AVWhat Makes a Play Unconventional?: Exploring for the Unconventional Play*

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Abstract

Rarely, if ever, does an unconventional play experience the romance of a discovery well. Rather, the validation of the play requires a series of deliberate evaluations and an extensive series of appraisal wells before sanctioning the initial development program. Furthermore, although these plays are extensive in area ("continuous"), the commercially viable prospective areas may be localized and segmented. The advancement towards a profitable venture in unconventional resources requires a progressively focused effort that ultimately identifies the prospective area, characterizes the spatial variability for appraisal and development programs, and accounts for the differing value tiers of the play. Our workflows must reflect this progression and be accompanied by the appropriate probabilistic tools that capture the ranges of potential outcomes, outcomes that hopefully narrows to a profitable venture as we increase knowledge of the play

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WHAT MAKES A PLAY UNCONVENTIONAL”?
EXPLORING FOR THE UNCONVENTIONAL PLAY

David J. Campagna, GM Unconventional Exploration

AAPG

Playmaker Forum – Calgary, Alberta
March 31, 2015

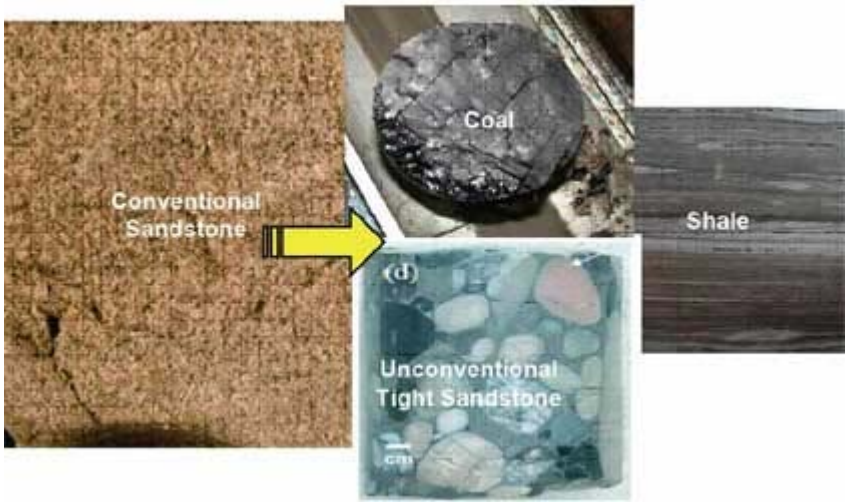
Canada’s Energy Geoscientists
cspg.org

KEY MESSAGES

- *How can we explore for new unconventional resources beyond known commercial operations?*
  - **Need to draw upon play-based exploration methods**
- *What makes a play "unconventional"?*
  - **Petroleum systems approach provides the geological framework for play type designation**
- *How do we implement play-based exploration methods for new unconventional resources?*
  - **A workflow that addresses key decision points based on specific areas of investigation**
    - *From the play fairways to leads to the prospective areas to a developable area*

FROM ALTERNATIVE TO UNCONVENTIONAL

- Alternative resources became the legal designation of specified gas resources for tax-breaks
  - The US 1980 Windfall Profit Tax Act contained an additional tax-break incentive known as “Section 29” for alternative resources
- Later known as “unconventional” in the industry to distinguish from their taxable conventional operations



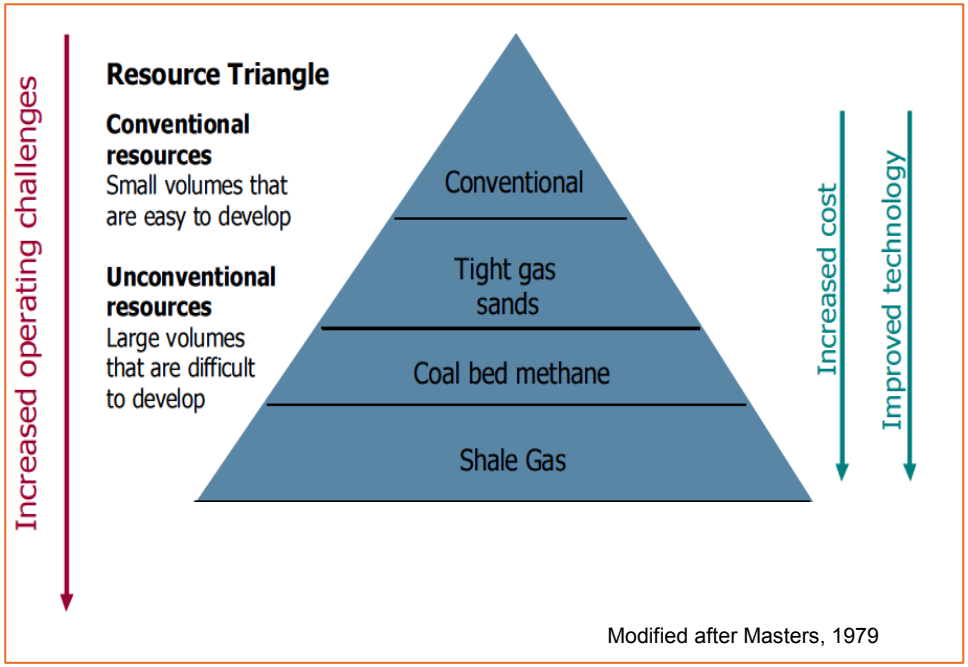
http://www.capp.ca/canadaIndustry/naturalGas/Conventional-Unconventional/

The trinity of “unconventional” gas that took on most of the credits:

1. Tight Gas
2. CBM
3. Shale Gas

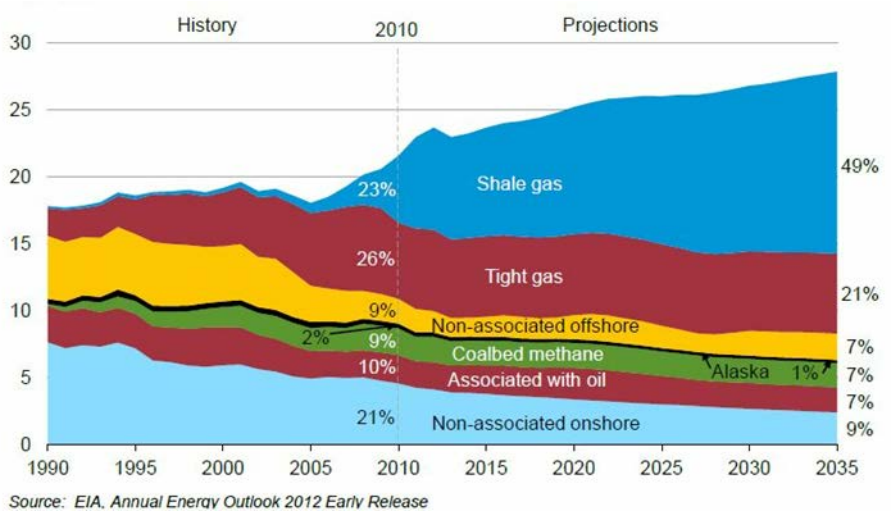
UNCONVENTIONAL: LARGE AND DIFFICULT

- Continued interest and activity post-subsidies driven by:
  - ***Resource In-Place*** a major driver as the quantity is massive
  - ***Technological Progress*** provided capability in unlocking these "difficult to develop" resources

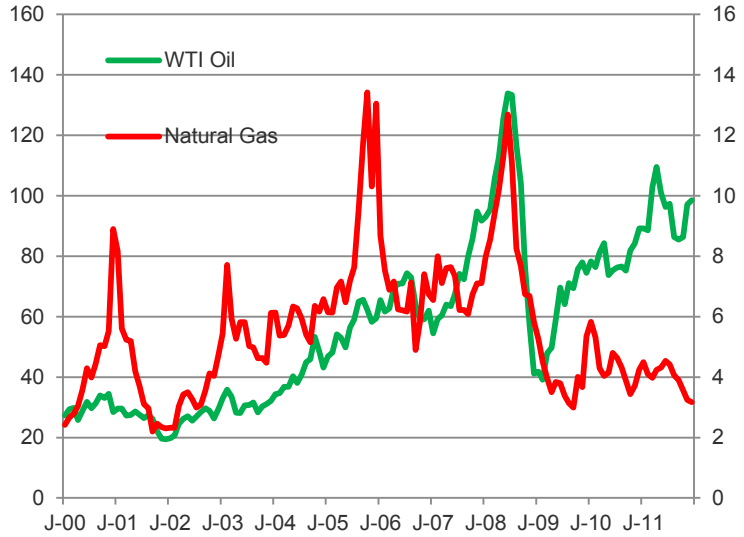


SHALE GAS SUCCESS AND MARKET RESPONSE

- Supply from successful Shale Gas exploitation led to depressed natural gas prices after the 2008 energy price collapse in the North American market
  - Starting in 2009 industry changed focus to unconventional resources of “Shale Oil”, “Tight Oil”



