Palynological Characterization Of The Tertiary Offshore Emi-1 Well, Dahomey Basin, Southwestern Nigeria.

Adeigbe O.C, Ola-Buraimo A.O, Moronhunkola A.O.

ABSTRACT:- Palynological investigation was carried out on a sedimentary sequence of Emi- 1 well ranging in depth from 900-8000ft (247-2440m) with a view towards determining the lithological sequence, palynological zones, relative age and paleoenvironment of deposition.Three main palynozones were identified, these include Magnastriatites howardii/P680 zone characterized by quantitative base occurrence of Pachydermites diederixi and co-occurrence of Borteria sp, Magnastritites howardii and Racemonocolpites hians; dated Early Miocene; Crassoretitriletes vanraadshooveni/P700 zone 2 characterized by assemblage of Crassoretitriletes vanraadshooveni, Belskipollis elegans, Verrutricolporites rotundiporus, and Psilatricolporites crassus, dated Middle Miocene and Echitricolporites spinosus/P820 and Younger zone 3, characterized by co-occurrence of Multiareolites formosus, Anthocerus sp and Nymphae lotus, dated Late Miocene age. Paleoenvironmental deductions were based on the relative abundance of mangrove pollen to grass pollen, presence of environmentally diagnostic dinoflagellates and incursion of freshwater algae into the setting. The paleoenvironment varies from fluvial, swampy through marginal marine to open marine setting.

Key words: Palynological zones, Paleoenvironment, Freshwater, Dinoflagellate and Swampy

INTRODUCTION

Palynological investigation of the Tertiary Offshore Dahomey Basin was undertaken from Emi- 1 well located in the offshore of the basin. The study becomes imperative because there is no documentation on the Tertiary sediments of the Basin located in the offshore part. Nearly all the research works on the southwest Dahomey Basin of Nigeria are on the Cretaceous sediment studies. Therefore, this study becomes interesting, by looking at the stratigraphy from palynological perspective and by giving detail account of the chronostratigraphy of the younger sediments (Tertiary) in the Dahomey Basin. The sedimentation style of the basin is progradational and younging offshore like the adjacent Niger Delta, but different in term of structures because while the Dahomey is characterized by deep seated structures such as horst and graben Niger delta is noted for growth faults and associated roll-over anticline (See Figures 1 and 2). It is hoped that this study will generate chronostratigraphic framework that will be useful for correlation of wells, solve stratigraphic problems such as unconformity, bounding surfaces for sequence stratigraphy and structures which will aid in optimizing hydrocarbon exploration and exploitation; thereby reducing drilling and overhead cost.

Notable early research works on this basin include [1], [2 et al], [3], [4], [5], [6], [7], [8], [9], [10], [11], and [12]. Other recent works include [13], [14], [15], [16], [17 et al],[18], [19 et al], and [20].This study aimed at establishing palynological zones, dating the sedimentary sequences penetrated by the well, deducing the paleoenvironment of deposition of the sediments based on the palynomorph frequency percentage distribution and occurrence of the abundance and diversities of the forms encountered.

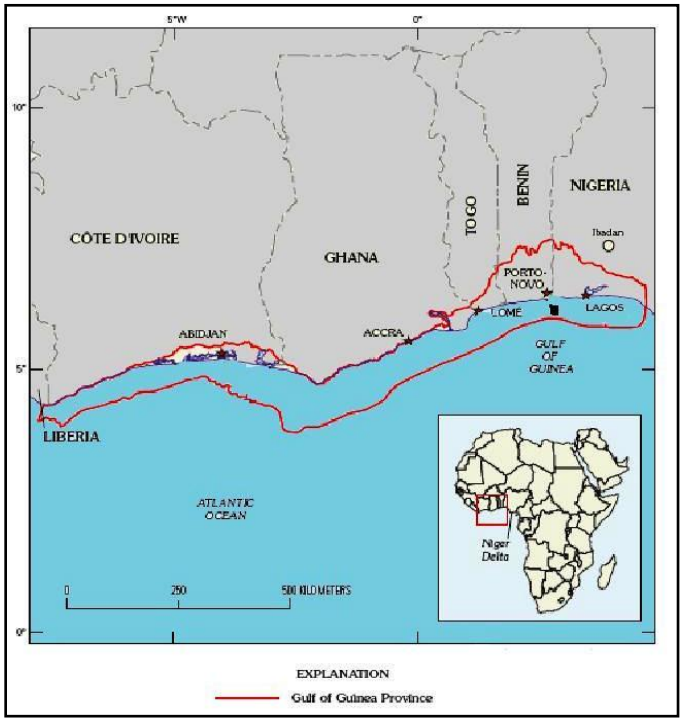

Fig 1: Location Map of the studied area.

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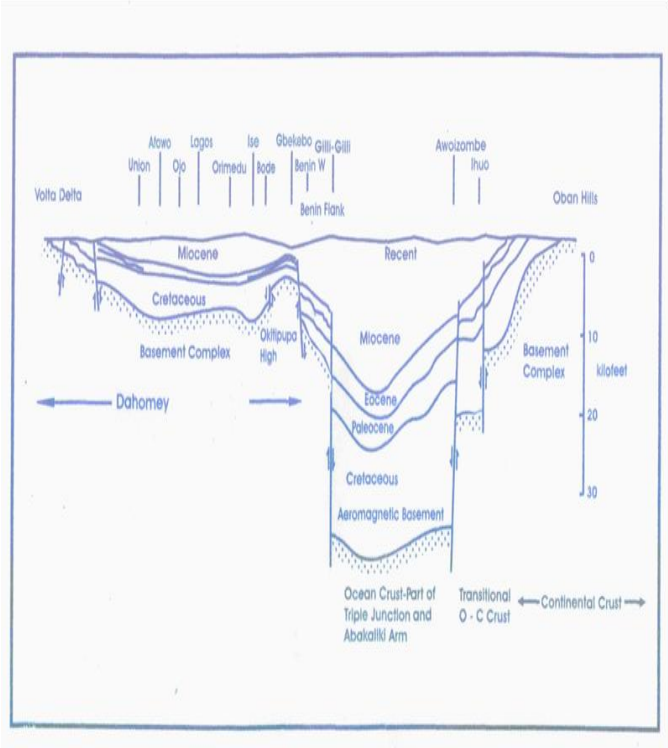

Figure 2: East-West geological section showing position, extent and thickness variation in the onshore Dahomey basin and upper part of the Niger Delta (After Whiteman, A. J, 1982)

