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Integration of Log Analysis and Dutta Crossplot to Identify Overpressure Zones and Hydrocarbon Potential in the Kujung and Ngimbang Formations

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Abstract: The North East Java Basin is one of the prospective hydrocarbon areas in Indonesia with the Kujung and Ngimbang Formations as the main intervals of the petroleum system. This study aims to identify the mechanism of overpressure formation and reservoir potential based on well log data analysis. The methods used include interpretation of Gamma Ray (GR), Resistivity (ILD), Neutron porosity (NPHI), and Bulk Density (RHOB) logs, as well as pore pressure estimation using the Eaton method. The analysis results indicate that the Kujung Formation has two prospective zones at depths of 4200–4800 ft and 7500–8500 ft indicating a gas-bearing carbonate reservoir, while the Ngimbang Formation is dominated by shale and dense carbonate that function as cap and source rocks. The beginning of the overpressure zone was detected at a depth of approximately 4400 ft, characterized by anomalies in the NPHI, RHOB, and Δt logs indicating undercompaction. Dutta crossplot analysis (DT–RHOB) confirmed the dominance of smectite minerals indicating that the overpressure was formed due to a loading mechanism. Thus, the Kujung Formation acts as a porous reservoir zone, while the Ngimbang Formation functions as a cap rock in the North East Java Basin petroleum system.

Keywords: Kujung formation; Loading mechanism; Ngimbang formation; Overpressure; Undercompaction

Introduction

The North East Java Basin is a key hydrocarbon exploration area in Indonesia with a long history. It stretches from Semarang to Surabaya, with a width of approximately 60–70 km and a length of approximately 250 km. The basin is bounded to the east and northwest by the Karimunjawa Arc and the Sunda Shelf, while to the north and west, the basin is bounded by the Meratus High and the Masalembo High in southeastern Kalimantan (Figure 1) (Webb et al., 2024). One stratigraphic interval with high potential is the Ngimbang Formation, particularly the Carbonate Development (CD) unit (Yusuf et al., 2025). This formation formed during the Eocene–Oligocene and is composed of limestone and carbonate shale that have undergone intensive diagenetic processes such as karstification (Wakita et al., 2025), dissolution, and fracturing, resulting in significant secondary porosity (Bilal et al., 2022; Wu et al., 2022). Several exploration wells around the North Madura Platform have demonstrated hydrocarbon accumulation in this interval, making it a prime exploration target in the North East Java region (Zaputlyaeva et al., 2020; Fahrudin & Yoga Aribowo, 2024).

One of the key challenges in developing the Ngimbang Formation is the presence of abnormal pore pressure (overpressure). Overpressure plays a dual role: operationally, it can increase drilling risks such as kicks, lost circulation, and even borehole instability (Huque et al., 2020; Zhao et al., 2023) and geologically, overpressure can be an indicator of hydrocarbon

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preservation and is related to subsurface fluid migration processes (S. Li et al., 2024; Radwan, 2022; Ahmed et al., 2016). Therefore, understanding the mechanisms of overpressure formation is crucial for both drilling risk mitigation and petroleum system interpretation (Zeng et al., 2023; Jintao et al., 2025; Asfha et al., 2024). In the context of the Ngimbang Formation, information on the dominant overpressure formation mechanisms is still limited, primarily based on well log data analysis. In fact, well data—including sonic logs, density, resistivity, and mud weight data—can provide important indications of pressure anomalies and rock physical properties (Chen et al., 2025; Shabangu et al., 2025).

This study aims to analyze the overpressure formation mechanism in the Ngimbang Formation in East Java by utilizing well log data as a basis for interpretation. The analysis focuses on identifying anomalies relative to the normal compaction trend and evaluating the relationship between petrophysical properties and pore pressure. The results of this study are expected to provide a more comprehensive understanding of the origin and distribution of overpressure, as well as contribute to improving the safety and efficiency of drilling operations in this region.

Method

Research Data and Location

This study utilized well log data, including sonic logs (Δt), density (ρb), resistivity (R), and Leak-Off Test (LOT) from one exploration well in the Ngimbang Formation, North East Java Basin. This data was used to analyze pore pressure conditions and determine the overpressure formation mechanism within the Ngimbang Formation interval. The Ngimbang Formation was selected based on its complex lithology (carbonate-shale) and indications of abnormal pore pressures found in several previous exploration wells (Bahi Dos Santos et al., 2025).

Figure 1. East Java Basin

Data Collection

The initial stage involved collecting log data from drilling reports and exploration databases. A quality control (QC) process was conducted to check the completeness and consistency of the data, including depth shifting, spike noise removal, and data adjustment to known formation boundaries.

Identification of Ngimbang Formation Intervals

The upper and lower boundaries of the Ngimbang Formation were identified based on gamma ray, density, and sonic log characteristics, and compared with regional stratigraphic data. Carbonate and shale intervals were interpreted to aid lithological analysis of the pore pressure log response. Normal Compaction Trend (NCT) Development: The normal compaction trend (NCT) was established as a reference for normal (hydrostatic) pore pressure. In sonic logs, the NCT describes the exponential relationship between wave delay time (Δt) and depth (z):

$$\Delta t_n = \Delta t_0 + Ce^{kz} \quad (1)$$

where:
Δtn = normalized delay time (μs/ft)
Δt0 = surface delay time (μs/ft)
C,k = empirical constants calibrated against normal pressure data.

