

PS A Successful Seismic Integration Case in Exploration of the Deep Thrust Zone in Mountain Area of Qaidam Basin, West China*

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Abstract

The western Yingxiongling Mountains in Qaidam Basin of China has very attractive hydrocarbon potential in the deep section, but the rough plateau condition and complex geology present major challenges in deep exploration. Early deep drilling without seismic in the 1980s resulted in about 20 dry holes and two discoveries, leading to 2 million bbl of oil production from four wells. To improve the operation, 3D seismic was acquired in 2013. With this dataset, Schlumberger has performed an integrated geophysical study with PSDM processing and seismic interpretation. As a result, two wells have been put in drilling in late 2014. The first well tested over 1,000 bbl/day and was put in production. The second well has penetrated 80m pay-zones and will be tested in the coming spring. This success has led to a breakthrough in deep exploration and production in this mountainous area. The workflow of our study include: (1) establishing a set of practical processing technologies for low signal/noise ratio, complex mountain area: integrated statics, combined noise attenuation, robust surface consistent deconvolution, and providing high quality dataset for subsequent imaging. (2) Enhancing imaging quality especially for overthrust and underneath: a proper strategy with well-constrain for velocity model building that leads to improved depth imaging results and good consistency with geological markers; Reverse time migration significantly improved imaging quality for underneath over-thrust which provide reliable stratigraphic contact and reasonable structure distribution. (3) Setting up proper regional structural -stratigraphic framework: low-angle imbricate thrust faults with associated multi-level decollement folds, which lays down the sound basis for further reservoir analysis. (4) Comprehending the main control factor on deep reservoir: the alignment of big thrust faults with lithology rich in brittle and soluble dolomite/limestone determines the sweet spots with rich oil accumulation and high production. (5) Taking the understanding of reservoir as the guidance and two old production locations as starting points, four favorable zones are delineated for scrolling drilling deployment. In contrast to our successful integrated seismic study, a parallel seismic study by another company has applied structural trapping and seismic attribute analysis in PSTM dataset as guidance in prospect generation and drilling location delineation, which has led to four dry holes until now.

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SUMMARY

This integration study demonstrates an effective E&P solution in mountain areas with highly-steeped structures in shallow and subsalt thrust faults with decollement folds in deep. High quality PSDM seismic processing enhanced the imaging quality, the improved depth imaging results show good consistency with geological markers. Set up a proper regional structural-stratigraphic framework in deep section (Fig1), which help understand the deep reservoir main control factor correctly. Four drilling locations were recommended, two wells were drilled in July 2014, while the first one was tested over 1000 bbl/day and put in production in late 2014, the second has penetrated 80m pay-zone and tested with high production in early 2015, the third is drilling now with good oil show. The success of the first well has been highly recognized as a breakthrough in the deep exploration in Yingxingling Mountainous area.

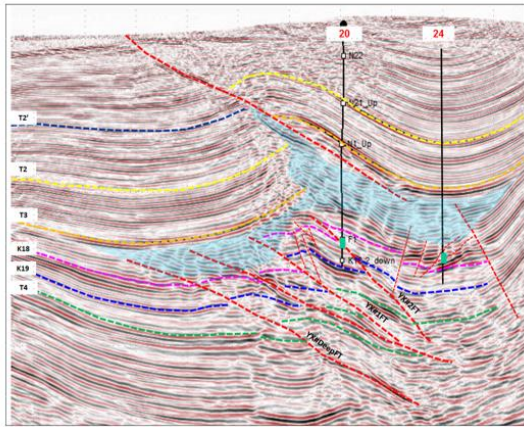


Fig1: Established correct structural-stratigraphic framework

INTRODUCTION

The western Yingxingling Mountain in Qaidam Basin of China has very attractive hydrocarbon potential in deep section, but the rough plateau condition and complex geology present the major challenges in deep exploration. Early deep drilling without seismic in 1980s had resulted in about 20 dry holes and two discoveries, which led to a total 2 million bbl of oil production from 4 wells. To improve the operation, 3D seismic was acquainted in 2013. With this dataset, Schlumberger has performed an integrated geophysical study with PSDM processing and seismic interpretation. As the study result, two wells have been put in drilling in late 2014 and one well drilling in early 2015.

