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Organic Petrographic Characterization and Paleodepositional Environment of Potential Source Rocks in the Patti Formation, Bida Basin, Nigeria

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Abstract: *The Patti Formation in the Bida Basin, Nigeria, is a promising sedimentary sequence for hydrocarbon exploration especially the coal and shale facies in the area. This study presents an organic petrographic characterization of the coal and shale samples from the Patti Formation focusing on the palynological and biostratigraphic investigation of the rock sequence exposed within the Agbaja Patti Formation, Nigeria. This study aims to provide insight into the paleoenvironment of deposition, and age and enrich the available literature for this study area. Field observations show clearly defined coal beds within the Agbaja plateaus, occurring in association with shales and sandstones. The result of the palynological analyses of 22 selected samples shows that palynomorph recovery from the analysed samples shows abundant pollen, spore, dinoflagellates, algae, and fungal spores, especially for the coal facies. This is followed by the shale, claystone, sandy shale and ironstone in the decreasing order. The studied area is dated Early-Late Maastrichtian based on the palynomorph assemblage of Proteacidites sp., Longapertitesmarginatus, Auriculiidites reticularis, Foveotriletes margaritae, Retidiporites magdalenensis, Milfordia sp, Proteacidites longispinosus, Cingulatisporites ornatus, and Monosulcites sp., and Syncolporites marginatus, Syncolporites subtilis, Auriculiidites reticularis, Longapertites marginatus, Proteacidites sp., Cingulatisporites ornatus, Proteacidites dehaani, Cyathidites sp., Proteacidites sigali, Crototricolpites crtonisculptus, Monosulcites sp., Longapertitites microfoveolatus, and Syncolporites lisammae. Therefore, the paleoenvironment of deposition of the investigated stratigraphic interval is composed of an admixture of terrestrially derived miospores and marine organic wall organisms of peridinacean forms, which are indicative of a marginal marine set.*

Keywords: *Organic Petrography; Palynomorphs; Coal; Shale; Agbaja; Patti Formation; Bida Basin.*

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1.0 Introduction

The exploration and development of hydrocarbon resources in Nigeria have historically focused on the Niger Delta Basin, which has yielded vast economic benefits. However, with increasing interest in diversifying energy sources and expanding domestic petroleum production, inland sedimentary basins such as the Bida Basin have attracted growing attention from geologists and exploration companies. Among the formations within this basin, the Patti Formation—a sequence of interbedded shale, sandstone, and coal—has been recognized as a potential source rock for hydrocarbons (Akinbami et al., 2020; Adekeye et al., 2021).

Understanding the petroleum system of a basin requires an integrated assessment of its source rock quality, maturity, and depositional environment. These parameters can be effectively constrained through the combined application of organic petrography, palynology, and geochemical analyses. Organic petrography enables the identification and classification of macerals (the organic constituents of coal and shale), which are critical for assessing hydrocarbon generation potential (Taylor et al., 2022). Palynology, the study of fossil pollen, spores, and other microscopic plant remains, offers additional insights into the age, paleoenvironment, and vegetational history of the depositional setting (Ola-Buraimo & Ehinola, 2022). When combined with geochemical techniques such as Total Organic Carbon (TOC) analysis and Rock-Eval pyrolysis, these methods provide a comprehensive evaluation of source rock potential.

Previous studies in analogous Nigerian basins, such as the Anambra, Benue Trough, and Sokoto Basin, have shown that organic-rich sediments deposited under anoxic to dysoxic conditions during the Late Cretaceous to Paleogene periods often exhibit favorable conditions for hydrocarbon generation (Obaje et al., 2004; Amajor, 1991). However, in the southern Bida Basin, particularly within the Patti Formation, such integrative studies are sparse or fragmented. Some geochemical investigations have hinted at moderate to high TOC values, and visual observations have confirmed the presence of coal seams, but there remains a lack of holistic data that incorporate biostratigraphy, palynofacies, and maceral analysis to characterize the formation's true petroleum potential (Adegoke et al., 2022; Odoma et al., 2023).

Moreover, recent field surveys have documented thick sequences of carbonaceous shale and bituminous coal on the Agbaja Plateau and adjoining areas, prompting renewed scientific interest. Still, the questions surrounding the exact age of deposition, the paleoclimatic conditions, the organic matter types, and the thermal maturity levels remain largely unresolved. The absence of detailed palynological studies in these sequences is particularly noteworthy, as palynomorph assemblages provide vital information not only about the age and stratigraphy but also about depositional settings, such as fluvial-deltaic, lacustrine, or paralic systems.

Although there have been efforts to assess the hydrocarbon potential of inland basins in Nigeria, including geophysical surveys and stratigraphic mapping, very few studies have comprehensively applied both organic petrography and palynology to the Patti Formation in the southern Bida Basin. Most existing data either rely solely on geochemistry or are limited to general lithostratigraphic observations. Thus, there is a critical need for multidisciplinary research that combines petrographic, palynological, and geochemical approaches to evaluate the organic matter quality, depositional environment, and thermal evolution of this formation.

