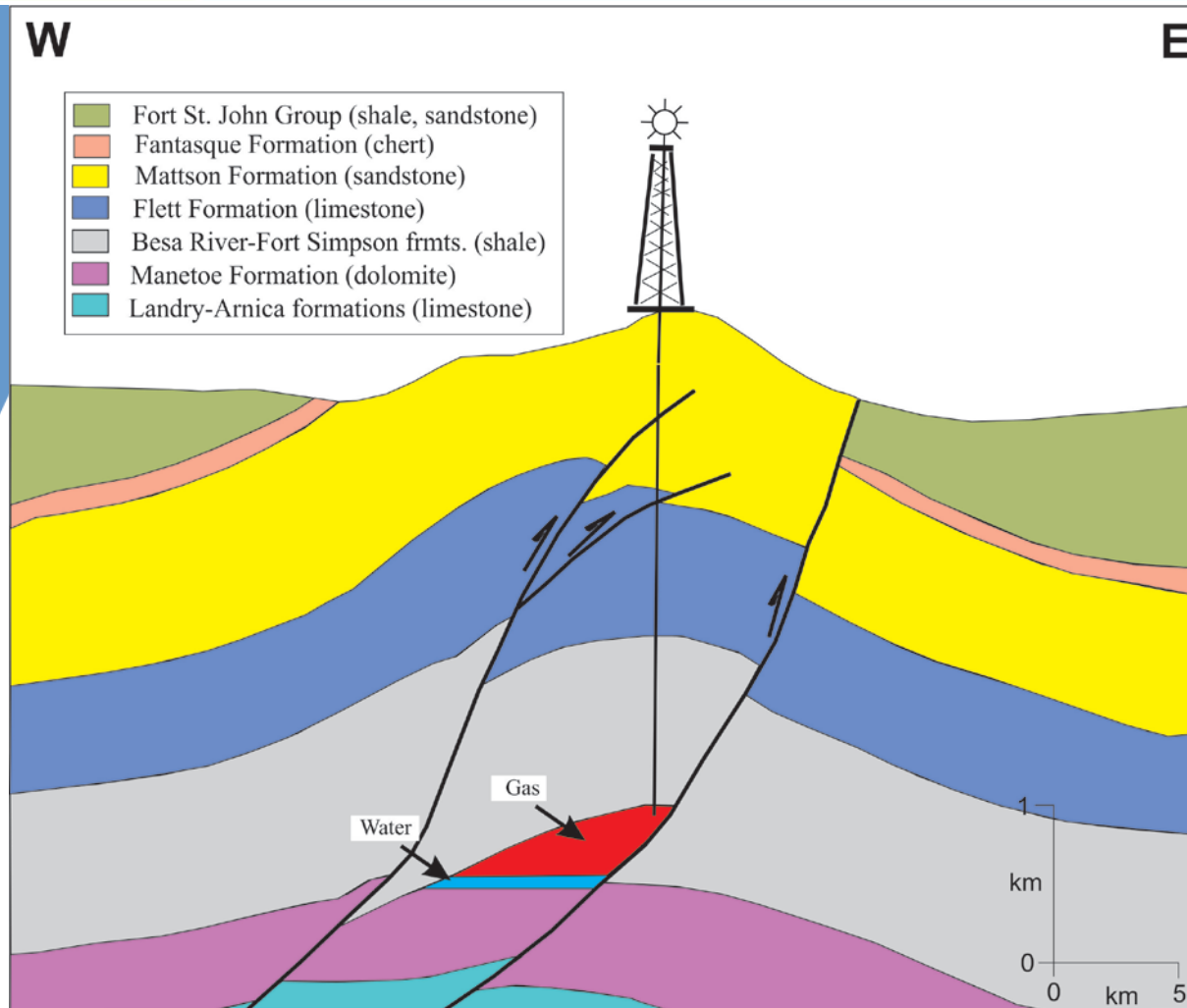
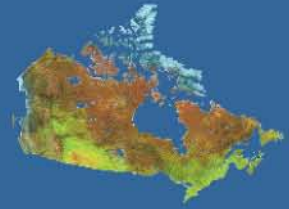
Ressources naturelles
Canada

Canada



- Established gas play, 13 discoveries (Pointed Mountain, Kotaneelee, Beaver River, Liard, Labiche)
- Reservoir: Manetoe dolomite
- Source: Besa River, Horn River shales
- Seal: Besa River & Horn River formations
- Trap-styles: faulted anticlines; post-depositional leaching & dissolution traps
- Exploration risks: adequate reservoir, timing, preservation





