Data & Drilling Methods from Horizontal Mississippian Reservoirs Across Northern Oklahoma

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Outline

Intro

• Play Observations
• Fairways

Geology

• Depositional
• Targets
• Depth and Thickness Relationships

West vs. East

Well Results

• Historical IPs vs Frac Volumes

Hz Well Completion Methods

Conclusions
INTRODUCTION
The Most Interesting Play in the World???
Mississippian Play “Fairway”

MISSISSIPPIAN ROCKS ABSENT

POSSIBLE EXTENSION

CHESTER OUTCROP

MISSISSIPPLIME PEAK LIQUIDS PERCENTAGE

Map Courtesy of ITG IR
Observations

• Infrastructure Dependent
  – Wells require SWDs (4-6 Wells per SWD)
  – Artificial Lift
    • ESP
    • Gas Lift

• In some wells, as water is pumped off, oil cut increases

• Differences between facies require stimulation changes
  – Different Geomechanical Properties
  – Brittle:Ductile Couplets
  – Vertically Stacked Pay in Reservoir Seal Pairs
  – Trapping Mechanisms
  – Migration Pathways

• At least 7 Productive Reservoir Facies
  – 3 Cherts, 2 Limestones, 2 Dolomites
  – Chat typically has different trapping mechanisms than the Lime

• Fractures are lithologically controlled; lithology is highly variable in the section. Fracturing correlates to rock brittleness.
Observations

• IHS Production Codes
  – “359MSSP”
  – “359MPLM”
  – “359MSLM”
  – “359MSCH”
  – “359CHAT”
  
  All can represent the same productive interval!!!
  
  This is Problematic

• Generalized Nomenclature
  – this data must be mined through to identify the productive reservoir
• Progradational Depositional Architecture
• Very fine grained limestones, argillaceous muds, spiculites, tripolites and cherts (penepcontemporaneous and diagenetic)
• Inter-Osagean Unconformities
• Several discrete reservoirs facies, with multiple porosity systems
  • Tripolitic (bedded and sheet), Intercrystalline, Spiculitic, Bed Bound Fractures, Vugular, Microporosity
Target Horizons

- Permian
- Pennsylvanian
- Cherokee Shale

- Mississippian (300’ - 600’ Thick)
- Woodford Shale
- Simpson Group

- Silicified Limestone
- Tripolitic Chert (Chat)
- Fractured Chert
- Arbuckle (Disposal Zone)
What is the Target?

Geology

“Mississippi Chat”

Woods County Section

A result of uplift, alteration, erosion and deposition of the original Mississippi limestone, several different levels of weathered cherts occur along the major Pennsylvanian-Mississippian unconformity.

Characteristics – low permeability, high porosity, often compartmentalized, stratigraphic combo traps by nature. The Chat drills very fast.

Rock with > 30% porosity can be produced open hole no stimulation. Sooner Trend style frac jobs of over 10,000 bbls fluid typically produced higher IPs, with cumulative production ~ 75,000 bbls.

Woods Co. Section
What is the Target?
Geology

“Mississippi Chat”

Osage County Section
A result of uplift, alteration, erosion and deposition of the original Mississippi limestone, several different levels of weathered cherts occur along the major Pennsylvanian-Mississippian unconformity.

Characteristics – low permeability, high porosity, often compartmentalized, stratigraphic combo traps by nature.

Originally Produced Naturally, then Sooner Trend style frac jobs of over 10,000 bbls fluid typically produced higher IPs, with cumulative production ~ 75,000 bbls

Osage County
Target Horizons
What is the Target?

Geology

Mississippi Lime

Garfield County Section

The Miss Lime has typically been produced from porosity streaks, or open natural fractures since the 1950’s in Oklahoma.

Lithologically – occurs as alternating beds of chert and limestone. Streaks of high porosity alternating with tight limestone.

Characteristics – low permeability, low-moderate porosity, combo traps beneath sub-unconformity surfaces.

Originally Produced Naturally, then Sooner Trend style frac jobs of over 10,000 bbls fluid typically produced higher IPs.
Vertical barriers are created by several cycles of deposition. Resulting thin-beds of alternating argillaceous limestones and cherts act as stratigraphic traps for hydrocarbons.

Fracture $\phi$ is necessary to create matrix permeability. Fractures occur in intense pockets or “swarms”. The horizontal drill we can encounter *multiple* swarms, in contrast to a vertical wellbore which would be lucky to encounter the edge of a single swarm.