This study aims to characterize the coal and shale units of the Patti Formation using organic petrographic and palynological techniques, complemented by geochemical analysis, to assess their source rock potential and paleoenvironmental history.

The findings of this study are expected to fill a major gap in the geological understanding of the southern Bida Basin. By providing detailed organic petrographic and palynological profiles, the research will contribute critical data to regional stratigraphic correlations, basin modeling, and hydrocarbon prospectivity assessments. Furthermore, the outcomes may guide future exploration programs in inland basins, reduce exploration risks, and support energy diversification policies in Nigeria. Additionally, by determining the paleoenvironments and thermal evolution of the Patti Formation, the study will advance academic knowledge on Cretaceous sedimentation in West Africa.

1.1 Geologic setting

The Bida Basin, otherwise known as the Middle Niger Basin, is an intracratonic sedimentary basin located in central Nigeria, trending northwest–southeast. It forms a crucial part of the Central West African rift system and is geographically defined between latitudes 8°30′N to 10°00′N and longitudes 4°30′E to 7°00′E (Obaje, 2009). The basin is flanked by the Southern Chad Basin to the northeast, the Anambra Basin to the southeast, and the Sokoto and Iullemmeden Basins to the west (Ola-Buraimo et al., 2013). Structurally, it is interpreted as a northwest extension of the Anambra Basin, from which it is separated by a basement complex ridge near the confluence of the Niger and Benue Rivers (Akande et al., 2005; Nton and Adebayo, 2009).

The Bida Basin owes its development to the Santonian tectonic event, which also influenced the formation of the Benue Trough. This tectonic regime led to crustal reactivation and the deposition of extensive Cretaceous sediments in a subsiding basin environment (Obaje, 2009). The lithostratigraphy of the basin is composed predominantly of the Lokoja, Patti, and Agbaja (or Mopa) Formations, along with interbedded members such as the Batati, Sakpe, Enagi, Jima, and Wuya (Adeleye, 1973; Braide, 1992).The Lokoja Formation forms the basal unit and consists mainly of poorly sorted, angular to sub-angular conglomerates, sandstones, and siltstones, deposited under high-energy, braided river conditions (Adeleye, 1975). Overlying the Lokoja is the Patti Formation, which comprises alternating beds of fine to medium-grained sandstones, siltstones, and dark shales, indicating a transition from fluvial to deltaic and shallow lacustrine environments (Akande et al., 2005). The overlying Agbaja Formation is characterized by ferruginous sandstones and ironstones, reflecting a subaerial, possibly oxidising depositional setting.

Stratigraphic members such as the Sakpe, Batati, Jima, Enagi, and Wuya exhibit distinct lithofacies and serve as important marker beds within the sedimentary succession. These units vary from shales and siltstones to ferruginous sandstones and oolitic ironstones, providing insight into cyclic sedimentation and fluctuating depositional energy (Nwajide, 2013). Shale units within the Patti and Sakpe formations are particularly rich in organic matter, often dark grey to black, indicating deposition under anoxic conditions conducive to hydrocarbon source rock development (Ola-Buraimo et al., 2013; Obaje et al., 1999). Geochemical studies show that these shales contain mostly type III and mixed type II/III kerogens, suggesting a gas-prone to mixed oil-gas generation potential (Obaje et al., 2004).

The depositional environment of the basin evolved from high-energy fluvial systems in the Lokoja Formation to more quiescent, organic-rich, lacustrine and deltaic settings in the Patti Formation, and later to subaerial oxidizing conditions in the Agbaja Formation (Akande et al., 2005). This vertical and lateral facies variation reflects progressive basin subsidence, tectonic quiescence, and changes in sediment supply and water depth. Given its structural setting, organic richness, and geochemical maturity, the Bida Basin has attracted attention as a potential frontier for petroleum exploration, particularly as an extension of the hydrocarbon-prolific Anambra Basin (Obaje, 2009; Nton and Adebayo, 2009).

1.2 Lithostratigraphic units of Bida basin

The Bida Basin, unlike other sedimentary basins in Nigeria, is distinguished by the absence of volcanic, carbonate, and tertiary-age rocks. The basin is divided into two main regions: the Northern Bida Basin and the Southern Bida Basin, with each possessing distinct lithostratigraphic units. Several studies have contributed to the understanding of the basin's stratigraphy, sedimentation, and overall geological framework, establishing a clear lithostratigraphic succession. The stratigraphy of the Bida Basin is widely agreed upon by various researchers, including Russ (1930), Adeleye (1974), Whiteman (1980), and Idowu and Enu (1992), who have described and classified the sedimentary layers within the basin.

Table 1 presents the lithostratigraphic units of the Bida Basin, summarizing the primary rock formations and their respective ages in both the Southern and Northern Bida Basins. The table outlines key formations such as the Agbaja Ironstone and Patti Formation in the Southern Bida Basin, and the Batati Ironstone and Edozighi Member in the Northern Bida Basin. It also includes important members like the Lokoja Sandstone, Bida Sandstone, and Precambrian crystalline basement rocks, among others. These units provide critical information on the basin's geological history and sedimentary processes.

