



Biostratigraphic Zonation and Paleoenvironmental Reconstruction of *UQ* Field, Niger Delta, Nigeria

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Abstract

The *UQ* Field, located in the southeastern Niger Delta Basin, is a marginal hydrocarbon-bearing field with complex stratigraphic characteristics that have hindered its full commercial exploitation. This study aims to establish a biostratigraphic framework for the *UQ* Field that enhances stratigraphic correlation, reconstructs paleoenvironmental conditions, and optimizes hydrocarbon exploration strategies. A biostratigraphic approach was used, integrating palynological analysis and paleoenvironmental reconstruction to delineate biozones, refine depositional models, and assess reservoir potential. Two primary biostratigraphic zones (P850 and P840) were identified based on key palynomorph markers such as *Peregrinipollis nigericus* and *Striatricolpites catatumbus*, representing a Late Miocene depositional environment. The biozones indicate a transition from lower delta plain to upper delta front conditions, influenced by marine transgressions and regressive sequences. These depositional shifts have significantly affected reservoir distribution, connectivity, and quality. By integrating biostratigraphy with hydrocarbon prospectivity analysis, this study provides crucial insights for improved reservoir characterization, well placement strategies, and future exploration within the Niger Delta. This study presents the first high-resolution biostratigraphic zonation of the *UQ* Field, offering a refined framework for understanding its depositional history and Paleoenvironments. This study advances existing knowledge by integrating biostratigraphy with depositional modeling, offering a more comprehensive approach to characterizing reservoir quality and connectivity. The findings provide a critical framework for future exploration efforts, guiding well placement strategies and reservoir evaluation in marginal fields within the Niger Delta Basin.

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1.0. Introduction

The Niger Delta Basin is one of the most prolific hydrocarbon-producing regions globally, covering approximately 300,000 square kilometers with sedimentary thicknesses exceeding 12 kilometers (Doust & Omatsola, 1990; Evamy *et al.*, 1978). The basin evolved from the rifting of the African and South American plates, leading to the deposition of thick marine shales (Akata Formation) and subsequent deltaic progradation (Agbada Formation) during the Tertiary period (Reijers, 2011). This basin is characterized by significant structural and stratigraphic complexities, including growth faults, rollover anticlines, and shale diapirs, which have played a pivotal role in hydrocarbon accumulation (Okon *et al.*, 2023).

The *UQ* Field, situated in the southeastern part of the Niger Delta, has been classified as a marginal field due to its historically suboptimal hydrocarbon production (Obidike & Chiazor, 2023). Despite being located within a hydrocarbon-rich province, the field's commercial viability has been constrained by poor reservoir connectivity, limited stratigraphic correlation (Harry *et al.*, 2018), and an incomplete understanding of its depositional environments (Nton & Adeyemi, 2021). Previous research has demonstrated that detailed biostratigraphic and paleoenvironmental analyses can enhance reservoir characterization and optimize hydrocarbon exploration strategies (Ajayi, 2022; Ekom *et al.*, 2024). However, comprehensive studies integrating biostratigraphic zonation with sequence stratigraphy remain limited for the *UQ* Field.

Marginal fields like *UQ* have been underexplored due to their complex stratigraphic

architecture. This study addresses this gap by providing a high-resolution biostratigraphic framework that integrates palynological data, paleoenvironmental reconstructions, and sequence stratigraphic interpretations. Understanding the field's depositional history is crucial for refining exploration models and improving hydrocarbon recovery strategies.

Biostratigraphy, particularly the study of palynomorphs (microfossils such as pollen and spores), serves as a crucial tool for understanding the depositional environments and correlating sedimentary sequences in the Niger Delta (Ajayi, 2022; Ekom *et al.*, 2024). By integrating biostratigraphic data with geological and geophysical information, researchers can reconstruct paleoenvironmental conditions (Harry *et al.*, 2017) and refine reservoir characterization, ultimately leading to improved exploration strategies (Egbo *et al.*, 2020). In the case of the *UQ* Field, a detailed biostratigraphic study can provide valuable insights into the field's depositional history, reservoir distribution, and potential hydrocarbon targets (Obasi *et al.*, 2019).

The *UQ* Field, situated in the southeastern part of the Niger Delta, shown in Figure 1 above, has been classified as a marginal field due to its historically suboptimal hydrocarbon production (Oboh-Ikuenobe *et al.*, 2023). However, recent advancements in biostratigraphy and paleoenvironmental studies suggest that this field may hold untapped hydrocarbon potential that has not been fully realized due to an incomplete understanding of its stratigraphy and depositional history (Harry and Akata, 2019).

