

Biostratigraphy, Palynomorph Assemblages and Paleoclimate of Avg-1 Well, Northwestern Niger Delta, Nigeria

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ABSTRACT

Eighty ditch cutting samples between 830-5580 ft of AVG-1 well were used for analysis and sampling of the ditch cuttings was done at 60 ft interval for palynofloral studies. A rich recovery of palynomorph was recorded, with dominant presence of land-derived species such as pteridophyte spores; *Laevigatosporites* spp. and *Verrucatosporites* spp., brackish water spore (*Acrostichum aureum*), *Zonocostites ramonae*, *Psilatricolporites crassus*, *Retitricolporites irregularis* and *Psilastephanocolporites sapotaceae*. Other diagnostic significant palynomorphs recorded include dinoflagellate cysts such as *Lingulodinium machaerophorum*, *Spiniferites* spp., *Hystrichokolpoma rigaudae*, *Polysphaeridium subtile*, microforaminiferal wall linings and algae such as *Botryococcus brauni*. Two palynological zones were proposed; *Pachydermites diderixi*-*Retibrevitricolporites obodoensis/protudens* interval zone and *Racemonocolpites hians* taxon range zone. The well was assigned Early to Late Miocene age. A transitional wet to dry climatic condition within the Niger Delta was inferred during the Early to Late Miocene.

Keywords; Miocene, Palynomorph, Biozone, Paleoclimate, Niger Delta

INTRODUCTION

The Niger Delta is an oil-rich province of Nigeria located on the West African Continental margin popularly called the Gulf of Guinea. The Niger Delta basin lies between 4°00'00" and 6°00'00"N and 5°00'00" and 8°00'00"E. Wells have been drilled across the delta, penetrating sediments in which petroleum generation, migration and accumulation have occurred (Reijers *et al.*, 1997 and Okosun *et al.*, 2012). Reijers (2011) proposed a delta-wide biostratigraphy framework with alphanumeric codes developed from the biostratigraphy zones of Shell Petroleum Development Company of Nigeria (SPDC), so as to develop and calibrate a unified foraminifera biozonation scheme, which can be applied in all concessions throughout the Niger Delta. The first study about tropical palynomorphs in West Africa to identify and describe in line with correct morphological parameters which showed family or botanical association was by Onema *et al.* (2019). This study aims to determine the biostratigraphic zone, age and paleoclimate of AVG-1 well based on recovered palynomorph and spore assemblages.

GEOLOGICAL SETTING OF THE NIGER DELTA

The sedimentary sequence owes its origin to three main tectonic phases, coupled with transgressive and regressive marine pulses (Murat, 1970, Reijers,

2011). The delta is divided into three diachronous formations, representing prograding depositional facies that are distinguished mostly on the basis of sand-shale ratios (Avbovbo, 1978; Doust and Omatsola, 1990; Kulke, 1995). The shape and internal structure of the Niger Delta Basin is controlled by fracture zones along the oceanic crust, such as the Charcot fracture zone and the Romanche fracture zone (Fig. 1; Corredor *et al.*, 2005). The Basin sediments show an upward transition from marine pro-delta shales (Akata Formation) through a paralic interval (Agbada Formation) to a continental sequence (Benin Formation). Two structural models have been proposed for the origin of the Niger Delta depositional belts (Doust and Omatsola, 1990), namely the mobile shale-like salt model and the gravity model.

METHODOLOGY

Sample Preparation for Palynomorphs

10 g of each sample were weighed and soaked with distilled water in a polypropylene beaker. Hydrochloric acid and Hydrofluoric acid was added to the samples to aid the removal of carbonates and silicates respectively and then boiled in the fume cupboard for safety purpose. Add distilled water and then decant over a 5-micron sieve mesh. Separation of the palynomorphs from inorganic particles was done using Zinc Bromide solution, and cleaning of the palynomorphs was done using Nitric acid, for the

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removal of cellulose was done. The residues were pipetted and dropped on rectangular coverslips, which were later placed on a hot plate for onward drying, and the coverslips were added using Norland optical adhesive. The palynological slides were labelled and studied using a Meiji binocular light microscope; corresponding photomicrographs were well.