Table 1: Lithostratigraphic Units of Bida Basin (Adopted After Russ, 1930; Adeleye, 1974; Whiteman, 1980; Idowu & Enu, 1992)

Age	Southern Bida Basin (Lokoja Area)	Northern Bida Basin (Bida Area)
Maastrichtian	Agbaja Ironstone	Batati Ironstone (Upper Ironstone)
	Patti Formation (75m)	Edozighi Member
		Kutugi Member
Campanian	Sakpe Ironstone (Lower Ironstone)	Wuya Member
		Baro Member
	Lokoja Sandstone (100-300m)	
		Bida Sandstone (80m)
		Jima Member
		Doko Member
Precambrian	Crystalline	Basement Complex

2.0 Materials and Method

This study involves the analysis of coal and shale samples from the Patti Formation of the Bida Basin to evaluate their potential as source rocks for hydrocarbon generation. A combination of organic petrographic and geochemical methods was employed to characterize the organic content, maturity, and depositional environment of the samples.

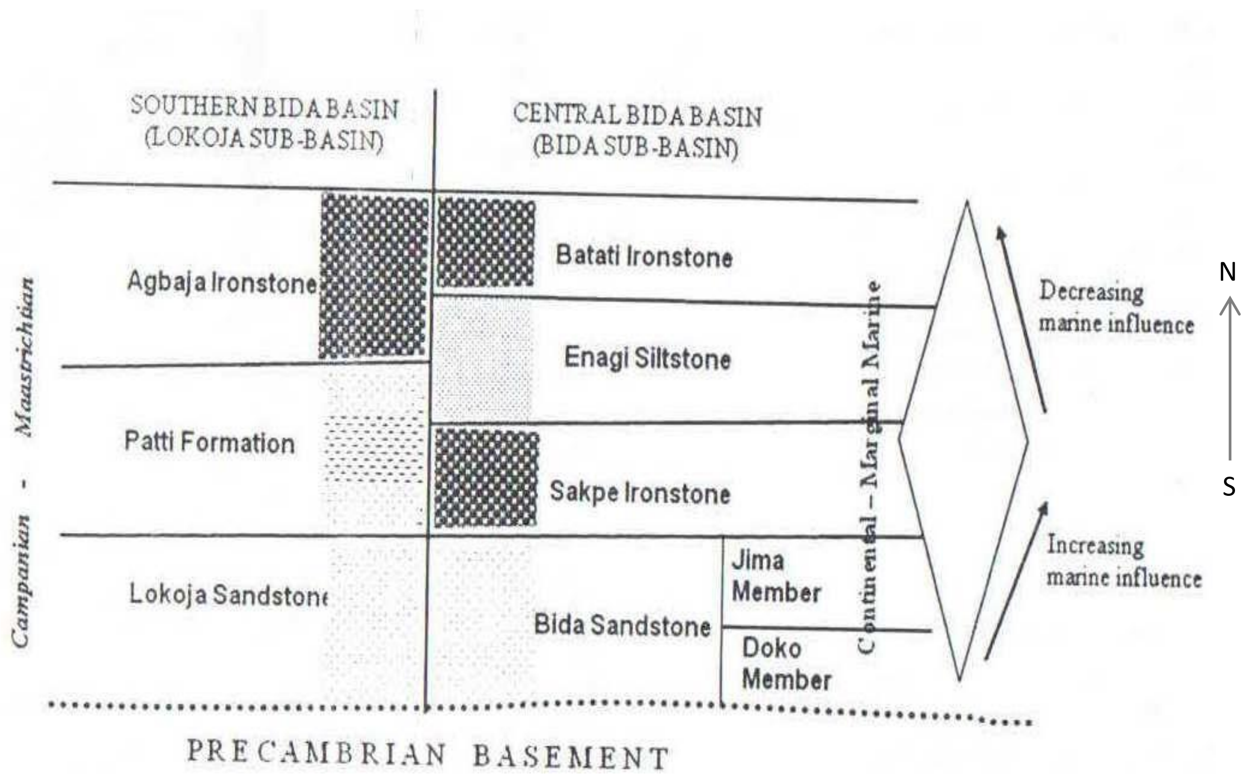

Fig. 1: Stratigraphic succession in the Bida Basin (adopted after Obaje, 2009, 2011)

