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Deriving Value in Unconventional Plays using Data Analytics: Case Study of the Denver-Julesburg Basin, Colorado

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Summary

Multivarible analyses using geological, completion and production data sets, offer an opportunity to understand key drivers that make areas of unconventional plays productive, as well as highlight areas that could potentially benefit from changing completion designs. The workflow demonstrated in this study can be applied to the majority of Canadian unconventional plays due to readily-available digital data sets as well as long production timelines. Results demonstrate effective porosity, geothermal gradient, isopach and fluid intensity are key drivers of well performance in Niobrara Formation and Codell Sandstone in the Denver-Julesburg Basin of eastern Colorado and southeastern Wyoming.

Introduction

Big data is transforming the energy industry and is changing the way geoscientists and engineers evaluate the subsurface. Unconventional plays require an integrated and innovative workflow, incorporating multiple data sets, to characterize and understand the mechanisms contributing to successful wells. This study evaluates the unconventional targets of the Niobrara Formation and Codell Sandstone within the Denver-Julesburg (DJ) Basin of eastern Colorado and southeastern Wyoming. It focuses on the Wattenberg field and peripheral regions, evaluating geological and completion drivers affecting well productivity. Results illustrate how these complex completion and geological relationships change from different regions in the basin, and how understanding and quantifying these metrics is necessary to gain insight into what drives productivity, and ultimately creates value in the basin. This workflow can be utilized within Canadian unconventional plays, such as the Montney and Duvernay formations, to help understand the completion and geological mechanisms that drive value creation.

The DJ Basin covers approximately 70,000 square miles and represents a large asymmetric foreland basin that formed largely in response to the Laramide orogeny (Sonnenberg, 2016). The Wattenberg field straddles the basin axis along the western edge and accounts for about 540 Mboe/d of production, 86% of the entire basin's output. Elevated temperatures beneath Wattenberg, associated with late Cretaceous to early Tertiary igneous intrusions named the Colorado Mineral Belt, drive overpressuring and greatly influence production trends across the field (Higley et al., 2003; Sonnenberg, 2012). These characteristics are observed from bottomhole temperatures derived from wireline logs and differing wellhead liquids percentages across the field.

The Niobrara Formation and Codell Sandstone of the Carlile Formation are the most-targeted intervals for horizontal drilling. The Codell represents a fine-grained, clay-rich sandstone found at depths ranging from 3,000 to 9,900 feet true vertical depths (TVD). The Niobrara Formation unconformably overlies the Codell Sandstone and consists of four alternating chalk and interbedded marl units, referred to in descending stratigraphic order as A-, B-, C-Chalk and the Fort Hays. The A- through C-Chalks represent the main horizontal targets, with the marl units representing the primary source intervals for the petroleum system. Total organic carbon (TOC) values range from 1-5% by wt.

Theory and/or Method

Roughly 4,000 horizontal wells were analyzed across the basin. Completion data including lateral length, fluid (gal/ft) and proppant intensities (lbs/ft) were put though a comprehensive scrubbing process to identify and fix incorrect data. Type curves were built off grouped wells by geographical area, operator, vintage and geological zone to try and minimize the impact of changing operational strategies and subsurface attributes. Bottomhole locations for horizontal wells were used to tag each well to a specific target interval, as well as derive geological parameters from the petrophysical and stratigraphic models. These models were generated from over 2,000 digital wells logs, with the sampled geological parameters including isopach, dominant mineralogy volumes, effective porosity and geothermal gradient. Several multivariable regressions were run for the Niobrara and Codell within four regions in the Wattenberg plus the remaining wells outside the main field to determine the relationships and the most impactful geological and completion variables on well productivity.

Examples

Across the entire basin, the three most impactful variables on well productivity for the Niobrara include fluid intensity, effective porosity and geothermal gradient. As for the Codell, the top three variables are isopach, fluid intensity and effective porosity. Our modeling suggests doubling fluid intensity from 1,000 to 2,000 gal/ft design boosts productivity by 5% to 30% on a total EUR basis, and 10% to 50% on an oil EUR basis. Conversely, the results are inconclusive on the impacts of increasing proppant intensities, with most regressions exhibiting non-statistically significant values. Altogether, the modeling suggests most operators in the basin could benefit from adopting a more fluid-intensive completion design, with the largest percentage uplifts occurring outside the highly-productive Wattenberg field.

Conclusions

The workflow demonstrated in this analysis, utilizing completion, geological and production data, can drive a more comprehensive understanding of unconventional plays, including Canadian unconventional plays such as the Montney and Duvernay formations. Our study shows effective porosity, geothermal gradient and isopach are the main geological parameters driving well performance across the DJ Basin. By adopting a more fluid-intensive completion design, operators in this basin can maximize value in the Wattenberg as well as create additional value in historically marginally economic areas outside the field.

References

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