

# **NORTHWEST TERRITORIES Hydrocarbon Potential and Exploration Play Trends**

**Focus on Oil & Gas  
NORTHWEST TERRITORIES  
Calgary, Alberta  
June 7, 2004**

**G. E. Reinson and K. J. Drummond**

- ▶ Today I would like to give you a review of the discovered resources and hydrocarbon potential of the Canadian Northwest Territories and Yukon.
- ▶ Over the last few years, there has been renewed interest in the oil and gas potential of NWT and Yukon. This interest stems from the strength of the gas market in terms of price and long-term supply, and from the substantial natural gas volumes recently encountered during exploratory drilling in the late 1990's in the Liard Plateau region
- ▶ More recently there is renewed interest in the various pipeline options for northern natural gas.

## **ACKNOWLEDGEMENT**

This presentation is based in part on the following multi-client study by Sproule Associates Ltd.

HYDROCARBON POTENTIAL AND  
EXPLORATION PLAY TRENDS  
NORTHWEST TERRITORIES AND YUKON  
A Technical Inventory and Geological Review  
July, 2000



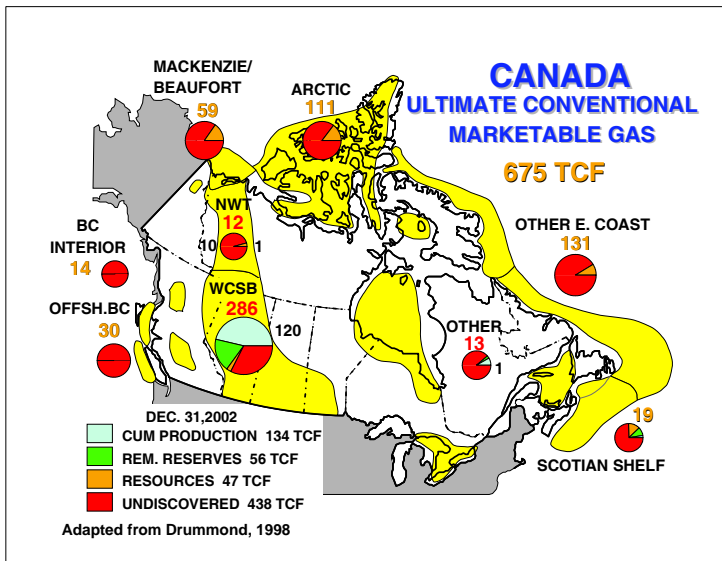
The authors would like to acknowledge and thank Sproule Associates Limited for permission to present this paper.

- ▶ This presentation is based in part on a study conducted by Sproule Associates and we would like to acknowledge and thank them for permission to present this review.
- ▶ In light of the interest a comprehensive review of the entire NWT/Yukon was conducted by Sproule in 2000, Gerry Reinson and Ken Drummond being the principal authors. The study was basically a summary overview and technical inventory of the ultimate oil and gas resource.

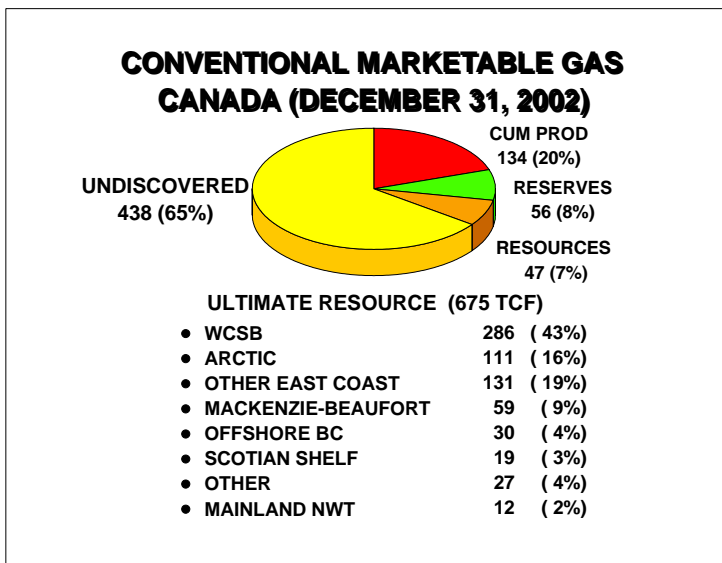
## **OBJECTIVES**

- ▶ **TO COMPARE HYDROCARBON PROSPECTIVITY AND RESOURCE POTENTIAL OF THE DIFFERENT REGIONS**
- ▶ **TO HIGHLIGHT THOSE REGIONS THAT ALREADY CONTAIN SUBSTANTIAL DISCOVERED RESOURCES**
- ▶ **TO HIGHLIGHT THOSE REGIONS OR BASINS THOUGHT TO HAVE SIGNIFICANT UPSIDE RESOURCE POTENTIAL - NOT YET DISCOVERED**

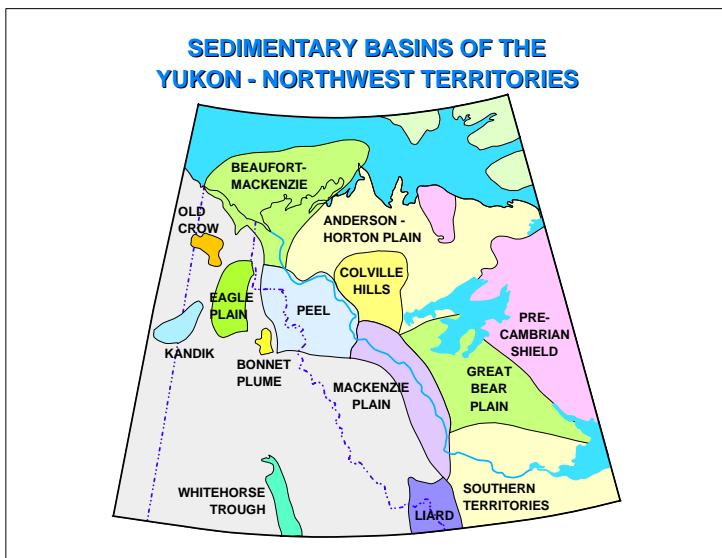
- ▶ I will give an overall review of the discovered resources and undiscovered potential, and highlight those areas thought to have the greatest potential for larger discoveries in the future.



- ▶ This slide shows the distribution of estimated ultimate marketable gas for Canada taken from Drummond, 1998, with update of production and reserves to Dec.31, 2002.
- ▶ The estimated ultimate marketable gas is 675 Tcf, with 59 Tcf to come from the Beaufort/Mackenzie area and 12 Tcf from the Mainland Territories.
- ▶ The Liard/ Southern Territories is included with the WCSB on this slide.