taken. The microfossils were identified by comparison with local palynological catalogues (Germeraad *et al.*, 1968; Legoux, 1978 and Evamy *et al.*, 1978). The biozone scheme of Evamy *et al.* (1978) was used for the palynomorph zonation of the

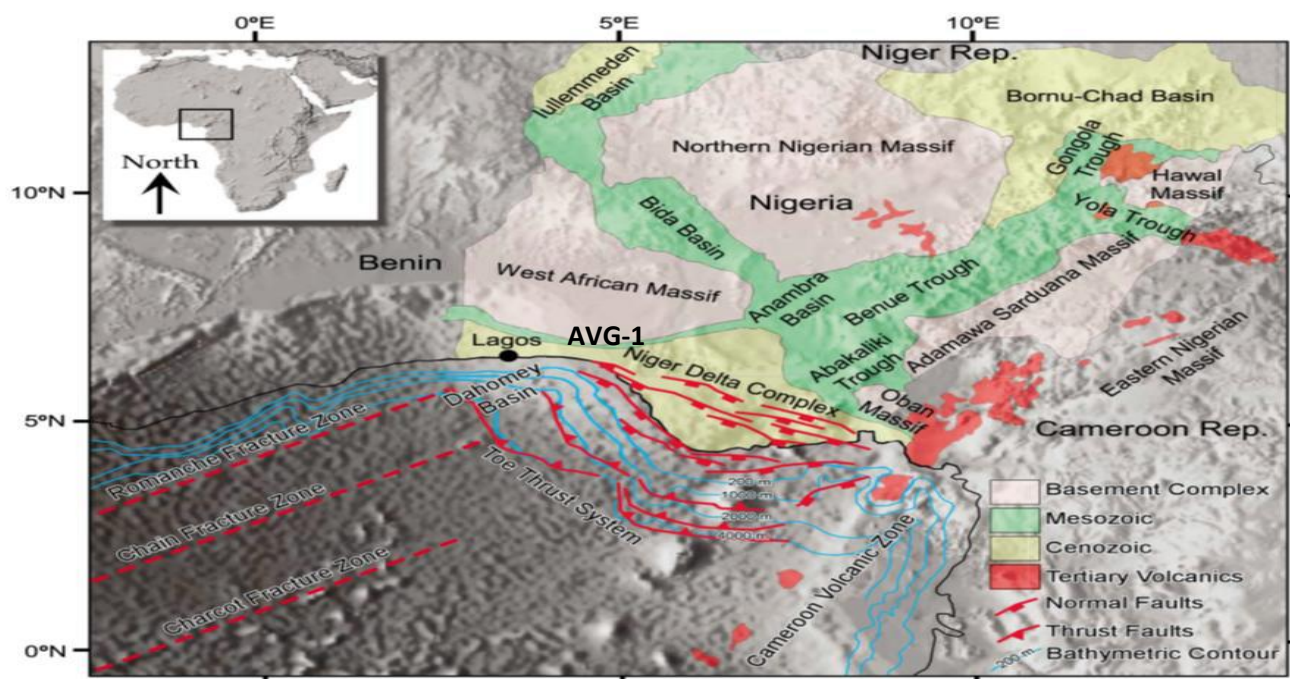


Figure 1: Part of West Africa and the Gulf of Guinea Showing Nigeria's Sedimentary Basin and some features controlling Sedimentation in the Niger Delta. In set is a map of Africa showing the Location of the Niger Delta region (Corredor *et al.*, 2005).

RESULTS AND DISCUSSION

The lithology of the study area is made up of sandstone and shale layers intercalation.

