Alberta Shale Resource Project: Liquid-Rich Prospects*

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Abstract

The Alberta portion of the Western Canadian Sedimentary Basin includes no less than 18 shale-dominated formations that may have unconventional resource potential. Seven key shale/siltstone formations that exhibit favorable resource characteristics and have attracted industry interest are evaluated. Porosity/permeability, organic content, Rock-Eval parameters, adsorption-isotherm capacity, organic petrology, mineralogy, fluid saturation, vitrinite reflectance, and geophysical log characteristics were used to generate in-place resource estimates and suggest preferred resource targets, geographic locations of initial development, fluid types, and reservoir characteristics conducive to development.

Alberta's shale resource estimates are based on a new probabilistic geostatistical model. Five units/formations show immediate potential in Alberta; namely, the Duvernay-Muskwa, Montney, Nordegg, and the Exshaw/Banff (sometimes referred to as ‘Alberta Bakken'). The study also includes a preliminary assessment of Colorado, Wilrich, Rierdon and Bantry stratigraphic intervals. These were systematically mapped, sampled and evaluated for hydrocarbon potential. A total of 3385 new samples (5400 individual analyses) were evaluated in this study.

The total combined P50 values for the Duvernay, Muskwa, Montney, Banff/Exshaw, Wilrich, Nordegg, and Rierdon show significant unconventional resources in-place for Alberta; specifically, 3406 Tcf natural gas, 58.5 billion barrels of natural gas liquids, and 432.5 billion barrels of oil. These estimates exclude conventional resources/reserves. Colorado Group results are preliminary and not included in the estimates; however, initial results indicate significant potential for this group of formations.

This study marks the first comprehensive unconventional resource evaluation of Alberta. Prior to this study, relatively few geochemical and petrophysical data from Alberta shale-dominated successions were available for resource evaluation. Extensive detailed sampling and analysis performed under this study allowed a robust geostatistical evaluation of hydrocarbon fluid type and resource distribution. A key result is the identification of NGL/condensate trends associated with shale horizons. This study validates Alberta's huge unconventional resource potential.

References Cited

Lyster, Steve, 2013, Quantification of uncertainty in shale gas resources: Alberta Geological Survey Open File Report (OFR) 2013-13, 42 p. Website accessed February 18, 2013. http://www.ags.gov.ab.ca/publications/OFR/PDF/OFR_2013_13.PDF

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Alberta Energy Regulator

AGS ALBERTA GEOLOGICAL SURVEY

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AAPG 2013 GeoTechnology Workshop

Hydrocarbon Charge Consideration in Liquid-Rich Unconventional Petroleum Systems workshop

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Outline

- **Introduction**
  - Purpose
  - Project rationale, and reality check
- **Resource Methodology**
  - Input variables and sources of uncertainty
  - Modelling workflow
  - PRMS Classification
- **Results**
  - Resource endowment and maps (Duvernay, Montney, Muskwa)
- **Activity**
  - HZ and HF activity
- **Conclusions**
- **Questions we are asking**

-fluid migration, grain density

Project Rationale

- Initial question to us was “How much unconventional shale gas do we have in Alberta?
- Project was to concentrate on gas resources, but the drop in gas price led us to include oil and liquids
- Methodology was built for a new shale to tight area with no production.

Reality Check

- Why do we incorporate uncertainty in our analysis?
  - Limited data relative to size of the prize
  - Expected variability of the geological framework/rock parameters on a laminae scale
  - State of knowledge of ultra-low permeability sediments

Reality Check Continued

Volume of the Duvernay evaluated: 60 000 km^2 x 16 m (average thickness) = 960 km^3

Mass: 960 x 10^9 m^3 ● 2.55 kg/m^3 (density) = ~2.5 quadrillion kg (2.5 trillion tonnes)

Samples: 172 samples = Total 16 kg

16 kg/2.5Tt = 6.4 x 10^{-15}% coverage

Resource Methodology

- **Focus on uncertainty**
  - The workflow is designed from the ground up to use the latest geostatistical methods (Dr. Steve Lyster; OFR 2013-13)
  - Every step incorporates uncertainty
  - Final resource numbers: P10/P50/P90 on a TWP-by-TWP basis, but calculated on a per section basis

Resource Methodology Continued

- Number fit into the SPE Petroleum Resource Management System (PRMS)
- Data driven: All maps, relationships, distributions, variances … come directly from the sample data
- MUST capture “most prospective areas” for drilling

Input Parameters

- Various analyses and log evaluation to derive standard input variables:

1. Areal extent, thickness, porosity, water saturation, pressure, temperature, compressibility, shrinkage factor, TOC
2. Maturity: % Ro >= 0.8