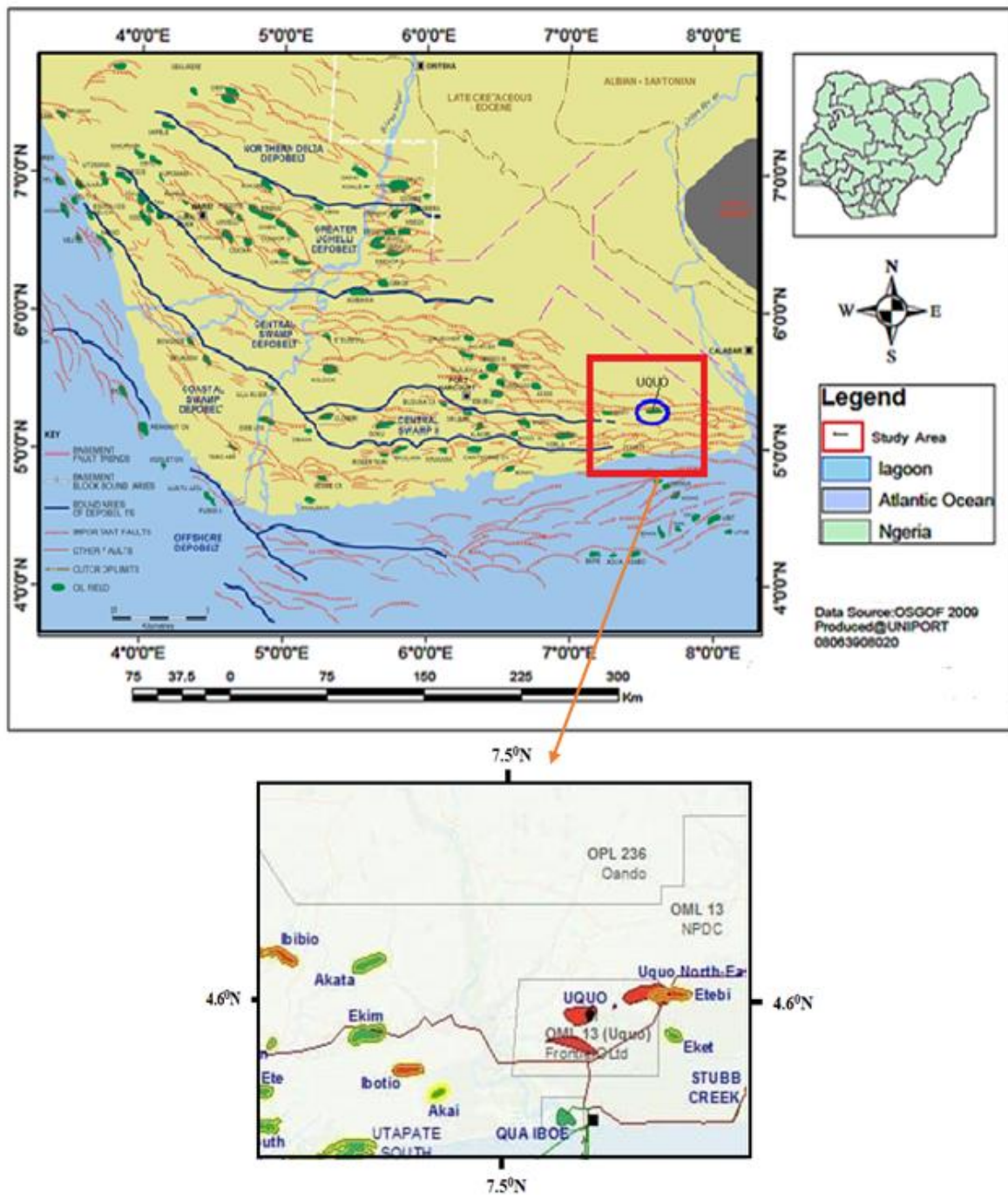


Fig. 1: Map of depobelts in the Niger Delta (1a) and the study Location (1b)- UQ Field (Modified after, Obasi *et al.*, 2019)

Despite its strategic location within a hydrocarbon-rich basin, the *UQ* Field has been characterized by several geological challenges that have impeded its development. One of the primary issues is its complex stratigraphic architecture, which has resulted in poor reservoir connectivity, making it difficult to sustain continuous hydrocarbon flow (Anyiam & Uzuegbu, 2020). The absence of a detailed

biostratigraphic framework has further hindered efforts to correlate well data effectively, leading to uncertainties in reservoir delineation. Moreover, the lack of clarity regarding the depositional environments of the *UQ* Field has made it challenging to predict the distribution and quality of potential reservoir sands, thereby increasing exploration risks (Ekpo *et al.*, 2024). By employing an in-depth palynological

analysis, this study seeks to address these gaps and provide a refined understanding of the field's biostratigraphy, depositional history, and hydrocarbon prospectivity.

