

Flow Assurance Principles Applied to Unconventional Gas Well Deliquification

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Flow Assurance For Unconventional Gas Wells

• Gas-Water

- Hydrate Formation
- Salt Scale Precipitation

• Oil

- Paraffin Deposition
- Asphaltenes
- High Viscosity
- Emulsions

Note: Potential problems vary with play & producing conditions. Consider this for other evaluation scenarios.

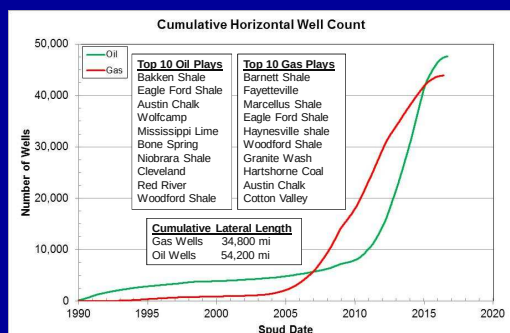
• Multiphase Flow Issues

- Slugging
- Corrosion

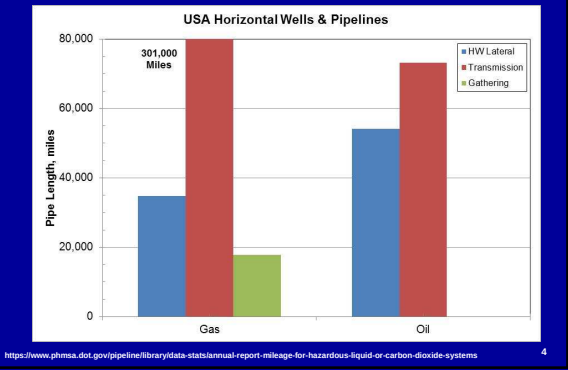
- Erosion

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Horizontal Well Count



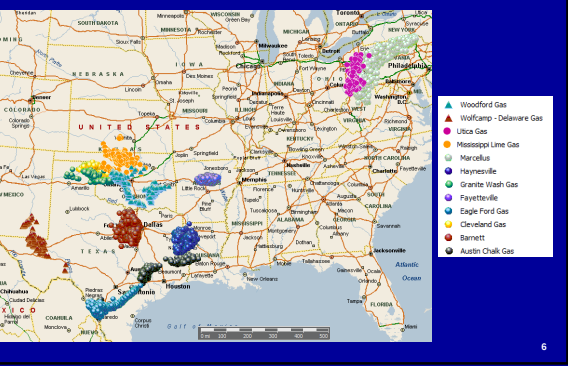
Horizontal Wells & Pipelines



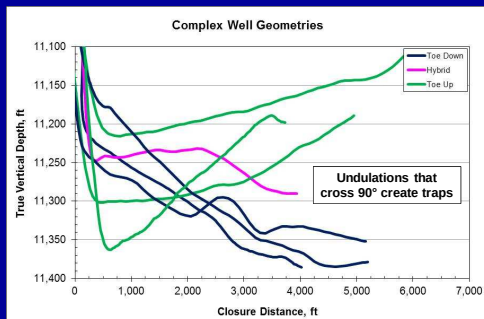
Talk Overview

- Unconventional Horizontal Gas Wells
 - Barnett
 - Fayetteville
 - Haynesville
 - Marcellus
 - Woodford
- Deliquification Solution
 - Drill Toe Up Wells
 - Potential Consequences

Gas Play Location



Complex Well Geometries

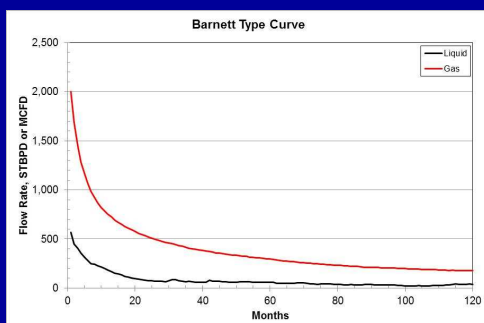


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More Complex Well Geometries

