Enhancing Reservoir Performance of a Marginal Oilfield through Advance Well Placement Application in North China*

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Abstract

The Du28 block located in North China that had been producing for more than 30 years, the highest primary oil production of 27,000 ton/year was reached in 1982 with 300m to 500m well pattern. The reservoir fell into a significant production decline phase beginning in 1996. The reservoir was on the brink of obsolescence in 2010 when the primary oil production was 3,500 ton/year and a 0.1% annual oil recovery factor was recorded. The lower sand communication, higher differences of oil/water viscosity ratio and imperfect well pattern all contributed to the lower overall development effect. A multidisciplinary study of bypassed oil and main layer optimization showed that horizontal well development is the most effective approach to enhancing reservoir performance. As the result of the study, 22 horizontal wells were planned in this block at the end of 2010 and three pilot horizontal wells were planned to be executed in advance. However, great challenges are often faced in this area including uncertain microstructure, lateral property change, unstable inter-beds, and a very thin oil column (2m to 4m) to increase the challenge. To overcome these challenges, a 3D near-well geological model was built to enhance pre-job analysis, and the real-time well placement was monitored by using high-resolution resistivity image; along with near-bit measurements in all horizontal wells drilled. Clear identification of structural dips for optimizing the landing, supported the fast real-time decision making. Finally, three pilot horizontal wells were finished successfully in mid-2011, with the average NTG at 94.7% and the daily production reaching 15ton/day per well. From 2011 to 2013, 22 horizontal wells were executed successfully. In these wells, the average NTG reached 95%, and initial average productivity of horizontal wells reached 10 to12 ton/day time rate of the primary production phase. Initial water cut is about 20~30%, and the predicted annual recovery factor is about 1.5% in 2013, which is about 1.4% higher than in 2010 (0.1%).The final recovery factor based on reservoir engineer predictions increased to 32%. The successful application of advanced well placement technology in Du28 block has achieved significantly increased productivity and enhanced the recovery factor. The nearly abandoned oilfield can be turned into an economically developed field.

Under the patronage of His Royal Highness Prince Khalifa bin Salman Al Khalifa Prime Minister of the Kingdom of Bahrain

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Outline

- Introduction
- Case study
- Conclusion
- Acknowledgements

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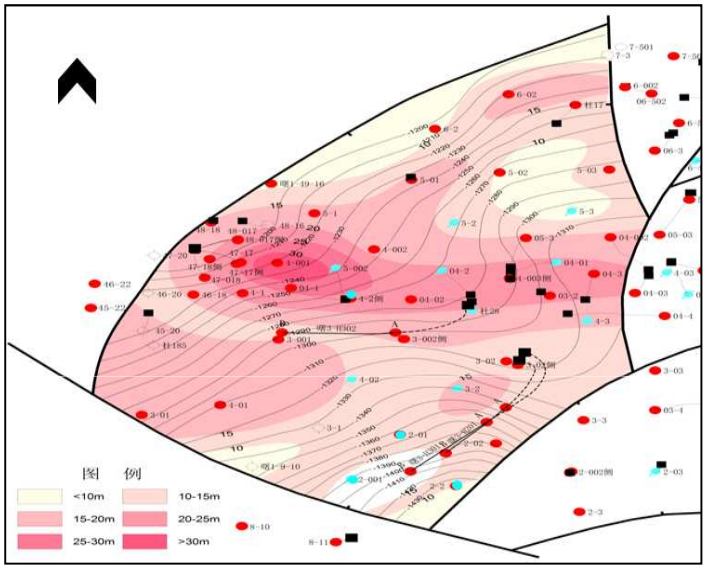
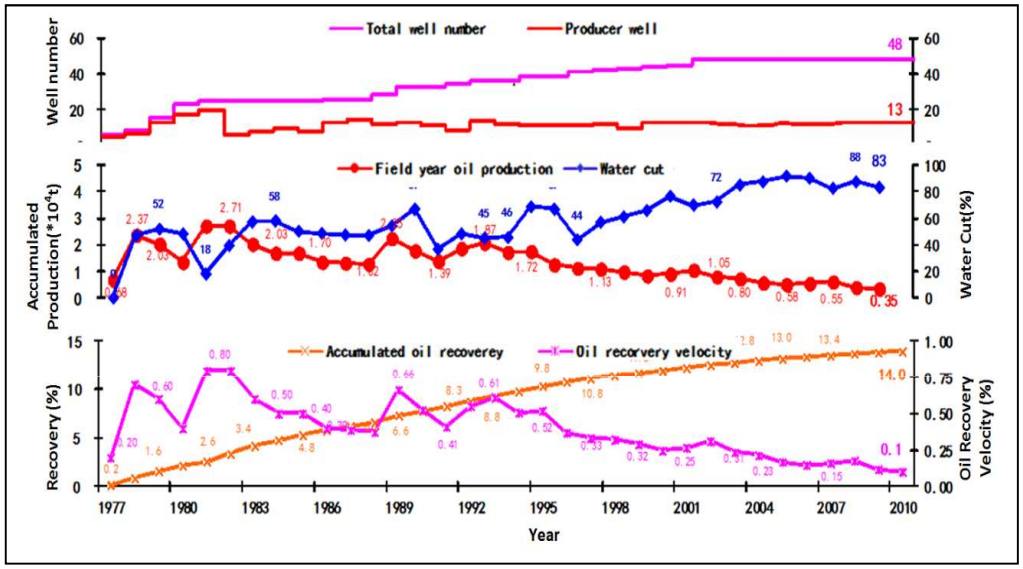
Background



