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Stratigraphy and Paleoenvironment of the Kuaro Formation, Muru River, Kutai Basin: A Paleontological Approach

Iwan Prabowo*, Fathony Akbar Pratikno, Efrina Chandra Agusti Putri, Jamaluddin, Eliza Putri Andrean, Imanuel Kaunang

Geological Engineering Study Program, Sekolah Tinggi Teknologi Migas, Jl. KM.8, Karang Joang, Balikpapan, Kalimantan Timur, 76127, Indonesia.

*Corresponding author. Email: iwan.prabowo@sttmigas.ac.id

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Abstract

The southern margin of the Kutai Basin remains poorly constrained regarding its Paleogene history compared to the well-studied northern depocenter. This research investigates the stratigraphic characteristics, relative ages, and depositional environments of the Kuaro Formation along the Muru River, Paser Regency. The study integrates a detailed measuring section with biostratigraphic analyses of Larger Benthic Foraminifera (LBF), calcareous nannofossils, and palynology to reconstruct the paleoenvironmental evolution. The results reveal a continuous stratigraphic succession spanning from the Late Eocene to the Late Oligocene. The lower interval comprises coal-bearing siliciclastics deposited in a coastal swamp environment, marking the initial terrestrial influence. This unit transitions upward into massive *Pellatispira* and *Discocyclina*-bearing rudstones, indicating the development of a stable shallow-marine carbonate platform during the Late Eocene. The sequence culminates in Late Oligocene fine-grained calcareous claystones yielding *Reticulofenestra bisecta* and *Reticulofenestra lockeri*, deposited in a lower-energy inner shelf setting. This vertical stacking pattern records a major transgressive phase, evolving from terrestrial-influenced environments to open marine conditions. These findings provide significant insights into the Eocene–Oligocene transition in the southern Kutai Basin, distinguishing its retrogradational stratigraphic architecture from the progradational deltaic cycles typical of the younger Neogene sequences in the northern basin.

Keywords: Biostratigraphy; Carbonate Platform; East Kalimantan.

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Introduction

The Kutai Basin in East Kalimantan represents one of the most significant Tertiary sedimentary basins in Indonesia, characterized by sedimentary thicknesses reaching up to 15 km and containing prolific hydrocarbon systems (Winarno et al., 2018). Geochemical assessments of the Lower Kutai Basin's younger sequences have verified its high organic content, primarily driven by deltaic deposition settings, which significantly contributes to its regional hydrocarbon potential (Jamaluddin et al., 2025). The structural framework and tectonic rotation of the Kutai Basin have been extensively studied (Advokaat et al., 2018; Irawati et al., 2022), while recent sedimentological and biostratigraphic studies have increasingly emphasized the complexity of deposition-al systems and facies heterogeneity within the Kutai Basin.

Recent studies on the Balikpapan Formation demonstrate that deltaic sys-tems in the Kutai Basin exhibit complex facies architecture, stacking patterns, and reservoir heterogeneity, which can be ef-fectively analyzed through integrated outcrop and digital modeling approaches (Rohmana et al., 2019). Additionally, in-tegrated micropaleontological approaches have successfully reconstructed Neogene paleoenvironments in the northern Kutai Basin (Darman, 2023; Jambak et al., 2024; Nisa et al., 2024). However, these existing studies largely focus on Miocene to Pleistocene sequences or rely heavily on subsurface data from the northern depocenters. Consequently, the high-resolution stratigraphic architec-ture and environmental evolution of the southern basin margin specifically during the Paleogene remain less understood, with limited published outcrop data that integrates multiple fossil groups to con-strain the complex Eocene–Oligocene transition.

In the Muru River, Kuaro District, Paser Regency – geographically situated within the southern segment of the Kutai Basin – the sedimentary record is expected to preserve comparable paleoenvironmental and stratigraphic signatures. This selection is supported by recent regional studies indicating that Eocene clastics and Oligocene carbonates are significantly better preserved in the southern margin compared to other parts of the Kutai Basin (Darman, 2023). Complementing this, Sehah et al. (2024) recently modeled the coal-bearing formations in the adjacent North Penajam Paser Regency using satellite gravity data, further highlighting the structural significance and distribution of these sequences in the southern basin margin and mapped basaltic intrusions (Sopan et al., 2024). Against this backdrop of diverse regional geology, this study focuses on the detailed biostratigraphic and facies analysis of the Kuaro Formation to refine the sedimentary evolution of the area. Previous work in the Sangatta area demonstrated that assemblages of calcareous nannofossils such as *Catinaster coalitus*, *Discoaster spp.,* and *Coronocyclus nitescens* define zonations NN6–NN11 (Middle to Late Miocene), while benthic foraminifera such as *Trochamina* and *Haplophragmoides* provide constraints on bathymetry ranging from tidal flats to prodelta–shelf environments (Jambak et al., 2024).

This research addresses this stratigraphic gap by presenting a detailed multi-proxy analysis of the Kuaro Formation exposed along the Muru River in the southern Kutai Basin. Unlike previous regional assessments that often generalize the southern margin's geology, this study integrates larger benthic foraminifera, calcareous nannofossils, and palynology to provide precise age control and paleoenvironmental reconstruction. By documenting the specific transition from carbonate platform facies to siliciclastic deltaic systems, this work offers new insights into the tectono-stratigraphic development of the southern Kutai Basin, distinguishing it from the well-documented northern trends and establishing a key reference section for Paleogene correlation in the region. The basin has long been the focus of stratigraphic studies where microfossils, particularly foraminifera and calcareous nannofossils, have been utilized to refine age determinations and reconstruct depositional environments.