GEOLOGICAL SETTING AND STARTIGRAPHY

Detailed geologic, tectonic evolution, sedimentologic and biostratigraphic studies of the different parts of the basin have been adequately reported in the literature such as the works of [1], [22], [23], [2 et al], [3], [4], [5], [24], [7], [25], [12], and [13]. Other important works include [11], [14 et al], [15], and [16]. Palynological studies of the basin documented in literature is few; these include [8], [9], [18], [19 et al], and [20]. Dahomey Basin, southwestern Nigeria is a wrench modified sedimentary basin containing rocks ranging in age from Cretaceous-Recent [14]. The basin extends from Southeastern Ghana (Volta Delta) in the west, to the western flank of the Niger Delta in the east {[1], [4], [7], [25]}. The basin is bounded by the Okitipupa Ridge to east (Figure 2). It is a marginal pull-apart basin or marginal sag basin initiated in the Late Jurassic to Early Cretaceous {[26], [7], and [27]}. It is characterized by both block and transform faulting superimposed across an extensive Paleozoic basin during the breakup of the African and South American continents [28]. This led to the formation of continental margin and coastal margin which was filled up by Cretaceous and Tertiary sediments. Seven lithostratigraphic sequences were recognized in the basin which include Abeokuta Group, comprising of Ise, Afowo and Araromi Formations; Ewekoro Formation, Akinbo Shale, Oshosun Formation, Ilaro Formation and the Recent Alluvium deposits referred to as Benin Formation [7].

METHODOLOGY

Sixty four ditch cutting samples ranging from interval 900-8000ft were used for both palynological and sedimentological studies. Lithologic description of the samples was done by examining them under the binocular microscope by noting the textural characteristics such as colour, grain size, shape (roundness), sorting, effect of ferruginization, presence of accessory minerals and fossil content in terms of plant remains and fossil fragments. Palynological slides were prepared by subjecting the samples to initial digestion by adding dilute hydrochloric acid into them in order to remove calcium carbonate ($CaCO_3$) that might be present. This is followed by hydrofluoric acid (HF) digestion overnight for proper liberation of the organic macerals present in the samples. Recovered macerals from sieving with nylon sheet of 10µm in order to remove clay particles present is followed by oxidation, heavy liquid separation and mounting of the residue on glass slides with D. P. X. mountant, ready for palynological analysis. The method of preparation conforms to international standard. Taxa counts were made to determine the relative frequency of each species in each sample, after which the diagnostic species photographs were taken using Koolpix camera 6000 model.

RESULTS AND DISCUSSION

Sedimentology

The litho-description follows the standard method of describing samples as described in the methodology. Four informal sedimentary units were deduced from the analysis of the Emi-1 well. These lithofacies units are unit 1- sandy shale (900-1400ft, 1800-2000ft), unit 2- silty shale (1400-1500ft), unit 3- shale (1500-1800ft, 2000-2100ft, 2900-3000ft, 3600-3800ft, and4700-6500ft), and unit 4- clayey shale (2100-2900ft, 3000-3600ft, 3800-4700ft, and 6500-8000ft) [Figure 3]. The sandy shale unit 1 is dark grey in colour, blocky to fissile in nature, fairly ferruginized and shows presence of macrofossils in some samples; micaceous (muscovite); evidence of plant remains in some horizons and contains carbonate grains that show effervescence on acid test with dilute HCl. The sand grains vary from fine to pebble in size, angular to rounded and poorly sorted. Silty shale unit 2 is dark grey in colour and fissile in nature; no evidence of fossil remains in term of plant and animal but micaceous (muscovite). The sand is silty in nature and very well sorted. The shale unit 3 is dark grey in colour, rarely blocky but mostly fissile at some intervals; few sand grains are present and fairly ferruginized (Haematite). The clayey shale unit 4 is grey to dark grey in colour, fissile with clay interbeds; non-fossiliferous, and fairly ferruginized (Haematite). The lithologic sequence (900-8000ft) described above when dated palynologically shows equivalence to Ilaro Formation.