Du28 Block Structure Map



Production data during the primary production

➢The Du28 block was developed with 300m to~500m vertical wells during the primary production phase

➢Although the number of the wells continued to increase gradually, both oil production and oil recovery velocity fell faster.

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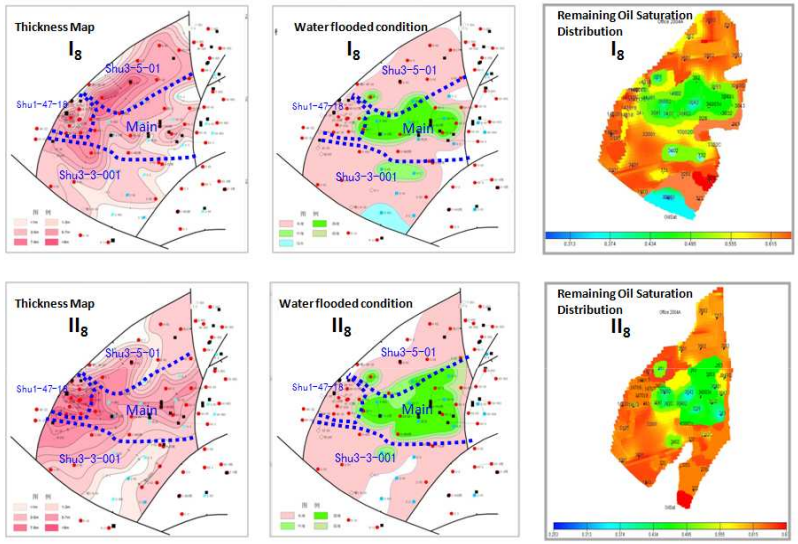
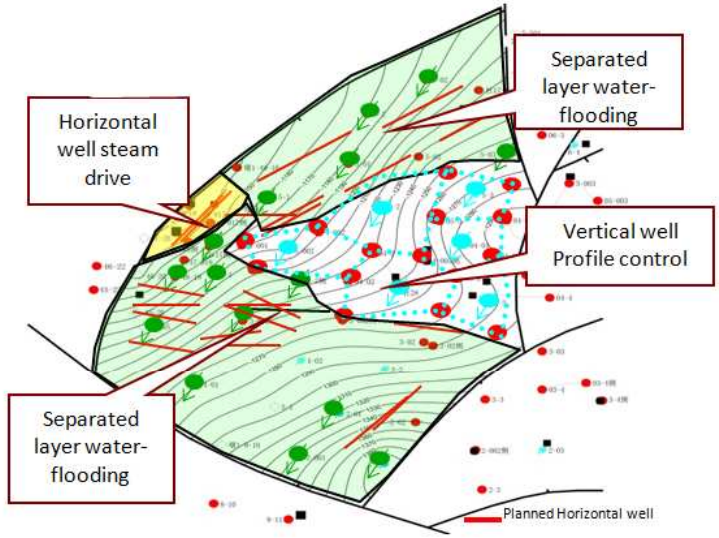
Integrated Study and New Development Strategy





➢Main layer optimization and a study of remaining oil saturation distribution.

➢Development strategy: water flooding in the north and the south of the reservoir, steam drive along a portion of the western side, and vertical well profile control along the middle.

