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PALYNOLOGICAL INSIGHTS INTO PALEOENVIRONMENTAL AND PALEOCLIMATIC RECONSTRUCTION OF THE BW–001 WELL, DAHOMEY BASIN, NIGERIA

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ABSTRACT

Major palynological abundance and diversity changes provide valuable tools for reconstructing paleoenvironmental and paleoclimatic conditions in sedimentary basins. This study investigates lithological and palynological characteristics of the BW–001 well in the Dahomey Basin, southwestern Nigeria, to establish its age framework, define palynozones, and infer depositional and climatic history. Thirty ditch-cutting samples were analyzed using standard laboratory preparation techniques for both lithological and palynological characteristics. Lithology is dominated by shales and sandy shales. Palynomorph assemblages include diverse marine dinoflagellate cysts (*Apectodinium*, *Senegalinium*, *Nematosphaeropsis*, *Subtilisphaera*, *Lejeunecysta*, *Homotryblium*, *Operculodinium*, *Lingulodinium*, *Spiniferites*) and terrestrial pollen and spores (*Cyathidites*, *Retibrevitricolporites triangulatus*, *Longapertites*, *Proxapertites cursus*, *Spinizonocolpites echinatus*). Five palynozones were recognized: K1 (Late Cretaceous, Maastrichtian), T1 (Early Paleocene, Danian), T2 (Late Paleocene, Thanetian), T3 (Early Eocene, Ypresian), and T4 (Early–Late Eocene, Ypresian–Priabonian), spanning the Maastrichtian to Priabonian interval. Persistent wet-climate indicators and the peak abundance of *Apectodinium* between 7620–7860 ft linked to Paleocene–Eocene Thermal Maximum (PETM) local event and Paleogene greenhouse conditions characterized by warm, humid environments. The BW–001 well records deltaic to marginal marine depositional settings and provides evidence of tropical paleoclimate signals during the Late Cretaceous–Eocene. These findings may contribute to regional stratigraphic frameworks and enhance understanding of West African paleoclimate evolution.

KEYWORDS: palynology, paleoenvironment, paleoclimate reconstruction, Dahomey Basin, Nigeria, dinoflagellate cysts, Late Cretaceous–Eocene

INTRODUCTION

Palynomorphs encompasses dinoflagellate cysts, spores, pollen, acritarches, and other organic walled organism.

Palynomorphs have been applied far and wide in the Nigerian sedimentary basins, from land (terrestrial) to marine environments: as a tool in resolving diverse geological problems.

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The uniqueness of the organic walled microfossils allows for data integration and robust results. Different approaches of study have initiated investigation in biostratigraphic studies (Adojoh, 2017; Adeonipekun and Sowunmi, 2019; Durogbo and Aroyewum, 2012); in reconstructing environments of deposition including palaeoecological studies (Taiwo et al., 2019), palynofacies approach for reconstructing environments (Adojoh *et al.*, 2015, Fadiya et al., 2020), paleoclimate (Adeonipekun and Sowumni, 2019); sequence stratigraphic correlations of sediment strata using palynology (Adojoh *et al.,* 2015, Adeonipekun, et al., 2015) and other works.

Palynomorph investigations in the Dahomey stratigraphy has not been left out, studies from many authors have been published: Bankole et al., 2007, Adeigbe et al., 2013, Bankole et al., 2017, Adeigbe and Ojekola, 2019; Umoh and Olaniyan, 2019, Ayok et al., 2020; Oluwajana et al., 2021; Agunsoye et al., 2022, Adeoye et al., 2022; Boboye and Chidiebere, 2023; Mohammed, 2025), who have centred their studies in various aspects of the basin. The study area (Dahomey Basin) can be seen as a combination of both the inland and offshore basin that stretches from southeastern part of Togo to the Republic of Benin and to the Nigerian portion of the basin. The body of recorded works and research in this basin has continued to kindle scholarly curiosity and the drive for new potential insights about the basin. Therefore, this study was carried out to determine biozones, relative age, paleoclimate and paleoenvironment of the studied interval.

Description of Studied Well

The well studied falls within the Nigerian Sedimentary record, the Dahomey Basin, geographically situated in the approximate coordinate of Latitude $6^{0}43'$ N and Longitude 5^{0} 12'E The study well is assigned BW- 001 well (Figure 1) due to proprietorship.