WORKFLOW

3D PSTM/PSDM processing and interpretation integration study led to the successful results. Establishing a set of practical processing technologies for low signal/noise ratio, complex mountain area: integrated statics, combined noise attenuation and robust surface consistent deconvolution, and providing high quality dataset for subsequent imaging. 3D data has high signal/noise ratio than 2D data, enable to do reasonable structure interpretation (Fig2).

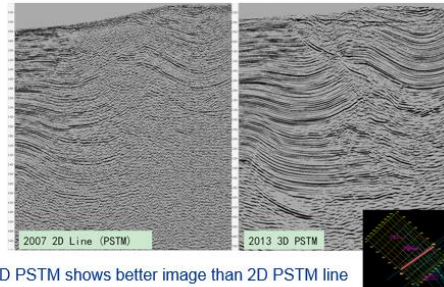


Fig2: 3D PSTM shows better image than 2D PSTM line

Enhancing imaging quality especially for over-thrust and underneath: Reverse time migration significantly improved imaging quality for underneath over-thrust which provide reliable stratigraphic contact and reasonable structure distribution (Fig 3). a proper strategy with well-constrain for velocity model building that leads to improved depth imaging results and good consistency with geological markers (Fig 4)

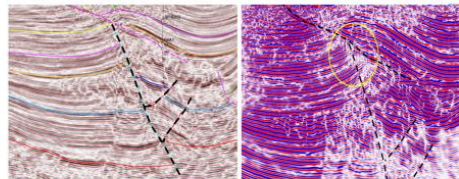


Fig3: Left: PSDM data: first run interpretation with high dip angle strike-slip thrust in deep area; Right: RTM test line doesn't support the main deep fault with high angle interpretation.

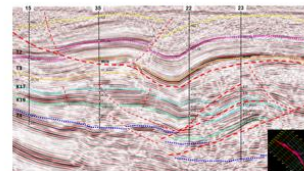


Fig4: Final PSDM data shows good consistency with geological markers

Setting up proper regional tectonic-stratigraphic framework: low-angle imbricate thrust faults with associated multi-level decollement folds (Fig 1), which lays down the sound basis for further reservoir analysis.

Comprehending the main control factor on deep reservoir: the alignment of big thrust faults with lithology rich in brittle and soluble dolomite/ limestone determines the sweet-spots with rich oil accumulation and high production (Fig 5).

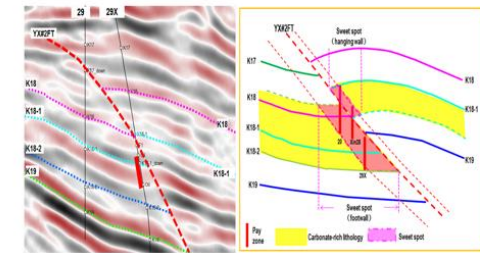


Fig 5 determined the main controlling factor on oil accumulation an production

Taking the understanding of reservoir as the guidance and two old production locations as starting points, four favorable zones are delineated for scrolling drilling deployment (Fig 6).

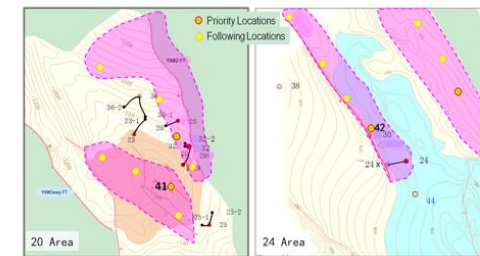


Fig 6 two drilling locations were accepted after four favorable zones were delineated

Drilling locations suggestion

Three drilling locations (41, 42 and 43) were suggested basing on the integration study (Fig 7 and Fig 8). Well 41 is located at the high of the trap, which also located between YX1#Fault and YX2#Fault, similar to well 20. faults developed and has a good alignment relationship with lithology rich in brittle and soluble dolomite/limestone. Well 42 and 43 also were suggested according the main control factor. The targets are under/hear the big faults.