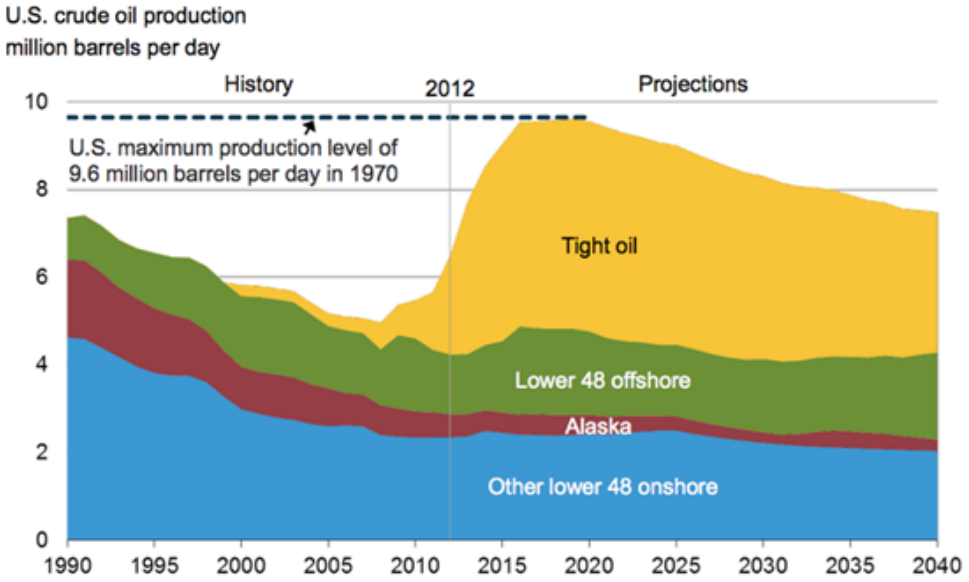
Source: EIA, Annual Energy Outlook 2012 Early Release



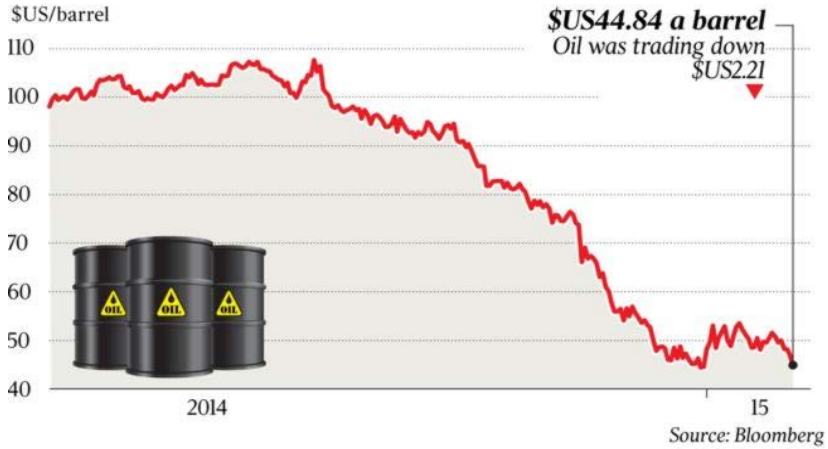
REPEATED SUCCESS AND RESULTS IN TIGHT/SHALE OIL

- The shift to liquids-weighted commodity resulted in a dramatic reversal of the declining oil production in the US
  - Decline in production from Eagle Ford, Bakken, and Permian plays expected to begin in 2020-2025

- Tight oil production is a factor in the overall decline of global oil prices



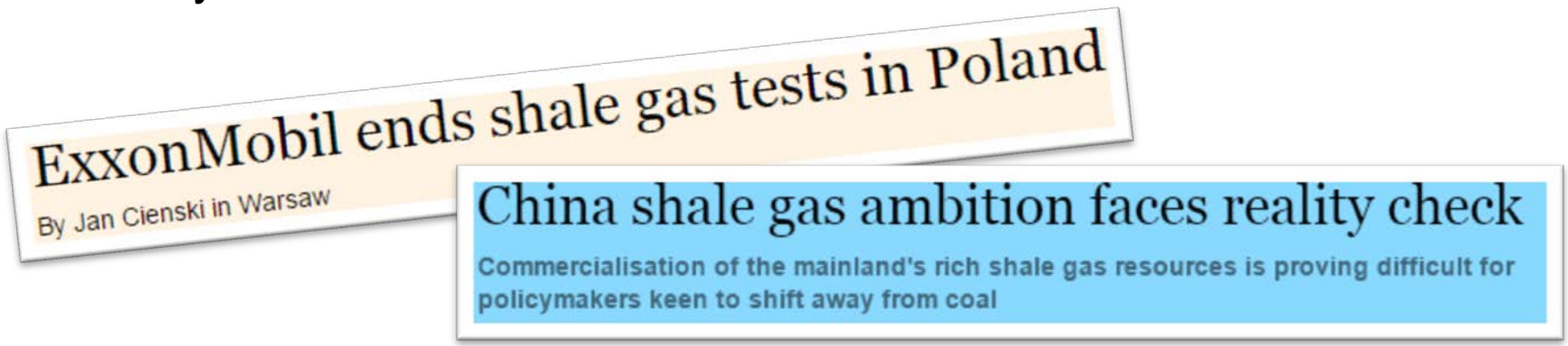
Source: EIA, Annual Energy Outlook 2014 Early Release



Source: Bloomberg

LACK OF SUCCESS WORLDWIDE BY DIRECT TRANSFER OF TECHNOLOGY

- Exploring for unconventional resources outside of the U.S. has been a slow and costly process
  - Simply exporting technology to unconventional reservoirs has not always been successful



"Some shale formations in Europe and China are impervious to drilling techniques that opened vast reserves of natural gas and oil from Texas to Pennsylvania"

- Rex Tillerson, CEO ExxonMobil 2012

APPLYING A PLAY-BASED EXPLORATION APPROACH FOR SUCCESS

"…the geologic complexity of varied unconventional resources requires new exploration philosophies." - Holditch and Ayers, 2009

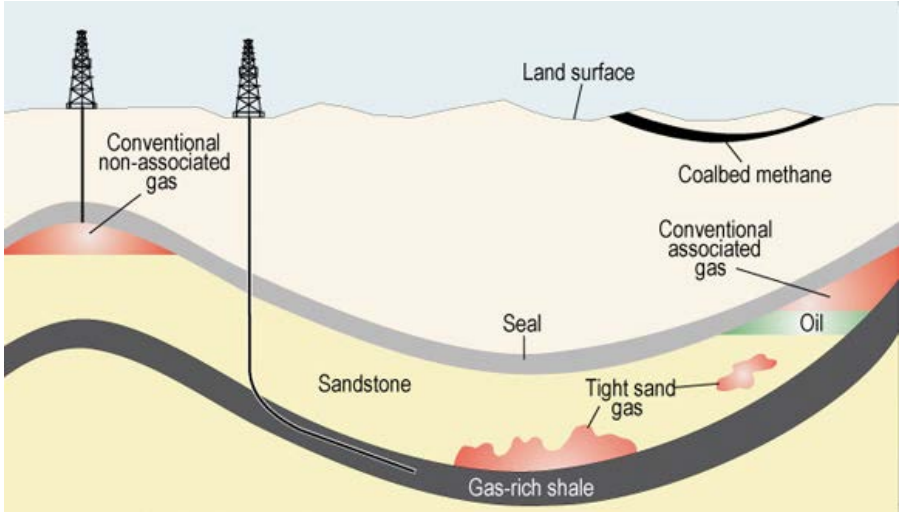
- **One "new" exploration philosophy may be to utilize a time-tested method that employs the play concept.**
- At its essence, the play concept provides a framework for appropriate expectations on the viability and value of an exploration program
  - Target identification (leads/prospects)
  - Risk characterization (based on previous occurrences)
  - Potential Yet to Find Resource (expectation of new additions)
  - Potential Value (based on previous successes)
- **What we need is a geologic context that describes the unconventional play.**

But…What is an unconventional play?

