The Lower Montney Turbidite Complex of Northwest Alberta and Northeast British Columbia: Evolution of an Oil and Gas Play From Conventional to Unconventional*

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Abstract

The Lower Triassic Montney formation is one of western Canada’s most lucrative unconventional hydrocarbon plays. With a thickness in excess of 300m, aerial extent covering approximately 130,000 km², the National Energy Board of Canada estimates the Montney Formation contains marketable resources of 449 TCF of gas, 14.5 billion barrels of NGL’s and 1.13 billion barrels of oil. The Lower Montney Formation in the Peace River Arch region of northwest Alberta and northeast British Columbia was one of the first areas of the Montney exploited for hydrocarbon beginning in 1980. The initial discoveries were made in turbidite channel complexes, using 3D seismic and conventional vertical drilling and completion methods. The reservoir are highly porous (15%) and permeable (1-5 md) fine-grained channel sands. The channels facies is very prolific but limited in aerial extent. Beginning in 2006, with the advent of horizontal drilling and multi-frac completion technology, it now became possible to economically exploit the thicker more aerial extensive, fan portion of the turbidite complex. These rocks are fine-grained laminated siltstones with lower porosity (3-10%) and lower permeability (less than 0.1 md) but, extremely thick (30-70 m). Detailed geological mapping reveals that the deposition and the thickness of the fan are structurally controlled by underlying Paleozoic fault systems that define the Fort St. John graben complex. Isotope geochemistry of the hydrocarbons reveals that they are internally sourced, and their distribution display a normal thermal maturity distribution with dry gas being found in the deepest portion of the basin, transitioning to wet gas condensate and light oil concentrated along the basin margin. The fan can be mapped into three cycles ranging in thickness of 15m to 25m. Each cycle has a preferred landing zone, which contains more highly porous and permeable rock which local operators target. Thru time, the more proximal portion of the fan has been
exploited but with the further advancement of drilling and completion techniques, more distal portions of the fan complex are economically being exploited.

**Selected Reference**

THE LOWER MONTNEY TURBIDITE COMPLEX
OF
NW ALBERTA AND NEBC

Evolution of an Oil & Gas Play
“From Conventional to Unconventional”

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Montney
“World Class Resource Play”

**Large Areal Extent & Thickness:**
- Extends over 50,000 sq. miles.
- Stacked resource up to 1000 ft. thick

**Massive Resource Potential:**
- Over 450 Tcf gas, 14.5 Bbbls Ngl’s and 1.2 Bbbls of oil (marketable). “NEB 2013”

**Fracability:**
- Low clay content, low Poisson’s ratio and high Young’s Modules.

**High Permeability:**
- Siltstone not a shale.

**Over Pressured:**
- Up to 2 times normal pressure

**Competitive Land Tenure and Royalty:**
- 5-20% royalty for life of well
- Multi-section licenses and leases continued by 1 well
Peace River Arch Stratigraphy

PRA Strat Column

- Cretaceous
- Jurassic
- Triassic
- Permo- Penn
- Mississippian
- U. Devonian
- PreCambrian

Triassic Strat Column

- Baldonnel-Pardonnet
- Charlie Lake
- Halfway-Doig
- Doig Phosphate
- Upper Montney
- Lower Montney

Rift Tectonics

Source

Mid Montney Marker

D-1
Area of Investigation

10,000 miles sq²

100 miles
Area Penetrations prior 1980

- **Lightly explored at the Montney Level prior to 1980**
- **A few wells in the Pouce Coupe area had penetrated the reservoir but were not tested**
- **Discovery well, 6-32, drilled by Dome Petroleum in 1980 after intersecting the reservoir a year earlier at 7-30 while drilling deeper target.**
Lower Montney Discovery Well

Dome Petroleum
6-32-76-11W6M
RR. Nov. 8/1980

IP. 30  1.65 mmcf/d
Cumulative Production Jan 1992-Pres.
Gas   5.9 bcf
Oil   655 bbls
Encana drills first Hz’s in 2006
★ Swan 1100 m 6-stage Hz multi frac.
★ Gordondale 1200 m 4-stage Hz-multi frac.
Industry Activity 2007 – 2016
The Unconventional Era

- 1980 – 2009 Verticals
- 2008 – 2016 Horizontals
Isopach
Mid Montney Marker
to Permian Belloy

Doig Phosphate
Upper Montney
Mid-Montney Marker
Lower Montney
Belloy

Lower Montney Basin Geometry
Lower Montney (D1) Log Facies

- **Gordondale**: 50m Turbidite Fan
- **Swan**: 40m Turbidite Fan over Channel
- **Mica**: 75m Turbidite Fan
- **Valhalla**: 12m Turbidite Channel

~ LEUCROTTA EXPLORATION INC. ~
Lower Montney Depositional Model (modified from Kendall 2012)

Conventional Channel and Levee Complex

Unconventional Vertical Nested and Offset Stacking Channels and Sheets

Valhalla

Gordondale

Swan

Mica

FSJ Graben Complex
- **Verticals wells** dominate the channel complex.

- **Hz wells** dominate proximal to distal fan.
Leucrotta “Places The Bet”

2010-2012
LXE Drill, core and test’d
- Sunrise 15-2-80-16W6
  - 247 mcf/d
- Doe 4-19-80-14W6
  - 211 mcf/d

Dec 2013
LXE Doe
- B4-19 IP30 4.0 mmcf/d & 234 b/d Cond.
TOU Sunrise
- A5-5 IP30 6.3 mmcd/d & 634b/d Cond.
- D5-5 IP30 5.6 mmcd/d & 525 b/d Cond.