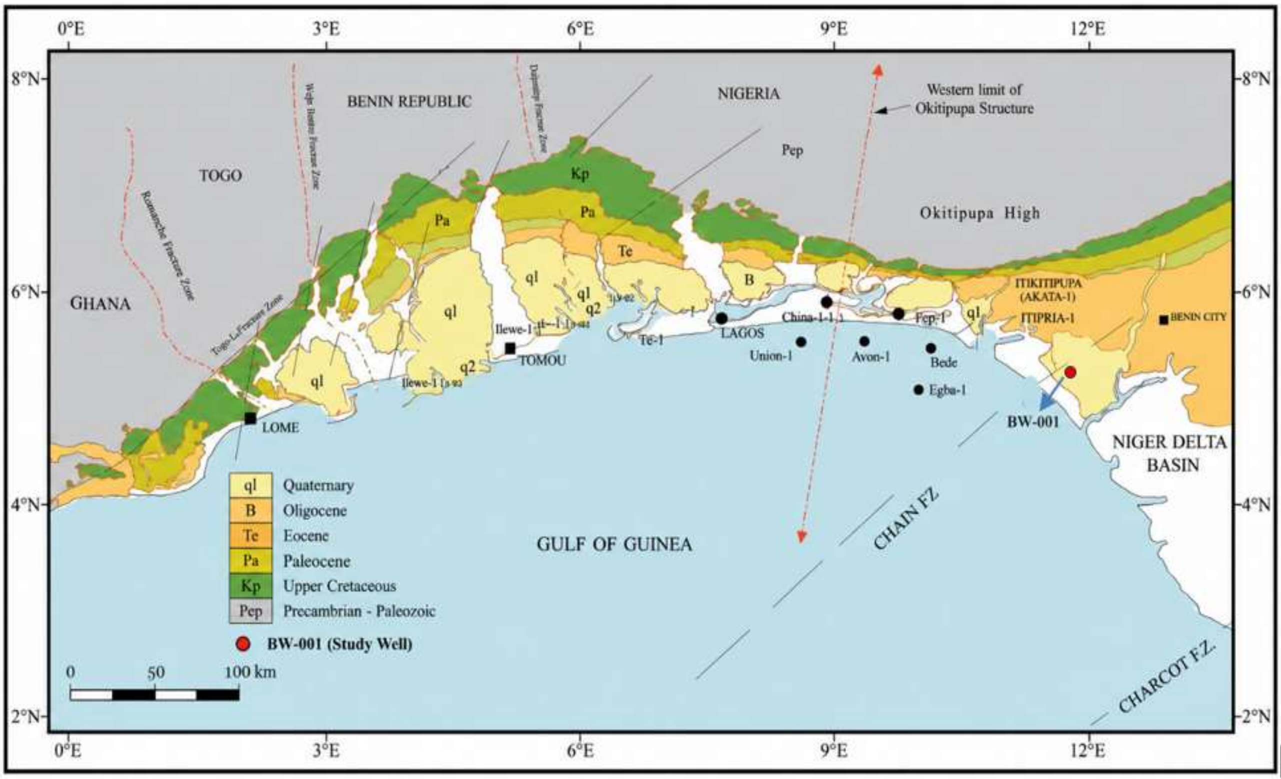

Figure 1: Location of BW-001 well (Modified after Billman, 1992).

Geology and Stratigraphy of the Dahomey Basin

The Dahomey Basin (Benin Basin) is one of the series of marginal basins located along the Gulf of Guinea in West Africa. It stretches from south-eastern Ghana through Togo and the Republic of Benin to south-western Nigeria (Omatsola and Adegoke, 1981) where it gradually fades with the Niger Delta Basin.

Within Nigeria the extensive Oligocene sedimentary basin encompasses the Ogun State and Okitipupa Ondo State regions. Hughes (1950) documented the discovery of extensive offshore oil reserves by Shell BP in 1946.

The natural resources are found in an area on the Okitipupa Ridge that extends southward from the Ewekoro limestone deposit and toward the continent shelf to the east of Lagos (Obaje, 2009; Billman, 1992). The Tectonic history revealed that, during the late Jurassic to early Cretaceous, the tearing apart of Gondwana and opening of South Atlantic Ocean led to development of the Dahomey Basin (Omatsola and Adegoke, 1981). Rift valleys formed as the tectonic plates of Africa and South America moved apart. These depressions received continental sediments before being invaded by the sea (Burke et al., 1971; Whiteman, 1982). The basin is particularly interesting because it preserves a clear record of environmental changes. The sediment fill shows a trend towards conditions of increased marine influence. In the southwestern region of Nigeria, the sediments unconformably overlie the Precambrian Basement Complex and range from Cretaceous to Recent (Obaje, 2009). For purpose of convenience, the stratigraphy is often grouped into two major divisions: the Cretaceous Abeokuta Group and the Tertiary formations that lie above it (Obaje, 2009), (Figure 2).

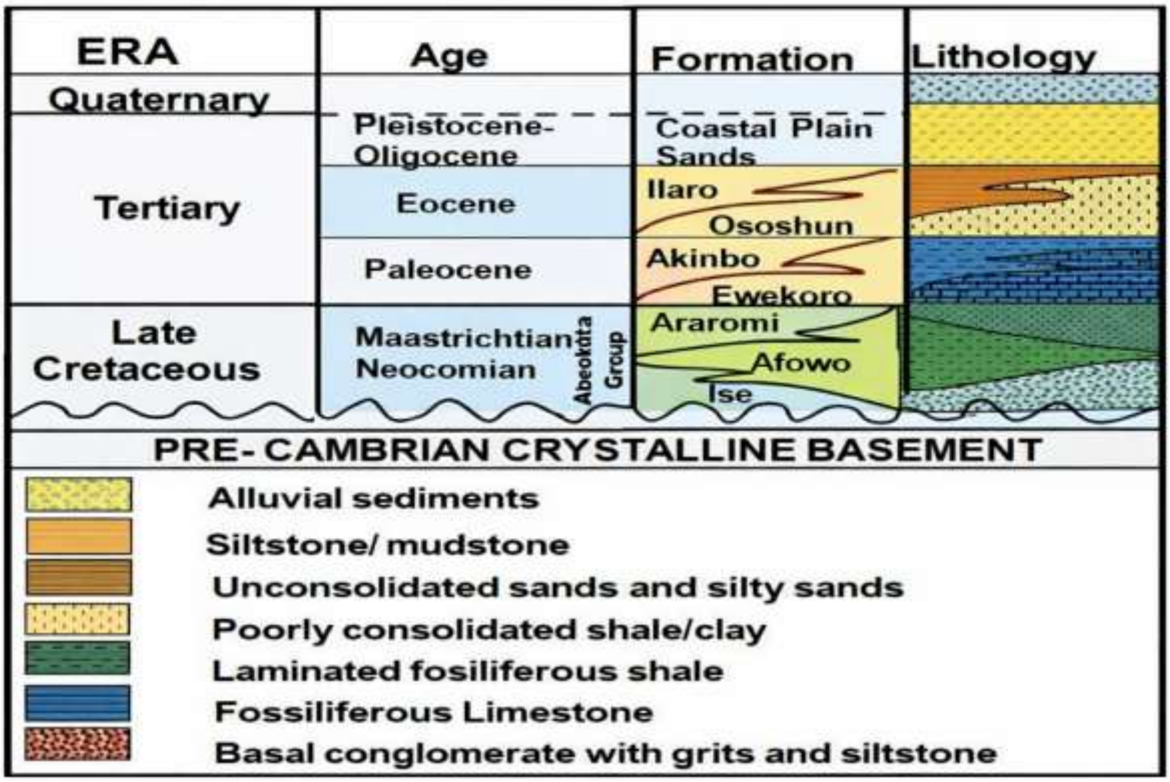

Figure 2: Stratigraphy and Lithology of Dahomey Basin (modified from Omatsola and Adegoke, 1981)

The Cretaceous Abeokuta Group (Figure 2) is the oldest sediments in the basin, overlying the crystalline basement. it consists of three formations which represents a transition from continental to marine conditions.