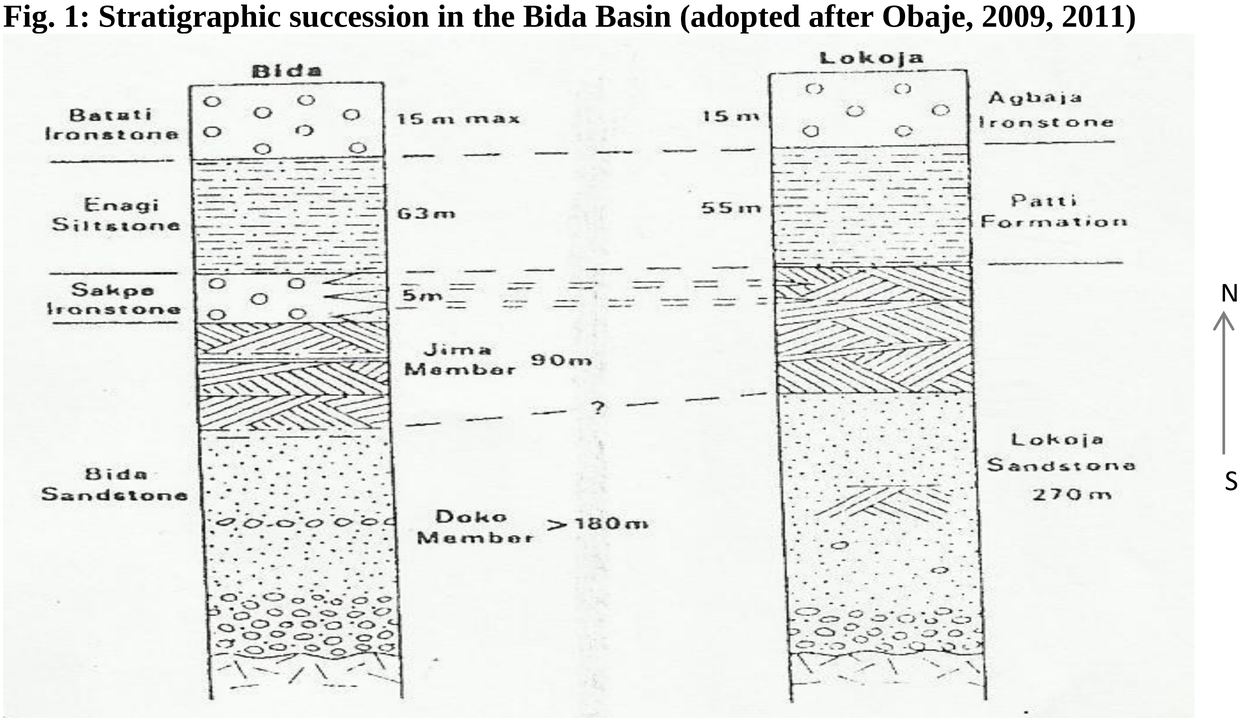

Fig. 2: Lithostratigraphic subdivision of Bida and Lokoja area of Bida Basin. Not to scale (Adopted after Adeleye, 1972)

2.1 Sample Collection and Preparation

The coal and shale samples were collected from selected outcrops within the southern Bida Basin, with particular focus on areas within the Lokoja region. Samples were carefully selected to represent different lithologies from the Patti Formation, including coal beds, shale, claystone, and sandstones. Each sample was labeled according to its location and depth, ensuring proper correlation with the stratigraphic sequence.

Before analysis, the samples were dried and crushed to a fine powder, ensuring uniformity for subsequent analysis. The samples were then subjected to several analytical procedures, including organic petrographic analysis, palynological examination, and geochemical testing.

2.2 Organic Petrographic Analysis

The organic petrographic analysis involved the examination of thin sections under a polarizing microscope. The analysis focused on identifying macerals within the coal and shale samples, including vitrinite, liptinite, and inertinite, which are key indicators of organic richness and maturity. The vitrinite reflectance (Ro) values were also measured to assess the thermal maturity of the samples. This technique provided insights into the depositional environment and organic facies of the samples.

2.3 Palynological Analysis

Palynological analysis was performed on the selected coal and shale samples to extract and identify palynomorphs such as pollen, spores, dinoflagellates, and algae. The palynological data were used to determine the paleoenvironment of deposition, including the influence of marine and terrestrial processes. The samples were treated with a combination of hydrochloric acid (HCl) and hydrofluoric acid (HF) to remove unwanted mineral components before the extraction of palynomorphs. The identified species were then analyzed and dated to constrain the age of the sediments, based on established biostratigraphic markers.

2.4 Geochemical Analysis

Geochemical analyses, including Total Organic Carbon (TOC) and Rock-Eval pyrolysis, were performed to assess the organic richness and thermal maturity of the samples. TOC content was measured to estimate the quantity of organic carbon present in each sample, indicating the hydrocarbon generation potential. Rock-Eval pyrolysis was conducted to analyze the oil and gas potential of the samples by measuring the quantity and quality of hydrocarbons released upon heating.

2.5 Lithostratigraphic Analysis

Lithostratigraphic data were integrated into the study to correlate the samples with established lithological units from the Bida Basin. The lithostratigraphy of the study area was assessed based on previous studies (Russ, 1930; Adeleye, 1974; Whiteman, 1980; Idowu and Enu, 1992), with a focus on the distinctive lithologies of the Patti Formation, including coal beds, shales, and sandstones. These data were used to further interpret the depositional environment and paleoenvironment of the basin.

2.6 Data Interpretation

The data collected from organic petrographic, palynological, and geochemical analyses were integrated to provide a comprehensive understanding of the source rock potential of the Patti Formation. The results were analyzed to identify the organic content and thermal maturity of the samples, as well as the paleoenvironmental conditions during deposition. The combined data were then used to assess the hydrocarbon potential of the coal and shale facies in the Bida Basin.

