TAXONOMY, PALYNOFACIES AND SEQUENCE STRATIGRAPHIC CHARACTERIZATION OF ORE-1, ORE-2 AND ORE-3 WELLS, ORE FIELD WESTERN NIGER DELTA BASIN, NIGERIA

BY

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CERTIFICATION

The thesis titled "**Taxonomy, Palynofacies and Sequence Stratigraphic Characterization of Ore-1, Ore-2 and Ore-3 Wells, Ore Field, Western Niger Delta Basin, Nigeria''** by GANA, DaramolaFunmilayo (PhD/ SPS/2016/868), meets the regulations governing the award of the degree of Doctor of Philosophy of Federal University of Technology, Minna and it is approved for is contribution to scientific knowledge and literal presentation.

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ABSTRACT

Taxonomy, palynofacies and sequence stratigraphic studies were carried out on sediments retrived from Ore-1, 2 and 3 wells. Ore-1, 2 and 3 wells are located on latitudes 6º 03′ 40″ N, 6º 03′ 40″ N and 6º 03′ 17″ N and longitudes 5º 35′ 44″ E, 6º 03′ 17″ E and 5º 37′ 22″ E respectively in the onshore part of the western Niger Delta.The study aims at the identification, description and classification of palynofacies assemblages and paleoenvironment under which they were deposited.One hundred and forty-three ditch cutting samples were analysed between the intervals of 9700 ft - 10350 ft in Ore-1, 9800 ft – 10575 ft in Ore-2 and 9700 ft – 10475 ft in Ore-3. The acid method for samples preparation were employed for the recovery of palynofacies assemblages present in the three wells. Palynofacies data were integrated with the gamma ray log data for paleoenvironmental, paleoclimatic and sequence stratigraphic study. A total of 501 palynomorphs were recorded in Ore-1, 1191 in Ore-2 and 678 in Ore-3. The assemblages were dominated by freshwater palynomorphs of *Botryoccocusbraunii.*Palynomaceralsanalysis of the three wells reveal over 90% of palynomaceral 1 (PM1), 80%ofpalynomaceral 2 (PM2), less than 5% of palynomrphs and low percentage of palynomaceral 3 and 4.Threepalynostratigraphic interval zones were established in Ore-1 well and four zones inOre-2 and 3 wells. The zones in Ore-1 well consists of *Verrucatosporitesusmensis- Ctenolophoniditescoastatus, Pachydermitesdeiderixi - Grismdalapolygonalis* and *Spinicolpitesechinatus - Proxapertitescursus*zones. Ore-2 has *Verrucatosporitesusmensis - Pachydermitesdeiderixi,Retibrevitricolporitesprotrudens–Grimsdaleapolygonalis, Pradapolisflexibillis - Proxapertites cursus* and *Longapertites* sp.– *Ctenolophoniditescoastatus*zones. Ore-3 comprises of *Verrucatosporites*sp. - *Grimsdaleapolygonalis, Doualadit*es*laevigatus– Ctenolophoniditescoastatus,Pradapolisflexibillis – Psilatricolporitescrassus* and *Retimonocolpitess*sp. -*Racmonocolpiteshians*zones. The studied intervals were dated middle (38 to 47.8 Ma)tolate Eocene (33.9 to38 Ma) based on the stratigraphic age range of marker species. The lithology of the wells consists ofalternation of course, medium to fine grainedsandstone units and shale beds. The shale and sand ratio in Ore-1 averages 66.2:33.8%, Ore-2 recorded 57.3:42.7% and Ore-3 average 45.8:54.2%. Integration of textural characteristics, gamma ray log and palynofacies assemblages revealed that the sediments from Ore-wells were deposited in upper to lower delta-plain environment. The studied interval comprises of one depositional system which consists of the lowstand systems tract (LST) at the base, transgressive systems tract in the middle (TST) and the highstand systems tract at the top (HST). The maximum flooding surface (MFS) has been dated 38.6 Ma - 41 Ma while the sequence boundaries (SB) dated 44.4 Ma. The sandstone and shale units of the systems tracts are prospective hydrocarbon source, reservoir and seal rocks. Integration ofseismic data analysis, sedimentology, porosity and permeability studies are recommended for better understanding of the hydrocarbon system within the wells.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The patriarch of taxonomy Linnaeus (1758) defines taxonomy as the methodology for identification, description, naming and classifying plants and animals based on their morphology and phylogenetic relationship. The patriarchdeveloped the binary nomenclature for naming and grouping living things using the concept of hierarchical order. The hierarchical concepts of Linnaeus (1758) include kingdom, phylum, class, order, family, genus and species.Weose*et al*. (1990) designates the term as a principle of classifying plants and animals and added the domain to the hierarchical idea of Linnaeus (1758).Shanoon (2017) describe taxonomy as the systematic classification of plants and animals with the goal of reconstructing their evolutionary history using their anatomy and morphology. Taxonomy is considered as the systematic classification of plants, animals and microbes using behavioural, genetic and biochemical observations (Centre for Botanical Nomenclature, 2018). Definition varies from author to author but paleontologist often use the cladistics to draw up evolutionary family tree.Unfortunately, till present times some of these microfossils especially palynomorphs are yet to be described and named in the western Niger Delta basin due to their complex nature and high diversity (Adekanmbi and Ogundipe, 2009).

Emphaseson morphological characters of palynomorphswas stressed by (Edoga and Ikem, 2002; Adeonipekun and Ige, 2007; Mbagwu*et al.*, 2008; Sung *et al.*, 2015) as it provides basis for phylogenic and palynofacies analysis. Palynofacies information could aid in refining taxonomy by adding time dimension to it. Thusprovides a better understanding of depositional environments that developed in reaction to sea level changes and sedimentation processes(Durugbo, 2016).Thepresenceof sporopollenin in theexinewallof palynomorphs makes them to be highly preserved in the fossil record. This allow identification of taxa even after a long period of deposition in sediment. This is because the morphological characteristics of palynomorphs are reflected in their exinewalls (shape, sculptural elements, ornamentation and apertures).The exine wall sructures and patterns are important in classification. Theirresilient nature, wide spread, copiousproduction and minute size make them common in sediments ofall ages and environments. Palynomorphs also have short reproductive rate and respond to changes in nutrient availability and water quality conditions. These attributes make them suitable for paleoenvironmental studies, chronostratigraphic studies, correlation, paleoclimatology, taxonomic studies, unconformity identification, paleobathymetric andlithostratigrahiccharacterisation.

The term palynofacieswas first presented by Combaz(1964) to designate aggregate organic matter recovered from sedimentary rocks deposit by palynological processes as observed under the microscope. Powell *et al*. (1990) redefined the term as a distinctive assemblage of palynoclast whose composition reflects a particular environment. Tyson (1995) added that it could be linked with hydrocarbon generation apart from reflecting a specificenvironment.However, some school of thought recognisedorganic component as macerals(Whitaker,1984; Oyede, 1992; Van der Zwan, 1990; Pienkoweski, 2004; Thomas*et al*.,2015) as first proposed by Stopes(1935). Some other authors refer to it aspalynodebris or organic debris (Manun, 1976; Habib, 1979; Lorente, 1990). (Brooks, 1981; Tyson, 1993)call it pyhtoclast, in present time the word kerogen is commonly used.

Palynofacies assemblage includes: (i) Phytoclast, (structured brown and black woody particles) that show high concentration in places where they are close to the parent plant (ii) Amorphous organic matter (unstructured particulate organic matter in sediment) it could be fibrous or granular common in area of low oxygen concentration (Batten, 1996). It could also be of terrestrial or marine origin (iii)Palynomorphs includepollen, spores, foraminiferal lining and dinoflagellates and (iv) Opaque are black woods and highly oxidized palynomorphs. Palynofacies when fully analysed could improve the use of fossils in geological inferences particularly in areas where calcareous and siliceous fossils are rare. This could also be used to give more accurate appraisal that is of stratigraphic value (Batten and Stead, 2005; Durugbo; 2016).

Application of palynofaciesconceptincludes: (i) Monitoring of wells during drilling operations (geosteering): (ii) Determination of thermal maturity of source rock (iii)Characterisation of depositional environment(iv) Identification of regressive and transgressive trends in stratigraphic and depositional sequence boundaries (v) Detailed understanding of the processes controlling deposition, facies recognition and provide a basis for paleogeographic reconstruction (Moore *et al*., 1991). Despitethe effectiveness of palynofacies in sequence stratigraphic analysis its application is still grossly under-utilised in the Niger Delta basin (Bankole, 2010).

Sequence stratigraphy is defined as the study of rock relationships within a chronostratigraphic a framework of repetitive genetically related strata bounded by surfaces of erosion or deposition or their correlative conformities laying emphasis on strata stacking pattern (Catuneanu, 2020). Sequences are controlled by sea level changes, sediment supply and accommodation space. Accommodation according to (Jervey,1998) is the space available for sediment and water to fill. Changes in sea level and sediment supply are responsible for different architectural pattern of sedimentary rocks. These in turn are used to identify a particular order of depositional environment. The framework is a genetically related stratigraphic facies that uses architectural pattern to explain a particular order of genetic deposit and their bounding surfaces and relate it to individual stratigraphic surfaces.The basic element of sequence stratigraphy is a depositional sequence. Depositional sequence is formed by a succession of genetically linked depositional system (Posamentier*et al*., 1988) bordered by significant stratigraphic surfaces (unconformities and conformities).These stratigraphic surfaces include maximum flooding surface (MFS), sequence boundary (SB) and transgressive surface (TS).