The Ise Formation forms the base and is composed largely of coarse-grained comprising conglomerates, grits sandstones and hardly clay. According to Omatsola and Adegoke (1981) and Obaje (2009), these sediments are consistent with a continental high energy environment and are generally ascribed to an early rifting stage. The Afowo Formation, which introduces further variability in lithology, overlies this. According to Billman (1992), the interbedding of sandstones with shale and siltstone suggests changing mineral deposition during a transition from a continental environment to that of a marginal marine. The Araromi Formation, at the top of the group, is much more marine in character. The shale, siltstone, and fine-grained sandstone make up most of the series although limestone may be present in some places. According to Omatsola and Adegoke, (1981), the deposit was laid in marine conditions and due to the presence of some marker fossils the age was placed as Maastrichtian–Paleocene.

Ewekoro Formation aged Paleocene conformably overlies the Abeokuta Group (Figure 2) and contains limestone. The large number of marine fossils such as molluscs suggest that they are formed in warm shallow marine conditions. It is greatly believed that this unit was formed at the time of marine transgression when the sea level rose to flood the entire basin (Adegoke, 1977; Okosun, 1990; Obaje, 2009). The Akinbo Formation consists mainly of shale and clay and sits above the Ewekoro or Ewekoro limestone. The rare presence of glauconite suggests that deposition took place on a marine shelf that experienced low energy conditions conducive for the settling of fine sediments (Ogbe, 1972). Oshosun Group is, characterised by clay, greenish grey shale, and phosphate horizons. The qualities and fossil proof proposed formation in a marine habitat possibly affected by intervals of limited flow or chemical enrichment (Adegoke et al., 1976). The Ilaro Formation (Eocenc - Oligocene) signifies a shift back to stronger conditions. The primary formation of these layers is generally due to sandy sediment deposition and is known to cause crossbedding or ripple cross-lamination in sediments. In the studied unit marks a regressive phase when the sea receded and sandy sediments began advancing across the basin.

Recent Oligocene Sediments of Benin Formation is the youngest deposit in the basin. Predominantly poorly sorted sands with some clay layers (Obaje (2009), the sediments were deposited in a continental and deltaic environment, indicating the continuing progradation of the shoreline.

METHODS

Thirty ditch cuttings from Well BW-001 in the Dahomey Basin were used for this study. Lithologic and palynologic contents of the samples were examined to cover a depth interval between 5160 ft and 8520 ft. Each sample was properly labeled according to its depth to maintain stratigraphic order during analysis. The samples were examined under a binocular microscope to determine their lithologic characteristics. Attention was given to grain size, mineral composition, fossil content, color, and textural features. Each sample was studied in sequence from the shallowest to the deepest depth in order to preserve vertical relationships. Observations were recorded and later used to construct a lithologic section for the well.

Palynological preparation carried out following all standard procedures. Carbonates were first removed using hydrochloric acid (HCl). After reaction, the samples were repeatedly washed with distilled water to eliminate any remaining acid. Silicate minerals were then dissolved using hydrofluoric acid (HF). The residues were thoroughly rinsed to remove reactions by-products. To improve separation between organic and inorganic components, a zinc bromide solution was used as a heavy liquid. The mixture was centrifuged to concentrate on the organic fraction. The recovered organic residue was washed, neutralized, and prepared for slide mounting.

In the analysis, controlled oxidation with nitric acid was applied to enhance visibility of palynomorphs. Where necessary, potassium hydroxide (KOH) was used to remove humic substances. The final residue was sieved using a 5 µm mesh to retain palynomorph-sized particles. The slides were prepared and examined under the microscope for identification and counting of pollen, spores, dinoflagellates, algae, and other microplankton. All palynomorphs encountered were recorded and data obtained were plotted against depth to produce a palynological distribution chart.

Paleoclimate and Paleoenvironmental Interpretation

The identified palynomorphs were grouped according to their known climatic and environmental preferences based on published literature like Germeraad, et al. 1968; Sowunmi, 1986, Ola and Adewale, 2014 Adojoh et al., 2015 and Ogbahon, 2019. These groupings were used to infer paleoclimatic conditions and depositional environments within the studied interval.

RESULTS AND DISCUSSIONS

Lithology of Well BW – 001

The lithologic succession within the intervals 5100 - 5940 ft and 7500 - 8520 ft are dominated by alternating shale and sandy shale units, and a large depth interval of 5940 ft – 7500 ft as a sample gap in the study (Figure 3). This vertical sequence reflects fluctuations in sediment supply and depositional energy conditions. The thickest sandy shale is within intervals of 7500-7880ft (380 ft thick) and the thickest shale interval is 7880-8100 ft (220 ft thick) the section exhibits repeated interbedding of sandy shale and shale, suggestive of cyclic sedimentation, possibly reflecting periodic variations in clastic influx and depositional conditions (Figure 3). The shale intervals indicate a phase of reduced sand input and more stable sedimentation under lower energy conditions influenced by paleoclimatic variabilities displayed in the study.

Figure 3: Lithologic description of Well BW– 001, Dahomey Basin

Biostratigraphy of Well BW–001

Thirty (30) ditch cuttings from the BW-001 Well processed and analysed for their palynomorph contents. The results were used to decipher the biozonation, date the well and possibly infer the paleoenvironment of the study succession. Samples were not available between 5940 - 7620 ft. (Figure 4, Table 1)

Palynomorph Characterization.

