Key Points

- Introduction
- Geology & Rock Mechanics
- Drilling Recommendations
- Drilling Fluid
- Completion / Stimulation Techniques
- Case History
Introduction

- CBM is a form of natural gas that can be extracted from various coal deposits around the world.

- Estimated CBM reserves around the world:
  - Russia 400 – 6,000 tcf
  - China 1,060 – 1,240 tcf
  - USA 700 tcf
  - Canada 263 – 2,700 tcf
  - India 525 tcf
  - **TOTAL 3,000 – 10,000 tcf**

(from SPE 102309)
Introduction

The carrot is there !!!
The challenge is getting it out economically.
Geology & Rock Mechanics

- Coalification: the process of coal formation from direct burial of organic materials in ancient swampy environments.

- Coal is a complex organic rock formed of macerals (vitrinite, inertite and liptinite).

- Extremely heterogeneous rock.
COAL RANK:

- Anthracite
- Bituminous Coal
- Sub-Bituminous Coal
- Brown Coal

High quality coal:
- high gas capacity
- high vitrinite reflectance
- high carbon content

Lower quality coal:
- low gas capacity
- high volatile matter
- high moisture content
Geology & Rock Mechanics

- The “loaf of bread”

- tectonics

- butt cleats

- face cleats
Geology & Rock Mechanics
Geology & Rock Mechanics

- Coal carries a strong surface electro-chemical charge that can change with pH.
- Methane is adsorbed to coal “micro-cleats” through:
  - Chemical adsorption (sharing of electrons)
  - Physical adsorption (Van der Waals forces)
In order to produce the CBM:

- Formation water typically has to be produced
- Formation pressure has to be dropped to allow for methane desorption, followed by methane migration through the fracture network

To produce 50% of the methane in place, the reservoir pressure has to be dropped by as much as 80% (Hycal Laboratories)
Geology & Rock Mechanics

- Vertical well design is supported by economics for shallow coals (< 600 m)

- However, due to its high well density, is not supported by economics for deeper coals (~1,500 m). Hence horizontal well design.
Geology & Rock Mechanics

- Poisson Ratio one order of magnitude higher than conventional rock.
- Drilling Hz perpendicular per lowest $\sigma$ ratio ($\sigma_v/\sigma_{Hz \text{ max}}$)
Geology & Rock Mechanics

- Lack of filter cake.
- Borehole collapse in coal – Bernoulli’s Law on pressure distribution in incompressible fluids.

\[\Delta P = BHP - FP = 0\]
Drilling Recommendations

- Best Well Trajectory & Well Design
- Correct Drilling Practices
- Right Drilling Fluid

Important that all three conditions are met
Drilling Recommendations

- Well Trajectory:
  - Intersect as many face cleats as possible
  - Be $\perp$ to $\sigma_{HZ\text{ max}}$
  - Smooth
  - Low build angles
Drilling Recommendations

- “Motherbore” Design:
  - Potential for multiple legs
  - Increased BHS issues
  - Increased formation damage
  - Lower dewatering efficiency
Drilling Recommendations

- “Classic” Design:
  - Perceived as single leg but potential for multiple legs “fork” design
  - No BHS issues
  - Decreased formation damage
  - Best dewatering efficiency
Drilling Recommendations

- Rigs with a top-drive preferred: controls pipe speeds better and reduces surge/swab pressures; MAX trip speeds < 0.5 m/sec
- “Dry reaming” technique
- Control drill: ROP < 15m/hr
- Drill bits should have
  - no nozzles
  - back reaming capability
  - generate large cuttings
- Slide if possible, rather than rotating
- Spin bits at lower RPM’s if possible
Drilling Recommendations

- Innovative fluid exploits coal surface charges, creates flexible bridges and prevents invasion.
- $\Delta P = BHP - FP > 0$
Drilling Recommendations

- Drilling fluid has two versions:
  - **Intermediate**: polymeric combination “A”, bentonite, matting agent, alkalinity control
  - **Horizontal**: polymeric combination “B”, matting agent, alkalinity control

- Fresh water or Brine based has:
  - **LOW** viscosity, density ⇒ low hydraulics (AV < 42 m/min DP and < 90 m/min BHA; NV < 30 m/s)
  - **NO** bridging or weighting particles
Completion & Stimulation

- Breaker Fluid Technology - completion
- Sonic Technology - stimulation
- $\text{N}_2$ Formation Pre-charge - stimulation
- Conventional Fracturing - stimulation
Completion

- **Breaker Fluid Technology:**
  - Intended for open-hole / slotted liner completions
  - Breaker displaces drilling fluid at TD using coil tubing, running from toe to heel (or others)
  - Hole blown dry above pay zone to limit hydrostatic
  - Soak time minimum of 48 hours
  - Hole blown dry with N₂ on coil
  - Production
Stimulation

- **Sonic Technology** - uses a tool called an **acoustic horn** to emit sonic waves that “shake” any fines plugging the fractures.

- **N₂ Pre-charge Technique** – consists of fast injection of N₂ into the coal, immediately followed by pressure released at high rates to obtain cavitations around the liner.

- **Conventional Fracturing** – with N₂ (successful for shallow coals) or fluid carrier & proppant (not successful due to formation damage)
Case History- 3 wells “Classic”

<table>
<thead>
<tr>
<th>Depth(m)</th>
<th>Hole Size(mm)</th>
<th>Casing Size(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>265</td>
<td>349</td>
</tr>
<tr>
<td>Inter KOP</td>
<td>1125</td>
<td>222</td>
</tr>
<tr>
<td>Inter Csg</td>
<td>1425 TVD/1585 mMD</td>
<td>222</td>
</tr>
<tr>
<td>HZ Liner</td>
<td>1985 to 2385 mMD</td>
<td>156</td>
</tr>
</tbody>
</table>

Well #1 used conventional polymer in horizontal section. Well #2 and #3 used innovative CBM fluid.
### Case History- 3 wells “Classic”

<table>
<thead>
<tr>
<th>Well</th>
<th>HZ. Length</th>
<th>Mud Type</th>
<th>Time to Complete</th>
<th>Trouble Time</th>
<th>Problems</th>
</tr>
</thead>
</table>
| #1   | 403 m      | polymer  | 9.3 days         | 147 hr       | - stop drilling early  
|      |            |          |                  |              | - stuck drill pipe  
|      |            |          |                  |              | - stuck liner       |
| #2   | 708 m      | CBM fluid| 5.8 days         | 10 hr        | - lost 20m³ mud                  |
| #3   | 792 m      | CBM fluid| 3.5 days         | 0 hr         | - none                           |
Questions and Answers
SPE 101231

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