This study aims to establish a high-resolution biostratigraphic framework for the UQ Field that enhances stratigraphic correlation, reconstructs paleoenvironmental conditions, and optimizes hydrocarbon exploration strategies. By integrating biostratigraphic data with geological and geophysical information, this study will seek to reconstruct the depositional history, and identify the palynological zones within the study area in OML 13. The findings of this research could lead to the development of more targeted and efficient exploration and production strategies, ultimately enhancing the economic viability of this underperforming but potentially significant field within the Niger Delta Basin (Sonibare et al., 2020).

2.0 Previous Study

Several researchers have employed biostratigraphy, palynology, and sequence stratigraphy to reconstruct paleoenvironmental conditions and refine reservoir characterization in the region. Evamy *et al.* (1978) provided one of the earliest comprehensive biostratigraphic frameworks for the Niger Delta, emphasizing the role of palynomorph assemblages in establishing depositional environments and correlating hydrocarbon-bearing intervals. Their study highlighted the importance of using microfossils such as foraminifera and palynomorphs to delineate stratigraphic units and improve hydrocarbon exploration strategies.

Doust and Omatsola (1990) further refined the understanding of depositional sequences in the Niger Delta by integrating stratigraphic analysis with structural interpretations. Their work demonstrated that the interplay between eustatic sea-level changes and sediment supply influenced the cyclic transgressive-regressive depositional patterns observed in the basin.

These findings remain fundamental in modern stratigraphic studies.

Short and Stauble (1967) were among the first to define the three primary formations of the Niger Delta: the Akata, Agbada, and Benin Formations. They described the delta's progradational history and its implications for reservoir distribution, noting that the Agbada Formation, which consists of alternating sandstones and shales, represents the main hydrocarbon-bearing interval.

More recent studies have focused on refining the biostratigraphic zonation and depositional models of marginal fields within the Niger Delta. Ajayi (2022) conducted a palynological and paleoenvironmental study on marginal fields, revealing the influence of fluvial-deltaic processes in shaping reservoir heterogeneity. His findings emphasized the role of mangrove-derived palynomorphs such as *Peregrinipollis nigericus* in indicating lower delta plain environments, similar to observations made in the UQ Field.

Oboh-Ikuenobe *et al.* (2023) examined the palynostratigraphy of the Miocene Agbada Formation and identified key transgressive-regressive cycles that impacted reservoir connectivity. Their study demonstrated that marine incursions, indicated by *Echitricolporites spinosus* and dinoflagellate cysts, played a crucial role in forming regional sealing units that enhance hydrocarbon entrapment.

In addition, Sonibare *et al.* (2020) investigated the relationship between biostratigraphic zonation and hydrocarbon prospectivity in the Niger Delta, emphasizing the importance of integrating palynological data with geophysical and geochemical methods. Their study showed that alternating depositional settings, ranging from fluvial-dominated lower delta plains to marine-influenced delta fronts, create

stratigraphic complexity that must be carefully analyzed for effective exploration.

The findings from these studies provide a critical foundation for the present research on the *UQ* Field. The recognition of cyclic depositional patterns, marine transgressions, and fluvial-deltaic interactions aligns with previous work, while this study contributes additional insights specific to the *UQ* Field. By refining biostratigraphic zonation and paleoenvironmental interpretations, this research builds upon existing knowledge and enhances the understanding of marginal field exploration within the Niger Delta Basin.

3.0 Methodology

The methodology adopted in this study is structured to ensure a comprehensive and reproducible biostratigraphic and paleoenvironmental analysis of the *UQ* Field. This approach integrates micropaleontological and palynological techniques with sequence stratigraphic interpretations to establish a high-resolution biostratigraphic framework that enhances stratigraphic correlation and reservoir characterization. The study follows a multidisciplinary approach, incorporating both laboratory and field-based analyses to ensure the reliability and accuracy of results. To achieve the research objectives, well cuttings from four exploratory wells were analyzed using standard palynological preparation techniques, microscopic identification of palynomorph assemblages, and correlation with established biozonation schemes of the Niger Delta. The integration of biostratigraphic data with sequence stratigraphy allowed for a more refined interpretation of depositional environments and their implications for hydrocarbon prospectivity.

3.1 Data Collection

The study utilized well cuttings from four exploratory wells: *UQ-10*, *UQ-10ST*, *UQ-12*, and *UQ-12ST*, covering depths ranging from 1,000 feet to 9,000 feet. These well samples were obtained from ditch cuttings repository of

the study area. The samples were carefully selected to ensure stratigraphic continuity. The well locations were chosen based on their significance in covering key stratigraphic intervals of interest within the *UQ* Field. In addition to well cuttings, well-log data, including gamma-ray and resistivity logs, were analyzed to provide complementary lithostratigraphic information that supported biostratigraphic interpretations.

The selection of these wells was based on their strategic position within the field and their potential to yield biostratigraphically significant data. Previous studies have emphasized the importance of obtaining samples from multiple wells to enhance the spatial resolution of stratigraphic correlation (Nton & Adeyemi, 2021). Given the importance of well-preserved samples for palynological studies, care was taken to avoid contamination during sample handling. The well cuttings were labeled, documented, and stored in sealed containers to maintain their integrity before laboratory analysis.