➢The horizontal wells were expected to be accurately placed in the optimum position and maximize the recovery factor

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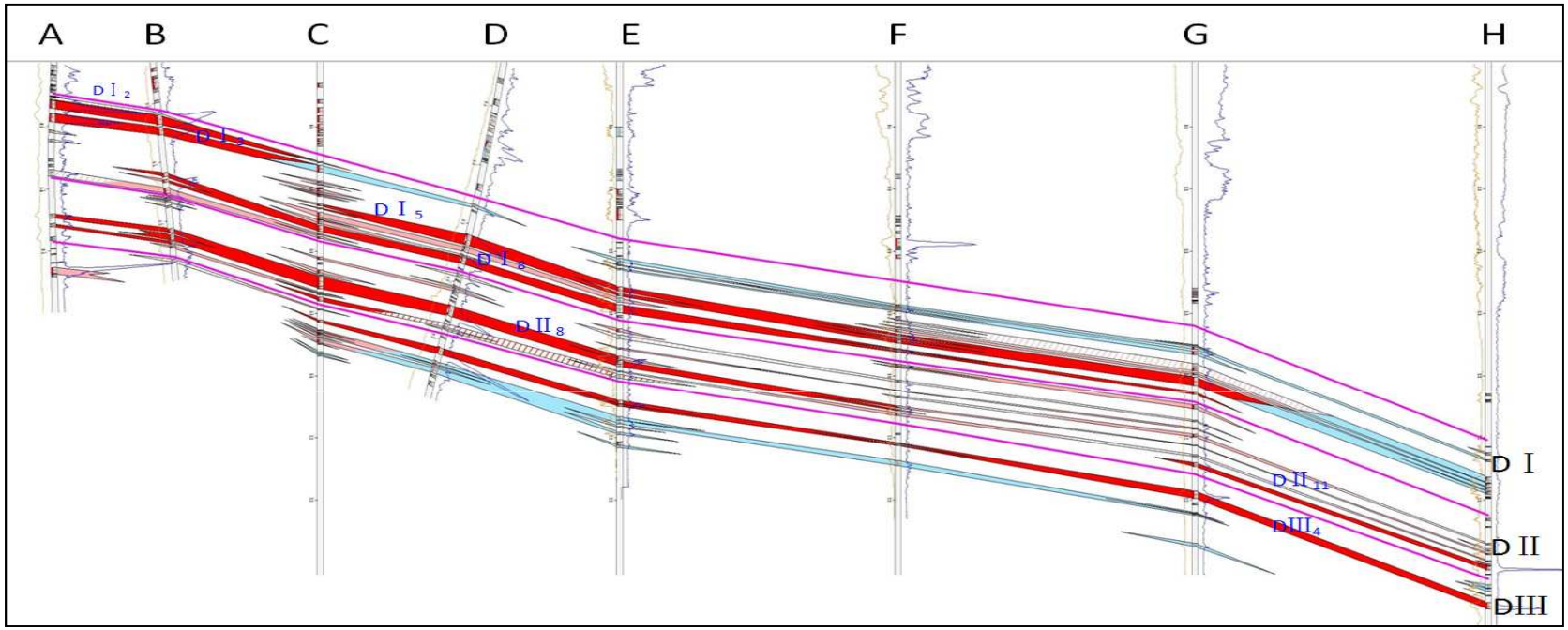
Challenges



- No clear maker above the target formation
- Unconfirmed formation dip, especially the sharp structure change near the fault
- Poor connectivity of the channel sand
- Unstable shaly inter-beds within the target reservoir

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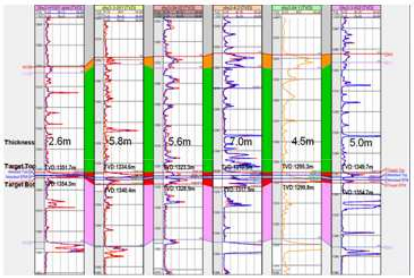
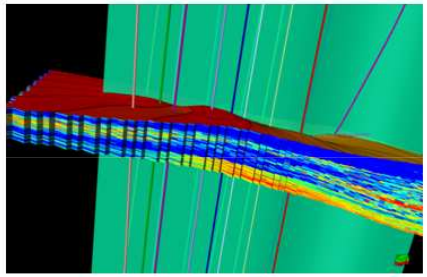
Solutions

Enhance Pre-Job Analysis Workflow

Data analysis
1.Offset well correlation
2.Interpretation result
3.Local structure map and so on