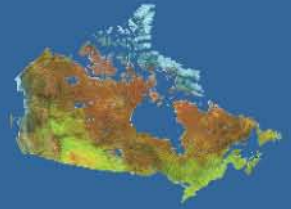
P5: $846 \times 10^9 \text{ m}^3$

Gas P50: $230 \times 10^9 \text{ m}^3$

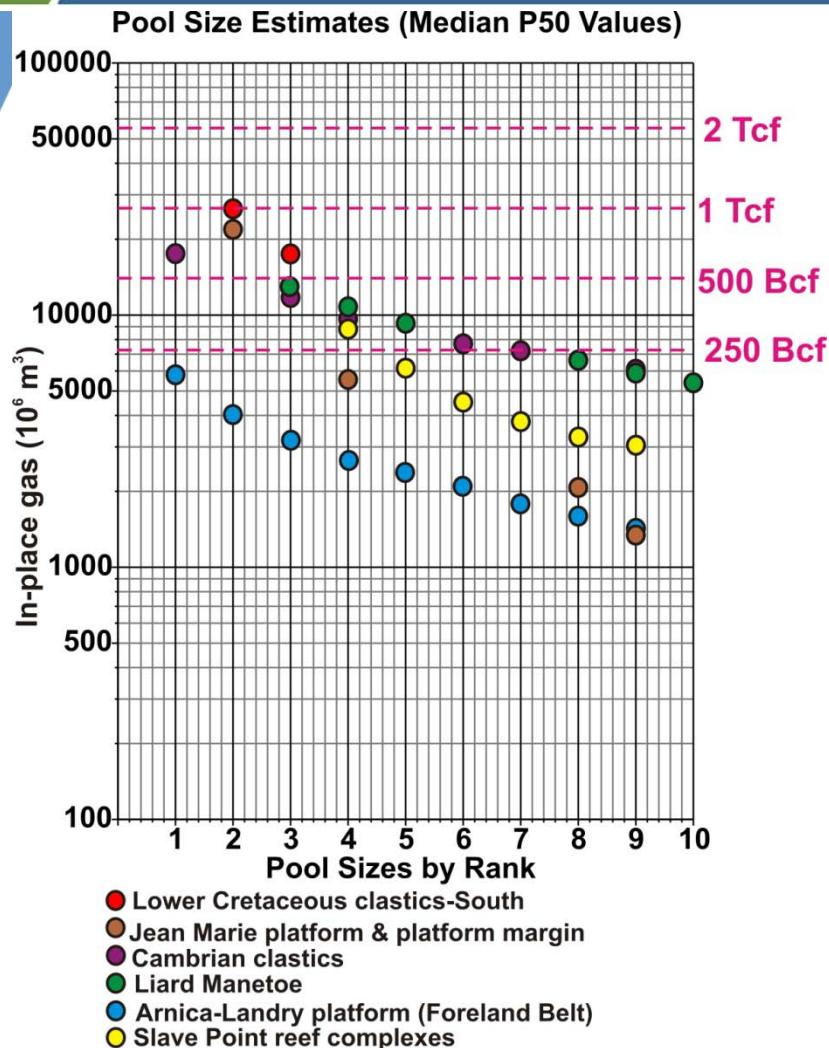
P95: $48 \times 10^9 \text{ m}^3$

(Mean: 12010 Bcf)