Palynological and foraminiferal studies from northern offshore Kutai Ba-sin wells (e.g., FN O-1) demonstrate that pollen, spores, and mangrove-derived palynomorphs serve as reliable indicators of terrestrial input into the Kutai Basin. When integrated with planktonic–benthic foraminiferal ratios, these biotic assem-blages provide valuable insights into se-quence stratigraphic system tracts, in-cluding the Transgressive System Tract (TST), Highstand System Tract (HST), and Falling Stage System Tract (FSST) during the Late Miocene to Pleistocene. This integrative, multi-proxy approach has been further validated by Nisa et al. (2024), who showed that combining small foraminifera with palynomorph data is highly effective for reconstructing dy-namic changes in depositional environ-ments within the Kutai Basin. Therefore, such a biostratigraphic framework high-lights the importance of integrating mul-tiple fossil groups to achieve a more comprehensive understanding of basin evolution. Palynomorph assemblages are widely used to reconstruct depositional environments during sea-level fluctua-tions, particularly transgressive phases, where an increase in palynomorph abun-dance is commonly observed (Senduk et al., 2021).

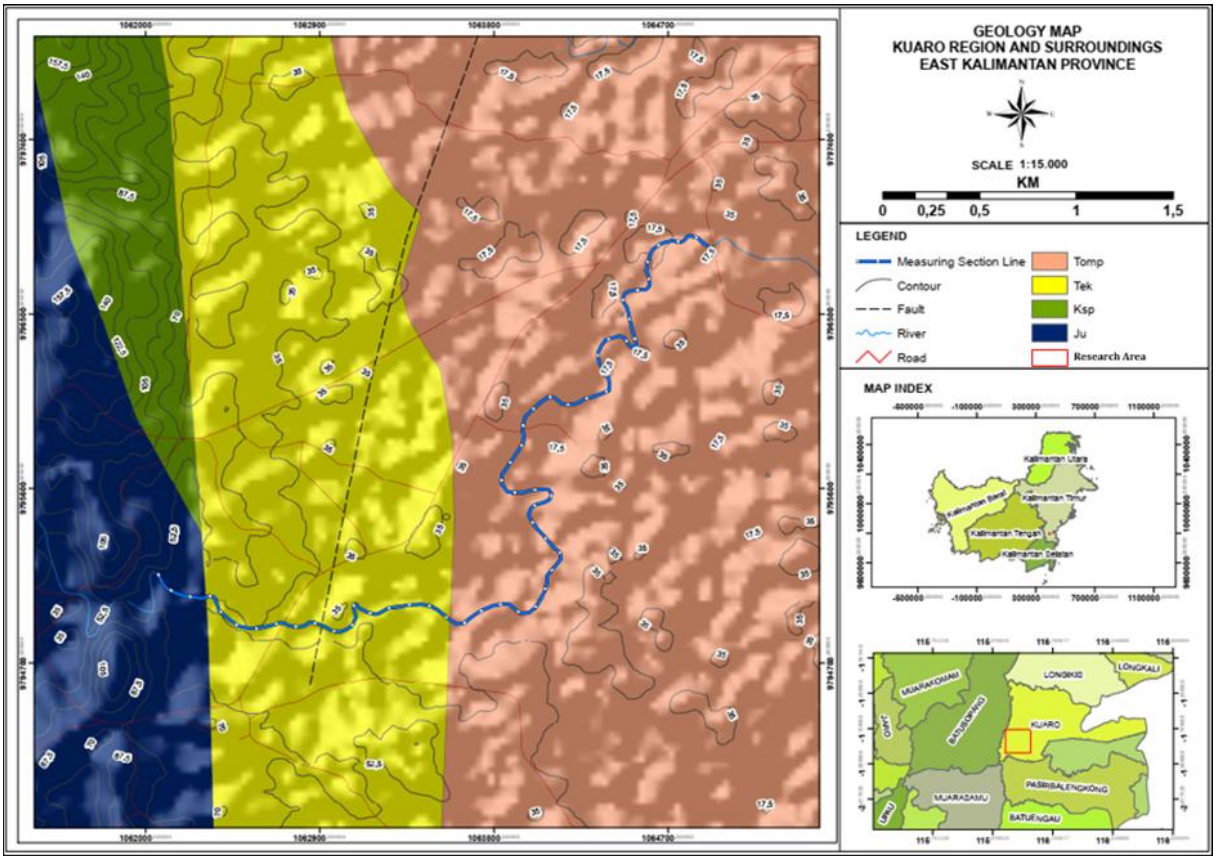

Figure 1. The Measuring Section (MS) route map of the Muru River overlaid on the regional geological map.