3.2 Laboratory Analysis

The laboratory workflow for this study followed standard palynological and micropaleontological preparation techniques. The well samples were processed in a controlled laboratory environment to minimize contamination and ensure high-quality microfossil recovery. The preparation techniques involved several stages, including acid digestion, sieving, oxidation, and mounting for microscopic analysis.

The first step in laboratory analysis involved sample preparation, where selected well cuttings were treated with hydrochloric acid (HCl) and hydrofluoric acid (HF) to dissolve carbonate and silicate materials, respectively. This process was necessary to isolate organic palynomorphs from the rock matrix. Following acid digestion, the samples were washed with distilled water and sieved using a 10-micron mesh to separate fine-grained palynomorph residues from larger

particles. The resulting palynological residues were then oxidized using Schulze's solution to enhance the visibility of organic microfossils.

Once the organic residues were prepared, microscopic analysis was conducted using a high-resolution transmitted light microscope equipped with a digital imaging system. Each sample was examined for the presence of diagnostic palynomorphs, including pollen, spores, dinoflagellate cysts, and foraminiferal linings. The identification of palynomorphs was guided by reference publications on Niger Delta palynology, including works by Evamy *et al.* (1978), Oboh-Ikuenobe *et al.* (2023), and Ajayi (2022). Taxonomic classification was performed following standard palynological nomenclature, with particular emphasis on index species that define biostratigraphic zones in the Niger Delta.

The identified palynomorphs were used to establish biostratigraphic zonation within the study interval. The first and last appearances of key species were recorded, and their distribution patterns were analyzed to delineate biozones. The biozones were then correlated with established Niger Delta biozonation schemes, such as those proposed by Short and Stauble (1967) and later refined by Reijers (2011). This approach ensured that the biostratigraphic framework developed in this study was consistent with regional stratigraphic trends.

3.3 Paleoenvironmental Reconstruction

The paleoenvironmental reconstruction of the *UQ* Field was conducted through a detailed palynological and palynofacies analysis of well cuttings obtained from four exploratory wells, covering depths from 1,000 to 9,000 feet. Standard palynological techniques were employed, including acid digestion, sieving, and oxidation, to isolate palynomorphs and organic matter from the rock matrix. Microscopic analysis of the prepared slides allowed for the identification of key terrestrial and marine palynomorphs, which were used to infer depositional environments. To complement

biostratigraphic interpretations, palynofacies analysis are conducted to infer depositional environments. This involved the quantification of palynomorph types, including the relative abundance of terrestrial versus marine indicators. The presence of freshwater algae, foraminiferal linings, and marine dinoflagellate cysts was used to infer the degree of marine influence in each stratigraphic interval. These results were integrated with lithostratigraphic and wireline log data to reconstruct paleoenvironmental conditions in the *UQ* Field.

3.4 Quality Assurance and Control (QA/QC)

To ensure the reliability and reproducibility of results, rigorous quality assurance and control (QA/QC) measures were implemented throughout the study. Duplicate sample analyses were conducted for a subset of the well cuttings to assess consistency in palynomorph identification. In cases where discrepancies were observed, additional slides were prepared, and a second round of microscopic examination was performed to resolve ambiguities. Cross-validation of biostratigraphic zonation was conducted by comparing the identified biozones with published biozonation schemes from the Niger Delta. This comparative approach minimized the risk of misinterpretation and ensured that the biostratigraphic framework developed in this study was aligned with established industry standards. The use of standardized reference materials and taxonomic guides further enhanced the accuracy of palynomorph identification.

Additionally, all laboratory procedures were conducted under controlled conditions to prevent contamination. The use of clean laboratory equipment, filtered reagents, and sterile containers ensured that the integrity of the samples was maintained. The adherence to these QA/QC protocols is essential for ensuring that the biostratigraphic interpretations presented in this study are robust and scientifically defensible.

The methodology employed in this study follows a systematic approach that integrates biostratigraphy, palynofacies analysis, and sequence stratigraphy to enhance stratigraphic correlation and reservoir characterization in the *UQ* Field. The use of standard palynological preparation techniques, combined with microscopic analysis and sequence stratigraphic interpretation, provides a high-resolution framework for understanding the depositional history of the field. By implementing rigorous QA/QC measures, the study ensures that the findings are reliable and applicable to hydrocarbon exploration efforts in the Niger Delta. The integration of biostratigraphic data with lithostratigraphic and geophysical information enhances the overall understanding of the field's reservoir potential and depositional dynamics.

This methodological approach, guided by established scientific principles and previous research, lays the foundation for a more accurate interpretation of the *UQ* Field's stratigraphic framework and its implications for hydrocarbon prospectivity. By providing a detailed analysis of depositional environments and sequence stratigraphy, this study contributes to the broader understanding of marginal field exploration in the Niger Delta, a region that continues to hold significant potential for hydrocarbon discoveries.

