New Technologies in the Development of Unconventional Resources in the U.S.*

Susan Nash¹

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¹Director of Innovation and Emerging Science and Technology, AAPG, Tulsa OK (snash@aapg.org)

Abstract

This presentation reviews the new technologies used in shale plays and other unconventionals, and it places them within a context of workflows and processes. Unconventional plays have become successful due to the implementation of new technologies, which include new methods for exploring for preferentially enriched (and exploitable) hydrocarbon stratigraphic units, horizontal drilling, hydraulic fracturing, innovative proppants, specially formulated drilling and fracturing fluids, and analytics.

With capital expenditures slated to rise 20% in 2018 among U.S. shale producers, the need is greater than ever for excellent decision-making tools, knowledge, and information. Here are new developments in 2018 among U.S. shale operators (Cunningham, 2018):

- Capital Expenditures for shale operators are slated to increase 20% in 2018.
- Many companies are funding their increased CapEx spending through sales of their non-core assets.
- Buying the divested acreage represents an opportunity for companies to build new companies.
- Large companies are at a great advantage in shale plays due to economies of scale and knowledge.
- Smaller operators need $70 / bbl oil to be profitable, while larger companies can be profitable at $40 - $50.
- Many companies are on a path to becoming "pure play" operators in the Permian basin.

What are the implications?

- Alternative ways to pay for operations: Debt and equity financing are expensive, and you may lose control of your destiny.
- Opportunities emerge in times of acreage optimization: Financing the 20% increase in capital expenditure by selling non-core assets can be effective. It also creates an opportunity for other companies to launch new initiatives.
- Optimizing Operations: Efficiency, cost-cutting, and economies of scale are key factors.
- Geology More Critical Than Ever: One must understand the reservoir very well in order to drill and complete efficiently. Geology is critical, and it needs to be integrated with other information.
• **Optimizing Experience via the “Pure Play”:** Pure Plays are efficient and they allow operators to take advantage of their specialized knowledge and experience. However, they are not diversified, and there are vulnerabilities that have to do with being concentrated in a single play.

• **Avoiding the technology “stand-alone” mindset:** Knowing where and when to deploy new technologies can make all the difference in recovering more hydrocarbons, and also minimizing costs. Clear workflows need to be developed with the understanding that new technologies are not "stand-alones" and must be incorporated carefully.

**Selected References**


**Websites**


NEW TECHNOLOGIES IN DEVELOPMENT OF UNCONVENTIONAL RESOURCES IN THE U.S.

SUSAN NASH, PH.D. / DIRECTOR OF INNOVATION, EMERGING SCIENCE AND TECHNOLOGY / AAPG
TYPES OF UNCONVENTIONAL PLAYS

- Low permeability oil
- Tight gas sands
- Gas shale
- Oil sands and heavy oil
- Coalbed methane
- Oil shale
- Gas hydrates
SUCCESSFUL UNCONVENTIONAL PLAYS

- Woodford
- Eagle Ford
- Meramec
- Marcellus
- Bakken
- Haynesville
- Wolfcamp
WORKFLOWS & NEW TECHNOLOGIES

- For optimal results, incorporate new technologies in the workflows
- New technologies are never “stand-alones”

Example: Using drones and robotics for site development and inspections
METHODS: EXPLORATION PHASE

- Petroleum Systems and Regional Geology
- Sequence Stratigraphy
- Core Analysis and Petrophysics
- Geochemistry
- (TOC)
- Seismic Survey
- Kerogen Typing
METHODS: EVALUATION PHASE

- Core analysis (pore architecture / fracture typing)
- Wireline logging / petrophysics
- Seismic attributes (ex. Paradise)
- Seismic inversion
METHODS: DRILLING & COMPLETION PHASE

- Horizontal and vertical wells
- Geosteering
- Well placement
- Hydraulic fracturing

Halliburton's SmartWell® system intelligent completion technology helps operators to optimize production without costly well intervention. Reliable and fit-for-purpose SmartWell systems enable operators to collect, transmit and analyze downhole data; remotely control selected reservoir zones; and maximize reservoir efficiency. [Link](http://www.halliburton.com/en-US/ps/well-dynamics/well-completions/intelligent-completions/default.page?node-id=hfqe19vs&nav=en-US_completions_public)
METHODS: PRODUCTION

- Production logging
- Productive data analysis and optimization
- Analytics
ISSUES & KEY PARAMETERS: EXPLORATION PHASE

- Total Organic Content (TOC)
- Thermal Maturity / Vitrinite Reflectance
- Adsorption
- Expulsion vs retention
- Reservoir continuity / heterogeneity
- Preferential enrichment (sweet spots)
- Seismic Attributes
ISSUES & KEY PARAMETERS: EVALUATION PHASE

- Geomechanics (Young’s Modulus / Poisson’s Ratio)
- Mineralogy and lithofacies
- Pore architecture / porosity typing
- Fracture characterization
- Stress anisotropy
ISSUES & KEY PARAMETERS: DRILLING & COMPLETION PHASE