In terms of biostratigraphic zonation, three fossil groups provide complementary resolution: (1) larger benthic foraminifera (e.g., *Nummulites*, *Lepidocyclina*, *Miogypsina*) are particularly useful for shallow-marine carbonates and often define Eocene–Miocene shallow-marine zones; (2) pollen and spores enable correlation with terrestrial depositional phases and provide insights into vegetation and paleoclimate, especially in deltaic to coastal plain settings; and (3) calcareous nannofossils such as *Discoaster*, *Sphenolithus*, and *Catinaster* form the basis of the Martini (1971) zonation (NN zones), which remains the standard for Miocene–Pliocene sequences. The integration of these datasets with measured stratigraphic sections provides a robust tool for relative age determination and depositional environment interpretation.

Accordingly, the objectives of this study are: (i) to determine the relative ages of the Muru River rock units using integrated biostratigraphy of larger foraminifera, pollen–spores, and calcareous nannofossils; (ii) to reconstruct the depositional environments from fluvial–deltaic to shallow-marine settings through facies and fossil evidence. This study is expected to provide new insights into regional geological development and contribute to the geological inventory supporting geotourism development as previously identified by Adha et al. (2023) and further emphasized by Putri et al. (2025) regarding the strategic value of Paser geosites, as well as serving as a reference for academic and applied geological studies in East Kalimantan.

Materials and Methods

This study employed a comprehensive approach integrating field measurements and laboratory analyses. Fieldwork involved detailed stratigraphic logging along the Muru River to record lithological variations, sedimentary structures, and fossil content (Figure 2). For laboratory analysis, representative rock samples were selected based on lithological characteristics. Carbonate samples were prepared as petrographic thin sections to identify microfacies and Larger Benthic Foraminifera (LBF) assemblages following the classification of BouDagher-Fadel (2018). Meanwhile, fine-grained clastic samples (marl and claystone) were processed for calcareous nannofossils using the standard smear slide technique. The preparation involved scraping fresh rock surfaces and suspending the sediment in distilled water without centrifugation to preserve the original assemblage composition. Nannofossil identification was conducted using a polarizing microscope at 1000x magnification, with taxonomic identification referring to Martini (1971) zonation.

Results and Discussion

Lithological Characteristics

The measured stratigraphic section along the Muru River outcrop exhibits a heterogeneous lithological succession indicative of transitional depositional environments (Figure 2).

The excellent exposure of these rock units along the river does not only provide stratigraphic data but also serves as a potential object for edu-geotourism, as identified by Battu et al. (2023). Regionally, the development of these carbonate units during the Oligocene aligns with the stable platform conditions known as the Barito Platform, which extends offshore to the Paternoster Platform, allowing for extensive carbonate growth in the southern basin margin (Darman, 2023). The limestone intraparticle and fenestral porosity, and sparite cements with meniscus and drusy morphologies (Figure 3).

These features indicate deposition under warm, clear, shallow-marine conditions. Overlying marl beds contain higher clay fractions, suggesting increased terrigenous input from the hinterland. The rock has an allochthonous material composition, with material sizes ranging from < 0.1 mm to 9 mm, more than 10% material measuring > 2 mm, a massive, closed-packed structure with skeletal components, intersecting grains, and intraparticle and fenestral porosity, with sparite morphology, meniscus and drusy. The composition of this rock is 60% allochem (Alc), 35% micrite (Mc), 4% sparite (Spr), and 1% oxide minerals (Ox). Microfacies analysis identifies this in-terval as a bioclastic rudstone, character-ized by a consist primarily of abundant Larger Benthic Foraminifera (LBF). Grain supported texture dominated by large skeletal grains (> 2 mm).

Large benthic Foraminifera (LBF)

Paleontological analysis of limestone samples revealed abundant larger benthic foraminifera (LBF), dominated by *Discocyclina* and *Pellatispira*, with a little *Miliolids* (Figure 4).

Discocyclina, characterized by flat to elongated morphologies, indicates deposition within the oligophotic zone, reflecting slightly deeper marine settings within the photic zone. Petrographic thin sections show evidence of bioerosion and micritization, with skeletal grains partly replaced by dark micrite. The occurrence of *Pellatispira* provides a robust biostratigraphic marker for the Late Eocene, confirming the age of the lower limestone unit. This aligns with the global evolutionary framework established by BouDagher-Fadel (2018), which identifies the stratigraphic range of the genus Pellatispira as being restricted to the Late Eocene (Priabonian), particularly within the Tethyan and Indo-Pacific realms. The composition of this assemblage contrasts sharply with the younger Miocene LBF faunas common to the Northern Kutai Basin, confirming that this interval belongs to an older Eocene sequence.