Deviations from the Actual Log Value to the NCT Indicate Overpressure Zones

Pore Pressure Estimation Using the Eaton Method (1975) in (Wahidaulhusna & Sukmawati, 2025). Pore pressure is calculated using the Eaton method, which relates log deviations from the normal trend to effective pressure. For sonic logs, Eaton's formula is:

$$P_p = P_o - (P_o - P_h)(\frac{\Delta t_n}{\Delta t})^E \quad (2)$$

For the resistivity log, Eaton's equation is expressed as:

$$P_p = P_o - (P_o - P_h)(\frac{R}{R_n})^E \quad (3)$$

Where:
P_p = pore pressure (psi)
P_o = overburden pressure (psi)
P_h = hydrostatic pressure (psi)
Δt_n = NCT value (μs/ft)
Δt = actual log value (μs/ft)
R_n = normal resistivity
R = actual resistivity
E = Eaton exponent (typically 3 for sonic, 1.20–1.50 for resistivity).
Overburden pressure (P_o) is calculated by integrating the rock density with depth:

$$P_o = \int_0^z g\, \rho_b\, dz \quad (4)$$

With g=9.81" " 〖"m/s" 〗 ^2. The hydrostatic pressure (P_h) is assumed based on a formation water gradient of 0.433 psi/ft.

Formation Mechanism

The overpressure mechanism in the Ngimbang Formation was determined based on pore pressure estimation using the Eaton method, combined with interpretation of sonic, density, and resistivity logs. Overpressure zones were identified from intervals with pore pressures higher than hydrostatic pressure. The log response pattern is then compared with the normal compaction trend (NCT) to determine the formation mechanism. Increasing Δt values and decreasing ρb with respect to NCT indicate undercompaction, while Δt values approaching NCT but with high resistivity and density indicate smectite–illite diagenesis as the primary cause. Intervals with high resistivity and low density in organic-rich zones are interpreted as the result of hydrocarbon generation. The final interpretation is validated using drilling data such as LOT. This approach allows for a more accurate and integrated identification of the dominant overpressure mechanism in the Ngimbang Formation. There are two main possible mechanisms: loading and unloading. The loading mechanism (undercompaction) occurs when the sedimentation rate is faster than the pore water release process, resulting in water being trapped within the sediment pores. As a result, pore pressure increases because the overlying sediment load is not fully supported by the grain framework (Figure 2) (Yang et al., 2021).

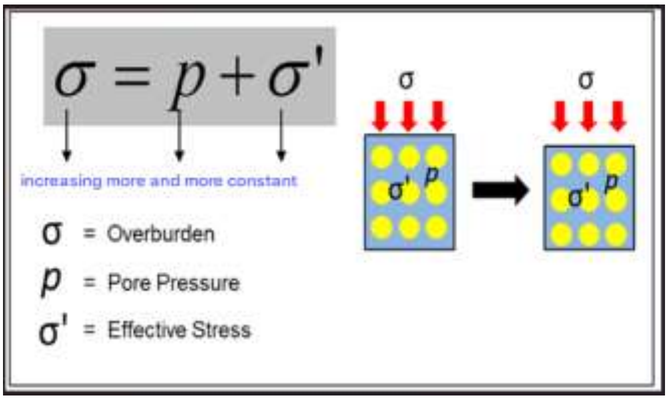

Figure 2. Overpressure in rock under disequilibrium compaction conditions

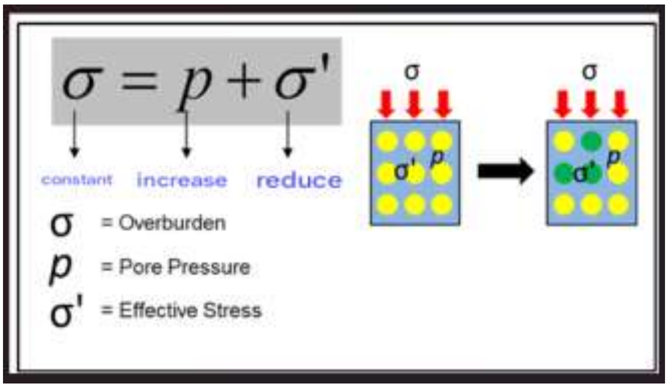

Figure 3. Cartoon illustration of overpressure due to the disequilibrium compaction mechanism

The unloading mechanism occurs after the rock has undergone normal compaction, but the pore pressure increases again due to other processes such as hydrocarbon generation, diagenetic reactions (smectite–illite), or thermal heating of fluids without any increase in sediment load (Figure 3) (Ling et al., 2025).

Result and Discussion

Based on the interpretation of gamma ray (GR), resistivity (ILD), neutron porosity (NPHI), and bulk density (RHOB) logs (Figure 4), we obtain a picture of the lithology and potential hydrocarbon zones within the 0–10.000 ft depth interval. In general, the lower Kujung Formation exhibits a dominant shale lithology at depths above 4.400 ft. In the 0–4.000 ft interval, GR values show moderate to high variations, indicating the presence of interbedded shale-sand layers, thus assuming a non-reservoir zone or containing formation water. Furthermore, in the 4.000–7.000 ft interval, GR values decrease in several areas, indicating the presence of clean sandstone zones with potential reservoirs. Below 7.000 ft, GR values fluctuate, with some areas being very low, which can be interpreted as carbonate rocks (Kujung Formation). In general, initial interpretations indicate reservoir potential at depths of 4.200–4.800 ft and 7.500–9.000 ft. Resistivity log (ILD) analysis results support this indication. In the 0–4.000 ft interval, ILD values are relatively low, indicating a water-saturated shale layer.

