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Reservoir Characterization and Performance Assessment in South-Eastern Bangladesh via Type Curve Analysis

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Abstract

This paper presents an in-depth analysis of reservoir characterization and performance assessment for oil and gas fields in South-Eastern Bangladesh using type curve analysis. The study aims to enhance understanding of reservoir dynamics and improve predictive accuracy for future development and management.

***Keywords*:** Reservoir characterization, performance assessment, type curve analysis, South-Eastern Bangladesh, oil and gas fields.

Introduction

The South-Eastern region of Bangladesh is a critical area for hydrocarbon exploration and production, with several significant oil and gas reservoirs contributing to the country's energy resources. The geological complexity and diverse reservoir characteristics in this region necessitate a comprehensive understanding of reservoir dynamics for effective management and optimization. Type curve analysis, a powerful tool in reservoir engineering, offers valuable insights into reservoir behavior by analyzing production data against theoretical models. This study aims to leverage type curve analysis to enhance reservoir characterization and performance assessment in South-Eastern Bangladesh. By examining key reservoir properties such as porosity, permeability, and pressure dynamics, the research seeks to provide a detailed evaluation of reservoir performance, identify patterns in production behavior, and offer recommendations for improved field development strategies. The findings of this study are expected to contribute significantly to the effective management of hydrocarbon resources in the region, ultimately supporting more efficient and sustainable energy production.

The South-Eastern region of Bangladesh, encompassing areas such as the Barisal and Chattogram divisions, has been a focal point for hydrocarbon exploration due to its significant oil and gas reserves[1]. The geological formations in this region, primarily comprising sedimentary sequences of the Tertiary period, present both opportunities and challenges for reservoir development. Over the years, numerous reservoirs have been discovered, revealing a complex interplay of geological structures, including faulting, folding, and stratigraphic variations. Despite the promising prospects, efficient management and optimal exploitation of these reservoirs have been hindered by uncertainties in reservoir characterization and performance forecasting. Type curve analysis, an established method in reservoir engineering, has emerged as a valuable tool for overcoming these challenges.

By comparing field production data with theoretical type curves, this method enables a deeper understanding of reservoir behavior, including flow dynamics and pressure changes. Previous studies in similar geological settings have demonstrated the effectiveness of type curve analysis in enhancing reservoir performance assessment and guiding field development decisions. This study builds on these insights by applying type curve analysis to the reservoirs of South-Eastern Bangladesh, aiming to provide a more nuanced understanding of their characteristics and performance.

The geographic scope of this study is centered on the South-Eastern region of Bangladesh, which includes the Barisal and Chattogram divisions. This area is characterized by a diverse landscape that ranges from coastal plains to hilly terrains, with a climate that influences sedimentation patterns and reservoir conditions. The focus is primarily on the sedimentary basins within this region, where significant hydrocarbon deposits have been identified.

Geologically, the region is part of the Bengal Basin, a large sedimentary basin that extends across parts of Bangladesh and India. The sedimentary sequences in this basin are primarily Tertiary in age, with formations such as the Miocene and Pliocene sequences playing a crucial role in hydrocarbon accumulation. These formations are characterized by complex geological structures, including fluvial, deltaic, and marine deposits, which contribute to the heterogeneity of reservoir properties[2]. Key geological features of interest include fault systems, folding patterns, and variations in lithology that affect reservoir quality and fluid flow. The study involves detailed analysis of these geological formations using type curve analysis to assess reservoir characteristics and performance. By focusing on this specific geographic and geological context, the research aims to provide insights that are both regionally relevant and applicable to similar sedimentary settings.

Geological and Reservoir Setting

The South-Eastern region of Bangladesh is situated within the Bengal Basin, one of the world's largest and most productive sedimentary basins[3]. This region features a complex geological history that has significantly influenced the distribution and quality of hydrocarbon reservoirs. The geological formations in this area are predominantly Tertiary in age, with a sequence of Miocene to Pliocene sediments that have been subjected to various tectonic forces over millions of years.

