Palynology and Paleoenvironmental Analysis of OL-A Well Eastern Niger Delta, Nigeria

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ABSTRACT

Palynological analysis was carried out on 133 ditch cutting samples of a section (7810-3340 ft) of OL-A well, Eastern Niger Delta, Nigeria with the view of determining the age, biozone, and depositional environment of the sediment within the interval. Acid method was used for the palynomorph recovery. A total of fifty five (55) palynomorph species were recovered. The section was dated Oligocene-early Miocene due to the occurrence of the diagnostic marker species such as: *Cicatricosisporites dorogensis, Arecipites exilimuratus, Echiperiporites estelae.* A taxon range zone of *Cicatricosisporites dorogensis* Zone, Concurrent range zone of *Arecipites exilimuratus-Striatricolpite catatumbus* Zone, and interval zone of *Pachydermites diederixi-Peregrinipollis nigericus* Zone was established. Based on the Palynomorph marine index, the section was inferred to be deposited in freshwater to brackish and marine environments.

1. INTRODUCTION

Palynology finds its use in petroleum exploration both in terrestrial and marine environment. When integrated with other tools like wireline logs and seismic stratigraphy, it is useful for paleoenvironmental studies, paleoclimatic interpretation, chronostratigraphic correlation and evaluation of potential source reservoir and sealing rock (Copestake, 1993). Palynological information about the age and paleoenvironment of the Niger Delta basin have been published by Adebayo *et al*. (2012), Olajide *et al.* (2012), Ojo and Gbadamosi (2013), Adojoh *et al*. (2015), Onoduku and Okosun (2014) and Imaseun *et al*. (2012). However, palynological work on OL-A well has not been reported or published. Therefore, this work aims at identifying the recovered palynomorphs and using them to zone, date and infer depositional environment of the section of the OL-A well.

2. Location and Geology of the Study Area

The Niger Delta lies between latitude 4° and 6° N and longitude 3' and 9' E in the southern part of the Nigeria. The studied well (OL-A) is located on the onshore part of the Eastern Niger Delta, Greater Ughelli Depobelt. OL-A well is located around latitude 5º43'00"N and longitude 6°33'00"E (Figure 1).

The litho-units of the Niger Delta have been grouped into three formations ranging from marine prodelta shale (Akata formation), through a sand/ shale paralic unit (Agbada formation) to continental sands (Benin formation) (Short and Stauble, 1967). The lithological succession of the Niger Delta is an overall coarsening upward sequence. Growth faults, rollover anticlines and antithetic faults are the commonest structure in the Niger delta and most wells in the Niger Delta are anticlinal rollover structure.

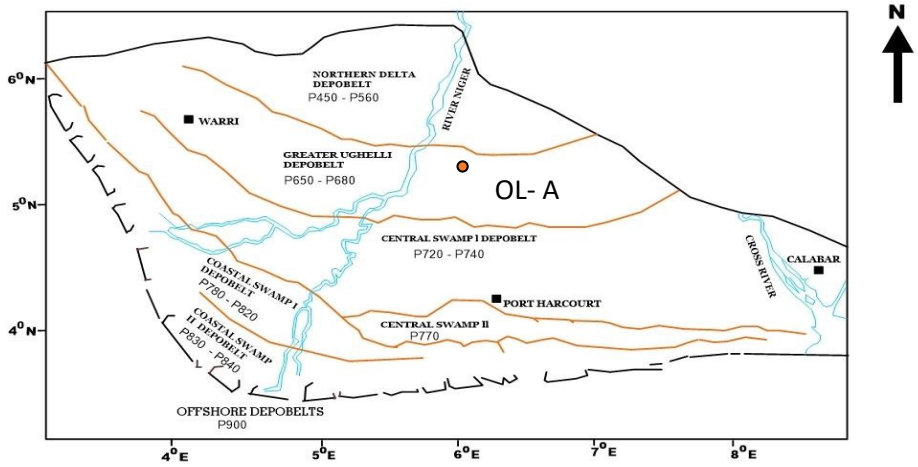

Figure 1 Location of OL-A well, on Greater Ughelli depobelt, Eastern Niger Delta, Nigeria. (Modified after Doust and Omatsola, 1990).

