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

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DECISIONS WITH CONFIDENCE

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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

1 INTRODUCTION

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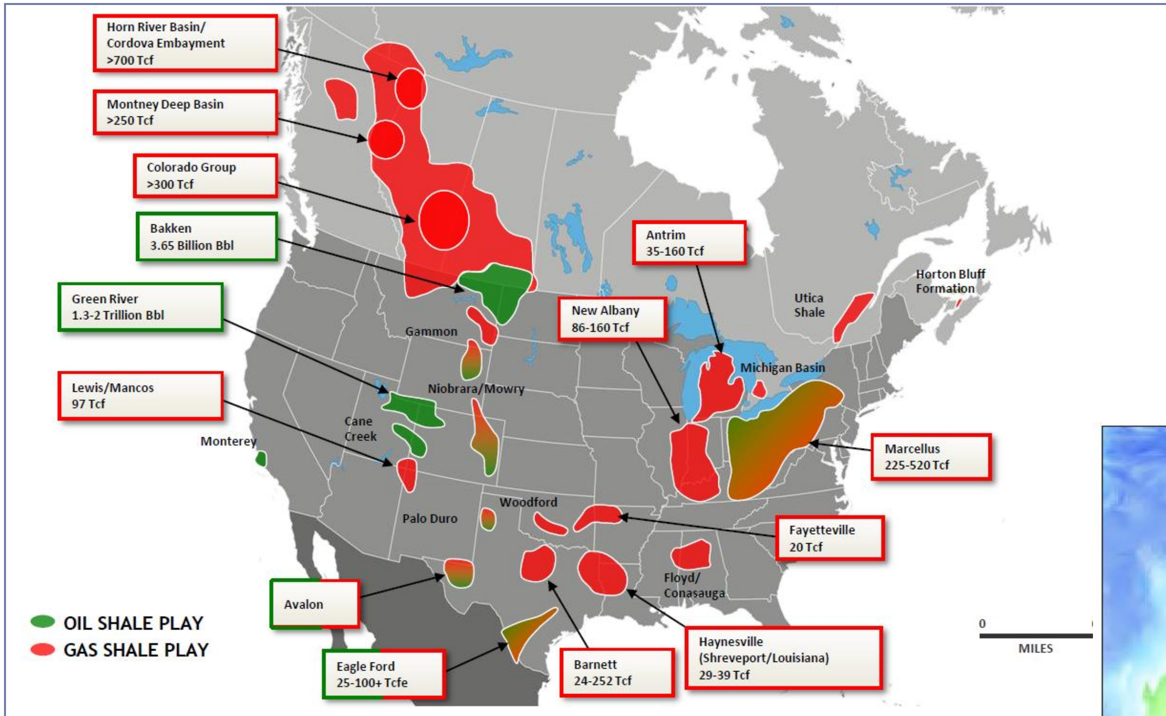
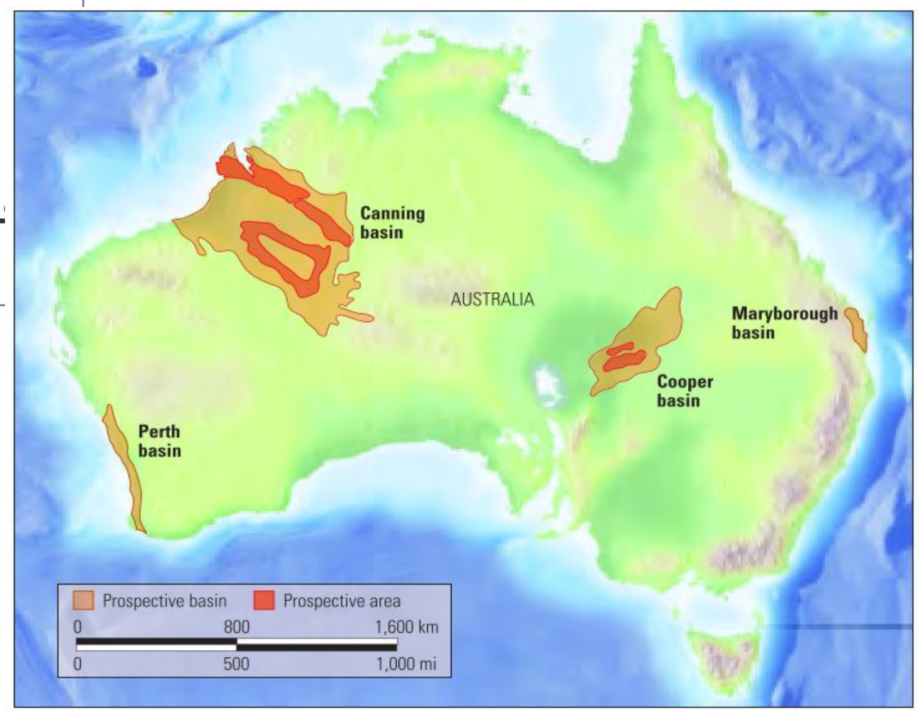
NORTH AMERICAN & AUSTRALIAN SHALE PLAYS





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

Parameter	Horn River (Canada)	Barnett (USA)	Eagle Ford (USA)	Cooper (Australia)	Perth (Australia)	Canning (Australia)
Target Formations	Muskwa / Otter/ Evie	N/A	N/A	Roseneath Epsilon Murteree	Caryngginia & Kockatea	Goldwyer
OGIP (Tcf)	400 - 500	>700	250	342	198	≈480+
Gas Resource (Tcf)	78	64	21	85	60 – 90 ← *Estimates!* →	300
Permeability* (md)	10^{-6} (maybe lower)	10^{-6}	10^{-4}	Highly variable. However, permeability is comparable to North American analogs.		
EUR /Well**	4 – 6	2 – 5	3 - 7	<u>It is believed Australian shales are all capable producing between 2 to 6 Bcf/well, as observed in North America.</u>		
NET Thickness (m)	182	100 – 200	30 - 90	>100 m	60 – 90	60 - 90
Liquids Potential	Negligible	Variable Yield	Low to High Yield	High Potential	Unknown	Possible

*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

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IMPACT OF RESERVOIR QUALITY

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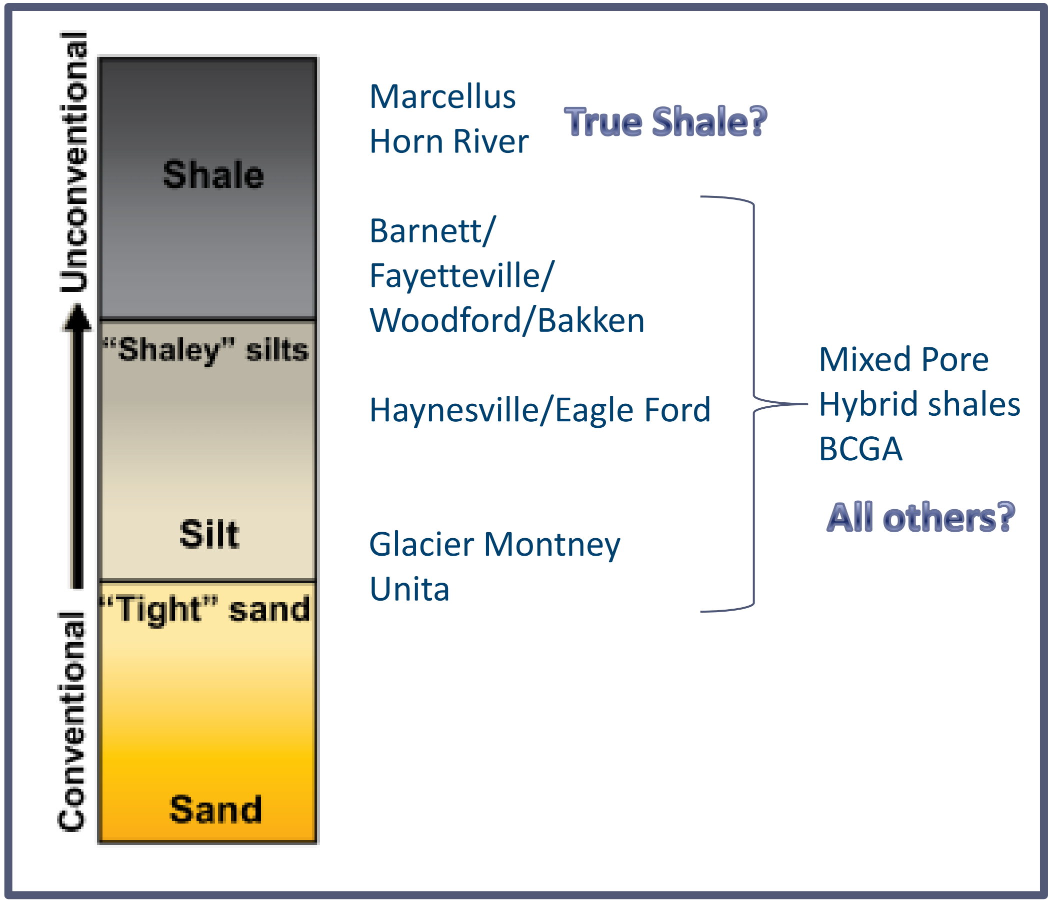
SHALE-TIGHT GAS CONTINUUM