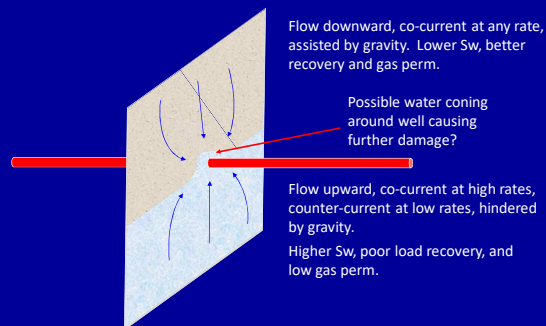
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Flow Type Curve



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Cleanup and Load Recovery in Vertical Fractures is Affected by Gravity, Viscous, and Capillary Forces



Barree - SPE 168612

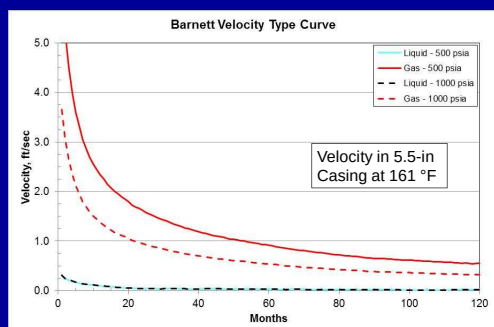
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Casing & Tubing Size

Play	Casing	Liner	Tubing
Austin Chalk	7-5/8, 7 & 5-1/2	4-1/2 & 3-1/2	2-7/8 & 2-3/8
Barnett	5-1/2		2-7/8 & 2-3/8
Cleveland	7	4-1/2	2-3/8 & 2-7/8
Eagle Ford	5-1/2 & 9-5/8		2-3/8 & 2-7/8
Fayetteville	5-1/2		2-3/8
Granite Wash	7 & 5-1/2	4-1/2	2-7/8 & 2-3/8
Haynesville	7-5/8 & 5-1/2	4-1/2	2-7/8 & 2-3/8
Marcellus	9-5/8 & 5-1/2		2-3/8
Mississippi Lime	7	4-1/2	2-7/8
Utica	5-1/2		2-7/8 & 2-3/8
Wolfcamp - Delaware	7 & 5-1/2	4-1/2	2-7/8 & 2-3/8
Woodford	9-5/8, 7 & 5-1/2	4-1/2	2-3/8 & 2-7/8

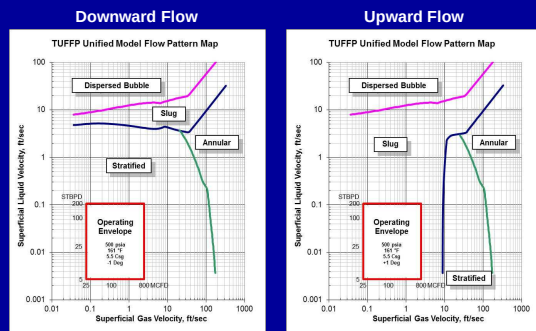
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Velocity Type Curve



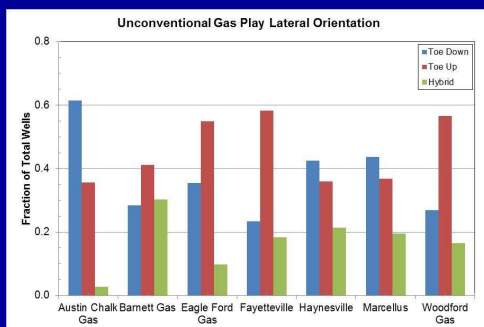
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Typical Flow Patterns in Lateral ($\pm 1^\circ$)



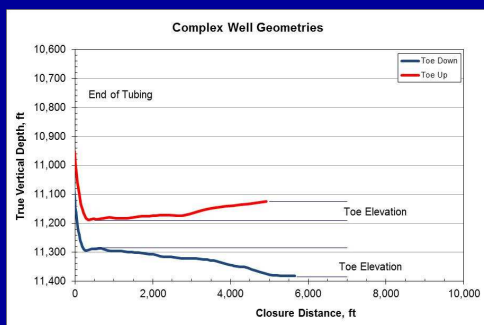
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Lateral Orientation