3.0 Results and Discussion

3.1 Palynozonation

The analysis of the palynological data from the various intervals revealed distinct characteristics indicative of the Early and Late Maastrichtian ages. At 46.5 m, the sandy shale interval contained a moderate abundance of palynomorphs, with key fossils such as Foveotriletes margaritae and Milfordia sp., which are indicative of Early Maastrichtian age. Similarly, at 44.0 m, the claystone interval also exhibited a moderately rich abundance of palynomorphs, with notable fossils like Foveotriletes margaritae and Milfordia sp., which further corroborate the Early Maastrichtian age, as confirmed by previous studies (Ola-Buraimo, 2020). Moving to 41.0 m, the shale facies showed an increase in the quantitative abundance and diversity of pollen and spores, though a reduction in dinoflagellate cysts. The presence of Milfordia jardinei and other key forms reinforced the Early Maastrichtian age, with some pollen forms being consistent with those described in the Lower Mamu Formation (Ola-Buraimo, 2020; Ola-Buraimo and Mohammed, 2024).

At 36.5 m, the coal facies displayed an increase in dinoflagellate cysts, with similar assemblages to those found in the Fika Formation, Borno Basin, dated to the Maastrichtian. The interval at 31.5 m, composed of shale, exhibited a lower abundance of palynomorphs, yet the presence of Milfordia sp. and other important fossils allowed for its assignment to the Early Maastrichtian. At 25.5 m, the coal facies revealed a high abundance of organic-walled organisms, including dinoflagellate cysts like Batiacasphaera sp. and Polysphaeridium sp., which are consistent with Early Maastrichtian age. The 21.5 m interval, composed of sandy shale, showed a poor to fair abundance of palynomorphs, but the presence of Foveotriletes margaritae and Auriculiidites reticularis affirmed its Early Maastrichtian age. At 14.5 m, the shale interval exhibited a significant increase in both miospore and dinoflagellate cyst diversity, with key fossils such as Milfordia sp. and Buttinea andreevi. This interval marked the first downhole appearance of Milfordia spp., a significant marker of Early Maastrichtian age, aligning with data from the lower part of the Patti Formation in Bida Basin (Ola-Buraimo, 2020; Oladimeji and Ola-Buraimo, 2021). The final interval, between 8.5 m and 2.0 m, was characterized by a decrease in palynomorph abundance, indicating a shift to a more marine environment, consistent with a Late Maastrichtian age. This interval was defined by the presence of marker forms such as Syncolporites marginatus and Longapertites marginatus, which are typical of Late Maastrichtian sediments in tropical West Africa.

Overall, the palynological data suggest that the stratigraphic sequence is primarily of Early Maastrichtian age, with a transition to Late Maastrichtian at the uppermost interval, reflecting a marginal marine depositional environment. The presence of both terrestrial and marine fossil contributors further supports this interpretation, indicating a dynamic paleoenvironment influenced by changing sea levels and coastline positions during the Maastrichtian period.

3.2 Palynology Analysis Sheet

Palynology, the study of pollen, spores, and other microscopic plant and microbial remains, offers valuable insights into past environmental conditions. Through the analysis of palynomorphs, one can infer details about climate, vegetation, and other environmental factors that prevailed during various periods of deposition. Below are the palynological results from several soil samples collected at different depths, with corresponding tables and interpretations that help in understanding the ecological history of the studied area. The first sample (FS1A) was collected from a depth of 2.0 meters. It represents an early depositional phase with a moderate diversity of palynomorphs. The results offer insights into the environmental conditions that may have been present at this depth. Table 2 presents the palynological analysis of Sample FS1A, detailing the abundance of various palynomorphs observed at this depth.

At 2.0 meters, the palynological composition suggests a mixed environment with possible marine or brackish conditions, as indicated by the high abundance of Dinoflagellate cysts (6). The presence of Syncolporites lisammae and Monosulcites sp. reflects a more varied environment with less specificity in terms of ecological setting.

Table 2: Palynology Analysis of Sample FS1A (Depth: 2.0 m)

S/N	Palynomorph	Abundance
1	Syncolporites lisammae	1
2	Dinoflagellate cyst	6
3	Indeterminate	2
4	Monosulcites sp.	2

The relatively low abundance of Indeterminate types may indicate a less diverse ecosystem at the time of deposition. Sample FS1B, also collected from the same depth of 2.0 meters, presents a broader range of palynomorphs, suggesting a more complex and fluctuating environment compared to FS1A.Table 3 presents the palynological data from Sample FS1B, showing a diverse array of species.

Table 3: Palynology Analysis of Sample FS1B (Depth: 2.0 m)

S/N	Palynomorph	Abundance
1	Oligosphaeridium sp.	1
2	Dinoflagellate cyst	1
3	Longapertites sp.	5
4	Botryococcus braunii	2
5	Longapertites microfoveolatus	1
6	Indeterminate	3
7	Phelodinium bolonienae	2
8	Cyathidites sp.	1
9	Fungal spore	1
10	Andalusiella polymorpha	4
11	Proteacidites sp.	1

The diversity of species observed in FS1B, particularly the abundance of Longapertites sp. (5) and Andalusiella polymorpha (4), suggests a dynamic ecosystem with mixed terrestrial and aquatic influences. The presence of Dinoflagellate cysts and Fungal spores points to organic decomposition and possible shifts in environmental conditions over time. The Indeterminate species may reflect periods of ecological transitions or varying preservation conditions. Sample FS2A, taken from a depth of 5.5 meters, shows a slightly different palynological profile, indicative of deeper deposition. This depth may represent a period with less diverse ecological conditions. Table 4 shows the palynological composition for FS2A.