A depositional sequence is made up of sequences, system tracts and parasequencesand are bordered above and below by unconformities or correlative conformities. Every depositional sequence is a record of one complete cycle of relative sea level thathas a predictable internal structure. A depositional sequence is said to be complete when it starts from one sequence boundary and end in another sequence boundary. A sequence boundary is formed as a result of fall in sea level. A large drop in sea level will lead to erosion of the shelf area and coastal plain beyondwhich is characterised by type-one sequence. A type-one sequence is defined by the three system tracts, lowstand, transgressive and the highstand system tracts. Incised valleys and canyons may also be formed from the shelf or slope break. Thisleadto deposition of basin floor fan (coarse sediment) called the lowstand system tract. Situation whereby sealeveldo not dropbeneaththe break it is called type-two sequence. This means a fall in sea level does notneccessary force the position of the shore line to shift and is defined by transgressive and highstand system tracts. Sequence stratigraphic concept provides an ideal model that point to a particular technique of depositional environment, potential hydrocarbon source rock, seal and traps.Parasequences are defined as a group of genetically related beds that are bounded by maximum flooding surface or their correlative unconformities. Parasequence beds areimportantchronostratigraphic surface that separates the rocks above and below it.

Although sequence stratigraphyis still a new revolutionary paradigm in the field of stratigraphic geology. Integrationof taxonomical studies, palynofacies and gamma ray log can provide optimal result that aid to reduce error in interpretation (Catuneanu,2010).Thereforethis present study looks at the application of taxonomy and palynofacies analysis in an integrated approach with gamma ray log data(sequence stratigraphy) as an important tool in subsurface studies of the sequences penetrated by Ore-1,2 and 3 wells, western Niger Delta Basin.

1.2 Statement of theResearch Problem

Saveral researches in Niger Delta Basin have been concentrated on the use of foraminifera, calcareous nannofossils, palynomorphs, log signatures and seismic data as a basis of delineating paleoenvironment, paleoclimate, biozonation and biochronology (Chukuwu*et al*., 2012; Alkali *et al*., 2014). However the combine use of taxonomy and palynofacies for biostratigraphic studies are scanty, because this combined use is not done by many previous authours. Therefore there is need to continue to re-evaluate these formations as more exploration continue in the region with the aim of carrying out re-appraisal of the delta.

Thus systematic classification of these palynomorphs is necessary in order to recognize and describe new forms. Hence precise nomenclature is required for accurate recognition of short time range species for proper delineation of palynostratigraphic zones and paleoecological interpretation (Copestake, 1993;Adeonipekun*et al*., 2015).

This study focuses on taxonomy, palynofacies and sequence stratigraphic interpretation of Ore-wells.

1.3 Justification for the Study

Detailed taxonomical studies are useful in unravelling the evolutional history of the recovered palynomorphs. This could aid discovering of extinct and extant taxa useful for accurate dating, correlation and zonation of stratigraphic intervals of the study sequence. New species are hardly well described by previous authors in their new findings because of lack of taxonomic studies in their work. Hence precise identification and nomenclature which are based in taxonomy are required for recognition of short time range species (*Dauolaiditeslaevigatus* and *Grimsdaleapolygonalis*). This is useful for proper delineation of palynostratigraphic zones and paleoecological interpretation. Furthermore, palynofacies analysis finds its usefulness in paleoenvironmental interpretation and determination of kerogen type from the studied interval.

Integration of palynomorphs, palynomacerals with gamma ray log will provide the optimum model for geological modeling and petroleum system (Batten and Stead, 2005; Amadi *et al.*, 2015). Beside palynostratigraphic resolution can only be improved on application of taxonomy and palynofacies studies which is useful for geological practices.Thusthe use of palynofacies for sequence stratigraphy analyses is still scanty.

1.4 Aim and Objectives of the Study

The aim of this research is to carry out taxonomy, palynofacies and sequence stratigraphic characterization of the sedimentary succession penetrated by Ore-1, Ore-2 and Ore-3 wells, in the onshore part of the Western Niger Delta Basin, Nigeria. The objectives of this research are to:

i. Identify, describe and classify the palynomorphs and palynomacerals of the studied wells.

ii. Establish the palynostratigraphiczonations of the studied wells based on identified palynomorphs.

iii. Determine the paleoenvironment and paleoclimatic conditions under which the intervals penetrated by Ore wells were deposited.

iv. Delineate sequence boundaries, maximum flooding surfacesandsystem tracts from palynomorphs, palynomaceralsand gamma ray log stacking patterns.

v. Correlate the three wells based onpalynostratigraphiczonations and sequence stratigraphic framework.

1.5 Scope of the Work

The scope of this research work covers taxonomy, palynofacies and sequence stratigraphic analysis of the three wells in Ore field in order to deduce the paleoclimatic and paleoenvironmental condition of the studied wells.Theditch cutting samples and wire line log data provided by National Petroleum Development Company (NPDC), Benin was used for this study.

1.6 Location of the Studied Wells

Ore field falls within the Oil Mining Lease (OML)111 in the north western onshore partof the Niger Delta Basin and characterised by the geology of the Paleocene outcrop. Ore1, 2 and 3 wells are locatedon latitude 6º 03′ 40″ N, 6º 03′ 40″ N and 6º 03′ 17″N and longitude 5º 35′ 44″ E, 6º 03′ 17″ E and 5º 37′ 22″E respectively in the northern depobelt(Figure 1.1). The Niger Delta Basin is part of the inland lowlands of the southern Nigeria lying between 30m to 300m above the sea level. It is bisected by River Niger in the eastern and western part longitudinally. The western part is called the Ishan

Asaba plateauwhich is incised on both the southern and eastern margins (Udo, 1970). The lower terrain of the south consists of a sandy coastal plain which lie in Agbor and Benin City. The Niger Delta Basin is filled predominately by the basement complex dregs of the Cretacous and Cenozoic sediments derived from Niger, Benue and the Cross Rivers (Doust, 1990). Burke (1996) suggested that the delta be called the Benue Delta instead of Niger Deltaas most deposits were supplied by River Benue.Presentlythe U-shaped delta is a wave dominateddelta that is crisscrossed by distributary channels.