The studied interval was characterized by fairly abundant and diverse dinoflagellate cysts especially within intervals 7620 – 8520 ft. Relatively low records of pollen and spores were identified especially within interval 5160-5940 ft. Shallow to deepwater dinoflagellate cysts such as *Apectodinium* sp., *Senegalinium* sp., *Nematosphaeropsis* sp., *Subtilisphaera* sp., *Paleocystodinium australinium, Lejeunecysta fallax, Homotryblium tenuispinosum, Paleocystodinium golzowense, Operculodinium centrocarpum, Dinogymnium* sp., *Cribroperidinium* sp., *Lingulodinium machaerophorum, Phelodinium* sp. *Spiniferites* sp. and *Ceratiopsis* sp. quantitatively dominated the palynoflora (Figure 4).

In addition, few land derived pollen and spores' species such as *Cyathidites* sp., *Pachydermites diederixi Retibrevitricolporites triangulatus, Laevigatosporites* sp., *Longapertites* sp., *Proxapertites cursus, Monocolpites* sp. and *Spinizonocolpites echinatus* were also identified.

Sparse numbers of diatom frustules and freshwater algae *Botryococcus braunii* were also recovered.

Biozonation

Five (5) biozones namely k1, T1, T2, T3 and T4 were established based on the recovered marker species and palynomorphs association. These zones relate with the (?) P100, P250, P260-P330 and P370-P480 subzones of Evamy *et al*., (1978), the Cco – Cst., Sde-Aau and Aau-Rpe biozones of Powell (1992) and the Zone E, Zone F and Zone G of Oboh-Ikuenobe *et al*., (2017). Thus, Late Cretaceous (Maastrichtian) – Early Tertiary (Priabonian) age is interpreted for the studied interval. Details of the palynological results are discussed below (Table 1).

<u>Zone T4</u>

Depth: 5100-5940 ft

Age: Early Eocene (Ypresian) – Late Eocene (Priabonian)

Discussion: The top of this zone coincides with the first sample analysed encountered at 5160 ft. The base coincides with the upper limits of the sample break at 5940 feet.

This interval is characterised by the moderately abundant dinoflagellate cysts such as *Homotryblium tenuispinosum, Operculodinium centrocarpum, Sumatradinium* sp*., Nematosphaeropsis* sp*., Spiniferites sp., Lingulodinium machaerophorum, Cribroperidinium* sp*., Spiniferites ramosus, Subtilisphaera*sp*. Brigantedinium* sp*. Achomosphaera* sp. This assemblage suggests Early Eocene to Middle Eocene age of deposition (Powell, 1992).

Additional palynoflora that characterized this zone include low records of pollen and spores such as *Pachydermites diederixi* (with base occurrence at 5400 ft.), *Proxapertites cursus, Spinizonocolpites echinatus, Retimonocolpites obaensis, Retibrevitricolporites triangulatus, Longapertites* sp*.* and *Retistephanocolpites williamsii*. This interval correlates with the P370 – P480 subzones of Evamy *et al*., (1978), and the Aau-Rpe zones of Powell (1992).

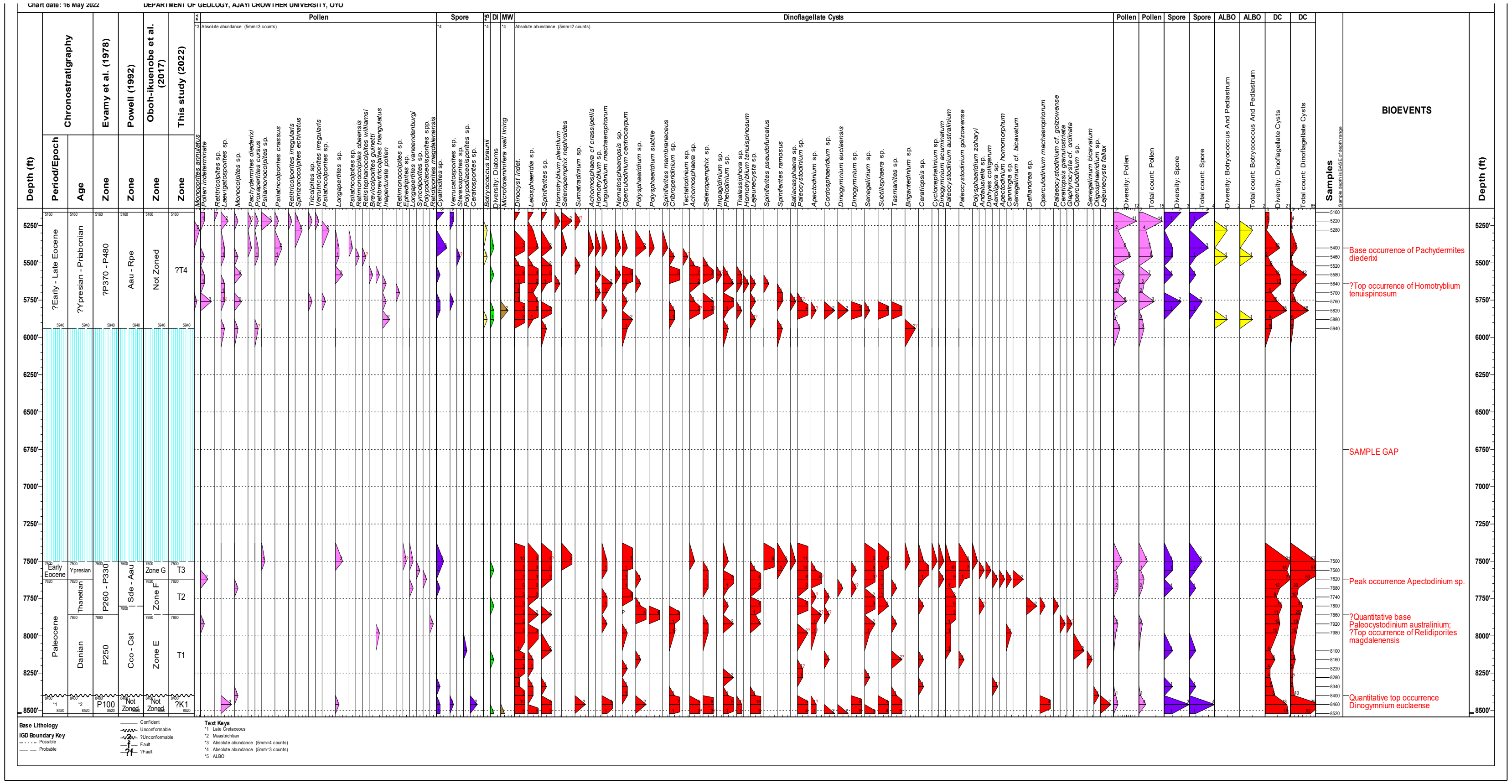

Figure 4. Palynomorph distribution chart of BW-001 Well, Dahomey Basin.