UNCONVENTIONAL DEFINITION #1: THE SOURCE IS RESERVOIR

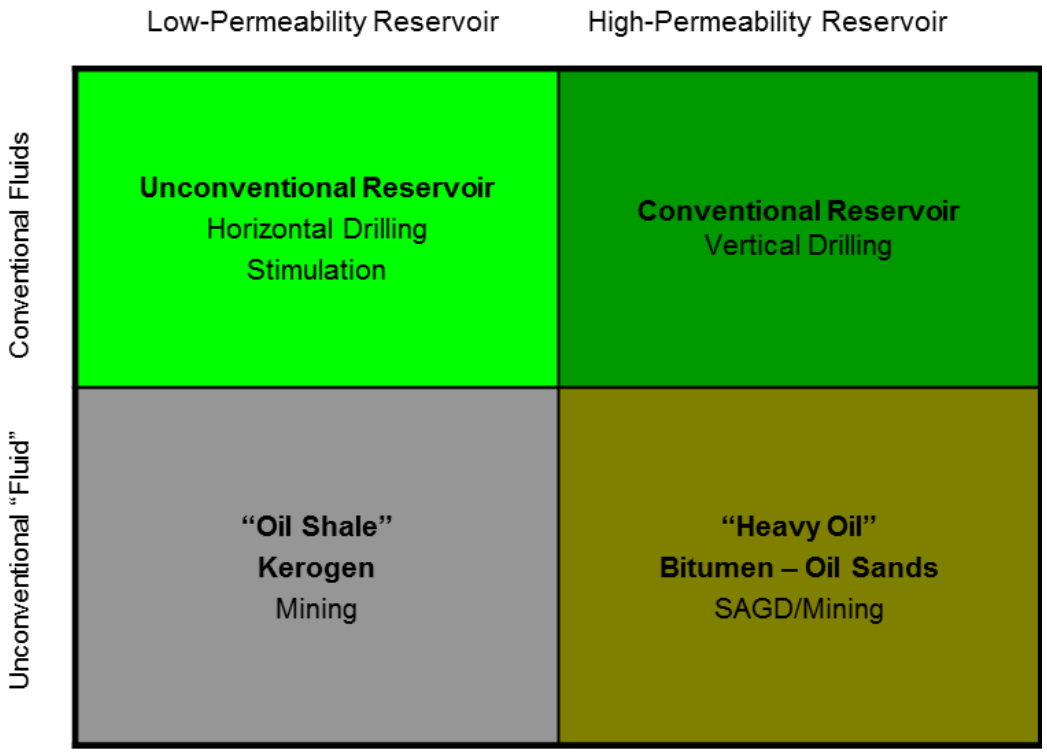
- The source rock retains significant resource depending expulsion efficiency, etc.

- It is a “continuous” resource that has potential over an extensive area



UNCONVENTIONAL DEFINITION #2: LOW-PERMEABILITY RESERVOIR

- A reservoir containing conventional fluids below some arbitrary permeability level
  - Interestingly, this view diminishes the static aspects of the play and focuses on key dynamic factors (i.e., permeability and fluid viscosity).



Modified from CSUR 2011

UNCONVENTIONAL DEFINITION #3
TECHNOLOGY DEFINES THE PLAY

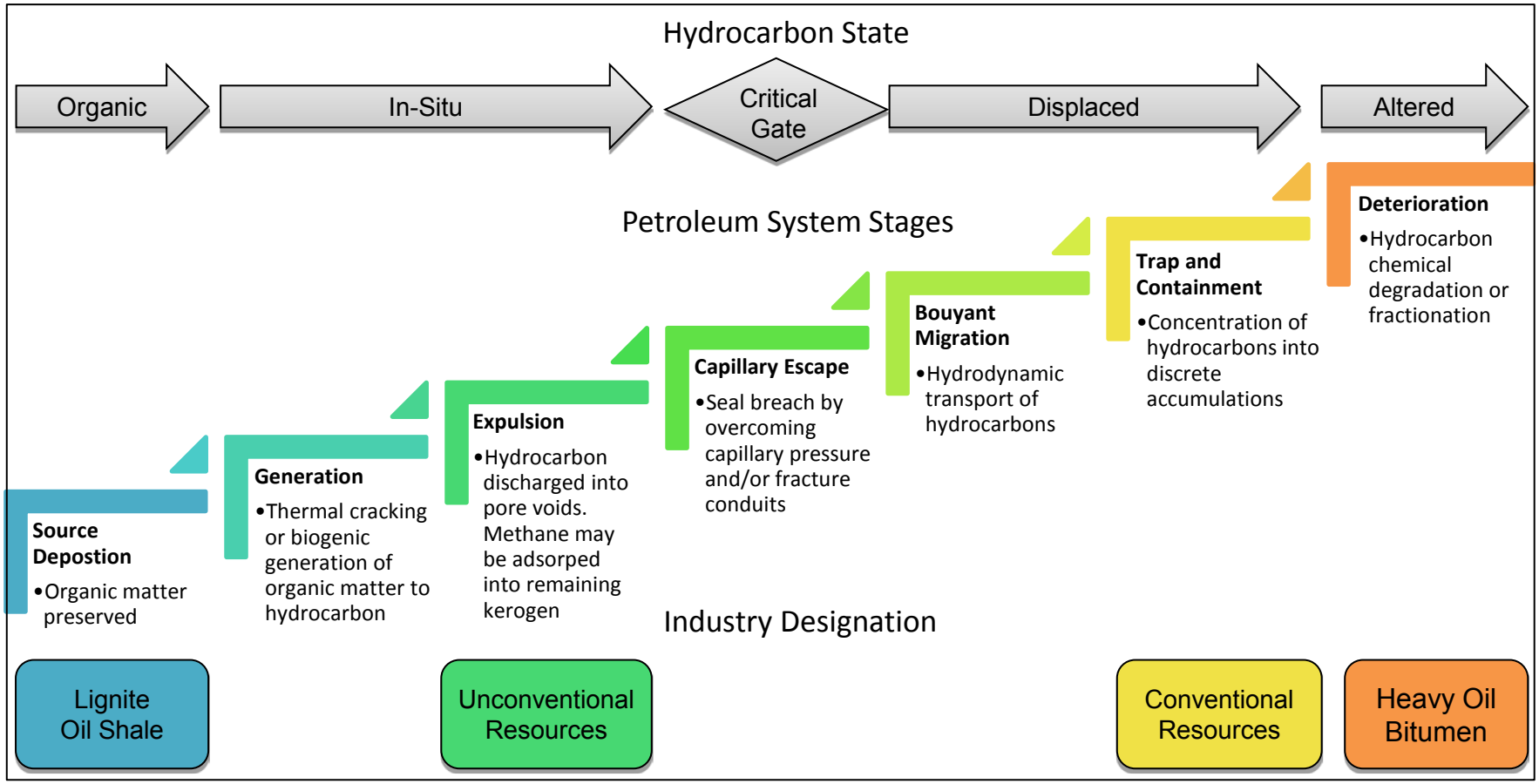
- Access to reservoir offsets low permeability

$$\textbf{Flow rate}, Q = \frac{kA}{\mu}(\partial P/\partial x)$$

- Thus the unconventional "*reservoir cannot be produced at economic flow rates … unless the well is stimulated by a large hydraulic fracture treatment, a horizontal wellbore, or by using multilateral wellbores*." Holditch (2006)

UNCONVENTIONAL DEFINITION USING A PETROLEUM SYSTEM FRAMEWORK

- The petroleum system perspective provides the definition of the unconventional play: An expulsed hydrocarbon resource that remains in the generative cell by a capillary seal



THE UNCONVENTIONAL PLAY TYPE

Any play can be constructed on a tiered, hierarchical framework based on the petroleum system:

Unconventional	Conventional
the source-seal	the source-migration
the reservoir-source	the reservoir-seal pair
the geomechanical setting	the trap type

