Abstract

The Bone Spring Formation is a Permian deposit characterized by a variety of facies, from well-layered fine-grained basinal turbiditic deposits to coarser grained flow deposits, to slumps and complex mass transport deposits. This case study focuses on integration of conventional core analysis and routine and advanced wireline logs including nine borehole image logs, all acquired within a 20 miles radius from the core. Core analysis included lithofacies, identification of sedimentary and/or biologically and/or chemically induced structures. The borehole image logs were analyzed for fracture distribution, identification of sedimentary facies, and their variation in the vertical and lateral space. A lithofacies catalog (mudstone, carbonate-rich mudstone, thick bedded silt, and thick bedded carbonate-rich silt) was produced and applied to all the nine wells by comparison between core, borehole images and advanced spectroscopy log available in one well. From the analysis of the borehole images, the structure is consistently gently dipping to the WNW with a rotation to the SE in the Southern most well. This is justified by the presence of a major fault, dissecting the basin into two parts. This major fault is also coincident with a rotation of the in situ max stress from E-W to WNW-ESE. Natural fractures show a strike bi-modal distribution: NE-SW and WNW-ESE. The southernmost well shows a different result with a NW-SE predominant and a NE-SW secondary trend. The presence of interpreted open fractures increases towards the West of the study area. Facies analysis on the borehole image highlighted the presence of laminations, dewatering structures, mud clasts, intense bioturbation, large concretions, oblate concretions, pyrite, patchy cement, cross laminations and highly deformed facies. Newly applied technologies allowed the quantification of laminations from high-resolution image data. Laminations frequency and thickness can give indications on sedimentary energy and provides information on the depositional settings. The variation on lamination thicknesses and densities supported in the identification of facies. The different depositional environments interpreted from this dataset are deep basin, distal turbidite lobe, and distributary channels. The integration between core and image logs helped propagate the facies and depositional environment interpretation from expensive cored wells to much more cost-effective logs datasets and it helped also in reducing wellbore risk.
References Cited


Second Bone Spring Borehole Image Derived Depositional Facies Characterization: Case Study From the Delaware Basin, West Texas

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**Abstract**

This project dealt with sedimentological analysis of 3 boreholes in the Bone Spring Formation of the Western US Permian Basin. The project encompassed various tasks, such as data processing, image analysis, and core description, to better characterize the depositional facies. The project was instrumental in understanding the stratigraphic and geologic structure in the northern Delaware Basin. The project was carried out in collaboration with other organizations and researchers, including Noble Energy, Inc., and Shell E&P.

**Introduction**

The Permian Basin is known for its unconventional reservoirs, with horizontal developments in unconventional reservoirs. The focus of this project was to better characterize these facies as not bioturbated facies. This suggests differentiation in the depositional setting and helps to better characterize the depositional style. The distribution of lithofacies and second order structures is shown regionally on the right side of the image. The project entailed processing and analyzing borehole image data for sedimentary research, with the goal of providing a better characterization of the depositional environment.

**Materials and Methods**

The dataset includes a vertical continuous whole core from the Second Bone Spring Borehole Image Derived Depositional Facies Characterization: Case Study From the Delaware Basin, West Texas. The dataset was acquired from the Second Bone Spring Borehole Image Derived Depositional Facies Characterization: Case Study From the Delaware Basin, West Texas. The dataset was acquired from the Shell E&P borehole in the Delaware Basin. The dataset was acquired from the Shell E&P borehole in the Delaware Basin. The dataset was acquired from the Shell E&P borehole in the Delaware Basin.

**Results**

The project resulted in a detailed sedimentological analysis of the bone spring facies. The facies were characterized as not bioturbated facies. This suggests differentiation in the depositional setting and helps to better characterize the depositional style. The distribution of lithofacies and second order structures is shown regionally on the right side of the image. The project was carried out in collaboration with other organizations and researchers, including Noble Energy, Inc., and Shell E&P.

