Jurnal Jaring SainTek
Vol.6, No.2, Oktober 2024, pp. 57 - 64
e-ISSN : 2656-9485

Optimization Of Hydrocarbon Exploration And Production Through Geophysical Data Integration And Reservoir Model Validation

Citra Wahyuningrum*[1]
[1]Program Studi Teknik Perminyakan, Fakultas Teknik, Universitas Bhayangkara Jakarta Raya, Jakarta, Indonesia
e-mail: [1*]**citra.wahyuningrum@dsn.ubharajaya.ac.id**

Abstract
Hydrocarbon exploration and production are complex processes that require a deep understanding of reservoir geological characteristics. This study focuses on production geological analysis as the main foundation in understanding hydrocarbon reservoir behavior. This study combines geological data with advanced technology to map reservoirs, model fluids, and simulate production, which in turn provide better insights into reservoir behavior. The main objectives of this study are to analyze the geological characteristics that affect reservoir behavior, develop new exploration methods, and validate geological models with actual production data. Validation of geological models and integration of actual production data are emphasized as essential steps to achieve accurate production prediction, optimal reservoir management, and appropriate decision making. The results of this study indicate that the integration of geological data and actual production not only improves the accuracy of production prediction but also enables continuous monitoring of reservoir performance, which is the main foundation in maintaining the sustainability of hydrocarbon resource exploration and management.

Keywords : *Production Geology, Hydrocarbon Exploration, Geological Models*

Abstrak
Eksplorasi dan produksi hidrokarbon merupakan proses kompleks yang memerlukan pemahaman mendalam tentang karakteristik geologi reservoir. Studi ini berfokus pada analisis geologi produksi sebagai landasan utama dalam memahami perilaku reservoir hidrokarbon. Studi ini menggabungkan data geologi dengan teknologi canggih untuk memetakan reservoir, memodelkan fluida, dan mensimulasikan produksi, yang pada gilirannya memberikan wawasan yang lebih baik tentang perilaku reservoir. Tujuan utama dari studi ini adalah untuk menganalisis karakteristik geologi yang memengaruhi perilaku reservoir, mengembangkan metode eksplorasi baru, dan memvalidasi model geologi dengan data produksi aktual. Validasi model geologi dan integrasi data produksi aktual ditekankan sebagai langkah penting untuk mencapai prediksi produksi yang akurat, manajemen reservoir yang optimal, dan pengambilan keputusan yang tepat. Hasil studi ini menunjukkan bahwa integrasi data geologi dan produksi aktual tidak hanya meningkatkan akurasi prediksi produksi tetapi juga memungkinkan pemantauan berkelanjutan terhadap kinerja reservoir, yang merupakan landasan utama dalam menjaga keberlanjutan eksplorasi dan manajemen sumber daya hidrokarbon.

Kata Kunci: Geologi Produksi, Eksplorasi Hidrokarbon, Model Geologi

PENDAHULUAN

Hydrocarbon resources such as oil and natural gas have been the main drivers of the global economy, however, in recent decades,

the industry has seen increasing pressure. Declining easily extracted reserves, demands for more sustainable extraction practices, and a global shift towards renewable energy are challenges that must be overcome.

Production geology analysis offers an essential foundation for understanding the behavior of hydrocarbon reservoirs in terms of production. A thorough understanding of

Submitted: **18/10/2024**; Revised: **24/10/2024**; Accepted: **30/10/2024**; Published: **31/10/2024**

geological characteristics, such as rock properties, reservoir structure, pressure changes, and fluid migration, is key to optimizing hydrocarbon production. This is not only essential for accurately estimating production potential, but also for designing efficient production strategies to maximize resource recovery and minimize environmental impacts.(Smith, 2019)

The involvement of advanced technologies in reservoir mapping, fluid modeling, and production simulation is becoming increasingly important. The combination of geological data with advanced technologies provides better insight into reservoir behavior, enabling the development of smarter and more sustainable production strategies.

With a deep understanding of the geological factors that influence hydrocarbon production, production geology analysis is a critical foundation in addressing the complexity of today's energy industry challenges, while maintaining a balance between environmental sustainability and global energy needs.

This study aims to analyze the geological characteristics that affect the behavior of hydrocarbon reservoirs, develop new exploration methods and techniques based on better geological understanding, and validate geological models and reservoir simulations with actual production data to improve the accuracy of production predictions.

Reservoir geology is a branch of geology that focuses on the study of geological formations that hold the Earth's oil, gas, and water commercially. Research in this field focuses on understanding the structure, physical properties, and characteristics of the rocks that form hydrocarbon reservoirs.

