ESTIMATING UNCONVENTIONAL GAS IN PLACE, RESOURCES & RESERVES

ENERGY RESOURCE CONSULTANTS LTD

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1. Introduction to ERC

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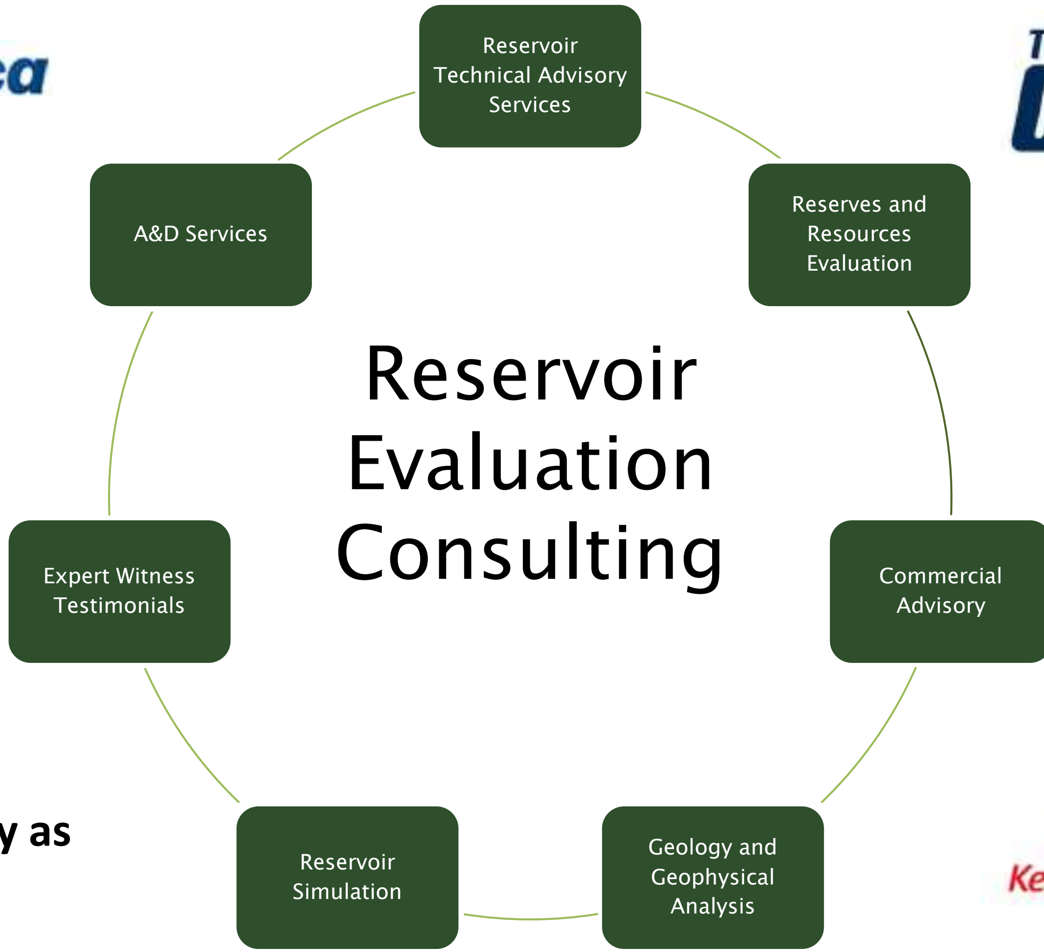
ERC since 2003



Petro Summit

Revus Energy as

ERC – The Principals

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Paul Chernik
Unconventional Experience

WEST ENERGY Ltd

DAYLIGHT RESOURCES TRUST

ENCANA

PennWest ENERGY

MIDNIGHT Oil Exploration Ltd.

DUVERNAY OIL CORP.