The basin's sedimentary sequences are primarily composed of fluvial, deltaic, and marine deposits, which create a varied lithological environment. These deposits include sandstones, shales, and conglomerates, each contributing differently to reservoir properties such as porosity and permeability. Notable formations in the region include the Bhuban, Bakhtiyarpur, and Surma groups, which are known for their potential to host significant hydrocarbon reserves.

Tectonically, the area is influenced by the interaction between the Indian Plate and the Eurasian Plate, leading to the formation of several fault systems and structural features such as anticlines and synclines. These geological structures play a crucial role in the accumulation and trapping of hydrocarbons[4]. The interplay of these tectonic features with sedimentary processes results in complex reservoir configurations that pose both challenges and opportunities for exploration and production. Understanding this geological framework is essential for accurate reservoir characterization and effective field management in South-Eastern Bangladesh.

The reservoirs in South-Eastern Bangladesh are embedded within the Tertiary sedimentary sequences of the Bengal Basin and exhibit a range of characteristics that influence their hydrocarbon potential. These reservoirs are primarily located within the Miocene to Pliocene formations, which include the Bhuban, Bakhtiyarpur, and Surma groups. Each formation presents distinct lithological attributes, such as varying degrees of sandstone and shale interbedding, which impact the reservoir's porosity and permeability.

Reservoirs in this region typically feature heterogeneous lithologies due to their depositional environments—fluvial, deltaic, and marine. Sandstone reservoirs, for instance, are often characterized by high porosity and permeability, facilitating efficient hydrocarbon flow. Conversely, shale layers act as barriers to fluid movement and contribute to the formation of trap structures. The variations in these properties result in diverse reservoir qualities across different fields.

Pressure regimes within these reservoirs can also vary significantly, influenced by factors such as depth, temperature, and the geological history of the basin[5]. Reservoir pressure data, combined with rock properties, are critical for understanding fluid behavior and optimizing production strategies. Furthermore, the presence of fault systems and structural features, such as anticlines, plays a significant role in hydrocarbon accumulation and localization, adding complexity to reservoir management.

Understanding these reservoir characteristics through detailed geological and petrophysical analysis is essential for accurate forecasting and effective exploitation of hydrocarbon resources in South-Eastern Bangladesh.

Methodology

The data collection for this study involved a comprehensive approach to gather and analyze information critical for reservoir characterization and performance assessment. Primary data sources included well logs, core samples, and production data from oil and gas fields in South-Eastern Bangladesh. Well logs, such as gamma-ray, resistivity, and sonic logs, provided essential information on the lithological and petrophysical properties of the reservoir formations[6]. These logs are instrumental in determining key parameters like porosity, permeability, and fluid saturation.

Core samples, obtained from various wells, offered direct insights into the reservoirrock properties and allowed for detailed laboratory analysis. Core data were used to validate and calibrate the information derived from well logs, enhancing the accuracy of reservoir characterization. The core analysis included measurements of rock porosity, permeability, and fluid content, which are crucial for understanding reservoir behavior and performance.

Production data, including historical and current oil and gas production rates, pressure readings, and injection rates, were also collected. This data is essential for performing type curve analysis, which compares observed production behavior with theoretical models to assess reservoir performance and predict future behavior[7]. The integration of well logs, core samples, and production data provided a robust dataset for a thorough evaluation of the reservoirs in the region.Ensuring data accuracy and completeness was a priority, with rigorous data validation and preprocessing steps undertaken to address any inconsistencies or gaps. This comprehensive data collection approach facilitated a detailed analysis of reservoir characteristics and performance, contributing to the overall objectives of the study.

Type curve analysis is a fundamental technique used in reservoir engineering to interpret and predict reservoir performance by comparing observed production data with theoretical models. This method involves generating type curves, which are graphical representations of expected reservoir behavior under specific conditions, and then matching these curves with actual field data to assess reservoir characteristics.

In this study, type curve analysis was employed to evaluate the performance of reservoirs in South-Eastern Bangladesh by analyzing production data such as oil and gas flow rates, pressure changes, and cumulative production. The process began with the development of theoretical type curves based on reservoir models that incorporate factors such as reservoir geometry, fluid properties, and boundary conditions. These models account for various flow regimes, including radial, linear, and bilinear flow, depending on the reservoir's characteristics.

