Evaluating Australian unconventional gas – use and misuse of north American analogues

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RISC ADVISORY

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BASIC AGENDA

1. Introduction
   ▪ North American & Australian shales

2. Shale Analogs: Impact of reservoir quality
   ▪ Examples

3. Shale Analogs: Petrophysical & stimulation complexities
   ▪ Examples

4. Shale Analogs: Completion & stimulation complexities
   ▪ Example

5. Shale Analogs: Economic considerations
   ▪ Examples

6. Demonstration & Conclusions

7. Backup Data
North American shales varying in size, depth, location, and maturity. Despite key indicators of shale prospectivity, these shales show significant variability in deliverability, UR, and costs.

Source: EIA/Stanford University, 2013
## Resource Comparison

Australia has “world-class” shale. Challenge is performance comparisons.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Horn River (Canada)</th>
<th>Barnett (USA)</th>
<th>Eagle Ford (USA)</th>
<th>Cooper (Australia)</th>
<th>Perth (Australia)</th>
<th>Canning (Australia)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Formations</strong></td>
<td>Muskwa / Otter/ Evie</td>
<td>N/A</td>
<td>N/A</td>
<td>Roseneath Epsilon Murteree</td>
<td>Carynginia &amp; Kockatea</td>
<td>Goldwyer</td>
</tr>
<tr>
<td>OGIP (Tcf)</td>
<td>400 - 500</td>
<td>&gt;700</td>
<td>250</td>
<td>342</td>
<td>198</td>
<td>480+</td>
</tr>
<tr>
<td>Gas Resource (Tcf)</td>
<td>78</td>
<td>64</td>
<td>21</td>
<td>85</td>
<td>60 – 90</td>
<td>300</td>
</tr>
<tr>
<td>Permeability* (md)</td>
<td>$10^{-6}$ (maybe lower)</td>
<td>$10^{-6}$</td>
<td>$10^{-4}$</td>
<td>Highly variable.    However, permeability is comparable to North American analogs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EUR /Well**</td>
<td>4 – 6</td>
<td>2 – 5</td>
<td>3 - 7</td>
<td>Highly variable.    However, permeability is comparable to North American analogs.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NET Thickness (m)</td>
<td>182</td>
<td>100 – 200</td>
<td>30 - 90</td>
<td>&gt;100 m</td>
<td>60 – 90</td>
<td>60 - 90</td>
</tr>
<tr>
<td>Liquids Potential</td>
<td>Negligible</td>
<td>Variable Yield</td>
<td>Low to High Yield</td>
<td>High Potential</td>
<td>Unknown</td>
<td>Possible</td>
</tr>
</tbody>
</table>

*Permeability affects gas production rate, and is highly variable in each basin. Nominal numbers presented.

** Not all shales in US and North America are economic due to high variability in production.

*** These numbers are based on public government documents, corporate reports, and SPE literature research.
IMPACT OF RESERVOIR QUALITY
**SHALE-TIGHT GAS CONTINUUM**

**SHALE VS. SILTS VS SANDSTONE**

- Tight gas, shales, and hybrids are all different petroleum systems:
  - Petrophysics,
  - Completion,
  - Stimulation,
  - Economics

- Each shales exhibits high vertical and lateral variability (despite lateral continuity)

Diagram:
- Marcellus
- Horn River
- Barnett/Fayetteville/Woodford/Bakken
- Haynesville/Eagle Ford
- Glacier Montney
- Unita
- Mixed Pore Hybrid shales BCGA

Legend:
- True Shale?
- All others?
SHALE-TIGHT GAS CONTINUUM

Biogenic

Combination gas system:
Both gas and oil, condensate, or natural gas liquids in either mudstones or hybrids
0.80 – 1.4% R₀

Hybrid gas system:
Combination organic-rich mudstones and organic lean nonmudstone intervals with dry gas, high thermal maturity
>1.40% R₀

Barnett

Colorado Shale
Antrim
New Albany
Utica Shale

Lewis Shale

Mudstone gas system:
Organic-rich, dry gas
High thermal maturity
>1.40% R₀

Mudstone or hybrid system:
Wet gas, low thermal maturity
<0.80% R₀

Thermogenic
BARNETT PRODUCTION VARIABILITY

2002 – 2007 Barnett IP as function of Area

Barnett shale gas:
- Significant production variability
- Estimated up to 25% of Barnett wells can be unprofitable.
- Permeability and porosity is often highly variable within a particular shale.
- Shales contain tiers of reservoir quality, sweet spots, and fairways

Source: U.S. Energy Information Administration
Porosity is often documented to have ranges of 2 – 15%.