PALYNOMORPHS MICROFAUNA

A total number of 80 ditch cutting samples were used for palynological analysis between 830-5580 ft intervals, sampling and analysis was done at 60 ft interval for palynofloral studies. The palynomorph assemblages were dominated by land, and freshwater derived sporomorphs. A prosperous recovery of palynomorphs was achieved, dominated by land-derived species such as pteridophyte spores like species of *Laevigatosporites spp.* and *Verrucatosporites spp.*, brackish water spore (*Acrostichum aureum*), *Zonocostites ramonae*, *Psilatricolporites crassus*, *Retitricolporites irregularis* and *Psilastephanocolporites sapotaceae*. Other diagnostic significant palynomorphs recorded

include dinoflagellate cysts such as *Lingulodinium machaerophorum*, *Spiniferites spp.*, *Hystrichokolpoma rigaudae*, *Polysphaeridium subtile*, microforaminiferal wall linings and algae such as *Botryococcus brauni*. The distribution of palynomorphs varied from one depth to another throughout the section. Pollen preservation was good in most samples, and the microflora was relatively rich and well-diversified. The pollen chart shows 91 most essential taxa for the well. These are considered ecologically significant and have therefore been classified according to their ecological zone. We analyzed these ecological groups based on the studies of Salard-Cheboldaeff (1981) and Germeraad *et al.* (1968). Palynological zonation of the well is based on the palynofloral assemblage of significant species and their stratigraphic distribution with reference to the zonation schemes of Evamy *et al.* (1978).

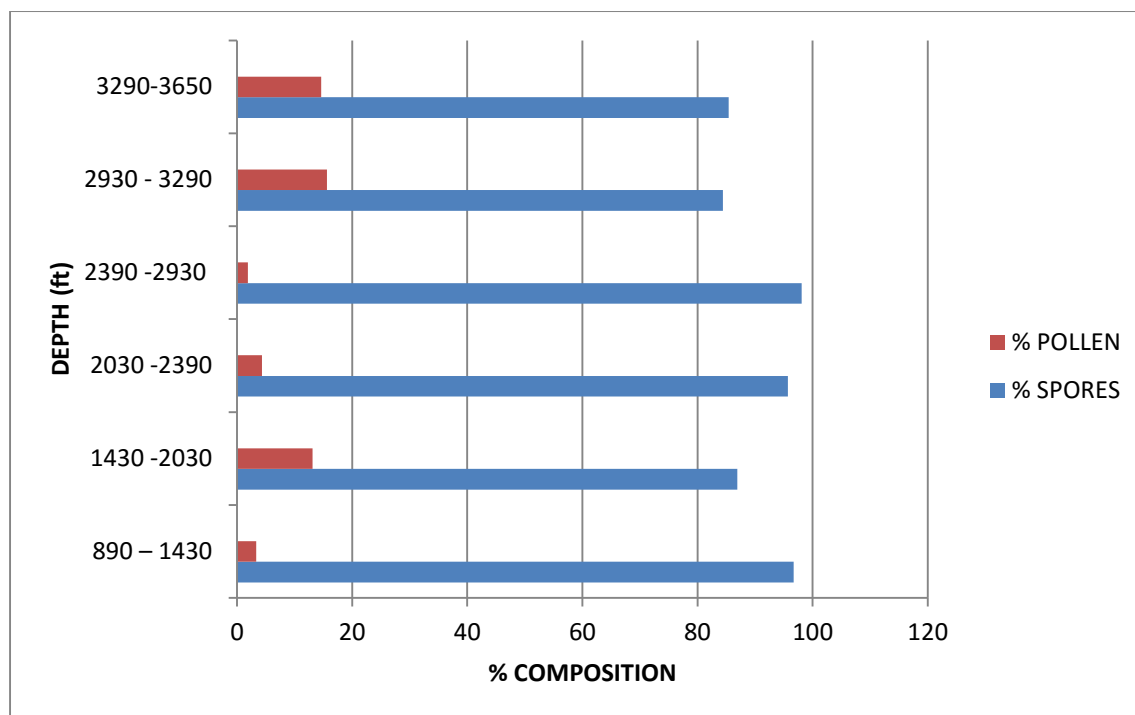


Figure 2: Bar chart showing Percentage composition of Pollen and Spore in the study well

Table 1: Table showing the quantitative count of in *Monoporites annulatus* and *Zonnocostites ramonae* in AVG – 1 well.