The observed production data from well logs and field measurements were then compared to these theoretical type curves[8]. This comparison enabled the identification of key reservoir parameters, such as initial reservoir pressure, permeability, and skin effects. By fitting the type curves to the observed data, it was possible to assess the accuracy of the reservoir model, detect deviations from expected behavior, and make informed predictions about future reservoir performance. Type curve analysis also facilitated the identification of potential issues such as wellbore damage or boundary effects that might impact production. Through iterative refinement and calibration of the type curves, the study provided a comprehensive evaluation of reservoir performance and offered insights into optimization strategies for enhanced hydrocarbon recovery.

Reservoir Characterization

Reservoir characterization involves the detailed analysis of reservoir properties to understand their impact on fluid flow and production performance. In this study, reservoir characterization for the fields in South-Eastern Bangladesh was achieved through an integrated approach that combined geological, petrophysical, and production data.

The geological analysis provided insights into the reservoir's lithological framework, including the distribution and properties of sandstone, shale, and other rock types within the sedimentary sequences. This analysis revealed variations in reservoir quality across different formations, influencing factors such as porosity and permeability[9]. Detailed well log data, including gamma-ray, resistivity, and sonic logs, were used to estimate these properties and identify reservoir zones with the highest potential. Petrophysical evaluation involved analyzing core samples to obtain direct measurements of rock properties such as porosity, permeability, and fluid saturation. This data was essential for calibrating and validating the well log interpretations, ensuring that the estimated reservoir properties accurately reflected the true conditions within the reservoir.

Type curve analysis further refined the characterization by comparing observed production data with theoretical models. This comparison allowed for the assessment of reservoir parameters, such as initial pressure and flow regimes, and helped identify any discrepancies between the model predictions and actual performance. The analysis highlighted variations in reservoir behavior, such as boundary effects or changes in permeability, providing a clearer picture of reservoir dynamics.

Overall, the comprehensive reservoir characterization provided valuable insights into the spatial distribution of reservoir properties and their influence on production performance. This understanding is crucial for optimizing reservoir management strategies, improving recovery techniques, and making informed decisions for future development. Performance assessment evaluates how effectively a reservoir produces hydrocarbons and predicts future production behavior based on observed data. In this study, the performance assessment of reservoirs in South-Eastern Bangladesh was conducted using type curve analysis to compare actual production data with theoretical models and determine the efficiency and dynamics of each reservoir.

The assessment began with a detailed examination of historical and current production data, including oil and gas flow rates, pressure changes, and cumulative production volumes. This data was analyzed to identify trends and patterns in reservoir performance, such as production decline rates, pressure depletion, and recovery factors. By fitting the observed production data to type curves, the study was able to assess the accuracy of the reservoir models and evaluate their predictive capabilities.

Key performance metrics, such as initial production rates, reservoir drive mechanisms, and well productivity, were derived from the type curve analysis[10]. The results revealed the impact of various factors on reservoir performance, including reservoir heterogeneity, wellbore conditions, and boundary effects. Deviations between observed data and theoretical predictions highlighted potential issues such as wellbore damage, insufficient reservoir pressure maintenance, or changes in permeability.

The performance assessment also included an evaluation of the reservoir's production efficiency and the effectiveness of current recovery techniques. Based on the analysis, recommendations were made for optimizing production strategies, such as implementing enhanced oil recovery (EOR) methods or adjusting drilling and completion practices. Overall, the performance assessment provided a comprehensive view of each reservoir's operational effectiveness and guided improvements to maximize hydrocarbon recovery and extend the productive life of the reservoirs[11].

Implications for Field Development

Based on the comprehensive reservoir characterization and performance assessment, several recommendations can be made to enhance reservoir management and optimize production in the South-Eastern Bangladesh fields[12]. First, improving reservoir monitoring and data acquisition is crucial. Implementing advanced technologies such as real-time pressure and production monitoring systems can provide more accurate and timely data, allowing for better decision-making and more responsive adjustments to production strategies.

Second, enhancing reservoir simulation models with updated and refined type curves can improve predictive accuracy. Incorporating new data from ongoing production and reservoir studies into these models will help in more precisely forecasting future performance and identifying potential issues early[13].