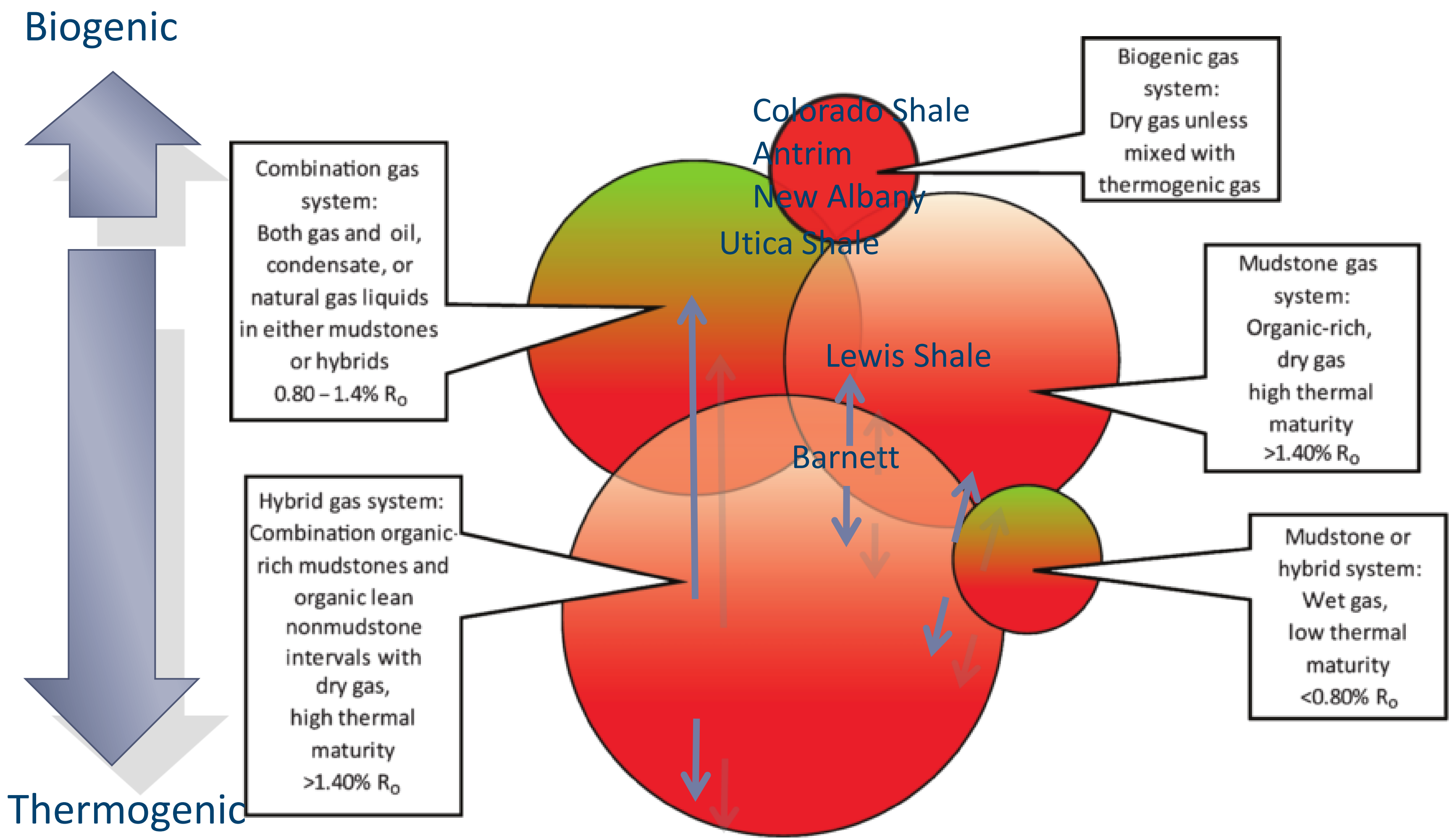
Shale vs. Silts vs sandstone



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

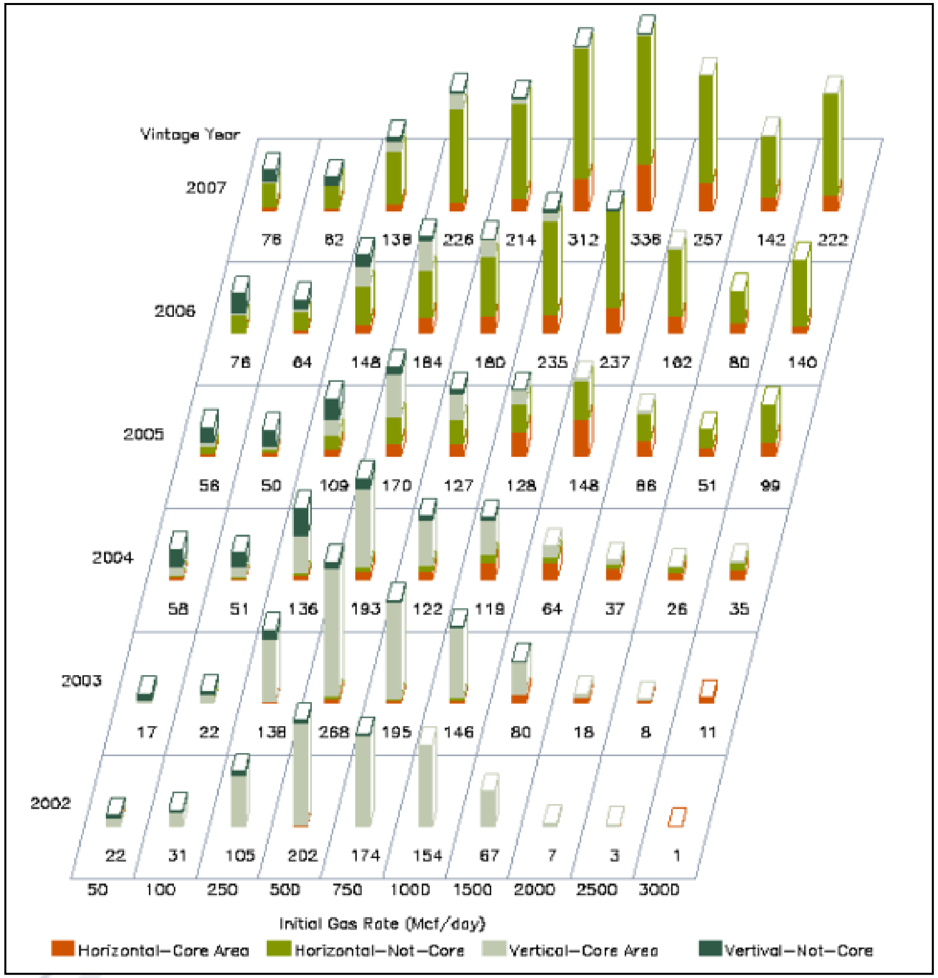
- Each shales exhibits high vertical and lateral variability (despite lateral continuity)