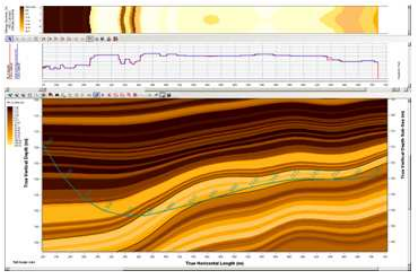


Creating 3D geological model
1.Creat 3D structure model and property model

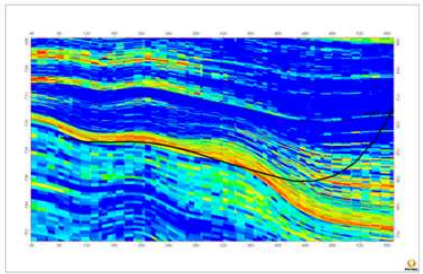


Enhance Pre-job Analysis Workflow

Creating Prejob model
1.Simulate the tool response



Creating vertical section
1.Display structure change
2.Display property change



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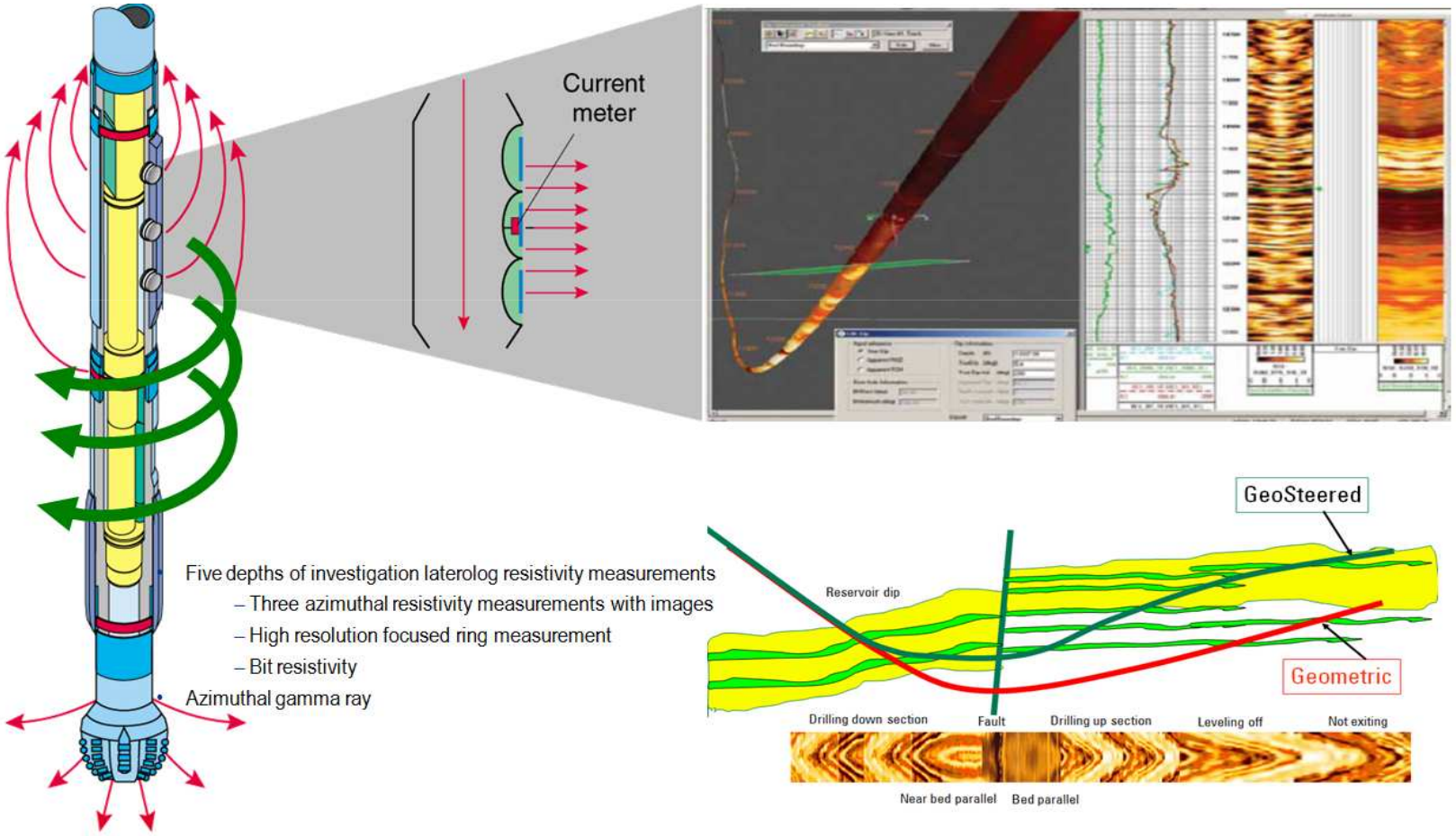
Solutions