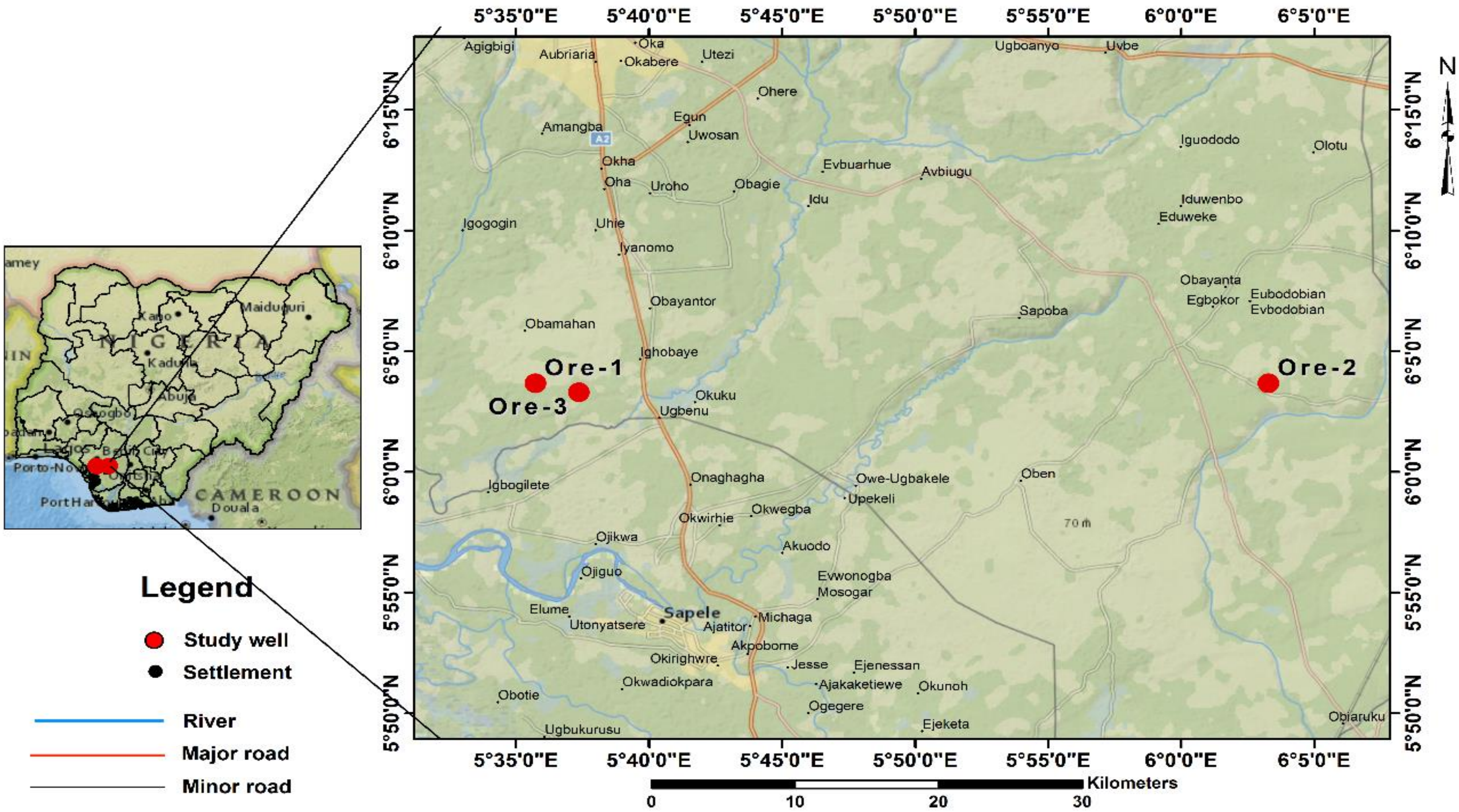


Figure 1.1: Location of the studied wells

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Previous Work

Information from research reveals the depositional environments, structure, tectonic origin, biostratigraphy, sequence stratigraphy and hydrocarbon potentials of the wetland Niger Delta Basin. Accessibilities to the subsurface formations has characterised the basin of which thousands of wells have been drilled to penetrate the basin which give a better understanding of the subsurface geology (Chukwu *et al*., 2012). In spite of research published works relating to integration approach using taxonomy and palynofacies with other related data in sequence stratigraphy analysis in the basin is veryrare. Earlest information on the use of palynomorphs in the Niger Delta Basin includes the works of Van Hoeken-Klinkenberge (1964); Clarke(1966); Clarke and Fredriksen(1968) while the most extensive work in the basin was carried out by Germeraald*et al*. (1968).

2.1.1 Taxonomic analysis of some wells

The specie of *Peregrinipollisnigericus* was first identified in the upper Tertiary of Nigeria by Clarke(1966) while other new forms were also recovered and described (Clarke and Frederiksen, 1968).Germeraald*et al*. (1968) carried out a widespread research on taxonomy and palynology of the Tertiary sediments of three tropical areas in parts of South America, Asia and Africa (Nigeria). These researchers established nine pantotropical zones based on numeric method and reported the absence of *Alnipollenitesverus* in Nigeria sediments but only present in Caribean during the Pleistocene age. This contrast the workofDurugbo*et al*.(2010); Ojo and

Gbadamosi(2013);who reported the presence of same specie of *Alnipollinitesverus* in the north eastern part of Nigeria. Adebayo and Ojo(2014) identified the presence of same speciesin the Miocene-Pliocene sediments of the Niger Delta.Durugbo*et al*.(2010) posited the presence of *Achomosphearaandalousiensis* in Niger Delta for the first time and added that the Last downhole was close to 11.6 Ma.

Raymer (2010) describedenvironmentally important taxa and potentially new species of pollens and spores in Alo-1 well in part of the south eastern Nigeria. The author identifies new species of *Camarozonosporites cretaceous* and *Balmeispotitesminutus.* Bankole (2010) carried out systematic description of Neogene palynomorphs in Agbada Formation of the Niger Delta Basin andobserved variation in morphological appearance of some speciesof*Laevigatosporitesdiscordatus*and*Laevigatosporitesnuticluscrassicoides*.Theres earcher stated that the former was smaller while the later is bigger than what was described by (Krutzsch, 1967; Takahashi andJux, 1989). The author also recorded age differences between the taxa and stated that the stratigraphic ages ranges from Paleocene to Miocene in Middle Europe, Late Cretaceous to Eocene in West Canada and Middle Tertiary in Nigeria.Oboh *et al.* (2012) posited the appearance of *Achomosphaeraalcicornu* for the first time in the mid-latitudes during the Deniaage.Other species associated with Dania age include *Cerodiniumdiebelii*, *Paleocystodiniumgolzowenze* and *Hafniasphaera septa*.Ojo and Adebayo (2012) also described the pollen and spores in Chev-1 well located in the south western part of Niger Delta Basin. The authors noticed the large nature of thelasurae of *Verrucatosporitesusmensis*in the wellcompareto the description ofGemerrald*et al*. (1968).

Ola and Adewale (2014) worked on some pollen and spores of the Meren 31 side tract-2 well and discovered that the spores of *Verrucatosporites*sp has a resemblance with the fern of *Stenochlanapalustria* of Germeraad*et al*. (1968). The authors also noticed a variation in the size and sculpture of *Germammonoporites*sp. Recently,Adojoh*et al*. (2019) presented harmonized taxonomic and photomontage of pollen, spores and non palynomorphsretrived from West Africa Magin (Niger Delta) phytoecology and family. According to these authors the shapeof the pollen of *Monoporitesannulatus* has remain constant with a lone distinct annulate pore.

2.1.2 Palynofacies and palynological analysis of some wells

Oboh*et al.* (2005) integrated sedimentological and palynofacies data in south eastern Anambra Basin and Afikpo syncline and established five depositional sequence. One in upper Nssuka Formation (Paleocene), two in Imo Formation (Paleocene) and one each in Ameki group and OgwashiAsaba Formation (Eocene). According to these authors, each of the sequence is bounded by type-1 sequence boundary and contains a basal fluvial-marine portion representing the early transgressive stand while the occurrences of estuarine cycle in Palaeogene infer relative sea level fluctuations. The authors suggested that the presence of type-1 signature may signify major drops in sea level during the Paleocene and Eocene period. Similarly, Durugbo*et al.* (2011) investigated the Middle Miocene to Early Pleistocene outcrop of western Niger Delta and stated that dinoflagellates cysts when used in combination with pollen and spores could contribute to palynological scheme particularly in areas where microfossils are scarce.

Adegoke (2012) integrated well logs and palynofacies data of three well in coastal swamp depobelt and identified three depositional sequences of deltaic shelf transitional type and assigned the ages of Middle - Late Miocene to the sediments based on palynological zonation.

Ojo and Gbadamosi (2013) studied the palynostratigraphy of Dell-2 southwest of the Niger Delta Basin and identified three depositional environments of shallow, deep and open marine. Based on the abundance distribution of miospores they proposed four palynozones and assigned the age of Early to Late Pliocene to the sediments. Ola and Adewale (2014) use palynogical signatures as a proxy in understanding the paleoclimate of the sequences penetrated by the Meren-31 side track-2 well in the offshore part of the Niger Delta. The researcher infers alternation of wet and dry climate period in the Miocene to the sequence penetrated by the Meren-31 sidetrack-2 well.

Adojoh e*t al*.(2015) investigated the Okan-1 well and stated that palynocycles are recurrent palynological sequences reflecting vegetational changes determined by cyclic sea level oscillations and associated with climatic variations. According to these authors, thisallow the prediction of reservoir and sealing sequences in Agbada Formation and should be used in recognition of sequence stratigraphy, sea level and climatic changes. Adeonipekun and Oyelami (2015) worked on the palynology of Late Paleocene and Early Miocene sediments from Benin Basin, south western Nigeria in order to gain insight into the paleoclimate of this important geological period. The researcher established that the abundance and diversity of palynomorphs decreased upward from the Late Paleocene to the Earliest Eocene and recorded four phyto-climatic zones. The Late Pleocene section was wet except for a brief period of dry interval with abundant Poaceae and fungal spores while the Earliest Eocene was dry. Occurrence of *Apetodinium* acme and abundant *Botryococcus*within the marine transgression event probably inferred Paleocene-Eocene Thermal Maxima (PETM).

Harrington and Jaramillo (2007) reported that taxonomic diversity increases in the Late Paleocene of United States Gulf Coast, a trend replaced by marked extinction into the Early Eocene. Edeigbe and Emofuneta (2015) depicts dominance of type-3 palynofacies (gas prone) and environment of terrestrial to transitional deposition to sediments of southwestern Maastrictian dark shale of Anambra well and stated that the sequence has a good hydrocarbon potential.

Adebayo *et al*. (2016) posited a warm and humid climatic period for the Miocene-Pliocene vegetation and climate based on palynological signatures. Durugbo (2016) assigned the ages of Late Maastricttian to Middle Paleocene to Nsukka Formation using palynofacies data. The author stated that the Nsukka sequence consists of alternating successions of fine-grained sandstone and well bedded dark and sandy shale. This alternating succession was dominated by terrestrial organic components indicating a nearshore environments couple with the dominance of *Peridinoids* over *Gonyaulacoid.*

Inyang *et al*. (2016) employed palynomorphs data on the sediment of T-well in south western Niger Delta and observed two pantropical zones of *Magnastriatiteshowardi* and*Crassoratitriletesvanraadshooveni*.The ages of Early to Middle Miocene was assigned to the sediments. Based on dominance of mangrove swamp, rainforest and freshwater swamp they suggest a warm, humid and heavy precipitation of tropical coastal climate. High occurrence of terrestrially derived palynomorphs over the marine taxa infer continental influence in coastal area ranging from fluvio-deltaic to shallow marine setting.

