The Full Montney – A Critical Review of Well Performance by Production Analysis of Over 2,000 Montney Multi-Stage Fractured Horizontal Gas Wells

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Summary

A major issue with determining the effectiveness of different completion strategies is reservoir heterogeneity – which is to be expected with most unconventional resource plays. Two horizontal wells separated by 400 m or less lateraly, completed and stimulated identically may result in one well peforming significantly better than the other, with significantly higher estimated ultimate recovery (EUR).

Hence the statistical approach to the problem – developed and used in this case study. Rather than using 'closeology' with the assumption that the reservoir quality is the same in a confined area – we use a large number of wells across all geologies to 'normalize' the geological differences. For a large enough sample size statistical theory states that each different completion type to be compared is equally represented in permeability and net pay space (reservoir flow capacity). If this is true, then statistical variations in cumulative production from one group to another are more representative of completion and hydraulic fracture effectiveness. Therefore, the cumulative production metric may be used to compare directly different completion types, number of stages, fracture designs, fluid systems, etc.

Introduction

This paper will present a new style of statistical analysis of the well performance of approximately 2,000 Montney / Doig Multi-stage Fractured Horizontal (MFHW) gas wells completed since 2010. This analysis will review the important parameters to determine the effectiveness of the completion designs, such as:

- Fracture fluid systems;
- Open hole or cased hole multi-stage systems;
- Number of fracture stages / fracture spacing;
- Size of fractures, proppant tonnage per well;
- Cost.

The analysis was performed based upon normalized parameters including:

- Cumulative production at 3 and 12 months;
- Cumulative production: per proppant tonnage; completed well length; number of fracture stages; and completion cost.

We will outline the importance of applying advanced well performance analysis techniques to determine the efficiencies of specific completion and fracture designs. This illustrates the importance of looking back in order to optimize future completions. This paper reinforces the need to move completion designs from the current 'operational effectiveness' mode of fracture designs, to a 'fracture effectiveness' mode provided by optimizing designs to achieve higher recoveries and improved economics.

Theory and/or Method

The focus of this study was on the dry and wet gas areas of the Montney (below the gas condensate window as defined by McCain (1994)), as a large number of wells completed with many different types of fracture fluid systems were represented. Only wells with on production dates of 2010 or greater were chosen, as the desire was to have only wells using the most up-to-date completion practices represented in the data set. Wells must have a minimum of 12 months of production data, with any shut-in periods removed or compressed. The following criteria were used to populate the well list used in the study:

- Only public data sources with production up to Dec. 2014
- All licensed Montney / Doig horizontal wells: 3,500
- All wells with at least 12 months production data: 2,200
- Designated Montney / Doig gas wells:
  - On production date > the year 2010
  - GOR > 13,333 scf/bbl
  - OGR < 75 stb/MMscf
  - C7+ < 4%
- Final wells meeting the above criteria: 1,627

Data Sources

All data used in this study came from public sources. Production data was sourced from IHS Accumap and the hydraulic fracture details and costing data was from the Canadian Discovery Ltd. Fracture Database.

Probability Charts

Reservoir properties and completion design parameters tend towards a log normal distribution. The relative alignment of values provides a mechanism for quantitative comparison of different completion parameters at similar reservoir qualities (i.e.) the 50th percentile. The y axis is representative of a combination of reservoir quality and completion efficiency.

Examples

NOTE: We present only a portion of the analysis and results here – please refer to SPE 175948 for more details of the evaluation and results.