A significant increase in resistivity occurs at depths of 4.200–4.800 ft, indicating the possible presence of a hydrocarbon zone. Afterward, resistivity decreases again in the 5.000–7.000 ft interval, representing a water-bearing formation layer. In the 7.500–8.500 ft interval, resistivity increases again, indicating a second potential hydrocarbon zone. Below 9.000 ft, resistivity values fluctuate but tend to decrease, indicating a water-saturated compact carbonate layer. Neutron porosity (NPHI) and bulk density (RHOB) logs also support this interpretation. High NPHI values in the 0–4000 ft interval indicate a predominance of water-saturated, moderate-porosity shale. In the 4200–4800 ft interval, NPHI begins to decline, indicating an initial gas effect. Meanwhile, in the 5000–7000 ft interval, porosity increases again, characteristic of a saturated water zone. Gas crossover (NPHI < RHOB) becomes more apparent in the 7500–8500 ft interval, reinforcing the potential presence of gas at that depth. Meanwhile, RHOB values show a trend consistent with porosity and lithology characteristics. In the 0–4000 ft interval, high RHOB values (>2.55 g/cc) indicate a dense shale layer. A decrease in RHOB in the 4200–4800 ft interval (approximately 2.30–2.40 g/cc) indicates a porous zone with reservoir potential. RHOB values increase again in the 5000–7000 ft interval, indicating a compact layer. A decrease in RHOB values at 7.500–8.500 ft indicates high porosity and the possible influence of the gas effect, while at depths >9.000 ft, RHOB values are again high, indicating tight carbonate formation.

Overall, the combination of GR, ILD, NPHI, and RHOB logs indicates two zones with the strongest indications of hydrocarbon reservoir candidates: at depths of 4.200–4.800 ft and 7.500–8.500 ft, with gas-bearing formations likely dominating.

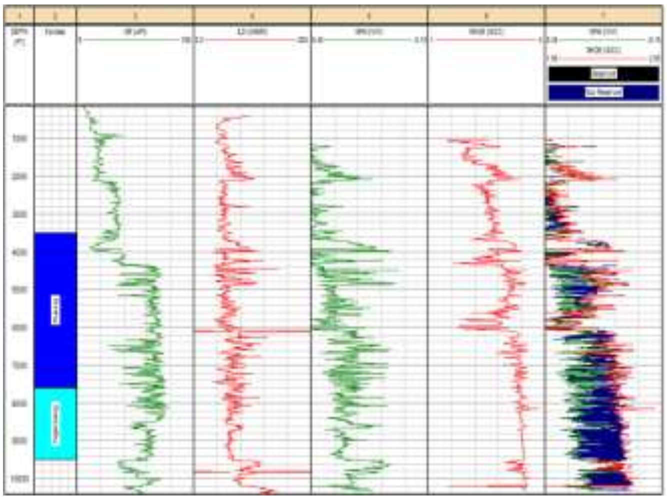

Figure 4. Sonic log, density, resistivity, and porosity data

An analysis of the relationship between neutron porosity (NPHI) and bulk density (RHOB) logs (Figure 5) in the Kujung Formation was conducted to identify lithological characteristics, porosity, and potential hydrocarbon presence. Based on the NPHI–RHOB crossplot, the data show a fairly wide distribution, with RHOB values ranging from 2.0–2.8 g/cc and NPHI between 0.05–0.55 v/v. This distribution indicates that the Kujung Formation possesses complex lithological variations, consisting of limestone, dolomite, and intercalated clays and carbonate sandstones. Most data points follow a major downward trend from the upper left to the lower right, a common pattern for carbonate rocks. In intervals of high RHOB (2.60–2.80 g/cc) and low NPHI (<0.15 v/v), the rocks are interpreted as tight limestone with low porosity. Conversely, the data group with lower RHOB (2.30–2.50 g/cc) and higher NPHI (0.15–0.25 v/v) indicates a dolomitic limestone or calcarenite lithology with moderate to good porosity, thus potentially representing a reservoir zone.

In addition to the main trend, there is a data crossover zone where RHOB values decrease (<2.40 g/cc) while NPHI also decreases (<0.20 v/v). This pattern indicates a gas effect, where the presence of gas simultaneously reduces bulk density and neutron porosity. This zone correlates with the depth intervals of 4.200–4.800 ft and 7.500–8.500 ft, previously identified from wireline logs as zones with high resistivity and low gamma ray flux. Therefore, this interval is interpreted as a porous zone with the potential to contain gas (a gas-bearing carbonate reservoir). Overall, the crossplot results indicate that the Kujung Formation is dominated by compact, low-porosity limestone, but contains several intervals with medium to high porosity (RHOB 2.20–2.40 g/cc; NPHI 0.10–0.20 v/v) that exhibit anomalous gas effects. This reinforces previous interpretations that the main productive zones of the Kujung Formation are at depths of 4.200–4.800 ft and 7.500–8.500 ft, characterized by gas-bearing, porous carbonates.