Olayiwola and Bamford(2016), combined palynomorphs, gamma ray log and lithofacies as a proxy in understanding the Miocene and Paleocene sediments in the offshore part of the Niger Delta. Infered environment were distributary channel, tidal channel and regressive barrier environment. The researchers concluded that paleoenviroment will be useful for deep water exploration and exploitation in other to reduce risk. Ihudaet *al*. (2017) used palynofacies data of the Bonny area to understand the coastal swamp development and respond to perturbation, such as sea level rise and tropical storm. According to the authors Bonny sediments are deposited by storm surge and diatom assemblage are dissimilar from the non-storm sediments. Alsopalynomorhs and diatom assemblage examination reveal that diatom are strongly influenced by salinity but less strongly by water level.Durugbo and Olayinwola(2017) worked with the Middle Meocene sediments and infer that the environment of deposition was coastal swamp to near shore marine environment based on palynofacies data.Adeigbe and Ochigbo(2017) worked with the Ochigbo-1 well in the offshore part of the Niger Delta integrating palynomorphs and foraminifera data and established four palynological zones which falls between the P700 and P400 and dated the sediments to be of Early Eocene to Late Oligocene.

Lucas and Fregene (2017) presented a palynostratigraphic zonation of the Greater Ugehli sediments and established five pollen zones and dated that the age range from Oligocene to Early Miocene. Chukwuma-Orji*et al*. (2017) carried out extensive research on the Miocene sediments in Ida-6 well, Niger Delta based on palynofacies analysis and identified three formal palynozones and deduce an environment of coastal deltaic to the strata penetrated. Okeke and Umeji(2018) used palynofacies data ofNanka and Ogwashi sediments situated in the south easthern part of the Niger Delta. The authors indicated that Ogwashi Formation is made of kerogen type IIIand is gas prone, while the Nanka Formation reflect type II and type IIIkerogen which are oil and gas.

Ikegwuonu*et al*. (2020) documented six informal palynomorphs zones in un-dip area of Bende-Umuahia. These are: (i)Middle Paleocene *Scraabratrisimpliformis-Bombaciditesannae* zone A (Middle Paleocene) (ii)*Foveotricolporitescrassiiexinus-Mauritidiitescrassiexinus* zone B (Late Paleocene) (iii)Early Eocene *Striatopolliscatatumbus-Momipites* africanus zone C (iv) Middle Eocene *Margocolporitesumuahiaensis-Gemmastephanocolporitesbrevicolpites* zone D (v) Late Eocene *Cicatricolsisporitesdorogenensis-Perfotricolpitesnigeriansis* zoneEand lastly (vi)Olygocene-Early Miocene *Verrucatosporitesusmensis-Magnastriatiteshowaidi* zone F.

2.1.3 Sequence stratigraphic analysis of some wells

Onyekuru*et al.* (2011) employed biostratigraphic well log data in XB field and established four third order depositional sequences. According to the authors the sands of the lowstand and highstand consist of a good quality reservoir and the shale of good capacity to seal the reservoir.Ojo and Adebayo (2012) worked on the palynostratigraphy and paleoecology of Chev-1 well of the southern western part of Niger Delta and reported that the sequence consists primarily of mangrove swamp flora which suggest the predominance of high sea level and wet climatic condition in the Miocene-Pliocene period.

Odedede*et al*. (2012) studied sequence stratigraphy and paleoenvironmental analyses of E-12 well the section yielded high percentage of *Zonocostitesramonae*and they infer a coastal to marginal environment of deposition of sediment in the strata penetrated by the well. The first appearanceof*Nymphaepollisclarus*and increase in *Monoporitesannulatus*also suggestMiocene-Pliocene sediment. Furthermore, the authors stated that the sequence boundary of the well consist of maximum flooding surface (MFS), lowstand system tract (LST), transgrssive system tract (TST) and the highstand system tract (HST). According to these aurthors the maximum flooding surface recorded high palynoflora population which was considered to represent the condensed section of the well associated with the flooding surface and infer a brackish environment of deposition. Adegoke (2012) integrated biostratigraphic and wire line log data to carryout sequence stratigraphic interpretation of Middle to Late Miocene sediments in the coastal swamp depobelt in the western part of the Niger Delta and identified three depositional system defined by the highstand system tract,transgressive system tract and the low stand system tract. The author also delineate three maximum surface and three sequence sequence boundaries and concluded that environment of deposition was deltaic to shelfal transition type.

Ojo and Gbadamosi (2013) also recorded one sequence boundary and a type one sequence in Dell-2 well based on palynostratigrapy of the well and delineate four sequence boundaries and three system tracts.Olaleye (2017) worked with the sediment of Unik field in the onshore part of the Niger Delta and identified six depositional cycles compresing oflowstand system tracts, transgressive system trscts and the highstandsystmtracts.Alege (2017) carried out a sequence stratigraphic interpretation of Akos field in the coastal swamp depobelt of the Niger Delta Basin integrating resistivity and gamma ray log and dated the sequence boundary to be of 12.1 Ma, 10.6Ma, 10.4Ma and 9.5Ma respectively. The author also dated the maximum flooding surface to be 11.5Ma, 10.4Ma and 9.5Ma and stated that the maximum flooding surface represent the Dodo shale, *Nonion*-4 and *Uvigerina*-8 markers falling within the coastal swamp depobelt. The author also identified three major parasequence stacking patterns which are progradational, retrogradational and aggradational as well as four system tracts namely lowstand, highstand, transgressive as well as the falling stage system tracts and stated that the sands of the lowstand and highstand and that of shale units of the tressgressive system tracts are of excellent traps for hydrocarbon.

2.2 Geology and Tectonic Setting of the Niger Delta Basin

The wet landmarginally sag epicontinental Niger Delta Basin lies in the westernmost part of the Benue Trough and defined by the geology of the southern sedimentary basins. Ojoet *al*. (2009), stated that theNiger Delta Basin is situated within latitude 4° and 6° N and longitude 3° and 9° E. Situated at the base of the basin is the Imo Formation and on top is the Nsukka Formation of the Anambra Basin which was demarcated by an unconformity (Avbovbo andAyola, 1981). The basin is anextensional basin surrounded by other basins. The onshore part is delimitedin the west by Benin Flank which relate to thechainfracture zone, Calabar Flank in the eastern partand to the south by Gulf of Guinea (Figure 2.1).

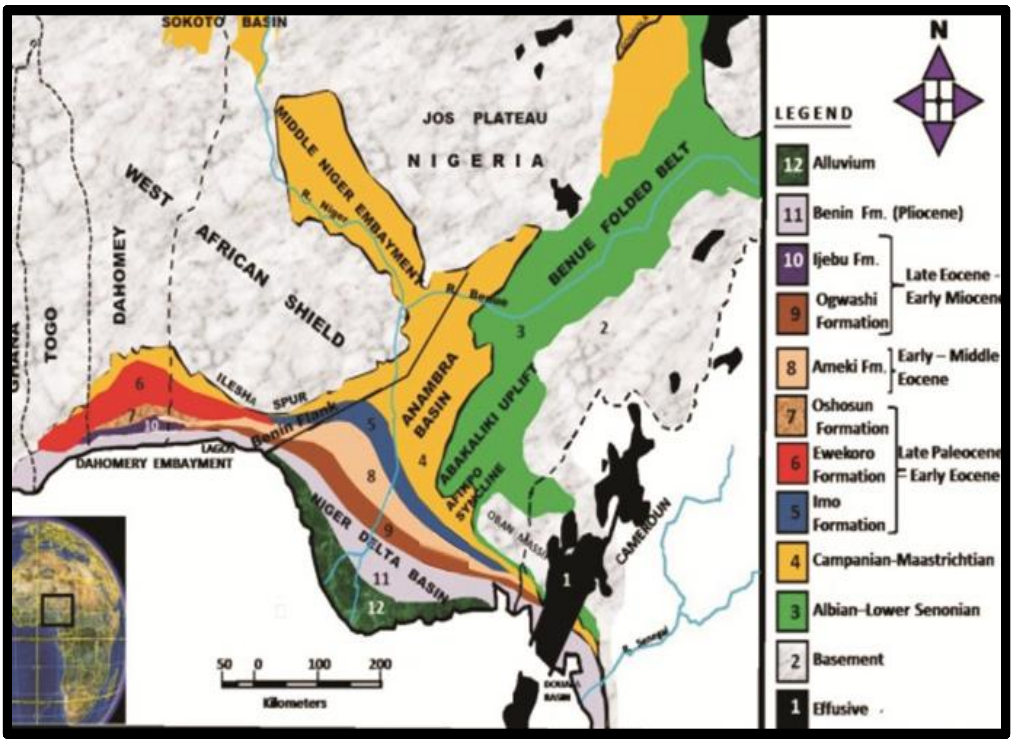


Figure 2.1: General geology and tectonic map of Niger Delta Basin (Ikegwuonu*et al*., 2020)

The delta spans an area of over 256,000 km^2 Whiteman (1982) andcontained over 12,000 m thick of regressive sediments and the youngest of the three large sediment bodies that fill the aulacogen (Benue Trough) (Aizebeokhai and Olayinwola, 1997).

The formation of theembryonicNiger Delta Basin was connected to the major continental embayment that feasts out over the cooling and subsiding oceanic crust. Thiswasgenerated from the breaking up of South American from the African plate which led to the opening of the Atlantic Ocean. Presently the Niger Delta Basin is sited in the rift triple junctionwhere two of the rifted arms form the Gulf of Guinea and equatorial Atlantic and the third form the Benue Trough (aulacogen). This isthefoundation of the Niger Delta Basin development and other southern Nigeria sedimentary basins. Three major phases defined the tectonic evolution of the southern sedimentary basins (Burke, 1972; Murat, 1972).