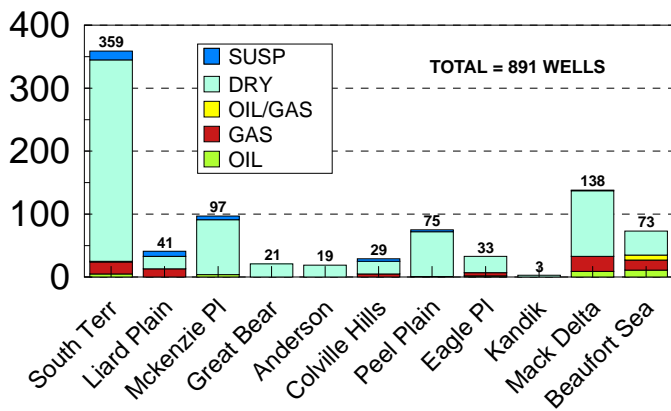


- ▶ This pie chart shows the relative distribution of the ultimate conventional marketable gas resource. Frontier conceptual plays are unrisks on this slide.
- ▶ 43% of the ultimate is in the WCSB, with 57% to come from the Frontier areas.
- ▶ Much of the potential is in presently inaccessible regions, as the Arctic Islands, other East Coast offshore, and offshore BC.
- ▶ The available undiscovered resource for the near term is possibly the gas (11% of the total) from the Northwest Territories and in particular the Mackenzie Delta/Beaufort Sea.
- ▶ It is this area that will be the focus of the presentation today.



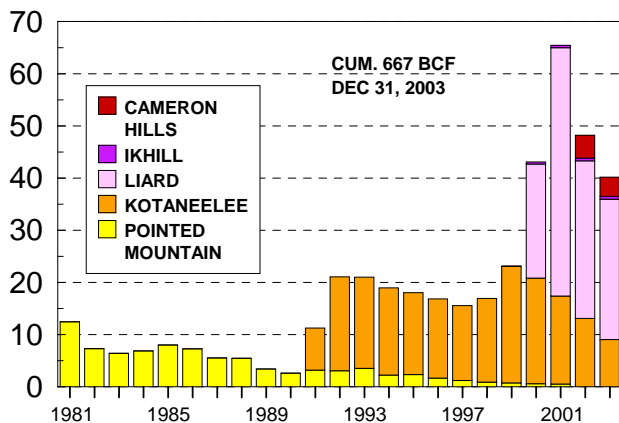
- ▶ This slide shows the 13 exploration regions or "sedimentary basins", based on physiographic and geological controls. The sedimentary basins occupy an area of approximately 300,00 square miles. The region is characterized by a disturbed mountain and foothills belt along the west with a foreland basin and shelf overlapping the Precambrian Shield to the east.
- ▶ The more important basins which I will be discussing include the Liard Fold Belt and adjacent Southern Territories, Mackenzie Plain, Colville Hills, Peel, Eagle Plains, and the Mackenzie/Beaufort
- ▶ This division provides a viable framework upon which to compare hydrocarbon prospectivity and resource potential in the different regions.

### YUKON AND NORTHWEST TERRITORIES NUMBER EXPLORATION WELLS BY AREA



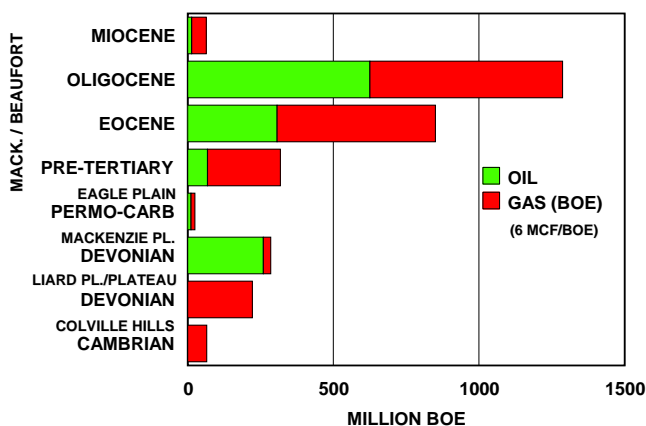
- ▶ A look at the number of wells drilled by area gives a perspective of the exploration trends and shows the level of exploration.
- ▶ By far most of the exploration activity over the years has occurred just north of 60 (Alberta/B.C.) with substantial activity in the Mackenzie/Beaufort as well.
- ▶ A total of 891 exploration wells have been drilled, with an overall success rate of 14%, ranging from no success in some of the poorer basins to 39% in the Liard Fold Belt and 48% in the Beaufort Sea.

### YUKON/ NORTHWEST TERRITORIES ANNUAL GAS PRODUCTION

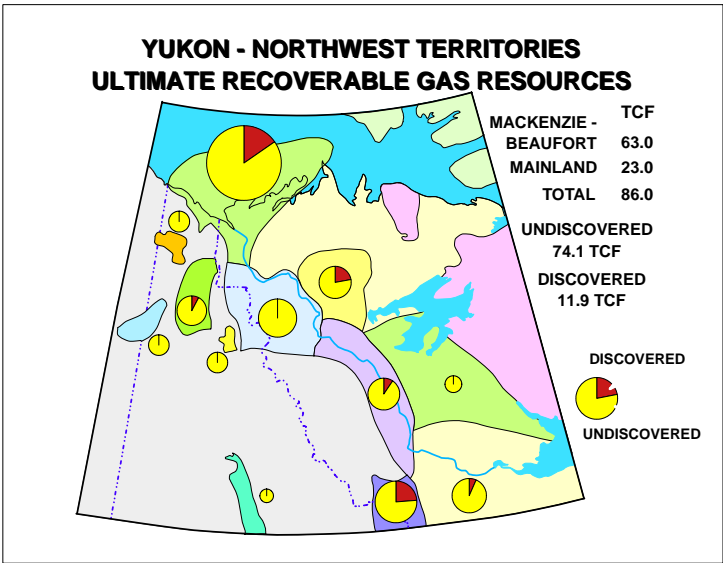


- ▶ This slide show the historical gas production for the Northwest Territories from 1981 to the end of 2003, minus Norman Wells .
- ▶ Net cumulative production for the NWT/YT to Dec.31, 2003 is 667 BCF.
- ▶ Cum. production from the fields is; Liard fields - 128.8 Bcf, Kotaneelee - 204.7 Bcf, Pointed Mtn - 315.7 Bcf, Ikhill - 2.0 Bcf, Cameron Hills - 8.1 Bcf, and Beaver River - 7.7 Bcf.