Syncrude

- HEAVY OIL
- H_2S
- TIGHT GAS
- TIGHT OIL
- OIL SANDS

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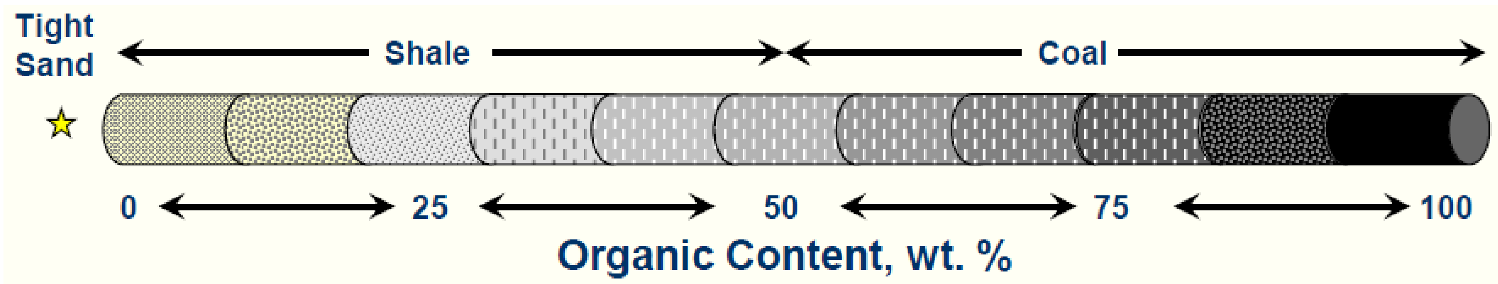
2. Defining Unconventional Gas

Unconventional Tight Gas

- “Tight Gas” is a relative term



Source: Weatherford Laboratories 2009

- In today’s talk, “Tight Gas” will mean when you drill and only perforate there is negligible gas flow at uneconomic rates and volumes due to low permeabilities
- Permeabilities are typically in the microdarcy to nanodarcy ranges

Key Characteristics

- Gas flow from the rock comes from either:
  - Free Gas within gas filled porosity (Sandstones)
  - Adsorbed Gas within Organic Material (Coals)
  - A combination of the two (Shale)
- Unconventional gas reservoirs need advanced fracture stimulation:
  - Types: Vertical Limited Entry, Multi-Stage Horizontal, etc.
  - Size: Large sand volumes (ex. 400 tons in a single stage; up to 20 stages per well)
  - Fracture Propagations: "Cloud" vs "Bi-Wing" fractures
- Different stimulation techniques apply to different reservoir types.

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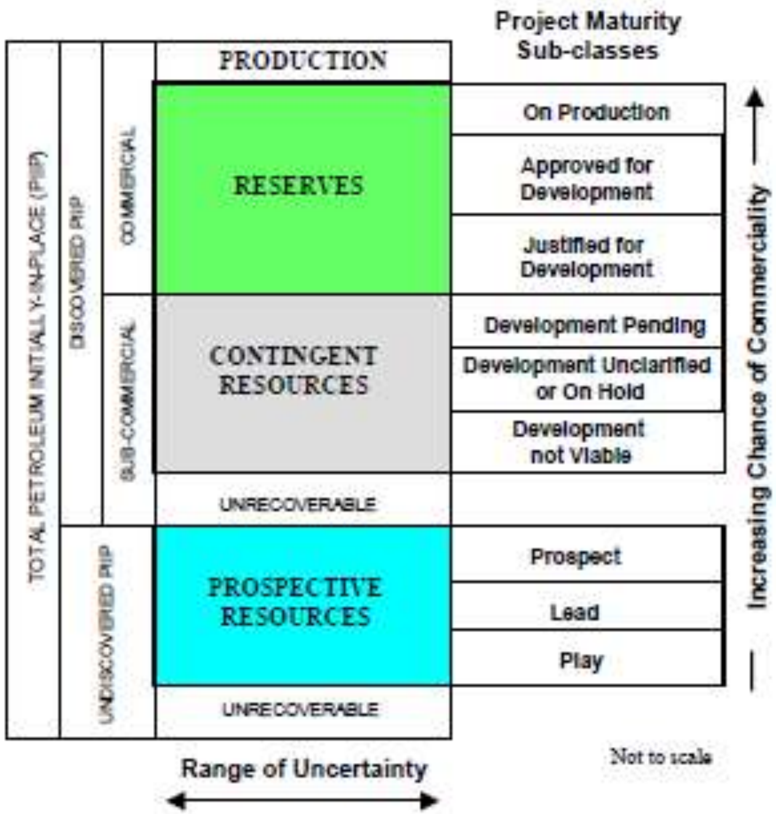
3. Going from “Play” to “Reserve”