SHALE-TIGHT GAS CONTINUUM



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

Backup: Other Comparisons

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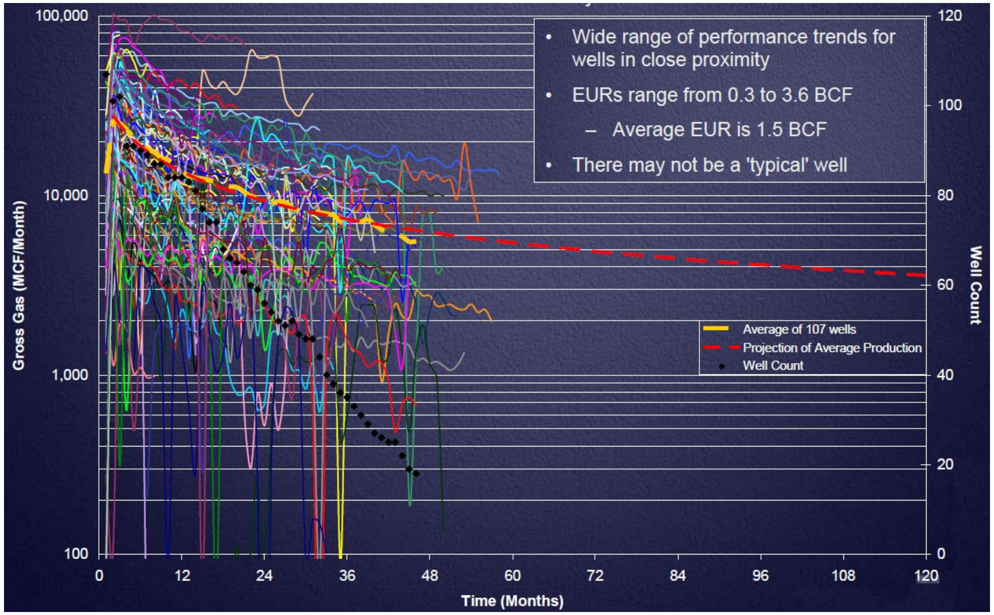
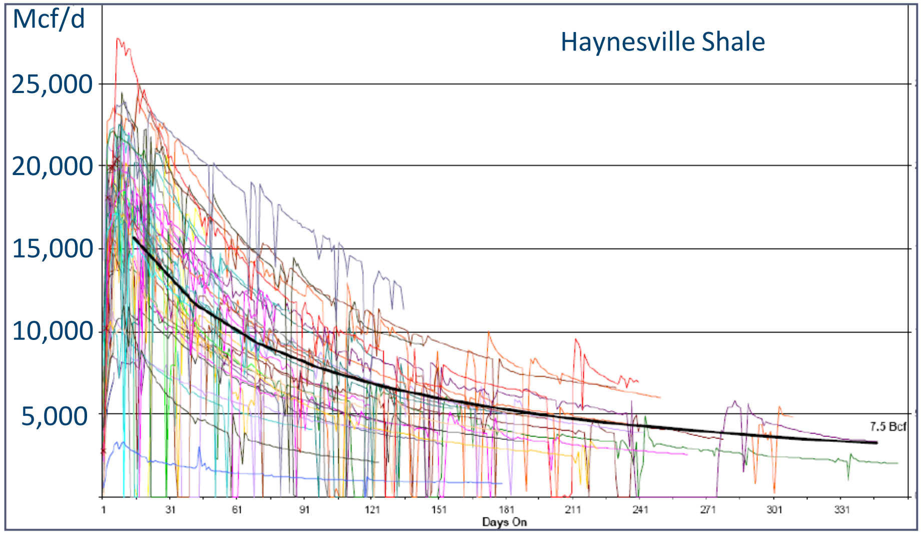
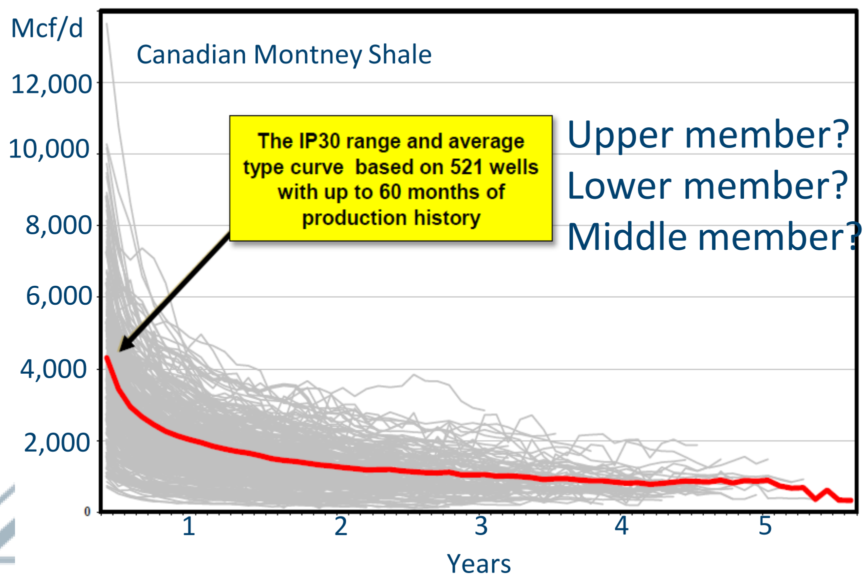
OTHER EXAMPLES







Porosity is often documented to have ranges of 2 – 15%.

Permeability varies by factor of 10

UR is NOT repeatable statistical distribution

Backup: Other Comparisons

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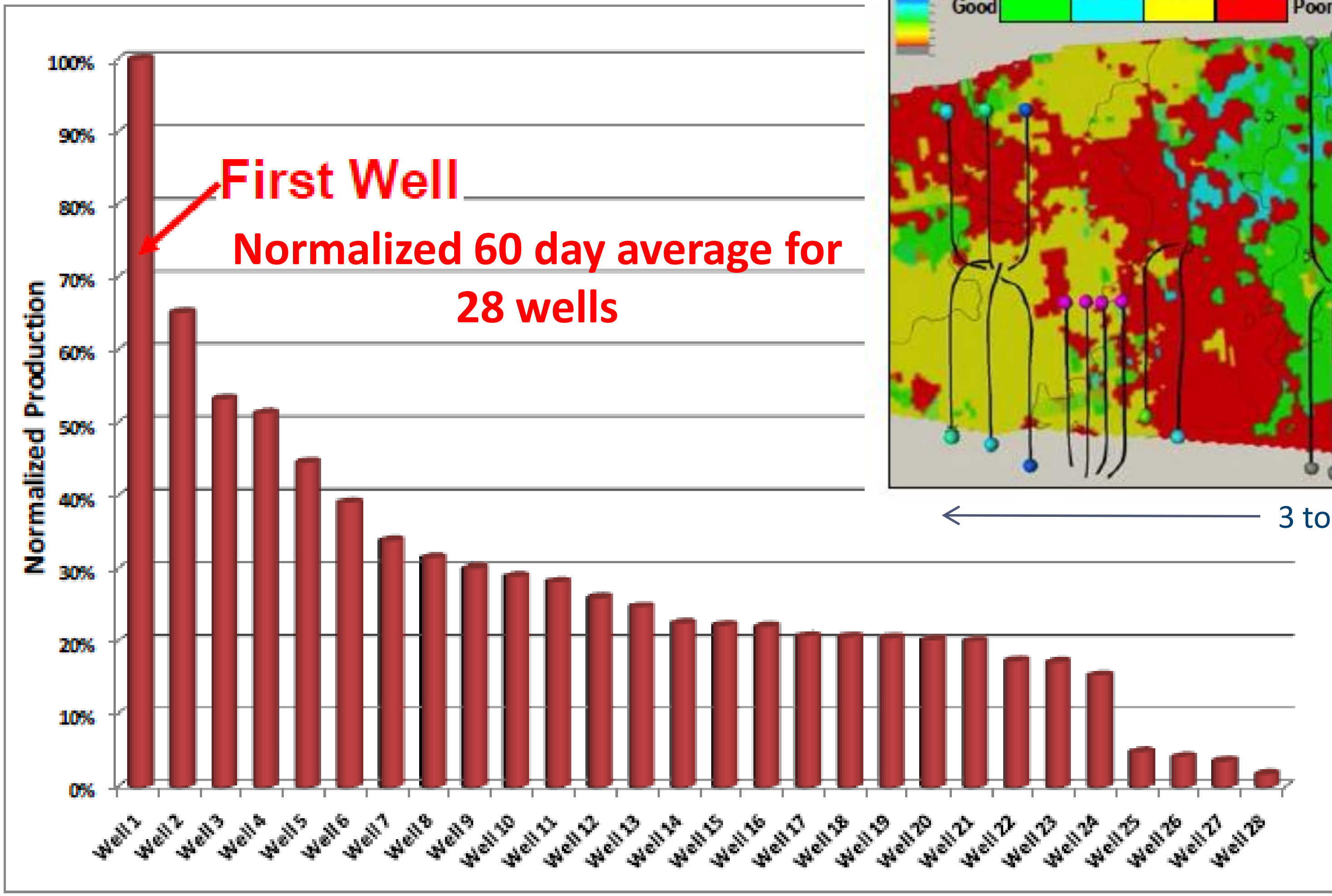
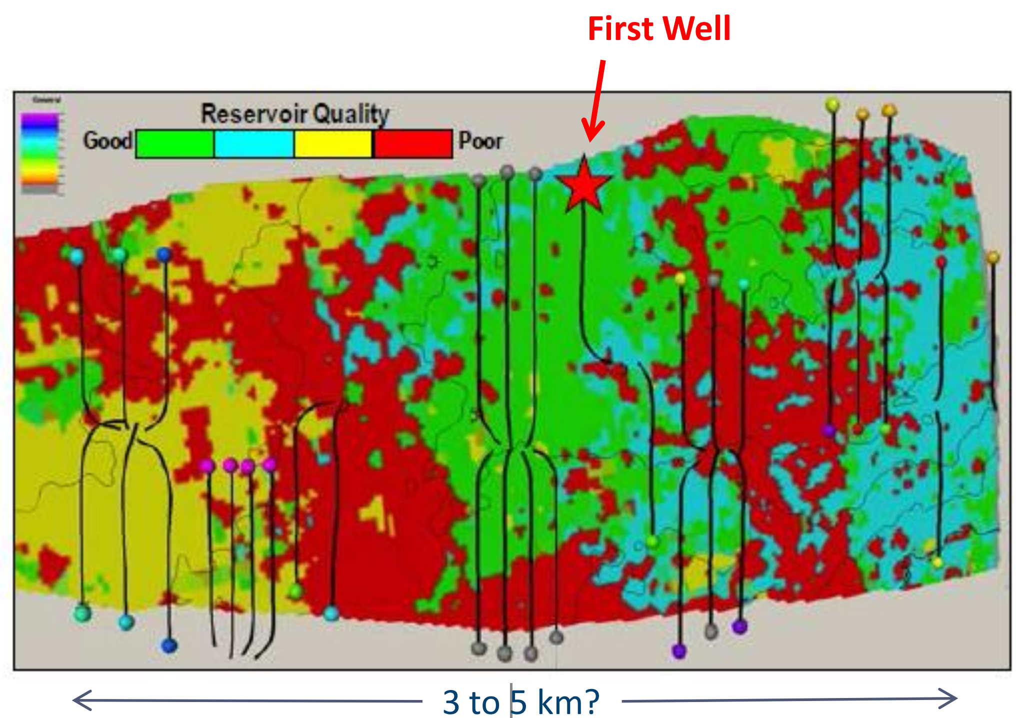
Source: SPE 164345