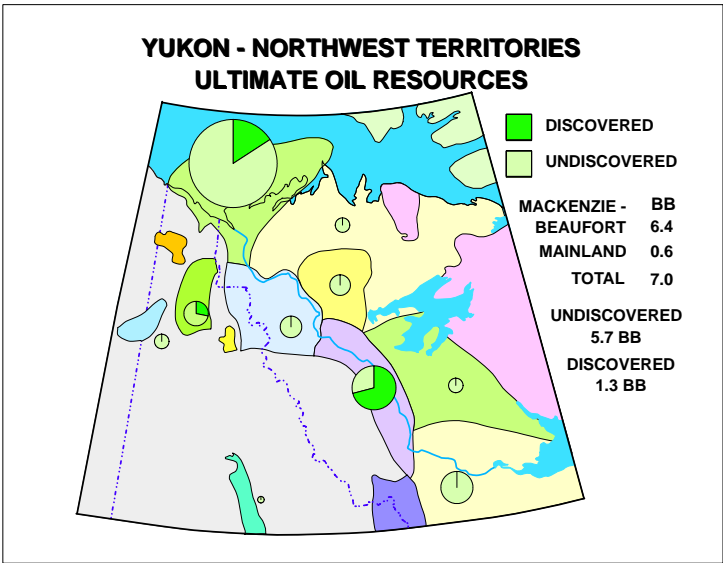
### YUKON / NORTHWEST TERRITORIES DISCOVERED RESOURCES BY STRATIGRAPHIC SYSTEM



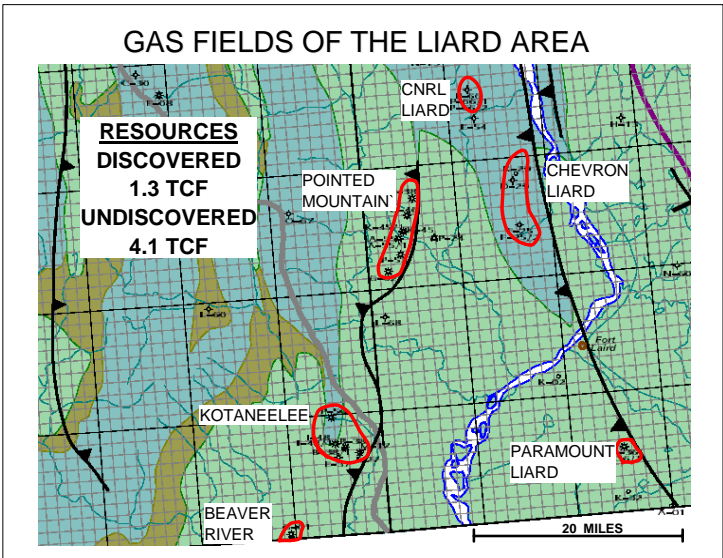
- ▶ This slide shows the distribution of discovered resources on a BOE basis for the major stratigraphic systems of the Territories.
- ▶ The Cambrian of the Colville Hills and the Devonian Liard are essentially Gas. The Devonian of the Mackenzie Plain is oil with some associated gas.
- ▶ Minor amounts of oil and gas have been discovered in the Permo-Carboniferous of the Eagle Plains.
- ▶ By far the largest resource occurs in the Mackenzie /Beaufort with 2 oil & gas petroleum systems, the Pre-Tertiary and the Tertiary, with the largest volumes in strata of Oligocene age.



- ▶ This slide shows the distribution of the ultimate gas resources for the Yukon/NWT.
- ▶ The largest portion, 63.0 Tcf, or 73% of the total is expected in the Mackenzie-Beaufort.
- ▶ Currently discovered reserves/resources are in the Liard/Southern Territories, Colville Hills, Eagle Plains and the Mackenzie/Beaufort.

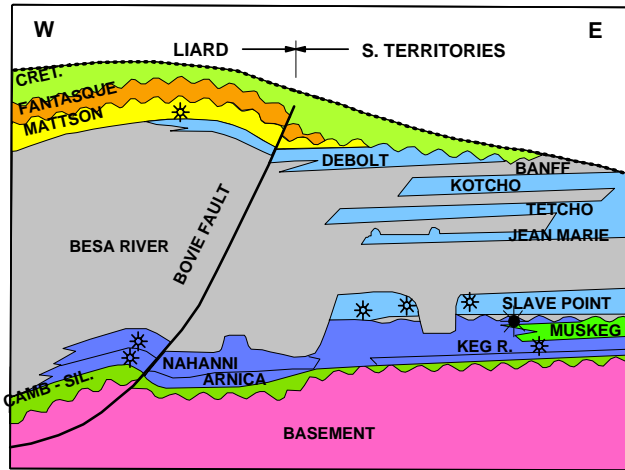


- ▶ Again the largest expected ultimate oil resource is in the Mackenzie/Beaufort with 6.4 Billion barrels or 91%
- ▶ The only oil production is from Norman Wells.
- ▶ Cumulative production to December 31, 2003 is 219 MMB.
- ▶ Cum. to April, 2004 is 221 MMB.
- ▶ Remaining reserves are 83 MMB from the initial recoverable oil reserves of 302 MMB.



- ▶ This slide shows the surface geology for the Liard Fold belt and the discovered gas fields.
- ▶ Total discovered resources of 1.3 TCF, with an estimated future potential of 4.1 TCF.

### LIARD - S. TERRITORIES SCHEMATIC SECTION



Modified from NOGD, 1995

- ▶ The petroleum system of the Liard area is shown by this schematic section. The primary reservoir is the Manetoe dolomite facies of the Devonian Nahanni/Arnica and Slave Point Formations, with the Besa River and equivalent shales providing both the source and seal.
- ▶ Gas has also been discovered in the Mattson sandstone.
- ▶ The Besa River is possibly also the source for gas in the overlying Carboniferous Mattson sandstone.

### Fort Liard, NWT

Production to Apr. 30, 2004

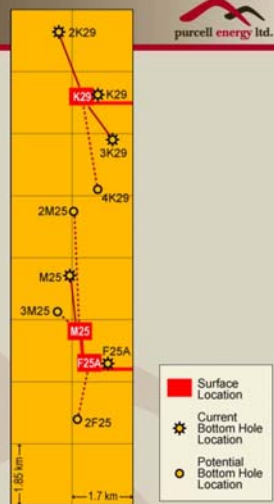
K-29	43.8 bcf
M-25	29.1 bcf
F-25A	5.2 bcf
2K-29	5.9 bcf
<b>Total:</b>	<b>84.0 bcf (sales)</b>

Gross raw gas to date: 120.0 bcf

PEL current production: ~12 mmcf/d (sales)

M-25 presently shut in pending tubing change and repairs to gas/water line

3K-29 to be side-tracked summer, 2004

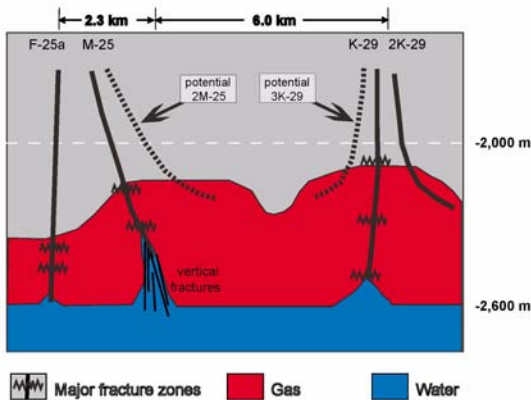


- ▶ This slide from the Purcell website shows the location of the four producing gas wells in the field, K-29, 2K-29, M-25, and F-25A. The production numbers have been updated to the end of April 2004 by the author.