2014 – 2015
LXE adds 150 net sections
Montney rights in the thick portion of the fan.

Isopach Lower Montney Porosity Gt. 3% (Lst)
Two expl. wells Q4/2014

- 13-7 30 day test 270 b/d oil & Ngl's and 1.5 mmcf/d.
- 8-18 30 day test 150 b/d oil & Ngl's and 1.7 mmcf/d gas.

Re-examine to understand test rates compared to the 5-5 & b4-19 and the extent of the oil at 13-7.
Density Log Normalization

- Vertical log data set consist of a wide variety of logging companies and vintage of density logs that needed to be “normalized”.

- More ‘Art” than “Science”.

- Identify specific stratigraphic mappable log packages that have preferential higher zones of porosity and permeability to target landing zones.
Lower Montney Zone 1
Isopach Net Porosity GT 5%

Type Log

00/02-23-081-14W6/0

Top L. Mntn

Zone 3

Zone 2

Zone 1

5-5

B4-19

13-7

8-18

B4-19

8-18

5-5
Lower Montney Zone 2
Isopach Net Porosity GT 5%
Lower Montney Zone 3
Isopach Net Porosity GT 5%

Type Log
00/02-23-081-14W6/0

Top L. Mntn

Zone 3

Zone 2

Zone 1

5-5
B4-19
13-7
8-18
Lower Montney Zone 1 thru 3
Isopach Net Porosity GT 5%

Porosity thick in FSJ Graben

Paleozoic faults

12 kPa/m
10 kPa/m
Two more exploration wells were drilled in the Q4/2015

- 8-22 8 day test 355b/d oil & Ngl's and 2.2 mmcf/d.
- 13-19 3 day test of 6.8 mmcf/d gas and 179 b/d free cond.
- The D&C costs below $4 MM

The size of the oil window expanded 6 miles to the SW. The Position of the landing of the well significantly increased the productivity of the wells.
Better Predict the Composition of the Reservoir Fluid

- **Mud Gas Chromatography**
  - Collected and interpreted before the production string is placed in the ground.
  - “CHEAP” Tried and true but only gives you a relative wetness.
  - When calibrated it will accurately predict if “Rich Gas” vs “Hi GOR Oil”

- **Mud Gas and Produced Gas Carbon Isotope Analysis**
  - “Cheap” It will give you a VRE of your gas before the well is completed.
  - When calibrated to produced gas it can predict your gas composition and oil API before the well is completed.

- **Oil Typing**
  - Are the hydrocarbons locally – internally sourced or the result of long distant migration from down-dip or from deeper horizons thru faults and fractures.
Mud Gas Chromatography

Wetness Ratio = \( \frac{C_2-C_5}{C_1-C_5} \times 100 \)
Balance Ratio = \( \frac{C_1-C_2}{C_3-C_5} \)

* Maintain constant MW & ROP *

* Rich Gas - Condensate *

* Hi GOR Oil *

Decrease Subsea Elevation
Carbon Isotopes in Gases are driven by temperature as are processes of oil and gas formation.

From Schoell and LeFever, 2011
Lower Montney Displays a Normal Maturation Profile

- **Dry Gas in the SW to Rich Gas Cond & Light Oil to the NE**
- **High API free liquids in the SW to Lower API oils in the NE.**
- **Mud Gas VRE 1.3 in SW to 0.96 in the NW.**

Gordondale Anomaly!
What is Controlling Reservoir Fluid Distribution?
Monocline surface with no significant faulting at Lower Montney level.
Gordondale
Lower Montney Gas Wetness Ratio
Gordondale

Porosity is Controlling Reservoir Fluid Distribution?

Oil Trapped in Tighter Rocks!
IC4/NC4 to C1 Ratio
Gordondale Area

Wells with elevated Methane in the Higher Porosity Region

Normal Thermal Maturity Trend

Methane Secondary Trend
Maturation Profile at Gordondale has been effected by variations in porosity as a result of a later phase of gas migration, displacing the oil in the more porous rock.
Lower Montney oil with varying API gravities (37 - 44° API) were generated from a Triassic age source rock (Type II-III) in a distal shale setting characteristic of the Doig Phosphate GeoMark Family 3-11 oils.

More oil-source rock correlations need to be done confirm findings.
Leucrotta is positioned in the High GOR Oil - Rich Gas Window, Over-Pressured, Thick Portion of the Turbidite Fan Complex.
• **The Montney is a world class resource play that competes with all the major resource plays in North America.**

• **Lower Montney Play has evolved over a 30 year period from a conventional to unconventional play. This evolution is a result of the geology of a submarine fan complex and advancement of technology in the E&P sector.**
• **Fan complex deposition is controlled by the Paleozoic fault system of the Ft. St. John Graben Complex.**

• **Reservoir fluid display a normal maturation hydrocarbon profile with dry gases in the basin center, transitioning to rich gas and light oil on the basin margins.**

• **The maturation profile can be displaced due to local changes in porosity (permeability?).**

• **Hydrocarbons were generated from a Type II-III Triassic aged “Doig Like” source rock whose biomarkers correlate to Geomark Family 3-11 oils.**
“When you change the way you look at things, the things you look at change.”
Max Plank, Nobel Laureate and father of Quantum Physics

“We changed the way we looked at this play and the play changed to enable us to find oil & gas in a new place with new idea’s!”