Input Parameters Continued

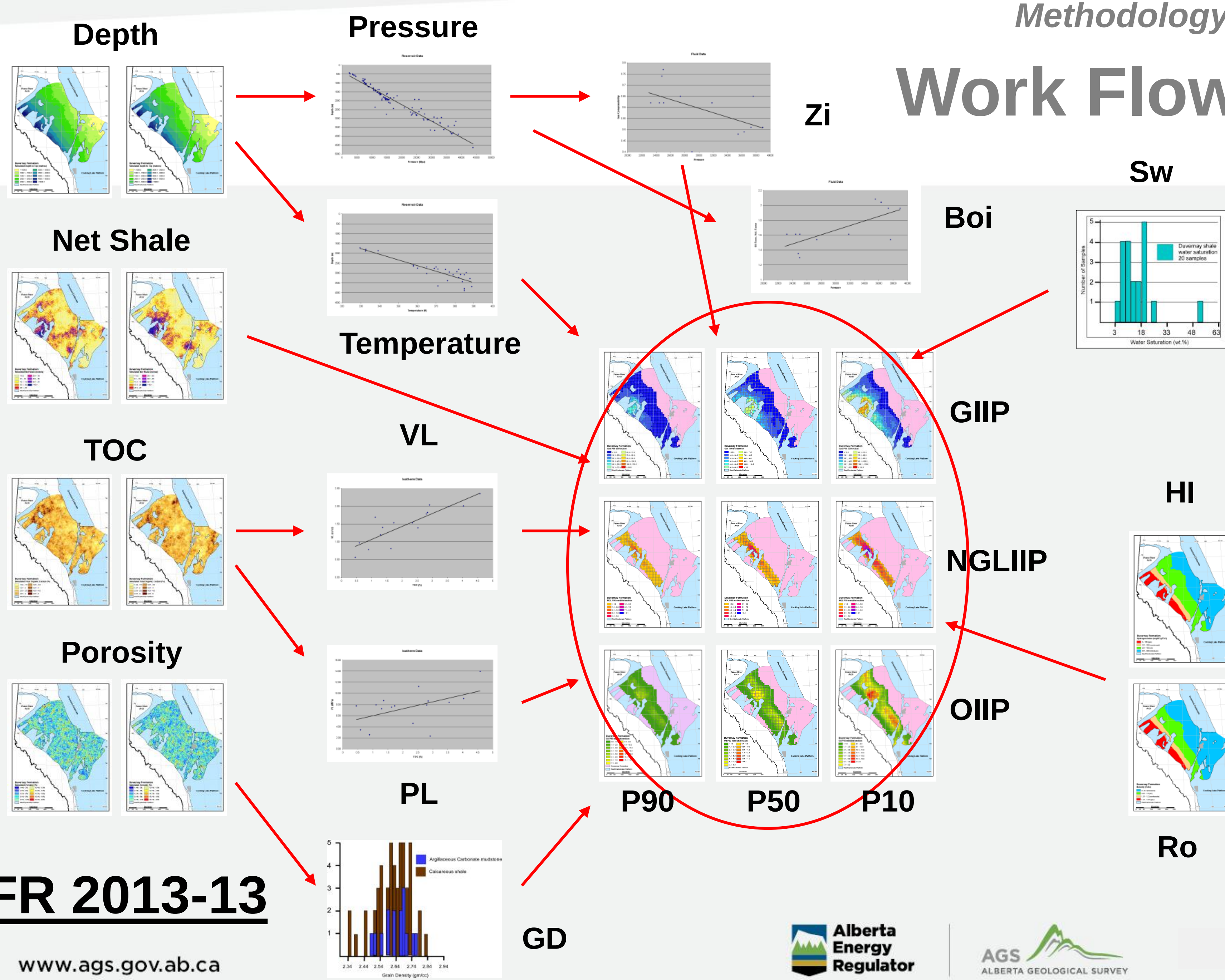
3. Gas-Oil Ratio – linear interpolation; (Danesh 1998; relating GOR to fluid distribution - dry gas, wet gas, condensate, volatile oil, black oil, immature; then pin maturity to these)

4. Fluid: Gas - C1 is dominant but also some C2-C4; Liquids - C2 to C5 plus; Oil – C5 plus (calculate CGR from gas analyses on each wells- eq. 30; bootstrap - e.g., 79 Duvernay samples; pin P90 to 'condensate', calculate GOR and CGR at each well location – eq.31, 32)

Input Parameters Continued

5. Does not account for migration/redistribution with a source rock; or multiple source rocks.
6. We have not used any cutoffs (e.g., porosity, thickness) except for gamma ray to isolate lithology.
7. We have not excluded potentially restricted areas (e.g., urban, parks).
8. After 1000 iterations: extract P10, P50 and P90 of the distribution.

