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IRP06

Addressing The Formation Evaluation Challenges in South Iraq: Re-Writing The Recipe With Advanced Analysis

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SUMMARY

Formation evaluation challenges in mature oilfields of South Iraq are aplenty. From arresting the production decline, to finding that long-lost additional pay; from drilling the wells through the most productive facies to compartmentalize the drain-hole to avoid early water-cut; the advanced log measurements are extremely helpful these days. This work tried to understand the challenges posed by the sub-surface complexities and attempts to find answers through thematic solutions. Geological and petrophysical challenges are mostly attributed to formation heterogeneity and solutions are suggested to address them. Reservoir and production challenges are also influenced by by external agencies like completions and facilities. How various measurements help in answering specific challenges raised in these fields makes the core of this work .



Introduction

South Iraq has been a prolific hydrocarbon province for decades, where the largest oil fields produce mostly from the Cretaceous formations (predominantly carbonates, along with Zubair clastics; Figure-1). Many of these are brown-fields; however, they still have huge amount of oil yet to be produced. Various operators are deploying the advanced technology for secondary and tertiary recovery. Amidst all the efforts to maximize the production, advances in well-logging technology have greatly helped to understand the reservoirs in a better way enabling optimal exploitation. This work attempts to address the formation evaluation challenges, re-writing the recipe in mature fields of South Iraq by identifying the thematic solutions with the help of advanced well-log measurements.



Figure 1 Stratigraphy in Study Area (Middle Jurassic to Middle Cretaceous); After Ibrahim, 1983

The various challenges in these mature fields can be addressed under thematic solutions; such as

- 1. Finding the by-passed oil
- 2. Intelligent compartmentalized completion
- 3. Arresting the production decline
- 4. Exploration in mature field
- 5. Optimizing injection plans
- 6. Stimulation design
- 7. Tertiary recovery plans
- 8. Heterogeneity and diagenesis modelling



The main challenges centre around the fact that the reservoir continuity and heterogeneity still continues to baffle and the models get continuously updated with the dynamic data. Various shoaling upward regressive depositional cycles of carbonates from low energy deep open marine outer-shelf to high energy middle to inner-shelf settings with localized restrictions; coupled with bioturbation and selective diagenesis make the entire subsurface geology very complex; thereby controlling the petrophysical and reservoir properties distribution within the field. For clastics, the predominantly deltaic sandstone reservoirs distribution and geometry is governed by the architectural elements of depositional sub-environments where reservoir properties change abruptly.

To address the various challenges posed by such complex geology, solutions are prepared around the conceived challenges in the sub-surface and the logging technology to address them.

Subsurface Challenges in Formation Evaluation in South Iraq

The formation evaluation subsurface challenges faced in the South Iraq reservoirs have been clubbed under different domains, with the suggested integration of technology. The paper then builds upon these specific answers to address the larger field-wide issues and provide solutions.

- Geological and Petrophysical.
- Reservoir & Production and Well Integrity

Some challenges have been presented in a tabular format, with the advanced wireline measurements solutions. Geological and Petrophysical challenges are the ones controlled directly by subsurface complexities, and need proper characterization.

Geological & Petrophysical	Logging-Based Solution
Optimizing the completion in heterogeneous carbonates	Compartmentalization of drain hole for intelligent completion, capturing the formation heterogeneity/ fractures with borehole images and advanced capture and inelastic spectroscopy and acoustic measurements.
Quantifying the saturation of oil not- yet drained	Cased hole measurements of resistivity, advanced spectroscopy for formation sigma and saturation. Advanced analysis behind casing.
Formation heterogeneities and pore system characterization/porosity portioning.	Image logs and NMR integration to understand the distribution of various pore-size distribution
Sedimentary Analysis and facies characterization/ diagenesis mapping	Borehole image log/ core calibrated facies integrated with advanced spectroscopy, clustering and neural network-based propagation
Well-bore instability, acoustic anisotropy, stress imbalance	Advanced sonic measurements across wide frequency band, for radial profile of compressional and shear
Variable formation water salinity(connate and injection water) and unknown Archie's parameter	Resistivity independent formation evaluation; Saturation computation with Dielectric dispersion and advanced spectroscopy
Grain size distribution, heterogeneity, fluids ability to move, fluids distribution	Bound and free fluid, continuous permeability measurement, radial fluid analysis, continuous fluid typing, fluid diffusion maps at different depths of investigation, multiple independent measurements

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The Reservoir & Production challenges are partly controlled by the subsurface complexities, and partly by the completions and facilities, especially the well-integrity issues are mostly controlled by the factors, external to sub-surface.

Reservoir & Production and Well Integrity	Logging-Based Solution
Fluid Compartment modelling, Partial depletion in heterogeneous layers	Downhole sampling with advanced measurements to model the barriers and compositional variations, express Pressure gradient measurement
Productivity evaluation for wells, Multilayer evaluation	Interval Pressure Transient Analysis with advanced measurements and high precision and accuracy
Water entry points detection and water shutoff planning; Multiphase flow in deviated/ horizontal wells.	Evaluating reservoir saturation and zonal contribution, Probes technology with azimuthal coverage
Completion optimization, Perforation efficiency	Zonal contribution and cross flow evaluation for commingled layers; Evaluating the productivity per zone for different types of guns used
Multi stage cement evaluation, light cement and contamination evaluation	For wells suffering issues in drilling –losses/ washouts, multistage cement is a need, different sheath properties to be evaluated simultaneously
Flow behind pipe evaluation;	While drilling due to losses and for production wells, flow behind pipe required for cement diagnosis.
Multi Pipe inspection for external/internal corrosion	For old wells especially for shallow sections where its multiple casings and would have external corrosion

These challenges are being addressed regularly now; and new thematic solutions are being proposed, re-writing the recipe for formation evaluation in mature fields of South Iraq. Based on the preferred natural flow-path understood from the image logs, injection plans can be optimized. Stimulation designs are planned honouring the stress imbalance magnitude and preferred direction. Advanced analysis behind the casing, coupled with the data from infill wells leads the exploration in mature fields. Diagenetic modelling honouring the heterogeneities helps in placing the well through the best facies, and compartmentalization of drain-hole after smart and oriented perforations.

Summary

This work brainstorms the potential of advanced logging technologies and their optimal combination in South Iraq where production challenges are aplenty and keep on springing surprises for proper evaluation. Understanding the subsurface geology helps in preparing a formation evaluation program; and a synergic multi-domain analysis approach is adopted to ensure high-quality and time-effective formation evaluation for critical decision making.

The benefits of using advanced technologies providing fit-to-purpose and cost effective solutions for successful exploitation are maximized by the thematic solution approach where challenges are understood and addressed with a new recipe of thematic solutions.



Acknowledgements

The authors are grateful to their colleagues at Schlumberger and various operating companies in South Iraq. Numerous discussions with them during operations support helped in shaping up this work. They also acknowledge Schlumberger management for their support.

References

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