- ▶ Total raw gas production to April 30, 2004 is 120 Bcf, with sales gas of 84.0 Bcf.

### FORT LIARD CROSS SECTION

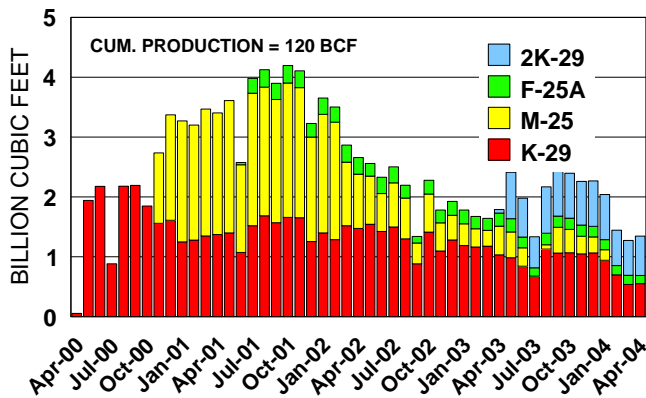
- Water traveling vertically up M-25 fractures and entering well bore
- M-25 successful recompletion in August 2003 increased rate to over 15 mmcf/d raw gas
- M-25 has sidetrack potential
- 3K-29 & 2M-25 to be drilled during 2004



From: Purcellenergy.com

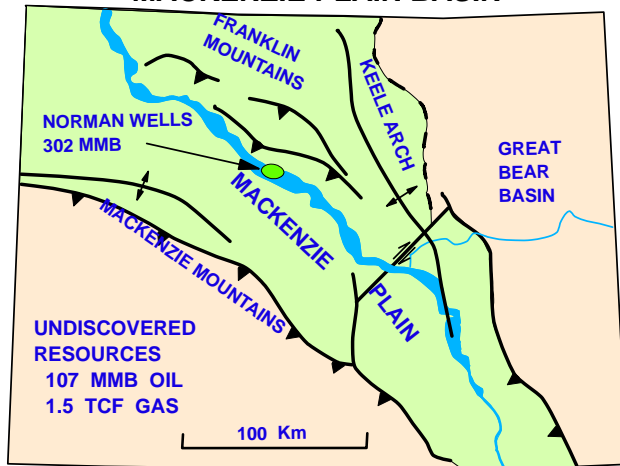
- ▶ This is a schematic cross section of the Chevron K-29 gas field taken from the Purcell website showing the structural setting of the four producing gas wells, and the two locations proposed for 2004.

## CHEVRON FORT LIARD GAS FIELD PRODUCTION



- ▶ Cumulative gas production from the four wells in the Chevron Fort Liard field to April 30, 2004 is 120.0 Bcf.
- ▶ K-29 62.8 Bcf, M-25 41.7 Bcf, F-25A 7.4 Bcf, and 2K-29 8.4 Bcf.
- ▶ Note the increased production from the M-25 re-completion in Sept. 2003. M-25 is presently shut-in waiting for repairs to be done upon the completion of the sidetrack 2M-25 well.

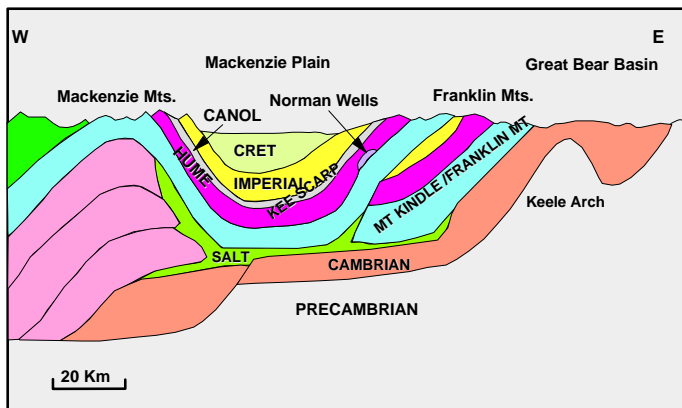
## MACKENZIE PLAIN BASIN



Modified from NOGD, 1995

- ▶ We'll now move further north along the Mackenzie to the Mackenzie Plain, bordered by the Mackenzie Mountains to the west and the basement rooted Keele Arch to the east.
- ▶ The Mackenzie Plain is a foreland basin dominated by the Norman Wells oil field, discovered in 1920, developed in the 1940's, with the major development occurring in the 1980's.
- ▶ Initial estimated reserves are 302 million barrels of recoverable oil. To December 31, 2003, cumulative production was 219 million barrels. Cumulative production to April 30, 2004 is 221 MMB.

## MACKENZIE PLAIN - SCHEMATIC SECTION

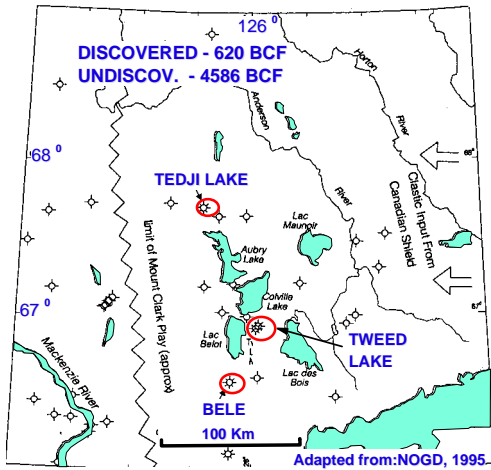


Modified from NOGD, 1995

- ▶ This schematic section shows the structural setting of the Mackenzie Plain and the Norman Wells oil field. The reservoir is the Devonian Kee Scarp reef. The source rock is the Canol shale.
- ▶ Although several exploration efforts have tried to find another Norman Wells, it remains the only discovery in the area. A truly unique field size distribution.

