

Palynological Zonations and Sequence Stratigraphic Analysis of Sediments in Benin West-1, Anambra Basin, Nigeria

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Abstract

Palynoflora analyses from Benin west -1, Anambra Basin has unfold three palynozones based on abundance, composition of palynoflora and cluster analysis. Palynozone-1 has been dated as Late Maastrichtian age and belong to the lowermost Imo Shale, palynozone-2; Middle Eocene and palynozone -3 is dated Lutetian to Bartonian age. Sediments between depth intervals of 2649-2560 m is marked a sequence boundary, 1650-2560 m, and 970-1190 m is delineated as high stand system tract. Shaly intervals from the depth of 1644 m, and 1234 m recorded acme of palynoflora (*Zonocostites ramonae*, *Monoporites annulatus*, *Verrucatosporites spinosus*, *Botryococcus braunii*) and probably fingerprints a condensed section. The condensed section intervals (1644 m and 1234 m) may depict good source rock and exploration targets.

Keywords: Late Maastrichtian; Middle Eocene; Palynological; Palynozones; Sequence boundary.

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1. Introduction

Palynological zonation is the characterization and subdivision of sedimentary strata on the basis of palynofossils content. This differentiation allows small scale units to be dated, correlated and interpreted within a precise framework of geologic time. According to Aswal, palynofossils play a very significant role in dating sequence stratigraphic surfaces and in understanding the process sedimentology [1]. The Anambra Basin has been investigated by previous workers [2,3] as a result of renewed interest in the exploration for oil and gas due to Federal Government of Nigeria comparative advantage for these resources. This necessitated the revisit to abandon well (Benin west-1). The aim of this work is to determine the palynomorph composition, establish the zonation, date with a view to establish sequence stratigraphic framework.

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2. Study Area and Geological Setting

The studied area (Fig.1) is located in the northern part of Anambra Basin where sediments of Imo and Ameki Formation were encountered. Anambra Basin evolved tectonically after the Santonian tectonism that affected the Benue Trough, characterized by uplift of the Abakaliki structure and subsequent downward displacement of the Anambra Platform and Afikpo Syncline, trending SW and SE of the Abakaliki structure [2,4].



Fig. 1. Map of Niger Delta showing location of Benin West- 1 [modified after 3].

3. Materials and Methods of Study

Twenty-seven ditch cuttings of Benin west-1 well were selected based on stratigraphic position and sedimentary attributes. Samples were screened palynologically following the procedure reported elsewhere [5]. Samples were digested with 30 mL of 10 % HCl to remove carbonates. It was then digested with 30 ml of 40 % HF for 24 h to remove silica, filtered with 10 microns sieve with water, oxidized and separated from debris with the use of $ZnCl_2$. Palynoflora residuum were set on glass slides and examined for palynofossils with the aid of Mieji binocular microscope. Identification of forms were made possible by correlating it with published works [6]. Palynological forms recorded in the selected section aided the creation of sequence stratigraphic framework. Palynological association were also obtained from cluster analysis using the agglomerative method [7].

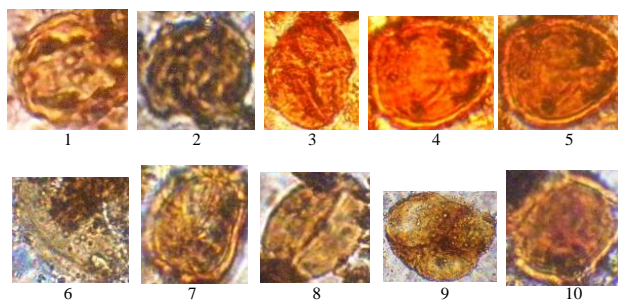
4. Results and Discussion

Relative ages deduced from the palynoflora (Table 1, Figs. 2 - 4) were derived from earlier reported palynoflora works [6,8,9]. Benin west-1 recorded 42 species of palynoflora counts and displayed a diverse pattern of palynoflora (Figs. 2-4) allowing a subdivision of the Imo shale and Ameki Formation into three (3) zones (Figs. 3-4) based on the first occurrences of two or more forms (Fig. 5).

Zone 1: The base of the sequence (1854-2607 m) is marked by the occurrence of *Zlivisporites blanensis*, *Lycopodium phlegmaria*, *Pachydermites diderixi*, *Psilatricolporites* sp., *Retibrevitricolporites protrudens*, *Laevigatosporites* sp., and *Leiotriletes* sp. Dinoflagellate cysts (Fig. 5) dominates the top of the sequence and is equivalent to the P1 zone [10]. Palynostratigraphic data suggest Late Maastrichtian age and belong to the lowermost Imo Shale (Fig. 5).