PRMS – Project Maturity



Source: PRMS 2007

Moving from a Play to a Reserve

PROSPECTIVE RESOURCE "Play"	No Detailed Reservoir Information
CONTINGENT RESOURCE "Development Unclarified or On Hold"	Vertical Appraisal Wells, Geological Interpretation Complete, OGIP Calculated
CONTINGENT RESOURCE "Development Pending"	Have artifically stimulated wells and demonstrated significant and sustained gas flow
RESERVES "On Production"	Have proven commerciality of individual wells
RESERVES "Non-Producing Locations"	Understand production mechanism and apply to future development locations

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4. Understanding the Unconventional Reservoir

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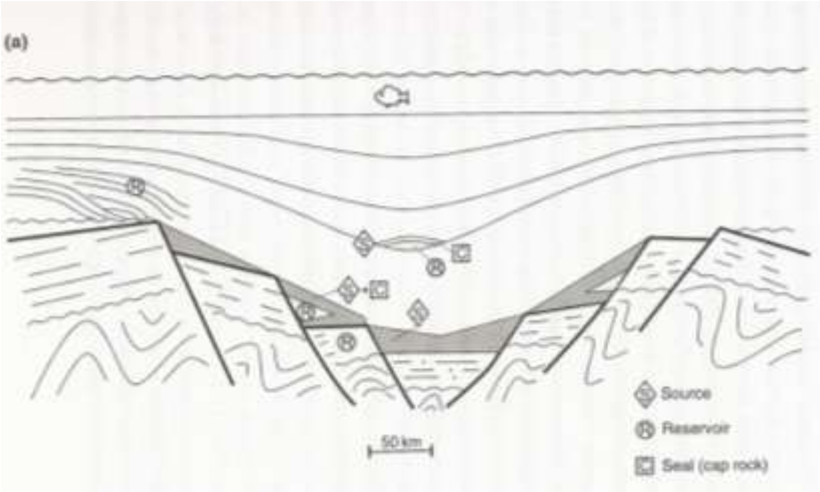
Review of Conventional Prospects

- Conventional Traps:
  - Structurally or Stratigraphically defined within a contained area.
  - Risks include source, seal, reservoir trap and commerciality
  - <u>Can</u> be often be delineated using seismic
  - Other than in extreme environments (Arctic, ultra-deepwater, etc.) there is little to no technology risk

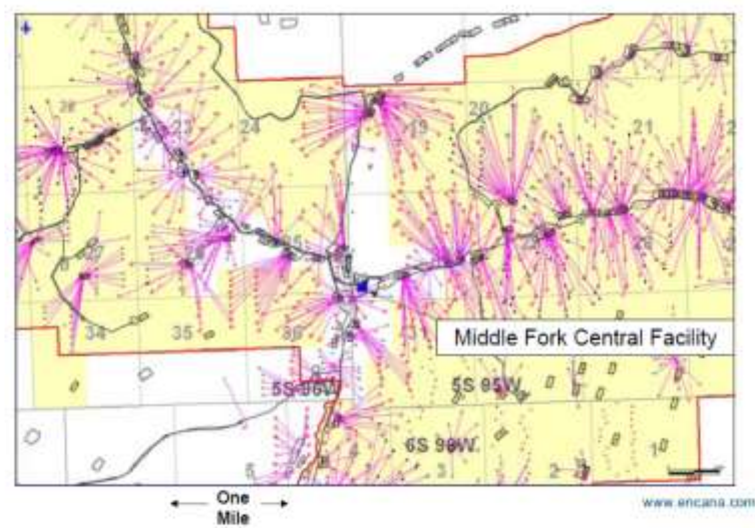


Source: Equipoise Solutions, Adam Law

Unconventional Prospect

- Unconventional Gas Assets
  - <u>Heterogeneous</u> accumulations pervasive over large regions
  - Reservoir changes sometimes happen gradually (over kilometres), and other times very quickly (over metres)
  - Risks are reservoir quality, rock properties, hydrocarbon fluid type, technology and commerciality
  - Reservoir variation often <u>cannot</u> be resolved with seismic
  - Typically, not every part of the reservoir will be economically viable using existing technologies