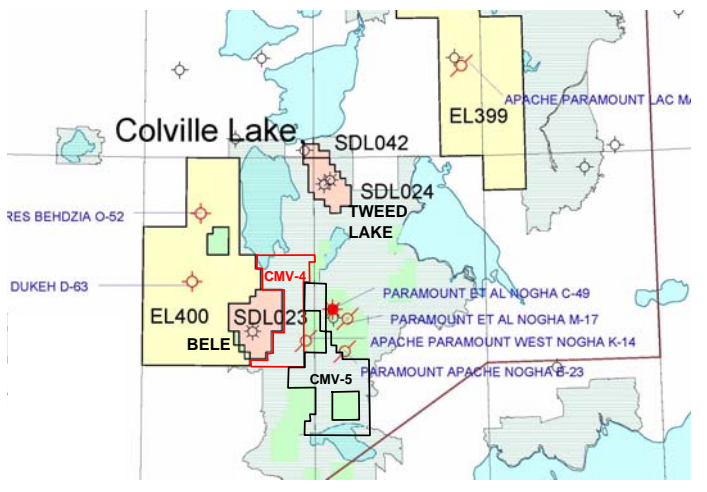


## COLVILLE HILLS, NWT SHOWING LOCATION OF CAMBRIAN SANDSTONE GAS DISCOVERIES



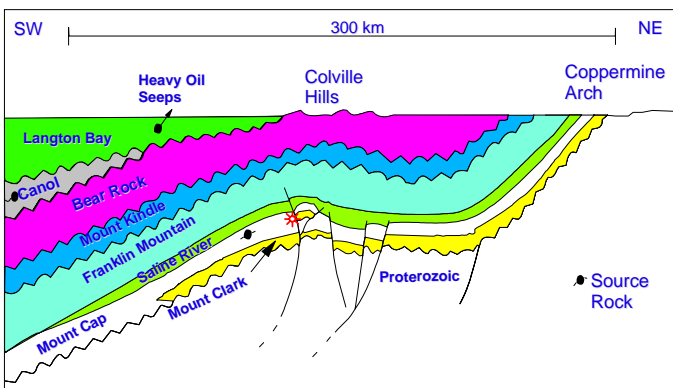
- ▶ To the northeast of the Mackenzie Plain is the Colville Hills.
- ▶ This slide shows the location of the three Cambrian gas discoveries in the area. Two discoveries have been made at Tweed Lake, with one each at Tedji and Bele.
- ▶ Total discovered recoverable gas resources are estimated at 620 Bcf. Undiscovered potential is estimated at 4.6 Tcf recoverable gas

## COLVILLE HILLS - DRILLING 2003/2004



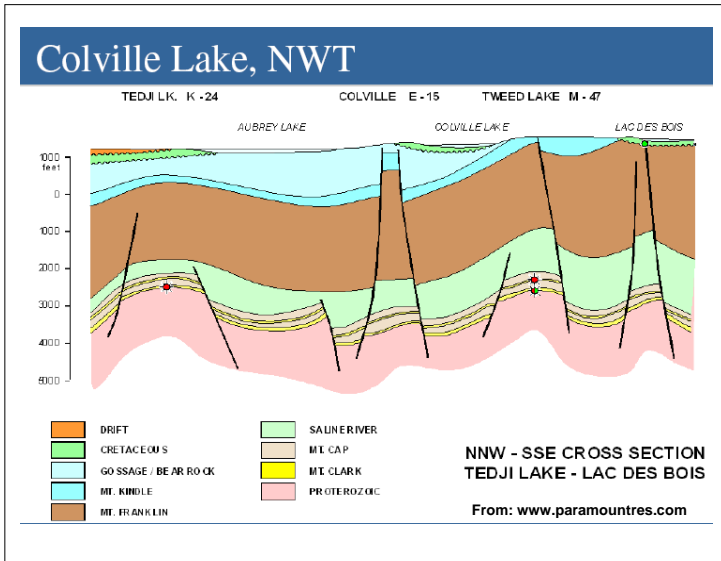
- ▶ Four wells were drilled in the Colville Hills area in early 2003, and another two in 2004.
- ▶ Operators have indicated gas was discovered in the Cambrian sandstone in the eastern wells, whereas the two wells on the west are dry and abandoned.
- ▶ However results are still confidential.
- ▶ The two land blocks CMV-4 and CMV-5 are shown. Call for bids on these blocks closes at noon June 7, 2004.

## SCHEMATIC SECTION, COLVILLE HILLS AREA

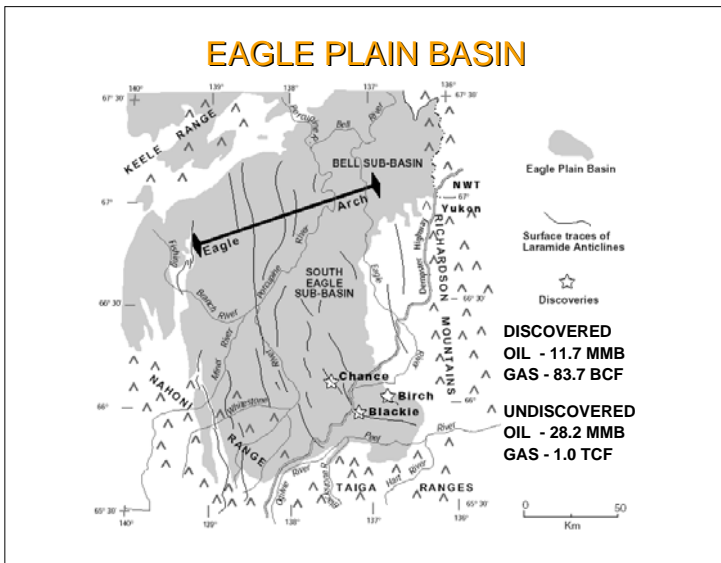


Modified from NOGD, 1995

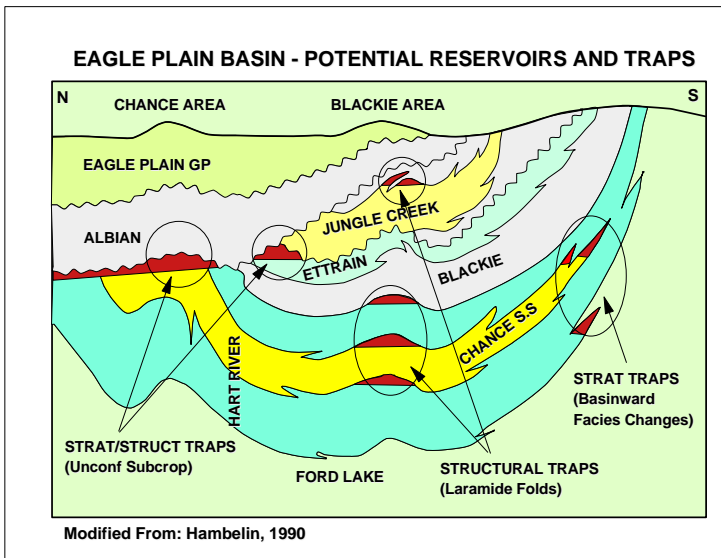
- ▶ This schematic shows the structural/stratigraphic setting of the Cambrian petroleum system of the Colville Hills.
- ▶ Gas occurs in the reservoirs of the basal Cambrian Mount Clark sandstone.
- ▶ The source rock is the Cambrian Mount Cap shales and the seal is provided by the Cambrian Saline River salt.
- ▶ Gas is trapped in basement block faulted structures. Stratigraphic traps onlapping basement highs may also occur.



