Unlocking the Tight Oil Reservoirs of the Powder River Basin, Wyoming

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U.S. Department of Energy - National Energy Technology Laboratory
Oil & Natural Gas - 2020 Integrated Review Webinar
Project Cost, Dates, and Objectives

– **Project Cost** (Total for 4 years, plus 1-year NCTE): $14,425,550
  - $7,893,649 Federal share
  - $6,531,900 Cost share (45.28%)

– **Important Dates**:
  - Project Kickoff meeting: October 2019
  - NCTE granted: July 2020
  - Project Completion: June 2024

– **Objectives**:
  - Establish field laboratory in emerging PRB plays
    - Shale plays: Belle Fourche and Mowry
    - Tight sands: Frontier
  - Create basin-wide development strategy plan
Background

– The PRB is a premier, emerging tight oil basin in the U.S.
  • 5,000 bbl in 2010
  • >130,000 bbl in 2019

– Currently, Parkman, Niobrara, and Turner contribute most to production

– Mowry (focus of project)
  • By far largest unconventional resource in basin
  • 1,280 MMBOE gross recoverable resource potential
Background

– Mowry shale is the most prolific source rock in PRB
– Unconventional production from Turner, Frontier, and Mowry
  • In 2019:
    – Turner contributed 67,000 bbl/D
    – Frontier produced >10,000 bbl/D
    – Mowry shale produced 3,000 bbl/D

Source: Enverus, 2020
Background

- Mowry shale characteristics in PRB
  - TOC ranges from 2 to 3+% Type II and Type III kerogen
  - Expelled 11.9 BBO in the basin (Momper & Williams, 1984)
  - Mowry is extensive and pervasive across the PRB
    - Thickness ranges between 150 ft and 200 ft everywhere in PRB
    - Graphic indicates extent of the Mowry at greater than 8000’ of burial depth (the Mowry “kitchen” area)

(Source: Lawrence 2009)
Technical Approach/Project Scope

– Develop “optimized” completion design for emerging shale play
  • Characterize (basin-wide) Mowry, Belle Fourche, and Frontier formations in southern PRB
    – Detailed geological mapping across southern PRB from well logs
  • Learn from recent and current completion practices
    – Perform SOA analysis and MVA using recent completion data (type, stage spacing, proppant volumes, etc.) to develop optimized completion design
    – Incorporate machine learning to aid optimization
  • Characterize rock
    – Collect core from pilot hole or other appropriate location
    – Pore-scale visualization of fluid movement
    – Geomechanical studies: mineralogy, stress, permeability, fracture mechanics
Technical Approach/Project Scope

– Drill and complete new horizontal well (field laboratory)
  • Incorporate latest technology to monitor completion and production in real time
– Refine completion design as informed by feedback from field laboratory
– Share development strategy with stakeholders
  • Developmental benefits, impacts, and challenges
  • Technical and economic viability for proposed strategy
  • Project risks and mitigation strategies
– Identify possible consortium members – additional operators
Historical Well Completions Data

- 66 columns of data on 805 different wells
- Still a work in progress (green cells)
- Data collected from online sources and physical well files at WOGCC
- Data used for state-of-the-art analysis and multi-variate analysis
- All new core/data to be added
Completion Practices: a State-of-the-Art Analysis

- Finished SOTA analysis on Turner, Frontier, and Mowry formations
- Results of Mowry analyses shown here as examples:
  - 42 horizontal wells in emerging play, one-third completed after 2018
  - 26 wells located in south-central portion of basin
  - Most recent activity occurring in areas of higher thermal maturity
Completion Practices: a State-of-the-Art Analysis

- Mowry Results (as example):
  - Mowry partitioned into four categories (see map)
    - Central basin, high maturity (green dots)
    - NE basin, low maturity (orange dots)
    - NW basin, moderate maturity (blue dots)
    - South basin, high maturity (red dots)
  - Partitions further separated by time-slice to show changes in completion designs over time
  - Key learnings:
    - Lateral length has increased with time (currently approaching 9,000 ft) along with number of fracture stages
    - Proppant/stage increased from 50 tons to 370 tons
    - EUR/1000 ft increased from 20 MBOE to 42 MBOE
Concerns

– Collect core from pilot hole or other appropriate location(s) has been delayed
  • Causing critical lab work to be delayed as well
  • Originally planned to drill and collect core for characterization in 2020
  • Drilling of pilot hole postponed due to oil price collapse & COVID
Current Plans to Obtain Suitable Core

- Working with additional operators active in area of interest (AOI)
- Work with nearby Glenrock field operator to obtain core drilled through Mowry and Belle Fourche shales in November/December 2020
  - Well location is roughly 8 miles from AOI and less mature
  - Geomechanics and fracture characteristics will be similar
  - Belle Fourche logs indicate possibly higher TOC than in AOI
  - Mowry logs appear very similar between Glenrock and AOI
  - Obtaining Bell Fourche and Mowry core will allow:
    - establishment of facies relationships
    - better understanding of TOC and organic distribution
    - calibration of core to logs
    - understanding of how the bentonites affect these horizontal plays
  - Core data are always helpful in some way
- Core from well to be drilled through Mowry at Dry Fork Station (CarbonSAFE Phase III) in June 2021 (65 mi north of AOI)
Future Plans

– Complete multi-variate analysis of completion designs to determine critical variables and optimize design

– Characterize rock
  • Collect core from pilot hole or other appropriate location(s)
  • Pore-scale visualization of fluid movement
  • Geomechanical studies: mineralogy, stress, permeability, fracture mechanics

– Drill and complete new horizontal well (field laboratory)
  • Incorporate latest technology to monitor completion and production in real time

– Refine completion design as informed by feedback from field laboratory

– Share development strategy with stakeholders
  • Developmental benefits, impacts, and challenges
  • Technical and economic viability for proposed strategy
  • Project risks and mitigation strategies

– Add additional operators/consortium members if possible
Summary

- Project will significantly aid the development of a key emerging unconventional oil play in Wyoming’s Powder River Basin
  - A young project (< 1 yr) with delays (COVID-19, very low oil prices)
  - Expected to achieve outlined goals
- Key findings include better understanding of Mowry and completion practices
  - Pervasive, continuous, uniform thickness, and has at lease three main zones of higher TOC rock
  - Small number of wells, but operators are beginning to focus in on a standard completion
- Future plans include:
  - Continue with work to promote further exploitation of the Mowry resource
  - Partner with additional operators to grow the impact of its results
Appendix

– Organizational Chart
– Gantt Chart
Organization Chart

Enhanced Oil Recovery Institute (EORI)

Lead Principal Investigator (PI)
Dr. Steven Carpenter, Director
Dr. Eric Robertson, PM

Advanced Resources International
Mr. George Kaperna
Mr. Dave Rustenberg

Wold Energy Partners
Mr. Aaron Otteman

Goolsby, Finley & Associates
Mr. Andrew Finley

NSI Fracturing
Mr. Larry Britt

Southern Illinois University
Dr. Satya Harpalani

Piri Technologies
Dr. Mohammad Piri

Battelle Memorial Institute
Mr. Mark Moody

Len Paugh Consulting
Mr. Len Paugh

FIELD & ANALYSIS

LABORATORY
Gantt Chart
## Gantt Chart

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