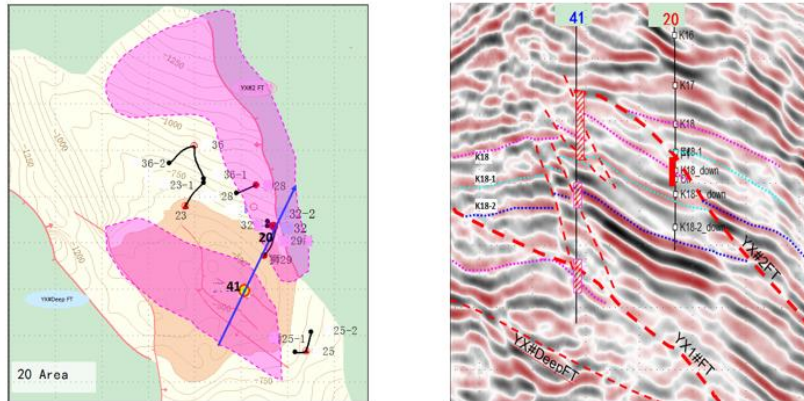


Fig 7 well41 suggestion

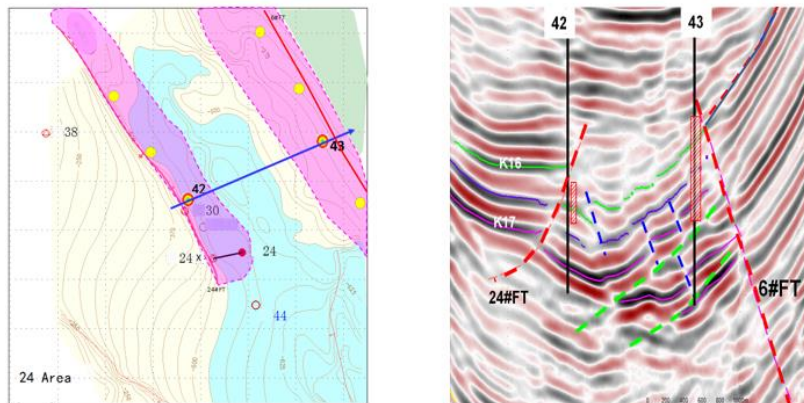


Fig 8 well42 and well43 suggestion

DISCUSSION

There are two main reasons for this successful integrated seismic study: Firstly, high quality 3D PSDM image ensured to perform the reasonable stratigraphy interpretation; Secondly, reasonable main controlling factor on oil accumulation and production analysis ensured to determine the right drilling locations.

Previous existing seismic structural-interpretation (fault style showed as Fig9) has misled reservoir study as structural trapping. Drilling locations (37~40) were suggested in the trapping area. The drilling results were poor.

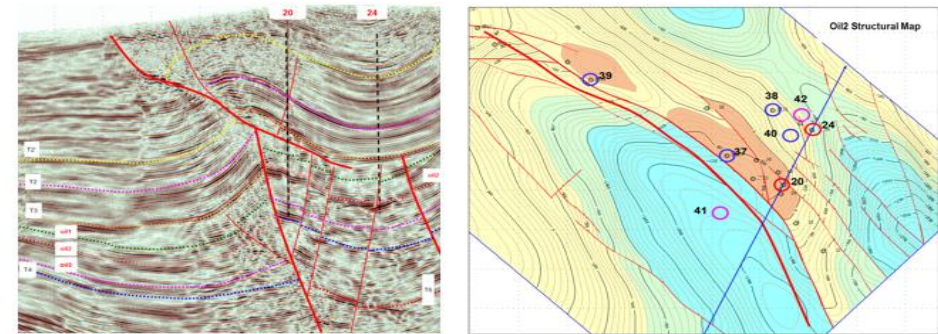


Figure 9: A structural style with high-angle strike-slip fault dominated flower-structures, which was interpreted in a PSTM data; 4 drilling locations supported by the structural mapping and seismic attribute analysis.