Work Flow



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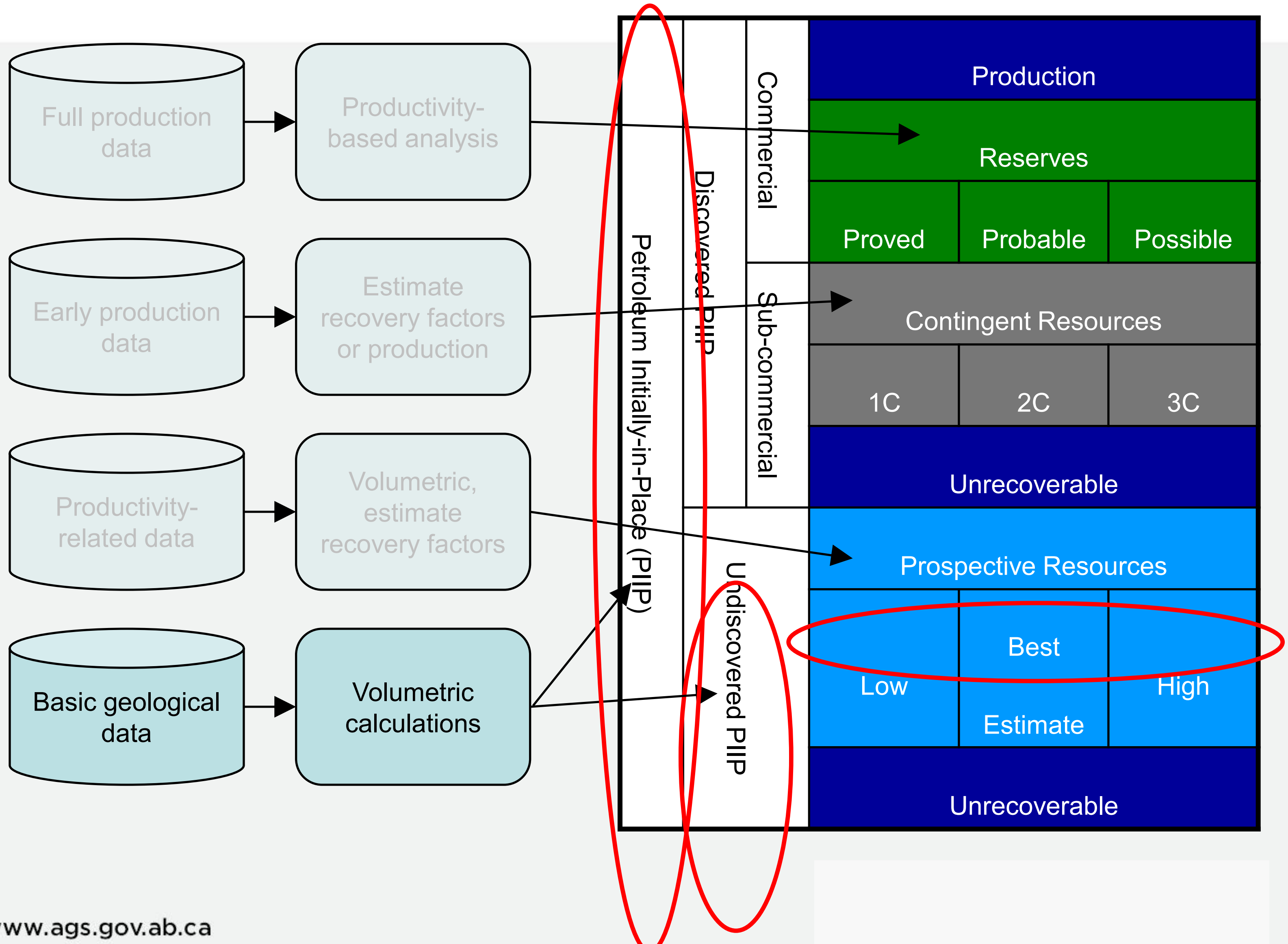
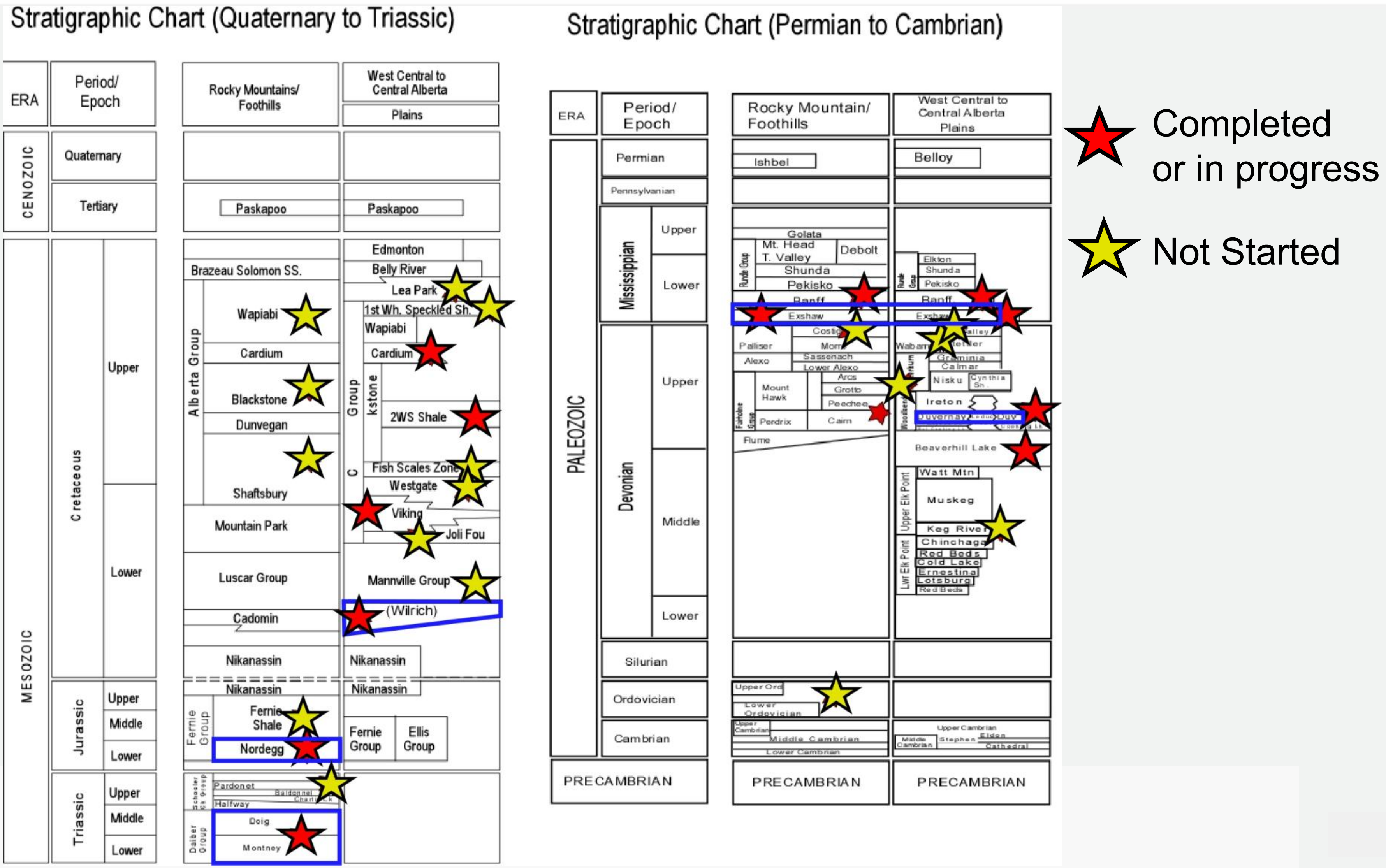
Resource Classification SPE PRMS