*Hydrocarbons (green) occur in matrix & oriented along azimuth of fracture planes, proving the East to be more than a fracture play*
Pawnee County, Oklahoma
31°22'N-4°E

Facies
- Tight Dense Lime

**Ripley 1-31H**

~55,000 bbls

- First 12 Months Production

Little Historical Miss. Production
- 1 Vertical Well—Produced 28,000 bbls

- Large Frac Job
  - connecting the matrix porosity to the fracture porosity

Several Reservoirs are Vertically Segregated within the Silicified Mississippian Lime
Is the West similar to the East?

*It is the same, in that, it is different, but has similar characteristics*
Is the West similar to the East?

Woods County

Osage County

IP Test: Oil: 98 BBL, Gas: 130 MCFD, Wtr: 20 BB
Schematic Cross Sections

- Woods
- Alfalfa
- Grant
- Kay
- Osage

Cherokee Shale

Arbuckle Disposal Zone

Mississippian

Woodford Shale

Nemaha Ridge

Igneous Basement

Courtesy of Vitruvian Exploration
Top Mississippian Structure Map
(Shows only vertical productive wells in Mississippian)

WESTERN CORE AREA (WCA)

EASTERN CORE AREA (ECA)

Courtesy of Vitruvian Exploration
What Does the Production and Completions from Vertical Wells Really Tell Us?

FRAC VOLUMES
MSSP Frac Volume's (in Bbls)

Map Courtesy of Spyglass Energy Group
MSSP Frac Volume's (in Bbls)

Completions Greater than 10,000 Bbls

Map Courtesy of Spyglass Energy Group

IHS Data
HORIZONTAL COMPLETIONS
Considerations

- Integrate hydraulic fractures with specific type of reservoir
  - Lithology
  - Rate
  - Lateral Length
- Number of Stages
  - Placement
    - Shows?
    - Intervals?
  - Number of Shots
  - Spacing between Shots
  - Hydraulic Diversion
Frac Fluids

- Slickwater
  - How Much Sand??
  - Gel?
    - X-Link
    - Linear
- How Much Acid?
- Hybrids
  - Alternating Stages
- Formation Water?
Early Fracs
Sandridge & Chesapeake

~ 6,000 barrels per stage

4 to 5 sets of perfs per frac stage
(6 shots per foot over 2' every 100' of lateral)

~1,000-1,200 barrels per set of perfs
Early Fracs
Sandridge & Chesapeake

~ 6,000 barrels per stage

4 to 5 sets of perfs per frac stage
(6 shots per foot over 2' every 100' of lateral)

~1,000-1,200 barrels per set of perfs
Very Different Approaches
More Holes vs. Less Holes

**Limited Entry**
- 350’
- 3 2’ clusters and 6 shots psf
  - 12 shots per foot cluster
  - 36 shot holes per stage
- 80-90 bpm
- 3750 bw/stage
- .05#/gal water

**Hydraulic Diversion**
- 300’
- 4 5’ perf clusters, 6 spf
  - 30 shot per foot cluster
  - 150 shot holes per stage
- ~60 bpm
- 10k bw/stage
- .4#/gal water
- Drop 60 “bio ball sealers” 4x per 2500 bw

*LE wells have seen large decreases in fluid production*
Ideas

• Longer Laterals

• Frac
  – How Much Sand?
    » .25–.33#/gal
  – More Acid
  – More Stages and ~70 bpm rate
    » Not as much vertical growth as previously thought

• Casing
  – 7” with 4½” liner
    » Larger Pumps
  – Open Hole Packers
    » Packers Plus
      • Can bleed off from packer be overcome?
Conclusions

1. Eastern Core Area is Analogous to Western Core Area
   - East is More Prospective for Oil
     - Doesn’t Need to be Frac’d as Much!
     - Potentially More Trapping Mechanisms
   - More Wells Need to be Drilled for better Comparisons

2. Different Lithologies Require Different Completion Techniques
   - Know Your Lithology!!!
   - ESP’s handle fracture water

3. Fracturing is Lithologically Controlled
   - Brittle:Ductile Couplets

4. High Volume Frac Jobs Mechanically Open & Clean Healed Fractures
   - West vs. East Production Volumes Debunked!
Thank You and Stay Thirsty My Friends