Furthermore, the trend of the data following the dolomite–limestone line in the crossplot indicates the influence of advanced diagenetic processes, such as recrystallization and dolomitization, which have caused porosity heterogeneity in the Kujung Formation. This variation reflects the carbonate facies shift from compact limestone to porous dolomite, which played a significant role in the development of reservoir quality in the Oligocene carbonate system of the North East Java Basin (Syah et al., 2019; Pwavodi et al., 2023).

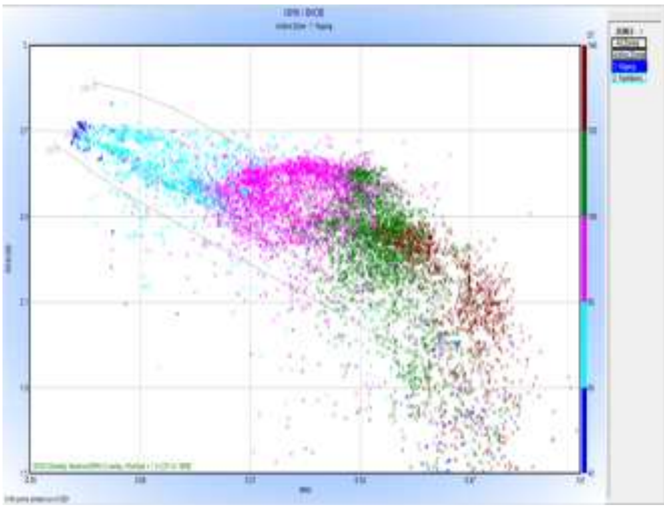

Figure 5. Crossplot between sonic and rhob Formation Kujung

Analysis of the relationship between neutron porosity (NPHI) and bulk density (RHOB) logs (Figure 6) in the Ngimbang Formation was conducted to understand the lithology characteristics, porosity, and indications of hydrocarbon presence in this formation. Based on the results of the NPHI-RHOB crossplot, the data distribution shows a concentrated and compact pattern with RHOB values ranging from 2.45–2.75 g/cc and NPHI between 0.10–0.30 v/v. This pattern illustrates that the Ngimbang Formation is dominated by rocks with low to moderate porosity, which are most likely composed of carbonate shale, fine sandstone, and argillaceous limestone. Most data points follow a linear trend that decreases from the top left to the bottom right, which is a typical trend of compact rocks with a mixed carbonate-siliciclastic composition. No significant deviation (crossover) is seen between the NPHI and RHOB values as seen in the Kujung Formation, indicating that indications of gas effects do not develop in the Ngimbang Formation. Thus, this formation can be categorized as a non-reservoir zone or a water-bearing zone.

At relatively high RHOB values (2.65–2.75 g/cc) and low NPHI (<0.15 v/v), the rocks are interpreted as dense limestone or compact dolomite. Meanwhile, at lower RHOB values (2.45–2.55 g/cc) and slightly higher NPHI (0.20–0.25 v/v), they can be interpreted as fine-grained sandstone or argillaceous carbonate with little effective porosity. The data distribution, which tends to follow the limestone–dolomite reference line in the crossplot, indicates that the Ngimbang Formation has undergone strong compaction and cementation due to advanced diagenesis, resulting in a decrease in natural porosity. These results indicate that petrophysically, the Ngimbang Formation has poor reservoir characteristics, with limited effective porosity and no gas anomalies. This is consistent with previous vertical log results, where the Ngimbang Formation exhibited high gamma ray values, low resistivity, and high density, all of which indicate characteristics of dense, water-saturated shale and carbonate layers (Guo et al., 2023; Y. Li et al., 2021; Hu et al., 2024). Thus, the Ngimbang Formation functions more as a source rock and seal in the petroleum system in the North East Java Basin, while the main reservoir zone is more developed in the overlying Kujung Formation, which has better porosity and shows indications of gas.