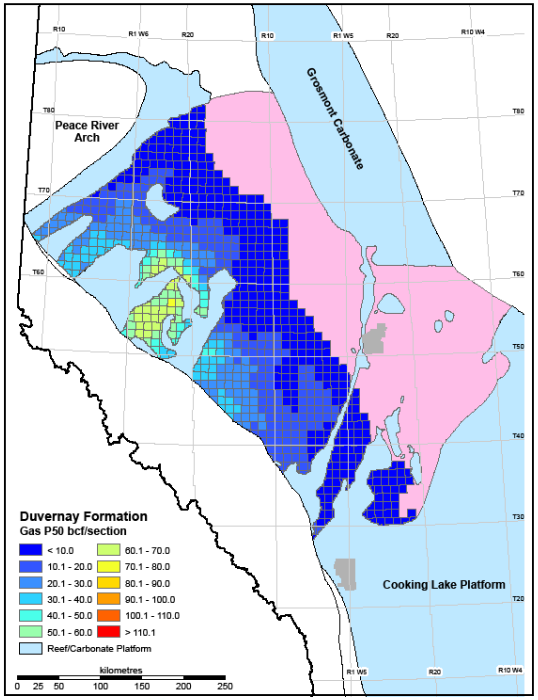
Prospective Formations (Tight or Shale)



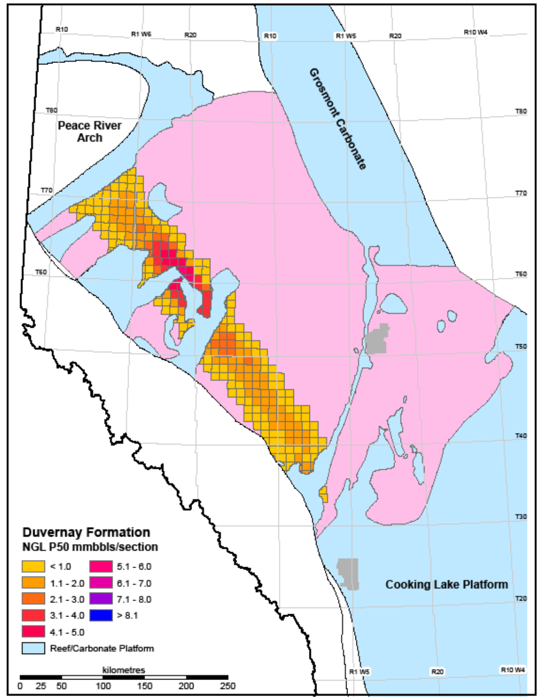
Duvernay

Liquids

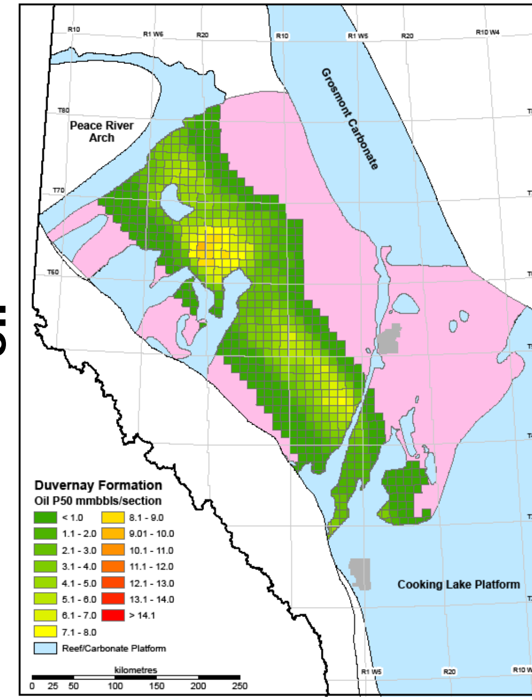
353 / 443 / 540 Tcf — natural gas

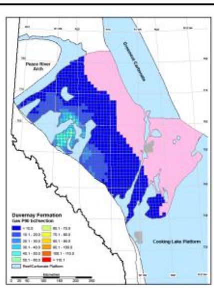


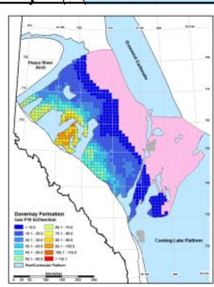
7.5 / 11.3 / 16.3 Bbbl — natural gas liquids