- ▶ This is a more detailed cross-section from the latest Paramount presentation on their website.
- ▶ It shows the gas zones within the Mount Clarke for the Tedji and Tweed Lake discoveries.

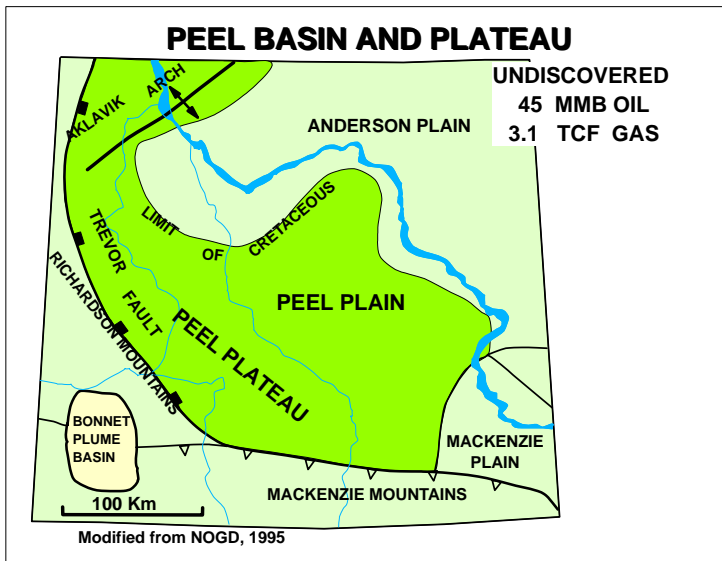


- ▶ The Eagle Plain is an intermontane basin, with a stratigraphic section from Lower Paleozoic to the Cretaceous.
- ▶ Shown is the location of the three gas discoveries in the basin. Birch and Blackie are gas discoveries in Permian sandstones. Chance is an oil and gas field with 11.7 MMB of oil and 51 BCF of gas in the Carboniferous Chance sandstones.
- ▶ Undiscovered resources are estimated at 28 MMB of oil and 1 TCF of natural gas.

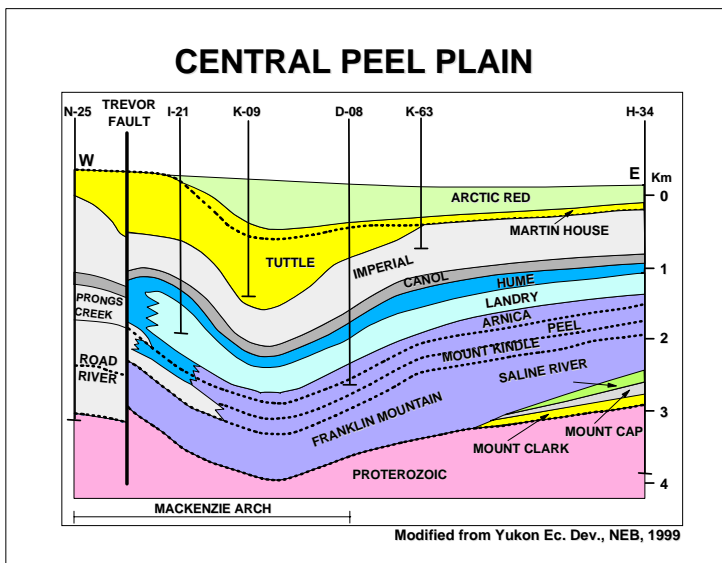


- ▶ This slide shows the various potential reservoirs and traps which could occur in the Eagle Plains basin.
- ▶ Main reservoirs are the Chance and Jungle Creek sandstones.
- ▶ Source rocks are thought to be the Ford Lake, Blackie and Albian shales.

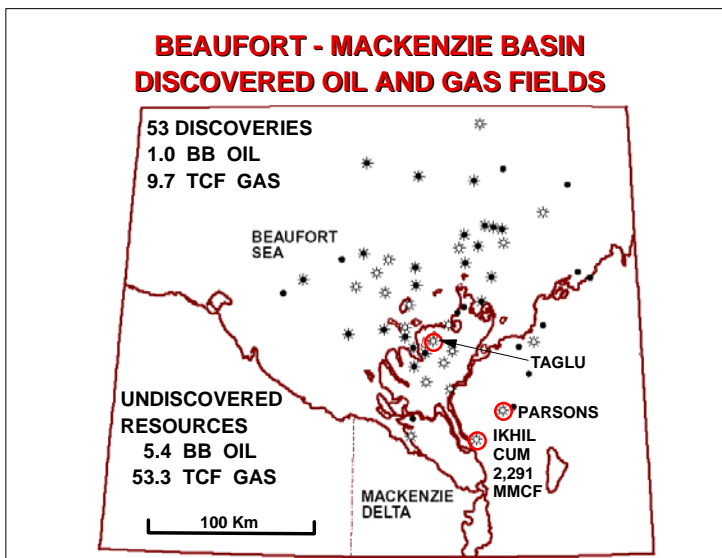




- ▶ The Peel Plain, lying to the north of the Mackenzie plain is characterized by a foothills belt of the Peel plateau along the west and a foreland basin of the Peel Plain.
- ▶ Although 72 wells have been drilled, no discoveries have been made. The basin is considered to be very sparsely explored and significant oil and gas potential could occur in the basin.
- ▶ The undiscovered potential is estimated at 45 MMB of oil and 3.1 TCF of gas.

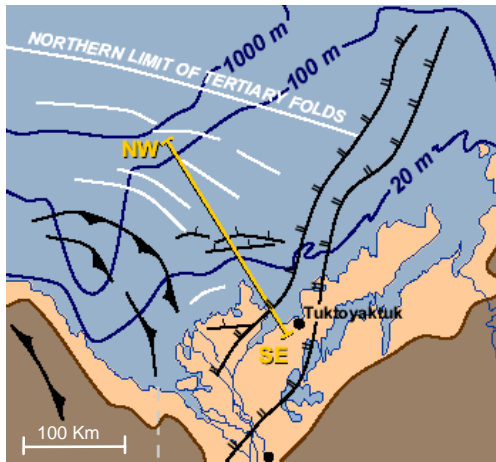


- ▶ This section shows the geological setting of the Peel basin.
- ▶ Reservoirs capable of containing oil and gas could occur in the Paleozoic carbonates and the Tuttle sandstone, in both the foothills and the foreland basin.
- ▶ Potential source rocks are the Canol, Road River and Prongs Creek shales.



- ▶ This slide shows the oil and gas discoveries of the Beaufort/Mackenzie. A total of 53 oil and gas fields have been discovered with discovered recoverable resources of 1 BB of oil and 9.7 TCF of gas.
- ▶ The Ikhil gas field was developed to provide gas to the local community of Inuvik. The field went on production in Feb, 1999 and has produced 2.3 BCF to the end of April 2004.
- ▶ Also shown is the location of two of the major gas fields which I will show later.
- ▶ Undiscovered resources are 5.4 BB of oil and 53.3 TCF of gas.