Table 4: Palynology Analysis of Sample FS2A (Depth: 5.5 m)

S/N	Palynomorph	Abundance
1	Senegalinium sp.	1
2	Crototricolpites crotonoiscultus	1
3	Triporites sp.	1
4	Longapertites marginatus	1
5	Auriculidites reticularis	1
6	Natiacasphaera sp.	1
7	Proteacidites sigali	1
8	Indeterminate	2
9	Dinogymnium sp.	1

The palynological composition at this depth indicates a terrestrial environment with limited aquatic influence, as reflected by the presence of Triporites sp. and Senegalinium sp.. The relatively low abundance of species and the presence of Indeterminate types may suggest a more stable or less diverse ecosystem, possibly due to climatic or environmental constraints at the time. Sample FS2B, also from 5.5 meters, offers further insights into the conditions present at this depth. The palynological data from FS2B shows similar ecological characteristics to FS2A but with slight differences in species composition. Table 5 presents the results for Sample FS2B.

FS2B, like FS2A, suggests a predominantly terrestrial environment with some evidence of aquatic influences, as indicated by the presence of Senegalinium sp.. The relatively low abundance of species, including Longapertites marginatus and Proteacidites dehaani, may reflect a stable but not particularly diverse environment.

Table 5: Palynology Analysis of Sample FS2B (Depth: 5.5 m)

S/N	Palynomorph	Abundance
1	Auriculidites reticularis	1
2	Cyathidites sp.	1
3	Laevigatosporites sp.	1
4	Verrucatosporites sp.	1
5	Senegalinium sp.	1
6	Proteacidites dehaani	1
7	Longapertites marginatus	1
8	Cingulatisporites ornatus	1

Sample SH1A, taken from a deeper depth of 8.5 meters, reveals a more complex palynological profile. This sample provides insights into deeper depositional environments, where a greater diversity of species may be found. Table 6 presents the palynological analysis of Sample SH1A.

Table 6: Palynology Analysis of Sample SH1A (Depth: 8.5 m)

S/N	Palynomorph	Abundance
1	Andalusiella polymorpha	3
2	Cingulatisporites ornatus	1
3	Proteacidites sp.	1
4	Syncolporites sp.	1
5	Longapertites marginatus	1
6	Dinoflagellate cyst	1
7	Syncolporites subtilis	1

Sample SH1A reveals a more complex mix of marine and terrestrial influences. The presence of Andalusiella polymorpha (3) and Dinoflagellate cysts suggests environmental transitions between marine and terrestrial conditions. The other palynomorphs, such as Syncolporites sp. and Proteacidites sp., further support the idea of dynamic environmental conditions at this depth. Sample SH1B, taken from the same depth as SH1A (8.5 meters), offers additional palynological data. The results provide further clarification of the environment at this depth. Table 7 presents the data for Sample SH1B.

Table 7: Palynology Analysis of Sample SH1B (Depth: 8.5 m)

S/N	Palynomorph	Abundance
1	Syncolporites marginatus	1
2	Auriculidites reticularis	1
3	Senegalinium sp.	1
4	Longapertites marginatus	1

The palynological composition of FS1B suggests a mainly terrestrial environment with occasional aquatic influences. The Syncolporites marginatus and Auriculidites reticularis are consistent with these conditions, indicating a stable terrestrial ecosystem with occasional environmental changes. Sample SH2A, taken from a depth of 14.5 meters, reveals a more diverse palynological composition. This deeper stratigraphic sample may reflect more varied environmental conditions.

Table 8 presents the palynological analysis for SH2A.

Table 8: Palynology Analysis of Sample SH2A (Depth: 14.5 m)

S/N	Palynomorph	Abundance
1	Milfordia jardinei	1
2	Cyathidites sp.	2
3	Proteacidites sp.	2
4	Milfordia sp.	1
5	Buttinea andreevi	1
6	Senegalinium sp.	1
7	Proteacidites sp.	1
8	Dinoflagellate cyst	2
9	Longapertites marginatus	2
10	Proxapertites operculatus	2
11	Stephanocolpites sp.	1
12	Deltoidosporites sp.	1
13	Indeterminate	1

The palynological composition of Sample SH2A points to a dynamic environment, with Milfordia jardinei and Proteacidites sp. suggesting a mix of terrestrial and aquatic influences. The relatively high abundance of Dinoflagellate cysts (2) may indicate the influence of marine or brackish water at the time of deposition.