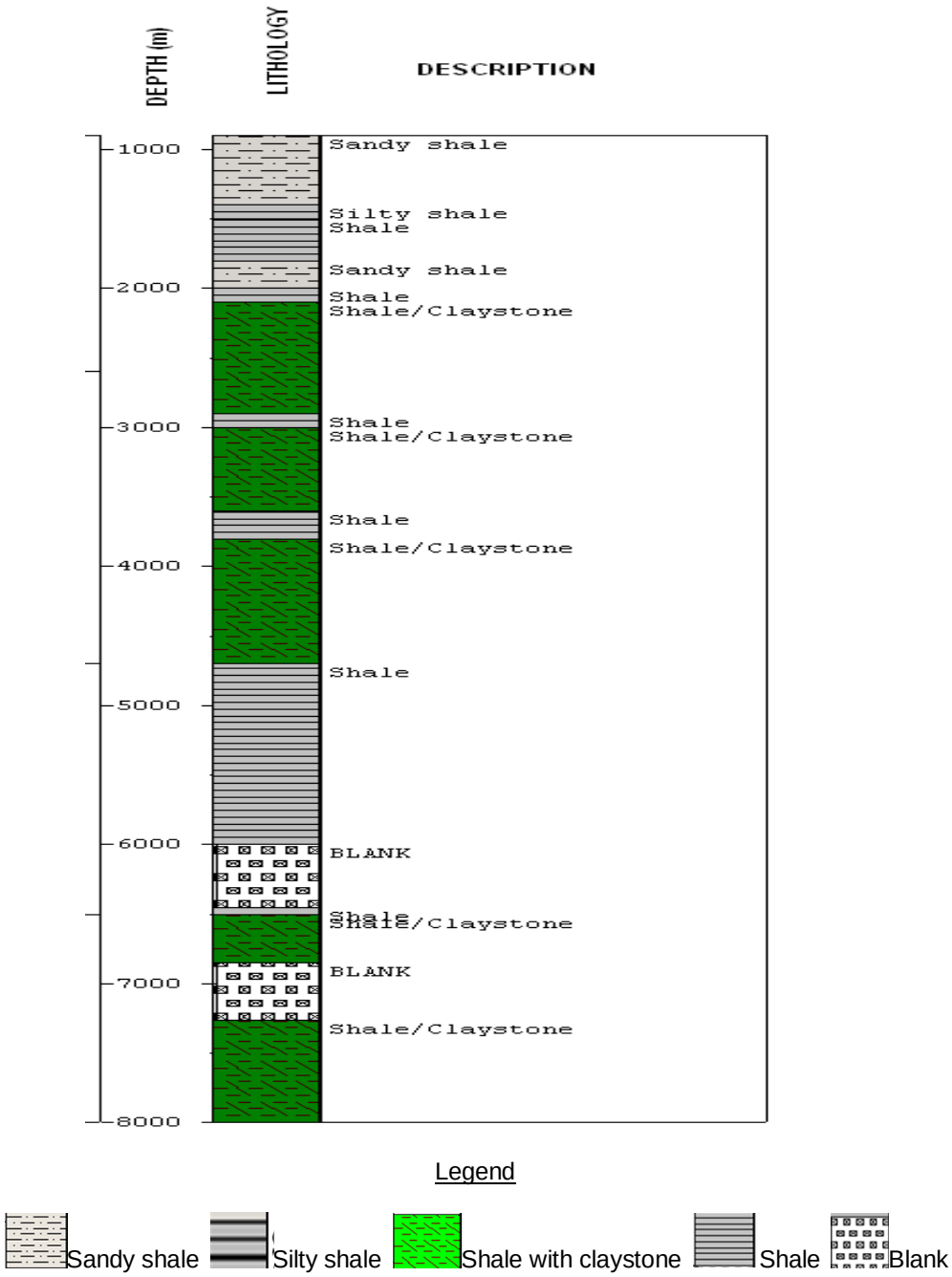

Figure 3: Lithological descrpition of interval 900-8000ft, EMI-1 well, offshore Dahomey Basin, Nigeria.

Palynology

Palynomorphs that are stratigraphically significant and environmentally necessary, recovered in the analyzed samples were plotted in order to interpret for the chronostratigraphy and zonal age dating of the interval (900-8000ft).The pollen and spores are relatively moderate in abundance and diversity, moderately rich dinoflagellates cysts, few freshwater algae (*Botryococcus brunii*), foraminiferal wall linings and numerous diatoms frutules. Three palynological zones were identified and established after the works of [29], and [30 et al]. The basis for characterization of the palynozones established is given below.

Zone 1: *Magnastriatites howardii*/P680
Interval: 6500-8000ft
Age: Early Miocene

Characteristics:

The base of the zone is placed at the depth (8000ft) where the analysis ended. The basal part of the interval is characterized by quantitative occurrence of *Verrutricolporites rotundiporus*; also strongly associated

with other important taxa such as *Magnastriatites howardii, Retibrevitricolporites obodoensis, R. protrudens, Retitricolporites irregularis, Psilatricolporites crassus, Sapotacaee sp, Zonocostites ramonae, Monoporites annulatus, Acrostichum aureum* and *Polypodiaceoiporites sp*. The upper part of the interval shows continuous occurrence of some of the forms that appeared bellow, but there is reduction in abundance of the marker forms such as *Verrutricolporites rotundiporus*. The top of the interval is marked by the first uphole appearance of *Crassoretitriletes vanraadshooveni*. The interval is further characterized by quantitative base occurrence of *Pachydermites diederixi*; co-ocurrence of *Borteria sp* and *Racemonocolpites hians*. This assemblage is similar to those reported by [30 et el], for the adjacent Niger Delta, Nigeria and stratigraphically equivalent to zone P600 of subzone P680, dated Uppermost Early Miocene age (Figures 4 and 5).

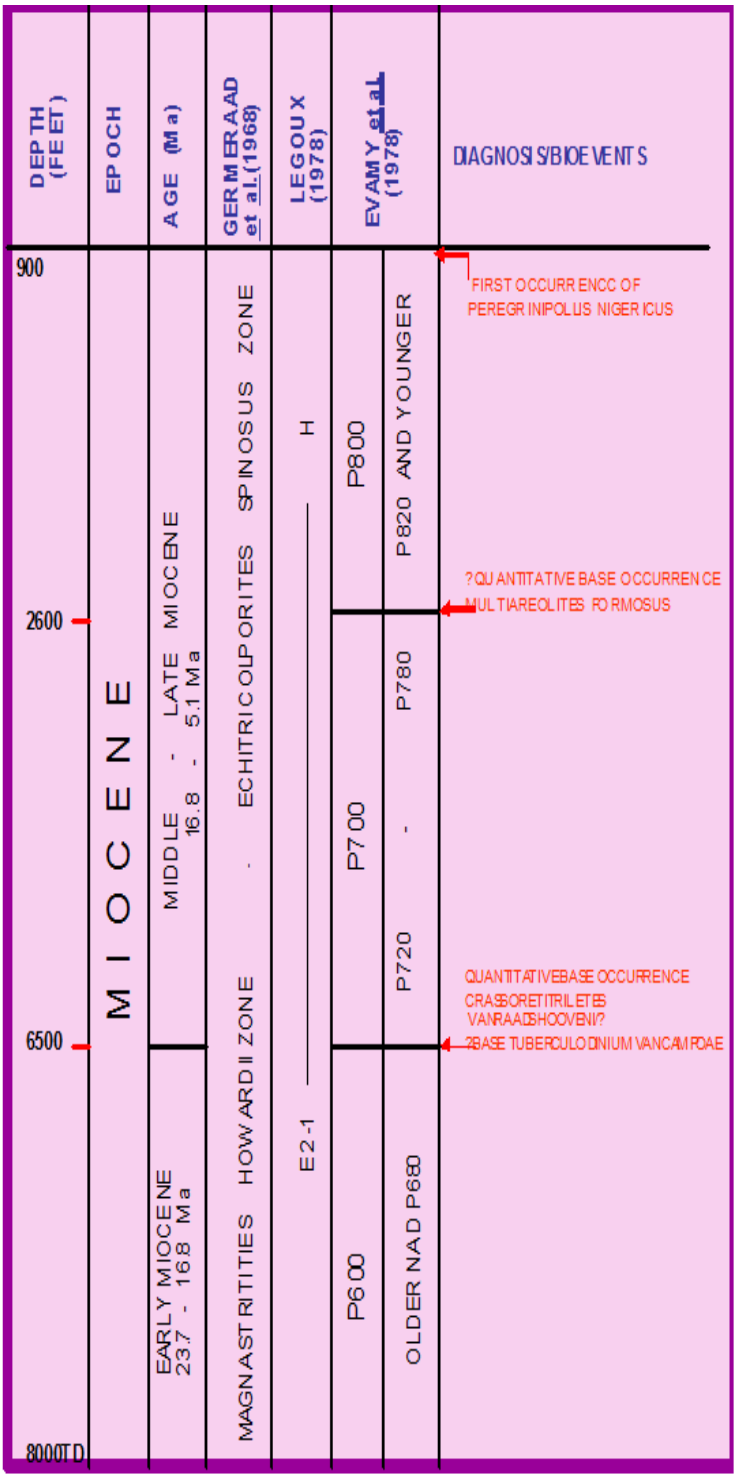

Figure 4: Palynozones recognized in the studied EMI-1 well, offshore, Dahomey Basin, Nigeria

