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Research Article

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Palynomorphs and Paleo-depositional Environment of Well Z, OPL 310, Dahomey Basin, South-Western Nigeria

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Abstract Fifty (50) ditch cutting samples from well Z, OPL 310, Dahomey basin South western Nigeria has been investigated for their lithological and paleo - ecological significance following standard palynological sample processing procedures and analysis. The result of the lithological analysis revealed that the rock succession in well Z, consist of two lithofacies units: the basal sandstone unit with alternation of shale and the light to dark grey shale/mudstone sequence at the top with accessory mineral assemblage which includes: Mica flakes, glauconite pellet, carbonaceous detritus and ferruginous materials. The basal sandstone/shale unit is characteristic of the Oshosun Formation while the upper shaly unit is typical of Afowo Formation. Palynological analysis also revealed moderately good recovery. Sixty (60) pollen and spores, one (1) fungal spores and nine (9) dinoflagellate cysts species were identified. Based on the occurrence of the mangrove swamp species such as *Zonocostites ramonae, Acrostichum aureum, Psilatricolporites crassus and Botryococcus brauni* and fungal spore, a brackish condition of sedimentation with fresh water incursion was inferred for interval 1620 to 2980ft, while interval between 2,980 and 3,500ft which recorded appreciable number of dinoflagellate cysts with gonyaulacacean affinity such as *Homotryblium tenuispinosus, Spiniferites ramosus*, *Systematophora aerolata, Lingulodinium machaerophorum* anad *Operculodinium centrocarpum.* The presence of *Operculodinium centrocarpum* and the authigenic mineral, glauconite indicates deposition in an outer neritic setting. The rock succession studied were deposited in an environment ranging from marginal marine environment with marine influence to outer neritic environment.

Keywords Dahomey Basin, Palynomorphs, Environment, Formation, Deposition

Introduction

Palynomorphs are well distributed in all environments due to their easy dispersal hence useful in paleo-ecological studies. The identification of association of organisms representing a particular depositional environment reveals a valuable amount of information on the control of sedimentary successions and interpretation of depositional environments. The various markers of high and low sea-level phases, such as palynomorphs, provide particularly reliable data as they are very sensitive to any change in the environment. A total number of fifty (50) ditch cutting samples from interval 1620 to 3500ft of well Z, located in OPL 310 offshore Dahomey basin, south western Nigeria (Figure 1), were subjected to palynological analysis. The aim of this study was to decipher the paleoenvironment of deposition of rocks in well Z using the palynofloral signals recorded while the objectives were to determine the lithofacies units and the formation(s) penetrated by the well and to use the recovered palynomorph assemblage to determine the environment of deposition of the rock units penetrated by the well. Standard palynological sample processing procedure of maceration with Hydrochloric acid to rid the sample of Calcium carbonate and Hydrofluoric acid to remove siliceous matter; separation of inorganic matter with heavy liquid and oxidation to rid the sample of pyrites and to liberate palynomorphs from extraneous organic matter were followed.