In the earlyphasefrom Aptian to Santoniais the Abakaliki-Benue segment this phase is characterised by a period of non-deposition, erosion and upliftmentof sediments in the lower Benue trough. Intense folding and compression of the trough led to series of anticlinal and synclinal fold which changes the architectural geometry of the basin. This tectonic event changes the architectural pattern of the basin and causes the basin to be placed in a westward direction. This incident resulted in theAbakaliki area to be flexural reversed forming theAbakaliki fold, Afikpo syncline and the Anambra Basin. Also characterizing this phase is the deposition of the Asu River group, Ezeaku and Awgu Formation, Benue gorge and Calabar flank.

In Campanian to Maastrictian, the second phase commenced after the orogenic events in the Santonian that led to the deformation of the Benue gorge, another upliftment and folding took place in Abakalikiareaand a marine transgression led to the sedimentation of the Anambra Basin.This phase is defined by the deposition of Nkporo group, Mamu Formation and the Ameki group (Nanka, Nsugbe and Ogwashi-Asaba Formations).The third phase was characterised by the deposition of the embryonic Niger Delta sediments which began in the Eocene to Recent time as a result ofAbakalikiarea being flexurally reversed. In the early phase (Early Eocene) the outbuilding of theNigerDeltawas in three distinct depocentres (megasequence) defined by a lobate-elongate, river dominated delta. Thephaseconsists of the Enugu/Nkporo, Mamu, Ajali and Nssuka Formations (Petters, 1977). In Middle-Late Eocene sediments were deposited in a westward direction of the Abakaliki high and Anambra south forming the Northern depobelts. Ejedawe*et al*. (1984) stated that the Niger Delta Basin subsided in the Late Eocene and prograded along three sedimentary axes which eventually merged forming the Greater Ughelli depobelt. Till recent the Niger Delta has prograded in a south westward direction forming different depobelts with sediments coming mainly from Niger River.

Seven major depobelts have been identified in the Niger Delta oil field; they are Northern delta, Greater Ughelli, Central swamp-1 and 2, Coastal swamp 1, 2 and 3.The depobelts also present a change in regional dip of the delta and consists of genetically related sediments (Doust and Omatsola, 1990).Thesedepobelts are characterised by paleontological distinct, transgressive shale horizon and include smaller scale structures and depocentres which are separated by large growth faults. Episodically movements of progressive sand are transported to the delta top which harmonized with a seaward shift in deposition and subsidence.

In the Late Oligocene progradation of the delta continued and cut into the Opuama canal in the western part even though subsidence remains constant (Petters, 1984; Knox andOmatsola, 1987). In Middle Miocene the delta prograded in a landward dipping direction which causes the eastern depobelt to come togetherlaterallyandenlargement of the delta front making the coast line to have a convex geometry. During the Late Miocene extensive sediment was deposited in the Central Swamp forming the Central Swamp depobelt while in the eastern part there was an obstruction of sediment deposits as a result of cutting and filling events which resulted to the formation of Agbada, Elekelu, Soku, and the Afam gorge (Burke, 1972; Petters, 1984).

2.2.1 Stratigraphy of Niger Delta Basin

The Niger Delta Basin lithicfill havebeensubdivided into three major lithostratigraphic units that are interpreted based on sand and shale ratio and dated based on fossil micro fauna(foraminifera and calcareous nannofossils). Inrecent times the stratigraphic framework is based on the use of pollen and spores (Ejedawe, 1989). These three lithostratigraphic units are the basal marineprodeltaAkata Formation, themiddle shallow marine delta front Agbada Formation and the top continental delta Benin Formation.

Stratigraphic equivalence of the three formations is exposed in the southern part of Nigeria (Short andStuable, 1967).Esan(2002) theseformationsconsists of progradational sequence and a gross upward coarsening deltaic marine, inter lope and abyssal plain deposits of about12, 000m thick(Figure 2.2)(Weber andDaukoru, 1975).

2.2.2 The Akata formation

Thedarkfine grey marine mudAkata Formation is the oldest and most time transgressive lithological unit of the three formations (Short and Stauble, 1967). The formation consists of turbidite and channel fill sands which represent the prodelta facies of the Niger Delta. The upper portion is considered to be sandy where it grades into Agbada Formation and top defined by the deepest deltaic facies considered to be Agbada Formation. The turbidite and channel sands is about 6400 m thick (Doust andOmatsola, 1990) with type section recognised in Akata-1 well east of Port Harcourt.

Akata Formation is assumed to be the main hydrocarbon producing units of the delta (Doust andOmatsola, 1990; Stacher, 1995). Presently Akata Formation is deposited in the continental shelf and slope. The age of the formation ranges from Paleocene to Recent (Murat, 1972; Doust and Omatsola, 1989). In the initial phase of development of the prograding delta the dark grey shale thickens along the Benue and Bidaaxis trough. It is also exposed in the onshore part of the northeastern Nigeria where it is referred to as the Imo Shale(Imo Formation).

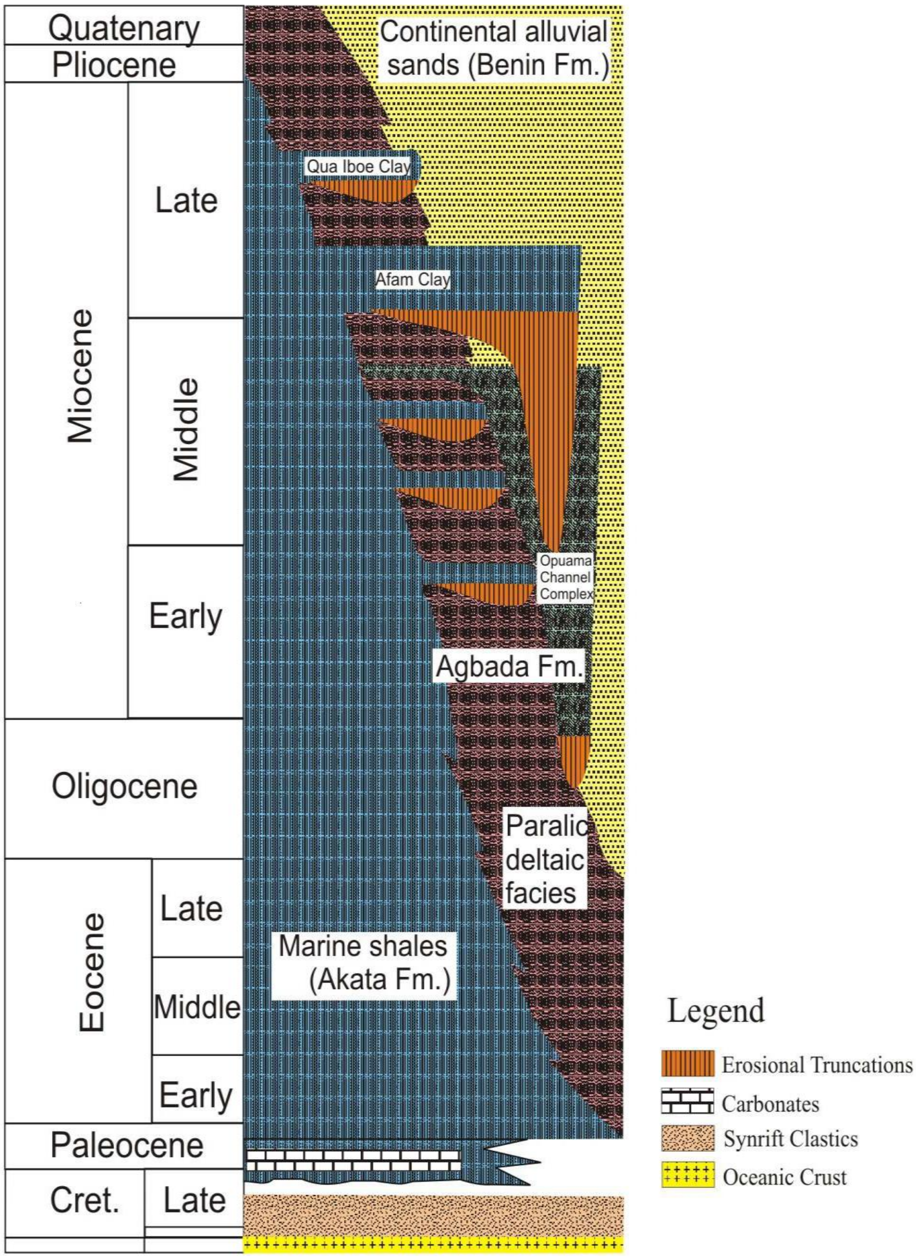


Figure 2.2: The three stratigraphic units across the Niger Delta Basin (Bankole, 2010)

2.2.3 The Agbada formation

The Agbada Formation is the middle and the main hydrocarbon producing units of the three formations in Niger Delta Basin. Texturallythe formation consistsofalternation of clean sand that are poorly graded and siltstoneand thin intercalation of shale in various proportion and thickness(Weber, 1971; Murat, 1972; Esan, 2002). Alternation of fine sand and coarse sand act as a seal and reservoirforhydrocarbon. The fine sands are well sorted defined by beach-barrier, tidal mouth bar andof upper shoreface setting while the coarse and poorly graded sand characterised as high energy, fluvial, estuarine channels and of proximal submarine canyon channels.