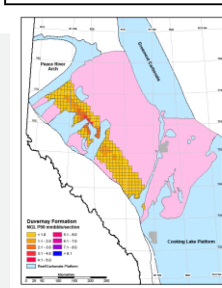


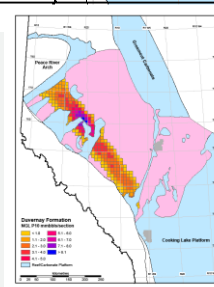
44.1 / 61.7 / 82.9 Bbbl — oil

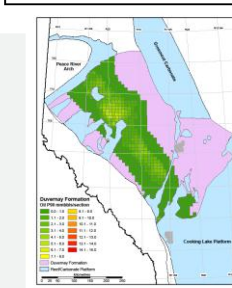


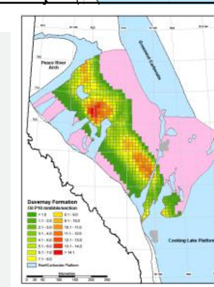










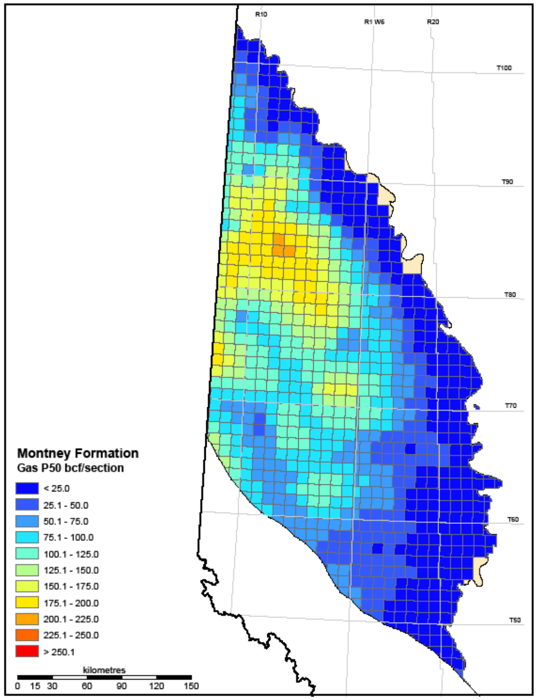


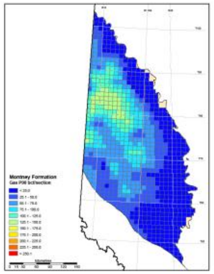
Montney

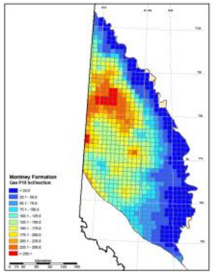
Liquids

1630 / 2133 / 2828 Tcf | **11.7 / 28.9 / 54.4 Bbbl** | **78.6 / 136.3 / 220.5 Bbbl**