MARCELLUS EXAMPLE



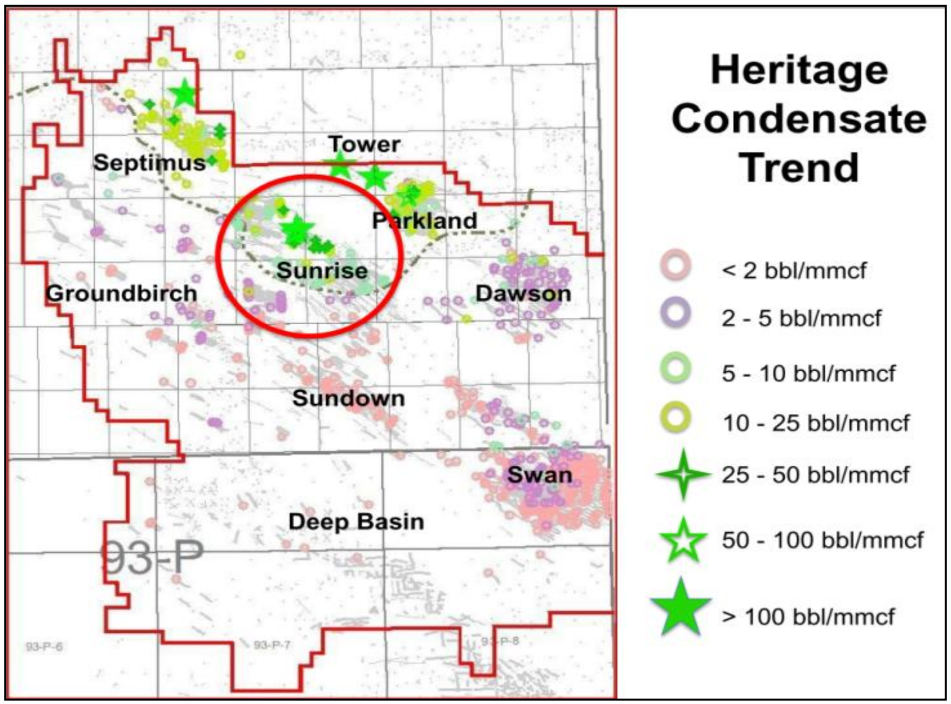


Shales can have significant porosity and permeability variations, within relatively small areas

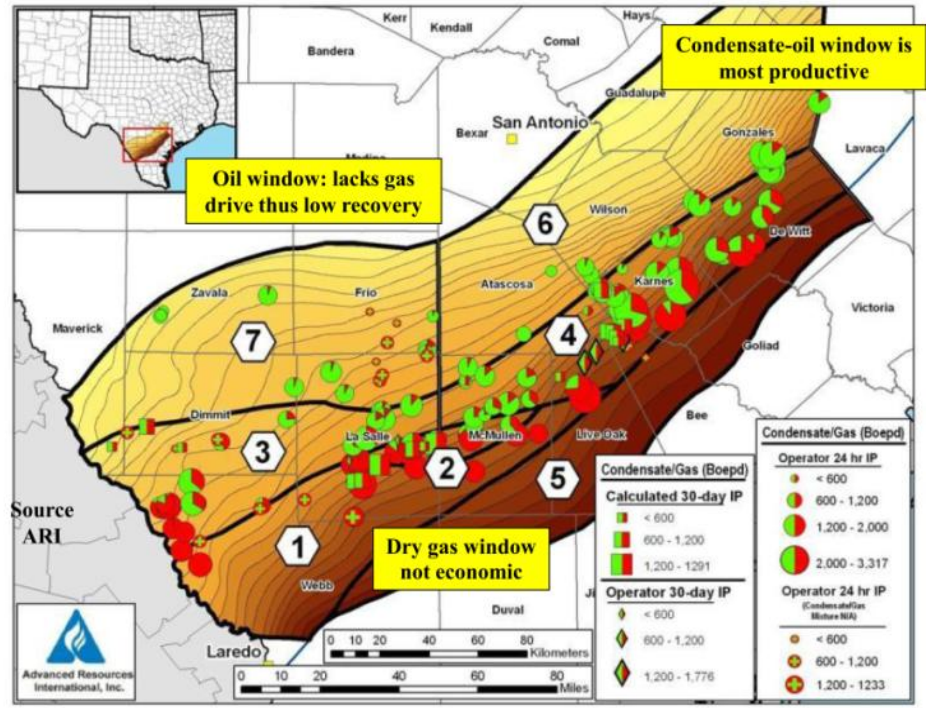
OIL WINDOW / CONDENSATE PRODUCTION

CANADIAN MONTNEY AND USA EAGLE FORD

Canadian Montney (Heritage Trend)



Eagle Ford



Thermal maturity is also highly variable within any particular shale

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PETROPHYSICS & STIMULATION COMPLEXITIES