Zone 2: *Crassoretitriletes vanraadshooveni*? P700
Subzone: P720-P780
Interval: 2600-6500ft
Age: Middle Miocene

Characteristics:

The base of this interval coincides with the top of the underlying zone, marked by the first uphole appearance of *Crassoretirriletes vanraadshooveni*. This marker fossil shows continuous appearance throughout the interval (Figure 5). Some of the miospores that occurred in the lower and older interval continued into this zone; they are *Verrutricolporites rotundiporus, Psilatricolporites crassus, Retibrevitricolporites protrudens, P. obodoensis, Zonocostites ramonae, Monoporites annulatus, Racemonocolpites hians, Retitricolporites irregularis,* and *Acrostuchum aureum*. However, new forms of assemblage that occurred include *Peregrinipollis nigericus, Verrucatosporites sp, Laevigatosporites sp,* and *Belskipollis elegans.* The interval is particularly characterized by the presence of organic wall microplankton such as *Tuberculodinium vancampoae* (6500ft), *Polysphaeridium zoharyi, Operculodinium centrocarpum, Selenopemphix sp, Leiosphaeridia sp, and Histrichokolpoma rigaudiae*. Other important dinoflagellate cysts present are *Lejeunecysta sp, Spiniferites pseudofurcatus, Brigantedinium sp and Homotryblium sp.* This assemblage is similar to those reported for Neogene sediments of Anambra Basin, Nigeria. [31] The top of the zone is marked by the first uphole co-occurrence of *Multiareolites formosus* and *Anthocerus sp* at 2600ft. The characteristic assemblage of palynomorphs in this interval is similar to that defined by [29], [30 et, al] and [31] for Tropical regions, Niger Delta, and Anambra Basin Nigeria respectively. Thus, the interval is conveniently dated Middle Miocene age (See Figures 4 and 5).

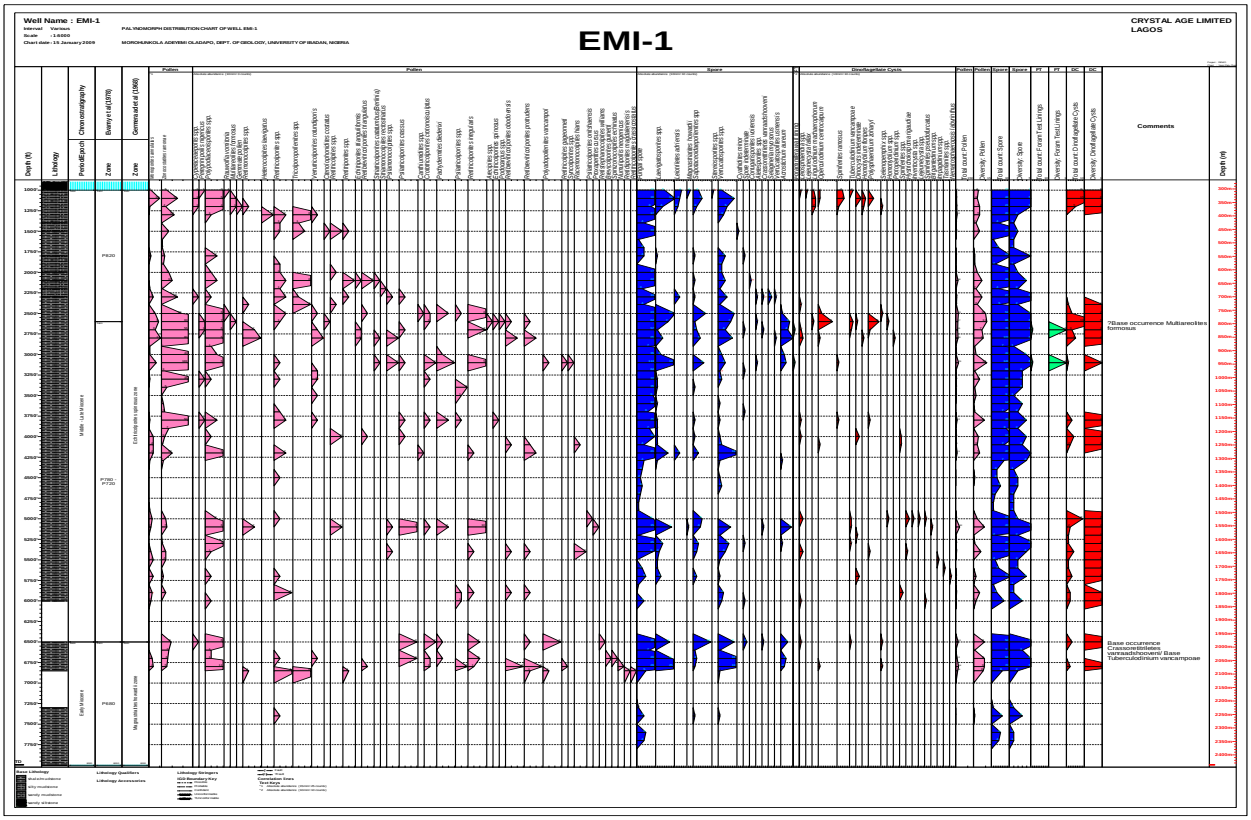

Figure 5: Palynomorph distribution chart of interval 900-800ft of Emi-1 well, offshore Dahomey Basin, southwestern Nigeria

Zone 3: Echitricolporites spinosus/P800
Interval: 900-2600ft
Age: Late Miocene

Characteristics:

The base of the interval is marked by the occurrence of diagnostic forms such as *Multiareolites formosus* and *Anthocerus sp.* The interval is rich in pollen, spores, and dinoflagellates. The microflora assemblage recovered are *Perigrinipollis nigericus, Retitricolporites irregularis, Retibrevitrocolporites protrudens, R. obodoensis, Verrucatosporites usmensis, Magnastriatites howardii, Zonocostites ramonae, Monoporites annulatus* and *Verrutricolporites rotundiporus*. Dinoflagellate cysts that characterize the interval include *Lejeunecysta fallax, Operculodinium centrocarpum, Spiniferites ramosus,* and *Tuberculodinium vancampoae* The top of the interval is defined by occurrence of *Perigrinipollis nigericus*. However, the top of the zone is tentatively placed at 900ft where the first analyzed sample commenced. Some of the pollen and spores reported in this interval are those that define Late Miocene sediments as established in the works of [29], [30 et al], and [31]. Therefore, the interval is conveniently dated Late Miocene age (See Figures 4 and 5).