Twelve different types of lithofacies have been recognised in Agbada Formation and grouped into seven comprising coastal barrier, back barrier, distributary channels, lagoonal system, transgressive sand, suspension fall out and allochthonous lumps (Reijers,1995). The lithofacies are believed to be deposited mainly in a wave-tide environment and characterised by high energy. The type section of Agbada Formation was recognised in Agbada-2 well which is 11 km north of Port Harcourt. The formation is well exposedOgwashi-Asaba and Ameki areas known as Ogwashi-Asaba and Ameki Formations (Avbovbo, 1978). The age of the formation ranges from Eocene to present and occur throughout theNigerDeltaBasin with average thickness of about 300m to 4500m.

2.2.4 The Benin formation

The continental delta top Benin Formation is the youngest of the three formations. The formation was deposited in a continental environment that is made up of the braided and meandering system of the upper delta plain. The sand unit comprises of about 70-100% clean fluvialtal sand of about 2000m thick and deposited from Eocene to Recent (Avbovbo, 1978). Texturally the fluviatal sand is granular, sub rounded to well-rounded and poorly graded. The type section of the formation can be recognised in Elele-1 well in the north-northwestern part of Port Harcourt and can be recognised across the whole Niger Delta from Benin to Onitsha. The age of the formation was assumed to be of Oligocene to Recent.

2.2.5 Structural disposition of NigerDeltaBasin oil field

The Niger Delta Basin oil field is characterised by complex subsurface structures related with largesyn-sedimentary growth fault. These growth faults are found underneath the Benin Formation associated with rollover anticlinal structures, shale diapirs anden-echelon normal faults closure that are caused byshale upheaval ridges. These structures are typical of extensional rift system form during the active phases of development in the delta by the interplay of sediment deposition (supply) and subsidence rate.Doust and Omatsola (1990) described growth fault as a series ofmajor fault bounded depobelt.Allen (1965); Merki (1972); Cazes (2004) defined growth fault as syn-depositional extensional fault that evolve at the margin of continental plate associated with depocentre (area of high sediment load) and regarded as product of gravity sliding.Mostof thefaultsin the Niger Delta extend deep down into the mobile under-compacted, over pressuredAkata Shale which readily forms a detachmentzone (Figure 2.3).

Deformation of the delta and displacement of sediment are aided by elasticunderlyingAkatashaleswhich createaccommodationspace for sediment tofill. These growth faultstrendin a northeast to southwest and northwest to southeast (Hosper, 1971)landward dipping direction separating the depobelts. Along with the growth faults are primary roll over anticlines which separate the depobeltsand repeat each other en-echelon.

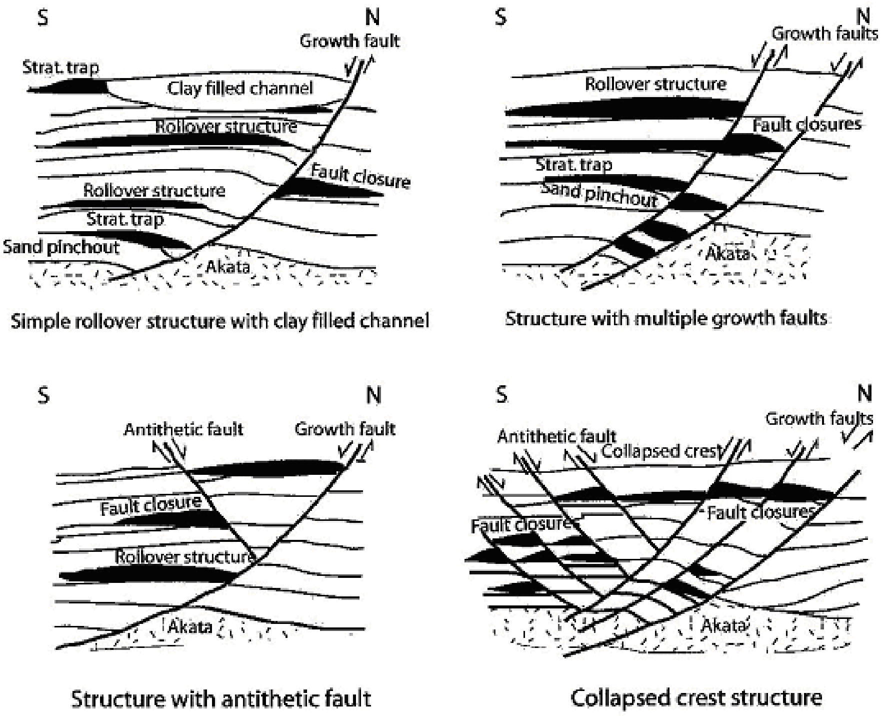


Figure 2.3: Types of structural style in Niger Delta Basin (Bankole, 2010)

Obreinand Braunstin(1968) discussed the importance of growth fault and diapiric structure which serve as an excellent trap and seal for hydrocarbon. The traps are form as sediments are producing oil, these also account for eustatic sea level rise and fall (Chapman, 1973). Higheraccumulationsof hydrocarbon are located in roll-over anticlines in the hanging-walls of growth faults, where they may be trapped in fault closures. The seal are produced when the throw of fault surpass that of sand thickness which depends on the magnitude of shale smeared into the fault plane. Mud diapers are the most common and occur on the landward side of the growth faults restricting sedimentation on the up-thrown side of the faults rather enhancing sedimentation on the down-thrown side.Therefore, the magnitude of throws in the downthrow is younger than that of the up throwside. Thepresent-day shelf is dominated by long counter regional faults and anthetic fault which define the southern boundary of the depobelts (Ojo, 1996).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

Ditch cuttings and gamma ray logs were obtained from National Petroleum Development Company (NPDC) of which about 150 ditch cuttings were used for this study. The intervals of the ditch cuttings range from 9705 ft -10350ft,9795 ft -10575ft and 9710 ft -10475ft in Ore-1,2 and 3 wells respectively.Laboratory analysis was carried out in Crystal Age, Lagos and Federal University of Technology Minna.

3.2 Methods

The following methods were adopted for this research: acid method of palynofacies recovery, microscopic study, lithologic description of the ditch cuttings and sequence stratigraphic analysis.

3.2.1 Sample preparation for palynofacies recovery

The acid method was used for the recovery of palynofacies(palynomorphs and palynomacerals)(Figure 3.1). A hundred and forty-three (143) ditch cutting samples from the Ore wells were analysed. 10 grams of each samples were equally ditch into a cleanwell labelled glassbeakersand treated mildly with 10% of hydrochloric acid(HCI) under a fume cupboard for complete removal of carbonates materials (foraminifera, calcareous nanno fossils and shell fragments) present in samples for thirty minutes. The process was followed by complete neutralisation with a clean tap water and sieved with an acid resistance five micronlylon mesh sieve that can hold the palynomorphs. The samples that have been processed from HCl was digested with 40% of hydrofluoric acid(HF) which was stirred mildlywith nickel stirring rod and transfer inside the fume cupboard for twenty-fourhours. After twenty-four hours the samples were neutralised with water and decanted. Samples were then transfer to the Brasonsonifier250to remove further any inorganic matter (clay and mud) left in samples to produce avery clean residue. Residues are then divided into two portions; a portion was oxidized with nitric acid (HNO_3)and this was closely monitored by the laboratory technicians. This process is known as maceration and used for palynological analysis whiletheunoxidised portion was used for palynofacies analysis.

The residue for palynofaciesanalysis was not oxidised in order to maintain the natural colours of the particulate organic matter in their natural state. The second portion of residues for palynological analysis was further stained with Safranin-O due to its high relieve to enhanced identificationof marinedinoflagellatescysts present in slides during observation processes under the Olympius Binocular light transmitted microscope.Two drops of each residuewas pipetted into a clean circular cover slide, mix with Loctite (impruv) as a permanent mounting medium and cured in ultraviolet light for five minutes.