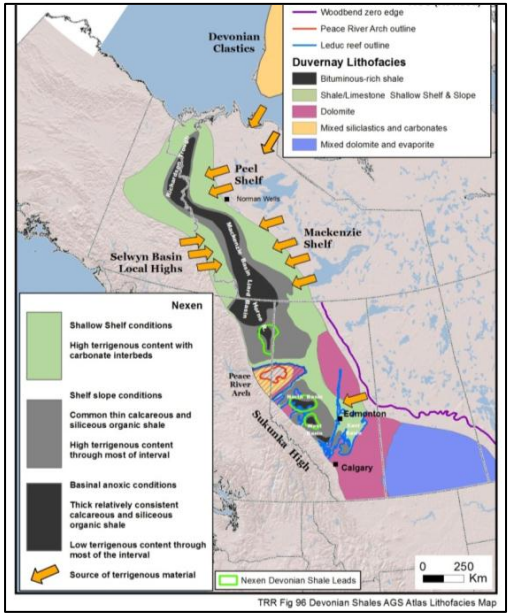
GEOHORIZONS

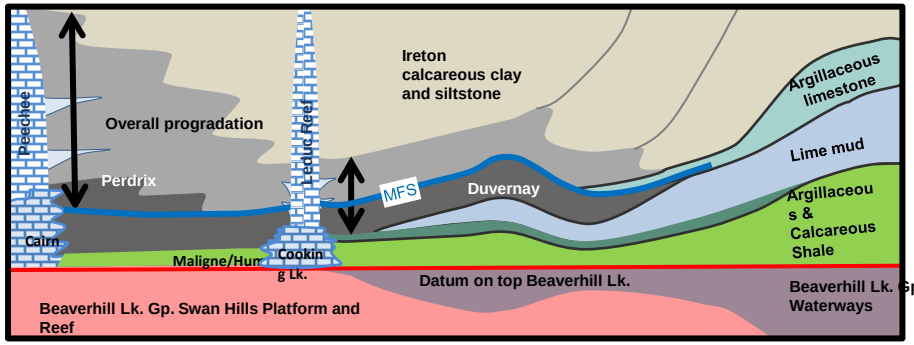
The exploration play: What do we mean by it?

Harry Doust **AAPG Bulletin, v. 94, no. 11 (November 2010), pp. 1657–1672**

FIRST TIER: SOURCE-SEAL PAIR

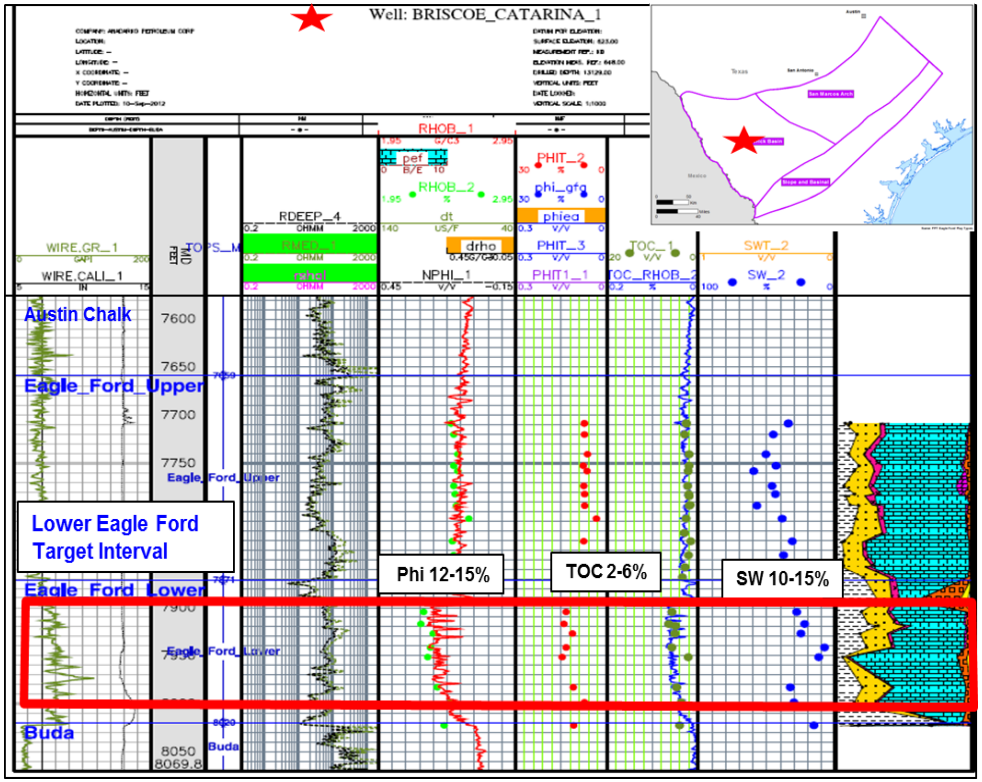
- The geologic characteristics of the source rock and its relationship to a capillary seal are first tier.
- The components of this tier are three-fold and include:
  - Depositional setting and traits of organic material accumulation and preservation
  - The generation of hydrocarbons including basin history
  - The capillary seal and its efficiency





SECOND TIER: SOURCE-RESERVOIR CHARACTERISTICS

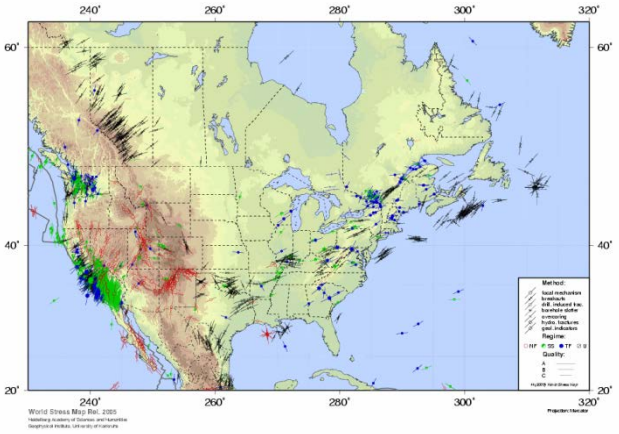
- The target interval and its relationship between the source of the hydrocarbon designate the second tier of the play type.
  - Target interval is the section accessed by stimulation
  - In its simplest construction, there are three possible pairings,
    1. Source – Reservoir are equivalent
    2. Source – Reservoir are different
    3. Source – Reservoir Hybrid