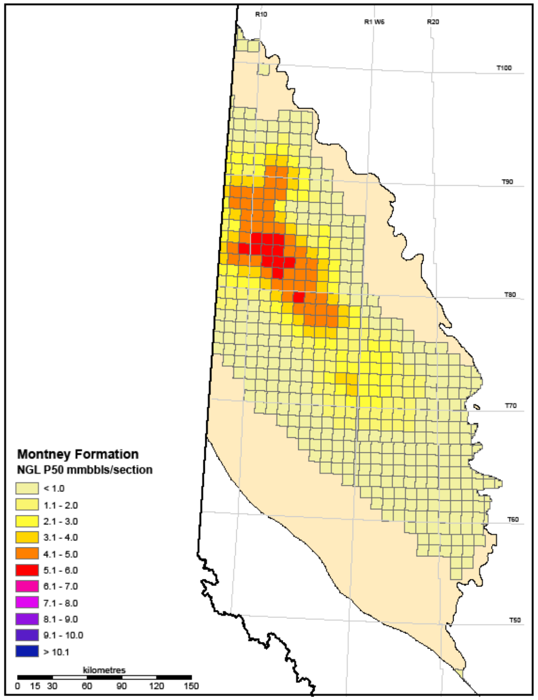
natural gas

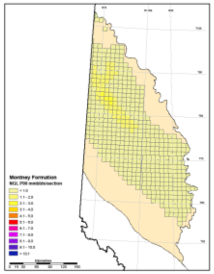


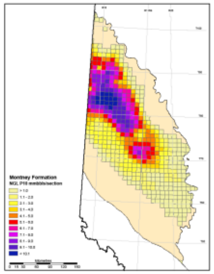




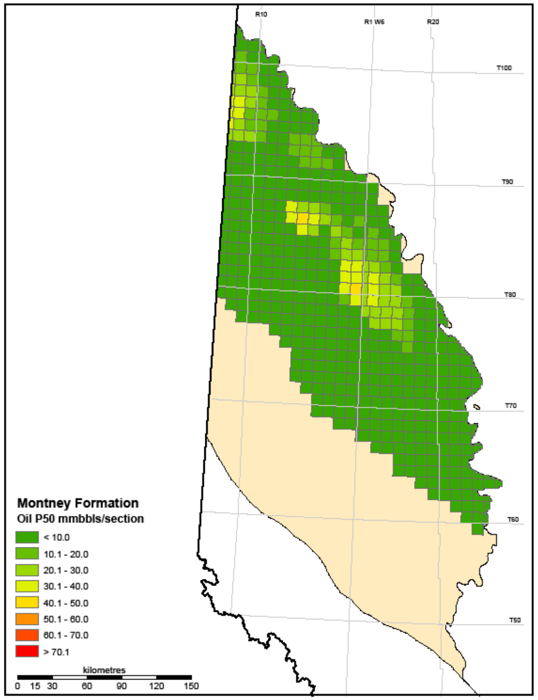
natural gas liquids

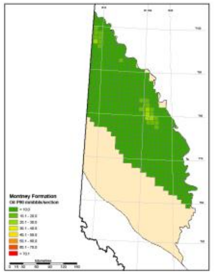


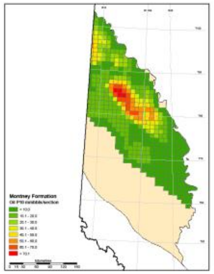




oil





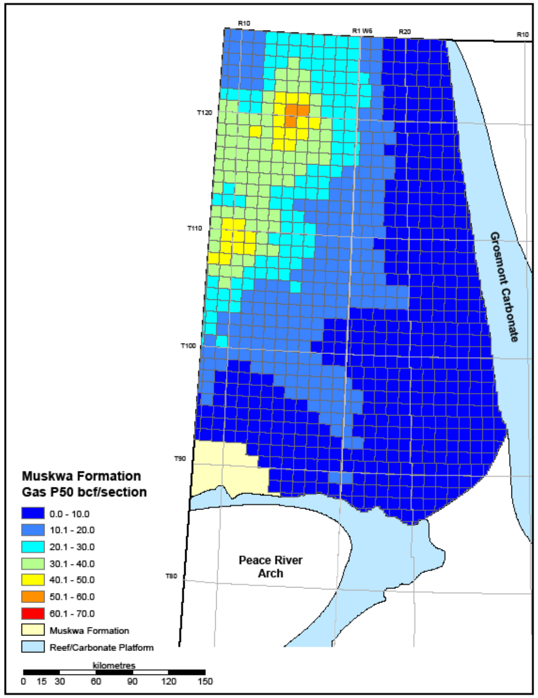


Muskwa

Liquids

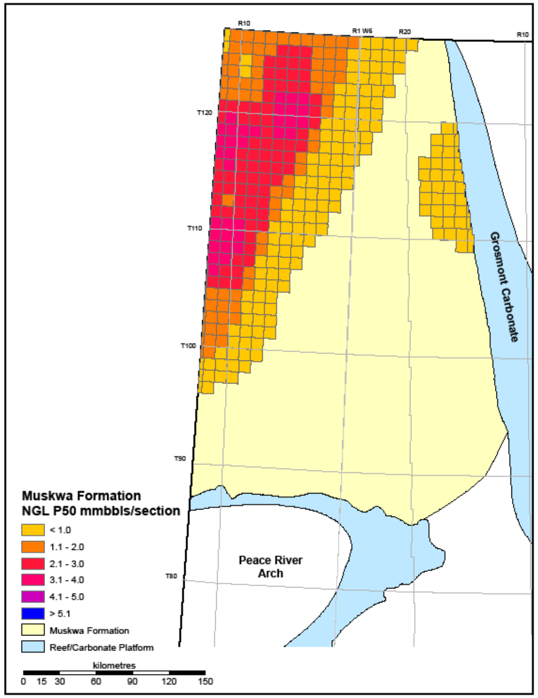
natural gas

289 / 419 / 527 Tcf



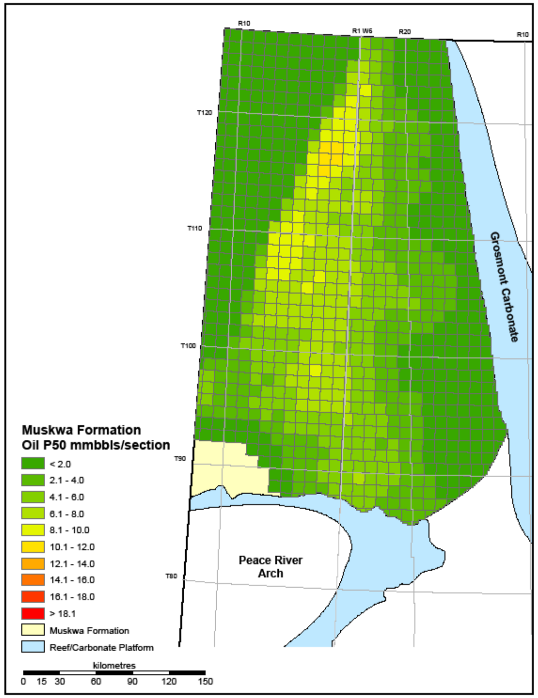
natural gas liquids

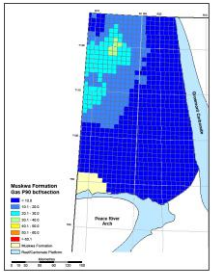
6.0 / 14.8 / 26.3 Bbbl

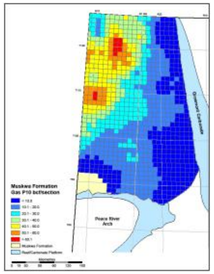


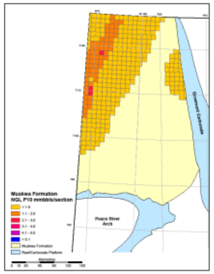
oil

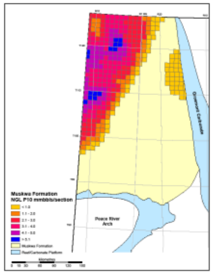
74.8 / 115.1 / 159.9 Bbbl

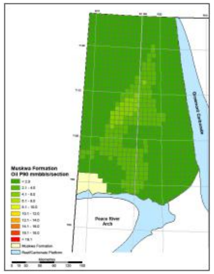


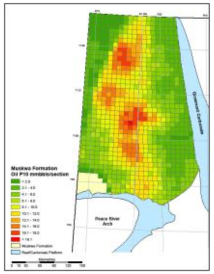












Summary Resource Numbers P50

Unit	Natural Gas (Tcf)	Natural-Gas Liquids (billion bbl)	Oil (billion bbl)
Duvernay P50	443	11.3	61.7
Muskwa P50	419	14.8	115.1
Montney P50	2133	28.9	136.3
*Basal Banff/Exshaw P50	35	0.092	24.8
*North Nordegg P50	148	1.4	37.8
*Wilrich P50	246	2.1	47.9
Total P50	**3424**	**58.6**	**423.6**

* Preliminary Numbers

Technically Recoverable Resources

- Move from 'Resource in-Place' to 'Technically Recoverable'.
  - e.g., start with formations in the shale report and then to tight zones
  - Porosity cutoff to geographically isolate areas of interest, but may include the "cutoff" resources
  - Thickness of shale (gross) and thickness below thick carbonate
  - Beneath cities and towns?