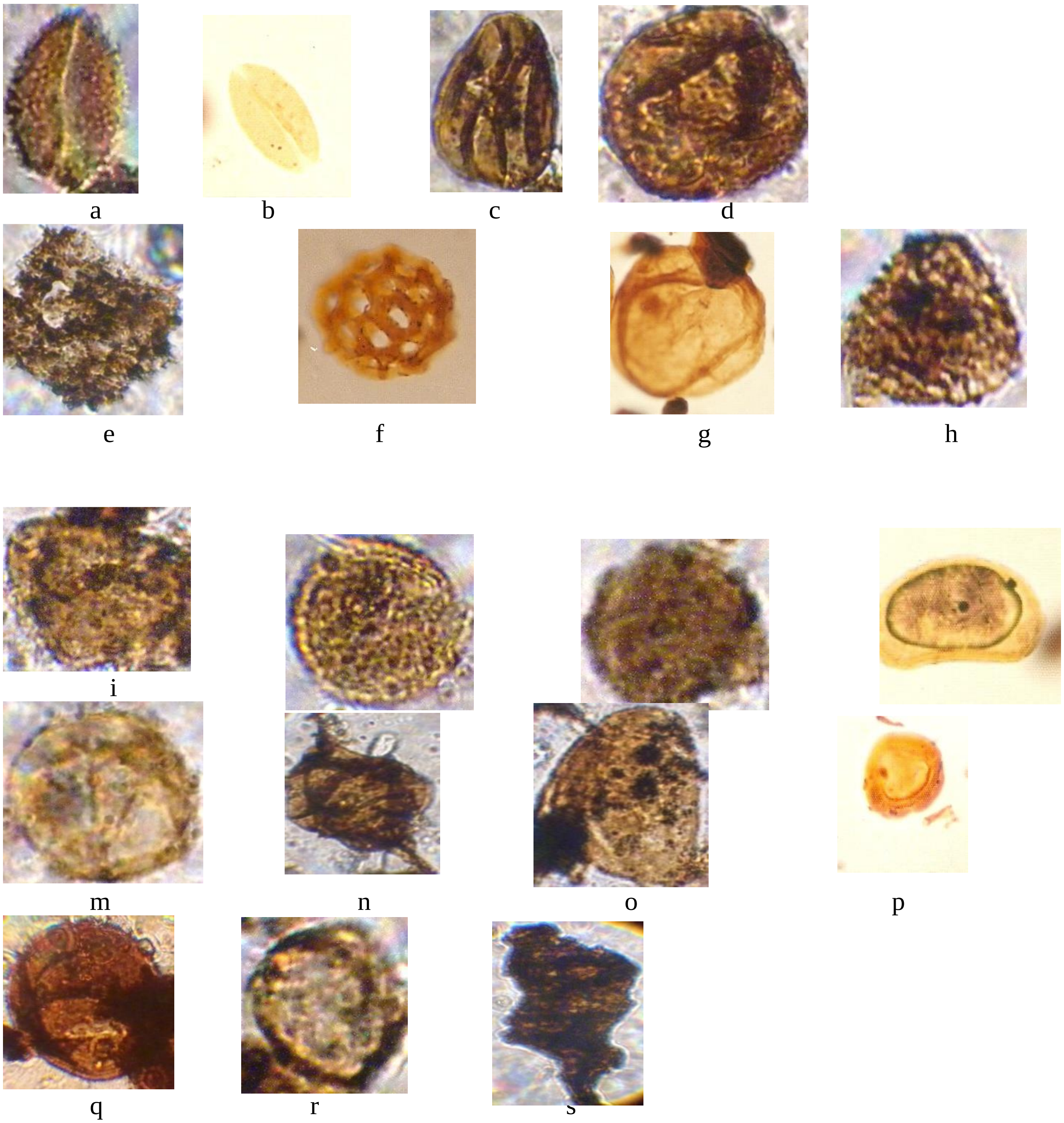

Fig. 1: Photomicrograph of palynomorphs x 800

4.4.3 Photomicrographs interpretation

a). *Retimonocolpites* sp. b) *Monosulcites* sp. c) *Tricolpites* sp. d) *Araucariacites australis e) Phelodiniumbolonienae f) Buttineaandreevi g) Inaperturopollenites* sp. h)*Trichotomosulcites* sp. i) *Verrucatosporitesusmensis j)*

Syncolporites sp. k) *Cicatricosisporites dorogensis* l) *Retidiporitesmagdalenensis* m) *Batiacasphaera* sp. n) *Andalusiella polymorpha* o) *Longapertites marginatus* p *Cingulatisporites ornatus* q)*Monoporites annulatus* r)*Syncolporites subtilis* s) *Ctenolophonitides costatus*