Overall Montney / Doig Gas Production Analysis

The performance of the 9 fracture fluid systems vs. 3 mo. cumulative BOE volumes are shown in Figure 1. All of the foams perform well, especially the binary foams in the lower percentile area of the chart (poor reservoir quality). Note the significant difference between the binary foams and slickwater at the 10th to 20th percentile. This illustrates the Montney is water sensitive (phase trapping) and explains why the slickwater systems are slow to cleanup. At the higher percentiles (>90%) the distribution curves all come together, illustrating that at the highest reservoir quality, phase trapping is not a major issue, and the wells perform about the same regardless of the fracture fluid system. The insert shows an expanded picture of the performance of the four best fluid systems at the median (40th to 60th percentile), where the differences have been quantified. The binary foam system was found to be 37% better than slickwater in terms of 3 mo. cumulative BOE at the median.
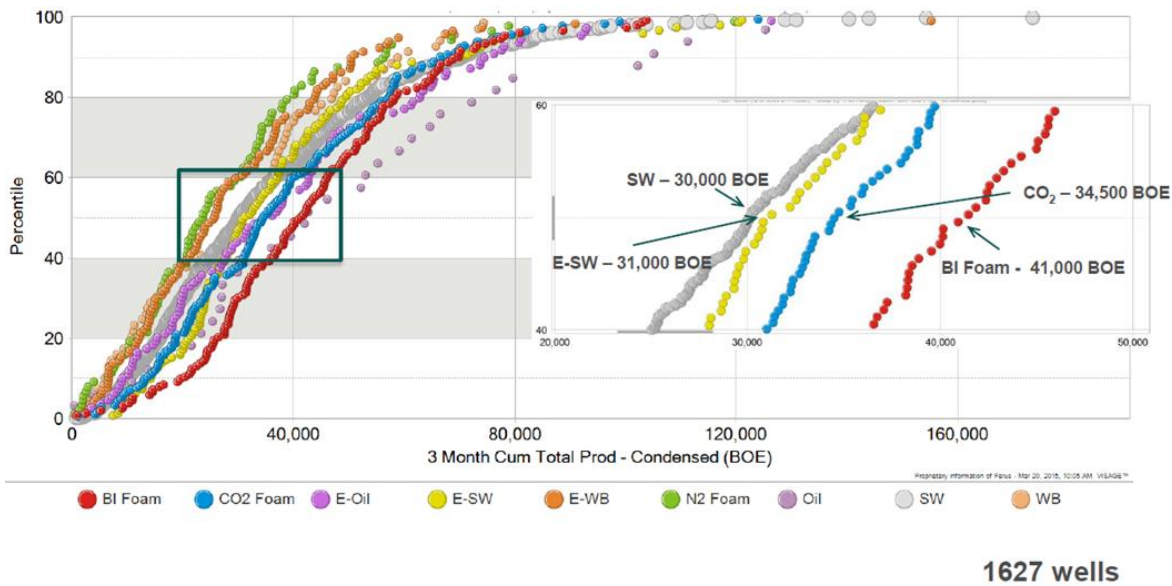
Figure 1 – 3 mo. Cumulative Production by Fracture Fluid System

Overall Montney / Doig Normalized and Cost Data

The normalized 12 mo. data for the top 4 fluid systems used, is shown in Figure 2. The cumulative production was normalized by: proppant tonnage; completed well length; number of fracture stages; and completion cost. One or more of these metrics are used by most E&P companies operating in the Montney in order to define an 'optimized' fracture treatment.