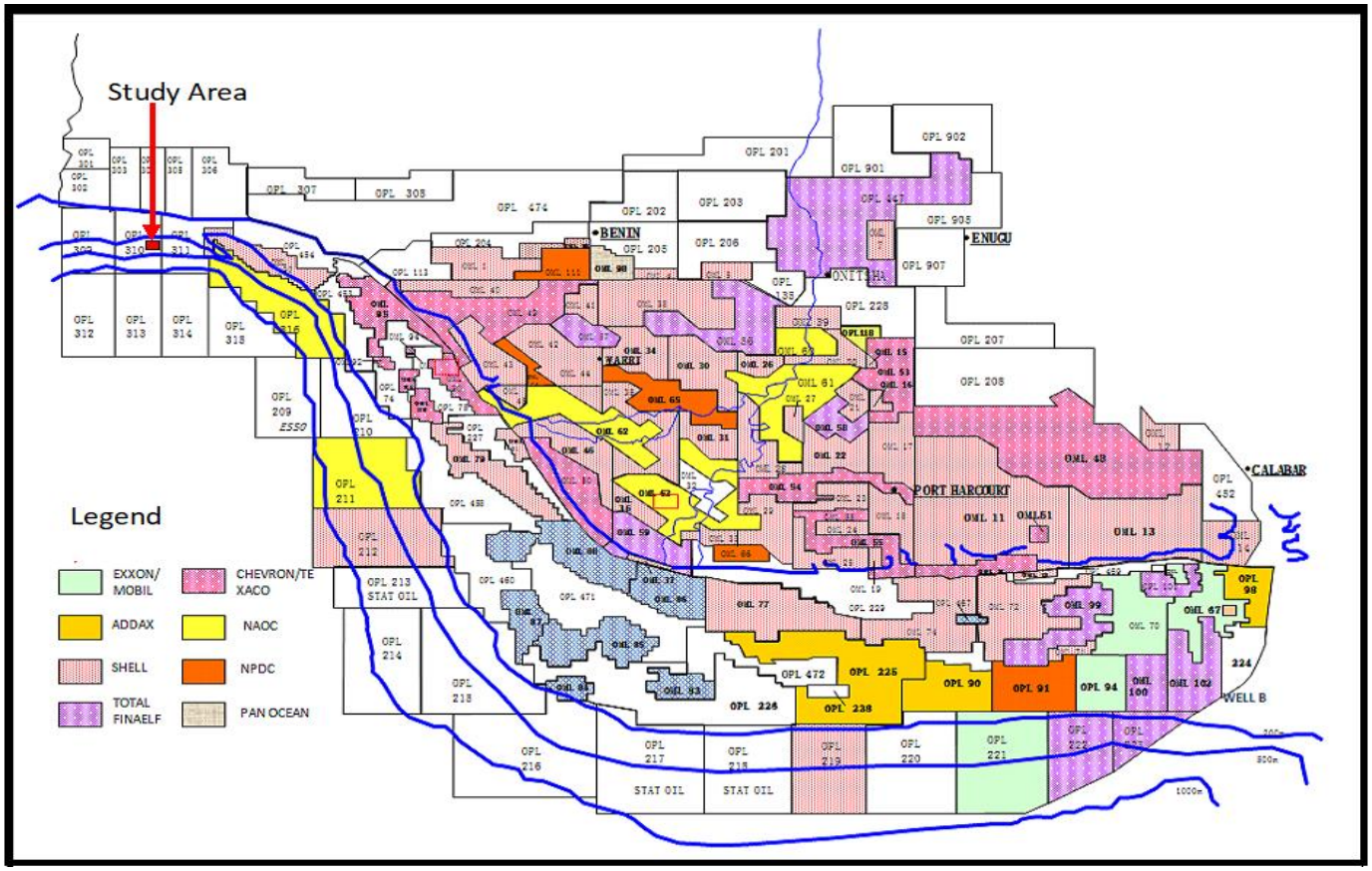


Figure 1: Niger delta oil mining lease (OML) map and adjoining basins showing location of the study area

Basin Geology

The Dahomey (Benin embayment) Basin is an extensive basin located in West Africa; it covers much of the continental margin of the Gulf of Guinea, extending from Volta-delta in Ghana through Togo and Republic of Benin to southwestern Nigeria, where it is separated from and cut off by stratigraphically younger Niger Delta. Dahomey Basin is a marginal pull apart basin which was developed as the African and South American lithospheric plates separated in the Mesozoic and continental margin was formed [1-2] (Figure 2). Little work has been published on the Cretaceous stratigraphy of the Dahomey Embayment. This is due in part to the confidentiality of oil company reports and the absence of deep borehole cores. Among the published works in the basin are that of Billman [3], Jan du Chene et al. [4] and Okosun, [5]. The stratigraphic sequence spans from Cretaceous to Recent. This includes the Cretaceous Abeokuta Group which comprises Ise, Afowo and Araromi Formations; the Paleocene Ewekoro Formation; the Late Paleocene to early Eocene Akinbo Formation; the Eocene Oshosun and Ilaro Formations and the Pleistocene to Recent Benin Formation [2] and [6]. Fadiya & Ojoawo [7] and Adebiyi [8], also presented a regional stratigraphic summary for the entire Western Nigeria coastal basin (Table 1).

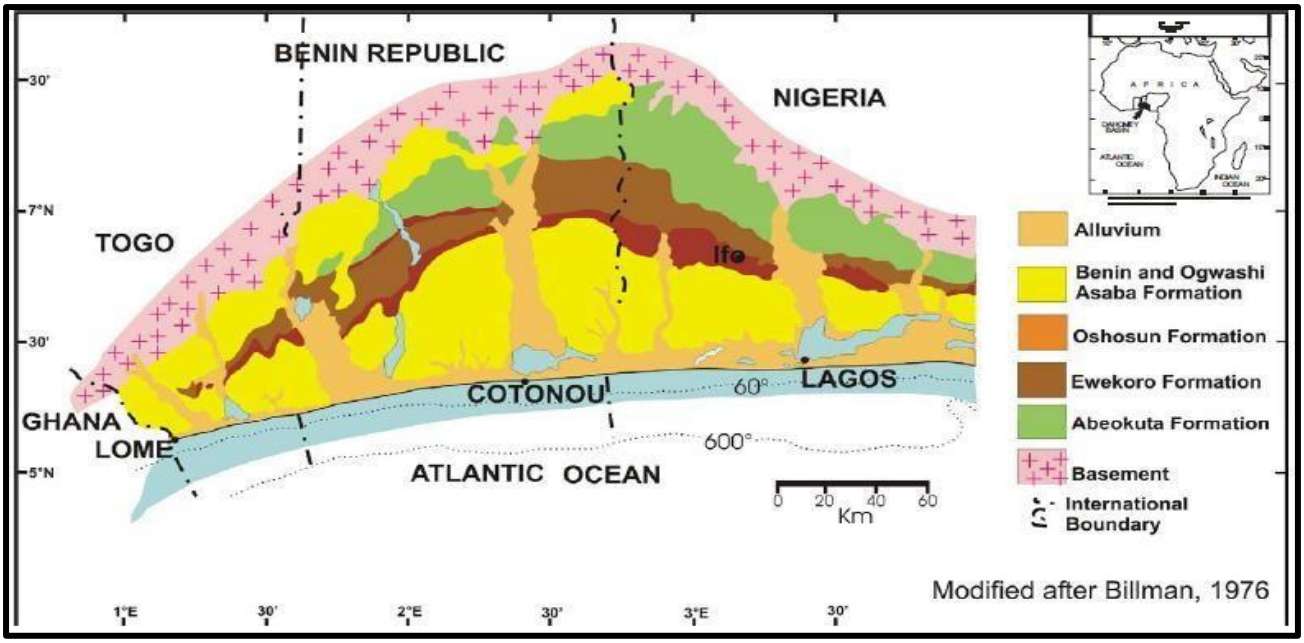


Figure 2: Geological Map of the Eastern Dahomey Basin, (modified from Agagu 1985) [3]