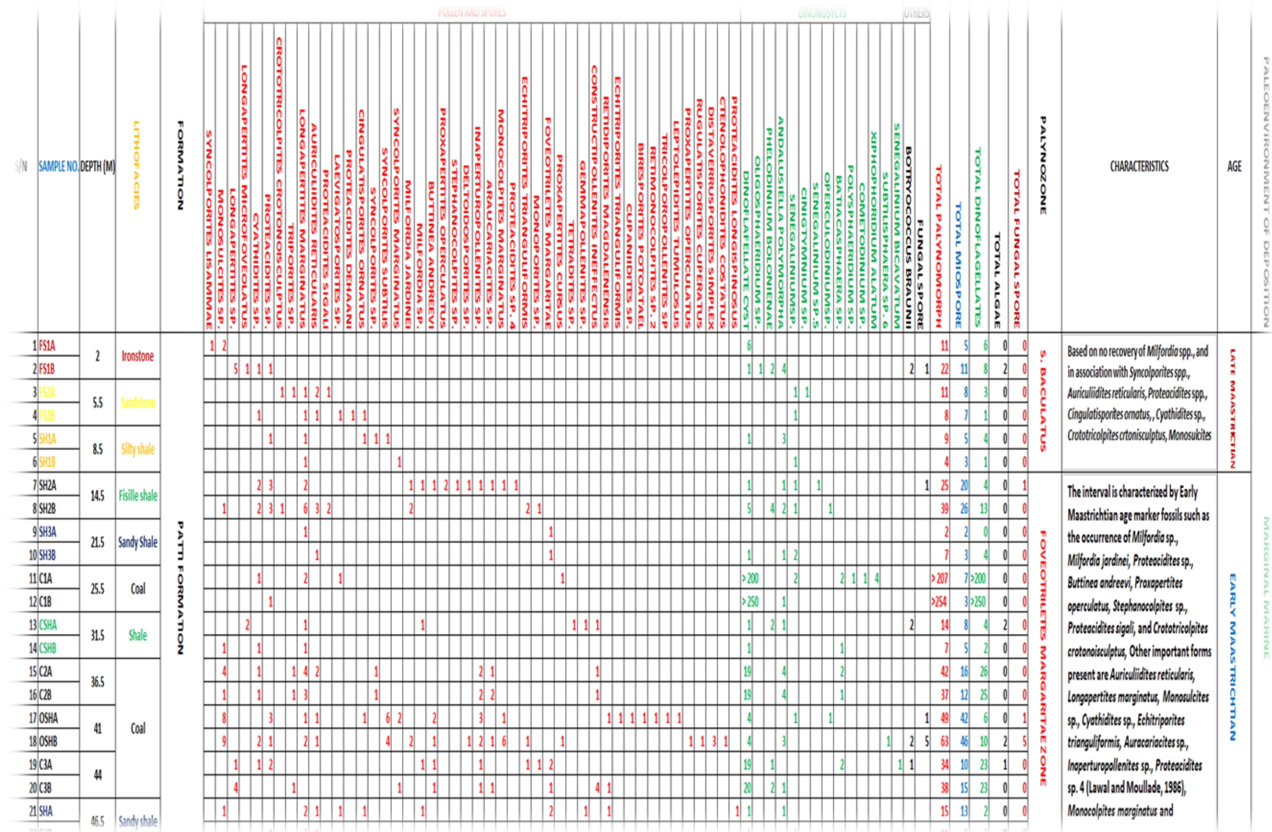

Fig. 3: Palynomorph distribution chart, palynozonation, Age and paleoenvironment of deposition of PattiFormation.

4.0 Conclusion

This study on the organic petrographic characterization and palynological analysis of the Patti Formation within the Agbaja area of the Bida Basin, Nigeria, focused on evaluating the potential of the coal and shale facies as source rocks for hydrocarbons. Field observations revealed the presence of clearly defined coal beds interbedded with shales, sandy shales, claystones, and ironstones. The palynological analysis of twenty-two selected samples showed that palynomorph recovery was highest in the coal facies, followed by the shale, with decreasing abundance observed in the claystone, sandy shale, and ironstone units. The recovered palynomorph assemblage included abundant pollen grains, spores, dinoflagellate cysts, algal remains, and fungal spores, indicating a diverse and productive paleoenvironment.

The identified marker species, including *Proteacidites* sp., *Longapertites marginatus*, *Auriculiidites reticularis*, *Foveotriletes margaritae*, *Retidiporites magdalenensis*, *Milfordia* sp., *Proteacidites longispinosus*, *Cingulatisporites ornatus*, *Monosulcites* sp., *Syncolporites marginatus*, *Syncolporites subtilis*, *Proteacidites dehaani*, *Cyathidites* sp., *Proteacidites sigali*, *Crototricolpites crotonisculptus*, *Longapertitites microfoveolatus*, and *Syncolporites lisammae*, established an Early to Late Maastrichtian age for the studied stratigraphic interval. The organic petrographic features and palynomorph composition indicated that deposition occurred in a marginal marine setting influenced by fluctuating terrestrial input and shallow marine conditions, as evidenced by the admixture of terrestrially derived miospores and marine organic-walled dinoflagellate cysts of peridinacean affinity.

Based on these findings, it is concluded that the Patti Formation within the Agbaja area holds significant promise as a hydrocarbon source rock, particularly due to its rich organic content and favorable paleoenvironmental conditions. It is recommended that further detailed geochemical analyses, including Rock-Eval pyrolysis and biomarker studies, be conducted to fully assess the maturity and generation potential of the coal and shale facies. Additionally, subsurface investigations such as core drilling and seismic studies are encouraged to delineate the lateral extent and thickness variation of the coal and shale units to better understand their economic viability for future exploration activities.

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