3. MATERIALS AND METHODS

A total number of thirty three (33) ditch cutting samples from OL-A well collected from Addax Nigerian Petroleum Limited (ANPL) Lagos, were subjected to palynological analysis. The sample preparation and analysis were done in Mosunmolu Laboratory Nigeria Limited, Lagos.

Standard laboratory technique was involved, which include weighing and cleaning of the sample, followed by digestion of the sample in hydrochloric and hydrofluoric acids for carbonates and silicates removal respectively (Ediger, 1986). Separation and sieving were done using brason sonifier for removal of silt and clay particles. Controlled oxidation was carried out on the sieved residue using concentrated nitric acid (HNO3). The residue were then spotted on cover slips of 22/32mm and allowed to dry for mounting; Loctite (impruv) was used as the mounting medium. The slide were then stained with safranin O to enhance the appearance of any dinoflagellate cyst. Forms viewed were identified and named using palynological albums and also different systematic publications of Cenozoic palynomorphs such as Van der Hamman and Wymstra (1964), Germeraad *et al*. (1968), Evamy *et al*. (1978), and Legoux (1978). The identified forms were counted using the tally system and recorded on the analysis sheet. The process was repeated for all the slides and the result inputed into the stratabug software to prepare the palynomorphs chart.

4. RESULT AND DISCUSSION

The palynomorphs recovered from OL-A well were abundant, diverse, and well preserved from the depths sampled. There are fifty five (55) palynomorph specimen recorded in OL-A well. Pollen and spores were good in OL-A well with a total species count of forty two (42), Dinoflagellates were fairly represented with ten (10) species found in well OL-A well. Algae were poorly recovered with three (3) species. The recovered palynomorph are presented in figure 2.