DEPTH (Feet)	SYSTEM/ PERIOD	SERIES / EPOCH	STAGE /AGE	Evamy et al., (1978)	Powell (1992)	Oboh-Ikuenobe et al., (2017)	This study 2022	BIO-MARKERS EVENTS
5100 – 5940 (5400, 5640)	TERTIARY	(?) Early-Late Eocene	? Ypresian-Priabonian	(?) P370 – P480	Rpe - Aau	Not Zoned	? T4	Base occurrence of *Pachydermites diederixi*; (?) Top occurrence of *Homotryblium tenuispinosum*
5940 – 7500	TERTIARY			SAMPLE GAP	SAMPLE GAP	SAMPLE GAP	SAMPLE GAP	SAMPLE GAP
7500 – 7620	TERTIARY	Early Eocene	Ypresian	P260 – P330	Aau - Sde	Zone G	T3	Peak occurrence *Apectodinium* sp.
7620 – 7860 (7800)	TERTIARY	Paleocene	Thanetian	P260 – P330	Aau - Sde	Zone F	T2	(?) Quantitative base *Paleocystodinium australinium*/ (?) Top occurrence of *Retidiporites magdalenensis*
7860 – 8400	TERTIARY	Paleocene	Danian	P250	Cst - Cco	Zone E	TI	Quantitative top occurrence *Dinogymnium* sp.
8400 – 8520	(?) CRET.	Late Cret.	Maast.	P100	Not Zoned	Not Zoned	(?) KI	

Table 1: Palynological Zonation of Well BW – 001, interval 5100ft – 8520ft.

Indeterminate Zone

Ditch cutting samples were not available for processing and analyses from 5940 to 7500 ft (Table 1; Figure 4).

Zone T3

Depth: 7500 – 7620 ft

Age: Early Eocene (Ypresian)

Discussion: The base of this zone is defined by the peak abundance of *Apectodinium* sp. at 7620 ft. The top coincides with the lower limits of sample gap at 7500 ft. This interval is characterized by the moderate abundant *Paleocystodinium golzowense, Subtilisphaera* sp., *Selenopemphix* sp., *Areoligera* sp. and *Senegalinium cf. bicavatum*. Other palynoflora that characterized this zone include *Longapertites* sp., *Cyathidites* sp. and *Psilamonocolpites* sp.

This interval correlates with the P260-P330 subzones of Evamy *et al*., (1978), Aau-Sde zones of Powell (1992), Zone G of Oboh-Ikuenobe *et al*., (2017) such as presence of *Apectodinium, Paleocystodinium golzowense, Subtilisphaera* sp., *Areoligera* sp., *Senegalinium cf. Bicavatum,*

Zone T2

Depth: 7620-7860 ft

Age: Late Palaeocene (Thanetian)

Discussion: The basal definition of this zone is the quantitative base occurrence (QBO) of *Paleocystodinium australinium* and top occurrence of *Retidiporites magdalenensis* at 7860 ft. The top is marked by the abundant occurrence of *Apectodinium* sp at 7620 ft. fairly abundant *Subtilisphaera* sp., *Lingulodinium machaerophorum, Apectodinium* sp., *Deflandrea* sp. and *Lejeunecysta* sp. characterized this zone. Also, sparse records of pollen and spores such as *Longapertites vaneendenburgi, Monocolpites* sp. and *Cyathidites* sp. were recovered.

The zone also aligns with P260 - P330 subzone of Evamy *et al*., (1978), Aau-Sde zones of Powell (1992) and zone F of Oboh-Ikuenobe et al., (2017).

Zone T1

Depth: 7860-8400 ft

Age: Early Paleocene (Danian)

Discussion: The basal level of this zone is marked by the quantitative top occurrence of *Dinogymnium* sp. at 8400 ft. This lower limit is also the Cretaceous/Tertiary boundary. The top of the zone is defined by the - quantitative base occurrence QBO) of *Paleocystodinium australinium* and top occurrence of *Retidiporites magdalenensis* at 7860 ft. Additional palynoflora events include *Paleocystodinium australinium, Senegalinium* sp*., Ceratiopsis* sp*., Polysphaeridium* sp. and *Spiniferites* sp. *Monocolpites* sp*., Cyathidites* sp. and *Retibrevitricolporites triangulatus* were also recovered.

The zone connects with the P250 subzone of Evamy *etal*., (1978), Cst-Cco zone of Powell (1992) and Zone E of Oboh-Ikuenobe *et al*., (2017).

Zone K1

Depth: 8400-8520 ft

Age*:* Late Cretaceous (Maastrichtian)

Discussion: The last basal zone corresponds with the last sample analysed while the top is marked by quantitative top occurrence (QTO) of *Dinogymnium* sp. at 8400 ft.

This thin zone is indicated by the occurrence of *Cribroperidinium* sp*., Achomosphaera* sp*., Spiniferites pseudofurcatus, Senegalinium* sp*., Subtilisphaera* sp. and *Dinogymnium euclaense.* Rare occurrence *of Laevigatosporites* sp., *Longapertites* sp. and *Cyathidites* sp. were also identified. This interval correlated with the P100 subzone of Evamy *et al*., (1978), (Figure 4 and Figure 5, document all information on the zonation and images of this study).