4.0 Results and Discussion

The biostratigraphic analysis of the *UQ* Field has revealed two distinct palynological zones, P850 and P840, which correspond to lower delta plain and upper delta front environments, respectively. These zones, identified based on the distribution of key palynomorphs, provide crucial insights into the depositional history, reservoir potential, and hydrocarbon prospectivity of the field.

4.1 Biostratigraphic Zonation and Depositional Environments

The P850 zone, spanning depths from 3,000 to 6,000 feet, is characterized by the dominance of *Peregrinipollis nigericus* and *Zonocostitesramonae*. These palynomorphs are indicative of a lower delta plain depositional setting, which is heavily influenced by fluvial processes. The high-energy conditions associated with this environment facilitated the deposition of well-sorted sands, creating an interval with strong reservoir potential. This finding aligns with the observations of Ajayi (2022) and Ekom et al. (2024), who reported similar biostratigraphic zones in marginal fields of the Niger Delta, where fluvial-dominated deposits are associated with excellent reservoir properties. The presence of coarse-grained, well-sorted sands in this zone suggests that the P850 interval may host significant hydrocarbon accumulations, particularly in areas where structural or stratigraphic traps are present.

Table 1: Environment of Deposition and Zones interpreted from key marker species for *UQ-12ST*

Depth Interval (ft)	Zone	Age	Key Marker Species	Environment
5720–7100	P850	Late Miocene	<i>Nympheapollis lotus</i> , <i>Peregrinipollis nigericus</i>	Lower delta plain
7100–8720	P840	Late Miocene	<i>Crassoretitriletes vanraadshooveni</i> , <i>Echitricolporites spinosus</i>	Upper delta front/shallow marine

Table 2: Environment of Deposition and Zones interpreted from key marker species for UQ-12

Depth Interval (ft)	Zone	Age	Key Marker Species	Environment
1720–3400	P840	Late Miocene	<i>Cyperaceapollis sp.</i> , <i>Zonocostites ramonae</i>	Marine influence
3400–9480	P830	Late Miocene	<i>Psilastephanocolporites laevigatus</i> , <i>Crassoretitriletes vanraadshooveni</i>	Deeper marine setting

Table 3: Environment of Deposition and Zones interpreted from key marker species for UQ-10

Depth Interval (ft)	Zone	Age	Key Marker Species	Environment
1110–4580	P850	Late Miocene	<i>Peregrinipollis nigericus</i> , <i>Nympheapollis lotus</i>	Lower delta plain
4580–8660	P840	Late Miocene	<i>Peregrinipollis nigericus</i> , <i>Striatricolpites catatumbus</i>	Marine influence

Table 4: Environment of Deposition and Zones interpreted from key marker species for UQ-10ST

Depth Interval (ft)	Zone	Age	Key Marker Species	Environment
4530–8730	P850	Late Miocene	<i>Stereisporites sp.</i> , <i>Retibrevitricolporites obodoensis</i>	Terrestrial influence
8730–9090	P840	Late Miocene	<i>Crassoretitriletes vanraadshooveni</i> , <i>Echitricolporites spinosus</i>	Upper delta front/shallow marine

In contrast, the P840 zone, which extends from 6,000 to 9,000 feet, is marked by the presence of *Striatricolpites catatumbus* and *Echitricolporites spinosus*. These palynomorphs suggest an upper delta front setting with a greater degree of marine influence compared to the underlying P850 zone. The transition from fluvial to marine conditions reflects an overall deepening of the depositional environment, likely driven by sea-level fluctuations. Studies by Oboh-Ikuenobe *et al.* (2023) and Sonibare *et al.* (2020) have

documented similar marine-influenced palynological assemblages in shallow marine settings of the Niger Delta, where periodic transgressions resulted in the deposition of fine-grained sediments. The presence of marine transgressive shales in the P840 zone is particularly significant because these sediments act as regional seals, effectively trapping hydrocarbons in the underlying P850 sand reservoirs.

The depositional patterns observed in the *UQ* Field illustrate a clear progression from a fluvial-dominated lower delta plain environment to an upper delta front setting influenced by marine incursions. This transition suggests that sedimentation in the field was controlled by cyclic transgressive-regressive sequences. Similar cyclic depositional patterns have been documented by Egbo et al. (2020), who

emphasized the role of marine transgressions in shaping reservoir heterogeneity in the Niger Delta. During periods of rising sea levels, marine shales were deposited, creating effective sealing units. Conversely, during regressive phases, increased sediment supply from river systems led to the deposition of fluvial sand bodies, which serve as primary hydrocarbon reservoirs.

