
Energy & Mineral Resources

Environmental Science & Energy

Oil & Gas Division

Branch Offices: Richmond, VA / Kingsport, TN / Charleston, WV / Morgantown, WV / Lexington, KY / Raleigh, NC / Harrisburg, PA / Kansas City, KS
Coalbed Methane Completion and Production Optimization

Presented to:
Midcontinent Coalbed Methane Symposium
Tulsa, Oklahoma

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November 8, 2004
US Coalbed CBM Resources

- **Established Basins**
  - Powder River: 103 TCF
  - San Juan: Fruitland 50 TCF, Menefee 18-34 TCF
  - Piceance: 84 TCF
  - Uinta: 10 TCF
  - Greater Green River: 30 TCF
  - Powder River (includes Sand Wash): 30 TCF
  - Big Horn: 15 TCF
  - Powder River: 103 TCF
  - Fruitland: 50 TCF
  - Menefee: 18-34 TCF
  - Raton Mesa: 8-18 TCF
  - Arkoma: 4+ TCF
  - Warrior: 20 TCF
  - Raton Mesa: 8-18 TCF
  - Arkoma: 4+ TCF
  - Warrior: 20 TCF

- **Emerging Basins**
  - Powder River: 103 TCF
  - Fruitland: 50 TCF
  - Menefee: 18-34 TCF
  - Piceance: 84 TCF
  - Uinta: 10 TCF
  - Greater Green River: 30 TCF
  - Powder River (includes Sand Wash): 30 TCF
  - Big Horn: 15 TCF
  - Powder River: 103 TCF
  - Fruitland: 50 TCF
  - Menefee: 18-34 TCF
  - Raton Mesa: 8-18 TCF
  - Arkoma: 4+ TCF
  - Warrior: 20 TCF

- **Frontier Basins**
  - Powder River: 103 TCF
  - Fruitland: 50 TCF
  - Menefee: 18-34 TCF
  - Piceance: 84 TCF
  - Uinta: 10 TCF
  - Greater Green River: 30 TCF
  - Powder River (includes Sand Wash): 30 TCF
  - Big Horn: 15 TCF
  - Powder River: 103 TCF
  - Fruitland: 50 TCF
  - Menefee: 18-34 TCF
  - Raton Mesa: 8-18 TCF
  - Arkoma: 4+ TCF
  - Warrior: 20 TCF
CBM Overview
Factors that Govern Project Success

- Gas in-place
  - Coal thickness
  - Gas content
- Permeability
- Pipeline access
- Gas price
- Cost control
Coal Thickness – Geophysical Logs

- Bulk density < 2 gm/cc
- High resolution presentation:
  100 feet: 25 inches vs 5 inches
- Clean gamma ray < 75 API units
- Note adjacent formations
Gas Content - Cores

- Continuous coring rig
- Desorption testing
- Offset core data
- Cores have other value
Gas In-Place

- Some operators only complete coal seams greater than one-foot thick
- Little evidence of significant gas from thinner coals
- Perforating and fracture initiation problems in thin seams
- High-resolution open-hole and cased-hole logs
**Permeability**

- Without permeability, gas-in-place is not a producible reserve
- Structure governs permeability
- Structural deformation, especially anticlines, enhance permeability apparently by opening cleats
- Mapped peak production usually overlays mapped structural features very closely
Permeability Testing

- Pressure transient analysis provides permeability, skin factor, extrapolated reservoir pressure
- Recommend pre-stimulation injection-falloff testing
- Reliable low-cost data with surface build-up testing, providing composite permeability and most-stimulated seam skin
Well Types

- High structure wells behave like conventional gas wells with hyperbolic gas production decline
- Low structure wells have a classic CBM incline-decline profile and produce more water
Production Graph
High Structure Well

Graph showing the production of gas (MCFD) and water (BWPD) over months online.
Completions
Completion Criteria

- Select clean (GRU < 75) coal seams with acceptable thickness
- Complete in separate frac stages whenever possible
- Run cement bond/correlation log on same scale as the open-hole density log
- Recommend four perforations per foot of coal, shooting top and bottom, with 90° or 120° phasing, except in multiple-seam stages
- May want to overshoot thin seams
Frac Treatments

- Optimal treatments place 1,000 to 5,000 pounds of proppant per foot of coal
- Low treatment rates generally better, limiting fines generation and fracture height growth in deeper coals
- Low gel loading is better
- More rate sometimes required to place sand with less gel or in multi-seam frac stages
- Know your treatment fluids
Treatment Fluids

- Know the reason for and effects of all fluids, chemicals, and additives
- Some surfactants and gels can be damaging with up to 85% matrix permeability loss
- Treatment fluids can be reliably evaluated in core plugs
- Case studies – damaging gels and surfactants
Fracing Out of Zone

- Communication with adjacent wet permeable formations can:
  - Require pumping large water volumes
  - Allow coal seam invasion and scaling
  - Introduce corrosive water

- Examples:
  - Bluejacket Coal / Bartlesville Sandstone
  - Rowe Coal / Tucker Sandstone
  - Riverton Coal / Mississippi Limestone
Radioactive Tracer Surveys

- Evaluate whether horizontal or vertical fractures
- Evaluate frac height growth
- May alter completion-zone selection, frac staging, and treatment design depending on results
Production
On-line Procedure

- Shut the well in after frac.
- Install tubing, rods and pump and start pumping ASAP after frac plugs removed.
- Initially pump well with casing shut-in, monitoring the wellbore liquid level.
- Gradually open casing after pressure stabilizes.
Procedure Benefits

- Mitigate sand production
- Minimize coal fines plugging
- Prevent gas pockets forming that can reduce near wellbore relative permeability to water thereby slowing dewatering
- Reduce cross-flow that can cause scale and emulsion problems and potentially deep invasion of lower coal seams
Producing the Wells

- Stress-dependent permeability can sometimes cause cleat closure, reducing effective permeability and producing rate
- Slowly lower casing pressure
- If producing rate drops or wellbore liquid level rises, do not reduce the casing pressure further and perhaps increase it
- Casing pressure eventually should be very low to desorb and produce maximum gas, but be careful early in the well life
Production Testing

- Consider individual seam production testing
- Costly, but probably will save money in the long run
- Can help determine which seams are economic to complete
- Obtain and have analyzed individual seam water whenever possible
- Obtain good water production data
Production Monitoring

- Closely monitor gas and water production and casing and tubing pressures, especially on new wells
- Record the data
- Graphically evaluate the data
- A good data management system helps
Graphic Data Evaluations

- Composite project-level production
- Composite geological or geographical area production
- Time-zero average well production for project and areas, indicating well count
- Composite production for wells completed in various coal seams
- Time-zero average well production for well groups completed in various coal seams
- Time-zero gas/water ratio for project and areas
- Peak well production versus completed gas-in-place
Coal Seam Restimulation

- Refracing individual coal seams originally fraced together in a common treatment stage have provided good production responses
- Refracing seams apparently damaged by completion fluids have shown good responses when treatments are sufficiently large
Summary

- Gather good data, especially early time
- Analyze the data and learn from it
- Talk to other operators to quickly move up the learning curve
- Learn the idiosyncrasies of your own development since they are all different