Resistivity- and Imaging While Drilling Service



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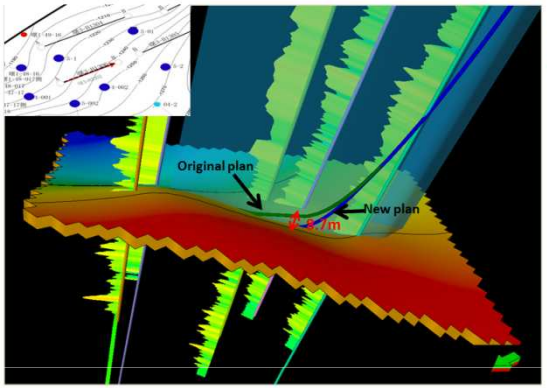
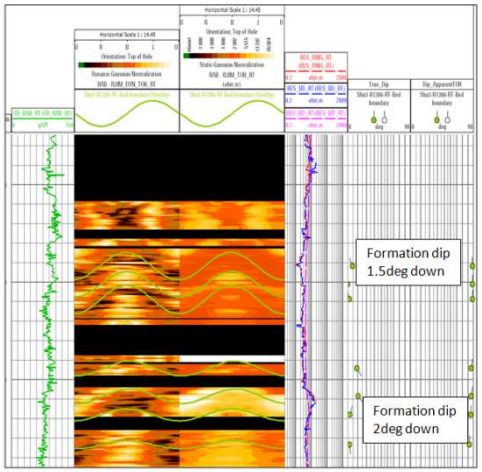
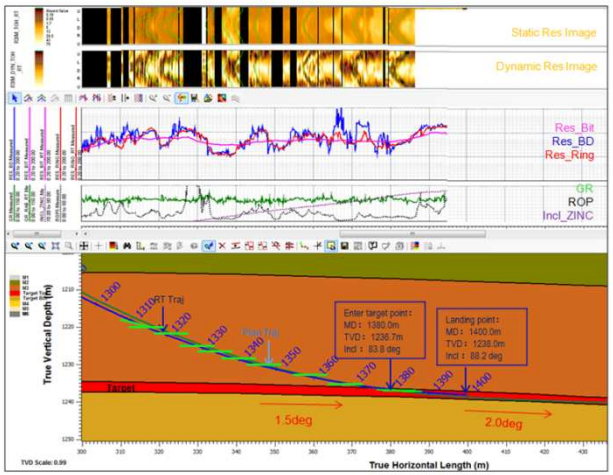
Execution

Case1: Uncertain microstructure, lateral thickness change and unstable inter-beds







Precise Landing

- 3D geological model- especial the structure model
- 2. Real-time formation dip analysis

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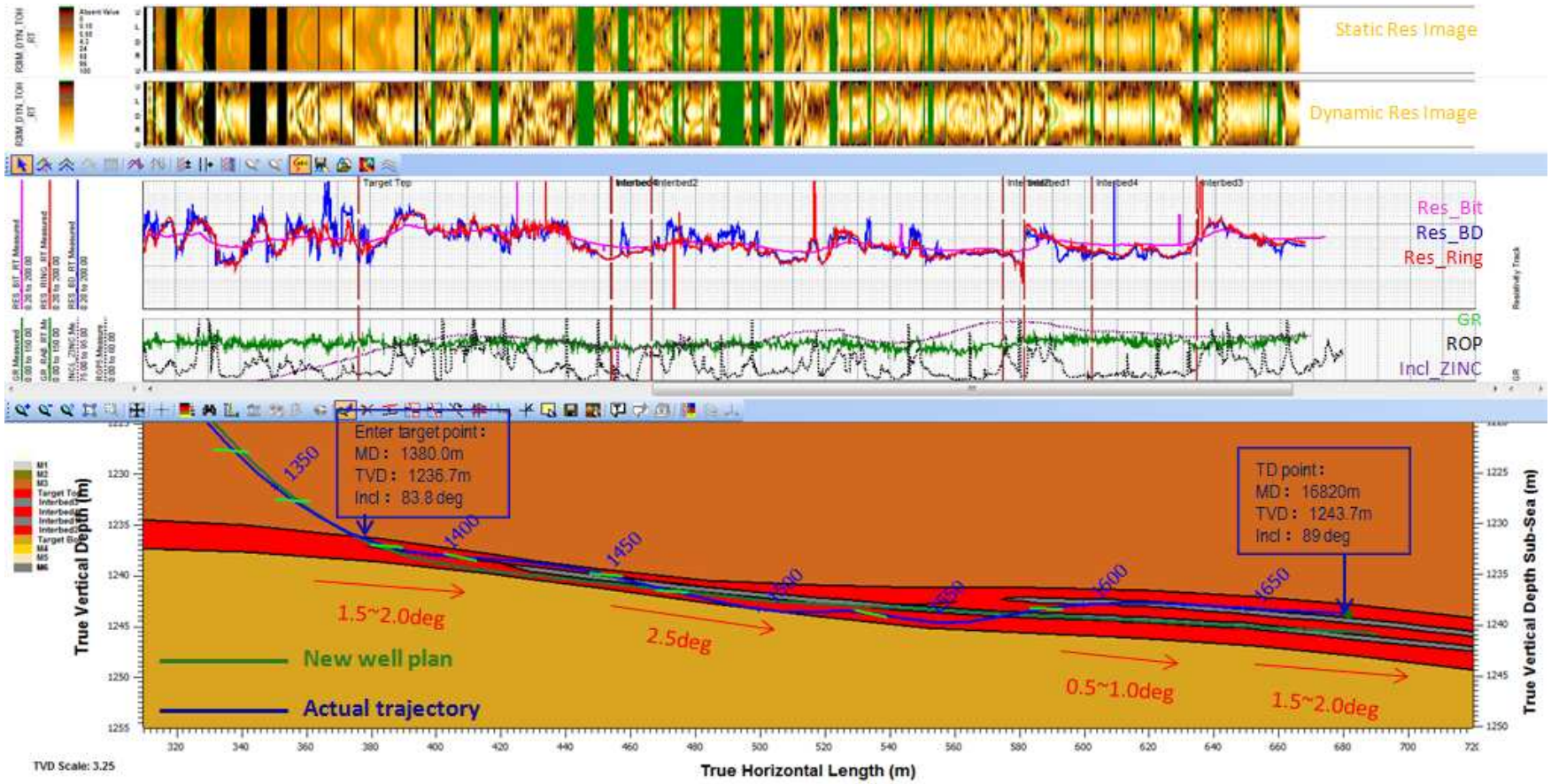
Execution