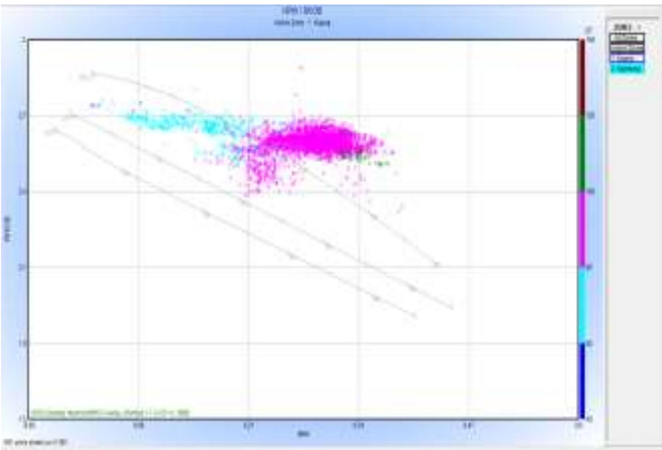

Figure 6. Crossplot between sonic and rhob Formation Ngimbang

Mechanisms Causing Overpressure

Based on the analysis results in Figure 7, it can be interpreted that the beginning of the overpressure zone (top of overpressure) began to be detected at a depth of approximately 4.400 ft within the Kujung Formation. This is indicated by the log response, which begins to deviate from the normal compaction trend. Theoretically, neutron porosity (NPHI) values should decrease with depth due to increasing lithostatic pressure and rock compaction (Pwavodi et al., 2023; Mkinga et al., 2020). However, in the depth interval from 4.400 ft to approximately 6.000 ft, the NPHI value appears constant and does not show a significant decrease, indicating undercompaction in the layer. This condition is supported by the density log response (RHOB), which should increase gradually with depth due to porosity reduction due to overburden pressure (Ubuara et al., 2024; Dong et al., 2018). However, in the same interval, the RHOB value shows a constant trend, indicating that rock density does not increase despite increasing lithostatic pressure (Zuza et al., 2022; Luisier et al., 2019). Furthermore, the sonic propagation time (Δt) or DT log values do not show the expected decrease at deeper intervals, but rather tend to remain stable, indicating that acoustic wave velocity does not increase in line with the normal compaction trend. The anomalous combination of these three log parameters—a persistently high NPHI, a constant RHOB, and a steady DT—indicates incomplete compaction at depths ranging from 4.400 to 6.000 ft. This indicates that formation water remains trapped within the rock pores due to sedimentation rates exceeding pore fluid release, leading to increased pore pressure (overpressure). Therefore, this zone can be identified as the initial area of overpressure formation due to undercompaction in the Kujung and Ngimbang Formations (Xu et al., 2024; Ren et al., 2022; Sun et al., 2022).

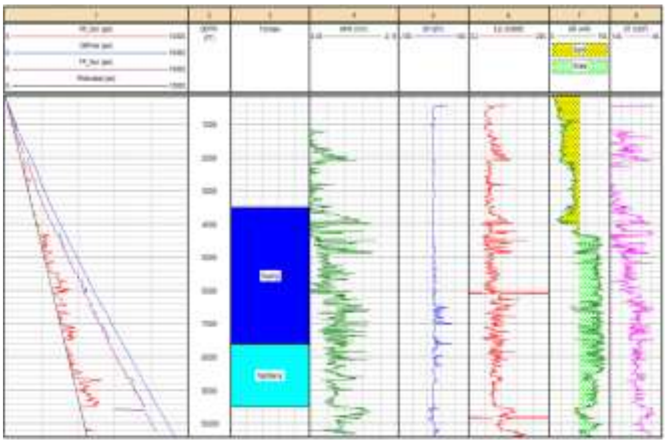

Figure 7. Determination of top overpressure

Dutta Crossplot and Clay Mineralogy

A Dutta crossplot (DT–RHOB) analysis (Figure 8) of the Kujung Formation shows that the data distribution is largely between the smectite and illite lines, with a tendency to approach the smectite line. This pattern indicates that the Kujung Formation has not undergone advanced diagenesis and is still dominated by smectite clay minerals, which are expansive and highly porous. This condition indicates incomplete compaction (undercompaction), where pore water is still trapped within the sediment, leading to increased pore pressure. Therefore, the presence of dominant smectite is a key indication of the formation of an initial overpressure zone due to loading mechanisms in the Kujung Formation (J. Li et al., 2023; Tanikawa et al., 2010).

The Dutta crossplot analysis (Figure 9) of the Ngimbang Formation shows that the data distribution lies between the smectite and illite lines, with a tendency to approach the smectite line. This pattern indicates that the Ngimbang Formation has not yet undergone complete diagenesis, with most clay minerals still in the early stages of transformation from smectite to illite. The relatively constant RHOB value (2.55–2.70 g/cc) and the relatively high DT (85–105 μs/ft) indicate incomplete compaction (undercompaction). This condition occurs due to the loading mechanism, namely increasing overburden pressure that is not balanced by effective pore water release. As a result, pore fluids remain trapped within the rock, causing increased pore pressure (overpressure) and inhibiting the normal compaction process (C. Li et al., 2022; Amjad et al., 2022). Thus, the Ngimbang Formation can be categorized as an undercompacted zone due to the loading mechanism, which marks the initial stage of excess pressure formation beneath the Kujung Formation (Suryana et al., 2023).

