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Integrating Structural Modeling and Borehole Imaging to Improve Risk Control During Drilling Operations in Southern Mexico

D. Contla* (Schlumberger), L. Melendez (Schlumberger), G. Garcia (Schlumberger) & N. Salinas (Schlumberger)

SUMMARY

Borehole images are logged in many South Mexico wells, but these data are not used in further analyses. Recently, special projects have been developed for integrated drilling contracts, where it was shown how borehole images can create a detailed model that includes structural analysis, a fracture corridor, and morphofacies analysis that can be integrated with petrophysics to generate a geocellular model. A recently developed software has helped in analyzing and constructing 3D structural models with borehole imaging data. The software tool used for developing the two recent projects aimed to control risk and minimize uncertainty in southern Mexico. Both case studies showed considerably good results and provided valuable information, such as subseismic faults, that drastically changed the previous structures interpreted for development purposes.

Objectives

Using two case studies from southern Mexico, demonstrate and divulge the usefulness of borehole images to control risk during drilling.

Borehole images in southern Mexico

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A recently developed software has helped in analyzing and constructing 3D structural models with borehole imaging data. The software tool used for developing the two recent projects aimed to control risk and minimize uncertainty in southern Mexico. Both case studies showed considerably good results and provided valuable information, such as subseismic faults, that drastically changed the previous structures interpreted for development purposes.

Two cases in southern Mexico: A multiwell modelling case

The first case shows a complex, depleted field with high uncertainty that is associated with dolomite distribution in the Lower Cretaceous. The dolomite caused perforation fluid loss and stuck pipe in two wells.

In seismic data, this field showed an apparent low relief structure with little structural complexity. The project was developed in a portion of the field where three wells with image logs were available. The analysis showed how complex small blocks can be; the three faults and high-dip-angle strata that were interpreted from borehole images changed the panorama of this field sector. The new interpretation, which integrated seismic, well-tops, and image-log data showed a horst-graben structure. This structure interpretation was confirmed by one well that was drilled targeting the horst; the original plan was to drill with the same final depth as the other wells, but it was not necessary as long as the horst and high dip angle was lifting the target—the Middle Cretaceous (**Fig 1**).

This type of study show that many brownfields in southern Mexico are compartmentalized, and remnant oil can be found in blocks that require detailed structural analysis with borehole imaging to find subseismic features that can produce oil accumulations.

Single-well modelling case

One of the most complex geological structures in southern Mexico, an original extensive regime during the Mesozoic followed by salt tectonic magnified later by the Chiapaneca compressive event, produced an oil field of high structural and geological complexity where very large accumulations of hydrocarbons are found.

New wells have been drilled in this area, where the reservoir is beneath a 300-m salt layer that substantially reduces the seismic image quality so much that not even large faults within seismic resolution were visible.

Analyzing eight wells with borehole images demonstrates that existing interpretations and maps were based only on seismic data and well-top interpretations from previous wells and do not consider the high dip strata and faulting observed in image logs.

A development well was designed trusting only the seismic information. Even though the whole field has eight wells with image logs, the new well's zone only had one correlation well with this data; a small and simple model was developed using this dip information. Unfortunately, this special project using borehole images started after drilling began; imaging showed that a high dip structure and the faults present in this area will make the well navigate inside the Eocene system instead of reaching its objective system, the Upper Cretaceous. This information was showed to the customer in time to redirect the objective, but it was decided to keep drilling to gather more information about this fault that considerably affected the field structure. The well drilled until it found an anomalous column of almost four times the normal Eocene thickness, and the well gather enough information to characterize the area with greater certainty. Then, the well was closed and a sidetrack was planned and drilled, taking into account the new information interpreted with the help of borehole images.

Figure 1 The multiwell study case. The yellow wells had image logs, and the red dotted well was drilling. The well is displayed as it was planned, with same final depth as the correlation wells. Ultimately, it was not necessary to drill deeply because it found its objective (Middle Cretaceous) almost 200 m above the expected depth.

Conclusions

Analysis and construction of 3D structural models with boreholes images can generate a detailed model that provides greater certainty while drilling as well as more complete reservoir visualization. Borehole images enhance seismic and can be used in areas with low quality or inexistent seismic data. This type of models can also be complemented with additional borehole imaging data to create facies models of up to 2-mm resolution.

References

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