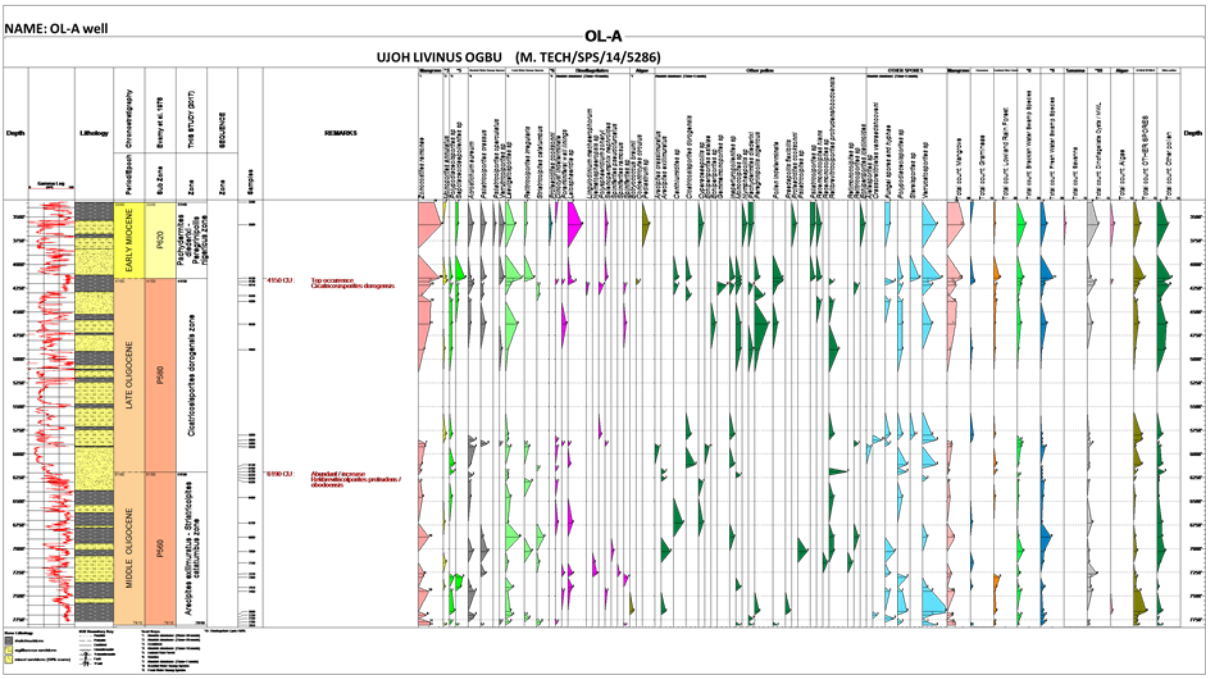

Figure 2 Palynomorph Distribution chart of OL-A well

4.1 Palynological Zonation and Age Dating

Zone I: *Arecipites exilimuratus- Striatricolpite catatumbus* Zone
Zone type: Concurrent range zone
Depth: 7810-6190 ft
Age: Middle Oligocene

Diagnosis: The top of this zone is marked by the FDO of *Arecipites exilimuratus* at 6190 ft and at the base by the LDO of *Striatricolpite catatumbus* at 7810 ft..

The base (7810 ft) of this zone is characterized by the LDO of *Monocolpite* sp., *Pachydermites diederixi*, pollen indeterminate, *Verrucatosporite* sp., *Zonocostite ramonae, Monoporite annulatus, Sapotaceoidaepollenites* sp., *Psilatricolporites crassus*, *Spiniferites* sp. Within the zone are the FDO and LDO of *Nematosphaeropsis* sp. Also found in this zone is the single occurrence of *Spiniferites pseudofurcatus, Spiniferites ramosus, Botryococcus braunii, Praedapollis flexibilis, Psilatricolpites* sp., *Recamonocolpites* sp., and *Retimonocolpites* sp. The top of this zone is marked by the abundant/ increase occurrence of marker species *Retibrevitricolporites obodoensis/protrudens* at 6190 ft as it relates to the P560 subzone of Evamy *et al*. (1978).

Zone II: *Cicatricosisporites dorogensis* Zone
Zone type: Taxon range zone
Depth: 6190-4150 ft
Age: Late Oligocene

Diagnosis: This zone is marked by the FDO and LDO of *Cicatricosisporites dorogensis*. The base is characterized by abundant/increase of marker species *Retibrevitricoporites obodoensis/protrudens.* Other associated species within the zone are *Lingulodinium machaerophorum, Arecipites crassimuratus, Concentricytes circulus, Echiperiporites* sp*., Aletesporites* sp., *and Echiperiporites estelea*. Other long ranging species running through this zone are dinocyst indeterminate, *Selenopemphix nephroides, Inaperturopollenites* sp*., Monocolpites* sp., *Pachydermites diederixi, Recamonocolpites hians, and Retitricolporites* sp. The zone correlates with the P580 subzone of Evamy *et al*. (1978) which is marked by top occurrence of marker species *Cicatricosisporites dorogensis.*

Zone III: *Pachydermites diederixi- Peregrinipollis nigericus* Zone
Zone type: Interval zone
Depth: 4150-3340 ft
Age: Early Miocene

Diagnosis: The top of this zone is marked by the FDO of *Pachydermites diederixi* at 3340 ft and the base is marked by the FDO of *Peregrinipollis nigericus* at 4150 ft. Other species marking their FDO at the top of this zone are *Zonocostite ramonae*, *Monoporite annulatus, Sapotaceoidaepollenites* sp., *Laevigatosporites* sp., *Retitricolporites irregularis*, dinocyst indeterminate, *Leiosphaeridia* sp., *Psilatricolporite* sp. and fungal spores and hyphae. Species with their FDO at the base of this zone include *Canthiumidites* sp., *Cicatricosisporites dorogensis*, *Inaperturopollenites* sp*., Monocolpite* sp., and pollen indeterminate. Species marking their only occurrence within this zone include *Pediastrum* sp., *Nympheapollis* sp., *Psilatricolporites operculatus, Proteacidtes cooksonni* and *Echiperiporite icacinoides.* This zone corresponds with P620 of Evamy *et al.* (1978), as it is bounded at the base by the top occurrence of marker species *Cicatricosisporites dorogensis*.