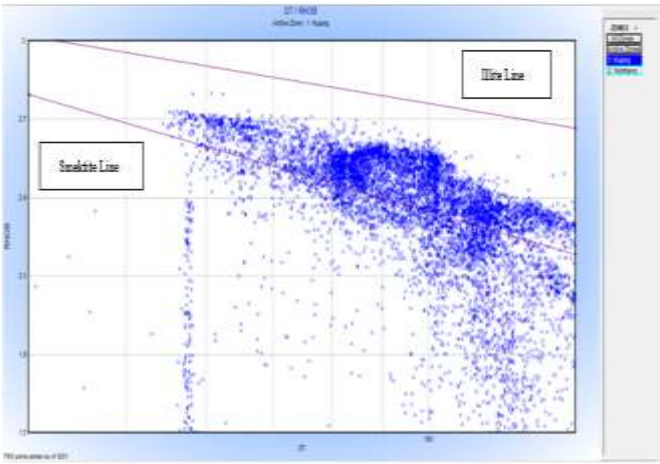

Figure 8. Dutta Crossplot between sonic and rhob Formation Kujung

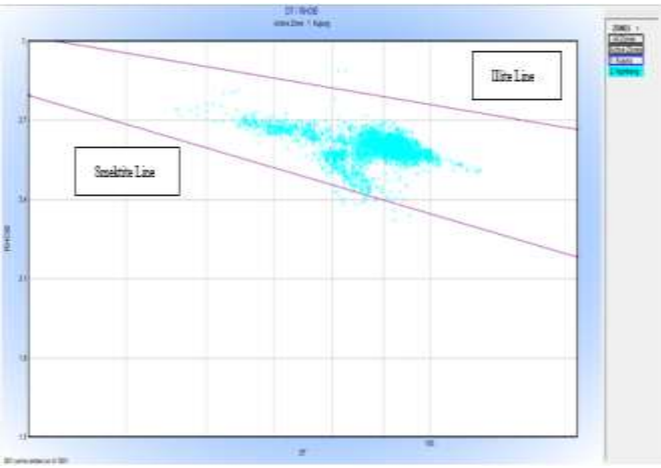

Figure 9. Dutta Crossplot between sonic and rhob Formation Ngimbang

Conclusion

Based on the results of wireline log analysis, petrophysical crossplots, and formation pressure evaluation, it can be concluded that the Kujung Formation exhibits a dominant carbonate character with two main potential hydrocarbon zones at depths of 4200–4800 ft and 7500–8500 ft, which are characterized by high resistivity values, low gamma ray, and gas crossover anomalies in the NPHI–RHOB log. Meanwhile, the Ngimbang Formation is dominated by shale and argillaceous limestone with low porosity and no indication of gas, thus acting as a seal and source rock. Pressure analysis shows that the initial overpressure zone (top of overpressure) is identified at a depth of approximately 4400 ft within the Kujung Formation, which is characterized by constant NPHI values, non-increasing RHOB, and stable DT with depth. This condition indicates the presence of incomplete compaction (undercompaction) due to the loading mechanism, namely an increase in overburden pressure that is not balanced by the release of pore fluids. The Dutta crossplot (DT–RHOB) results also show that both the Kujung Formation and the Ngimbang Formation are still between the smectite–illite lines with a tendency to approach the smectite line, indicating that both have not experienced advanced diagenesis and still contain reactive smectite minerals. Thus, it can be concluded that the overpressure in the North East Java Basin was formed due to a loading mechanism (undercompaction), where the Kujung Formation acts as a porous carbonate reservoir zone containing gas, while the Ngimbang Formation functions as a cap rock and source that controls the petroleum system in the area.

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Author Contributions

Conceptualization; methodology.; validation; formal analysis; investigation; V. W.; resources; data curation; writing—original draft preparation; writing—review and editing.; visualization: A. H. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

No conflict interest.

References

Ahmed, M. A., Hegab, O. A., & Sabry, A. (2016). Early detection enhancement of the kick and near-balance drilling using mud logging warning sign. *Egyptian Journal of Basic and Applied Sciences*, *3*(1), 85–93. https://doi.org/10.1016/j.ejbas.2015.09.006

Amjad, M. R., Zafar, M., Ahmad, T., Hussain, M., & Shakir, U. (2022). Overpressures Induced by Compaction Disequilibrium Within Structural Compartments of Murree Formation, Eastern Potwar, Pakistan. *Frontiers in Earth Science*, *10*, 903405. https://doi.org/10.3389/feart.2022.903405

Asfha, D. T., Gebretsadik, H. T., Latiff, A. H. A., &

Rahmani, O. (2024). Predictive pore pressure modeling using well-log data in the West Baram Delta, offshore Sarawak Basin, Malaysia. *Geomechanics and Geophysics for Geo-Energy and Geo-Resources*, *10*(1), 196. https://doi.org/10.1007/s40948-024-00903-5

Bahi Dos Santos, C., Stallivière Corrêa, I., Weschenfelder, J., & Stone, J. R. (2025). Grain-size parameters and diatom records as indicators of environmental changes along the southern Brazilian coastal plain. *International Journal of Sediment Research*, *40*(2), 269–285. https://doi.org/10.1016/j.ijsrc.2025.01.005

Bilal, A., Yang, R., Mughal, M. S., Janjuhah, H. T., Zaheer, M., & Kontakiotis, G. (2022). Sedimentology and Diagenesis of the Early–Middle Eocene Carbonate Deposits of the Ceno-Tethys Ocean. *Journal of Marine Science and Engineering*, *10*(11), 1794. https://doi.org/10.3390/jmse10111794

Chen, Y., Sun, T., Yang, J., Chen, X., Ren, L., Wen, Z., Jia, S., Wang, W., Wang, S., & Zhang, M. (2025). Prediction of Mud Weight Window Based on Geological Sequence Matching and a Physics-Driven Machine Learning Model for Pre-Drilling. *Processes*, *13*(7), 2255. https://doi.org/10.3390/pr13072255

Dong, S., Shalaby, M., & Islam, Md. (2018). Integrated Reservoir Characterization Study of the McKee Formation, Onshore Taranaki Basin, New Zealand. *Geosciences*, *8*(4), 105. https://doi.org/10.3390/geosciences8040105

Fahrudin & Yoga Aribowo. (2024). Review: Geological Structure impacts to hydrocarbon potential and active faults in the East Java Basin, Indonesia. *Journal of Geoscience, Engineering, Environment, and Technology*, *9*(3), 379–383. https://doi.org/10.25299/jgeet.2024.9.3.16736