**Largest
undiscovered pool
ranks 3rd among
156 gas pools**

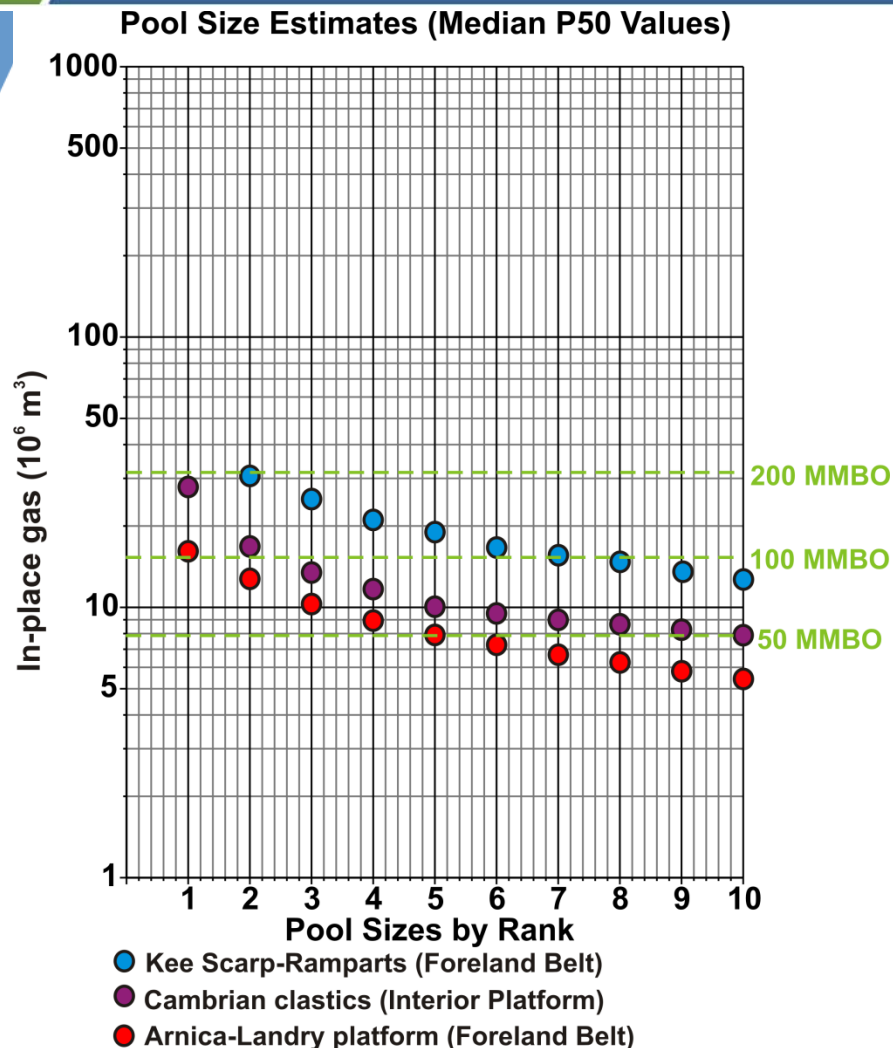
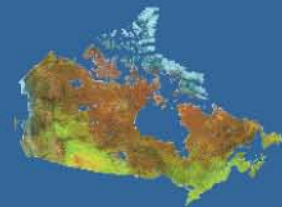


- **Shale gas: Horn River/Bluefish/Hare Indian (M. Devonian)**
Road River (Ordovician-Devonian)
Canol/Muskwa/Imperial/Ft. Simpson
(M-U. Devonian)
Besa River/Exshaw/Banff (Carboniferous)
Arctic Red/Fort St. John (M. Cretaceous)
Boundary Creek/Smoking Hills (U. Cret.)
- **Tight gas: U. Dev. Jean Marie shelfal carbonates**
Mackenzie Valley
- **Coal bed methane: Mattson/Wapiti (Liard Basin)**
Little Bear/Summit Creek (Brackett Basin)
- **Oil shales: Canol (Norman Wells area)**
Smoking Hills (Anderson Plain)



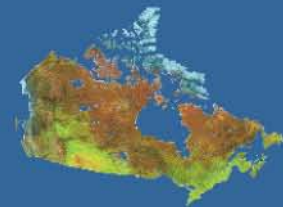
Largest Pool
28.3 Billion m^3
(1 Tcf)

Twelve Pools
> 7.1 Billion m^3
(250 Bcf)



Largest Pool
30.8 Million m^3
(194 MMBO)

Nine Pools
> 15.9 Million m^3
(100 MMBO)

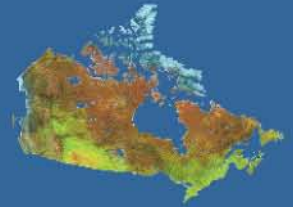


37 conventional oil & gas exploration plays have been defined
25 in Interior Platform; 12 in Foreland Belt
30 have enough data for quantitative analysis

Interior Platform plays have total mean in-place potential of
 $1717 * 10^9 \text{ m}^3$ of gas (61 Tcf)
 $661 * 10^6 \text{ m}^3$ of oil (4158 MMBO)

Plays with greatest total mean potential are:
Jean Marie platform gas - $314 * 10^9 \text{ m}^3$ (11 Tcf)
Slave Point reef complex oil - $217 * 10^6 \text{ m}^3$ (1363 MMBO)