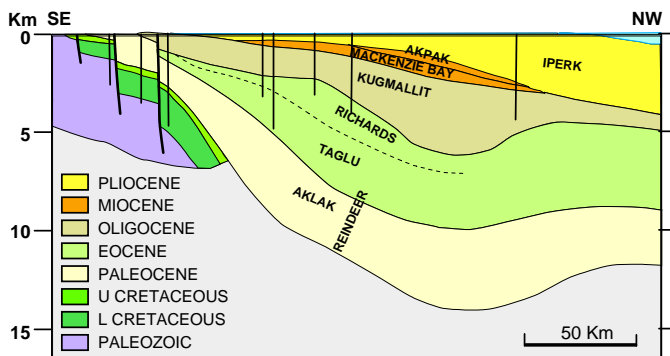
## BEAUFORT MACKENZIE - STRUCTURAL SETTING



Modified from Dixon, et al, 1992

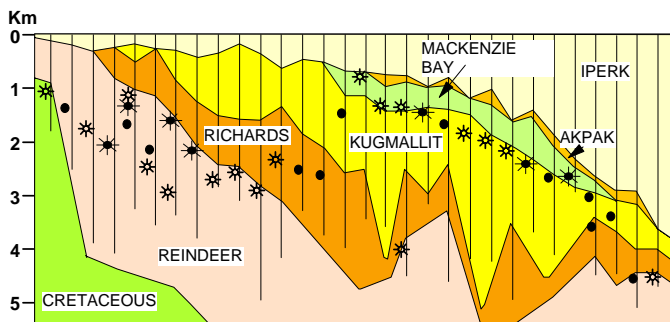
- ▶ This slide shows the structural setting of the Mackenzie Beaufort, with basement faulting along the basin margin, down to the basin faulting, and associated folds in the Beaufort Sea.

## BEAUFORT MACKENZIE BASIN



- ▶ The Beaufort/Mackenzie basin developed over a rifted margin of Cretaceous clastics unconformably overlying Devonian and older carbonates
- ▶ Shown on the section are the Tertiary sandstone sequences prograding seaward.

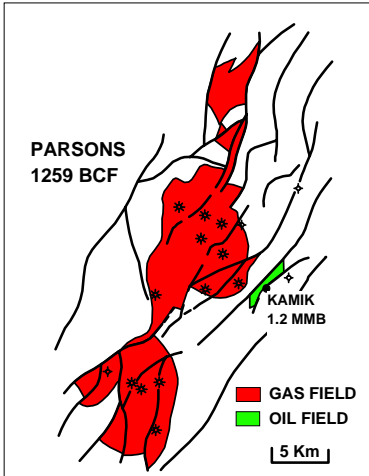
## BEAUFORT-MACKENZIE BASIN STRATIGRAPHIC POSITION OF 30 DISCOVERIES



Adapted from: Hitchon, et al, 1990

- ▶ This section the progressively younger prograding sequences, with the location of several of the oil and gas discoveries.
- ▶ Generally the discoveries occur in successively younger sediments seaward. Onshore discoveries are primarily in the Reindeer, and further offshore discoveries are primarily in the delta plain and delta front facies of the Kugmallit sequence.
- ▶ There are also some discoveries in the deeper Richards sequence offshore. Further offshore not represented on this section, discoveries occur in deepwater turbidites.

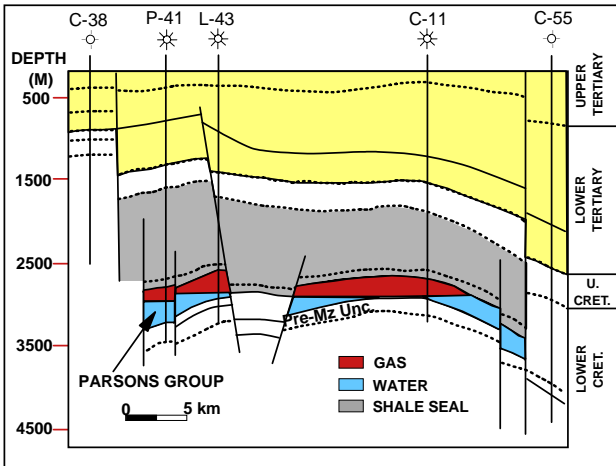
## PARSONS GAS FIELD



Adapted from: G.R MORRELL, 1996

- ▶ The Parsons gas field is reservoired in Lower Cretaceous sandstones in block faulted structures of a rifted margin.
- ▶ The field has discovered resources of 1.26 TCF of gas. A small oil field with 1.2 MMB occurs along the southeast flank of the Parsons structure.
- ▶ In addition to oil in the Cretaceous section, oil also occurs in Devonian carbonates of the rifted margin.
- ▶ Shales of Cretaceous age are believed to be the source for the oil and gas in Cretaceous and Devonian of the pre-tertiary rifted margin.

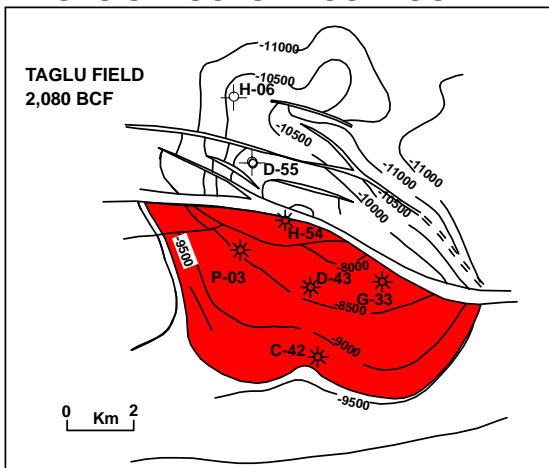
## PARSONS LAKE GAS FIELD



Adapted from: R. A. Meneley, 1986

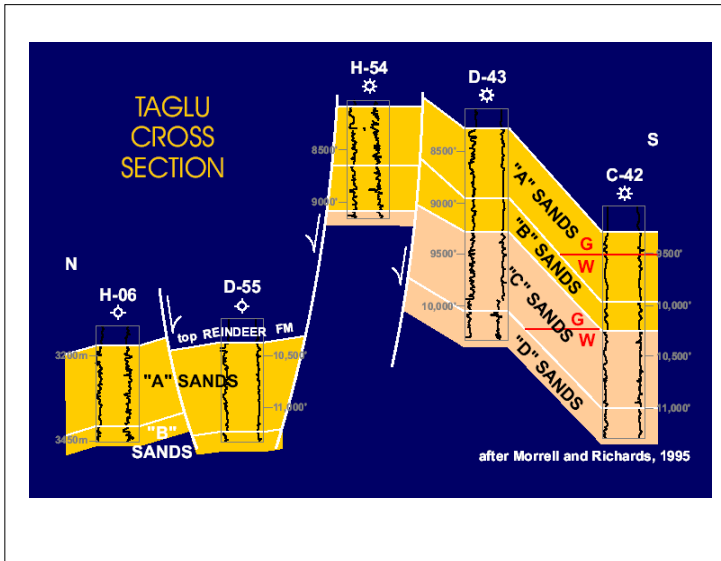
- ▶ This section shows the block faulted structure of the Parsons Lake gas field, with Cretaceous shales forming the seal, and unconformably overlain by the Tertiary deltaic clastics of the Beaufort Mackenzie basin.