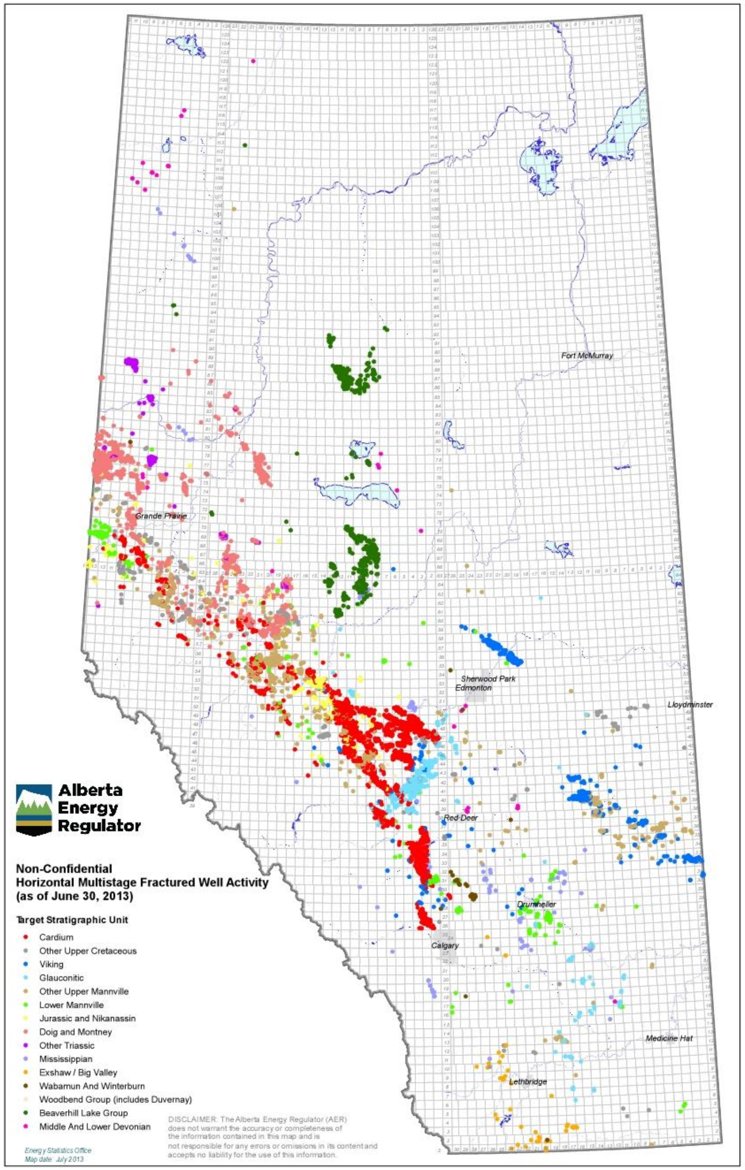
Resources

- Oil, Gas, Liquid Activity

  (to end of July 2013)

- Horizontal Multi-Stage Hydraulically Fractured oil and gas wells

Top 5: Cardium, Doig/Montney, Mannville, BHL, Viking



Conclusions

1. **We are learning**, especially about methods of analysis.

2. We are continuing to evaluate shale and tight zones. All data will be released to the public: **http://www.ags.gov.ab.ca/**

3. We absolutely invite advice/criticism.

4. We have generously received funding from Alberta Energy.

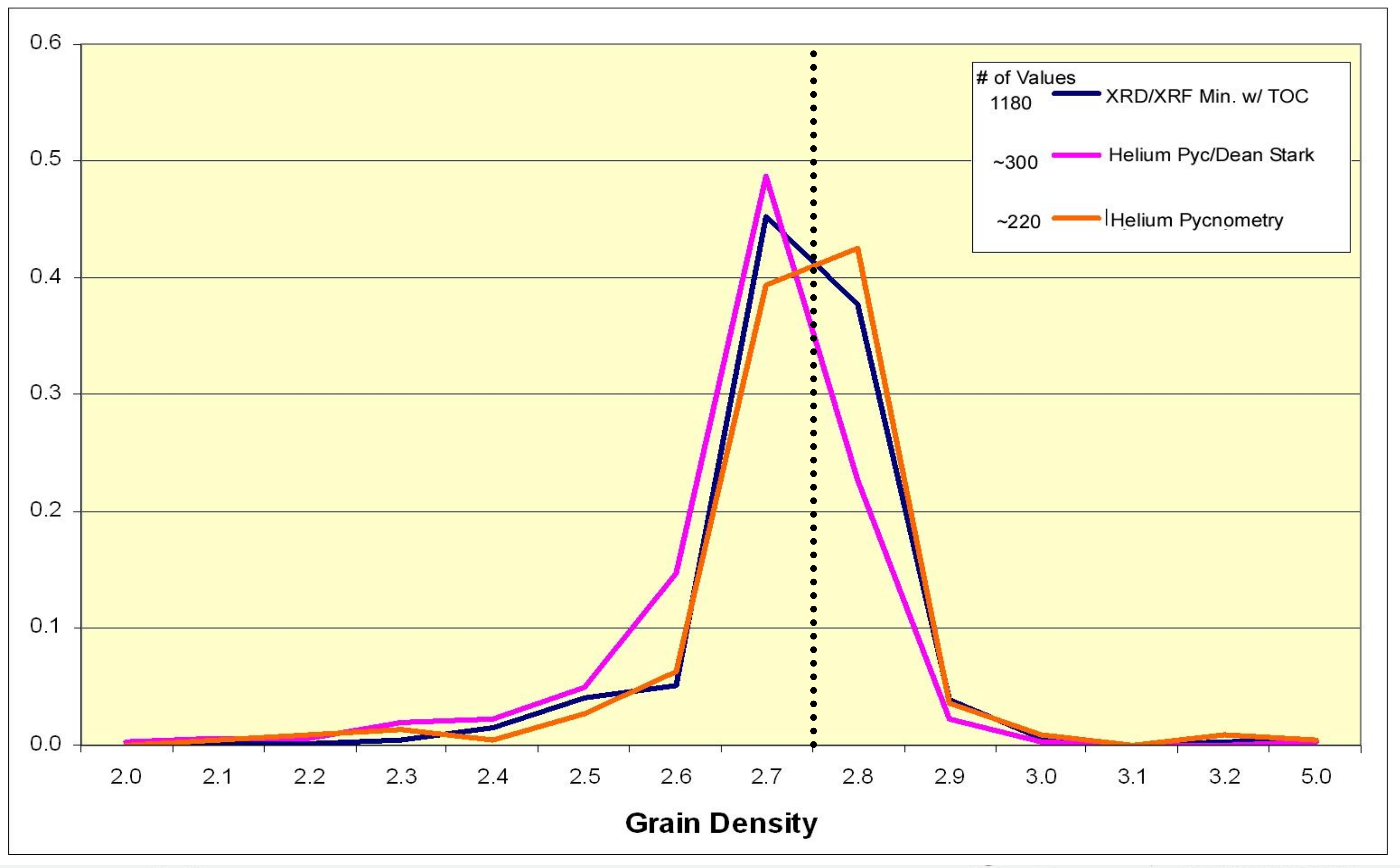
?Questions we are asking?