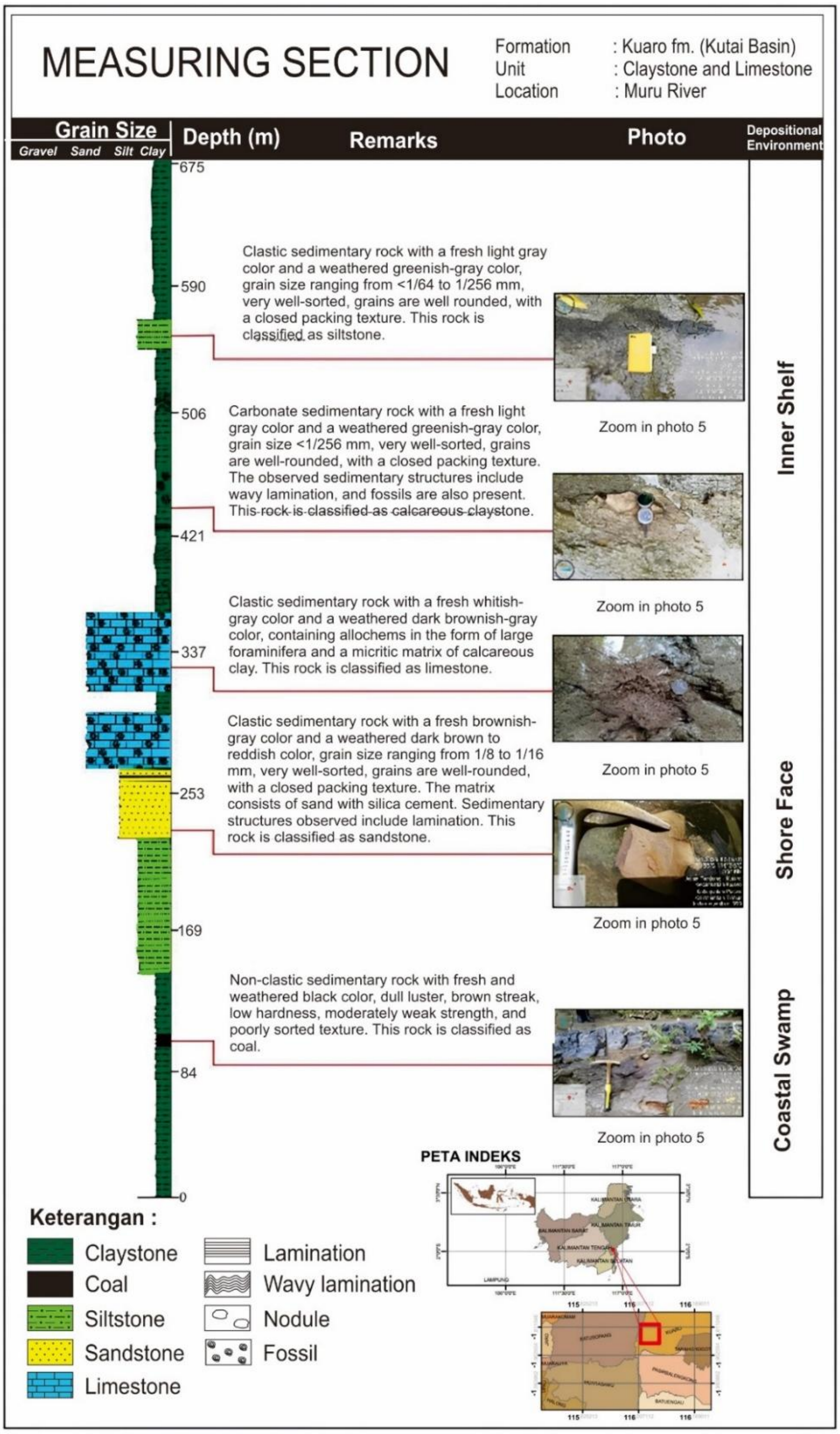

Figure 2. Measuring stratigraphic section of Muru River showing lithology and interpreted depositional environments.

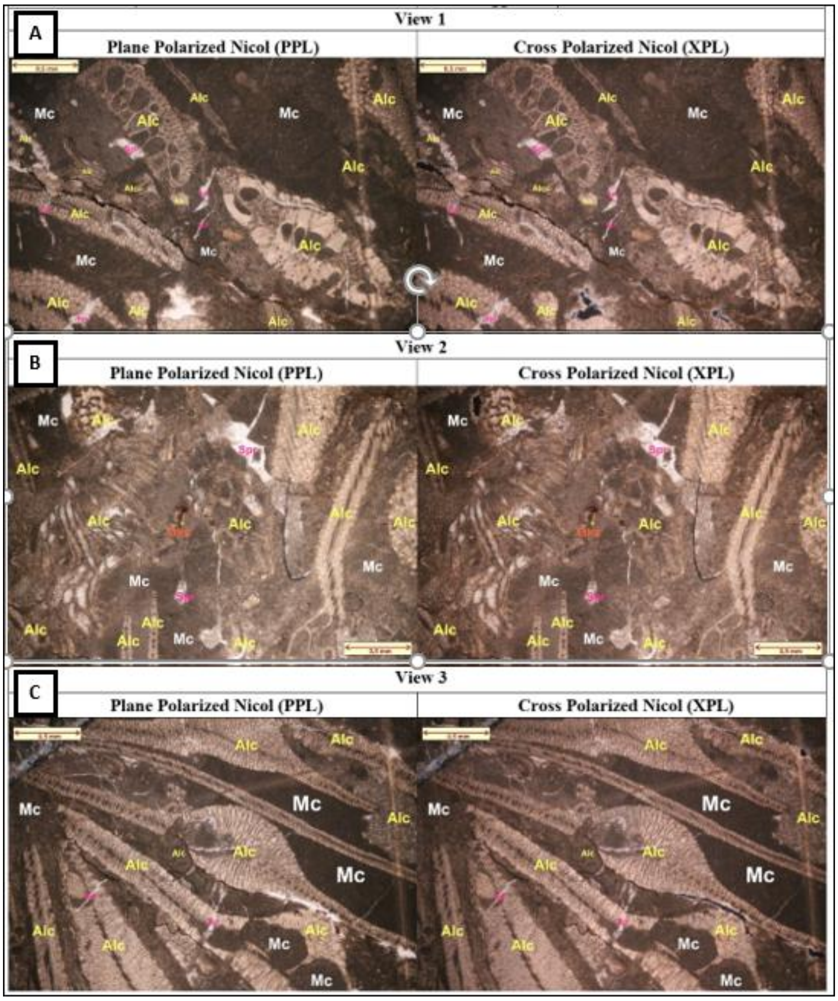

Figure 3. Thin-section photomicrographs of rudstone limestone (ALC : Allochem; MC : Micrite; SPR : Sparite).