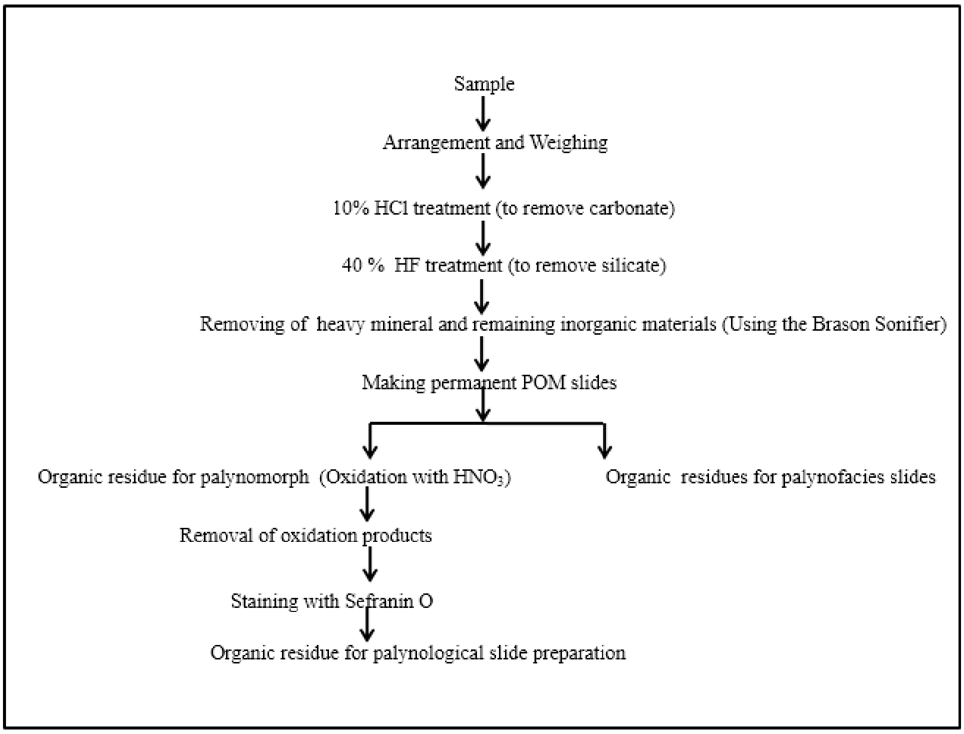


Figure 3.1:The acid preparatory method forpalynofaciesanalysis

3.2.2 Microscopic study

Prepared slides for both palynofacies and palynology were observed under the CIX IV OlypiusBinocular transmittedlight microscope. The different palynomacerals types (palynomaceral 1, 2, 3 and 4) and palynomophsconstitutents of each prepared sample mounted on the slides were described and counted under the microscope. Identificationof recovered palynomorphs and palynomacerals were compared with works of (Germeraad*et al*., 1968;Van Hoeken-klinkenberge, 1966;Oyede, 1992; Salard-Cheboldaeff*et al*., 1992; Ige*et al*., 2011;Thomas *et al*., 2015 and Adejoh*et al*., 2019) and other palynological albums available. The data generated from palynomorph and palynomacerals including the lithological data were plotted using the Stratabug software package.

3.3 LithologicDescription

Lithologic description was carried out by physical observation of samples using the sense of touch, grain and Munsell colour chart. The description was also assisted by the gamma ray log which measured the radioactive elements embedded in rocks with API as its unit. High value of gamma ray signifies shale and low value indicate sand. The gamma ray provides us with the relationships between different log shapes and grain size thus this method is used to classify lithology since the Niger Delta Basin consists of intercalation of sand and shale. The gamma ray log descriptions after Durogbitan, (2010) and Omoboriowo*etal*. (2012) were adopted in this study (Figures3.2 and 3.3).

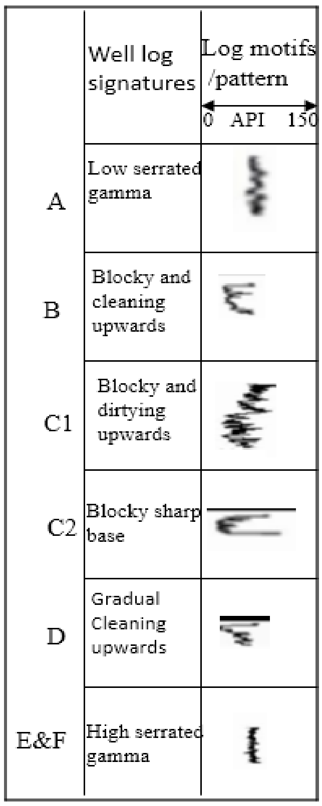


Figure 3.2: Gamma ray log motif A (Durogbitan, 2010)

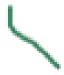
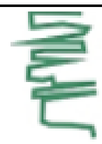
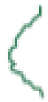
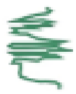
Log shape type	Log signature type
Blocky cylindrical	
Funnel	
Saw teeth/ serrated	
Irregularly blocky	
Symmetrical hour glass/ egg	
Serrated blocky	

Figure 3.3: Gamma ray log motive B (Omoboriowo*et al*., 2012)

The gamma ray log signatures indicating irregularly blocky shape are described as aggrading stacking pattern which are intercalated with silt stones and mudstone. Blocky cylindrical shape, dirtying upward indicate deep marine shale with high gamma value, alsocylindrical log motif with sharp base and top are refered to as channel sand. Gradually cleaning upward with thin funnel shape are interpreted as upper shoreface while the blocky and cleaning upward trend with thick funnel shape morphology intercalated with serrated high gamma values within are characterised as coastal barrier bar deposit(Figure 3.2and 3.3). The bell shape is interpreted as tidal-fluvial channel sand or deltaic.

3.4 Sequence Stratigraphy Analysis

Sequence stratigraphic interpretation employed model independentmethod in the initial stage to delineate the sequence stratigraphic surfaces using palynomorphs, palynomaceral and gamma ray log patterns belonging to Ore wells. This was followed by model dependent stage where system tracts were named based on depositional sequence IV (Hunt and Tucker (1992; 1995). The procedures are as follows:

i. The lithology was interpreted from the different architectural patterns of the gamma ray log and ditch cuttings.
ii. The depositional environment was deduced from palynomorphs, palynomacerals and log architectural pattern
iii. Condesed sections (CS) and maximum flooding surfaces (MFS) were deduced from the palynomorphs abundance, peaks of diversity and palynomacerals types and sizes.
iv. The various system tracts and sequence boundaries were identified from the log archetectural pattern and palynofacies characteristicsretrived from the studied wellsusing depositional sequence IV model.
v. Sequences are dated based on palynomorph data retrived from host sediments of the studied intervalsand correlated.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Lithologic Description of Ore-1, 2 and 3 Wells

The results of lithologic characteristics of Ore-1, 2 and 3 wells are presented in (Figures 4.1, 4.2 and 4.3). The lithologyof Ore wells consists mainly ofalternation of sandstone, shale, mudstoneand sandy mudstones beds. Texturally the sandstone units have fine to very fine grains interbeded with sandy mudstone units and occasionally shale beds. The sandstonebeds are poorly sorted, angular to subangular to rounded. The sandstone units aredorminatedbylight gray, pinkish to grayish pink colours. The shale/mudstone units composed of fine, powdery laminated units with dark whitish gray colour while the sandy mudstone arecharacterised by grayish pink to orange colours. Also, evidence of woody materials is observed from the wells studied.Detailed lithologic description of Ore wells are presented in appendices A, B and C.

The integration of gamma ray log patternsas also aided in the lithological description of Ore wells. The high values of gamma ray log indicate dirtying upward sequence and low values indicate cleaning upward sequence. The gamma ray log patterns as also enable the studied sections in Ore-1, 2 and 3 to be divided into three intervals base on shale and sand ratio. High values of gamma ray log signify shale and low values implies sandstone units.