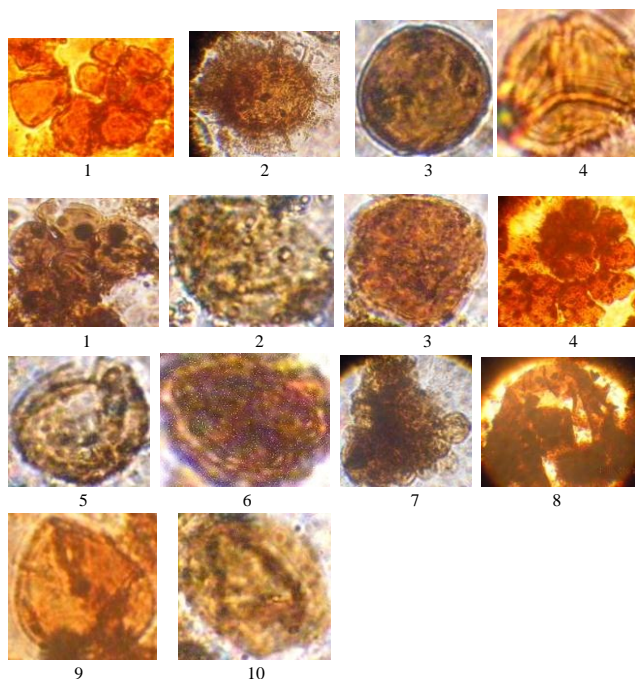
Zone 2: The top of the zone is characterized by the occurrence of *Nyphae lotus* and *Restistephanocolpites gracilis*. Other miospores associated with this interval include *Elaeosis guineensis*, *Pteris* sp., *Multiareolites formosus* and *Retibrevitricolporites protrudens*. It is subdivided into four subzones equivalent to P430 [9] and is dated Middle Eocene.

Zone 3: This zone is associated with the top of the Imo Shale (1234-1034 m) and part of the Ameki Formation (972-324 m). It is subdivided into two subzones, characterized by the occurrence of *Monoporites annulatus*, *Operculodinium giganteum*, and *Selenopemphix nephroides*. This zone is similar to P300-P400 zones described in literature [9,11]. This zone is dated Lutetian – Bartonian age (Fig. 5). A total of three zones and six subzones have been recognized in the Benin west-1. Statistically, three assemblages/association were also recognized (Fig. 6). The first assemblage (1) is composed of mangrove and freshwater elements (*Monoporites annulatus*, *Botrycoccus braunii*). The second assemblage (2) is composed of mixture of marine, mangrove palynoflora while the third (3) associations are made up of marine components (dinoflagellate cyst, microforaminifera wall linings and *Nympha lotus*). These associations of mixed palynoflora, probably suggests a transgressive - regressive conditions. This scheme corroborates the line of evidence from palynostratigraphy.



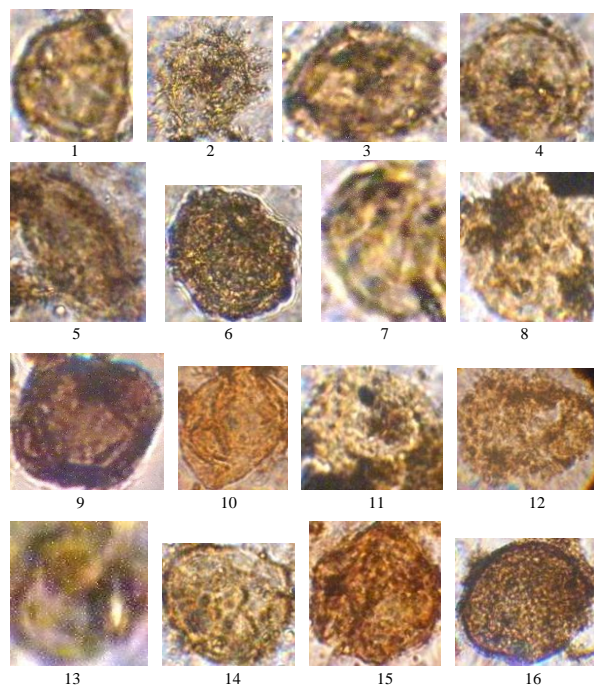
- | | | | |
|------|----------------------------|----|--------------------------------|
| 1 | Zonocostites ramonae | 6 | Monosulcites sp |
| 2 | Ctenolophonidites costatus | 7 | Monoporites annulatus |
| 3 | Sapotacae | 8 | Monocolpites sp |
| 4, 5 | Psilatricolporites crassus | 9 | Microforaminiferal wall lining |
| | | 10 | Pachydermites diederixi |

Fig. 2. Photomicrographs of some characteristic Palynomorphs associated with Benin West –1, Benin Flank.



- | | | | |
|---|--------------------------------|----|---------------------------------------|
| 1 | Microforaminiferal wall lining | 6 | Retistephanocolpites gracilis |
| 2 | Psilatricolporites crassus | 7 | Polyadadpolinites sp of Nymphae lotus |
| 3 | Elaeis guineensis | 8 | Nymphae lotus |
| 4 | Microforaminiferal wall lining | 9 | Leiotriletes sp |
| 5 | Nymphae lotus | 10 | Monoporites annulatus |

Fig. 3. Photomicrographs of some characteristic Palynomorphs associated with Benin West-1, Benin Flank.