Permeability varies by factor of 10

UR is NOT repeatable statistical distribution
Shales can have significant porosity and permeability variations, within relatively small areas.
OIL WINDOW / CONDENSATE PRODUCTION

CANADIAN MONTNEY AND USA EAGLE FORD

Canadian Montney (Heritage Trend)

Eagle Ford

Thermal maturity is also highly variable within any particular shale
Petrophysics & Stimulation Complexities
FRACTURE CONTINUUM

What is the impact of rock type?

North American Shales:

- Significant petrophysical differences
- Significant permeability ranges
- Highly variable thicknesses

Therefore, highly variable fracturing and completion methods within each shale

Therefore, highly variable fracturing and deliverability outcome

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North American Shales:

- Barnett Tight Gas
- Haynesford
- Eagleford
- Woodford
- Bakken
- Marcellus
- Horn River Tight Gas
- Montney
- Australian Shales

- Shale
- "Shaley Silts"
- Silts
- Tight Hybrids

- Slick Water
- X-linked Fluid System

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North American Shales:

- Barnett
- Bakken
- Marcellus
- Woodford
- Haynesford
- Eagleford
- Tight Gas
- USA

- Horn River
- Montney
- Tight Gas
- Canada

- Australian Shales

- Slick Water
- X-linked

- Fluid System

RISC
Fracturing design can be highly variable within any given shale
WHERE DOES AUSTRALIA FIT?

What kind of fracture do we need for Australian shales?

Where does the other Australian Shales Fit?

What kind of stimulation will be required?

Will completion technology have an impact?

Stress orientation? Pre-existing fractures?

Materials supply
COMPLETIONS AND STIMULATION COMPLEXITIES
Eagle Ford example – Part 1

Stimulated rock volume (SRV)?
Enhanced permeability?
Lower cost?
Lower productivity?

- Longitudinal Frac?
- Less spacing between perf clusters?
- Higher cost?
- More flexibility?

Both are stimulated horizontal wells.
Fracture stimulation outcome varies with delivery method

Backup: Hz Well Completions

Source: SPE Paper 148642
COMPLETIONS VARY BETWEEN SHALES

Montney stacked laterals
(24 wells per pad)

Horn River pad drilling

Source: EnCana 2011, Macquarie Tristone 2012
ECONOMIC CONSIDERATIONS
Economies of scale have allowed Canadian projects to compete with lower 48 projects, despite significant logistics and environmental challenges.

Source: Stanford University, 2012
- Substantial cost reductions
- 18% - 25% cost savings for first 5 wells
- Cost reductions are due to a unique business model:
  - Vertical integrated services
  - “success fee” for contractors
  - Stock piling
  - New material sources
  - Concurrent processes

Source: Innovation Alberta

Backup: Economics Data
DEMONSTRATION 1

• Recommended Process
  • Detailed review of analogue data on a local level
    • Rock and petrophysical properties
    • Completion methods
    • Stimulation methods
    • Business plan and model

• Adjust your parameters for local conditions
• Build your predictive model!
Predictive model, after local adjustment, actually gave us a higher UR, and deliverability profile than traditional analogue.
CONCLUSION
CONCLUSION 1

- Shale analogues can be useful, however:
- Gross rock properties are not enough to define a shale analog.
- The petrophysical, completion, stimulation, and economic model often varies within any particular shale.
- Detailed comparative analysis of analogue data on local scale
- Need to compare with detailed local conditions of Australian shale
- Be prepared to modify and adjust predictive models
CONCLUSION 2

- The predictive, adjusted model for local conditions is the best estimate of UR, and deliverability for your Australian project.

- Deliverability profiles may need to be adjusted depending upon availability of completion and/or stimulation equipment.

- Completion and stimulation plans may need to be altered depending upon the availability of supplies, and even business partners, which quite likely will affect business partners.