Paleoenvironment of Deposition

The reconstruction of the depositional environment of the studied well is dependent on some parameters such as relative percentage of *Zonocostites ramonae* to grass pollen (*Monoporites annulatus),* Palynomorph frequency distribution, organic wall microplankton, palynomorph abundance and diversity, palynomorph assemblage, freshwater algae and lithologic characters. The relative percentage of *Zonocostites ramonae* (Rhizophora type) to grass pollen (*Monoporites annulatus*) to the total palynomorph sum is an important factor. Muller [32], and [29], indicated that high percentage of Rhizophora occur in mangrove environment and very close to marine environment. Therefore, the frequency of Rhizophora is expected to decrease towards the offshore. Hence, its quantitative distribution makes it significantly useful for environmental interpretation [33]. *Zonocostites ramonae* is moderate to abundant in frequency throughout most of the sequences described but decreases down the well; suggesting mangrove environment. Percentage varies from about 2.2% to about 64.8%. However, absence or rarity of the species to increase in grass pollen (*Monoporites annulatus*) in some horizons indicates sediment deposition in areas away from the mangrove edge, probably an upland that is associated with unfavourable ecological conditions. Palynomorph frequency percentage distribution shows that there are more pollen and spores than dinoflagellates in the palynomorph sum in each palynozones; that is, there are more terrestrially derived miospores than marine dinoflagellates which indicates that the sources of organomaceral are plant and the environment of deposition is likely to be fluviatile to brackish systems of marginal marine system (Figure 6).

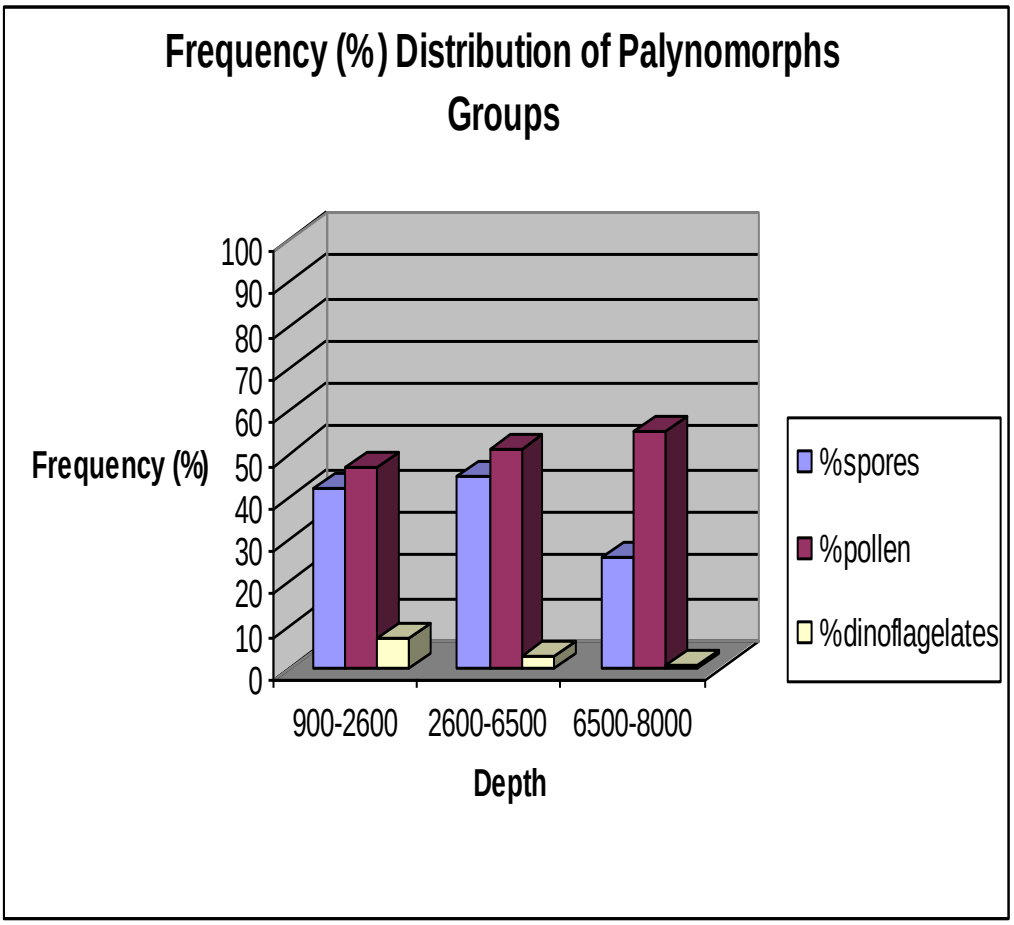

Figure 6: Histogram of frequency percentage (%) of palynomorphs in Emi- 1

Well, offshore Dohomey Basin, Nigeria.

Palynomorph marine index (PMI) is another important factor that suggests paleoenvironment of deposition. The PMI shows environmental variation from freshwater through brackish to typical marine setting at the top. The interval 1720-1780ft contains more freshwater forms in association with PMI forms such as *Tuberculodinium vancampoae, Operculodinium centrocarpum, Selenopemphix sp, Leiosphaeridia sp, Histrichokolpoma rigaudiae,* and *Lejunecysta sp* which are indicative of inner neritic to outer neritic setting {[34], [35], [31]}. However, the co-occurrence of the freshwater algae and PMI is suggestive of admixture of freshwater and saline water resulting to a fluviomarine depositional environment formed by prograding sedimentational system (Figures 7 and 8).