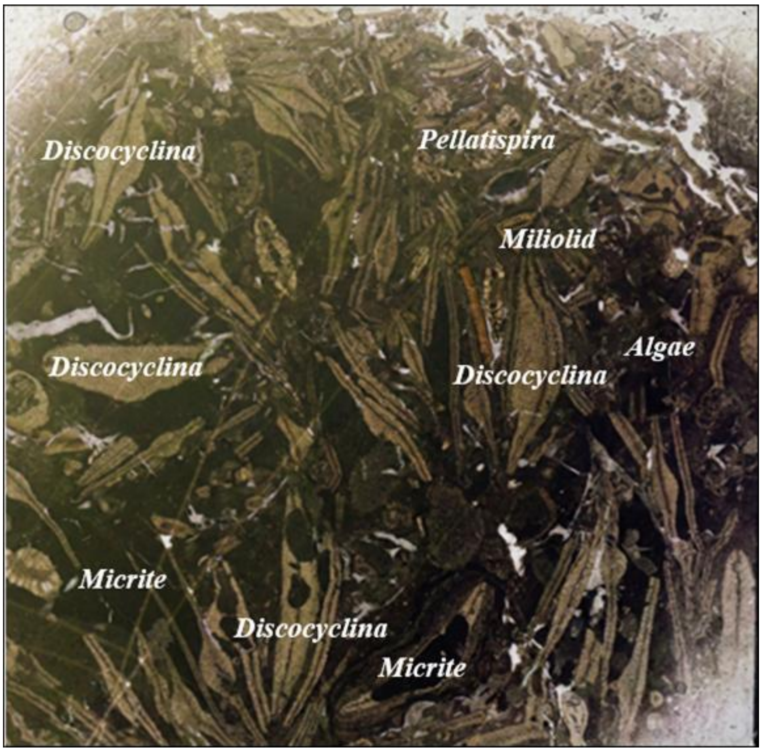

Figure 4. thin section of rock illustrating the distribution of large foraminifera in rudstone.

Calcareous Nannofossil Assemblages

Nannofossil analyses from marl and shale horizons yielded diverse assemblages, including *Cyclicargolithus floridanus*, *Reticulofenestra dictyoda*, *Reticulofenestra lockeri*, *Reticulofenestra bisecta*, *Helicosphaera mediterranea*, and *Braarudosphaera bigelowii*. Key species such as *Reticulofenestra bisecta* and *Reticulofenestra lockeri* are diagnostic of the Late Oligocene, thereby extending the stratigraphic range beyond the Late Eocene age indicated by the foraminiferal assemblages. While Jambak et al. (2024) utilized nannofossils to successfully define Miocene zonations (NN6–NN11) in the Kutai Basin, and Jamaluddin et al. (2024a) recently demonstrated the effectiveness of integrating nannofossils with sedimento-logical data to reconstruct depositional environments in the overlying Balikpapan Formation, our study confirms that nan-nofossil biostratigraphy remains a reliable tool for constraining the older Late Oligo-cene sequences as well. The identification of diagnostic markers in our samples validates the utility of this multi-proxy approach across different stratigraphic intervals of the basin. These results suggest that the section records a transition from the Late Eocene to the Late Oligocene, with overlapping fossil evidence reflecting temporal changes in depositional environments.

Coal and Shale Intervals

The section is generally dominated by interbedded limestone and calcareous claystone but transitions into a lower interval of thick shale with siltstone and coal intercalations (Figure 6), indicating a significant environmental shift. These characteristics strongly suggest deposition within a coastal swamp environment. The presence of coal confirms a regime of high organic productivity coupled with anoxic conditions, which are necessary for the preservation of organic matter (peat accumulation). The dull luster specifically points to a specific depositional setting within the swamp, likely indicating a slightly higher mineral content or 'ash' influx—possibly due to periodic flooding from nearby fluvial channels—or the accumulation of more decomposed plant material in a stagnant, low-energy mire. The poorly sorted texture further supports an autochthonous or hypo-autochthonous origin, implying that the vegetative matter accumulated in situ with minimal transport or winnowing by water currents. The coal indicates deposition in a coastal swamp or deltaic environment (lower delta plain), while the associated shale is interpreted as representing shore face or intertidal conditions (Figure 6).