Plays with the largest undiscovered median pool size are:
Lower Cretaceous clastic-South gas - $28 * 10^9 \text{ m}^3$ (1.0 Tcf)
Cambrian clastic oil - $28 * 10^6 \text{ m}^3$ (178 MMBO)

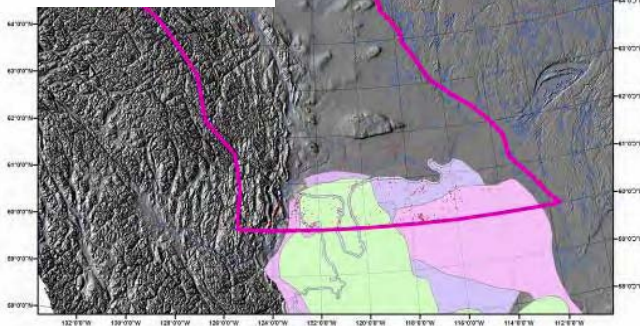
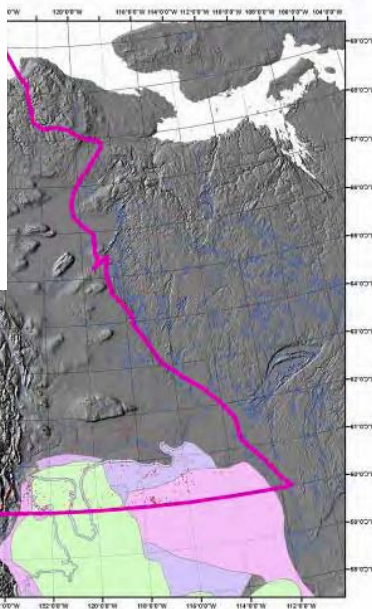
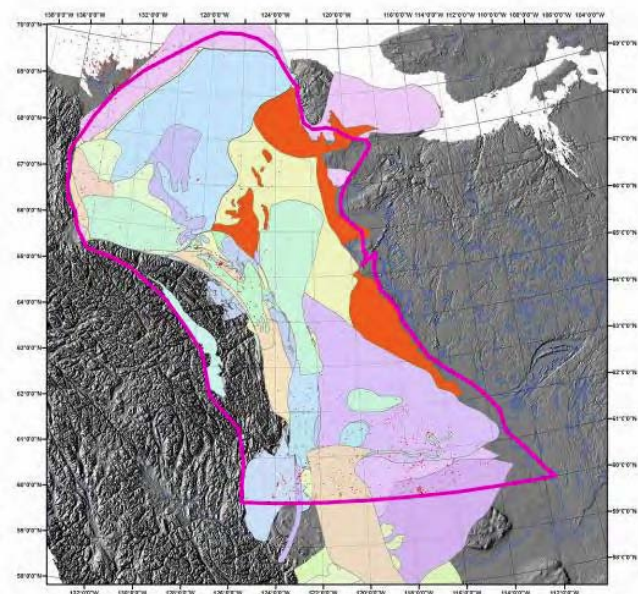
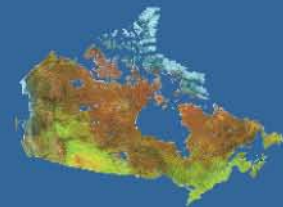


Foreland Belt plays have total mean in-place potential of
 $425 * 10^9 \text{ m}^3$ of gas (15 Tcf)
 $384 * 10^6 \text{ m}^3$ of oil (2415 MMBO)

Plays with greatest total mean potential are:
Liard Manetoe gas - $340 * 10^9 \text{ m}^3$ (12 Tcf)
Kee Scarp reefs-Ramparts platform oil - $212 * 10^6 \text{ m}^3$ (1337 MMBO)

Plays with the largest undiscovered pool size (P50) are:
Liard Manetoe gas - $13 * 10^9 \text{ m}^3$ (0.5 Tcf)
Kee Scarp reefs-Ramparts platform oil – $30.8 * 10^6 \text{ m}^3$ (194 MMBO)

Unconventional oil & gas have not been quantitatively analyzed.
However, multi-Tcf of recoverable resources have
been announced from initial testing and fracturing (Horn River)



Play Definition Totals
77 Tcf gas
6623 MMB oil

Project Area Totals
32.8 Tcf gas
4790 MMB oil

GEM

Thank you!

**For further information:
Peter.Hannigan@NRCan-
RNCAN.gc.ca**

**Free download of Open File 6757:
<http://geopub.nrcan.gc.ca/>**



Natural Resources
Canada

Ressources naturelles
Canada

Canada