The results of this portion of the analysis illustrate the superior performance by all normalized metrics of the binary and CO_2 foam systems in comparison to slickwater. In terms of cumulative production per tonne proppant, binary foams were 88% better than slickwater; production per completed length: 18% better for binary and CO_2 foams; production per stage: CO_2 foams were 5% better; and production per completion $: 15% better for CO_2 foams.
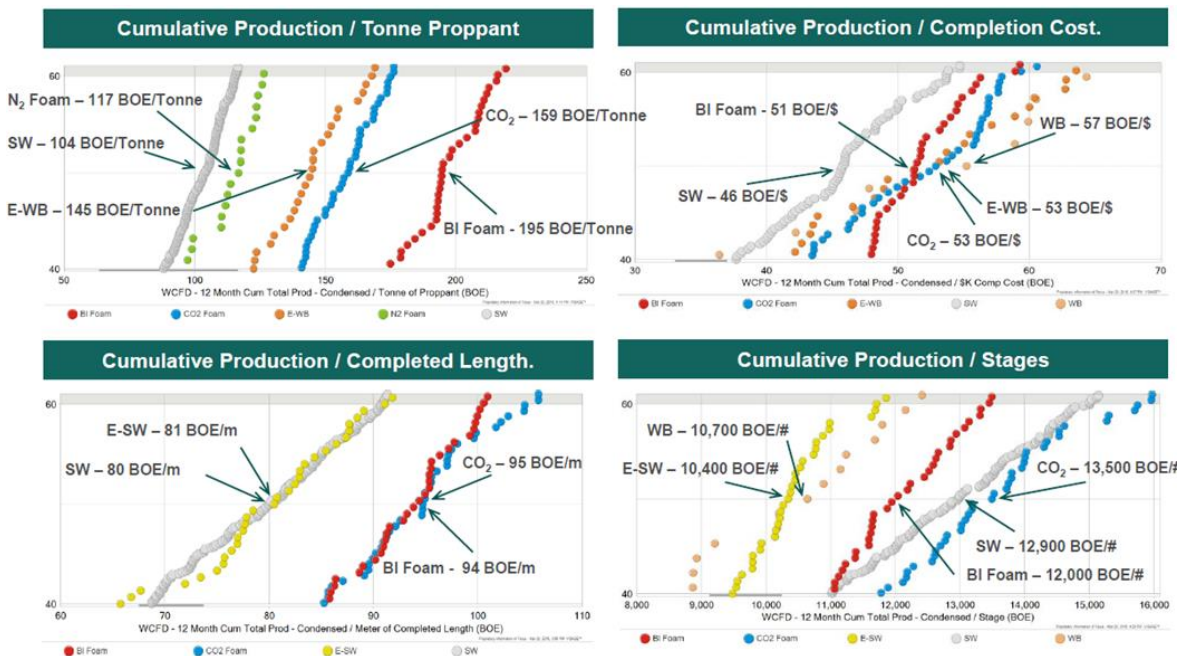

Figure 2 - 12 mo. Cumulative Production and Cost (Median Values) – Normalized Analysis

Conclusions

The following conclusions may be made as a result of this study:

- Data driven analyses used to do look backs on well performance and cost are a powerful tool to assist with completion design and fracture optimization in the Montney;
- The greater the sample size, the more statistically significant is the result / conclusion;
- Geology differences and other difficult challenges related to other comparative techniques are inherently self-correcting with larger sample sizes using the data driven approach;
- Define your metrics of importance and normalize the data to understand the drivers of completion and hydraulic fracturing efficiencies;
- Fracture fluid decisions and the type of completion technology employed makes a large difference in well performance and cost and economics in the Montney;
- Much talk has been made about driving down hydraulic fracturing costs through the use of slickwater and manufacturing type completions. Evidence from the first 2,000 Montney MFHW completions suggests that this is just talk – slickwater is consistently higher cost than any of the foamed fracture fluid systems. At the median, slickwater costs were $850k/well higher compared to the binary or CO_2 foams, or 22%;
- Slickwater fluid design has recently become the focus for treatment optimization, with significantly larger fluid and proppant volumes being pumped – without a corresponding benefit to net cash flow;
- CO_2 and binary foams showed better well performance and lower cost compared to slickwater in the Montney – the overall impact to net cash flow at 12 mo. was estimated at $1.65MM;
- In the Regional Heritage area, ball and seat completions recovered 20% more hydrocarbons at 12 mo. compared to plug and perf completions;
- Leaving large volumes of water trapped behind bridge plugs for weeks will reduce 12 mo. hydrocarbon recovery by 25%, illustrating that phase trapping is a problem in the Montney;
- Fracture conductivity was found to be important in the Montney tight gas areas, with the optimum sand concentration found to be 600 to 700 kg/m^3. This concentration can only be delivered with high quality foams;
- The optimum range of proppant tonnage in the Regional Heritage was found to be 75 to 100 tonnes of proppant per stage – larger tonnages are potentially wasting proppant and result in higher treatment cost.

Acknowledgements

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