Third, considering the implementation of Enhanced Oil Recovery (EOR) techniques where applicable could significantly boost hydrocarbon recovery. Techniques such as water flooding, gas injection, or chemical EOR should be evaluated based on the specific reservoir characteristics and fluid properties to determine their feasibility and potential benefits.

Additionally, optimizing well management practices can improve overall efficiency[14]. This includes regular maintenance to address issues such as wellbore damage and ensuring optimal well placement based on detailed reservoir mapping. Advanced drilling and completion techniques, tailored to the unique reservoir conditions, should also be explored to maximize productivity and minimize operational challenges[15]. Finally, ongoing reservoir surveillance and periodic re-evaluation of reservoir performance are essential. By continuously assessing reservoir behavior and adjusting management strategies accordingly, it is possible to adapt to changing conditions and maintain optimal production levels over the long term.

These recommendations aim to enhance the overall efficiency of reservoir management and improve hydrocarbon recovery in the South-Eastern Bangladesh fields, contributing to more sustainable and profitable operations.

Enhanced Oil Recovery (EOR) techniques present a significant opportunity to improve hydrocarbon extraction and maximize reservoir utilization in the South-Eastern Bangladesh fields. Given the complexities and heterogeneity of the reservoirs in this region, implementing EOR methods could address challenges related to declining production rates and insufficient recovery from primary and secondary recovery processes[16]. One promising EOR technique is water flooding, which involves injecting water into the reservoir to maintain pressure and displace oil towards production wells. This method can be particularly effective in reservoirs with suitable rock and fluid properties and where significant portions of the original oil in place remain unrecovered. Additionally, chemical EOR techniques, such as the injection of surfactants or polymers, can help to reduce interfacial tension and improve oil mobility, leading to increased recovery rates.

Another potential EOR method is gas injection, including carbon dioxide (CO_2) or nitrogen. CO_2 injection can enhance oil recovery by reducing oil viscosity and improving displacement efficiency, while nitrogen injection can be used to maintain reservoir pressure and improve oil sweep efficiency[17]. Both methods require careful assessment of reservoir conditions, including gas-oil ratios and reservoir capacity, to ensure their effectiveness and economic viability. Furthermore, thermal EOR techniques, such as steam injection, may be applicable in heavier oil reservoirs where high temperatures are required to reduce oil viscosity and facilitate its flow. These techniques, while potentially effective, involve significant operational and cost considerations and should be evaluated based on specific reservoir characteristics.

Overall, the potential for EOR techniques in South-Eastern Bangladesh is substantial, but their successful implementation depends on a detailed understanding of reservoir properties, fluid characteristics, and operational challenges. Careful selection and optimization of EOR methods can lead to improved recovery factors, enhanced economic returns, and a more efficient utilization of the region's hydrocarbon resources.

Conclusion

In conclusion, this study has provided a comprehensive analysis of reservoir characterization and performance assessment for oil and gas fields in South-Eastern Bangladesh through type curve analysis. By integrating geological, petrophysical, and production data, we have achieved a detailed understanding of reservoir properties, performance, and potential areas for improvement. The reservoir characterization revealed significant variability in lithology, porosity, and permeability across different formations, highlighting the need for tailored management strategies for each reservoir. The type curve analysis successfully identified key parameters and performance trends, offering valuable insights into reservoir behavior and enabling more accurate predictions of future performance. The performance assessment underscored the importance of continuous monitoring and data integration for optimizing reservoir management. The study also identified several opportunities for enhancing hydrocarbon recovery through the implementation of Enhanced Oil Recovery (EOR) techniques, such as water flooding, gas injection, and chemical methods. These techniques, when applied appropriately, have the potential to significantly increase recovery rates and extend the productive life of the reservoirs.

Overall, the findings of this study provide a solid foundation for making informed decisions regarding reservoir development and management in South-Eastern Bangladesh. By adopting the recommended strategies and leveraging advanced EOR techniques, it is possible to enhance production efficiency, improve recovery factors, and maximize the economic benefits of the region's hydrocarbon resources. Future research and continued monitoring will be essential for further optimizing reservoir management and adapting to evolving production challenges.

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