Ise Formation: This formation unconformably overlies the basement rocks and consists of basal conglomerate overlain by coarse to medium grained loose sand, sandstone with kaolinitic clay. This formation has been dated Neocomian, probably Valanginian-Barremian age with the recovery of some sporomorphs including *Cicatricosisporites* sp., *psilacosisporites*, *trichopapillosus*, etc; from Ise-2 borehole by Shell-BP geologists.

Afowo (Abeokuta) Formation

Afowo Formation is the main petroliferous Formation in Dahomey Basin. It overlies the Ise formation and consists of coarse to medium grained sandstone with thick intercalations of shale, siltstone and pyritized clay. According to [2], the basal part of the formation consists of well sorted sub-rounded fluviatile sand with mixed brackish to marine sediments. This formation was assigned a Turonian age by [3] on the basis of palynological assemblages which include *Elytranthe* subzone and *Multiporopollenites aff. M. maculosus* zone. It has been assigned a Late Cenomanian-Santonian age on the basis of palynology [8] and a Cenomanian-Coniacian age on the base of occurrence of planktonic foraminifera *Rotalipora Greenhornensis* [9].

Araromi (Nkporo) Formation

Araromi Formation conformably overlies the Afowo Formation. From bottom to top, it is composed of fine-medium grained sandstone overlain by shale, siltstone with limestone inclusions, marls and lignite. The shale is dark and contain abundant planktonic and benthic foraminifera (*Globorotalia mayaroensis and Globotrucana stewartiformis*), ostracods, pollens and spores. The dark shale unit in the Western Nigeria offshore basin is correlated with the Nkporo Shale in the Anambra Basin by [3]. Based on faunal content, a Maastrichtian to Paleocene age is assigned to this Formation [1, 8].

Ewekoro Formation

The Ewekoro Formation overlies the Abeokuta Group. Four carbonate microfacies have been described in this formation. This consists of a sandy biomicrosparite, shelly biomicrite, red phosphatic biomicrite and algal biosparite with abundant skeletal debris. The structure and texture of the limestone indicate a shallow marine environment of deposition. A Paleocene age has been assigned to this formation [8].

Akinbo Formation

The Akinbo Formation uncomformably lies on the Ewekoro Formation. Some glauconitic bands with lenses of limestone occur at the basal part. The top of the formation is pure grey, gritty sand with little clay. The

claystone are rich in kaolinitic concretions. The formation is Upper Paleocene to Lower Eocene in age [10]. Akinbo Formation is not always distinguished and separated from Oshosun Formation.

Oshosun Formation

Akinbo Formation is overlain by the Oshosun Formation which consists of various colored laminated and glauconitic clay and shale with sandstone intercalations. The Formation is phosphate-bearing. The fossil assemblage as consists of molluscs, corals, pelagic and planktonic foraminifera. Based on palynological assemblage, a Lower Eocene-Middle Eocene age has been assigned to this Formation [8]. Fishes and sea snakes in the shale specify that the Formation was deposited in a marine environment.

Ilaro (Ijebu) Formation

The Formation consists of massive, poorly consolidated; cross-bedded sandstone which conformably overlie the Oshosun Formation. Sub-rounded to rounded pure quartz grains dominate the base of the formation. This texture indicates a beach or shoreline and nearshore environment. The formation is sparsely fossiliferous but the occurrences of some benthic foraminifera have been described on the basis of which the formation was assigned an Eocene-Oligocene age.

Benin Formation (coastal plain sands)

The Benin Formation, also called the Coastal Plain Sand [2], consists of poorly sorted sand with lenses of clay. The sand is in parts cross-bedded and show nearshore to continental distinctiveness. The Formation age covers the Miocene to Recent periods.

Table 1: The stratigraphic units of Eastern Dahomey Basin. (modified from Ikhane, *et al*, [11])

Jones and Hockey (1964)		Omatsola and Adegoke(1981)			Agagu (1985)	
	Age	Formation	Age	Formation	Age	Formation
Quaternary	Recent	Alluvium			Recent	Alluvium
Tertiary	Pleistocene - Oligocene Eocene Paleocene	Coastal plain sand Ilaro Ewekoro	Pleistocene- Oligocene Eocene Paleocene	Coastal Plain sand Ilaro Oshosun Akinbo Ewekoro	Pleistocene- Oligocene Eocene Paleocene	Coastal Plain sands Ilaro Oshosun Akinbo Ewekoro
Cretaceous	Late Senonian	Abeokuta	Maastrichtian - Neocomian	Araromi Afowo Ise	Maastrichtian - Neocomian	Araromi Afowo Ise
Precambian Crystalline Basement Rocks						

Results and Discussions

Lithostratigraphy: The lithological analysis revealed a generally fining upward sequence of basal sandstone unit with alternation of shale and sandstone characteristically milky white to transparent and brownish, Fine to coarse, pebbly, sub-angular to rounded and poorly to well sorted with light to dark grey, non-fissile shale/mudstone sequence at the top. Authigenic and detrital mineral assemblage present include: Mica flakes, glauconite pellet, carbonaceous detritus and ferruginous materials. The basal sandstone unit belong to the Oshosun Formation while the upper shaly unit is typical of Afowo Formation (Figure 4).