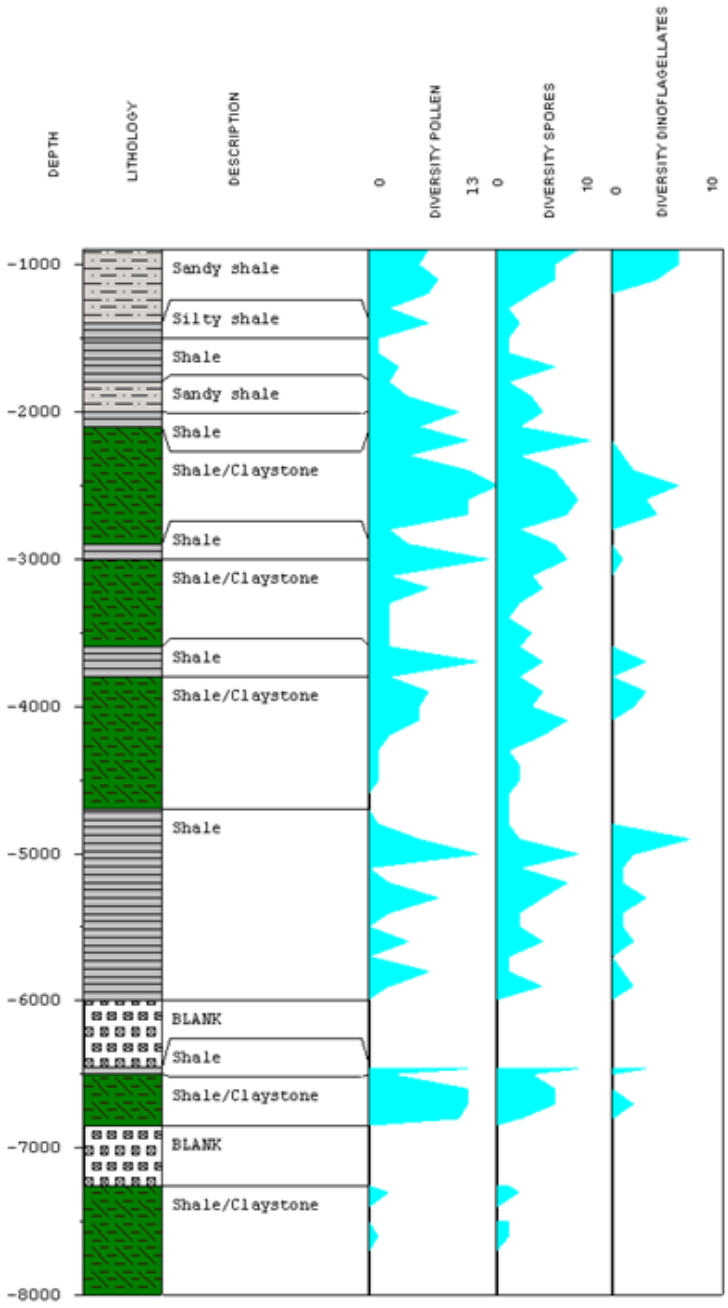

Figure 7: Depth versus PMI values, Diversity and Abundance of EMI-1 well

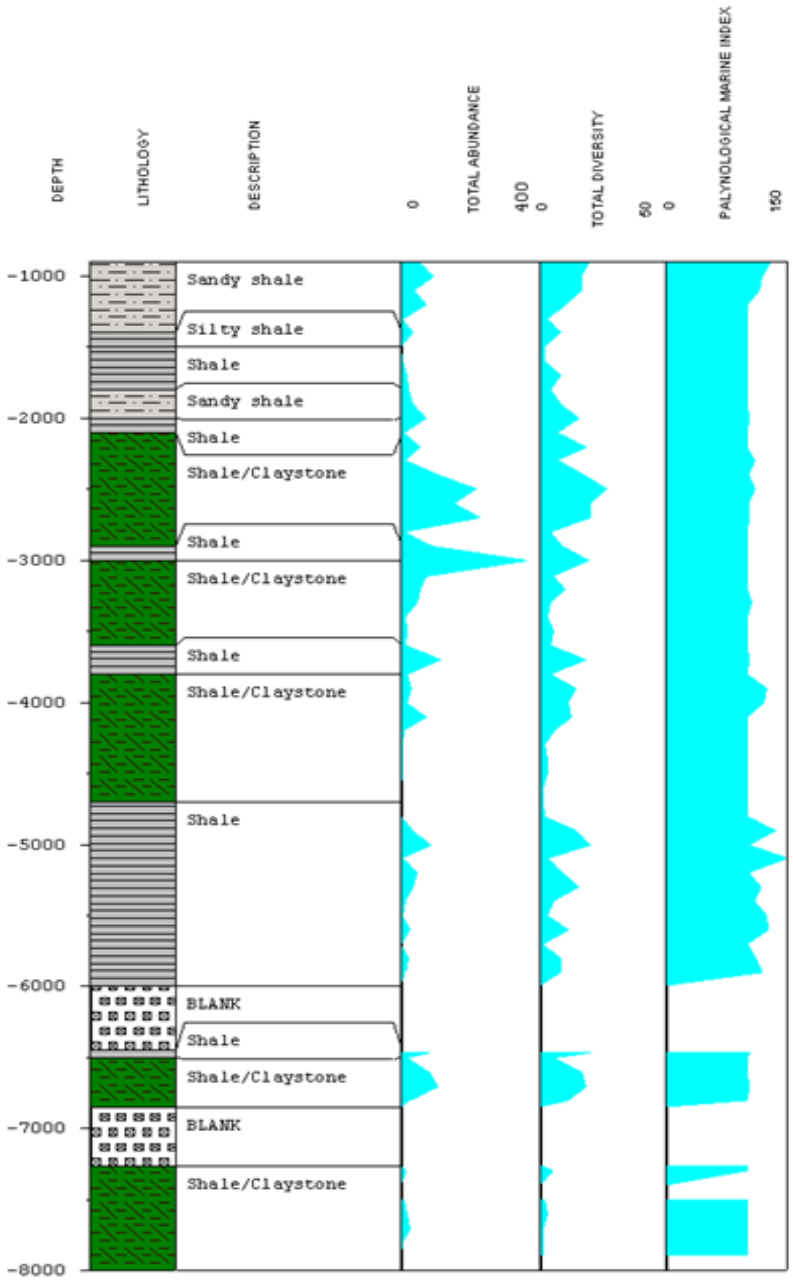

Figure 8: Depth versus Diversity of Pollen, Spores and Dinoflagellates

The underlying older sequence (6500-8000ft) is mainly fluviatile system; containing more of terrestrially derived and freshwater forms with few dinoflagellate cysts compared with overlying intervals (Figures 7 and 8). However, the palynomorph abundance and diversity plot complements other paleoenvironmental indices; this tends to show the effect of the sea level changes and its resultant effect on plant growth and distribution. The periods of high palynomorph abundance and diversity (Figures 7, 8 and 9) may suggest rise in sea level, leading to landward marine incursion, while a low palynomorph abundance and diversity suggests drop in sea level and adverse ecological conditions. The presence and association of some environmentally diagnostic miospores such as Crassoretitricolporites vanraadshooveni, Zonocostites ramonae, Magnastriatites howardii, Peregrinipollis nigericus, Verrutricolporites rotundiporus and Pachydermites diederixi are indicative of coastal plain environment, while the presence of Botryococcus brunii-colonial alga which produces a biomarker- botrococcane could suggests two things; either the environment indicates freshwater input (fluviomarine), or as a biomarker which suggests that oil production could be generated from the interval if subjected to adequate temperature [36].