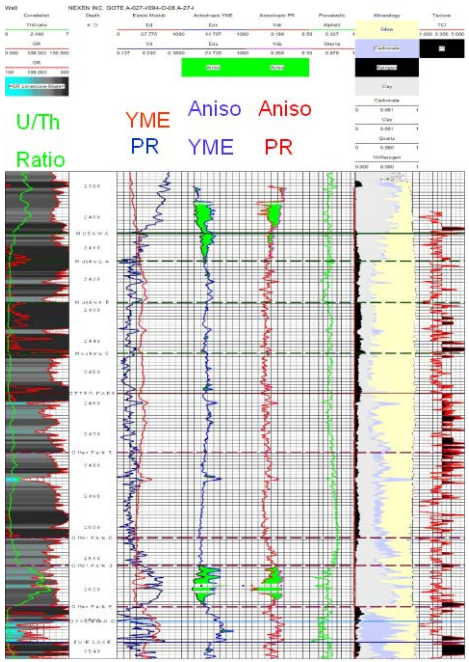


- It is the target interval that key reservoir characteristics can be measured

THIRD TIER: GEOMECHANICAL STATE

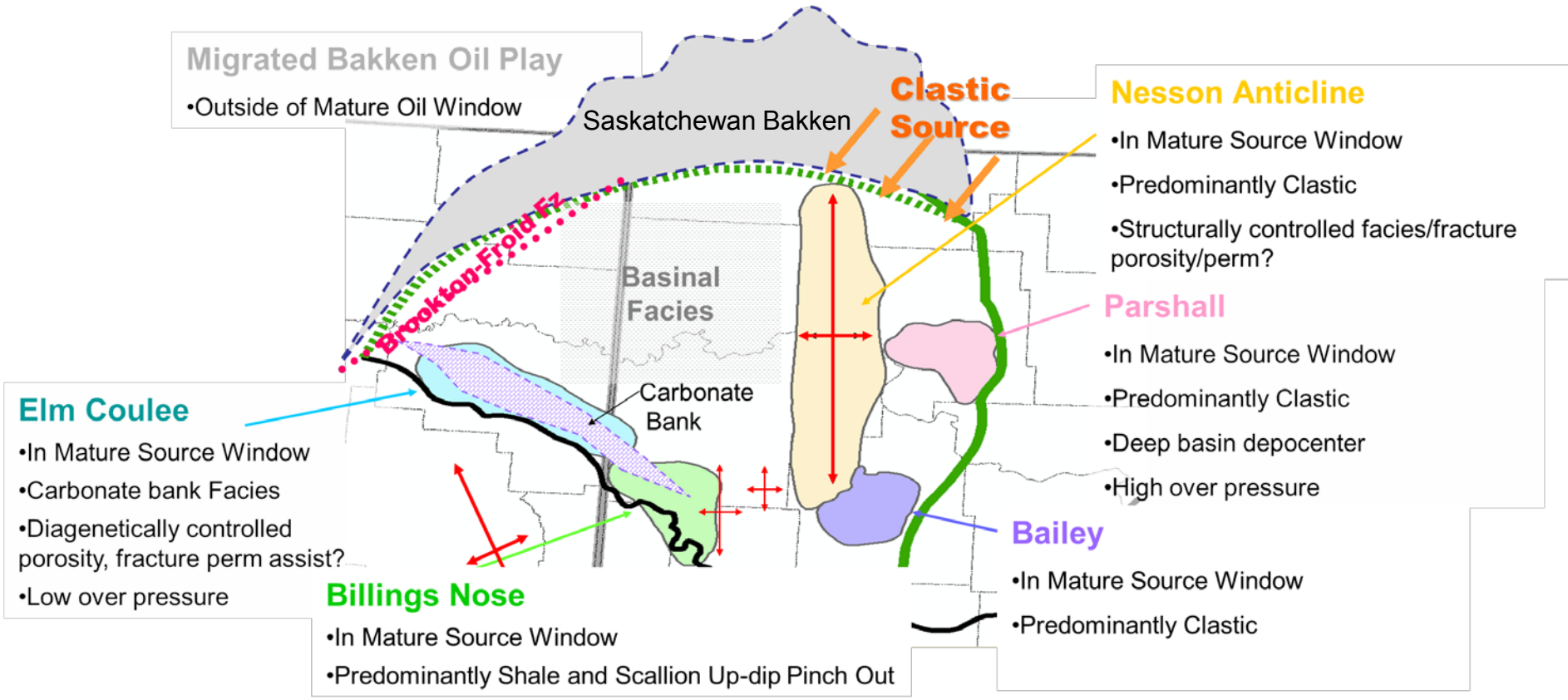
- Geomechanical qualities of the reservoir and surrounding beds directly influence our ability to access the resource beyond borehole.
  - The term geomechanical is used here in its broadest sense and includes aspects of rock mechanics, fracture mechanics and in-situ stresses.
- Rock properties such as elastic moduli that influence fracture initiation, propagation and closure
- Structural fabric such as Faults, Bedding and Natural Fractures
- In-Situ Stress state and its local variations





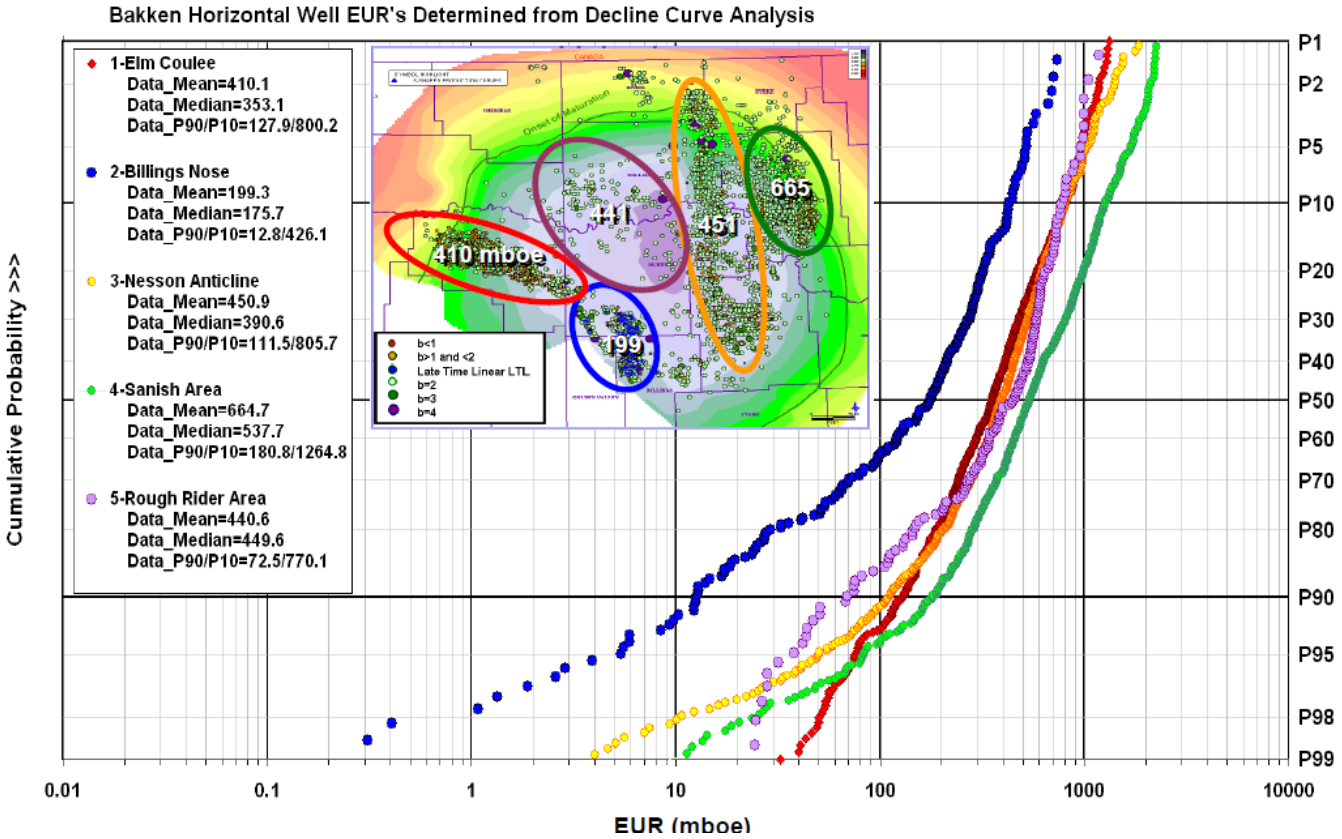
BAKKEN IS NOT SIMPLY “THE BAKKEN”

- Although often discussed in singular, the Bakken of North Dakota has been separated in terms of play areas