Paleoenvironmental Interpretation

A moderate rich recovery of palynomorphs dominated by land-derived species such as brackish water spore, *Acrostichum aureum,* pteridophyte spores such as species of *Laevigatosporites spp.* and *Verrucatosporites spp.*, brackish water swamp *Psilatricolporites crassus; Retitricolporites irregularis,* and *Psilastephanocolporites sapotaceae*, among others were recorded. Abundant and diverse dinoflagellate cysts such as *Lingulodinium machaerophorum, Operculodinium centrocarpum, Spiniferites ramosus, Distatodinium craterum, Melitasphaeridium choanophorum, Systematophora aerolata and Homotryblium tenuispinosus* constitute the other environmentally significant palynomorphs recorded. *Diatom frustule, Botryococcus brauni* as well as *Fungal spores/hyphae* were also recorded. The distribution of the palynomorph species, total pollen and spores and total dinoflagellate cyst plots are presented in figure 4 and the photomicrographs of some of the identified species are shown in plates 1-2.

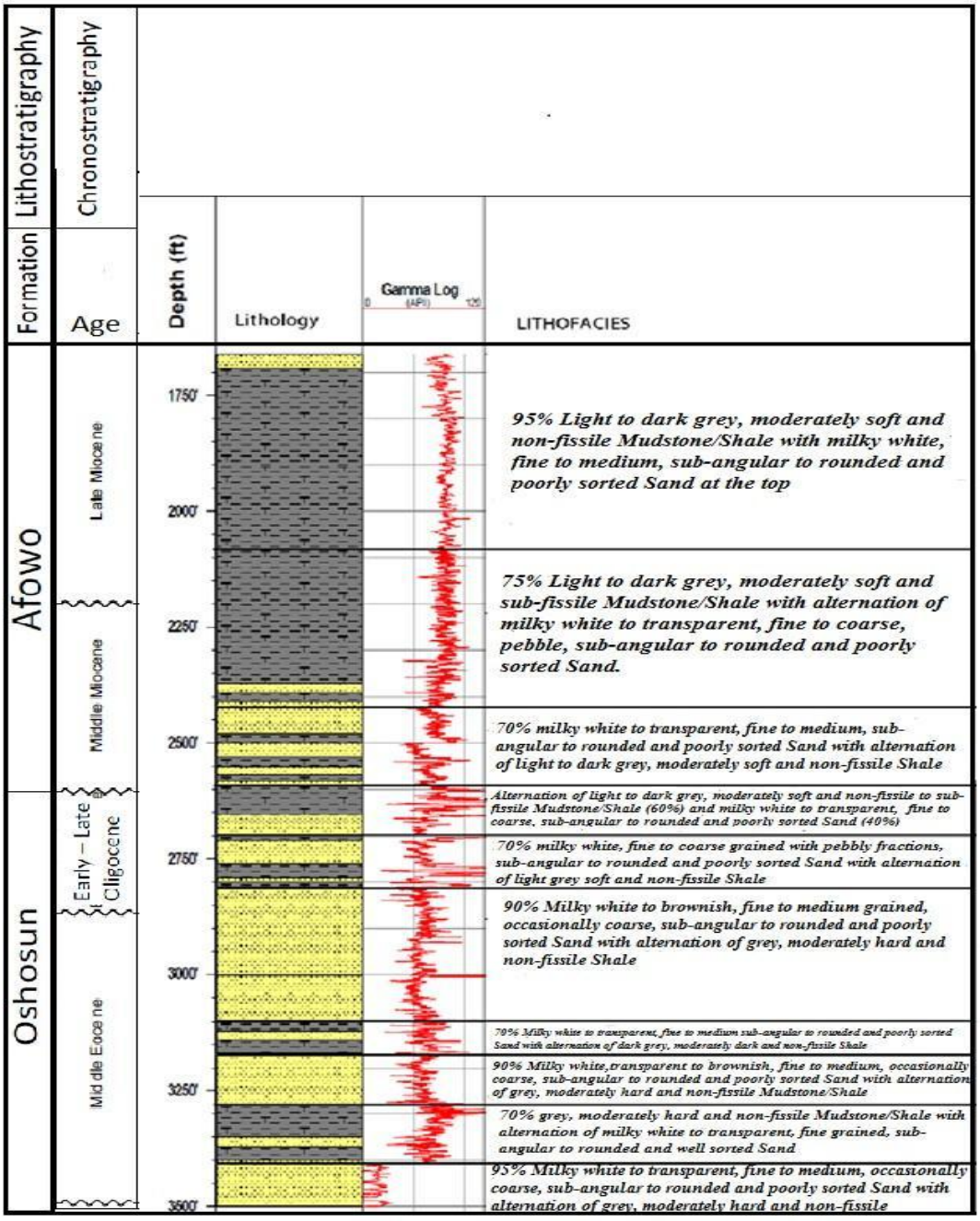


Figure 3: Lithostratigraphy of well Z

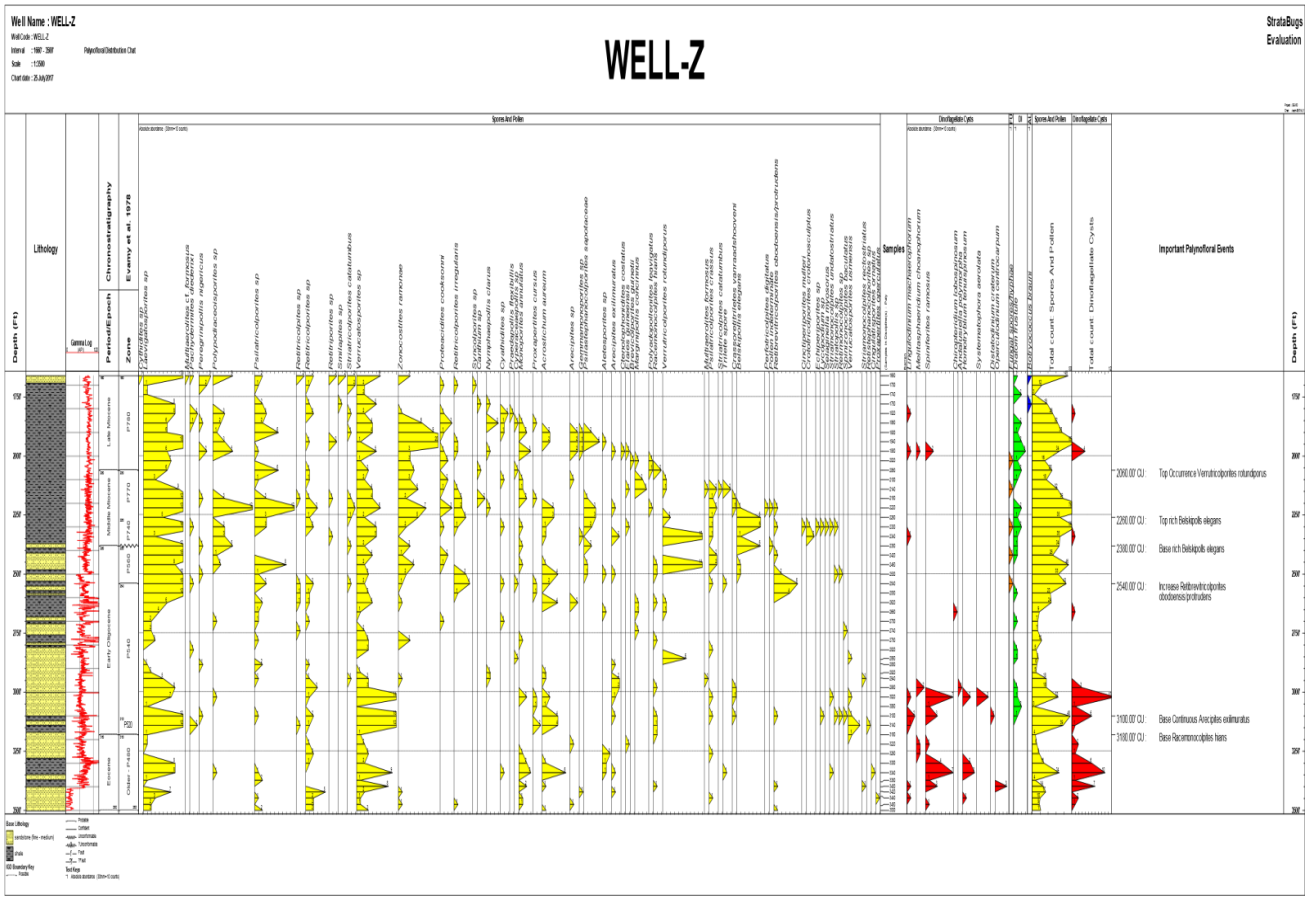
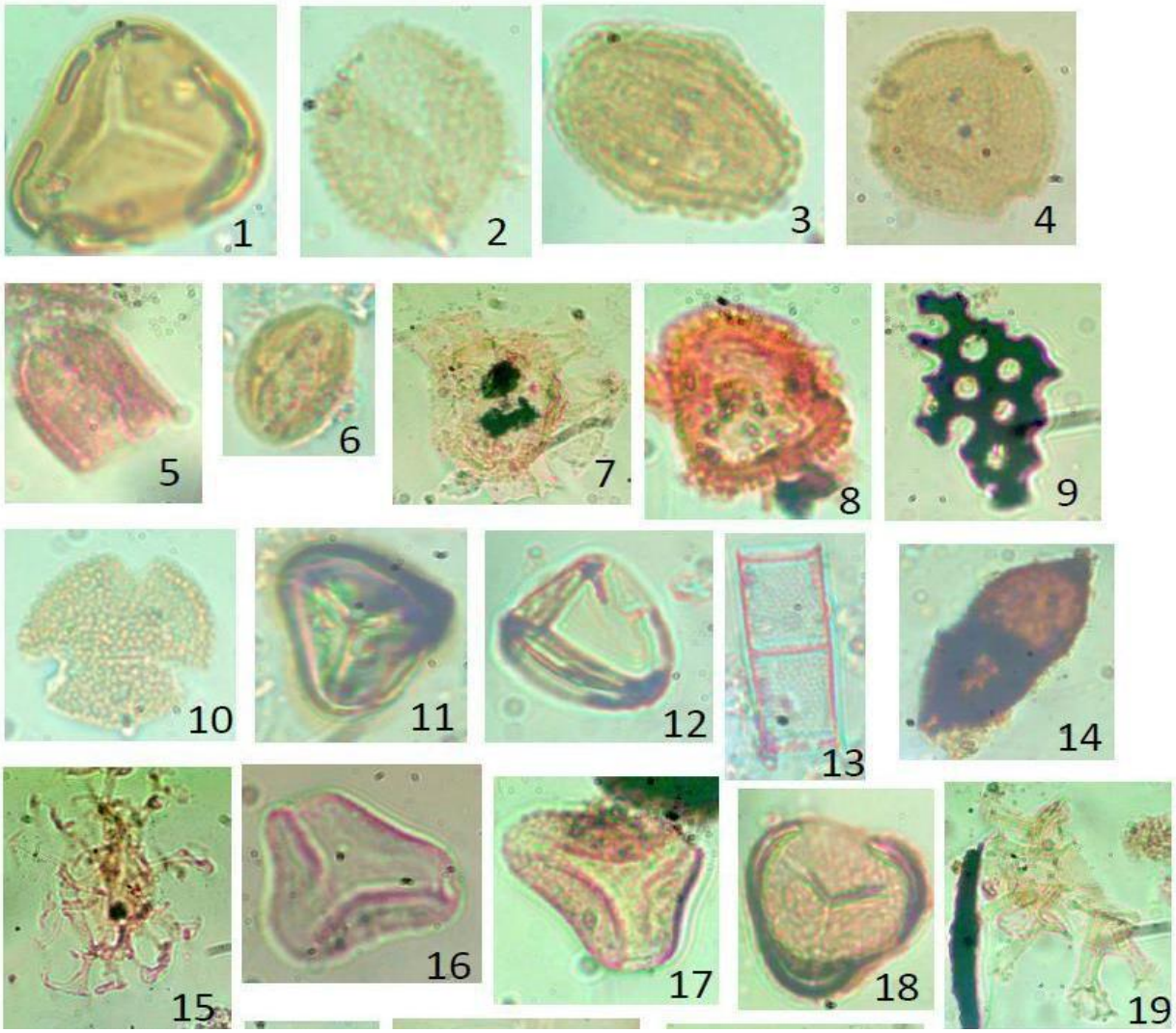