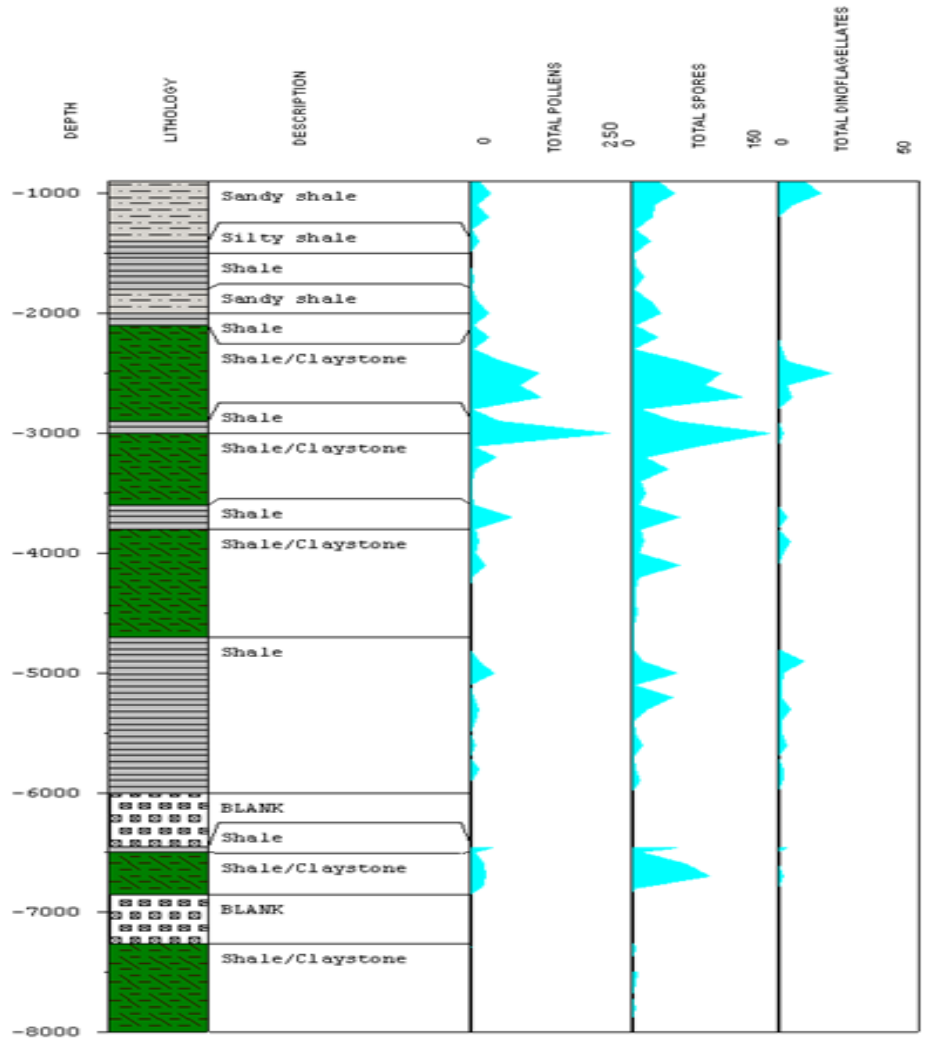

Figure 9: Depth versus Total Pollen, Total Spores and Total Dinoflagellates

CONCLUSION

Palynological investigations of Emi-1 well located in the deep offshore Eastern Dahomey Basin resulted in the establishment of lithofacies units, palynological zones, ages and paleoenvironment of deposition of the studied stratigraphic interval (900-8000ft). The litho-section was informally sub-divided into four lithfacies units varying from sandy shale, silty shale, through shale to clayey shale. They are generally dark gray in colour, blocky to fissile, calcareous, fossiliferous, micaceous and ferruginized at various stratigraphic horizons. The zones established include *Magnastriatites howardii*/P680 Zone 1, characterized by quantitative base occurrence of *Pachydermites diederixi, Magnasriatites howardii* and *Racemonocolpites hians*, dated Early Miocene; *Crassoretitriletes vanraadsooveni*/P700 Zone 2 marked by co-occurrence of *Crassoretitrilets vanraadsooveni, Verruticolporites rotundiporus* and *Belskipollis elegans,* dated Middle Miocene and *Echitricolporites spinosus*/P820 Zone 3, characterized by co-occurrence of *Multiareolites formosus* and *Anthocerus sp* dated Late Miocene. The paleoenvironment of deposition varies from fluviatile at the base through marginal marine to typical marine setting strongly influenced by the relative abundance of terrestrially derived miospores and palynomorph marine index (PMI). This work could help in optimizing hydrocarbon exploration and exploitation through the use of the chronostragraphic framework generated and adequate correlation of the study with other well drilled nearby.

PLATE 1


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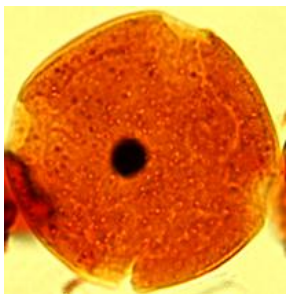
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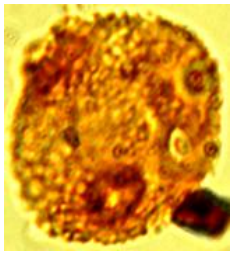
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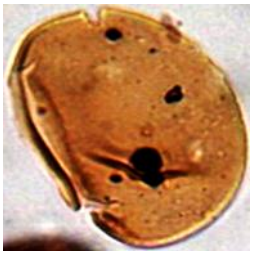
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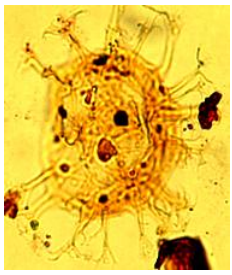
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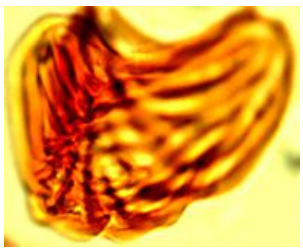
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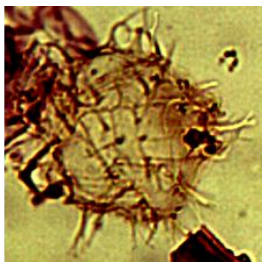
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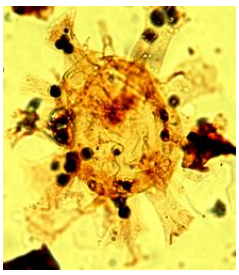
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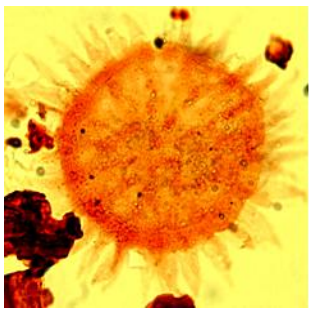
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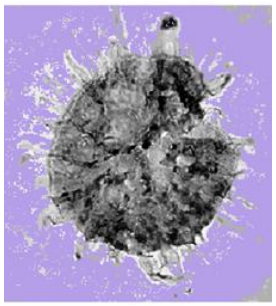
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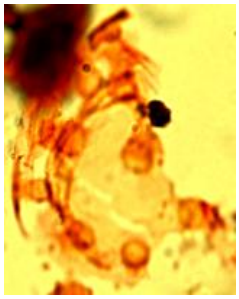
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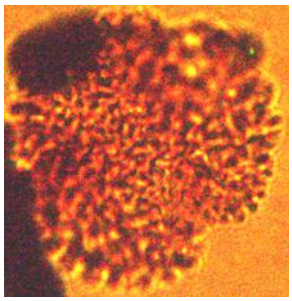
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All magnification at ×800 Plate 1