Guo, J., Ling, Z., Xu, X., Zhao, Y., Yang, C., Wei, B., Zhang, Z., Zhang, C., Tang, X., Chen, T., Li, G., & Zhao, Q. (2023). Saturation Determination and Fluid Identification in Carbonate Rocks Based on Well Logging Data: A Middle Eastern Case Study. *Processes*, *11*(4), 1282. https://doi.org/10.3390/pr11041282

Hu, X., Meng, Q., Guo, F., Xie, J., Hasi, E., Wang, H., Zhao, Y., Wang, L., Li, P., Zhu, L., Pu, Q., & Feng, X. (2024). Deep learning algorithm-enabled sediment characterization techniques to determination of water saturation for tight gas carbonate reservoirs in Bohai Bay Basin, China. *Scientific Reports*, *14*(1), 12179. https://doi.org/10.1038/s41598-024-63168-8

Huque, M. M., Imtiaz, S., Rahman, A., & Hossain, M. (2020). Kick detection and remedial action in managed pressure drilling: A review. *SN Applied Sciences*, *2*(7), 1178. https://doi.org/10.1007/s42452-020-2962-2

Jintao, A., Jun, L., Huang, H., Zhang, H., Yang, H., Zhang, G., & Chen, S. (2025). An investigation into the impact of diapir structures on formation pressure systems: A case study of the Yinggehai Basin, China. *Geothermal Energy*, *13*(1), 3. https://doi.org/10.1186/s40517-025-00332-x

Li, C., Zhan, L., & Lu, H. (2022). Mechanisms for Overpressure Development in Marine Sediments. *Journal of Marine Science and Engineering*, *10*(4), 490. https://doi.org/10.3390/jmse10040490

Li, J., Qin, D., Yin, W., Wang, X., Dai, Y., Shi, H., & Fan, C. (2023). The Origin of Overpressure in the Pinghu Tectonic Zone of Xihu Depression and Its Relationship with Hydrocarbon Accumulation. *Energies*, *16*(24), 8055. https://doi.org/10.3390/en16248055

Li, S., Zhou, P., & Lan, B. (2024). Study of wellbore instability in shale formation considering the effect of hydration on strength weakening. *Frontiers in Earth Science*, *12*, 1403902. https://doi.org/10.3389/feart.2024.1403902

Li, Y., Hu, Z., Cai, C., Liu, X., Duan, X., Chang, J., Li, Y., Mu, Y., Zhang, Q., Zeng, S., & Guo, J. (2021). Evaluation method of water saturation in shale: A comprehensive review. *Marine and Petroleum Geology*, *128*, 105017. https://doi.org/10.1016/j.marpetgeo.2021.105017

Ling, K., Wang, Z., Cao, Y., Liu, Y., & Dong, L. (2025). Clay Mineral Characteristics and Smectite-to-Illite Transformation in the Chang-7 Shale, Ordos Basin: Processes and Controlling Factors. *Minerals*, *15*(9), 951. https://doi.org/10.3390/min15090951

Luisier, C., Baumgartner, L., Schmalholz, S. M., Siron, G., & Vennemann, T. (2019). Metamorphic pressure variation in a coherent Alpine nappe challenges lithostatic pressure paradigm. *Nature Communications*, *10*(1), 4734. https://doi.org/10.1038/s41467-019-12727-z

Mkinga, O. J., Skogen, E., & Kleppe, J. (2020). Petrophysical interpretation in shaly sand formation of a gas field in Tanzania. *Journal of Petroleum Exploration and Production Technology*, *10*(3), 1201–1213. https://doi.org/10.1007/s13202-019-00819-x

Pwavodi, J., Kelechi, I. N., Angalabiri, P., Emeremgini, S. C., & Oguadinma, V. O. (2023a). Pore pressure prediction in offshore Niger delta using data-driven approach: Implications on drilling and reservoir quality. *Energy Geoscience*, *4*(3), 100194. https://doi.org/10.1016/j.engeos.2023.100194

Pwavodi, J., Kelechi, I. N., Angalabiri, P., Emeremgini, S. C., & Oguadinma, V. O. (2023b). Pore pressure prediction in offshore Niger delta using data-driven approach: Implications on drilling and reservoir quality. *Energy Geoscience*, *4*(3), 100194. https://doi.org/10.1016/j.engeos.2023.100194

Radwan, A. E. (2022). Drilling in Complex Pore Pressure Regimes: Analysis of Wellbore Stability Applying the Depth of Failure Approach. *Energies*, *15*(21), 7872. https://doi.org/10.3390/en15217872

Ren, J., Xu, L., Shi, W., Yang, W., Wang, R., He, Y., & Du, H. (2022). Shallow Overpressure Formation in the Deep Water Area of the Qiongdongnan Basin, China. *Frontiers in Earth Science*, *10*, 922802. https://doi.org/10.3389/feart.2022.922802

Shabangu, P. P., Magoba, M., & Opuwari, M. (2025). Pore Pressure Prediction and Fluid Contact Determination: A Case Study of the Cretaceous Sediments in the Bredasdorp Basin, South Africa. *Applied Sciences*, *15*(13), 7154. https://doi.org/10.3390/app15137154