This environmental interpretation aligns with the regional geochemical characterization by Winarno et al. (2018), who demonstrated that the specific properties of Kutai Basin coals are genetically linked to their formation in terrestrial-dominated deltaic and coastal swamp settings. In a broader context, recent evaluations by Jamaluddin et al. (2023; 2024b) further corroborate that such organic enrichment is strongly controlled by depositional conditions fluctuating between humid and arid periods within these swampy systems. Comparative studies in the adjacent Barito Basin by Fikri et al. (2022) further characterize these tropical peat systems as 'Kerapah' type peats, which represent a transitional environment crucial for understanding the organic matter preservation in this region. The dominance of terrestrial organic matter observed in the Kuaro Formation is characteristic of the Kutai Basin's deltaic systems. A similar trend is observed in the overlying Miocene Balikpapan Formation, where organic petrology analysis reveals a predominance of vitrinite macerals derived from higher plants deposited in delta plain to delta front environments, indicating a consistent supply of terrigenous material throughout the basin's history (Permana et al., 2018) Sedimentary structures such as parallel bedding within these intervals further support their interpretation as shallow, regressive, and transitional depositional environments.

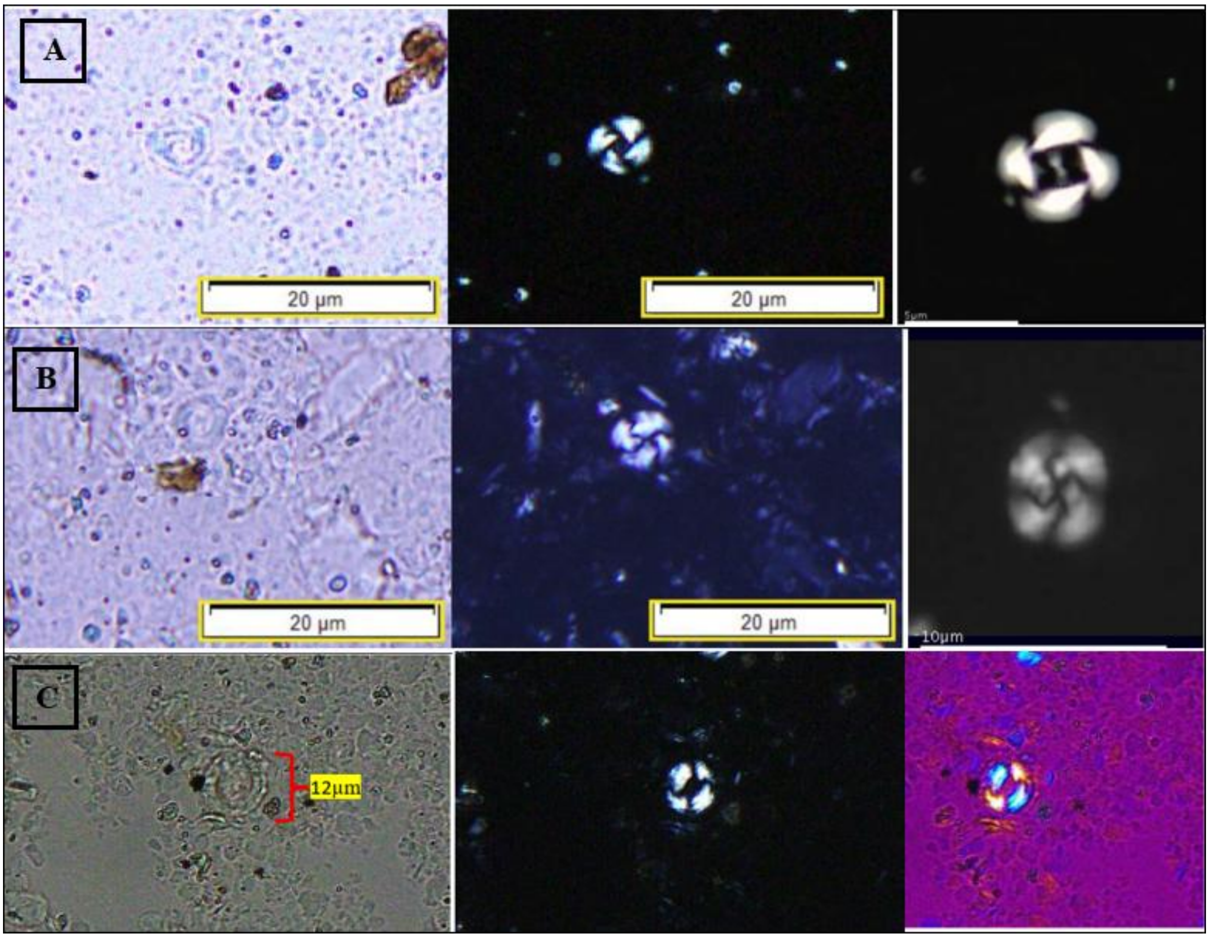

Figure 5. (A) *Reticulofenestra locker*; (B) *Reticulofenestra bisecta*, *Reticulofenestra dictyoda*.

Figure 6. A layer that shows a continuous layer of coal above a layer of shale and siltstone.