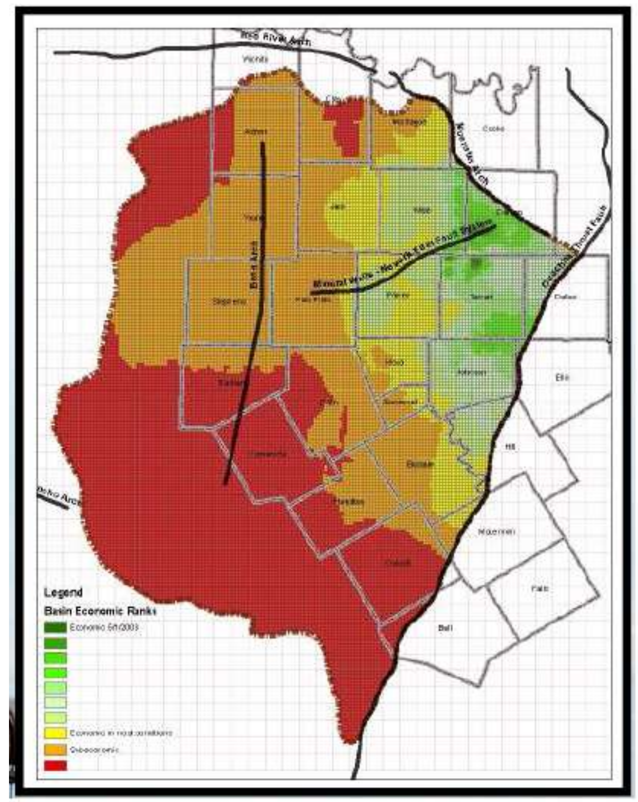
North Parachute Ranch Pad Drilling



Statistical Example – Barnett Shale

- "drillinginfo"

a US based company analysed the public data from the Barnett Shale, and used pay thickness & producing GOR (as a thermal maturity indicator) to rank Barnett acreage