DEPTH (Ft)	MONO	ZONO	TOTAL
890-1430	2955	3200	6155
1430-2030	109	143	252
2030-2390	142	875	1017
2390-2930	307	1416	1723
2930-3290	337	82	419
3290-3650	63	11	74
3650-4010	24	39	63
4010-4370	4	23	27
4370-4730	10	47	57
4730-4960	7	34	41
4960-5140	35	16	51
5140-5360	20	22	42
5360-5580	44	6	50

PALYNOSTRATIGRAPHY

Biozonation of the strata penetrated by the well was primarily based on the palynofloral assemblage of notable species and their stratigraphic distribution with reference to existing zonation schemes of Evamy *et al.* (1978). Two palynological zones were proposed; *Pachydermites* *diederixi* -

Retibrevitricolporites *obodoensis/protudens* Interval zone and *Racemonocolpites hians* Taxon range zone. The well was assigned Early to Late Miocene age as seen in figure 5.

Pachydermitesdiederixi -Retibrevitricolporites obodoensis/protrudens interval
Zone Stratigraphic range: 830 2210ft

The top is probably shallower than the first sample analyzed at 830 ft. The interval top was marked by the top occurrence (FDO) of *Retibrevitricolporites obodoensis/protrudens* and *Pachydermites diederixi*, which occur in higher frequencies. *Peregrinipollis nigericus* occurs in lower percentages, and *Nypheapollis clarus* is present. *Stereisporites sp.* occurs in low

percentage and the base by the top regular occurrence (FDO) *Racemonocolpites hians* in this interval. The assemblage of this interval is still dominated by abundant *Monoporites annulatus*, *Zonocostites ramonae*, *Laevigatosporites sp.* and *Verrucatosporites sp.* Co-occurring are *Retitricolporites irregularis* and *Echitricolporites spinosus*. This zone corresponds to the P820 subzone of Evamy *et al.* (1978). The assigned age of this interval is the Late Miocene age.

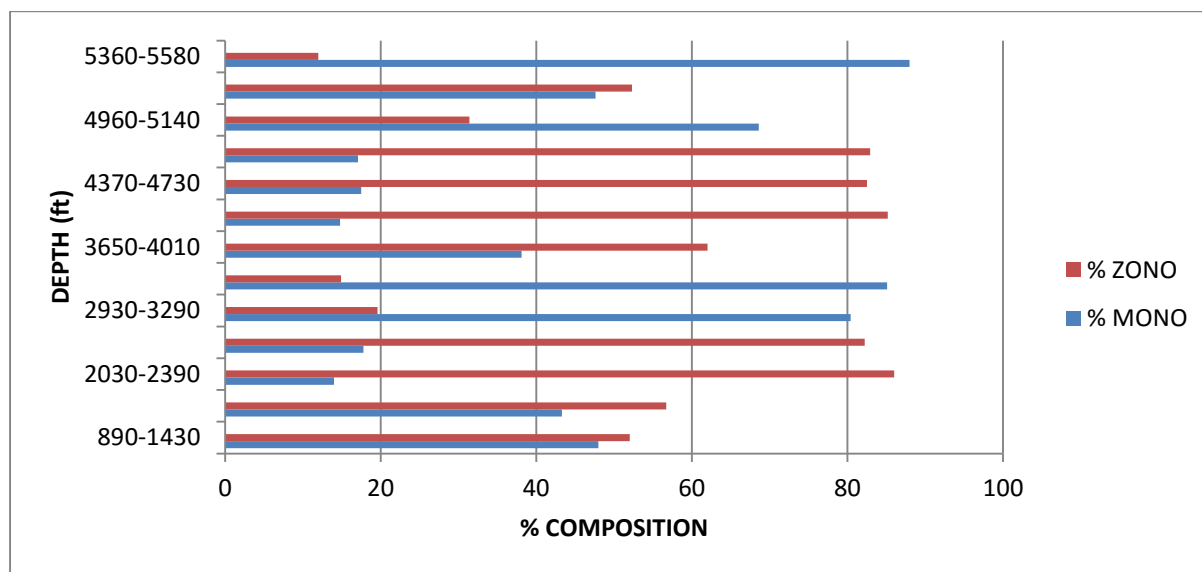


Figure 3: Bar chart showing *Monoporites annulatus* and *Zonocostites ramonae* percentage composition in AVG - 1 well.