Case1: Uncertain microstructure, lateral thickness change and unstable inter-beds



Horizontal Section Execution Result

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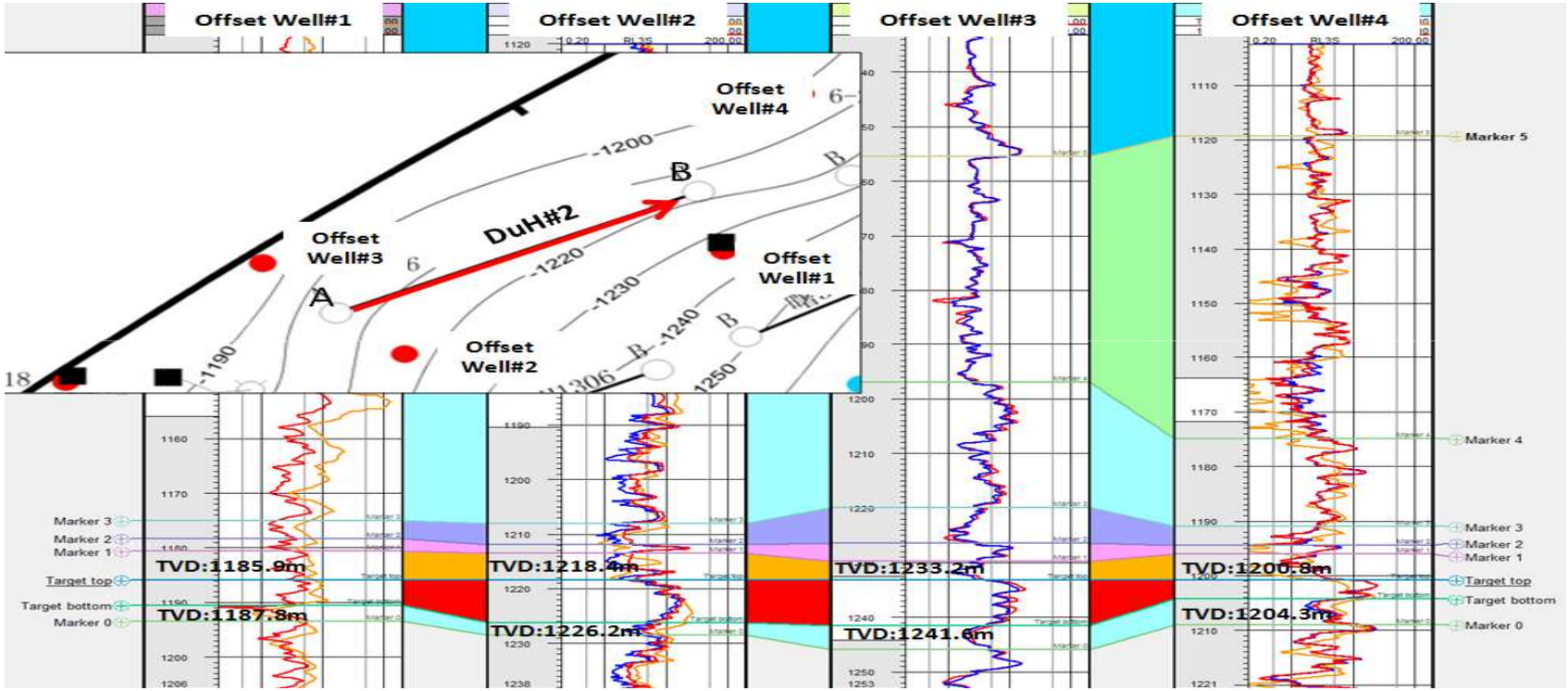
Execution