The biozones established from OL-A well were found to correlate to P560, P580 and P620 of Evamy *et al*. (1978). These palyzones fall within the Oligocene- Early Miocene Epoch with different ages. The palyzone P560 (Middle Oligocene) falls within the Rupelian stage ranging from 31.8-29.3 Ma, the P580 palyzone (Late Oligocene) falls within the Chattian stage with age range from 29.3 to 25.8 Ma and P620 pollen zone (Early Miocene) which falls within the Aquitanian stage and ranging between 25.8 to 22.5 Ma.

This is further supported by the presence of Oligocene-early Miocene marker species such as *Cicatricosisporites dorogensis* (late Eocene to Oligocene), *Arecipites exilimuratus* (Oligocene to Miocene), *Echiperiporites estelae* (Oligocene to Miocene), *Crassoretitriletes vanraadshooveni* (Oligocene to Miocene), *Spirosyncolporites bruni* (Oligocene to Miocene), *Praedapollis flexibilis* (Eocene to Pliocene*), Peregrinipollis nigericus* (Eocene to Pliocene), *Recamonocolpites hians* (Oligocene to Miocene), *Gemmatricolporites* sp., (early Miocene), *Zonocostite ramonae* (early Miocene to Pleistocene) (Palynological distribution chart of the Eastern Niger Delta).The presence of the above mentioned palynomorphs at different levels in OL-A well is an indication that the

stratigraphic interval under investigation was deposited during the Oligocene to early Miocene Epoch.

4.2 Paleoenvironment of Deposition

Plants are among the best indicators of the environment because of the presence of sporopollenin which is resistant to microbial decay and hence make them a useful tool in paleoenvironmental interpretation.

The parameter used in the interpretation of depositional environment is simply based on the analysis formulated by Helenes *et al*. (1998) called palynological marine index.

4.3 Palynological Marine Index (PMI) of OL-A well

Helenes *et al*. (1998) formulated palynological marine index (PMI) to support in the interpretation of depositonal environments. PMI is calculated using the formula:

PMI= (Rm/Rt+1)100. Where Rm is richness of marine palynomorphs (dinoflagellate, acritarchs and foraminifera test linings) and Rt is richness of terrestrial palynomorphs (pollen and spores) counted per sample. Rm and Rt were expressed as number of species per sample. In relation to the classification by Helenes *et al*. (1998), 0 % or nil PMI values denotes freshwater, 1-50 % as PMI values indicating brackish environment and 51-100 % as PMI values indicating marine environment.

Based on the formula, most depth in OL-A well had PMI values ranging from 1-50 % (Table 1 and Figure 3) they are 3340 ft (12.5 %), 3580 ft (14.6 %), 4150 ft (3.3 %), 4180 ft (18.5 %), 4210 ft (12.5 %), 4630 ft (10 %), 5800 ft (7.9 %), 5860 ft (9.1 %), 5890 ft (20 %), 5920 ft (5.9 %), 6130 ft (7.1 %), 6160 ft (33.3 %), 6280 ft (12.5 %), 6730 ft (50 %), 7030 ft (6.3 %), 7150 ft (14.3 %), 7300 ft (16.7 %), 7410 ft (20 %), 7450 ft (15 %), 7780 ft (5 %), 7810 ft (4.3 %). These depths indicate a brackish environment. Few depths had PMI values recording 0 % denoting a fresh water environment. At 7270 ft (recorded fairly abundant dinoflagellate cyst) a PMI value of 60 % was recorded significantly indicative of a marine environment. From the PMI readings, it can be concluded that the paleoenvironment of deposition range from freshwater, brackish to marine environments.