***Racemonocolpites hians* Taxon range Zone**
Stratigraphic range: 2210 – 5540ft

The top is defined by FDO of *Racemonocolpites hians* and top regular co-occurrence of *Multiaerolites formosus*, *Belskipollis elegans*, *Verrutricolporites rotundiporus* and *Magnastriatites howardi*. While *Monoporites annulatus*, *Zonocostites ramonae*, *Laevigatosporites sp.* and *Verrucatosporites sp.* continue to dominant in this interval. *Acrostichum aureum* and *Botryococcus*

braunii were also recorded in appreciable numbers. Also, of significance is the presence of *Echitricolporites spinosus*, *Striatricolporites catatumbus*, *Retitricolporites irregularis* and *Psilatricolporites crassus*. The base by the quantitative LDO of *Retitricolporites obodoensis*. This zone corresponds to the P780, P770 and P740 subzones of Evamy *et al.*, (1978). The assigned age of this interval is of the Late Miocene to the Early -Middle Miocene.

PALEOCLIMATE

The main criteria employed for environmental interpretation were: Association of environmentally restricted marker species such as *Magnastriatites howardi*, *Pachydermites diederixi*, *Zonocostites ramonae* and foram test linings. Marker species such as *Magnastriatites howardi* (a small aquatic fern of alluvial plain and coastal swamps), *Pachydermites diederixi* (an angiosperm of coastal marshes), *Zonocostites ramonae* (mangrove pollen) abundance of the freshwater algae *Botryococcus braunii* recorded, with also typical lowland

Germeraad *et al.*, (1968). *Monoporites annulatus* (gramineae pollen suggesting open vegetation found in savannah). At the depth 830 – 2650 ft as seen in figure 3; the quantitative count and percentage composition of mangrove pollen (*Zonocostites ramonae*) and the savanna pollen (*Monoporites annulatus*) within this interval were high. There is an overall increase in the recorded quantities of grass pollen numerically and in ratio to mangrove pollen, which showed the prevalence of dry climate. However, the rainforest (*Psilatricolporites crassus*), Freshwater swamp (*Retitricolporites irregularis*) and

Brackishwater swamp species (*Acrostichum aureum*) within this interval suggest a certain degree of wetness in the climatic condition. The presence of savanna species like *Echistephanoporites echinatus*, *Echitricolporites spinosus*, the high presence of charred gramineae cuticles. The charred gramineae cuticle has an extensive record throughout the Late Miocene to Early Pleistocene within the Nile Delta (Deibis *et al.*, 1986). It is beneficial for identifying phases of climatic cyclicity in the Late Pliocene and Early Pleistocene. The gramineae cuticle and pollen record suggest that climates became increasingly dry (Morley and Richards 1993). At depth 2650 – 4340 ft, there is an overall increase in the percentage composition of recorded quantities of grass pollen, when compared to the mangrove pollen. It shows the continued prevalence of a dry climate and a minor increase in wetness. The upper portion of this interval is dominated by abundant mangrove species, Peridophytes spores such as *Leavigatosporites* and *Verrucatosporites sp.* and common *Botryococcus brauni*, *Tasmanites sp.* and *Pediastrum sp.* This interval has a reduced occurrence of charred gramineae cuticles. In

Striatricolporites catatumbus, *Marginipollis concinnus*, *Polyadopollenites vancampori*, and *Polyadopollenites sp.* further confirms the prevalence of a dry climate within this interval. This interval is characterized by

contrast, at depths of 4340 – 5580 ft, the quantitative abundance of mangrove pollen (*Zonocostites ramonae*) and the savanna pollen (*Monoporites annulatus*) within this interval were low. However, there are abundant freshwater algae *Botryococcus braunii*, dinoflagellate cysts (*Lingulodinium machaerophorum* and *Spiniferites sp.*) and foraminiferal test linings within this interval, suggesting a certain degree of wetness, prevalent of marine environmental conditions. This interval is characterized by abundant lowland rainforest, brackish water swamp species, and pollen and spore species. Also characterized by the low to the absence of charred gramineae cuticle, indicating a wet climate. It means a transitional climate within the Niger Delta from wet to dry during the Early to Late Miocene.