BAKKEN PLAY TYPES AND PRODUCTION

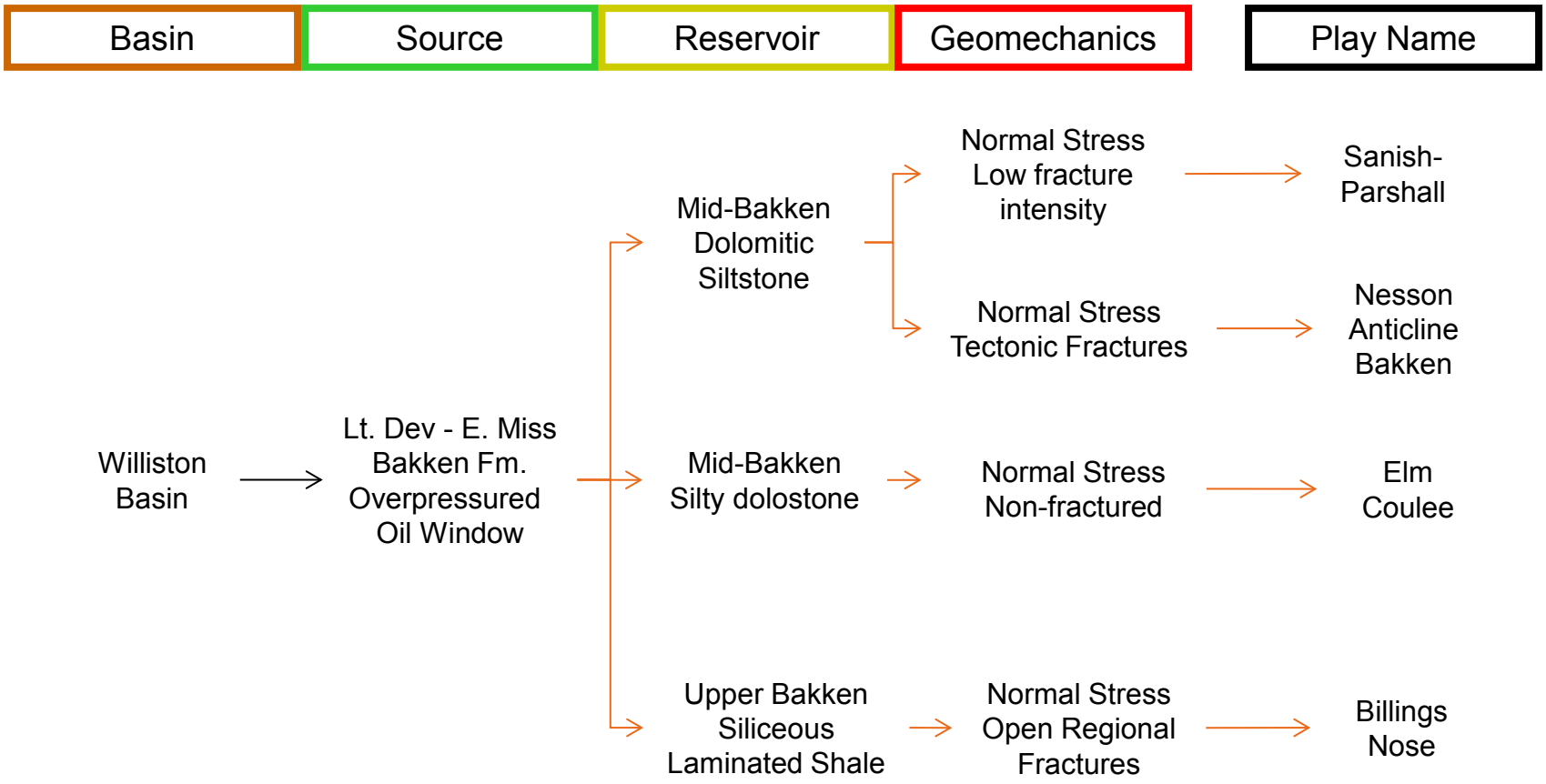
- After drilling 1000s of wells in the basin, it can be shown that the areas of distinct-type curves and EURs
  - Distinctions that would be missed if aggregated into a single play



Hough & McClurg, 2011

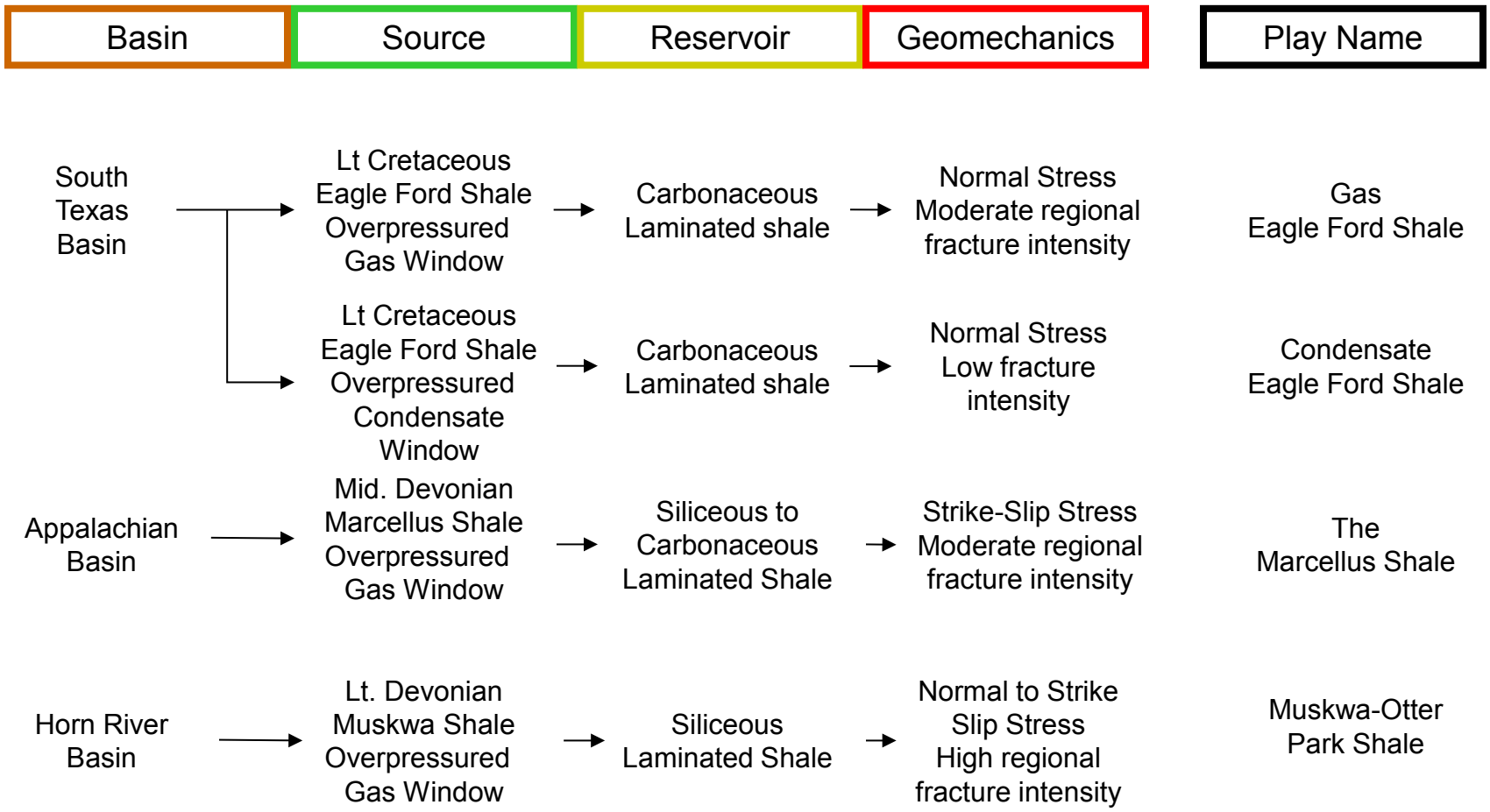
THE BAKKEN PLAY TYPES

- We can identify these areas of potentially unique characteristics before drilling 1000s of wells if we construct the Bakken as a series of unconventional plays



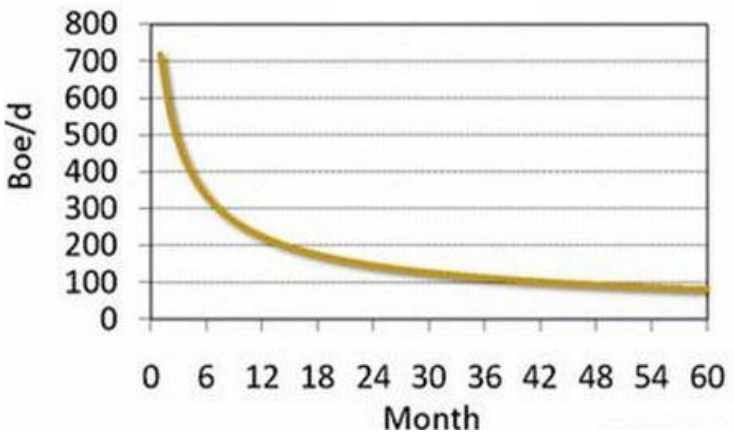
SHALE PLAY TYPES ACROSS BASINS

- Using Play types based on the petroleum system characteristics, plays can be compared across basins



USING THE PLAY CONCEPT: PROSPECTIVITY & ANALOGUES

- Play analogues provide us with means to:
  - When we don't have access to
    - Key geologic characteristics
    - Productive capability
    - Best practices
- We can apply analogues
  - Within Play Fairway
    - Remaining resource developable area-based surface and subsurface access and production characteristics
  - Across basins
    - Analogue correlation for emerging plays



