Resource Play Development in Colombia

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Overview

• Will present examples from Canada and compare to Colombia
• Will show that not all shales prove economic
• Industry preferred development location can change over time
• Development requires large amounts of material, in addition to rigs, money and people
• Water sourcing and recycling becomes critical, though only if the play becomes a primary focus of development
North American Shale Basins

Compared to 4 large shale natural gas plays in the U.S

- **Montney**: 449 Tcf, 5.2 Bcf/d
- **Marcellus**: 410 Tcf, 18.1 Bcf/d
- **Haynesville**: 74 Tcf, 5.8 Bcf/d
- **Utica**: 38 Tcf, 3.6 Bcf/d
- **Eagle Ford**: 21 Tcf, 5.6 Bcf/d

Tcf: Trillion cubic feet
Bcf/d: Billion cubic feet per day

NEI, FirstEnergy, EIA, USGS
Inventories of Thousands of Wells
Total BOE Production out of Western Canada is at near Record Highs

Overall BOE production is being limited not by supply, but transportation and demand.

Unconventionals and expansion of heavy oil production have dramatically increased oil and overall BOE production.

Hz Drilling Predominates

Multi-Frac’d Hz
Key Canadian Unconventional Resource Plays

Oilsands
Montney
Duvernay
Western Canadian Sedimentary Basin (WCSB)

- Large Basin
- Extends up to the arctic and down in the USA
- Montney and Duvernay plays cover a large portion of the basin
Montney Composition and Facies

- Facies are dominated by siltstone with minor very fine-grained sandstone and coquina horizons.
- Sediments are quartz dominated, dolomite is very common, feldspar common, mica and pyrite present.
- Very low proportion of clay minerals.
- TOC varies locally, both laterally and vertically; average is 0.8 wt % (0.1 - 4% range).
- GLJ evaluated lands are colored yellow.

Towns On Top of Resource Play Development

Regional Hz Stress due to Orogeny
Extent of WCSB Triassic Sediments

Come talk to me if you’d like to see the rock samples.
## Montney vs Source Rock Plays

### Unconventional Montney
- tight siltstone
- 0.8 – 5% TOC by weight (pyrobitumen)
- 1 – 6% porosity
- 1 – 10 µD permeability
- 20 – 40% Sw
- 5 – 10% clay (higher clay contents basinward)
- intergranular porosity
- up to 375m gross thickness

### Eagle Ford Shale
- organic rich mudstone
- 3 – 6% TOC by weight (kerogen)
- 6 – 14% porosity
- 250 – 700 nD (10-6 mD)
- 20 – 25% SW
- 15 – 25% Clay
- intergranular and organic hosted porosity
- 30 – 100m gross thickness
Overall Montney Production

- **GLJ PETROLEUM CONSULTANTS**
- Shell buys Duvernay Oil for $5.9 Billion
- Arc Resources buys Star Oil and Gas in 2003 for $0.71 Billion
- Petronas buys Progress for $5.50 Billion
- Mitsubishi/EnCana JV for $2.90 Billion
- Seven Generations IPO for $0.93 Billion
- Tourmaline IPO for $0.23 Billion

**Gas Production Summary**

Filter: _GLJ Resource Play - Montney (7118 Wells) - Group By: Date - Spud Year - CD Avg Gas (mcf/day)
The Montney is Becoming Canada’s Main Gas Supply, Especially in British Columbia

It is the largest (and growing) supply for gas in British Columbia

British Columbia is becoming a larger fraction of Canada’s gas supply
Well Performance: Improvement over Time

Montney

There has been a near-continuous improvement in average well performance

Duvernay

There has been a near-continuous improvement in average well performance

Performance changes have been driven by regions of new development and evolving well design.
The Proppant Used per Well has Increased...

Development of the Horn River stopped once its supply cost proved uneconomic.

The average amount of proppant placed in each Montney and Duvernay well is still increasing every year.
...Huge Increases in Total Proppant Demand

Proppant demand for unconventional wells now uses a huge proportion of all sand supply in Canada... and that includes construction!

Results for 2018 are still coming in...
Moving This Much Proppant Requires Dedicated Logistics

A single Montney or Duvernay well can require a "unit train" of sand. An entire train!

Each car carries 90T of sand

A really long train of sand!

Badger Mining Corp

Rangeland Energy
"Frac sand demand in the WCSB is expected to increase by 28 percent this year and a further 31 percent to a total of 10.3 million tonnes in 2019, according to GMP FirstEnergy."