1	Zonocostites ramonae	9	Spiniferites ramoxux
2,7	Laevigatodporites sp	10	Magnastriatites howardii
3	Pachydermites diederixi	11	Operculodinium vancampoae
4	Fungal spore	12	Histrichokolpoma rigaudae
5	Retibrevitricolporites protrudens	13,14	Lingulodiniummachaerorophorum
6	Verrutricolporites rotundiporus	15	Tuberculodinium vancampoae
8	Achrostichum aureum	16	Retitricolporites irregularis

PLATE 2

All magnification at ×800

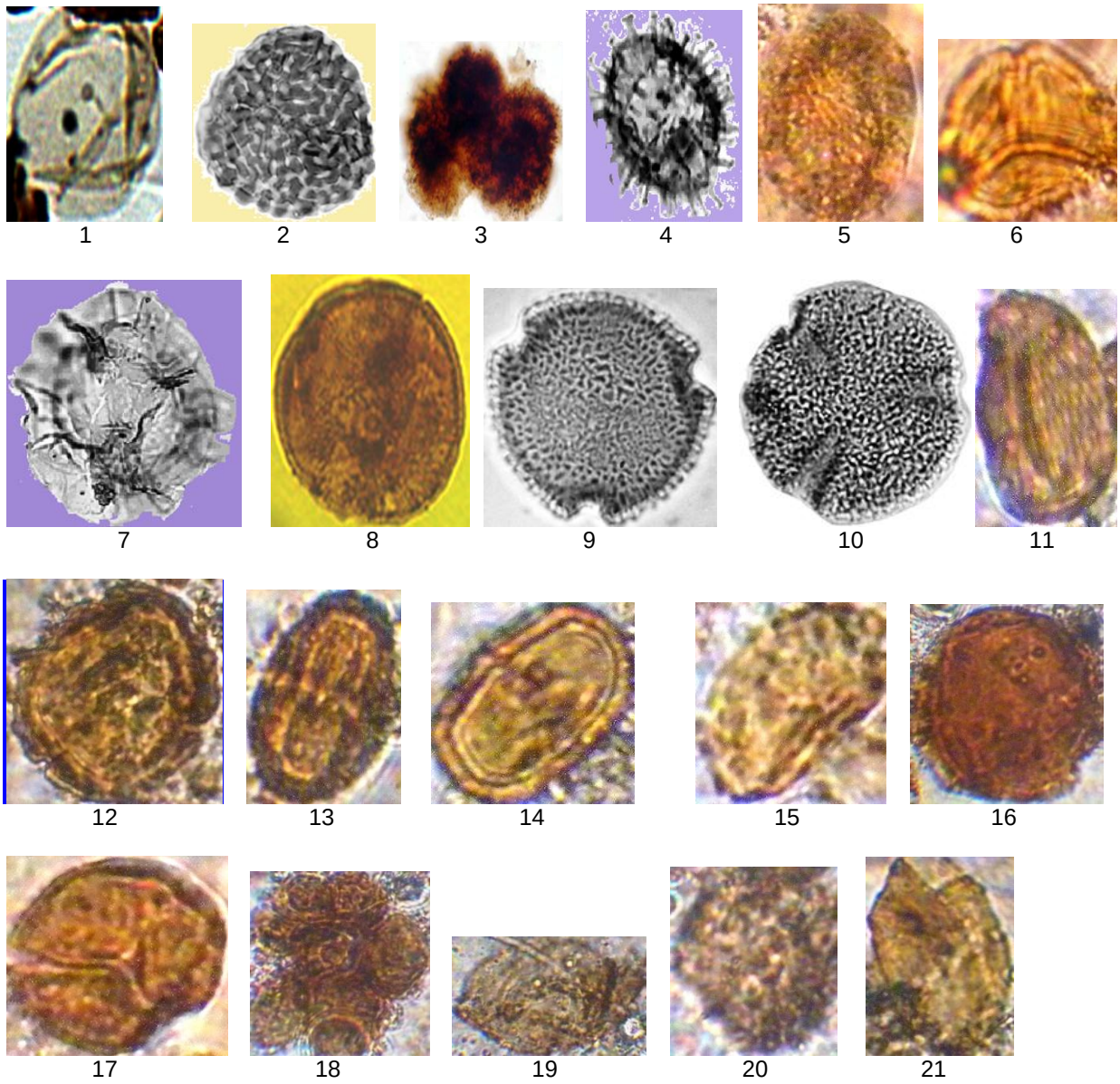

Plate 2

All magnification at ×800

1	Monoporites annulatus
2	Crassotriletes vanraadshooveni
3	Botryococcus brunii
4	Polysphaeridium zoharyi
5	Nymphae lotus
6	Anthocerus sp
7	Impagidinium sp
8,12	Psilatricolporites crassus
9	Canthimidites sp
10	Tricolporites sp
11	Striamonocolpites sp
13	Multiareolites formosus
14	Belkipollis elegans
15	Verrucatosporites sp
16	Pachydermites diederixi
17	Anthocerus sp

18 Microforaminiferal wall lining

19 Nymphae lotus

20 Elaies guineensis

21 Taxodinum sp

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