UNSYSTEMATIC UNCONVENTIONAL ANALOGUE COMPARISON

- Comparisons made on several characteristics without regard to play type

	Shale Prospect	Woodford	Barnett	Haynesville	Marcellus	Eagleford	Bakken
Porosity (%)	5.5	1-8%	~1.5 – 6 (Avg. ~3.8)	8 - 15%	✓ 3 – 8%	3- 15%	2 - 12 %
TVD (ft)	4,100 – 4,300	6,000 – 14,000	5,400 – 9,500	10,500 – 14,000	✓ ,500 - 8,500	5,000 - 13,000	8,000 - 11,000
Thickness (ft)	53	100 - 220	100 - 500	60 - 350	✓ 50 - 300	40-500	6-15ft & 80-145 ft
BHT (° F)	160	150-225	150	280-380° F	✗ 100-150	150 - 350	190 - 240
TOC (%)	3.95	3-9%	4-8%	2-5%	✓ 3-10%	0.5-9%	Upper-11%-40% Lower=8%-21%
Press Grad (psi/ft)	0.48	.45-.68	0.52	0.85 - 0.93	✓ 0.4 - 0.7	0.4 – 0.85	0.5 - 0.6
Frac Grad (psi/ft)	0.7	.7-.9	~0.6 – 0.75	>0.90	✗ 0.9 – 1.2	.88-1.1	0.70 – 0.85
Avg Perm (µd)	0.1	0.05-0.4	0.05 – 0.4	<0.005	✗ 0.2 - 2	400-1200	20 - 500
Sw (%)	27	33%	<35 no free water		✗ <25	10-30	25 - 60
Lithology (%)	Silica rich	Silica- Chert 30-60%	Silica rich 35-50 v/v	Shale is soft (ductile) Calcite rich-in areas silica rich (in areas) organic rich High clay mineral fraction	Variable formation properties Illite clay-dominated Quartz/Plagioclase/ Feldspar Carbonates Siderite/Pyrite	~3-5% carbon content High Illite-dominate clays Looks like "poker chips" High in Calcites	Silty, sandy, dolomite grading to laminated shaly interval. Some natural fractures. Below is Sanish
YM (x10^6 psi)	3.48	4-8	6-10	2-3	✗ 2-5	1-4	Upper/Lower= 2 - 4 Middle=4-6
PR (%)	0.206	0.15-0.25	0.13-0.25	0.23 – 0.27	✓ 0.19 – 0.23	0.20-0.27	Upper/Lower=-0.25-0.28 Middle= 0.2 – 0.25
Quartz, wt %	54	25-54	40-60	25-52	✗ 10 - 40	1—30	15 - 70
Plagioclase feldspar, wt %	10	7-13	2-5	8-17	✓ 0 – 10	0-17	1 - 3
Calcite, wt %	3.7	7-20	5-30	13-44	✗ 5 – 20	25-95	15 - 65
Smectite,wt %		2-8	1-5	-	< 2	0-23	2 - 6
Illite, wt %	11.9	17-46	5-25	12-20	✗ 25 - 60	1-50	1 - 13
Kaolinite wt %	8	0	0	-	✗ < 2	0-14	0 - 2
Chlorite, wt %	11.9	1	0	4-7	✗ 0 – 10	0-7	1 - 3
Ro (Maturity of Shale)	1.23	0.75 – 1.45	0.6-1.6	1 – 1.2	✓ 0.8 – 3.0+	0.75 – 2.16	0.45 – 0.60

Analog Analysis

PLAY TYPE ANALOGUE

Basin	Source	Reservoir	Geomechanics	Play Name
Western Canadian Basin	Devonian, Restricted shallow marine, Condensate Window	Siliceous Laminated shale	Normal Low regional fracture intensity	Duvernay Shale Condensate
Appalachian Basin	Devonian Anoxic deep marine Gas Window	Siliceous to Carbonaceous Laminated Shale	Strike-Slip High regional fracture intensity	Marcellus Shale Gas
South Texas Basin	Cretaceous, Restricted shallow marine, Condensate Window	Carbonaceous Laminated shale	Normal Low regional fracture intensity	Eagle Ford Shale Condensate
Horn River Basin	Devonian, Anoxic deep marine Gas Window	Siliceous Laminated Shale	Normal to Strike-Slip High regional fracture intensity	Muskwa Shale Gas

EXPLORING WITH THE PLAY CONCEPT

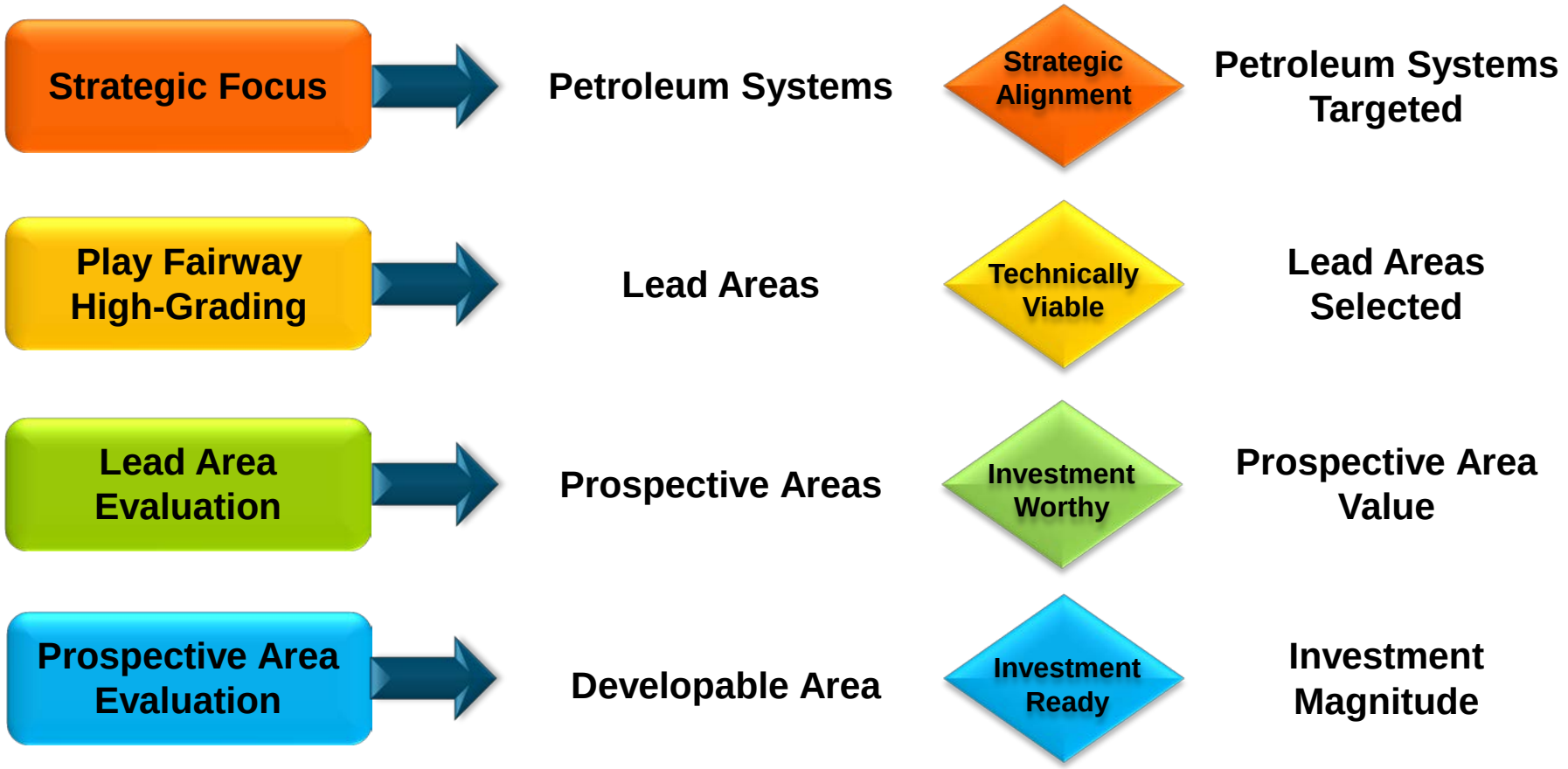
…the "play" has an almost mythical status—the successful play is the thing of which legends are made, and playmakers are regarded as heroes of the industry. – Doust, AAPG 2010

- Unconventional plays made not through simple discoveries
- Making the play requires a progressive methodology that explores the play's:
  - Resource accessibility
  - Productive capability
  - Operational capacity
  - Risked economics
- Exploration progression must be within a business context

Making the play = creating value

WORKFLOW BASED ON KEY DECISIONS

- The exploration process invariably includes key decision points that address investment and resource commitment



WORK FLOW DECISIONS SPECIFIC TO AREA OF INVESTIGATION

- Exploration decision points often are specific to an area of investigation and tied to the level of understanding of a play
  - These areas can be associated with key play characteristics that help define and assess the area

Play Fairway

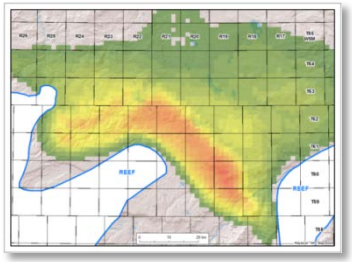
An Area where the Generative source rock is present.