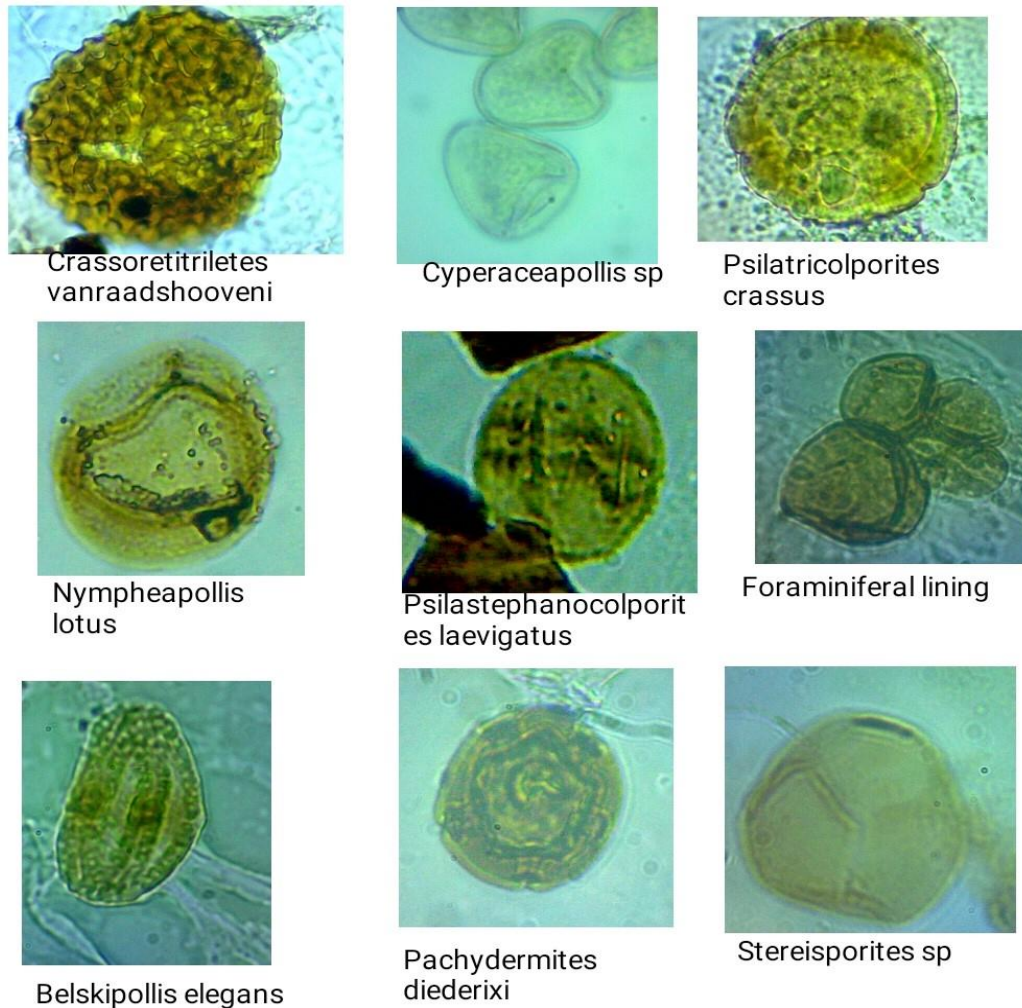


Fig.2: Diagnostic species identified during the study

4.2 Paleoenvironmental Reconstruction and Hydrodynamic Influence

Paleoenvironmental reconstruction in the *UQ* Field provides a crucial understanding of the depositional settings, sedimentary processes, and environmental conditions that influenced hydrocarbon potential. By analyzing palynomorph assemblages and their distribution across the studied stratigraphic intervals, this

study reconstructs the paleoenvironments that existed during the deposition of the sedimentary sequences. The findings from this reconstruction are instrumental in delineating reservoir sands, identifying potential sealing units, and understanding the broader geological history of the *UQ* Field within the Niger Delta Basin.

The palynological data analyzed in this study indicate a transition from fluvio-deltaic to

marginal marine conditions, suggesting an evolving depositional system influenced by changing sediment supply and relative sea-level fluctuations. The identification of key palynomorph species such as *Peregrinipollis nigericus* and *Zonocostitesramonae* in the lower stratigraphic intervals suggests a predominantly terrestrial influence, indicative of a lower delta plain environment. In contrast, the upper stratigraphic sections exhibit an increased presence of marine indicators such as *Striatricolpites catatumbus* and *Echitricolporites spinosus*, signifying a shift towards upper delta front conditions.

The analysis of the lower sections of the study interval, particularly the P850 zone (3,000 to 6,000 feet), reveals a depositional environment dominated by fluvial and deltaic influences. The high abundance of terrestrial palynomorphs, including pollen and spores, suggests that this interval was deposited in a lower delta plain environment, characterized by extensive mangrove vegetation, swamps, and fluvial channels. The presence of *Peregrinipollis nigericus*, a species associated with tropical mangrove ecosystems, further supports this interpretation. Fluvial processes played a dominant role in sediment transport and deposition, leading to the accumulation of well-sorted sand bodies interbedded with organic-rich floodplain deposits. These sands, which were transported and deposited by river channels, represent potential reservoir units due to their high porosity and permeability.