Figure 4: The stratigraphic distribution of the palynomorph species, total pollen and spores and total dinoflagellate cyst plots of well Z.

The paleoenvironment deduction for the studied well interval (1620-2980ft) is based on the combined pollen, spores, dinoflagellates, algae and fungal spores present in the samples. The presence of mangrove swamp species such as *Zonocostites ramonae*, *Acrostichum aureum*, *Psilatricolporites crassus* and *Botryococcus brauni* suggests a brackish condition of sedimentation. Pteridophytes spores represented largely by species of *Leavigatosporites sp.*, *Verrucatosporites sp.* and *Polypodiaceoisporites sp. characterized* this interval; the presence of *Verrucatosporites sp a*lso suggest a brackish condition of sedimentation, its presence also indicates a high sea level [12] which reflects a marine transgression while the presence of *Leavigatosporites sp* and *Verrucatosporites sp.* indicates a swampy fresh water or brackish water environment. Other environmentally diagnostic forms present are *Botryococcus braunii* and fungal spore which suggests an influx of freshwater redeposition and transgressive phase of sea level, and also suggestive of an environment characterized by the admixture of fresh and brine waters such as an estuarine setting. Marine dinoflagellate cysts such as *Spiniferites ramosus and Lingulodinium machaeroporum, Chiropteridium lobospinosus* were also recorded. This assemblage is indicative of deposition in marginal marine environment with fresh water incursion. The situation is different at the interval between 2,980 and 3,500ft where there is a recovery totally dominated by marine dinoflagellate cysts such as *Homotrybulium tenuispinosus, Systematophora aerolata, Lingulodinium machaerophorum, Operculodinium centrocarpum, Spiniferites ramosus, Distatodinium craterum, Melitasphaeridium choanophorum* among others. Based on exclusive dinoflagellate cysts as proposed by Wrenn and Kokinos, [13] the presence *Operculodinium centrocarpum* is indicative of an outer neritic setting. This is also supported by the dominance of the dinoflagellage cyst with gonyaulacacean affinity and presence of glauconite mineral which indicates sediment deposition in an open marine setting.