100,000s km^2

Lead Areas

Area where the play could be technically successful.

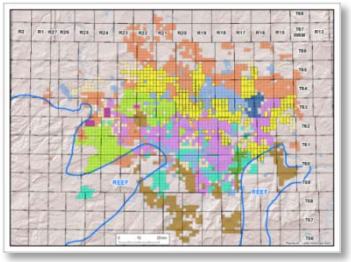
10,000s km^2



Prospective Area

An area that has positive value on a risk basis.

1,000s km^2



Developable Area

An area within a land base that could be developed.

100s km^2

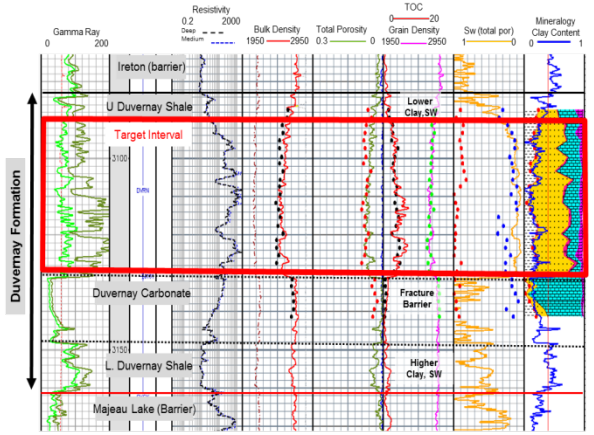
PLAY FAIRWAY MAPPING TO IDENTIFY LEADS

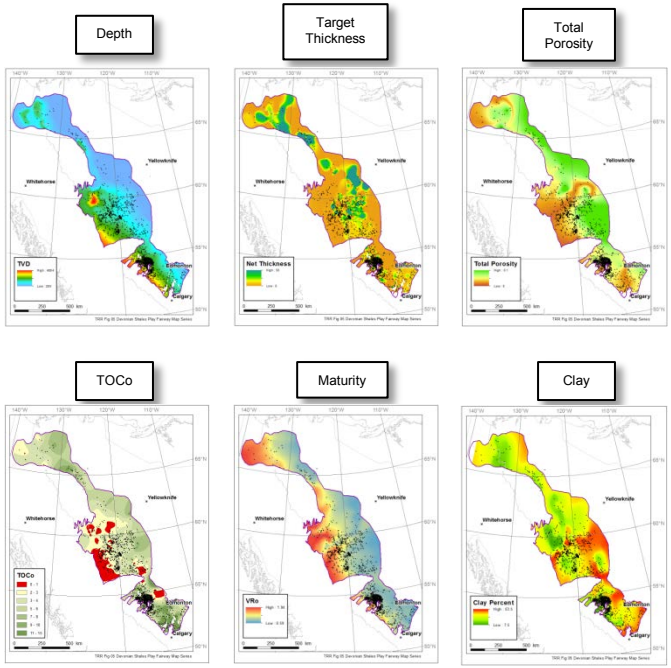
Goal:
Identify and rank Lead areas within a play fairway that have potential to deliver a technically successful unconventional resource

Components:
Play Characterization and Analogue Identification

- Regional Mapping of Key Play Criteria
- High-Grading to delineate Leads
- Lead Area Ranking with value indicators

Results
Selected play Leads for continued analysis



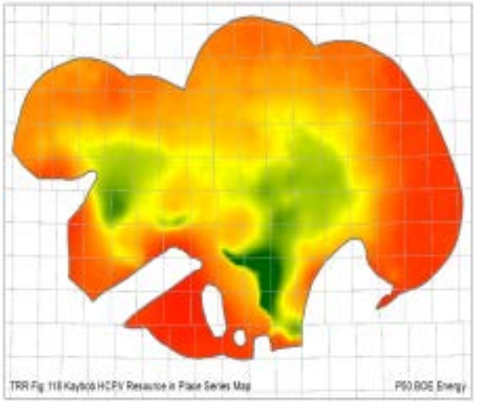


LEAD AREA ASSESSMENT TO IDENTIFY PROSPECTIVE AREAS

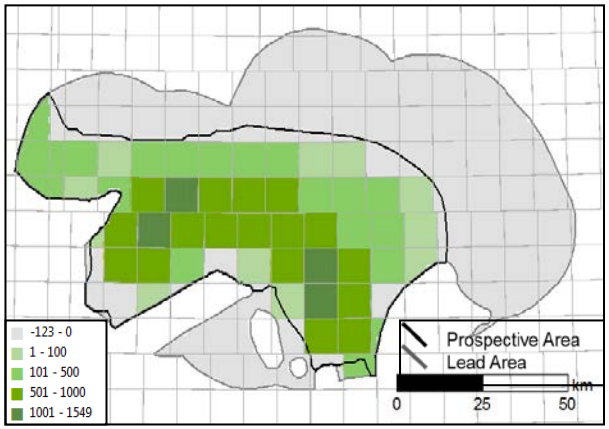
Goal:
Identify prospective area where the play can deliver value and describe a likely economic and productive scenario

Components:
- Probabilistic Resource-in-place
- Well/Pad Design and Cost Scenarios
- Unit Area Type Curves
- Relative Resource Value by Unit Area

Results:
Risked economics within prospective area that indicate positive value outcomes



P50 Resource-in-place



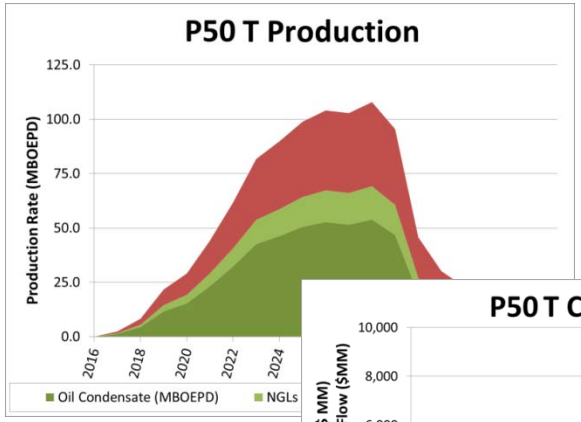
Prospective Area Relative Resource Value

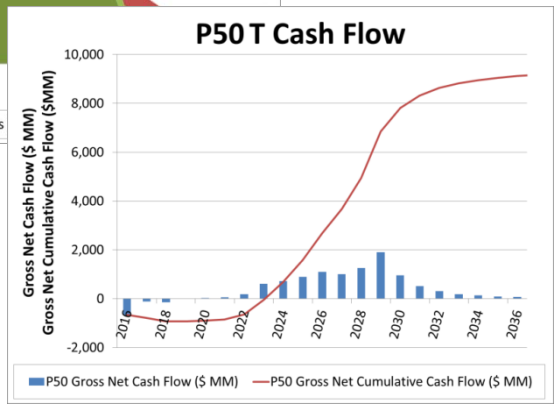
DEVELOPABLE AREA EVALUATION TO DETERMINE INVESTMENT

Goal:
Assess full cycle, risked economics for developable units that comprise a land base

Components:
- Probabilistic Resource
- Cost Breakdowns
- Production Forecast
- Project Cash-flow
- Commercial Risk and Market Outlook
- Resulting NPV

Results:
Production, Cash Flow and Risked Value for Investment recommendation





Investment Metrics	
ROR BT (%)	15
COS (%)	70
NPV ($MM)	1000
Gross Recoverable Resource (MMBOE)	280

PLAY-BASED EXPLORATION FOR UNCONVENTIONAL RESOURCES

- To expand the success of unconventional plays outside of US and Canada we can draw upon play-based exploration methods
  - Geologic understanding of the unconventional play by using a petroleum systems approach
- We can implement play-based exploration for new unconventional resources
  - A workflow that addresses key decision points based on specific areas of investigation
  - Uses key information from the play from fairways to leads to the prospective areas to a developable area