- 1) Data analysis: Accuracy versus Precision

  Biggest difficulty that we have had is determining if our data is accurate. We can achieve precision, but determining accuracy is a problem.

- 2) Fluid migration and perhaps multiple sources
  - Duvernay/BHL
- 3) Need better knowledge of liquid volumes in reservoirs; especially gas analyses

Data Questions?
Grain Density Derivation: Comparison of methods --- all data in all formations



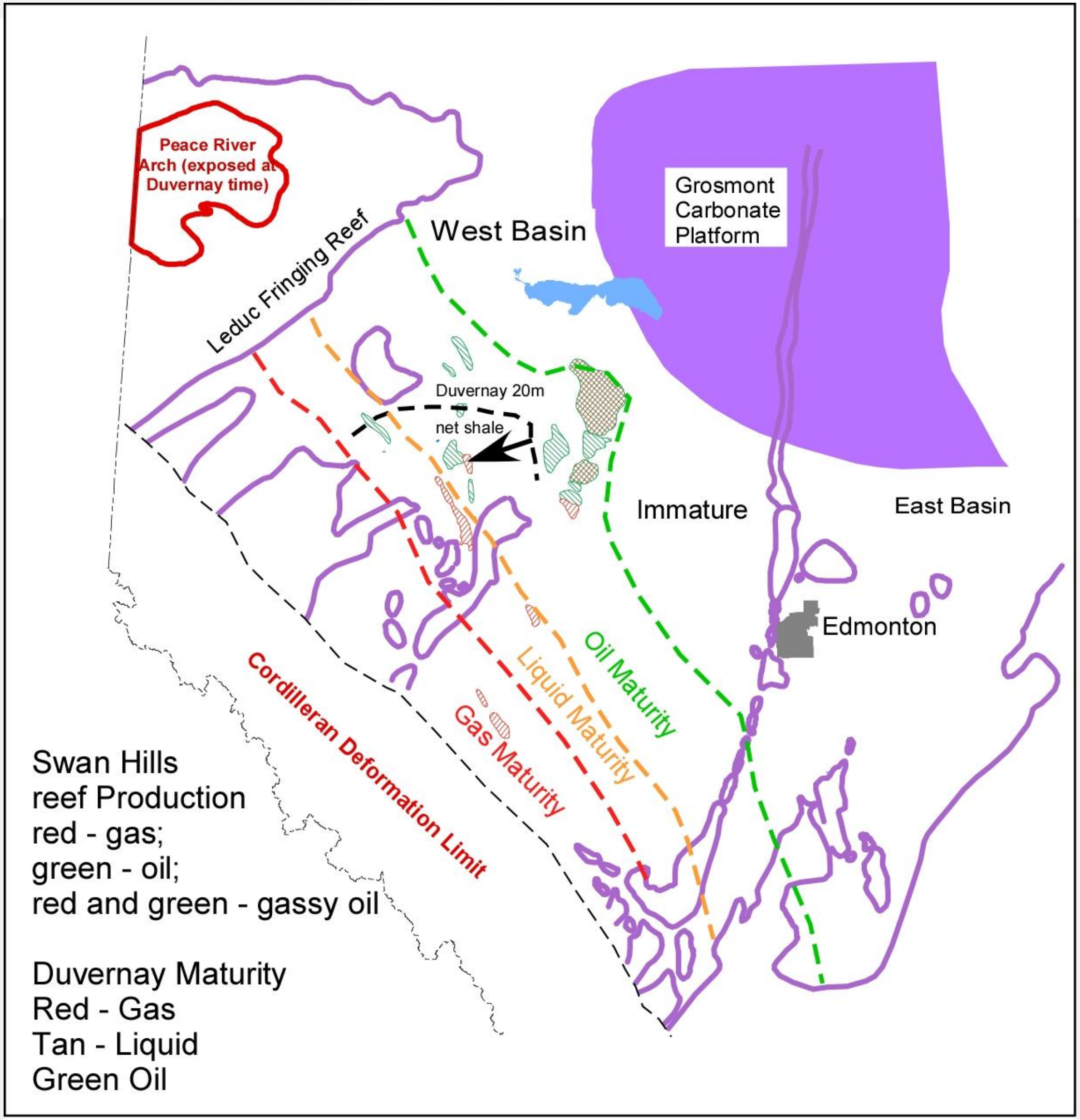


Figure 2.1.8. Swan Hills oil and gas pool distribution

Data Questions?

Fluid Distribution

e.g., Duvernay and Swan Hills

Questions

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Thank you