In conclusion, the rock succession studied were deposited in an environment ranging from brackish water environment with marine incursion to outer neritic environment.

PLATE 1



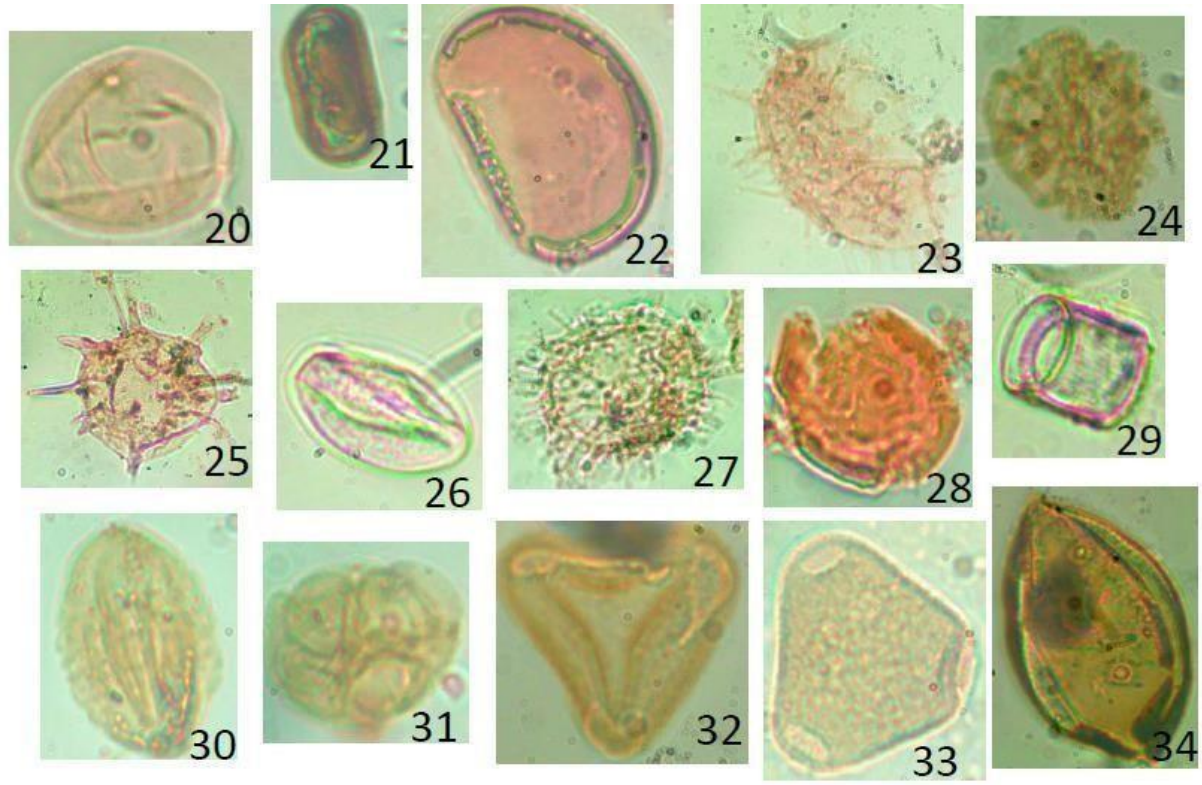


PLATE 1

1. *Acrostichum aureum* (2180-2220)
2. *Arecipites exilimuratus* (2180-2220)
3. *Belskipollis elegans* (2180-2220)
4. *Canthium* sp (1620-1680)
5. *cf Multiareolites formosus* (2300-2340)
6. *cf Verrutricolporites rotundiporus* (2060-2100)
7. *Chiropteridium lobospinosum* (2620-2660)
8. *Cingulatisporites ornatus* (3300-3340)
9. *Crassoretitriletes vanraadshooveni* (2980-3020)
10. *Crototricolpites crotonoisculptus* (2260-2300)
11. *Cyathidites* sp (1620-1680)
12. *Cyperus* sp (2020-2060)
13. *Diatom frusule* (2060-2100)
14. Fungal spore (1980-2020)
15. *Distatodinium craterium* (3060-3100)
16. *Elaeis guineensis* (2260-2300)
17. *Elaeis guineensis* (3180-3220)
18. *Lycopodium* sp (2260-2300)
19. *Homotryblium tenuispinosus* (3260-3300)
20. *Monoporites annulatus* (2340-2380)
21. *Multiareolites formosus* (2100-2140)
22. *Laevigatosporites* sp (2260-2300)
23. *Lingulodinium machaerophorum* (2300-2340)
24. *Peregrinipollis nigericus* (2140-2180)
25. *Melitasphaeridium choanophorum* (2940-2980)
26. *Marginipollis concinnus* (2700-2740)
27. *Operculodinium centrocarpum* (3380-3400)
28. *Pachydermites diederixi* (3100-3140)
29. *Diatom frusule* (2540-2580)
30. *Perfotricolpites digitatus* (2180-2220)
31. *Polyadopollenites laevigatus* (2180-2220)
32. *Polypodiaceoisporites sp.* (2140-2180)
33. *Proteacidites cooksonni* (2260-2300)
34. *Proxapertites cursus* (2140-2180)

