TECHNOLOGY AND INTELLIGENCE: Converting Tight Resources into Reserves

SPE Luncheon
Thursday, November 10, 2011
Calgary Chamber of Commerce

Authors:
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Agenda

- Resource Play Activity and Investment
- Case Study: Cardium Oil
- Case Study: Montney Distal Shelf Gas
- Case Study: Swan Hills/Slave Point Oil
- Aggregate Trends and Conclusions
Resource Plays in Western Canada

Emerging

Increasing Play Activity

Active Plays (>10 resource wells drilled in year)
Resource Plays in Western Canada

Number of Wells by Resource Play Group

Total Completions Investment ($M) by Resource Play Group

WELL COMPLETIONS & FRAC DATABASE
Reservoir contact for a typical 8½-in. borehole grows significantly when hydraulic fracturing is employed. When combined with horizontal drilling the growth is exponential.

(From Schlumberger, website)
CARDIUM OIL

Source: CDL Cardium Overview Study, 2010
Cardium Resource Development Milestones

1953
First well drilled

1990’s
First horizontal oil wells

2011
Further Consolidation

06
Successful Hz wells
eg TriAxon 13-22-49-10W5

07
Re-birth of the Pembina Bonterra 1-25-47-3W5 NAL 12-17-35-4W5

08
Re-birth of the Garrington

09
4 acquisitions $1.6B
Land sales peak above $7,000/ha

10
Pembina 6mo Oil Rate=600 bopd
Daylight 16-28-50-6W5
Cardium: Increasing Stages and Length

Actual Stages (#) Chart

<table>
<thead>
<tr>
<th>Completion Date Year</th>
<th>Actual Stages (#)</th>
<th>Completed Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 (5/1)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>2009 (51/37)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>2010 (340/140)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>2011 (175/30)</td>
<td>16</td>
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Cardium: New Technologies

All technologies are the property of their respective owners and subject to applicable trademarks and registrations.
### Cardium: Ball & Seat vs. Plug/Packer

<table>
<thead>
<tr>
<th>Comparative Metric</th>
<th>Ball &amp; Seat (389 wells)</th>
<th>Plug/Packer (29 wells)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg Frac Time</td>
<td>14 hrs</td>
<td>27 hrs</td>
</tr>
<tr>
<td>Problem Time &gt;50%</td>
<td>8%</td>
<td>36%</td>
</tr>
<tr>
<td>Downhole Problems</td>
<td>2.4%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Avg # of Stages</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Avg IP3 Oil</td>
<td>137 bopd</td>
<td>86 bopd</td>
</tr>
<tr>
<td>Avg D&amp;C Cost</td>
<td>$3.3M</td>
<td>$3.7M</td>
</tr>
</tbody>
</table>
Cardium: Stress
Detail: Minimum Principle Stress, Pembina Field

**Carrot Creek**
Low Stress Area
5.9% Frac* Failures

**Rat Creek**
High Stress Area
8.7% Frac* Failures

*No Breakdown, Omitted, Partial Frac
Re-Frac

Source: Stress Analysis Study, RPCL & BJ, 2005 + Frac Database
Cardium: Increasing IP3s, Flattening Costs

*Not normalized for load oil return*
Cardium: Size of the Prize

Incremental Cardium Resource Potential

Incremental Conventional
- Barrier Bar: 52 mmboe
- Shoreface A: 85 mmboe
- Shoreface B: 10 mmboe

Resource Halos
- Resource Halo A: 406 mmboe
- Resource Halo B: 667 mmboe
- Resource Halo C: 5 mmboe
- Unestablished

Total Additions: 1,225 mmboe
MONTNEY GAS
Distal Shelf Play

Source: CDL EDGE

Canadian Discovery Ltd. & Introspec Energy Group Inc.
Montney Resource Development Milestones

1997
- Encana first horizontal well 7-3-79-1W6
- ARC acq Star Oil & Gas for Dawson

2003
- Encana & ARC wells 6m=3300 mcf/d

2007
- Shell/Duvernay for $5.9B
- Record land sale $33,650/ha

2008
- Average land sale price $1,300/ha

2009
- ARC/Storm JV for $0.7B

2010
- Talisman/Sasol JV for $1.05B

2011
- Progress/Petronas JV for $1.1B
- 300 MMcf/d capacity added
Montney: # Stages and Length Trends

