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Integrating Petrophysical Analysis with 3D Seismic Data Helps Build Map of Marcellus Sweet Spots

Comprehensive predictive mapping and expert collaboration enables the completion of high-quality unconventional zones

CHALLENGE

Gain a common understanding of what causes production variability and investigate how to reliably predict and rank drilling locations.

SOLUTION

Collaborate with Schlumberger petrotechnical experts in integrating logging-while-drilling (LWD) measurements, pilot well log data, and 3D seismic data to develop an accurate predictive map of reservoir properties and sweet spots.

RESULTS

Guided completion of two additional top-quartile laterals, demonstrating the value of developing a predictive map of reservoir quality and integrating data to optimize unconventional asset exploitation.

Repeat early production success in Marcellus shale

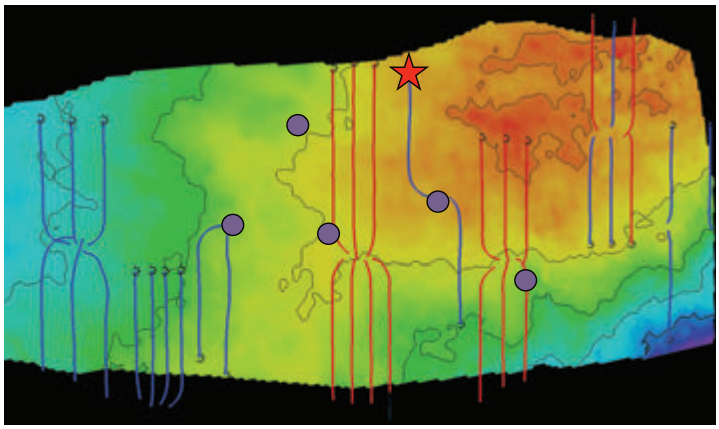
An independent operator began a Marcellus Shale campaign in Pennsylvania, capitalizing on its existing 3D seismic survey data and several vertical pilots that had targeted deeper stratigraphic intervals. The operator drilled and completed its first highly successful well using advanced EcoScope* multifunction logging-while-drilling service and sonicVISION* sonic-while-drilling service to ensure well placement, characterize the formation, and customize completions design. Unfortunately, repeating their early success proved to be problematic. The next 18 laterals, while accurately steered into the Lower Marcellus, had production results that were below expectations.

Seeking to reduce costs and improve drilling efficiency, the operator switched to using only LWD gamma ray techniques for well placement on its following 16 laterals with geometrically spaced completion stages. Production results remained unpredictable and inferior to the initial well.

Perform multidisciplinary evaluation to build prospect map

The operator chose to collaborate with Schlumberger to develop a petrotechnical solution to help meet its objectives, which included gaining a better understanding of the Marcellus reservoir, yielding knowledge that could be applied to an optimized completion practice. Schlumberger petrotechnical experts recommended a process that included conducting a detailed review and analysis of the operator's existing seismic survey data in the context of a 3D earth model built in the Petrel* E&P software platform. Schlumberger petrotechnical services started with a 3-month study to determine what factors control production variability, how to predict the geological properties that affect production, and how operational practices could be modified to address geological variability.

Because Schlumberger was the sole service provider for this project, access to data was seamless, and the evaluation tools and methods used were consistent. This enabled the initial QA/QC process as well as the data audit and assembly phase of the project to proceed so that maximum time could be spent interpreting and analyzing the measurements.



Predictive map of the study area showing the extent of the 3D seismic data mapping. The map indicates the locations of vertical wells (solid circles); the laterals drilled, steered, and evaluated using advanced LWD measurements (blue); the laterals drilled using only gamma ray for steering (red); and the well ranked highest in productivity (red star).