PLATE 2

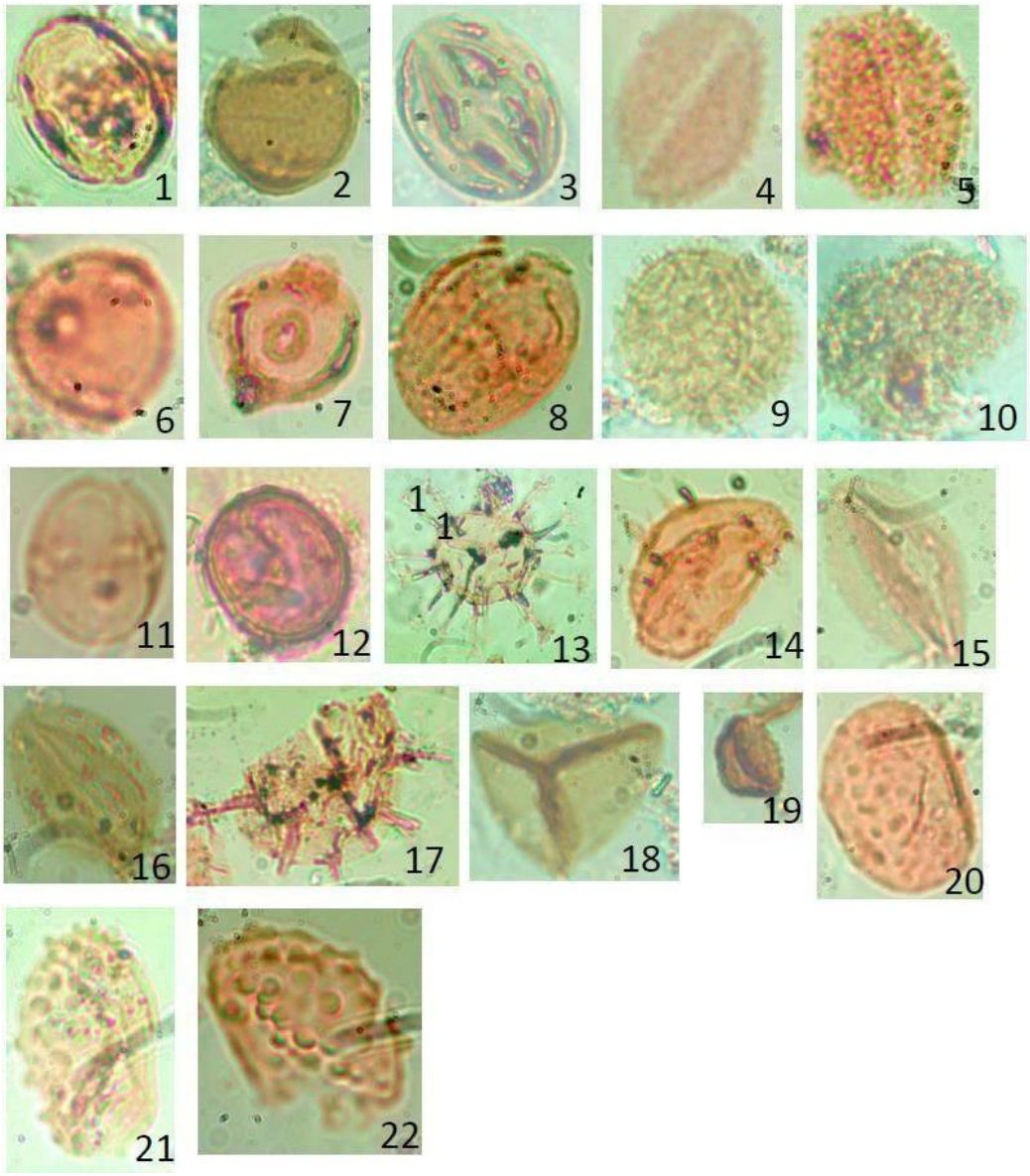


PLATE 2

1. *Proxapertites operculatus* (3420-3440)
2. *Psilatricolporites crassus* (2100-2140)
3. *Psilatricolporites* sp (2020-2060)
4. *Racemonocolpites hians* (2260-2300)
5. *Racemonocolpites hians* (3380-3400)
6. *Retibrevitricolporites protundens* (2460-2500)
7. *Retibrevitricolporites protundens* (2540-2580)
8. *Retistephanocolporites* sp (3100-3140)
9. *Retitricolporites irregularis* (2220-2260)
10. *Retitricolporites irregularis* (2220-2260)
11. *Sapotacea* sp (2260-2300)
12. *Selaginella myosorus* (2260-2300)
13. *Spiniferites ramosus* (3260-3300)
14. *Spinizonocolpites baculatus* (2700-2740)
15. *Striamonocolpites undertostriatus* (2260-2300)
16. *Striatricolporites catatumbus* (2140-2180)
17. *Systematophora areolata* (2980-3020)
18. Triletes spore (2100-2140)
19. *Verrutricolporites rotundiporus* (2100-2140)
20. *Verrrucatosporites sp* (2980-3020)
21. *Verrucatosporites usmensis* (2820-2860)
22. *Verrucatosporites usmensis* (3140-3180)

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