- Wellbore stability
- Well spacing
- Lateral length
- Proppant type and quantity
- Number of frac stages
- Perf clusters
- Fracture conductivity
- Water issues & environment
ISSUES & KEY PARAMETERS: PRODUCTION

- Simulation
- Optimization
- **Refracturing**
- Artificial lift
- Water management
- Flowback management
- History matching
CONSIDERATIONS: WELL SPACING

- Impacts production
- Spacing developed in conjunction with reservoir quality and fracture design
CONSIDERATIONS: LATERAL LENGTH

- Impacts the contact area between the wellbore and the formation
- A key determinant of production
- Designed in conjunction with number of stages
CONSIDERATIONS: FRACTURE SPACING

- Should be optimized with several variables
- Consider reservoir quality
- Completion quality
- Proppant effectiveness
- Likely frac height and propagation
CONSIDERATIONS: FRACTURING FLUIDS

- Fluids are used to create fractures in the formation
- They carry proppant into the fractures to prop them up
- Slickwater most common
- Others: cross-linked gel, gas-assisted, hybrid fluids
CONSIDERATIONS: CHEMICAL ADDITIVES

- Friction reducer
- Oxygen scavenger
- Scale inhibitor
- Surfactants
CONSIDERATIONS: INDUCED VS NATURAL FRACTURES

- Open and closed fractures
- Fracture geometry
- Fracture complexity
- Fracture modeling to avoid frac interference (FracGeo)

FIGURE 1. A) An equivalent fracture model was derived from seismic curvature and used as input in the geomechanical workflow. B) A strain map was derived after putting pressure in 40 frac stages. Red values represent high strain values indicating successful stimulation, while pink values represent the estimated geomechanical asymmetric half-lengths based on strain. (Source: FracGeo)
CONSIDERATIONS: PERFORATIONS

- Placement determination
- Perforation clusters
- Distance between perf clusters
- Shot density
- Charge type
CONSIDERATIONS: PROPPANTS

- Type and amount of proppant
- Sand proppant
- Coated proppants / ceramic proppants
- Correct size for propping open fractures
- Use as a mechanism for delivering surfactant and optimizing production
PRODUCTION DRIVERS FOR WELL PERFORMANCE I

- Petroleum system and charge access:
  - Geochemistry (kerogen type, maturity)
  - Pore pressure
- Formation continuity (degree of heterogeneity)
  - Thickness
  - Fracture networks
PRODUCTION DRIVERS FOR WELL PERFORMANCE 2

- Matrix and fracture permeability
- Mechanical properties and stress field
- Pore pressure and wellbore stability
- Wettability
- Geosteering (staying in zone)
- Frac interference
MARCELLUS SUCCESS FACTORS

- Largest volume of technically recoverable natural gas in the United States
- New technology solution? Better reservoir modeling that incorporates all the data (production, well logs, petrophysics, geomechanics)
的重要来源岩层

- 了解该地区相对的“裂解性”
- 新的技术解决方案？新的方法来识别厚度、TOC 和脆性
EAGLE FORD SUCCESS FACTORS

- Different regimes with highly variable composition of hydrocarbons (gas, liquids-rich, oil)
- New technology solution? Multiple designs for different temperatures, better fluids and proppants for high temperatures
HAYNESVILLE SUCCESS FACTORS

- Pressure – using the right kind of proppant
- Frac design for high-temperature environments
- New technology solution? High-tech ceramic proppants coated with surfactants
BAKKEN SUCCESS FACTORS

- Highly variable thickness – MUST stay in the zone
- Not all zones equally frackable
- Harsh winter conditions
- New technology solution? Robotics for better geosteering
An intercalated, thin-bedded shale / sand play in Anadarko basin

Excellent storage, but not always recoverable

New technology solution? Artificial intelligence and “deep learning” to reprocess well logs for better depositional environment modeling
VACA MUERTA SUCCESS FACTORS

- Thickness & TOC
- Fracture networks
- New technology solution? “Smart fracs” that automatically adjust based on pressures and flowback chemistry
- Experience since 2012

El mayor descubrimiento de Repsol
El yacimiento "Vaca Muerta" fue hallado el 7 de noviembre de 2011.

US$ 10.000 mills.
La inversión necesaria para explotación en primera fase

22.807
Reservas en millones de barriles de petróleo equivalentes

30.000
Los kilómetros cuadrados que tendría el yacimiento

12.000
Los kilómetros cuadrados del lugar que estarían en manos de YPF.

25%
Del total del yacimiento se ha explorado hasta la fecha
OTHER SHALES’ SUCCESS FACTORS

- Water solutions: Reprocessing to avoid using too much water
- “Smart injection mechanics” to avoid induced seismicity
- Inject with foam, CO2, gas? Sometimes works
CONCLUSIONS

- Bigger is not always better (frac design)
- “Smarter” is always better
- Analytics are important at all phases of exploration, development, and production
- New chemicals, equipment are making a difference