PALEOCLIMATE INTERPRETATION

Palynomorphs are relevant proxy for recognition and classification of spatial and temporal variations in paleoclimates. And this determines the vegetation type that will exist in any province (Ige, 2009). Depositional environments and climate situation affect the lithofacies (like silts, shales or sandstone) and the composition and diversity of the palynofloras present in each formation. Paleoclimate of this study is discussed by examining some selected wet and dry indicators assemblages (Table 2, 3, Figures 5a-e) evidenced in the delineated zones.

Zone T4 within depth intervals of 5160-7540 ft reflects dominance of humid conditions with the wet indicator as high as 89% (Figure 5a), supported by abundance of dinoflagellate cyst and mangrove pollen (Table 2). The dry indicators of 11% may geologically suggest an inception of a dry climatic cycle during the Ypresian – Priabonian. This interval represents a more transitionally humid to seasonally dry paleoclimate phase.

Zone T3 within depth 7500-7620ft with wet 75% experienced a slight reduction in wet condition with the highest dry peak of 25% amongst all zone's signals in the study (Table 3, figure .5b), reflecting a semi dry to seasonally dry paleoclimate because of slight increase in terrestrial influx. This interval falls in the Ypresian, Early Eocene age.

Zone T2,7620-7860ft, wet indicators (88%; Figure 5c, Table 3) returns to a warm, humid paleoclimate with continuous but slightly less intense precipitation than zoneT3. The condition is beneficial for organic productivity and burial. The slight arid pulse or dryness may suggest briefly localized climate fluctuations during the late Paleocene reflected by incursion of dry pollen *(Longaperties* sp.), but dominantly wet regime.

Zone T1, depth interval 7860-8400 ft displays 85% wetness (Figure 5d; Table 3) indicating continuous warm humid paleoclimate, high dinocyst diversity appearances. This is similar to Zone T2, but with a touch of greater climatic instability. The dry15% occurrences suggest short arid episode interval within the early Paleocene.

The Maastrichtian Zone K (8400-8520 ft) with the highest wet indicator 93% (Table 3; Figure 5e), almost absolutely dominant of wet reflecting a persistently, warm humid tropical paleoclimate. This aligns with an equatorial rainforest, usually high precipitation, and temperatures regimes. The paleoclimate interpretation of this zone could be supported by Huber et al. (2018) Cretaceous Greenhouse thermal evolution.

Based on the palynomorph assemblages recovered which included some paleoclimatic indicators (wet/dry) as arrayed in the intervals and zones T4 - K, the paleoclimate admits a dominantly warm wet humid tropical regime with marked peak of dryness between intervals 7620-8400 ft (Table 3; Figure 5b-c). A noticeable peak occurrence of *Apectodinium* sp. at 7620-7820 ft is a potential Palaeocene–Eocene Thermal Maximum (PETM) signal supported by the presence of associated occurrence of Dinocycts (Brinkhuis et al., 2006) examples *Deflandrea* sp., *Paleocystodinium australinium, Lingulodinium machaerophorum, Lejeunecysta* sp., (Table 3).The *Apectodinium* sp., bearing interval in this study aligns with works that have been reported globally as markers of dominant warming in Eocene zones, high nutrient rich in deltaic-marginal marine conditions and also reflecting more than 50-90% assemblages of dinocysts. The peak describes a strong clue for a potential PETM, although more analytical constraints may be necessary to support further claims of *Apectodinium* as PETM marker in this study. Crouch et al. (2001) reported its extensive bloom in marginal marine environments, while Sluijs, et al. (2006), Frieling, & Sluijs, (2018) reported its dominance in Artic sediments along with extreme warming.

In the Dahomey basin, Bankole et al. (2017) showed that *Apectodinium* acmes are diagnostic in tropical basins, which extends the evidence to the Oshosun Formation of Southwest Nigeria. The *Apectodinium* palynological assemblages have been described from diverse locations and accepted as Paleocene–Eocene Thermal Maximum (PETM) standard reference material.