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FRACTURE CONTINUUM

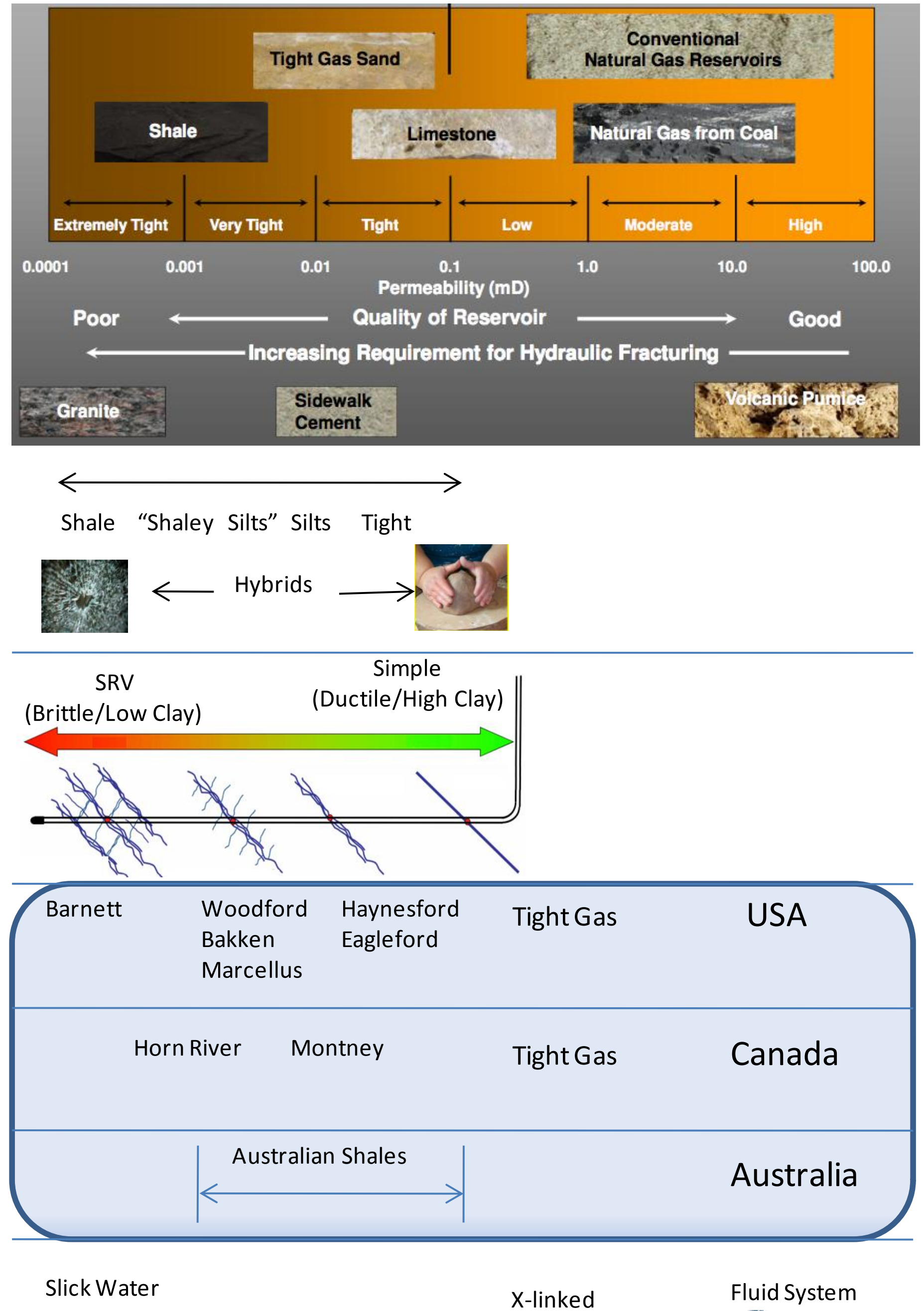
WHAT IS THE IMPACT OF ROCK TYPE?

North American Shales:

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

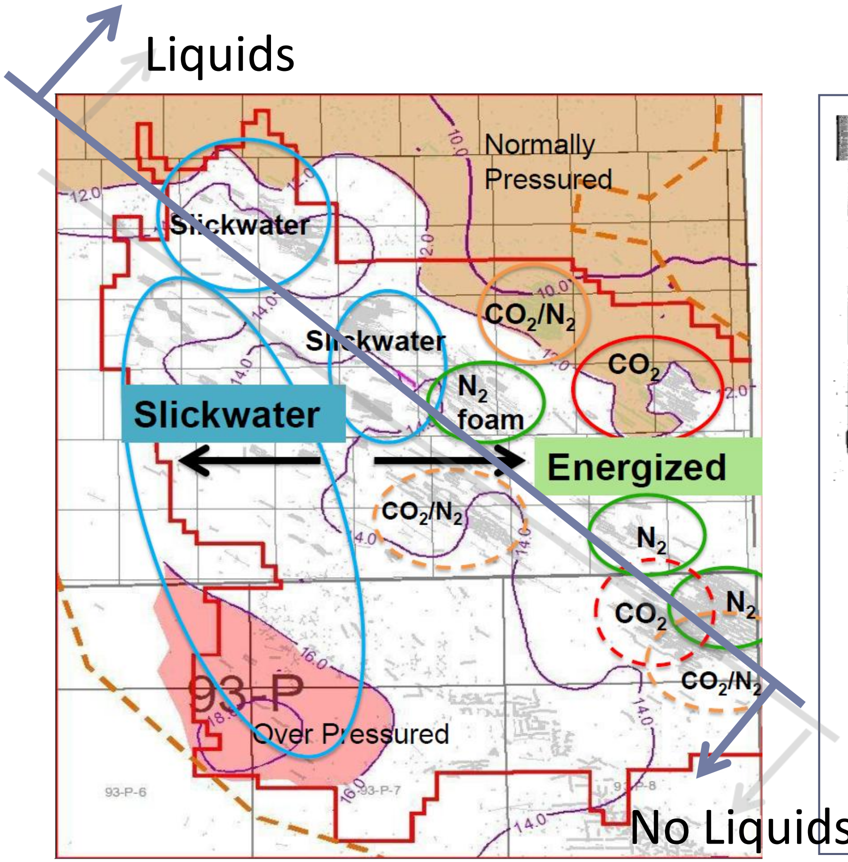
- Therefore, highly variable fracturing and completion methods within each shale

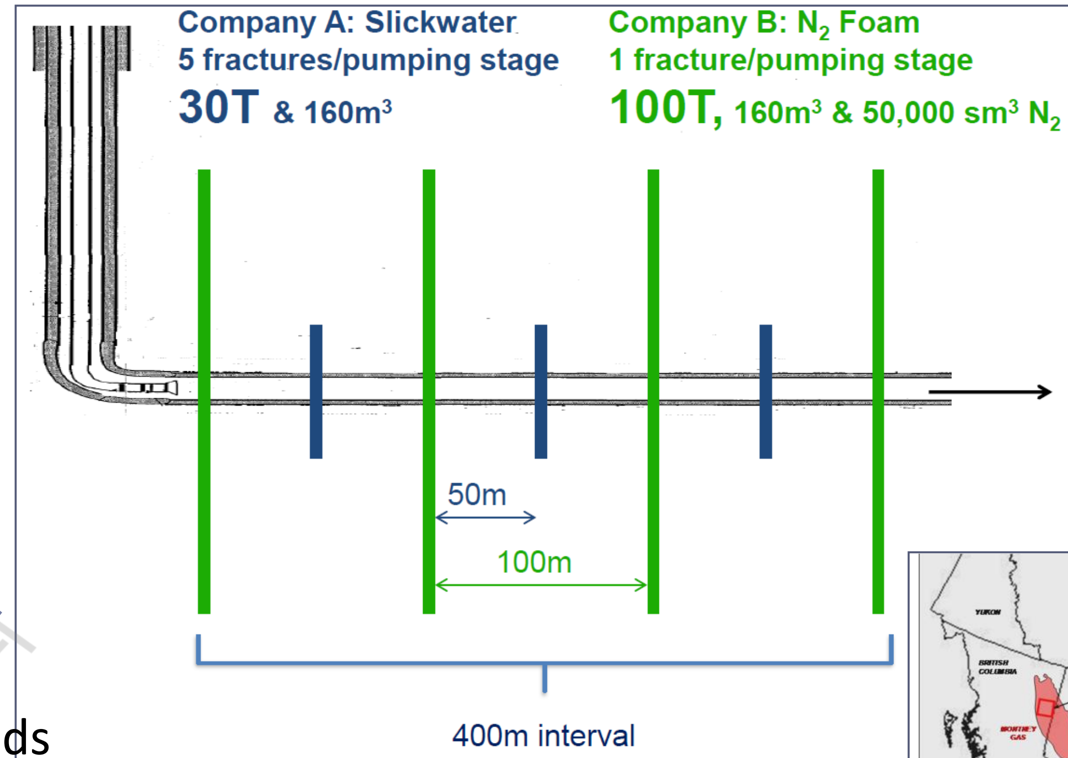
- Therefore, highly variable fracturing and deliverability outcome

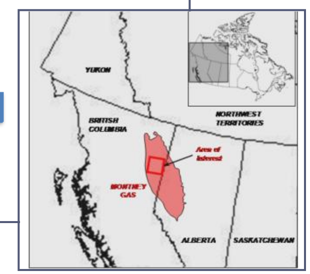


Source: B.C. Oil & Gas Commission

FRACTURING TRENDS IN MONTNEY (CANADA)