Stratigraphic Succession

This stratigraphic evolution reflects sustained relative sea-level fall, likely driven by a combination of eustatic and tectonic controls within the Kutai Basin margin. The stratigraphic succession records a distinct transgressive sequence, characterized by a transition from terrestrial-influenced deposits to open marine sediments. The depositional history commenced in a coastal swamp setting, evidenced by the accumulation of coal seams. The dull luster and poorly sorted texture of the coal imply a stagnant, low-energy, and anoxic mire environment where organic matter was preserved in situ. Following a relative rise in sea level, the environment evolved into a high-energy Shoreface to Shallow Marine zone. This transition is initially marked by the deposition of fine-grained sandstone exhibiting high textural maturity (very well-sorted and rounded grains). These characteristics indicate a regime dominated by wave action, effectively winnowing fine, clay-sized particles. Crucially, this interval is intercalated with bioclastic rudstones, characterized by a grain-supported texture and abundant Larger Benthic Foraminifera (LBF). The assemblage is dominated by *Discocyclina* and *Pellatispira*, with minor *Miliolids*. The presence of *Discocyclina* typically indicates deposition within the oligophotic zone (lower photic zone), while the rudstone texture implies that these skeletal grains were reworked by high-energy currents or waves. This development of a carbonate factory signifies a period of reduced terrigenous clastic input and warm, clear water conditions during the ongoing transgression. Finally, continued deepening of the environment.

The lithology fines upward into cal-careous claystone and siltstone, reflect-ing a significant reduction in flow energy as the depositional surface submerged below the fair-weather wave base. The presence of marine fossils and wavy lam-ination within these fine-grained units confirms a quiet, open marine setting dominated by suspension settling and weak bottom currents. This interpretation further supports the development of a ret-rogradational system controlled by re-duced sediment supply and increasing accommodation space during the Paleo-gene.

Conclusion

Based on the analysis, the measured stratigraphic section along the Muru River indicates a progressive and continuous marine transgression, an interpretation supported by both lithological changes and paleontological evidence. Initially, the Late Eocene depositional environment represented a warm, clear shallow marine setting, evidenced by massive rudstone limestone and confirmed by the presence of larger benthic foraminifera such as *Pellatispira* and *Discocyclina*. Subsequently, the section records an increase in clastic sediment input from the hinterland during the Eocene–Oligocene transition, characterized by alternating limestone and marl layers; although the coexistence of Eocene foraminifera and Late Oligocene nannofossils (*Reticulofenestra bisecta*) suggests potential fossil mixing or sam-pling variations, the overall succession confirms the section spans this transitional period. As the sequence progresses into the Late Oligocene and Early Miocene, a major environmental shift occurred to-ward transitional terrestrial, such as coastal swamps or deltaic systems, marked by the deposition of thick shale and coal layers to marine environments. This study provides one of the first integrated outcrop-based multi-proxy bio-stratigraphic frameworks for the Paleo-gene succession in the southern Kutai Basin. Ultimately, the stratigraphic succession records a progressive marine transgression, highlighting the transition from terrestrial to fully marine conditions and providing important implications for understanding Paleogene basin evolution in the Southern Kutai Basin.

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Author Contribution

Conceptualization, I.P.; methodology I.P., E.C.A.P.; validation, J., F.A.P.; Investigation and data curation, E.P.A., I.K.; writing-original draft presentation, J., E.C.A.P.; writing-review and editing, I.P. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

References

Adha, I., Utama, P. P., Eriyanto, M. I., Burhan, A. S., Opang, J. Y., Taslim, A. I., & Rhendo, A. Y. (2023). Identification and Analysis of Geoheritage Potential in Paser Regency as Supporter of the Geotourism Development in East Kalimantan. *Jurnal Ilmu Geologi Pangea*, 10(2), 51–60. https://doi.org/10.31315/jigp.v10i2.11183

Advokaat, E. L., Marshall, N. T., Li, S., Spakman, W., Krijgsman, W., & van Hinsbergen, D. J. J. (2018). Cenozoic Rotation History of Borneo and Sundaland, SE Asia Revealed by Paleomagnetism, Seismic Tomography, and Kinematic Reconstruction. *Tectonics*, 37(8), 2486–2512. https://doi.org/10.1029/2018TC005010

Battu, D. P., Adha, I., Kurniawan, T., Ryka, H., & Eriyanto, M. I. (2023). Potensi Geowisata di Kabupaten Paser, Kalimantan Timur. *Petrogas: Journal of Energy and Technology*, 5(1), 59–71. https://doi.org/10.58267/petrogas.v5i1.122

BouDagher-Fadel, M.K. (2018). *Evolution and geological significance of larger benthic foraminifera*. London: UCL Press. https://doi.org/10.14324/111.9781911576938

Darman, H. (2023). Paleogene paleogeographic reconstructions of the Kutai Basin: Refinement based on outcrop and subsurface data. *Berita Sedimentologi*, 49(1), 25–52. https://doi.org/10.51835/bsed.2023.49.1.397

Fikri, H. N., Sachsenhofer, R. F., Bechtel, A., & Groß, D. (2022). Organic geochemistry and petrography in Miocene coals in the Barito Basin (Tutupan Mine, Indonesia): Evidence for astronomic forcing in kerapah type peats. *International Journal of Coal Geology*, 256, 103997. https://doi.org/10.1016/j.coal.2022.103997

Irawati, S. M., Hidayat, H., Wijanarko, E., & Grandis, H. (2022). Integrated Magnetotelluric (MT), Gravity and Seismic Study of Lower Kutai Basin Configuration. *Journal of Engineering and Technological Sciences*, 54(1), 220103. https://doi.org/10.5614/j.eng.technol.sci.2022.54.1.3