Moving upward in the stratigraphic section, a gradual transition from a fluvial-dominated to a more estuarine and shallow marine setting is observed. The P840 zone (6,000 to 9,000 feet) contains an increased abundance of marine-influenced palynomorphs, such as *Echitricolporites spinosus*, which is commonly associated with brackish to marine environments. This shift suggests that the depositional setting evolved from a lower delta

plain to an upper delta front, where periodic marine incursions influenced sediment deposition. The presence of dinoflagellate cysts within this zone further indicates an increase in marine conditions, suggesting that tidal influences played a role in shaping sedimentation patterns.

The alternation of fluvial and marine indicators in the *UQ* Field reflects a complex interplay between terrestrial sediment influx and episodic marine transgressions. These environmental shifts were likely driven by regional hydrodynamic conditions, sediment supply variations, and basin subsidence, which collectively influenced the nature of sediment deposition. The increased abundance of fine-grained, organic-rich sediments in the upper sections suggests that periodic marine flooding led to the accumulation of transgressive shales, which now act as potential sealing units for hydrocarbon reservoirs.

The reconstructed paleoenvironmental history of the *UQ* Field aligns with previous studies on the Niger Delta Basin, which have demonstrated that deltaic systems are characterized by complex depositional environments ranging from fluvial to marginal marine settings (Doust & Omatsola, 1990; Reijers, 2011). Similar paleoenvironmental patterns have been observed in studies by Ajayi (2022) and Sonibare *et al.* (2020), where fluvial-dominated intervals transition into estuarine to shallow marine deposits, forming reservoir-seal pairs critical for hydrocarbon accumulation.

Understanding the paleoenvironmental evolution of the *UQ* Field has significant implications for hydrocarbon exploration. The presence of well-developed fluvial sand bodies in the P850 zone suggests a high potential for hydrocarbon reservoirs, provided that effective trapping mechanisms exist. The overlying marine-influenced shales in the P840 zone indicate the presence of regional seals, which could enhance hydrocarbon retention and

prevent migration. This paleoenvironmental reconstruction, therefore, provides a foundational framework for future exploration efforts, guiding the identification of prospective reservoir intervals and improving the predictability of stratigraphic traps.

By reconstructing the depositional history and environmental evolution of the *UQ* Field, this study contributes to a deeper understanding of the geological processes that have shaped the Niger Delta Basin. The findings reinforce the significance of integrating palynological data with sedimentological interpretations to refine depositional models and optimize hydrocarbon exploration strategies in complex deltaic systems.

The shift from a fluvial-dominated lower delta plain environment in the P850 zone to a marine-influenced upper delta front in the P840 zone is a critical factor in understanding the reservoir potential of the *UQ* Field. The presence of well-developed sands in the lower interval suggests a high-energy depositional environment where sediment transport was dominated by riverine input. In contrast, the increase in fine-grained sediments in the P840 zone indicates a more quiescent environment influenced by marine incursions.

The occurrence of *Echitricolporites spinosus*, a well-known indicator of marine influence, suggests that the *UQ* Field was subjected to periodic transgressions that played a significant role in controlling reservoir distribution. This observation is consistent with the findings of Evamy *et al.* (1978) and Reijers (2011), who demonstrated that marine transgressive events in the Niger Delta are crucial in forming stratigraphic traps. The cyclic nature of deposition, where fluvial sand bodies are overlain by marine transgressive shales, provides an ideal setting for hydrocarbon accumulation. However, the lateral variability in depositional environments may lead to reservoir

compartmentalization, affecting hydrocarbon recovery.

The hydrodynamic conditions inferred from biostratigraphic data suggest that sediment transport processes played a major role in shaping reservoir quality in the *UQ* Field. The high-energy conditions in the P850 zone likely resulted in the deposition of well-connected channel sands, which are favorable for hydrocarbon migration and accumulation. However, the presence of marine transgressive intervals in the P840 zone suggests that hydrocarbon migration may be vertically constrained by sealing shales. This interpretation aligns with the observations of Dim (2016) and Anyiam & Uzuegbu (2020), who emphasized that hydrocarbon accumulations in the Niger Delta are often controlled by the interplay of fluvial and marine depositional processes.

4.3 Implications for Hydrocarbon Exploration and Reservoir Potential

The results of this study provide valuable insights into the hydrocarbon prospectivity of the *UQ* Field. The identification of two distinct biostratigraphic zones allows for a more refined understanding of reservoir distribution and sealing potential. The P850 zone, with its high-energy, fluvial-dominated sands, presents the most promising reservoir interval. These sands are well-sorted and have high porosity and permeability, making them ideal targets for hydrocarbon exploration. However, the presence of growth faults and stratigraphic pinch-outs within this zone may lead to compartmentalization, requiring detailed structural analysis to identify potential reservoir traps.