**Discussion**

The project had several key findings, which included:

- **The importance of understanding the depositional facies:** Understanding the depositional facies is crucial for better characterization of the reservoir. The facies were characterized as not bioturbated facies. This suggests differentiation in the depositional setting and helps to better characterize the depositional style.
- **The significance of core description:** Core description plays a vital role in understanding the depositional facies. The facies were characterized as not bioturbated facies. This suggests differentiation in the depositional setting and helps to better characterize the depositional style.
- **The role of image analysis:** Image analysis provides a better understanding of the depositional facies. The facies were characterized as not bioturbated facies. This suggests differentiation in the depositional setting and helps to better characterize the depositional style.

**Conclusion**

The project provided valuable insights into the depositional facies characterization of the Second Bone Spring Borehole Image Derived Depositional Facies Characterization: Case Study From the Delaware Basin, West Texas. The project was instrumental in understanding the stratigraphic and geologic structure in the northern Delaware Basin. The project was carried out in collaboration with other organizations and researchers, including Noble Energy, Inc., and Shell E&P.

**Acknowledgments**

The project was supported by Shell E&P and Noble Energy, Inc. The authors would like to thank Valentina Vallega, Elia Haddad, Sourav Das, and all the other team members for their contributions to the project.

**References**


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PETROPHYSICAL INTEGRATION:

As an example of this work, we use images from the Delaware Basin in southeast New Mexico. These images were acquired in a lateral well that intersected multiple fracture zones. The borehole images allowed us to see the fractures and the heterogeneity of the depositional environment. This allowed us to understand what is driving the porosity, saturation, and TOC content in the reservoir. Conversely, the operator can also identify hard streaks and non-resolution evaluation. The image log allows the operator to identify any potential porosity and TOC from spectroscopy.

The plug was taken from a small resistive (likely cemented) layer within the reservoir. This has been extremely useful in calibrating our petrophysical model to the core data, as we are able to identify lithofacies and structures.

Throughout the project, we found multiple ways for the image log interpreter to tie petrophysical properties to both the first-order and second-order structures. We found that the image log interpreter could identify the exact facies within which the well was predominantly landed. The same fracture interpretation performed on the vertical images was performed in this lateral wellbore. We incorporated this information into a 3D facies model, which allowed us to better understand how fracture distribution and facies vary laterally within the wellbore, potentially highlighting the importance of the regional stress direction. Tying the information related to facies to productivity allows a clearer identification of the key reservoir zones.

The borehole images also allowed us to understand better the distribution in the Bone Spring formation and to observe the lateral variability of the facies. This is particularly important in understanding how fracture distribution and facies vary laterally within the wellbore, potentially highlighting the importance of the regional stress direction. Tying the information related to facies to productivity allows a clearer identification of the key reservoir zones. The authors thank Patricio Desjardins and Michelle Thomas (Shell Projects and Technologies) for their integration work in Petrel. Molly Rupp for the preliminary integration work in Petrel.
FACIES VARIABILITY IN THE LATERAL DIRECTION

In order to understand the distribution of facies within the lateral wellbore, a 3D facies model was created using Sequential Indicator Simulation (SIS). SIS is a stochastic modeling technique that depends on upscaled well log data, variogram, random simulation parameters, and the target facies model. In the given conditions, it appeared that the sequential indicator simulation was providing better and more realistic facies predictions compared to other approaches.

SIS was used to model the distribution of facies within the lateral wellbore, taking into account the upscaled well log data and the variability of facies within the wellbore. The results of this modeling were then compared to the real-time data obtained during the drilling process, allowing for better optimization of the drilling parameters and ensuring that the wellbore is landed in the most productive zones.

LAMINATIONS ANALYSIS:

Sequential Indicator Simulation is a stochastic modeling technique dependent on the upscaled well log data, variogram, random simulation parameters, and the target facies model. In the given conditions, it appeared that the sequential indicator simulation was providing better and more realistic facies predictions compared to other approaches.

The lateral image log can also be used to determine the facies within which the well is predominantly landed and the percentage of each facies type. This information is crucial for optimizing the drilling parameters and ensuring that the wellbore is landed in the most productive zones.

Massive Carbonate

Laminated Mudstone

Massive Siltstone

Above: Borehole images acquired in a lateral well to help with heterogeneity and facies variation.

The authors thank Patricio Desjardins and Michelle Thomas (Shell Projects and Technologies) for their contributions to this study. The images are courtesy of TGS; the authors also wish to acknowledge Molly Rupp for the preliminary integration work in Petrel.