Case2: Uncertain structure dips, lateral property change or reservoir pinch outs



➢DuH#2 was placed in channel sand with versions property sand, the fault and fewer offset wells add the local structure uncertainty

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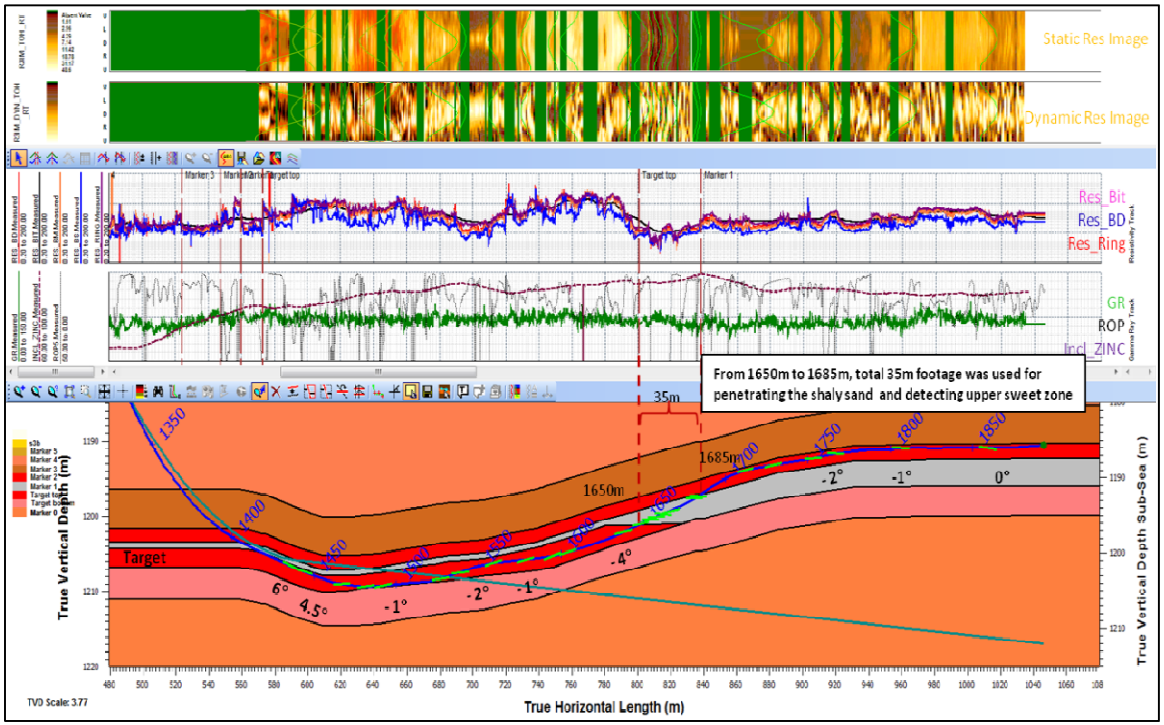
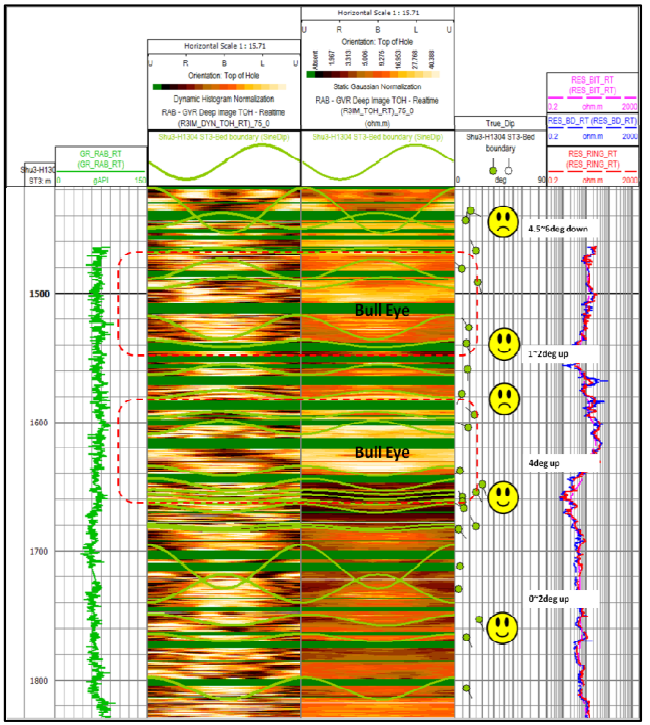
Execution

Case2: Uncertain structure dips, lateral property change or reservoir pinch outs





DuH#2 was placed in two difference sand bodies because of the pinch-out or lateral property change that was met in the middle of the horizontal section, the clear identification and determination of the structural dip enable the accurate model adjustment and avoided sidetracking or reaching TD in advance of the target.