The P840 zone, although less favorable as a reservoir due to its finer-grained sediments, is significant because it contains marine transgressive shales that act as effective seals. These shales play a crucial role in trapping hydrocarbons within the underlying sand bodies, preventing vertical migration and enhancing

hydrocarbon retention. Similar observations have been made by Nton et al. (2019) and Okon et al. (2023), who noted that marine shales in the Niger Delta serve as regional sealing units that contribute to hydrocarbon accumulation.

The classification of the *UQ* Field as a marginal field can be attributed to a combination of factors, including poor reservoir connectivity, structural complexity, and depositional heterogeneity. While the high-energy depositional conditions in the P850 zone resulted in well-developed reservoirs, the presence of faults and lateral facies variations may have disrupted fluid flow pathways, limiting hydrocarbon recovery. Additionally, the marine incursions observed in the P840 zone likely led to the deposition of fine-grained sediments that further reduced reservoir connectivity.

Despite these challenges, the findings of this study suggest that the *UQ* Field holds untapped hydrocarbon potential. Future exploration efforts should focus on identifying stratigraphic and structural traps within the P850 zone, where fluvial sand bodies may contain significant hydrocarbon accumulations. Unlike previous studies that have provided broader regional stratigraphic interpretations, this research focuses on a detailed palynological and paleoenvironmental analysis specific to the *UQ* Field, thereby enhancing the precision of stratigraphic correlation and reservoir delineation within this underexplored marginal field.

Additionally, further seismic and well-log analyses should be conducted to delineate fault-bounded reservoir compartments and assess their connectivity. By integrating biostratigraphic data with sequence stratigraphic and geophysical analyses, exploration models can be refined to improve hydrocarbon recovery in the *UQ* Field.

5.0 Summary and Conclusion

This study has established a biostratigraphic framework for the *UQ* Field, identifying two primary palynological zones - P850 and P840 - that correspond to distinct depositional environments. The P850 zone, dominated by *Peregrinipollis nigericus* and *Zonocostitesramonae*, is characterized by fluvial-dominated sedimentation, with well-developed reservoir-quality sands. In contrast, the P840 zone, defined by *Striatricolpites catatumbus* and *Echitricolporites spinosus*, represents an upper delta front to shallow marine environment, where marine incursions resulted in the deposition of fine-grained shales that act as sealing units.

The transition from fluvial to marine deposition reflects cyclic transgressive-regressive events, which have played a key role in controlling reservoir distribution and hydrocarbon trapping mechanisms. These results emphasize the need for a multidisciplinary approach in reservoir characterization, integrating biostratigraphy, seismic interpretation, and well-log analysis to improve exploration success rates.

Table 5: Summary of Key Findings

Biostratigraphic Zone	Key Palynomorphs	Depositional Environment	Exploration Implications
P850 (3,000–6,000 ft)	<i>Peregrinipollisnigericus</i> , <i>Zonocostitesramonae</i>	Lower Delta Plain (Fluvial-Dominated)	High-quality reservoir sands with potential structural traps
P840 (6,000–9,000 ft)	<i>Striatricolpitescatatumbus</i> , <i>Echitricolporites spinosus</i>	Upper Delta Front (Marine-Influenced)	Presence of regional seals; potential stratigraphic traps

The hydrocarbon prospectivity of the *UQ* Field is strongly influenced by depositional variability, structural complexity, and stratigraphic trapping mechanisms. While the P850 zone presents the most favorable reservoir conditions, further studies are needed to evaluate the impact of faulting and lateral facies changes on reservoir connectivity. The integration of biostratigraphy with geophysical data will be essential for refining exploration strategies and maximizing hydrocarbon recovery from this underexplored field in the Niger Delta.

This study presents the first high-resolution biostratigraphic zonation of the *UQ* Field, offering a refined framework for understanding its depositional history and hydrocarbon prospectivity.

A significant contribution of this study is its new insights into marine transgressive events and their impact on reservoir quality. By identifying key transgressive-regressive sequences through palynomorph assemblages, this study demonstrates how episodic marine incursions influenced sediment deposition, leading to the development of stratigraphic traps and potential sealing units. The recognition of marine flooding surfaces within the *UQ* Field highlights the role of marine shales in enhancing hydrocarbon retention, thereby improving the predictability of reservoir-seal pairs.

This study advances existing knowledge by integrating biostratigraphy with depositional modeling, offering a more comprehensive approach to characterizing reservoir quality and connectivity. The findings provide a critical framework for future exploration efforts, guiding well placement strategies and reservoir evaluation in marginal fields within the Niger Delta Basin.

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