Refracturing: Candidate Selection & Potential Solutions

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Outline

- Benefits and mechanism of refracturing
- Refrac candidate selection process
- Does refracturing work and is it applicable in Canada?
- Candidate selection and economic evaluation examples
Why Refracture Wells?

- Increase booked reserves
- Improved ROI
- Faster, higher cash flow
- Lower cost per BOE
- Faster payback
- Lower environmental impact
Mechanisms Contributing to Refrac Success

- Stimulating intervals initially bypassed
- Enlarged fracture geometry enhancing reservoir contact
- Increased fracture conductivity compared to initial frac
- Improved frac complexity
- Fracture re-orientation due to stress field alterations leading to contact of “new rock”
Steps Involved in Selecting a Refrac Candidate Well

- Four steps to the screening & selection process:

1. Merging of Canadian public data sets
   - GeoScout → production data, formation properties, and well information
   - Canadian Discovery Frac Database → Completion details

2. Candidate selection criteria
   - Frac spacing, tonnage, depletion, reservoir quality, etc.

3. Production type curve analysis
   - Compare to offset wells and expected production type curve
   - Estimation of production rates after refracturing

4. Economic potential of rejuvenation
   - Run through economical model
Candidate Selection Criteria

1. Reservoir and production data:
   - High IP and productivity in nearby wells
   - Low cumulative depletion

2. Original completion:
   - Older wells with large frac spacing
   - Intervals not fractured initially
   - Insufficient proppant tonnage (under stimulated)
   - Poor fluid choice

- Candidate Selection Criteria from Vincent et al. (SPE 134330)
Importance of Selecting the Right Candidate

Well A
- Lower reservoir quality
- Higher than average proppant placed

Well B
- Higher reservoir quality
- Lower than average proppant placed
Refrac Search in Western Canada
Horizontal Refracs Since 2010
Refracture by Formation

- Viking, 46
- Bakken, 30
- Other, 18
- Shaunavon, 6
- Swan Hills, 4
- Slave Point, 3
- Duvernay, 3

Average IP ratio = 61%
Average rate increase = 40 bbl/d
Average Oil Rate Before and After HZ Viking Refrac
Average Oil Rate Before and After HZ Bakken Refrac

- Incremental production after 3 years ~ 40,000 bbl
- Incremental revenue after 3 years ~ $1.6 mm (@ $40/bbl)
Injection Well Refracs
Summary of Refracs in Western Canada

- More than 100 horizontal wells refractured since 2010
  - > 15 different formations
  - > 30 different operators

- Positive results in producers and injectors
  - Average IP ratio = 60%
  - Average rate increase = 40 bbl/day
Using Historical Refrac Data

- Looking at results from historical refracs helps to:
  - Estimate expected production rates from refracturing
  - Helps refine candidate selection
  - Optimize future stimulations
Montney Candidate Selection Example
Location of Chosen Candidate Well

North offset well – ranked #63
Candidate well – ranked #2
South offset well – ranked #132
Comparing Production Declines and Completion Details

Well to the south
13 x 50t stage N₂ foamed water frac

Well to the north
12 x 51t/stage N₂ foamed water frac

Candidate well
12 x 16t/stage N₂ foamed water frac
Comparing Cumulative Production
Potential of rejuvenation
Methodology and Assumptions for Economic Analysis

- Decline analysis used to forecast base case and refrac production
- Peak rate after refrac set to 50% and 70% of IP
- Well Cost: $5MM
- Operating Costs: $3.4/boe
- Refrac Cost: $1MM
Cashflow Economic Analysis

- Payout period = 7 months
Waterfall Cashflow Economic Analysis

Undiscounted Pre-tax Cashflow Waterfall (IP 50%)

- Projected CF w/o Rejuv.: $2.5 MM
- Rejuv. Capex: $1.0 MM
- Incr. Rejuv. Revenue: $7.2 MM
- Production Taxes, Opex: $3.9 MM
- Incr. Rejuv. CF: $2.4 MM
- Projected CF with Rejuv.: $6.3 MM

$ MM
Bakken Candidate Selection Example
Location of Top Candidate Wells

- West offset candidate
- Infill well
- East offset candidate
Production of Potential Candidates and Infill Well

- **8 x 11t stage frac**
- **8 x 12t stage frac**
- **25 x 5t stage frac**
Methodology and Assumptions for Economic Analysis

- Decline analysis used to forecast base case production and production after refrac

- Peak rate after refrac set to 50% and 70% of IP of infill well with 25 stages

- Well Cost: $2MM

- Operating Costs: $9/boe

- Refrac Cost: $0.5MM
Waterfall Cashflow Economic Analysis

- Payout Period 10 months @ $40/bbl oil
Final Observations

- Refracing is a data driven approach

- Candidate selection is paramount and most important

- Know your refrac objectives before designing a solution

- More calculated approach to each well

- Stimulate new intervals and reconnect to currently producing zones

- A thorough understanding of your candidate well is necessary for refrac success
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