Table 1: PMI values for OL-A well

Depth (Ft)	Marine Richness (Rm)	Terrestrial Richness (Rt)	PMI (Rm/Rt+1)100
3340	3	24	12.5
3580	7	48	14.6
4150	2	60	3.3
4180	5	27	18.5
4210	4	32	12.5
4330	0	10	0
4390	0	20	0
4630	3	30	10
4900	0	16	0
5800	1	13	7.9
5860	1	11	9.1
5890	3	15	20
5920	1	17	5.9
6130	1	14	7.1
6160	1	3	33.3
6190	0	13	0
6220	0	5	0
6250	0	4	0
6280	1	8	12.5
6460	0	11	0
6730	3	6	50
6880	0	25	0
7030	1	6	6.3
7150	1	7	14.3
7270	6	10	60
7300	2	12	16.7
7410	2	10	20
7450	3	20	15
7690	0	16	0
7720	0	19	0
7750	0	8	0
7780	1	20	5
7810	1	23	4.3

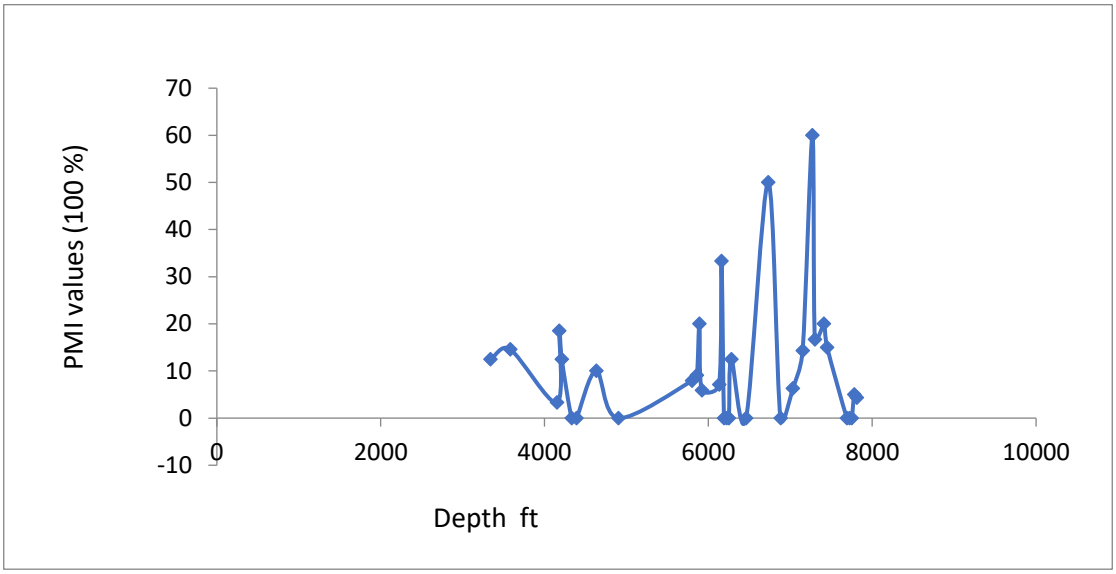

Figure 3 PMI plot for OL-A well

5. CONCLUSION

Palynological and paleoenvironmental analysis of OL-A well (7810-3340 ft) were carried out. Pollen, spores and dinoflagellates recovered were used as the basis for the dating of this section. The section is dated Oligocene-early Miocene due to the occurrence of diagnostic marker species such as *Cicatricosisporites dorogensis, Arecipites exilimuratus, Echiperiporites estelae.* Three zones each were established: *Arecipites exilimuratus- Striatricolpite catatumbus* Zone, *Cicatricosisporites dorogensis* Zone in accordance to the international stratigraphic-Biostratigraphic guide which correlates with the P560, P580 and P620 subzone of Evamy *et al*.(1978) and the *Magnastriatites howardi –Echitricolporites spinosus* combined zones of Germeraad *et al*.(1968) and this zones will help in improving the zonation scheme in the Niger Delta. The PMI readings suggest that the sediments of the studied interval were deposited within an alternation of marine and brackish to freshwater environment. The interval studied within the marine and coastal environment could be suitable for hydrocarbon exploration.

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