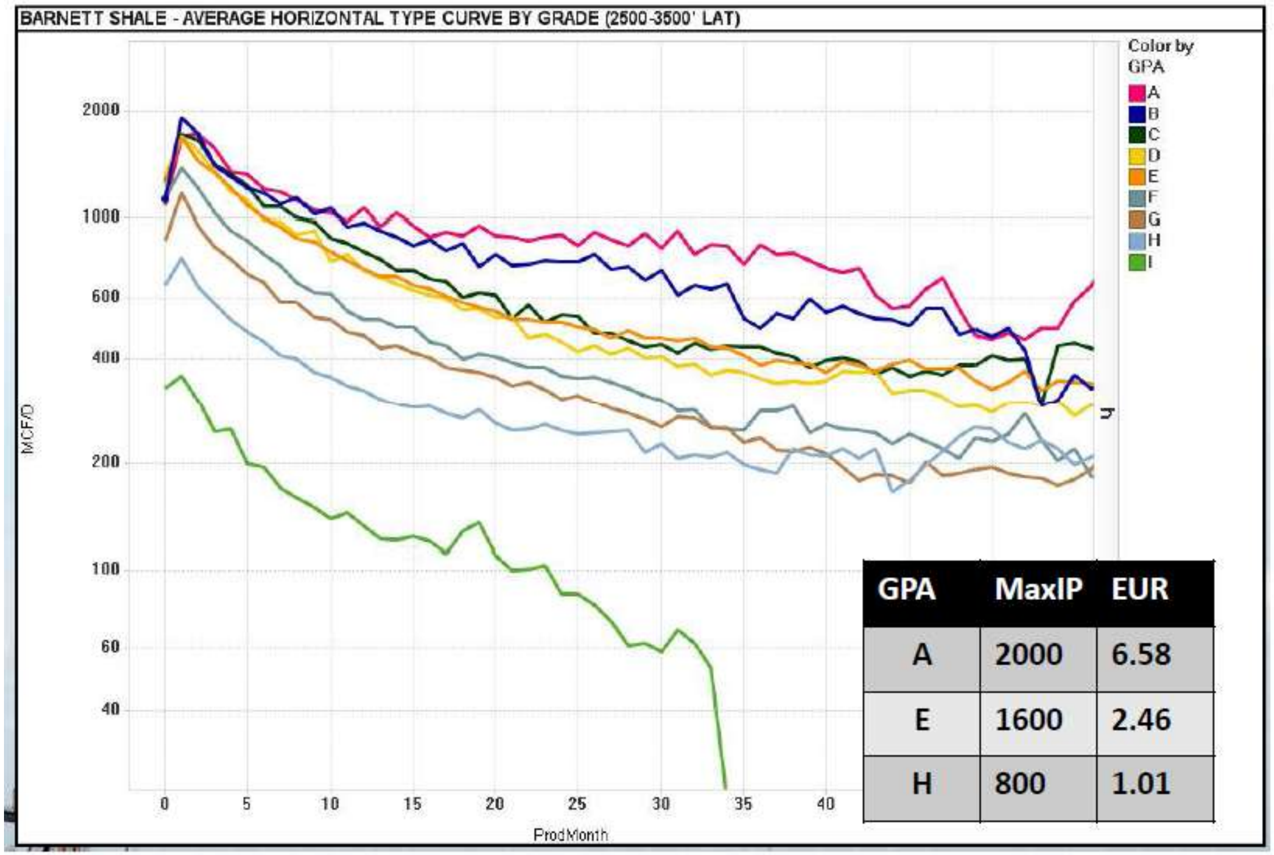


Source: drillinginfo, Ramona K. Hovey

180 miles

- Orange and Red are **sub-economic**

Normalised Barnett Production Curves



GPA	MaxIP	EUR
A	2000	6.58
E	1600	2.46
H	800	1.01

Source: drillinginfo, Romona K. Hovey

Defining the Geology

- While sandstones, shales and coals are very different rocks, the process for defining the geology is similar
  1. Identify the areal extent of the formation/play
  2. Understand the regional geology and depositional environment
  3. Drill vertical appraisal wells to take core, cutting samples and logs. Drill enough wells to have triangulation and to identify reservoir transitions within the acreage. Take Pressures.
  4. Complete core and cuttings studies to identify geology, mineralogy, geochemical, petrophysical and geomechanical properties, and rock-fluid compatibility
  5. Correlate logs to core, and then use all available data to generate geological mapping and to verify the regional geological and sedimentological models

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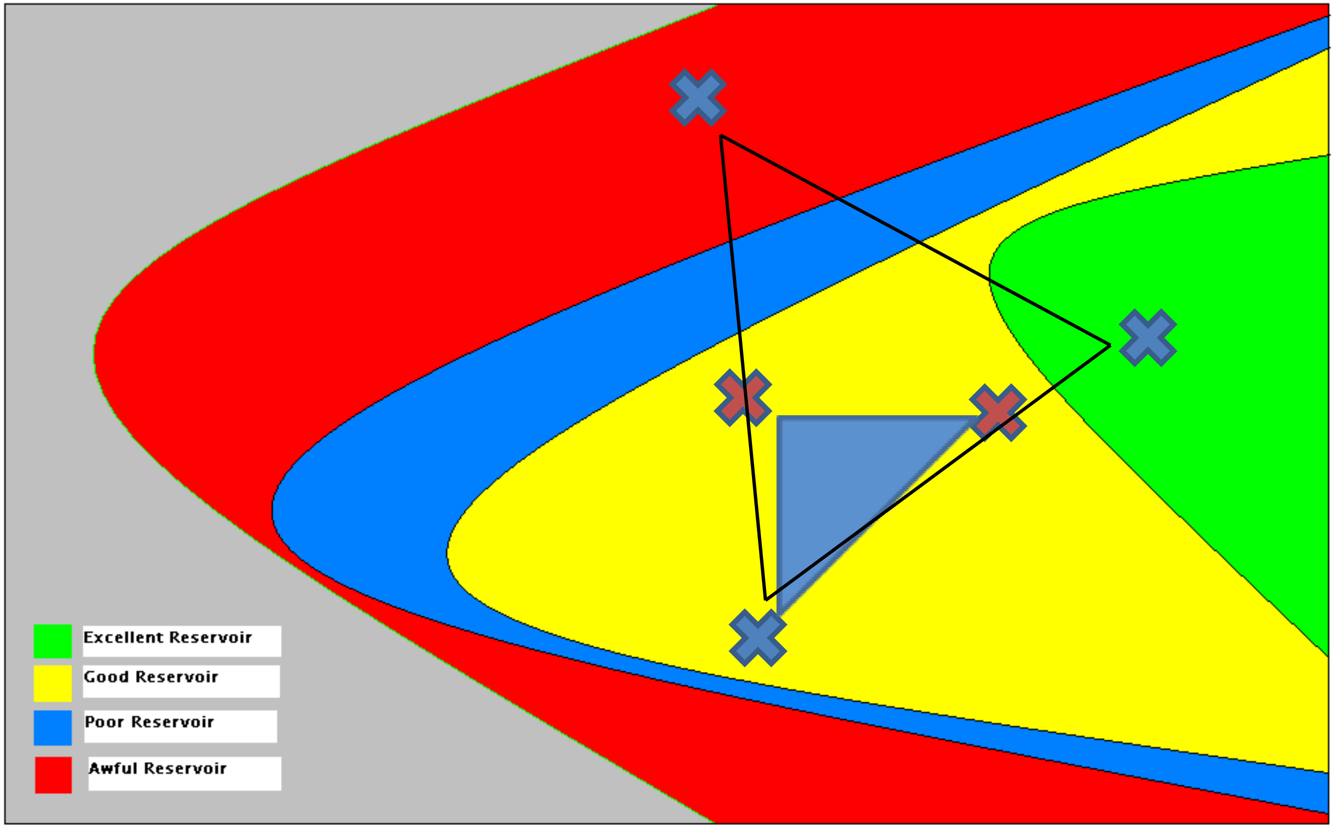
Well Control, Triangulation & Defining the Reservoir



