[PS]Integrated Case Study from Reservoir Characterization to Improved Well Performance Evaluation in Abnormal HPHT Tight Gas Reservoir*

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Abstract

Productivity evaluation of tight gas reservoir with permeability range from tight (<1 mD) to ultralow (<0.1mD) is crucial especially in deep HPHT reservoir in the South China Sea, as it contributes and feeds the key information to the later well testing plan, the completion design, reserves booking and further development plan. However, the production prediction in such tight formation with HPHT is extremely challenging and under the elevated level of uncertainty, such impact manifest in the four primary areas: (1) operational challenges to acquire the quality data; (2) the multi-controlling factors of reservoir quality; (3) the complex diagenesis and lithology for formation evaluation; (4) the various control parameters for evaluation of water and gas production and high CO_2 concentration across the gas reservoir. HPHT reservoirs became the exploration growing interest in the long-term energy planning in the South China Sea, and the case study from this ambitious exploration campaign investigated 6 wells data. Firstly, from the geological viewpoint, integrated borehole geology and mud logs and core data to understand the depositional micro-facies and sequence and analyze its impact on the reservoir properties. Secondly, formation evaluation based on the conventional and NMR logging was deployed and calibrated with core data and Wireline Formation Testing data to set up the correlations among porosity, permeability, water saturation, NMR bound fluid volume and free fluid volume. Thirdly, water saturation is further characterized utilizing NMR data and core data, and relative permeability model is set up from NMR and Park Jones equation and calibrated by core data. Lastly, integrate all the data and analysis result to build reservoir model for production prediction, and different scaled permeability from open-hole logs, wireline formation testing, and DST are utilized systematically to characterize reservoir heterogeneity. This comprehensive case study elaborated the vital role of integration of all available data to understand the impact of the geology deposition to the formation properties, identify the controlling factors of reservoir properties, analyze the lithological impact on the formation evaluation, and eventually find out the key factors that impact well performance and predict well production in the HPHT tight gas reservoirs. Further on, the case study derives the relationship between reservoir properties, lithology, and production, and minimizes the uncertainty of well productivity evaluation. Finally, it provides the excellent field correlations and workflow for the further exploration activities in HPHT reservoirs in Yingge Hai Basin.

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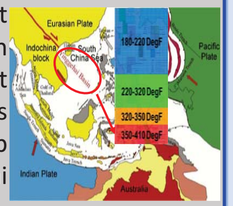
Introduction

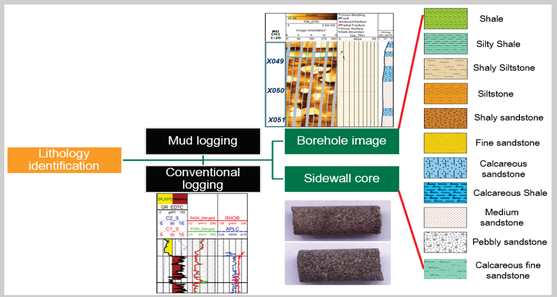


Productivity evaluation of tight gas reservoir in formation with permeability range from tight (<1 md) to ultralow (<0.1md) is challenging especially in deep HPHT reservoir in Yinggehai basin South China sea.

The challenges manifests in the four primary areas:

- Operational challenges to acquire the quality data;
- The multi-controlling factors of reservoir quality;
- The complex diagenesis and lithology for formation evaluation;
- The various control parameters for evaluation of water and gas production and high CO2 concentration across the gas reservoir.

This case study is to integrate all available data and maximize the data value for formation evaluation and further productivity evaluation to minimize the disadvantage that operational difficulties bring such uncertainty.