At a cost of $75 to $150/MT that's lots of Money!
Frac Water per Well has Also Increased...

Huge volumes of water were used to frac Horn River wells, prompting regulators to impose restrictions on some operators after public outcry.

Water use in other plays is increasing, but operators are looking for higher efficiencies than in the Horn River.
...Giving a Huge Increase in Water Demand

- Canada has lots of water and the unconventional resources under development are not in arid regions.
- However, regulators put restrictions on the use of fresh water and operators try to minimize water use.
- Produced water is saline, so disposing it is also expensive.
- The result is significant recycling of water: frac water is recovered and reused roughly three times before disposal.
Water Handling

- Roughly 100 active water injection disposal wells in NEBC
- Injection capacity largely unchanged in last 5 years
- Regulations continue to become more stringent on injection well applications
- Significant recycling of water and centralized handling, both on a temporary and permanent basis.
Multiple Targets for Placement of Horizontals

- Multiple intervals and layers of development
- Montney is developed using horizontal multi-stage fractured wells
- Wells stem from a common pad/surface location
- Interwell distances are generally 300 – 400 m apart (laterally)
Surface Disturbance is Minimized by Using Pad Drilling

20 to 30 wells can be drilled from one pad... maybe even more
Regulators Have Responded to Industry and Public Pressure with Data and Restrictions

- 2010: Montney Water Project
- 2012: Induced Seismicity Monitoring Project
- 2012: FracFocus.ca
- 2013: Directive 83
- 2015: Deep Aquifer Fluid Disposal Project

In Alberta, all seismic events greater than 2.0 on the Richter scale must be reported

If an anomalous seismic event occurs, regulators have the authority to stop operations immediately

In British Columbia and Alberta, an immediate suspension of operations occurs for any event measuring 4.0 or above. For example:

“B.C. Oil and Gas Commission has shut down oilfield fracking operations for at least 30 days in northeastern British Columbia while it investigates earthquakes that occurred there on Nov. 29. The regulator says the seismic events, which measured between 3.4 and 4.5 magnitude, took place near hydraulic fracturing operations being conducted about 20 kilometres southeast of Fort St. John by Calgary-based Canadian Natural Resources Ltd.”

- Alberta Interactive Seismic Events Map
But what about Colombia?

• Supply cost for unconventional solution gas is estimated to be in the range of $4.00/MMbtu to $5.00/MMbtu

• Gas demand and supply are likely to be reasonably balanced for a few years. With existing LNG import capacity, demand can be met for the next ten years (best estimate case).

• It is unlikely that reasonably paced development of unconventional resources will be adequate to meet gas demand without some LNG imports.

• Development analogous in pace to Argentine Vaca Muerta development could potentially delay the requirement for additional LNG import capacity, but not remove it entirely.
Most basins in Colombia appear to be mature... except for the Magdalena Basin and most especially for non-associated gas.
Supply from Undiscovered Conventional Sources

- Low, best and high estimates for new discoveries can be calculated by extrapolating the creaming curve over a 25-year period. The low estimate presents a primarily logarithmic trend while the high estimate is linear.

- The resulting resources per category are 0.75 Tcf for the low estimate, 1.5 Tcf for the best estimate and 3.0 Tcf for the high estimate.

- The development timing per field is scheduled as a three-trend production profile that includes a 3.5 to 4.5 year ramp up period, a peak production plateau followed by a 5 to 9 year decline period.

- This buys time for unconventionals to grow, testing of regulations and logistics to be planned out.
Unconventional Future Discoveries

- GLJ expects the development will start in the Middle Magdalena within a few years.
- Drilling and production will ramp up, though not to the same pace of activity present in the US or Canada.
- The incremental gas volume from Colombian unconventionals extends the period over which current LNG imports capacity is sufficient: from about five years to ten.

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Moderate Pace of Development in Colombia

- It is easy to build a forecast with 1000's of La Luna wells drilled every year.

- However, each well drilled will need proppant, fracture fluids, and fluid disposal.

- These logistics, coupled with regulatory requirements, will probably mean 100's of wells will be drilled a year.
Colombian Maturation Windows
Development Requires the Right Mix of HC Products and Access to Infrastructure
Average Liquid Yields are Changing Over Time as Companies Develop New Areas

The average liquid yield of development of unconventional resources can change over time as development shifts to new areas.

More conventional fields often show more consistent field behaviour.
Thank you

Questions?