Through in-depth analysis of porosity, permeability, layer thickness, and rock distribution and types, reservoir geologists aim to understand the potential for hydrocarbon storage and production.(Johnson & Garcia, 2020)

Understanding reservoir geology is essential in identifying potential hydrocarbon reservoir locations. For example, the presence of rock formations with high porosity and permeability is crucial because it allows the rock to store and transmit hydrocarbons efficiently.

Understanding the geological structure also helps in identifying target zones that may have significant hydrocarbon accumulations. Factors such as folding, faulting, and dipping of geological formations are also important considerations in describing reservoir behavior and directing exploration and production activities.

Migration and accumulation of hydrocarbons are key processes in the life cycle of oil and gas. Migration refers to the movement of hydrocarbons from their source to the reservoir that ultimately holds and stores them.

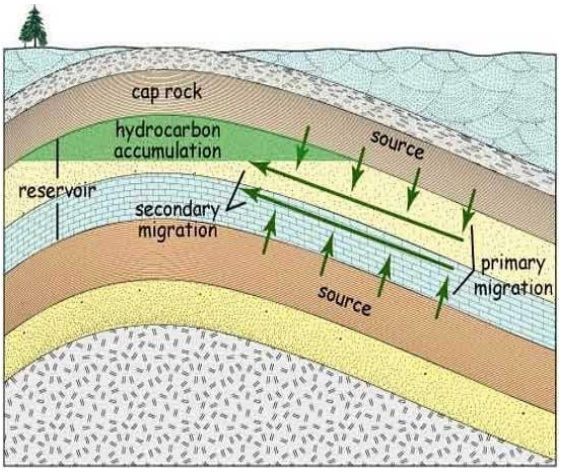

Figure 1. Petroleum System

This process involves the movement of hydrocarbon fluids (oil, gas, and sometimes water) through permeable rock layers to an area of accumulation. The source of hydrocarbons can be a layer of organic rock that has been transformed into oil and gas (e.g., shale or other sedimentary rocks) under pressure and heat. This process is known as hydrocarbon generation. Once formed, the hydrocarbons move through pores and fractures in the rock through the process of migration.

Migration occurs due to differences in pressure, capillary forces, and hydrostatic pressure gradients in rock layers. Hydrocarbons can migrate in permeable reservoir rocks, or through relatively impermeable rock layers that have fractures or faults that allow fluid movement. Hydrocarbon accumulation occurs when the migration process directs hydrocarbons to areas where geological and structural

conditions allow significant storage. This occurs in areas where reservoir rocks have favorable properties, such as sufficient porosity to store hydrocarbons and an impermeable cover that prevents hydrocarbons from continuing to move.(Johnson & Garcia, 2020)

Reservoir fluid behavior refers to the physicochemical properties of hydrocarbon fluids (such as oil, gas, and water) under reservoir conditions. A thorough understanding of these fluid behaviors is essential because it

affects the way in which they interact, move, and are produced in the reservoir environment. Some important factors related to fluid behavior in reservoirs are:

1. Viscosity
2. Permeability and Porosity
3. Pressure and Temperature
4. Fluid Mobility
5. Fluid Interactions

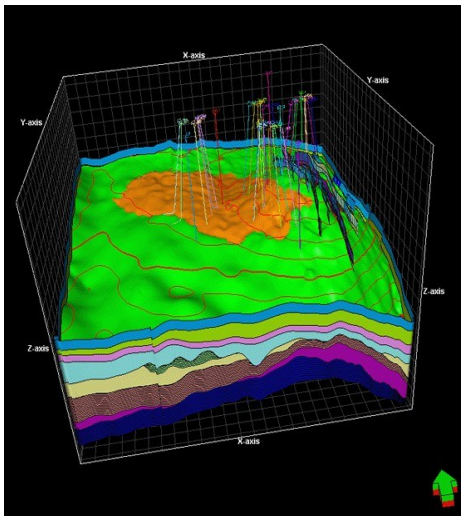

Figure 2. 3D Model of Reservoir Simulation

Reservoir modeling and simulation techniques are mathematical and computational approaches used to represent the complex behavior of hydrocarbon reservoirs on a scale that can be analyzed. This approach involves the use of specialized software that utilizes geological data, fluid physics, and field production information to build a numerical model that reflects the actual conditions within the reservoir. In the modeling process, factors such as geological structure, rock properties, fluid distribution, and production parameters, such as pressure and temperature, are integrated into a complex mathematical model.

This model is then simulated to predict the behavior of the reservoir under various production scenarios and different geological conditions. This process allows engineers to test alternative production strategies, estimate future production rates, and identify areas where production efficiency can be improved.(Li, 2019)

Reservoir simulation also allows the evaluation of reservoir performance over time, taking into account aspects of production sustainability. By utilizing actual production data, models can be updated and adjusted to improve prediction accuracy and design more effective measures in reservoir management.