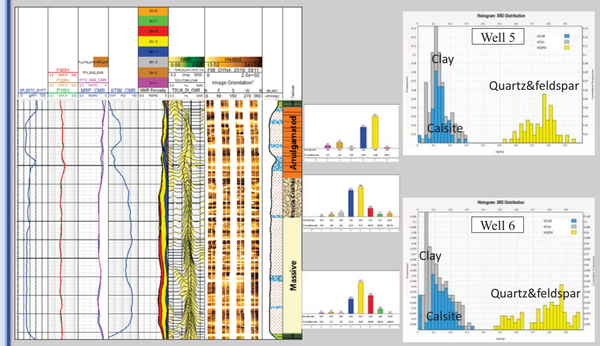
Geological Background

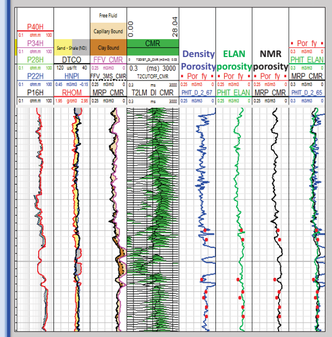
Submarine fan in shallow marine environment: Complex lithology and various occurrence modes of calcite, and different sedimentary sequences of channels impact the reservoir quality.

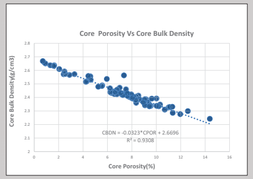
Petrophysical Evaluation

Porosity

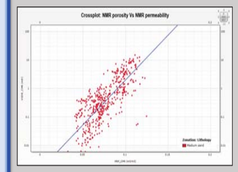
The formation contains more than 10% calcite, and three methods are employed to calculate porosity.

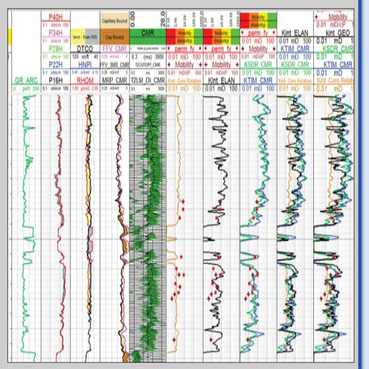


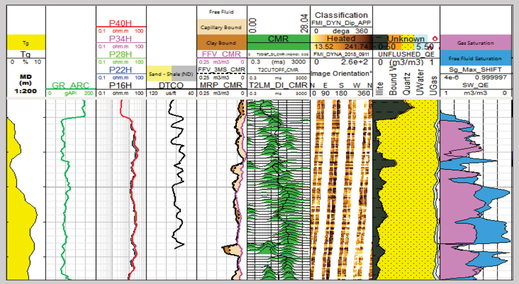




Permeability & Saturation



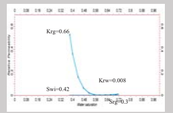


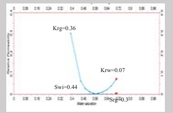


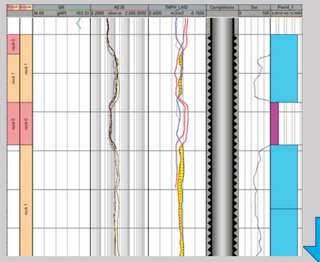
Productivity Evaluation

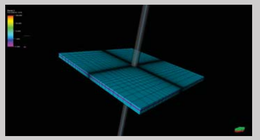
Derived relative permeability model

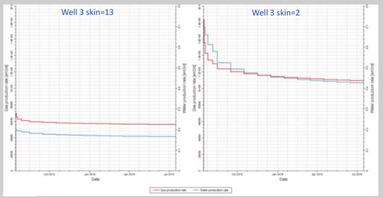
- Estimation of irreducible water saturation Swi, and calibrated with core data if possible. (Timur & Morris and Biggs methods)
- Calculate free water saturation
- Calculate end points of Krw & Krg and plot relative permeability curves (Park Jones and Corey method)











Summary

Integration of all available data is vital to evaluate the reservoir properties and understand the critical parameters that impact the productivity in the HPHT heterogeneous tight gas reservoirs. The methodology provides the solid field correlations and workflow for any new wells where the data is limited due to the complex operation challenges.

From this study, it is suggested of further integration of borehole images and seismic and geology in 3D model to better understand sands distribution; and more quality of core experiments for dynamic analysis including the capillary pressure and the relative permeability are strongly recommended to further calibrate the current relative permeability model.