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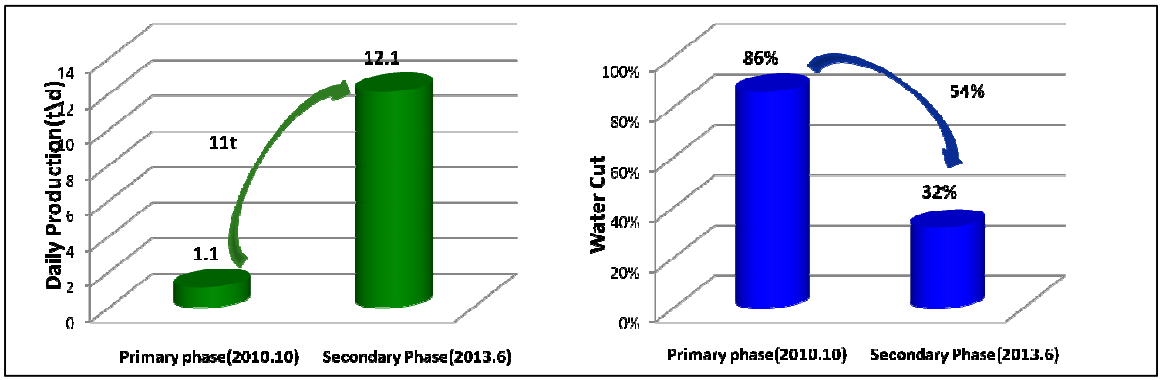
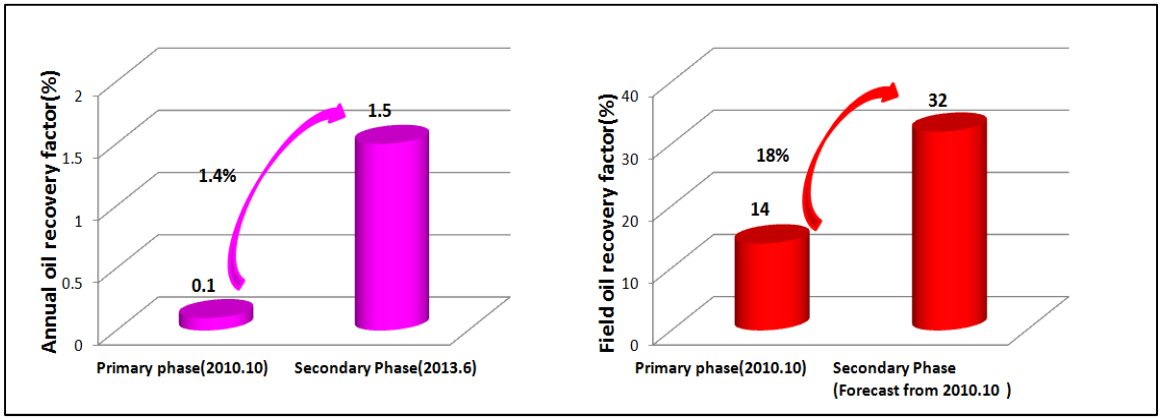
Conclusion

- Daily oil production increased from 1.1t to 12.1 t, and water-cut dropped from 86% to 32%.



- With the new strategy, the annual oil recovery factor increased by more than an order of magnitude and the field oil recovery factor increased by almost one-fifth.



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Conclusion

The ultimate objectives of enhancing the reservoir performance, increasing the production and final recovery factor, and decreasing the water-cut of the Du28 block were achieved successfully. The following factors contributed to this success:

✓Horizontal well producers and injectors that replaced the older vertical-well development strategy optimized the marginal oilfield's secondary development.

✓ The 3D near-well geological model enhanced pre-job analysis and optimized the landing job and supported the lateral section geosteering.

✓Real-time well placements with high resolution resistivity image, along with near-bit measurement were applied for all horizontal wells drilled. High-resolution resistivity image can clearly identify the formation dip along the lateral section in the complex reservoir, even with the local structure uncertainty, uncertain inter-beds, and variations in target zone thickness along the lateral section. The image helps to accurately geosteer the well and places it within the target zone for maximum reservoir contact.

Acknowledgements

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Schlumberger for giving this opportunity to present the result

Thank you for your attention!

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