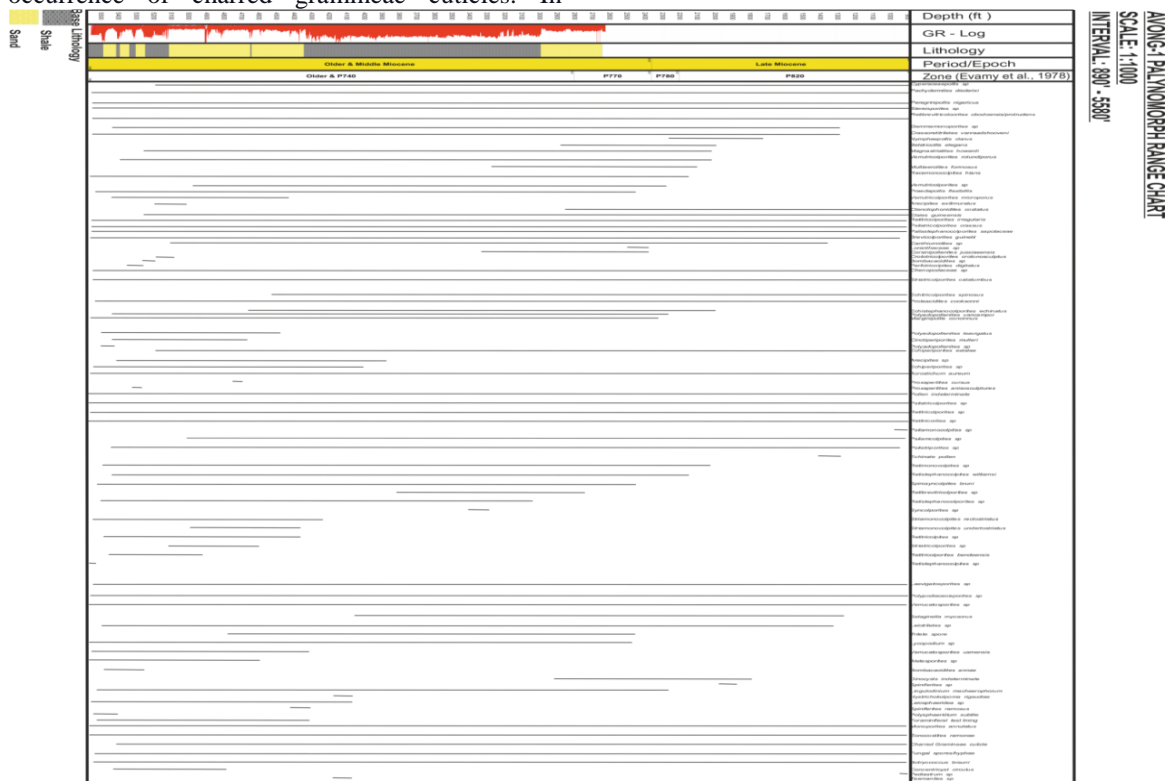


Fig 4: Palynology range chart of AVG-1 well

CONCLUSION

This study was performed using ditch cutting samples from AVG-1 well, northwest of the Niger Delta at a depth of 830-5580 ft interval. The lithology description of the well is of the paralic

Agbada formation. A total of ninety-one palynomorph and spore species were recovered. Two palynological zones were proposed; *Pachydermites diderixi* - *Retibrevitricolporites*

obodoensis/protudens Interval Zone (P820) and *Racemonocolpites hians* Taxon range Zone (P740-780). A transitional climate within the Niger Delta from wet humid to dry during the Early to Late Miocene.

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