METODE PENELITIAN

The methodology of this research is by summarizing references from several previous research journals related to this production geology analysis. This research uses a thought process according to the following flowchart.

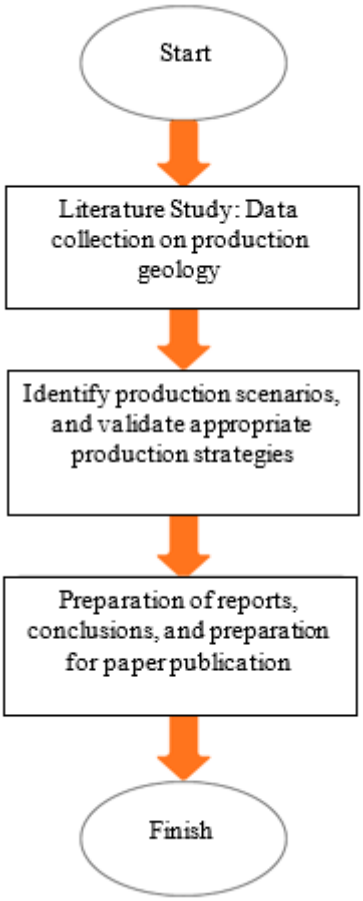

Figure 3 Research Methodology

Submitted: **18/10/2024**; Revised: **24/10/2024**; Accepted: **30/10/2024**; Published: **31/10/2024**

HASIL DAN PEMBAHASAN

The analysis results of the three journals highlight the important role of geological characteristics in influencing the behavior of hydrocarbon reservoirs and oil and gas exploration efforts utilizing new techniques. Although the journals provide insights into geological characteristics and the application of new exploration methods such as gravity, validation of geological models and reservoir simulations with actual production data is still a point that needs to be explored further.

In particular, an emphasis on the integration of actual production data into geological models and the use of advanced simulation tools is needed to improve the accuracy of hydrocarbon production predictions and optimize future reservoir management.

The importance of geological model validation and actual production data integration is not just an additional step, but a crucial one in facing the challenges of oil and gas exploration. This validation can provide a stronger foundation for predicting hydrocarbon reservoir behavior, help evaluate and refine models used in simulations, and enable more informed decisions in managing oil and gas resources.

By utilizing advanced simulation technology, the oil and gas industry can better understand reservoir complexity minimize

investment risks, and optimize sustainable production strategies. The integration of actual data also allows continuous monitoring of reservoir performance, provides a deeper understanding of changes that occur over time, and allows for more responsive adaptation of management strategies.

Therefore, focusing on geological model validation and actual production data integration is not just an additional step, but a key foundation in maintaining sustainable oil and gas exploration and effective management of hydrocarbon resources.

Table 1 Article Review

No	Journal Title	Analysis Result
1	The Role of Geology in Hydrocarbon Systems and the Potential and Challenges of Oil and Gas Exploration in Indonesia(Yudi Tryono, 2016)	In the mentioned journal, there are several aspects related to geological characteristics that affect the behavior of hydrocarbon reservoirs, new exploration methods and techniques, and validation of geological models and reservoir simulations with actual production data. Here is a summary of some relevant research results: Geological Characteristics and Hydrocarbon Reservoir Behavior: Research is focused on identifying the characteristics of unconventional oil and gas potential based on chemical, physical properties, and their relationship. This includes the development of seismic character analysis to better understand the behavior of hydrocarbon reservoirs. New Exploration Methods and Techniques: Pre-tertiary petroleum system research involves integrating the results of joint pre-tertiary studies in the Western Indonesia Region (KBI) and Eastern

		Indonesia Region (KTI) areas. This includes the use of new techniques such as Passive Seismic Tomography, Magnetotellurics, and Gravity to explore hydrocarbon potential. In addition, marine seismic surveys using air guns as a source of vibrations to identify oil and gas reserve prospects are also techniques used in exploration. Geological Model Validation and Reservoir Simulation: Although not explicitly mentioned in the given quote, validation of geological models and reservoir simulations is usually done by comparing the simulation results with actual production data. This is important to improve the accuracy of production predictions. In the context of oil and gas exploration in Indonesia, the results of exploration well drilling are used as a reference for field development, which includes the preparation of production facility infrastructure. This process involves using actual data to validate and refine geological models and reservoir simulations.
2	Identification of Subsurface Structures Based on Gravity Data Analysis in the Palembang Area and Surrounding Areas as Potential Hydrocarbon Basins(Mirnanda et al., 2023)	Research conducted in the Palembang area and its surroundings has identified geological characteristics that affect the behavior of hydrocarbon reservoirs through 2D and 3D modeling using gravity data. These geological characteristics include the identification of reservoir zones located in the Talang Akar Formation with a depth of around 4000 meters to 5000 meters below the surface, which has a density value of around 2.35 g/cm³. Rocks with a density value between 2.35 g/cm³ to 2.40 g/cm³ are identified as seal rocks that are effective in trapping hydrocarbons, in the form of shale. New exploration methods and techniques used in this study include Second Vertical Derivative (SVD) analysis and 3D gravity inversion modeling. SVD is used to identify fault structures such as normal faults and reverse faults, which are important aspects in understanding the behavior of hydrocarbon reservoirs. 3D gravity inversion modeling provides a more detailed picture of the