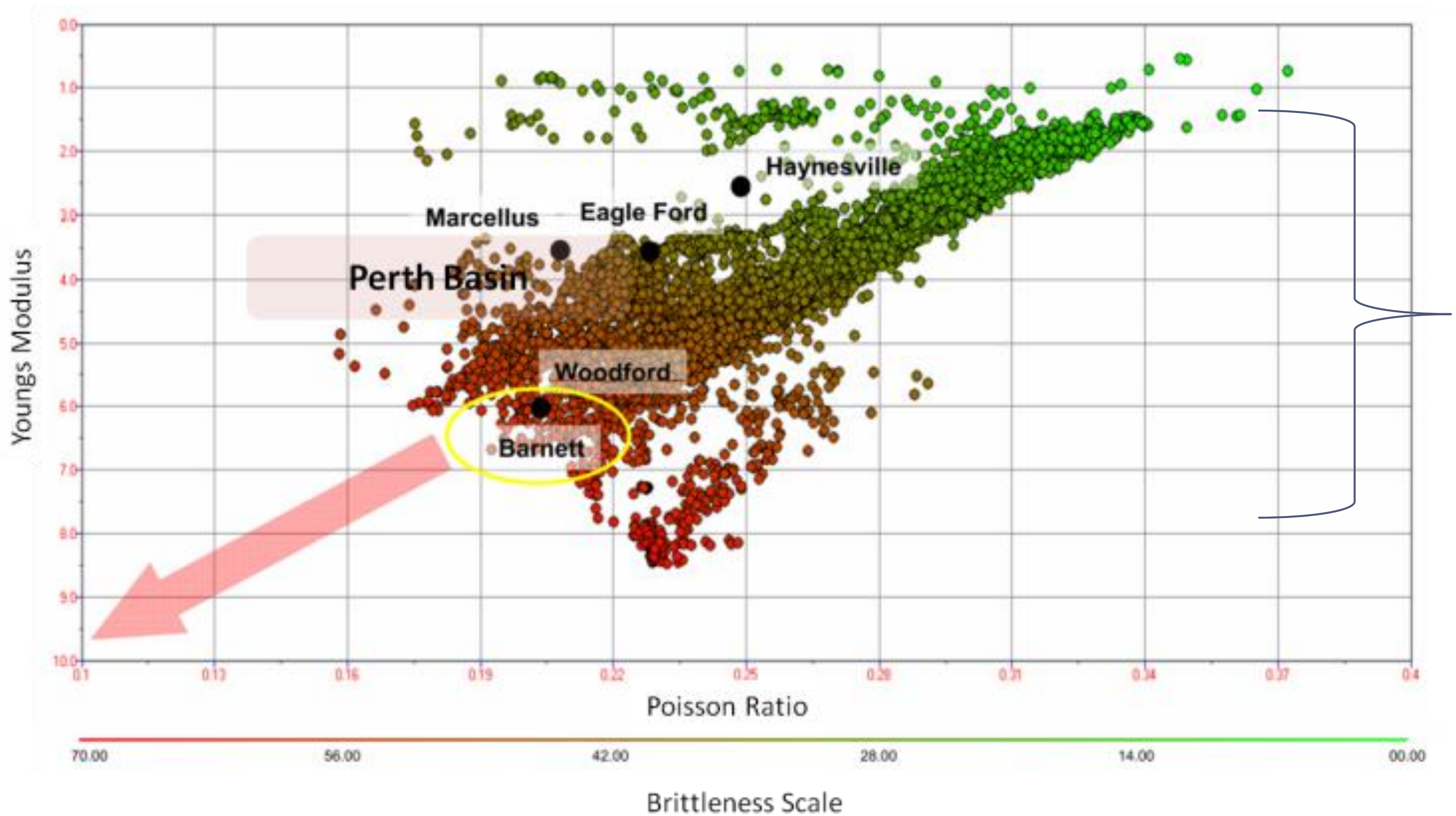
Fracturing design can be highly variable within any given shale

Backup: Montney

Backup: Other 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

4

COMPLETIONS AND STIMULATION COMPLEXITIES

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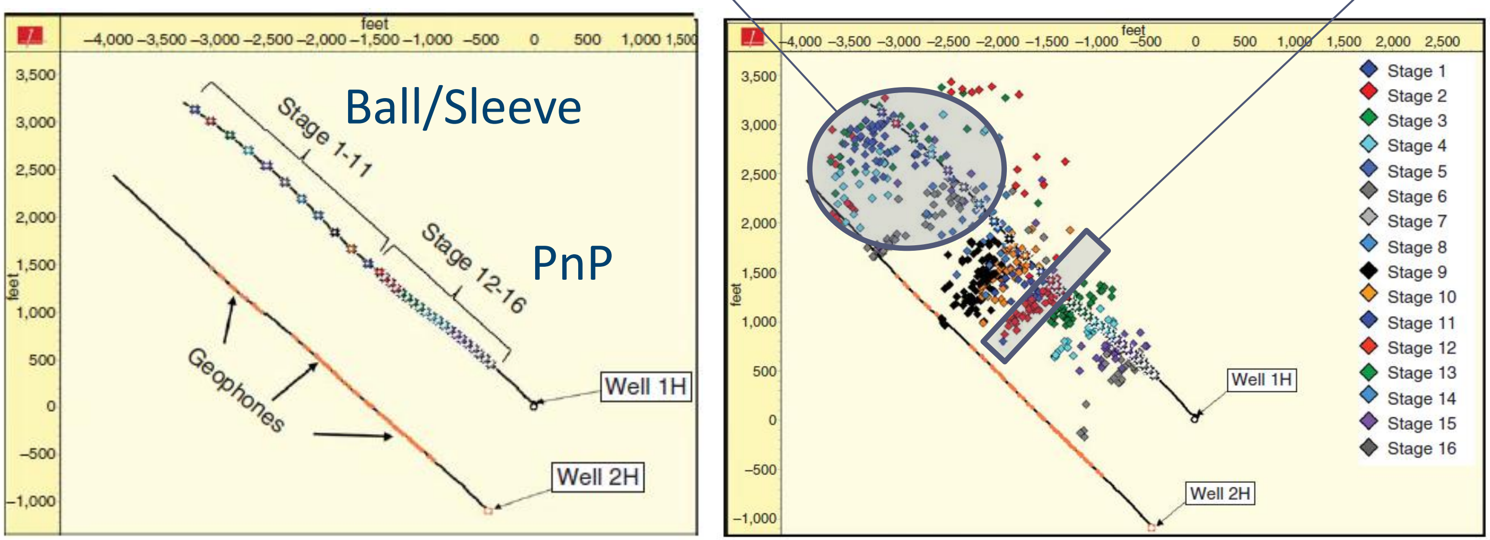
Source: SPE Paper 148642

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?

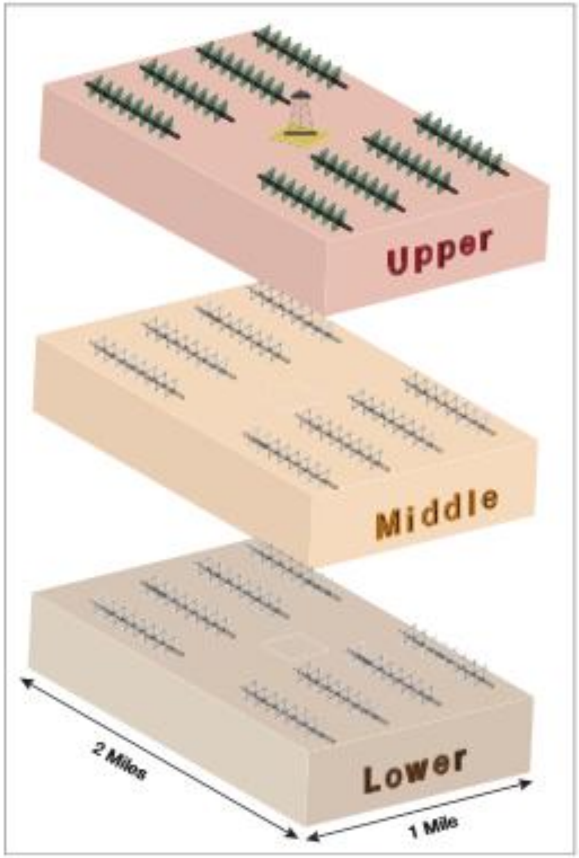


Both are stimulated horizontal wells.
Fracture stimulation outcome varies with delivery method