- | | | | |
|---|--|-------|-----------------------------------|
| 1 | <i>Nymphae lotus</i> | 9,10 | <i>Selenopenphix nephroides</i> |
| 2 | <i>Xandorodinium</i> sp | 11,12 | <i>Tuberculodinium vancampoae</i> |
| 3 | <i>Monoporites annulatus</i> | 13 | <i>Zonocostites ramonae</i> |
| 4 | <i>Lycopodium phlegmaria</i> | 14 | <i>Impagidinium</i> sp A |
| 5 | <i>Arecipites</i> sp | 15 | <i>Psilatricolporites crassus</i> |
| 6 | <i>Retibravitracolporites protrudens</i> | 16 | <i>Spirosyncolporites</i> sp |
| 7 | <i>Nymphae lotus</i> | | |
| 8 | Indeterminate | | |

Fig. 4. Photomicrographs of some characteristic Palynomorphs associated with Benin West –1, Benin Flank.

5. Sequence Stratigraphic Framework of Benin West-1

The Benin west -1 well sediments are composed of the following sequences:

Sequence Boundary- Sandstone at the depth of 2649-2560 m (Fig. 3) recorded lean population of palynoflora. It consists of granules and crystalline fragments. This marks the boundary with the overlying HST sediments and is dated 64.2-64.8 Ma.

Highstand System Tract (HST) - The highstand systems tract (1650-2560 m, and 970-1190 m) constitutes the lower and upper parts of Imo shale (Fig.5).. It lies directly on the sequence boundary, flooding surface and contains palynormorphs such as *Psilatricolporites crassus* *Pachydermites diderixi*, *Zonocostites ramonae* and *Botryococcus braunii* with percentage of 3.4 to 5%, probably represents a relative fall in sea level. Its numerical age is assigned 47.2-50.6 Ma [10,12]. The stacking pattern

indicates early rise or fall in sea level and the shaly portion may be a potential source rocks.

Flooding Surface -The depth of 1644 m, 1234 m (Fig. 5) is made up of shale and documented high populations of palynomorphs. This unit probably represents a condensed section associated with flooding surface. It is characterized by the maximum abundance (10%) and diversity (8.72 - 9.39 %). Palynoflora affiliated with the flooding surface include *Zonocostites ramonae*, *Monoporites annulatus*, *Verrucatosporites spinosus* and *Botryococcus braunii*. These intervals may constitute the sequence with high quality organic matter and is assigned 51 Ma [12-14].

Transgressive Systems Tract (TST) - The transgressive systems tract lies directly on the flooding surface and highstand systems tract. Depth interval of 1244-1634 m and 134-934 m (Ameki Formation) marks the transgressive systems tract. It contains palynomorphs such as *Verrucatosporite spinosus*, *Monoporites annulatus*, *Botryococcus braunii* and is assigned 37-47.4 Ma [12-14].

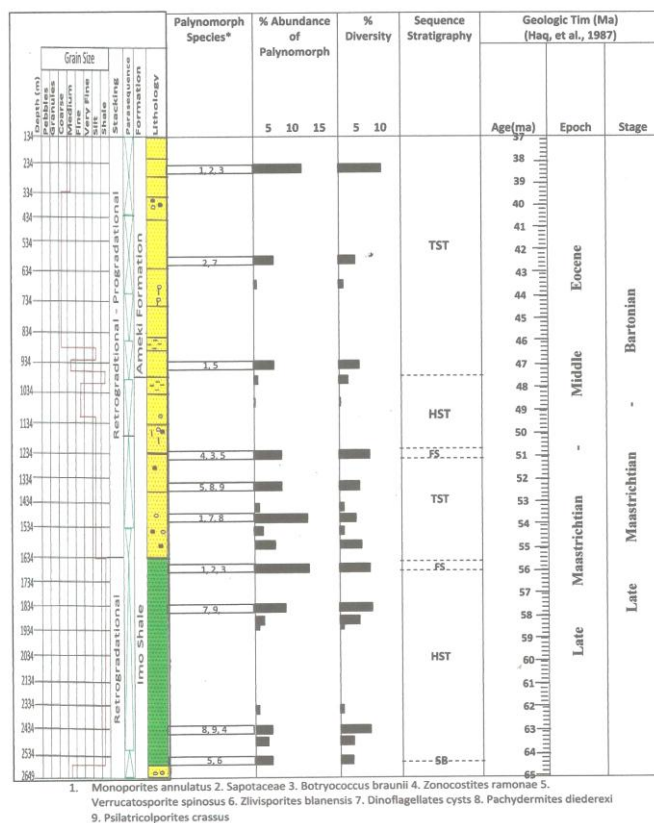


Fig. 5. A proposed sequence stratigraphic framework of Benin West -1, based on abundance and diversity of palynomorphs at depth.

the depth of 1644 m, and 1234 m recorded spike of palynormorphs (*Zonocostites ramonae*, *Monoporites annulatus*, *Verrucatosporites spinosus* and *Botryococcus braunii*) and probably represents a condensed section.

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