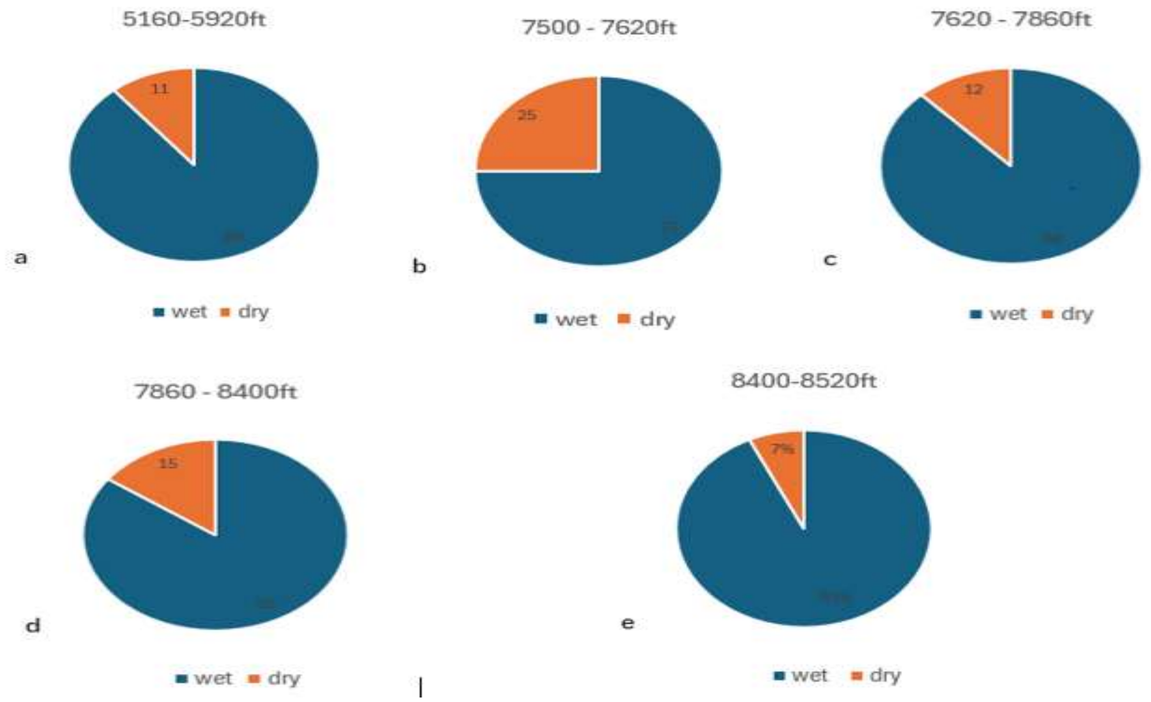

Figure 5: Percentage distribution of wet vs dry palynomorph indicators in BW-001 well, Dahomey Basin (a)early late Eocene (zone T4); (b) early Eocene (zone T3), (c) late Palaeocene (Zone T2) (d) early Palaeocene (Zone T1) (e)late Cretaceous (Zone K1).

PALEOENVIRONMENT INTERPRETATION

The abundance of marine dinoflagellate cysts such as *Spiniferites*, *Lingulodinium*, and *Operculodinium* suggests deposition under shallow marine to inner neritic conditions, while the occurrence of mangrove pollen (*Spinizonocolpites echinatus*) reflects paralic swamp environments. Intervals enriched in terrestrial pollen taxa such as *Longapertites* and *Monocolpites* indicate episodes of increased continental input, likely associated with regressive phases.

In the studied well, palm pollens occurrence is also common in West African coastal basins (Lawal, 1986). *Spinizonocolpites* sp. which include *S. bacalatus and S. echinatus* (Muller, 1968) shows the earliest palm pollen known and they are generally referred to as the ancestral to modern genus Nypa (Harley, 2006). Palynomorphs like *Longapertites* sp, *Spinizonocolpites* sp. and *Monocolpites* sp. are produced by plants which adapted to mangrove biome – marsh vegetation. *Monocolpites* sp. are commonly found in coastal lowland forests or mangroves (Germeraad *et al.,* 1968) where salt tolerant trees such as halophytes thrive in coastal saline or brackish water which are typical of tropical to subtropical climates. Presence of *Laevigatosporites* sp. indicates a brackish water condition. They are average pteridophye spores of ferns that occur mainly in humid climate (Bilobe *et al.,* 2021). Manifestation of *Cyathidites* sp. indicates an open freshwater depositional environment and are commonly found in humid climate, on the other hand fungal spores suggests a swampy depositional condition. Table 3 show the climate indicators of the various palynomorphs recovered and their biozones. Based on the occurrence of characteristic species in the well-studied (Figure 4), the paleoenvironment of deposition is interpreted to fluctuate between Deltaic – marginal marine environment (Table 3).

Table 2. Selected Palynomorphs and their paleoclimate affinity

Depth(ft)	Palynomorphs	Climate Indicators
5160- 5940	*Homotryblium tenuispinosum, Operculodinium centrocarpum, Sumatradinium* sp., *Nematosphaeropsis* sp*., Spiniferites* sp., *Lingulodinium machaerophorum, Cribroperidinium* sp, *Spiniferites ramosus,Subtilisphaera* sp, *Brigantedinium* sp, *Achomosphaera* sp., *Spinizonocolpites echinatus, Retimonocolpites obaensis, Retistephanocolpites williamsii*	Wet
	Pachydermites diederixi, Proxapertites cursus, Retibrevitricolporites triangulates, Longapertites sp.	Dry
7500– 7620	*Paleocystodinium golzowense, Subtilisphaera* sp., *Selenopemphix* sp., *Areoligera* sp., *Senegalinium cf. Bicavatum, Psilamonocolpites* sp.	Wet
	Longapertites sp*., Cyathidites* sp.	Dry
7620 -7860	*Paleocystodinium australinium Apectodinium* sp. *Lingulodinium machaerophorum, Subtilisphaera* sp*., Deflandrea* sp., *Lejeunecysta* sp.,	Wet
	Retidiporites magdalenensis, Longapertites vaneendenburgi, Monocolpites sp.	Dry
7860 -8400	*Dinogymnium* sp., *Paleocystodiniumaustralinium, Senegalinium* sp*., Ceratiopsis* sp., *Polysphaeridium* sp. *Spiniferites* sp.	Wet
	Retidiporites magdalenensis Monocolpites sp. *Retibrevitricolporites triangulates Cyathidites* sp.	Dry
8400- 8520	*Dinogymnium* sp., *Cribroperidinium* sp., *Achomosphaera* sp., *Spiniferites pseudofurcatus Senegalinium* sp*., Subtilisphaera* sp., *Dinogymnium euclaense*	Wet
	Laevigatosporites sp., *Longapertites* sp.	Dry

Table 3: Palynomorphs and their paleoclimate and Paleoenvironment Information

Depth(ft)	Age	Zone	Wet (%)	Dry (%)	Paleo-Interpretations	
					Climate signals	Environmental signals
5160- 5940	(?) Early - Late Eocene Ypresian-Priabonian	T4	89	11	Abundance wet indicator assemblages, Peak and dominance of humid climate phase, slight seasonal dry episodes.	Strongly deltaic/mangrove impact, paralic to shallow marine
7500– 7620	Early Eocene Ypresian	T3	75	25	Stronger dry signals arid peaks compared to the above. Reduced wet indicator assemblages compared to above interval. Partially semi-arid to seasonally arid.	More continental influx, suggestive of a regressive phase.
7620-7860	Late Paleocene Thanetian	T2	88	12	Climate shifts back to wet humid peaks, reduced dryness from previous interval. Transgressive recovery episode	Transitional deltaic to shallower marine
7860-8400	Early Paleocene Danian	T1	85	15	Transitional, still wet, warm, humid though elevated dryness episode compared to the above interval.	Transitional to shallow marine
8400-8520	Late Cretaceous Maastrichtian	K1	93	7	Commonly humid, wettest of all the zones/intervals with highest wet peaks in the study	Inner neritic to marginal marine