Actual Stages (#) Chart

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<tr>
<th>Completion Date Year</th>
<th>Actual Stages (#)</th>
<th>Completed Length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 (3/3)</td>
<td></td>
<td></td>
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<tr>
<td>2007 (12/8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008 (34/20)</td>
<td></td>
<td></td>
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<tr>
<td>2009 (68/25)</td>
<td></td>
<td></td>
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<tr>
<td>2010 (195/110)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011 (22/7)</td>
<td></td>
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</table>
Montney: Experimentation w/ Technology

Technology vs. Completion Date Year

All technologies are the property of their respective owners and subject to applicable trademarks and registrations.
Montney: Open versus Cased

2006 to Present

June 2010 to Present
Montney: Frac Spacing and Proppant Trends
SWAN HILLS/SLAVE POINT OIL

Source: CDL
Slave Point Resource Development Milestones

1950’s
First wells drilled

1994
First Horizontals

2008
First Multi Stage Acid Fracs

2009
Re-birth of Slave Point & Swan Hills
Lone Pine (Forest) Pengrowth

2010
Judy Creek 6m = 265 bopd
Pengrowth 02/04-13-063-12W5

2011
Land doubles to $14,000/ha?
SWHL/SLVP: # Stages and Length Trends

Actual Stages (#) Chart

- 2008 (5/0): 6 Actual Stages (#)
- 2009 (10/3): 5 Actual Stages (#), 600 Completed Length (m)
- 2010 (5/7/19): 8 Actual Stages (#), 800 Completed Length (m)
- 2011 (29/11): 12 Actual Stages (#), 1,200 Completed Length (m)

Completion Date Year

Actual Stages (#) vs. Completed Length (m)
7-30-069-9W5
Swan Hills
IP3 Oil = 565 bopd

- Apache Feb 2010
- 4 x 55m³/stage Sanjel
- 28% HCl/Xylene CO₂ Frac
- RapidMATRIX
- Ball/Seat (Packers Plus)
- $3.1M D&C
>10,000 Resource Play wells drilled and completed in Western Canada since 2005.
Increasing Number of Stages

Completion Date versus Number of Stages

Avg Number of Stages
2005 = 2.7
2008 = 7.1
2011 = 12.5

In Combination with:
- Increased Horizontal Length
- Multi-Laterals
- Cluster Fracking
- Monobore Systems
Larger Fracs: More Proppant and Fluid

![Bar graph showing the average proppant per stage and fluid pumped per stage for different years. The graph compares data from 2005 to 2011, with values indicating an increase in proppant and fluid usage over time.]
Experimentation and Fine-Tuning

![Actual Stages (♯) vs. Stages Attempted (♯)]

n = 2,346
Growing Resource Play Production

Annual Resource Play Production (mboe)

- Gas
- Oil
- Producing Event Count


2010: ~6 mo

8/22/2011  Canadian Discovery Ltd. & Introspec Energy Group Inc.
## Size of the Prize: Western Canada (Oil)

1. **Increased Conventional Production**
   - Bakken
   - Cardium
   - Viking
   - Swan Hills/Slave Point
   - Duvernay
   - AB Exshaw
   - 2WS
   - Nordegg

2. **Developing Halos**
   - *Cardium = 147 mmboe incremental / 2,934 mmboe produced + remaining = 5%*

3. **Emerging Resource Plays**

### Table

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<thead>
<tr>
<th>Light Oil (mmbo)</th>
<th>Original-in-Place (2009, CAPP)</th>
<th>Established Reserves (CAPP)</th>
<th>+5% * Recovery Adds X</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>78,126</td>
<td>20,069 (26%)</td>
<td>3,906</td>
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Worldwide Implications

- Western Canada is just the tip of the iceberg
- However, on the world-stage, Western Canada delivers on several fronts:
  - Publicly available data (knowledge-sharing)
  - Vertical offsets
  - Scale of activity (>10,000 wells)
  - Infrastructure
  - Business-ready
Conclusions

- Resource plays in Western Canada are delivering increased production and reserves
- Key drivers of success include ball & seat technology, more stages, larger fracs
- Results vary by play, with geology (and stress) contributing to final results
- Technology and intelligence will continue to expand what is possible
- Western Canadian activity is, and will continue to play a major roll on the world stage
Acknowledgements

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- Neil Watson
- Mike Seifert
- Matt Baird
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