Submitted: **18/10/2024**; Revised: **24/10/2024**; Accepted: **30/10/2024**; Published: **31/10/2024**

	reservoir zone with density values between 2.31 g/cm³ to 2.53 g/cm³. However, in the sources provided, there is no specific information regarding the validation of geological models and reservoir simulations with actual production data to improve the accuracy of production predictions. This study focuses more on the identification of basin structures and hydrocarbon potential based on geophysical modeling rather than the integration of production data into geological models and reservoir simulations. For further information on validating geological models and reservoir simulations with actual production data, other more specific sources on the topic should be consulted.	3	Application of Gravity Method Approach in Hydrocarbon Exploration: Subsurface Geology Study North East Java Basin Area, Lamongan Segment(Gaol et al., 2009)	The research presented in the cited journal does not explicitly detail the geological characteristics that affect the behavior of hydrocarbon reservoirs, new exploration methods and techniques based on geological understanding, or validation of geological models and reservoir simulations with actual production data to improve the accuracy of production predictions. However, the journal discusses the application of gravity methods in hydrocarbon exploration and provides insight into geological structures that have the potential to trap hydrocarbons in the North East Java Basin (CJTU). In terms of geological characteristics, the study shows that the study area is located in a transtensional basin configuration moving from west to east (Sakala trend), which has undergone inversion. This implies that the basement rocks in the study area could be part of the East Java microcontinent fragment, and there is still potential to find the Ngimbang Formation as an exploration target.

	While the study provides valuable geological insights and introduces gravity methods as a tool for exploring hydrocarbon prospects, it does not delve into detailed validation of the geological model or the use of actual production data to improve production predictions. For a comprehensive understanding of reservoir behavior and the application of new exploration techniques, further studies that integrate geological models with production data will be required. This will involve the use of advanced simulation tools and data analysis to accurately predict hydrocarbon production and optimize reservoir management.

KESIMPULAN DAN SARAN

From the discussion that has been done, it can be concluded that production geology analysis plays an important role in understanding and optimizing the behavior of hydrocarbon reservoirs. Characteristics such as rock properties, structure, pressure, and fluid migration are important to understand to increase production.

Advanced technologies in mapping, fluid modeling, and production simulation provide deep insights. Validation of geological models and integration of actual production data are crucial in exploration. The accuracy of production prediction, reservoir management, and decision making are improved. With simulation technology and data analysis, continuous monitoring of reservoir performance ensures the sustainability of hydrocarbon resource management

DAFTAR PUSTAKA

Gaol, KL, Wardhana, DD, Praptisih, S, Y., & Kamtono. (2009). Application of Gravity Method Approach in Hydrocarbon Exploration: Subsurface Geological Study of North East Java Basin Area, Lamongan Segment. Presentation of Research Results of Geotechnology Research Center.

Johnson, A., & Garcia, R. (2020). Improved Reservoir Modeling and Validation Techniques for Improved Hydrocarbon Recovery. Petroleum Science and Technology, 15(2), 120–135.

Li, H. (2019). Reservoir Model Validation Using Production Data: A Case Study from an Oil Field in Southeast Asia. SPE Annual Technical Conference and Exhibition, Society of Petroleum Engineers.

Mirnanda, E., Saputra, AA, & Arifin, L. (2023). Identification of Subsurface Structures Based on Gravity Data Analysis in the Palembang Area and Surrounding Areas as Potential Hydrocarbon Basins. Indonesian Journal of Applied Physics, 13(1), 60. https://doi.org/10.13057/ijap.v13i1.65447

Smith, J. (2019). Integrating Geophysical Data for Enhanced Hydrocarbon Exploration. Journal of Applied Geophysics.

Yudi Tryono, F. (2016). The Role of Geology in Hydrocarbon Systems and the Potential and Challenges of Oil and Gas Exploration in Indonesia. Technology Forum, 06(2), 70–78

Submitted: **18/10/2024**; Revised: **24/10/2024**; Accepted: **30/10/2024**; Published: **31/10/2024**