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Geological Model Verification

- The final geological model combines:
  - Seismic
  - Sedimentological Model
  - Core-correlated Well Log information
  - Rock properties
- By identifying and understanding discrepancies in the various analytical tools, the unconventional resource model can be understood and finalised
- After geological analysis, future development can now be risked at a "**Contingent Resource – Development Unclarified**" Level

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Why All The Preliminary Work?

- Unconventional activities in the US, Canada and elsewhere have taught us many lessons, and provide many analogies.
- Some unconventional reservoirs have been economic successes:
  - Portions of the Barnett/Haynesville/Montney Shales
  - Much of the Cutbank Cadomin sandstone
  - Much of the Horseshoe Canyon CBM
- Others have been economic failures:
  - Much of the Floyd/Conasauga/Chattanooga Shales
  - Portions of the Deep Basin Wild River region
  - Portions of the Mannville CBM
- By understanding the geology, we can determine what information from analogies carries over, and gain a better understanding of the unique risks of the reservoir and acreage under investigation.

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Some Key Questions

- What is the Original Gas In Place (OGIP)?
  - In Shales and Coals, OGIP cannot in any way be determined without lab studies.
    - Total OGIP is a function of the free gas and adsorbed gas components.
    - After logs are calibrated to core, then you can begin to map OGIP.
    - Very useful are "OGIP/unit area" maps, where you can see how the OGIP varies across the play. These maps take into account the storage mechanisms and the net thickness.
  - In Sandstones, core studies are not an absolute requirement. But they are highly recommended.

Some Key Questions Continued

- What else do I need to think about when conducting the geological analysis?
  - Thermal Maturity
    - Identifying whether you are in the gas, condensate or oil window is important
  - **Phase II, Applying Technology**. The rock must be fracture stimulated, often using massive frac jobs.
    - Clay, Quartz and Carbonate content are key
    - Presence of mobile water either above or below must always be considered
    - Must be aware of natural fractures and how they will impact your frac job in both positive and negative ways
    - Are there natural frac barriers?
    - Must think about water supply, disposal (ultimately could be 100's of millions of barrels)

5. Conclusions

Conclusions

- Unconventional reservoirs have the potential to be important parts of a company's portfolio of assets.
- The process from play to reserves involves
  - Technical studies and calculations based on well control
  - Proof of a company's ability to identify and apply well technology that creates sustained significant gas production
    - Initial Production rates and long term decline profiles will define success or failure
  - Demonstration that wells being drilled and completed by a company are economic
- It is a lengthy process, with many steps, milestones and contingencies.
- Companies should use the project maturity sub-categories in the PRMS and additional explanations to accurately describe where they are in the process. The market should look for those descriptions.

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