## TAGLU STRUCTURE CONTOUR MAP

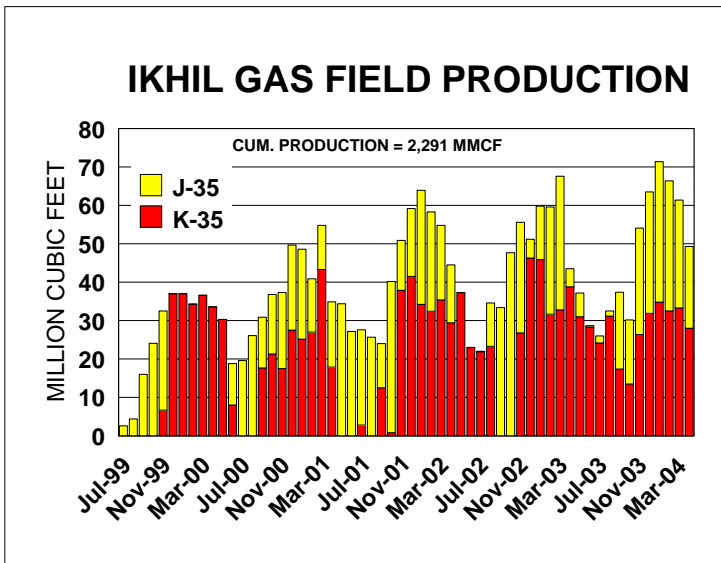


Adapted from: G.R MORRELL, 1996

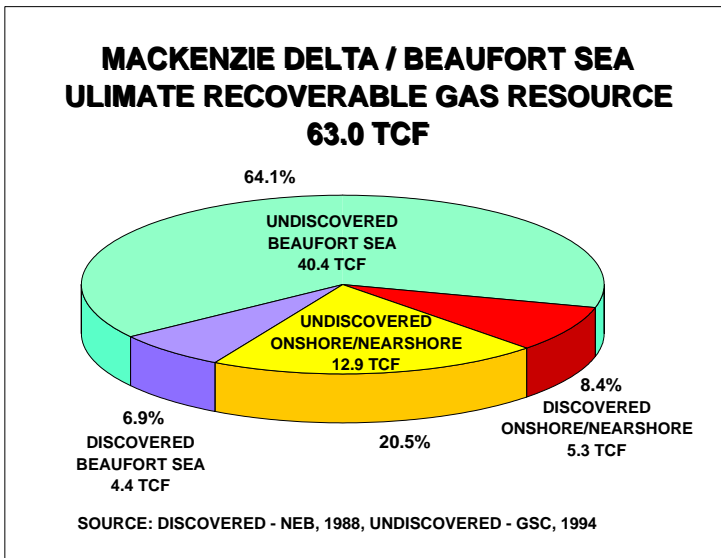
- ▶ The largest gas field to date is the Taglu gas field with discovered gas resources of 2 Tcf.



- ▶ This section shows the stratigraphic/structural setting for Taglu.
- ▶ Gas occurs in two thick sandstones, designated A and C.
- ▶ Down to the basement faulting, with significant throw, plays a dominant role in the trap for the accumulation.



- ▶ This slide shows the monthly Ikhil gas field production from the 2 wells J-35 and K-35.
- ▶ Cumulative production to April 30, 2004 is 2.29 Bcf.
- ▶ Gas from this field is supplying the local market at Inuvik.
- ▶ Cum Production: K-35 1.308 Bcf, J-35 0.983 Bcf.



- ▶ The ultimate recoverable gas resource for the Mackenzie Delta/ Beaufort Sea is estimated at 63 Tcf.
- ▶ 9.7 Tcf or 14.5% has been discovered, with an estimated 53.3 Tcf undiscovered, or 85.5%.
- ▶ 28.2% of the resource is onshore and in the shallow offshore of the Mackenzie Delta (less than 12 metres WD)
- ▶ 85.5% of the gas resource is in the deeper water of the Beaufort Sea.

**SUMMARY - YUKON / NWT  
RECOVERABLE OIL & GAS OF MAJOR AREAS**

	DISCOV OIL (MMB)	UNDISCOV OIL (MMB)	DISCOV GAS (BCF)	UNDISCOV GAS (BCF)
LIARD/ S. NWT	0	0	1,371	7,292
MACKENZIE PLAIN	302	107	156	1,500
COLVILLE HILLS	0	28	620	4,586
PEEL BASIN	0	45	0	3,149
EAGLE PLAINS	12	28	84	1,103
MACKENZIE DELTA	248	1,050	5,319	12,600
BEAUFORT SEA	767	4,350	4,376	40,700
TOTAL (+ OTHERS)	1,329	5,736	11,925	74,119

- ▶ This slide summarizes the recoverable oil and gas resources for the major areas of the Yukon and NWT, which have discussed.
- ▶ The Beaufort/Mackenzie clearly dominates with discovered oil of 1 BB and undiscovered potential of 5.4 BB. Gas resources for the BMB are 9.0 TCF discovered and 53 TCF yet to be discovered.
- ▶ Potential in the other areas is dominantly gas, with estimated undiscovered of 7.3 TCF in the Liard Plateau/Trout Plain area and 3.1 TCF in the Peel Basin.
- ▶ Totals shown are for all basins of the Yukon and NWT.
- ▶ The totals indicate a significant undiscovered oil and gas potential for the Yukon/NWT.

**CONCLUSIONS**

- ▶ DISCOVERED OIL AND GAS OCCUR IN CAMBRIAN,DEVONIAN,PERMO-CARBONIF, CRETACEOUS AND TERTIARY AGE STRATA.
- ▶ MAJOR OIL DISCOVERIES IN MACKENZIE PLAIN AND THE MACKENZIE/BEAUFORT.
- ▶ MAJOR GAS DISCOVERIES IN LIARD, COLVILLE HILLS & MACKENZIE/ BEAUFORT.
- ▶ FUTURE DISCOVERIES EXPECTED IN LIARD, COLVILLE HILLS, MACKENZIE PLAIN, PEEL BASIN, EAGLE PLAIN AND MACK/ BEAUFORT.

- ▶ Conclusions
- ▶ Significant discoveries of oil and gas have been made.
- ▶ And Significant volumes of oil and gas are expected in the future, with the most significant being the Beaufort/Mackenzie.