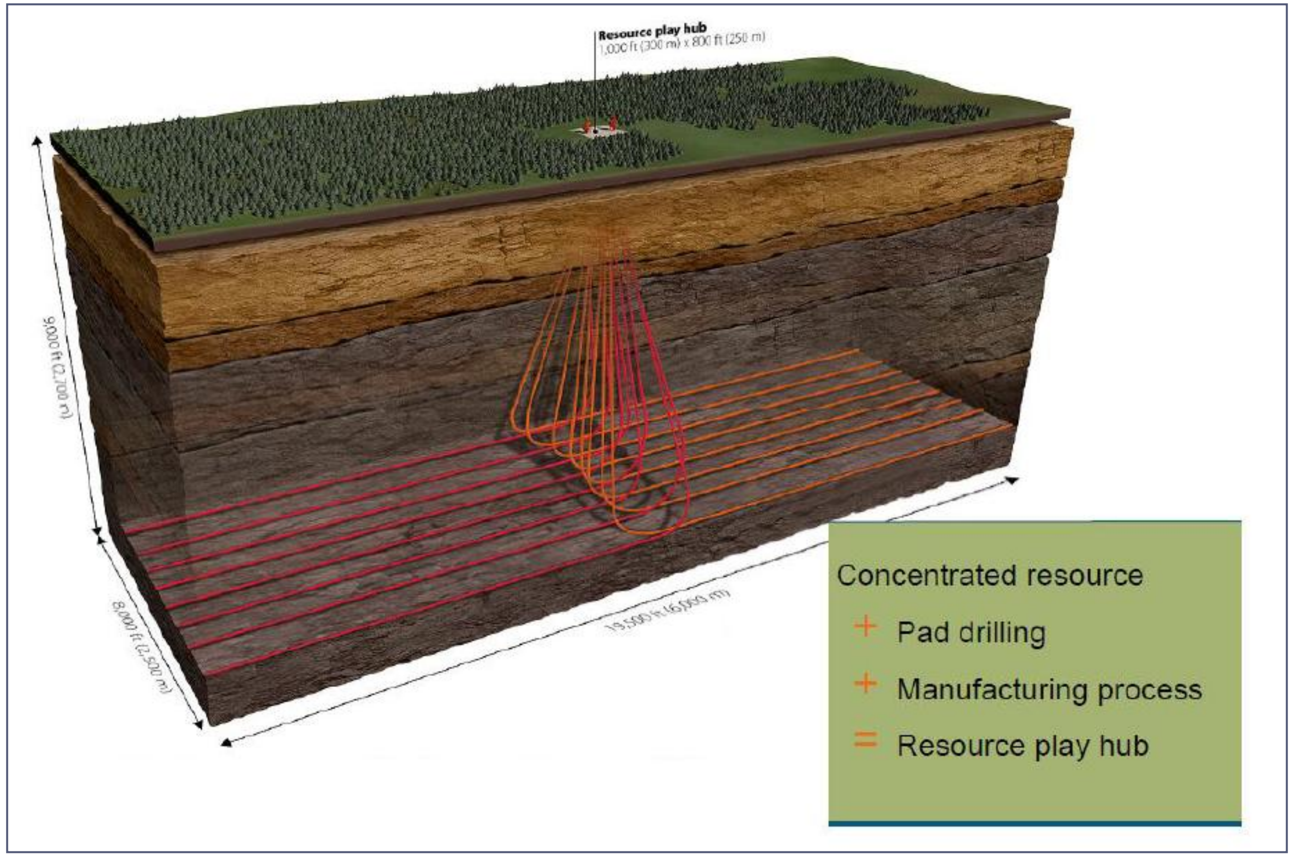
Backup: Hz Well Completions

COMPLETIONS VARY BETWEEN SHALES

Montney stacked laterals
(24 wells per pad)



Horn River pad drilling



Source: EnCana 2011, Macquarie Tristone 2012

5 ECONOMIC CONSIDERATIONS

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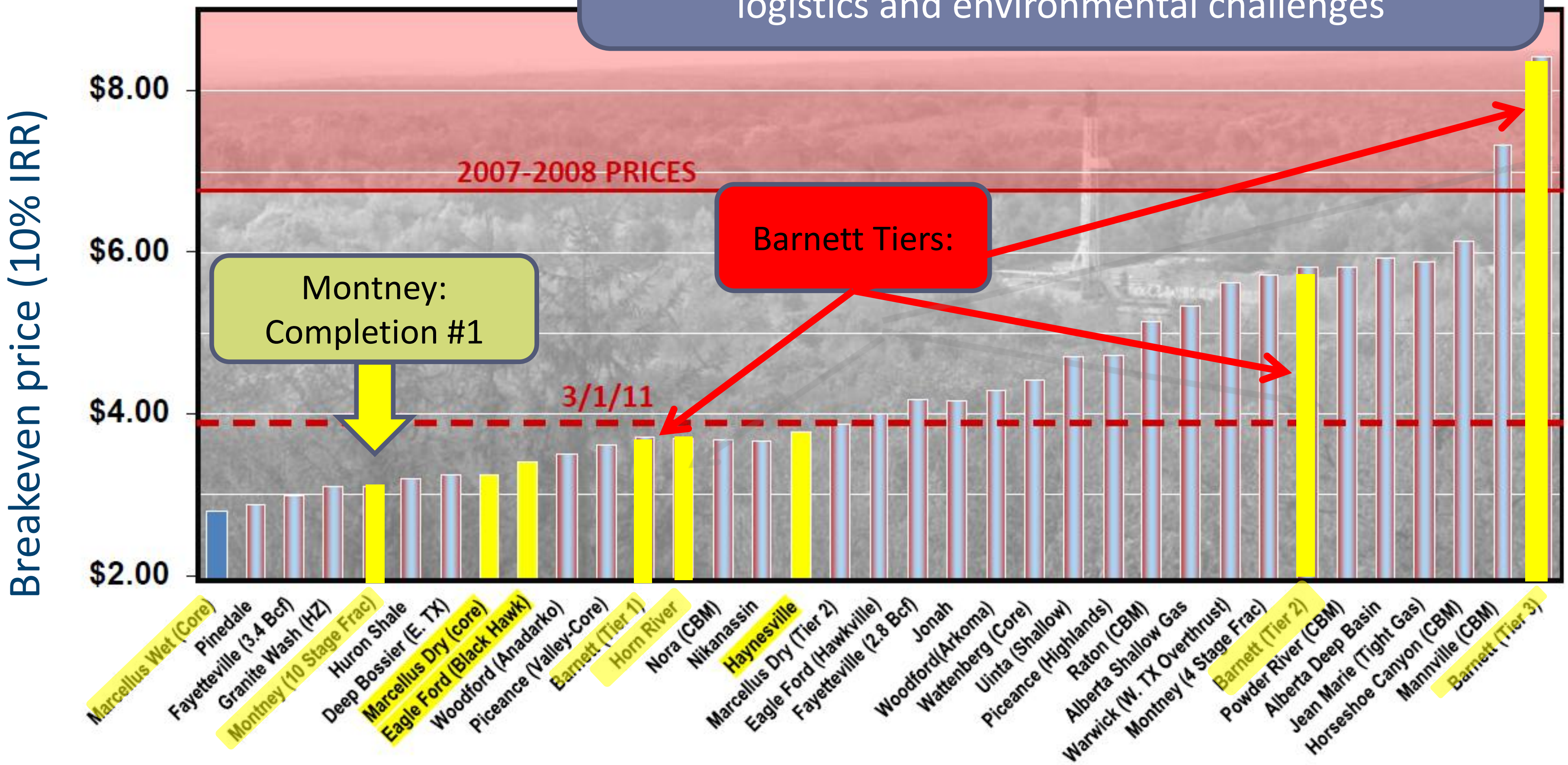
COMPARISON OF SHALE PROJECTS