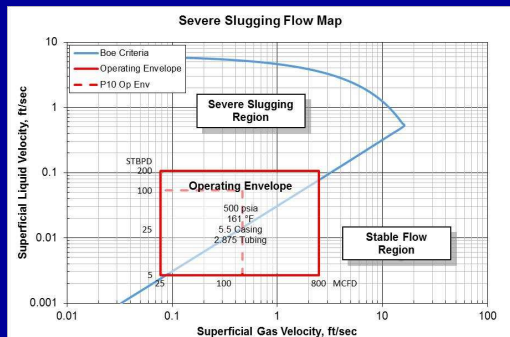
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Toe Elevation & Tubing Placement



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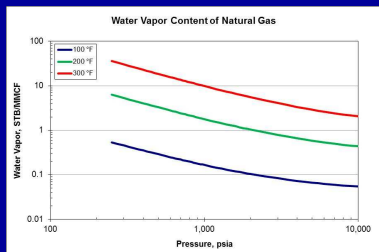
Severe Slugging



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Traps

- Contribute to liquid slugging
- Accumulation site
 - Liquids
 - Debris
 - Sand
 - Scale
 - Salt
- Corrosion

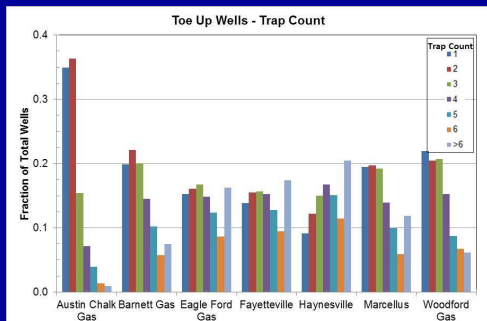


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Gas Flow Thru Traps

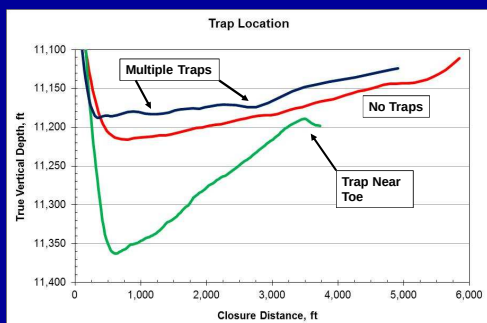
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Trap Count



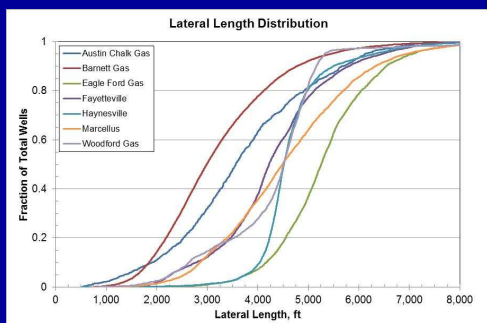
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Trap Location



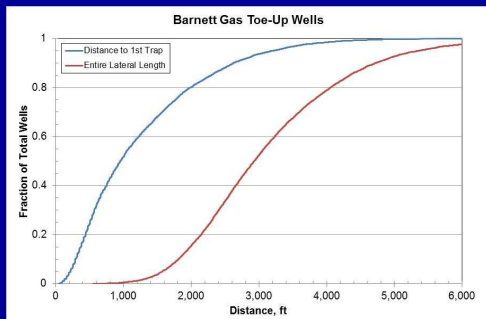
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Lateral Length



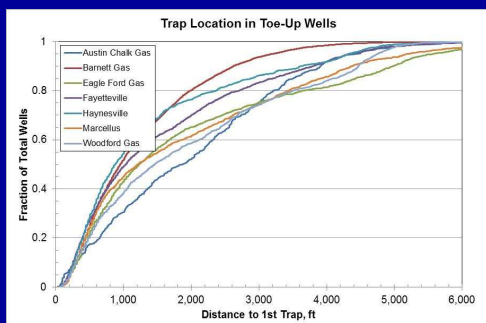
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Trap Location