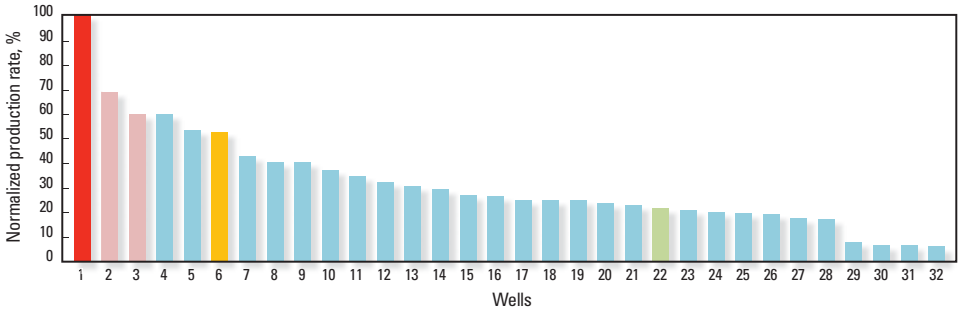
The acquired data included

- information about five openhole pilot wells, several with high-tier logging suites including the FMI* fullbore formation microimager, ECS* elemental capture spectroscopy sonde, and Sonic Scanner* acoustic scanning platform
- advanced LWD measurements obtained by EcoScope and sonicVISION services from 19 laterals
- gamma ray data only from 16 laterals
- 3D seismic with basic processing
- detailed completion data for 28 wells, totaling 390 stages
- StimMAP* hydraulic fracture mapping service results on four wells
- flowback and daily production data records for all 28 completed wells.

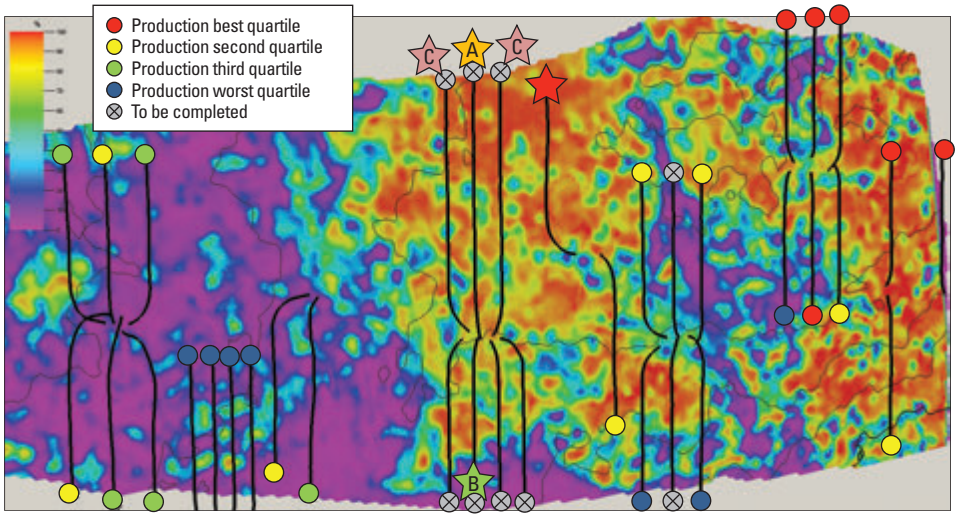
A virtual multidisciplinary team comprising Schlumberger petrotechnical experts and the operator's asset team developed a communication plan.

Although the cumulative drilling results indicated that better well placement could be achieved using images to guide geosteering, production results from these 28 wells did not show a correlation between better well placement and improved performance.

Selected seismic attributes were compared to production with reflection amplitude on an intra-Marcellus horizon and the total Marcellus isochron thickness, which was proven to have the strongest correlation to production results. The seismic amplitude of the Lower Marcellus also showed a weak correlation with production. The correlation between seismic attributes and production was cross-validated with the LWD sonic and density data, demonstrating that seismic attributes are related to the petrophysical properties of the Lower Marcellus. Using multiple seismic attributes conditioned by the LWD data, a map predicting the Marcellus reservoir quality was created.



Normalized average production rates over first year of production for all wells in operator's acreage. The operator's top-performing well, indicated with a red bar, was the well predicted to be and ranked as the most-productive prospect. Wells A, B, and C correspond to the orange, green, and pink columns, respectively.



Marcellus sweet spot map showing the probability of being in one of the best reservoir facies (sweet spots) classes (indicated in green or cyan). Wells are color-coded by the best 60-day well performance and grouped by quartile.

Enhance operational decisions with integrated expert analysis

Up to 19 high-ranking locations remained within the customer's acreage, including seven wells that had been already drilled and were awaiting completion. Fortuitous timing had scheduled completion of Wells A and B, one of which was in an area predicted to be of superior reservoir quality. After completions, the early production results from Well A, a north-facing lateral, was extremely encouraging; its 7-day IP rate made it one of the best wells in the acreage area to date. In contrast, the results of Well B, a south-facing lateral, were slightly below average.

In this blind test, the Marcellus sweet spot map accurately predicted the locations of the more productive wells. Although the operator was prepared to suspend completion activities, the results from this multidisciplinary petrotechnical study—and the successful drilling campaign—prompted the completion of two additional wells. These two wells (Wells C) had exceptional IP rates that placed them in the upper quartile of wells completed to date. The average production rates over their first year makes them three of the best six wells in the operator's entire acreage area.

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