Sun, F., Sun, J., Zeng, X., Yuan, W., Zhang, J., Yan, W., & Yan, W. (2022). Analysis of the Influencing Factors on Electrical Properties and Evaluation of Gas Saturation in Marine Shales: A Case Study of the Wufeng-Longmaxi Formation in Sichuan Basin. *Frontiers in Earth Science*, *10*, 824352. https://doi.org/10.3389/feart.2022.824352

Suryana, E., Hutasoit, L. M., Ramdhan, A. M., Nugroho, D., & Arifin, A. (2023). Pore Pressure and Compartmentalization of Carbonate Reservoirs in Northern Madura Platform—East Java Basin, Indonesia. *Indonesian Journal on Geoscience*, *10*(3), 297–307. https://doi.org/10.17014/ijog.10.3.297-307

Syah, M. H. F., Kano, A., Iizuka, T., & Kakizaki, Y. (2019). Depositional and diagenetic history of limestones and dolostones of the Oligo-Miocene Kujung Formation in the Northeast Java Basin, Indonesia. *Island Arc*, *28*(6), e12326. https://doi.org/10.1111/iar.12326

Tanikawa, W., Sakaguchi, M., Wibowo, H. T., Shimamoto, T., & Tadai, O. (2010). Fluid transport properties and estimation of overpressure at the Lusi mud volcano, East Java Basin. *Engineering Geology*, *116*(1–2), 73–85. https://doi.org/10.1016/j.enggeo.2010.07.008

Ubuara, D. O., Olayinka, Y. A., Emujakporue, G. O., & Soronnadi-Ononiwu, G. C. (2024). Evaluation of formation susceptibility and sand production potential in an offshore field, Niger Delta Basin, Nigeria. *Energy Geoscience*, *5*(1), 100213. https://doi.org/10.1016/j.engeos.2023.100213

Wahidaulhusna, S., & Sukmawati, F. D. (2025). Pore Pressure Predict Using Eaton Method and Sensitive Elastic Property Seismic of Overpressure Anomaly, Study Case: Poseidon Field, Browse Basin. *IOP Conference Series: Earth and Environmental Science*, *1458*(1), 012001. https://doi.org/10.1088/1755-1315/1458/1/012001

Wakita, K., Murakami, T., Tsuji, T., & Urata, K. (2025). Geological and Geographical Characteristics of Limestone and Karst Landforms in Japan: Insights from Akiyoshidai, Seiyo (Shikoku), and Okinoerabu Island. *Geosciences*, *15*(10), 393. https://doi.org/10.3390/geosciences15100393

Webb, M., Gough, A., & Endinanda, F. (2024). Depositional environments and sedimentary provenance of the Cenozoic deposits of Natuna Island, Indonesia: Implications for basin evolution in central Sundaland. *Gondwana Research*, *134*, 298–325. https://doi.org/10.1016/j.gr.2024.06.022

Wu, J., Fan, T., Gomez-Rivas, E., Travé, A., Cao, Q., Gao, Z., Wang, S., & Kang, Z. (2022). Impact of diagenesis on the pore evolution and sealing capacity of carbonate cap rocks in the Tarim Basin, China. *AAPG Bulletin*, *106*(12), 2471–2511. https://doi.org/10.1306/11082120136

Xu, Y., Yang, J., Hu, Z., Zhao, Q., Li, L., & Yin, Q. (2024). Causes of Multi-Mechanism Abnormal Formation Pressure in Offshore Oil and Gas Wells. *Applied Sciences*, *14*(22), 10149. https://doi.org/10.3390/app142210149

Yang, T., Liu, D., Li, Y., Guo, X., Zhang, J., & Jiang, Y. (2021). Grain Configuration Effect on Pore Water Pressure in Debris Flow. *Frontiers in Earth Science*, *9*, 660634. https://doi.org/10.3389/feart.2021.660634

Yusuf, M. F., Choiriah, S. U., Humairoh, W. A., Gutteres, S. A., Idea, K., & Amri, D. F. (2025). Porosity Analysis of Pliocene Limestone from the Mundu Formation Based on Core and Petrographic Analysis. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 282–291. https://doi.org/10.29303/jppipa.v11i8.12315

Zaputlyaeva, A., Mazzini, A., Blumenberg, M., Scheeder, G., Kürschner, W. M., Kus, J., Jones, M. T., & Frieling, J. (2020). Recent magmatism drives hydrocarbon generation in north-east Java, Indonesia. *Scientific Reports*, *10*(1), 1786. https://doi.org/10.1038/s41598-020-58567-6

Zeng, S., Qiu, N., Li, H., Gao, J., Long, K., Jia, J., & Zhu, X. (2023). Generation and distribution of overpressure in ultra-deep carbonate reservoirs controlled by intra-cratonic strike-slip faults: The Ordovician of Shuntuoguole area in the Tarim Basin. *Marine and Petroleum Geology*, *158*, 106515. https://doi.org/10.1016/j.marpetgeo.2023.106515

Zhao, K., Song, W., Deng, J., Tan, Q., & Wang, X. (2023). Evolution Law of Wellbore Instability Risk under Fluctuating Pressure. *Energies*, *16*(7), 2948. https://doi.org/10.3390/en16072948

Zuza, A. V., Levy, D. A., & Mulligan, S. R. (2022). Geologic field evidence for non-lithostatic overpressure recorded in the North American Cordillera hinterland, northeast Nevada. *Geoscience Frontiers*, *13*(2), 101099. https://doi.org/10.1016/j.gsf.2020.10.006