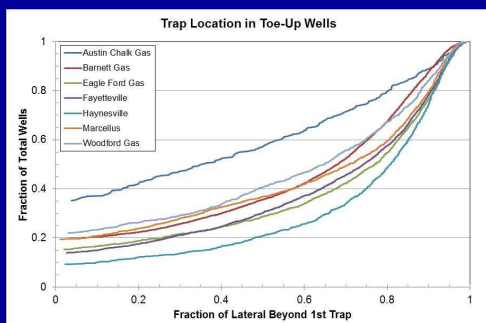
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Trap Location



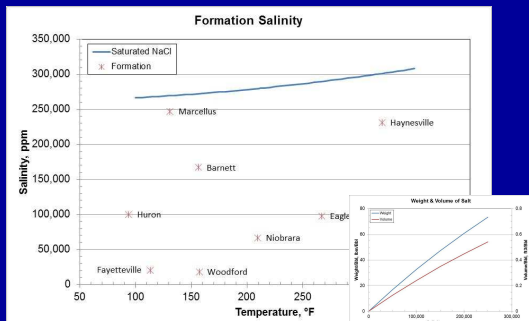
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Fraction of Lateral Beyond 1st Trap



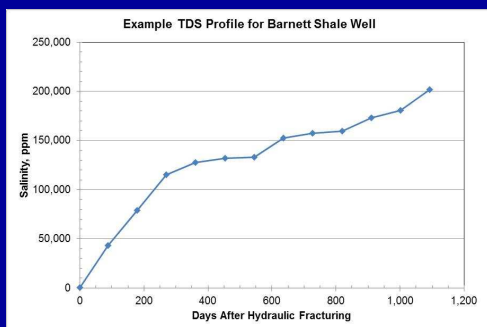
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Formation Water Salinity



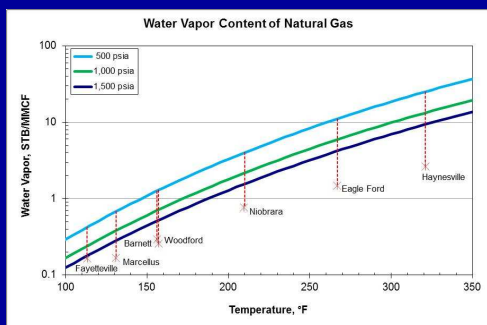
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Salinity Profile with Time



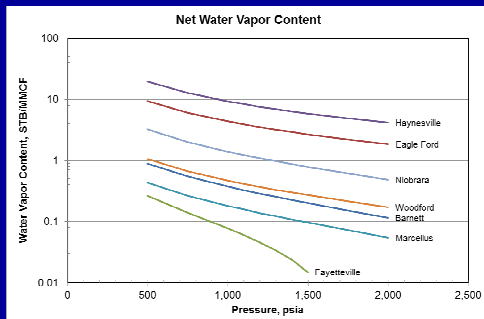
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Low Pressure Water Vapor Content



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Net Water Vapor Content



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Conclusions

- Reviewed major unconventional gas plays
 - Play Depth (Pressure and Temperature)
 - Produced Water Salinity
 - Well Configurations
- Horizontal Well Deliquification Solutions
 - Toe Up Lateral Orientation
 - Multiphase Flow Patterns
 - Downward flow regime: Stratified
 - Uphill flow regime: Slug
 - Severe Slugging
 - Traps
 - Accumulation site for water and debris
 - Potentially can isolate a significant portion of lateral

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Conclusions

- Natural Gas
 - Undersaturated at low BHP
 - Water vapor content depends on pressure & temperature
- Water Evaporation
 - Concentrates salts leading to salt/scale precipitation
- Flow Assurance Principles
 - Ensure proper long term producibility of lateral
 - Examine other aspects of well
 - Ensure deliquification, slugging & corrosion mitigation goals are attained
 - Reservoir inflow impairment

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Conclusions

- Plays with higher water salinity and higher temperature are more problematic
 - Greater potential for salt/scale deposits
 - Higher water vaporization potential
 - Reduced time frame for apparent problems
- Solution to problem
 - Avoid traps in toe-up wells
 - Avoid low bottomhole pressure operations
 - Utilize equipment to keep water moving in the lateral

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