Jamaluddin, J., Wagreich, M., Gier, S., Schöpfer, K., & Battu, D. P. (2023). Sedimentary Environments and Paleoclimate Control of the Middle

Miocene Balikpapan Group, Lower Kutai Basin (Indonesia): Implications for Evaluation of the Hydrocarbon Potential. *Minerals*, 13(10), 1259. https://doi.org/10.3390/min13101259

Jamaluddin, J., Wagreich, M., Schöpfer, K., Sachsenhofer, R. F., Maria, M., Rahmawati, D. (2024a). Hydrocarbon potential and depositional environment of the Middle Miocene Balikpapan Formation, lower Kutai Basin, Indonesia: Sedimentology, calcareous nannofossil, organic geochemistry, and organic petrography integrated approach. *International Journal of Coal Geology*, 293, 104591. https://doi.org/10.1016/j.coal.2024.104591

Jamaluddin, J., Wagreich, M., Schöpfer, K., Maria, M., Gier, S., Fathy, D. (2024b). Effect of Depositional Environment and Climate on Organic Matter Enrichment in Sediments of the Upper Miocene—Pliocene Kampungbaru Formation, Lower Kutai Basin, Indonesia. *Geosciences*, 14(6), 164. https://doi.org/10.3390/geosciences14060164

Jamaluddin, J., Jamaludin, S. N. F., Massinai, M. A., Zhang, S., Mansor, H. E., & Oscar, A. W. (2025). Paleoenvironmental Influences Evaluation on Sedimentary Organic Matter of the Kampungbaru Formation, Lower Kutai Basin: Organic and Inorganic Geochemical Approaches. *Journal of Geoscience, Engineering, Environment and Technology*, 10(4), 574–586. https://journal.uir.ac.id/index.php/JGEET/article/view/24526

Jambak, M. A., Deny, D., Rendy, R., & Syavitri, D. (2024). Miocene Paleogeographic Reconstruction in the Sangatta Area, East Kalimantan Based on Calcareous Nannofossil Biostratigraphy and Benthonic Foraminiferal Analysis. *Bulletin of the Marine Geology*, 39(2), 105–122. http://dx.doi.org/10.32693/bomg.39.2.2024.869

Martini, E. (1971). Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proceedings of the Second Planktonic Conference* (Rome, 1970), 2, 739–785.

Nisa, F. A., Jurnaliah, L., Winantris, W., & Nugrahanto, K. (2024). Environmental changes during the late Miocene to Pleistocene using small foraminifera and palynomorphs in the Kutai Basin, East Kalimantan. *Bulletin of the Marine Geology*, 39(2), 97–110. http://dx.doi.org/10.32693/bomg.39.2.2024.855

Permana, A. K., Sendjadja, Y. A., Panggabean, H., & Fauzely, L. (2018). Depositional Environment and Source Rocks Potential of the Miocene Organic Rich Sediments, Balikpapan Formation, East Kutai Sub Basin, Kalimantan. *Jurnal Geologi dan Sumberdaya Mineral*, 19(3), 171–186. https://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/407

Putri, E. C. A., Ryka, H., & Prabowo, I. (2025). Identifikasi dan Analisis Potensi Geosite sebagai Pendukung Pengembangan Kawasan Geowisata Daerah Paser, Kalimantan Timur. *Jurnal Teknik Geologi: Jurnal Ilmu Pengetahuan dan Teknologi*, 8(1), 20–27. http://dx.doi.org/10.30872/jtgeo.v8i1.15858

Rohmana, R. C., Fardiansyah, I., Taufani, L., & Harishidayat, D. (2019). Depositional processes and facies architec-ture of Balikpapan sandstone formation: Application of 3D digital outcrop model (DOM) to identify reservoir geometry and distribution in deltaic system. *Scientific Contributions Oil and Gas*, 42(1), 35–42. https://doi.org/10.29017/SCOG.42.1.379

Sehah, S., Rizqi, N. S., & Abdullatif, R. F. (2024). Modeling of Coal-Bearing

Rock Formations in The Kutai Basin, North Panajam Paser Regency, Kalimantan Based on Satellite Gravity Anomaly Data. *Earth Sciences Malaysia*, 8(2), 91–97. http://doi.org/10.26480/esmy.02.2024.91.97

Senduk, K. G., Jambak, M. A., Heriadi, R. R. S. A., & Syaifullah, K. A. (2021). Biostratigraphic analysis and age determination, depositional environment and paleoclimate at well X-section of the Kutai Basin, East Kalimantan region. *AIP Conference Proceedings*, 2363(1), 040016. http://dx.doi.org/10.1063/5.0063270

Sopan, L. E. P., Agustin, E., Kuncoro, K. H. A., Sarkowi, M., Kuswanto, A., Kumalasari, I. N., & Mulyasari, R. (2024). Identification of Basalt Rock Distribution Using Resistivity Geoelectric Method in The National Capital City (IKN), Paser, East Kalimantan. *Eksplorium*, 45(2), 91–98. https://doi.org/10.55981/eksplorium.2024.7081

Winarno, A., Amijaya, D. H., & Harijoko, A. (2018). Geochemical characterization of Kutai Basin coals using proximate and ultimate analysis. *IOP Conference Series: Earth and Environmental Science*, 212, 012033. https://doi.org/10.1088/1755-1315/212/1/012033