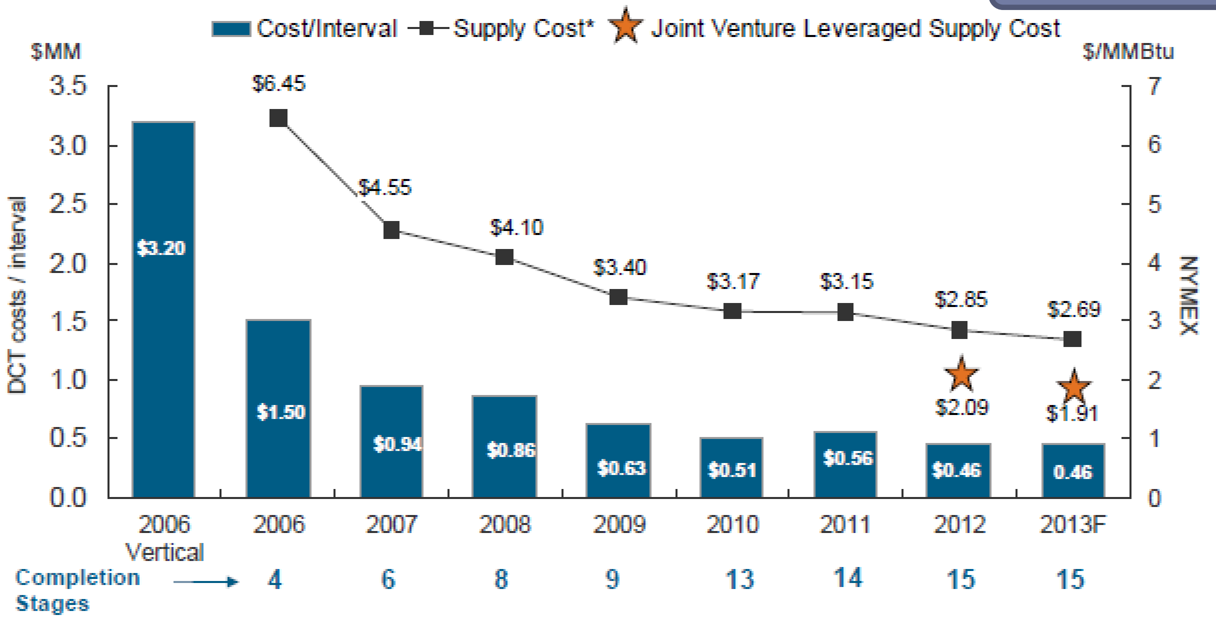
Economies of scale have allowed Canadian projects to compete with lower 48 projects, despite significant logistics and environmental challenges



Source: Standford University, 2012

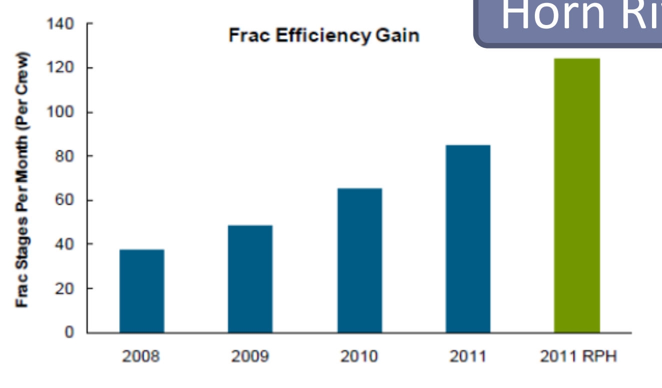
HUB RESOURCE MODEL/CONCURRENT PROCESSES / PAD DRILLING

Montney (Canada)



- 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

Horn River (Canada)



Source: Innovation Alberta

Backup: Economics Data

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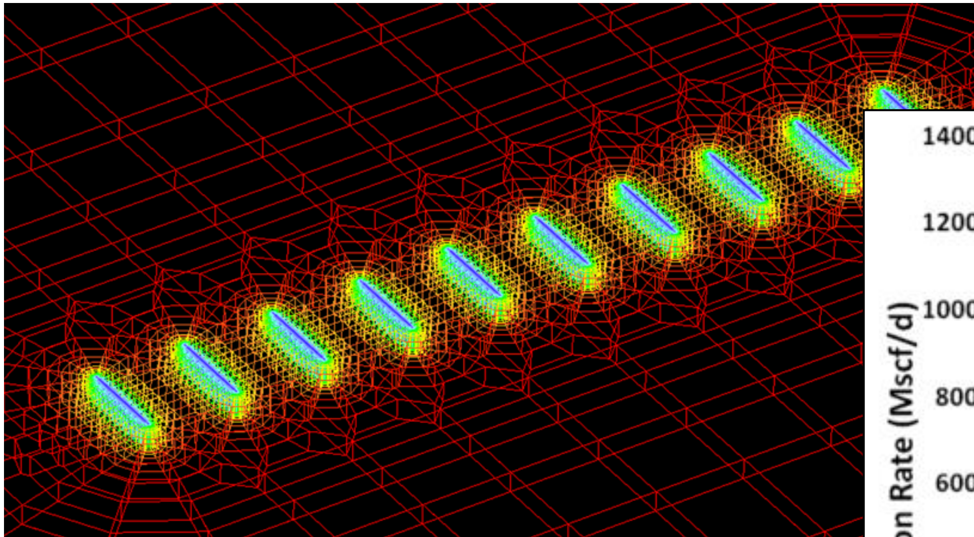
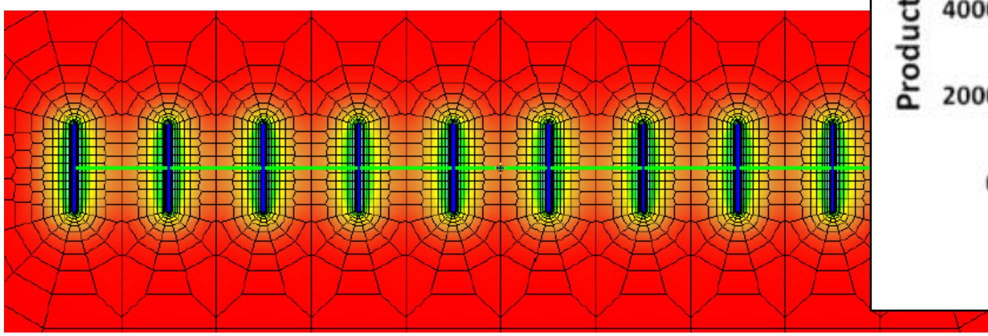
DEMONSTRATION 1

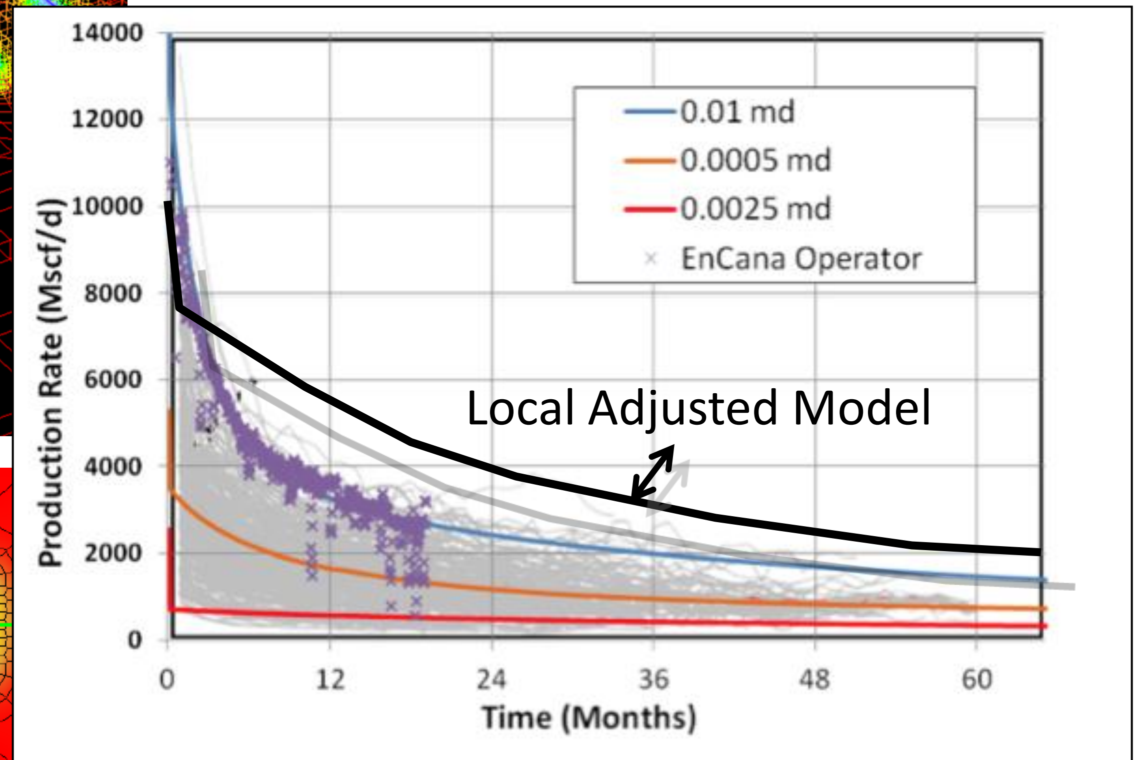
- Recommended Process
  - Detailed review of analogue data on a local level
    - Rock and petrophysical properties
    - Completion methods
    - Stimulation methods
    - Business plan and model

  - Adjust your parameters for local conditions
  - Build your predictive model!

DEMONSTRATION 2 (MONTNEY CANADA)







Predictive model, after local adjustment, actually gave us a higher UR, and deliverability profile than traditional analogue.

6 CONCLUSION

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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.

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