CONCLUSION

Palynological investigation of BW-001 well of the Dahomey Basin in the Southwestern Nigeria has resulted in the interpretation of the biostratigraphy, paleoclimate and environment of deposition. The abundance and diversity of the palynomorphs aided the delineation of the following:

i. Five palyzones and are dated starting from the youngest strata T4 - Ypresian - Priabonian; T3 Ypresian: T2 – Thanetian: T1 – Danian and k1- Maastrichtian. Overall age Early Eocene – Late Cretaceous.

ii. The paleoclimate of the study demonstrates a persistent warm, wet and humid tropical climate with slight marked peaks of dryness between intervals 7620-8400 ft as captured by their wet/dry percentage values from Zone T4 to Zone K.

iii. Acme of *Apectodinium* has been reported as global markers for the PETM, characteristically found in high temperature, nutrient rich zones and deltaic to marginal marine conditions. The peak occurrence of Apectodinium sp. in the 7620-7860 ft interval of this study have been tentatively linked to the PETM as a localized event and the Paleogene greenhouse climate.

iv. The overall paleoenvironment reflects deltaic to marginal marine settings under a warm, humid tropical with persistently wet conditions.

v. The findings if this study has contributed to the existing biozonation, paleoclimate and paleoenvironmental database in southern western Dahomey basin.

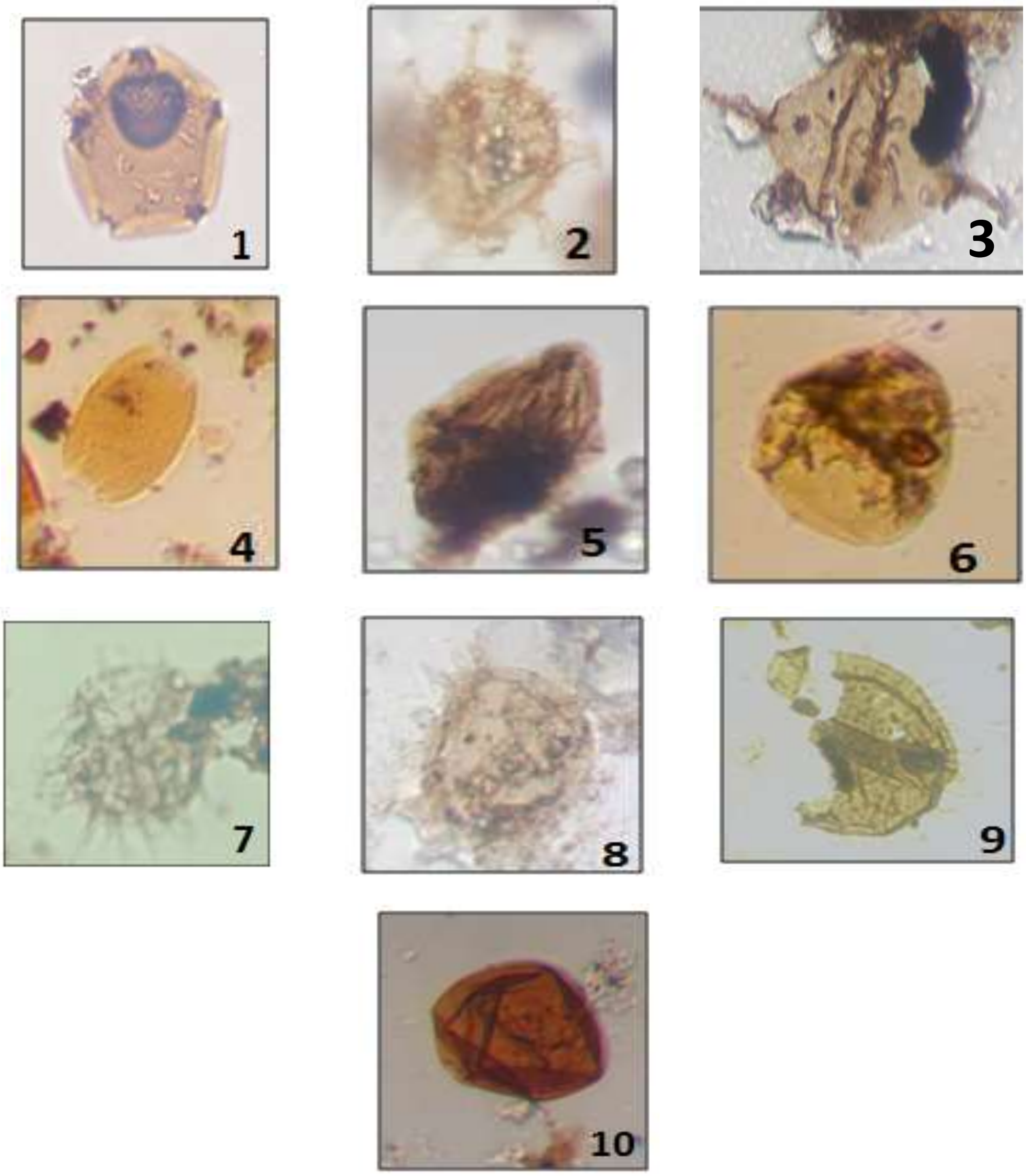

Figure 6: Selected Photomicrographs of Recovered Palynomorphs (X400 Magnifications)

1. *Pachydermites diederixi* (5400 ft.). 2. *Homotryblium cf. tenuispinosum*. (5640 ft.). 3. *Paleocystodinium australinium.* (7560 ft.), 4. *Retidiporites magdalenensis*. (7920ft), 5. *Dinogymnium* euclaense (8400 ft.) 6. *Longapertites vaneendenburgi*(7500 ft). 7. *Lingulodinium machaerophorum (*5640 ft). 8. *Spiniferites pseudofurcatus*(5640 ft). 9. *Operculodinium centrocarpum* (5580 ft). 10. *Lejeunecysta* sp. (5640 ft).

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