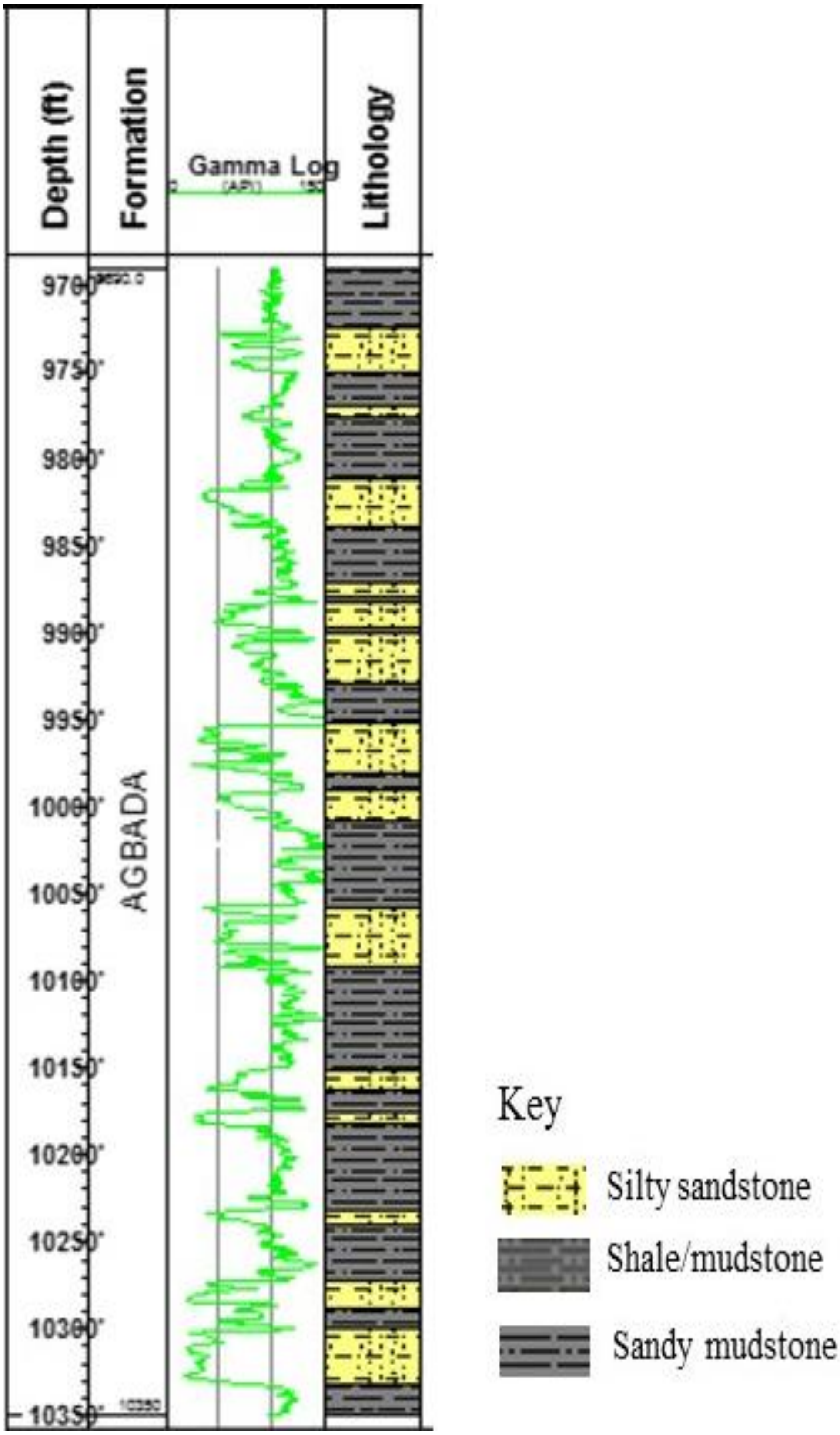


Figure 4.1: Lithologic log of Ore-1 well

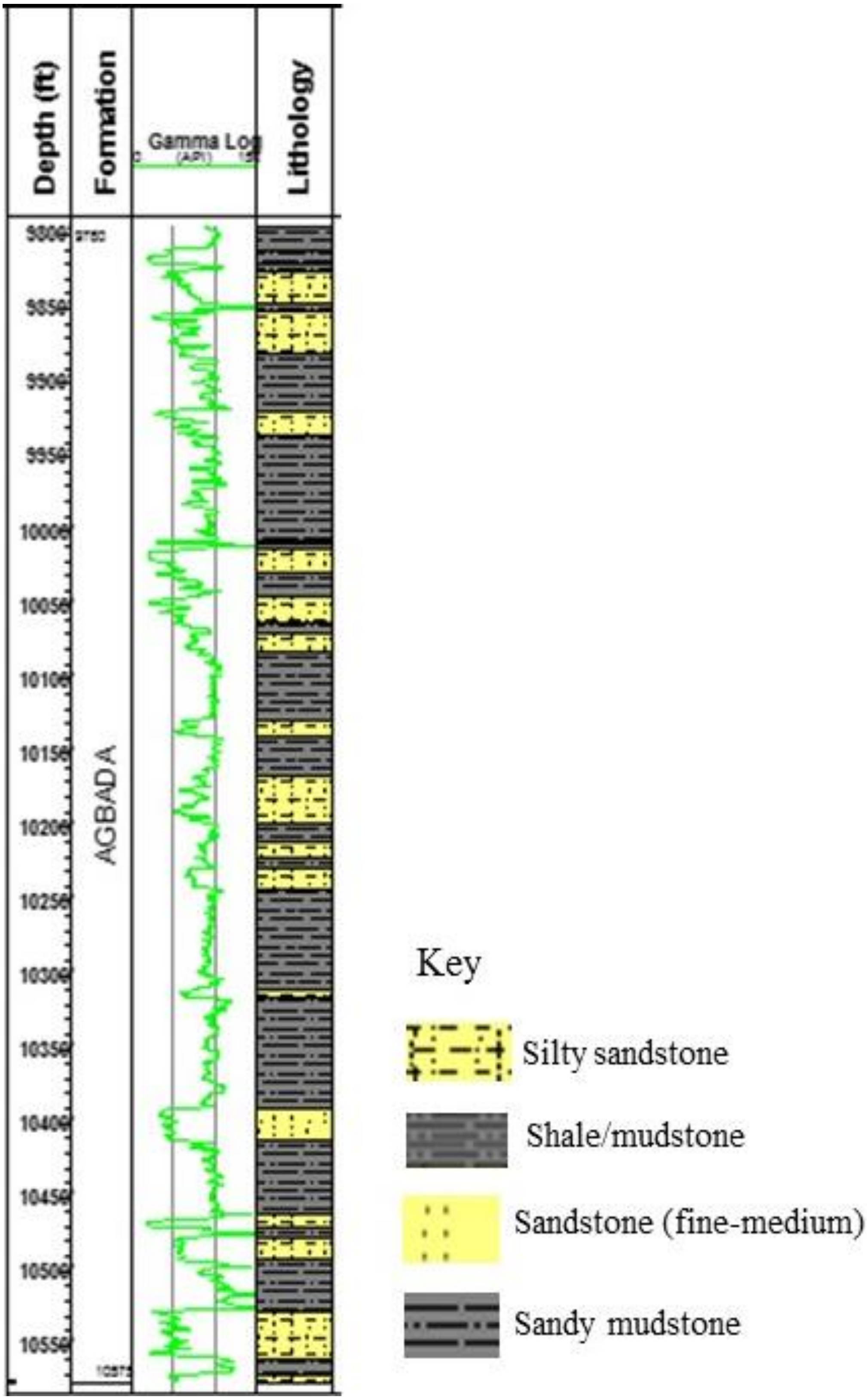


Figure 4.2: Lithologic log of Ore-2 well

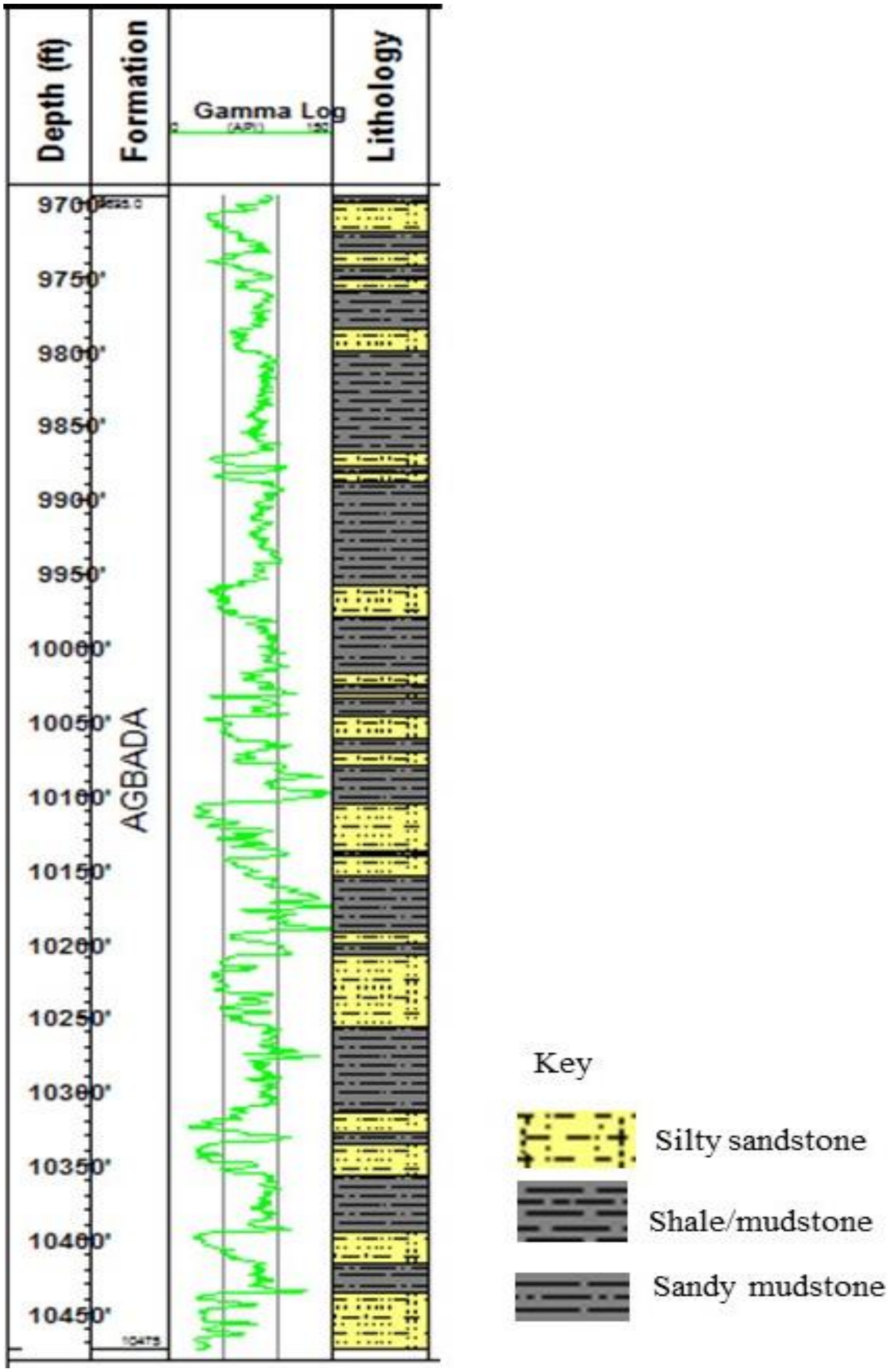


Figure 4.3:Lithologic log of Ore-3 well

4.1.1 Lithologic description of Ore-1 well (9700 ft –10350ft)

This studied interval consists primarily of heterolithic beds of intervening sandstone, silt stone and mudstone/shale units. The whole intervals of Ore-1 well haveaverage shale to sand ratio of approximately 66.2:33.8. The studied sediments in Ore-1 well have been divided into three intervals. They are:

The interval between 9700 ft - 9810 ft: This is the uppermost part of Ore-1 well with average shale to sand ratio of approximately 11.9: 3.5. The sediment colourwithin this interval ranges from pinkish gray, very pale orange and grayish pink. It is associated with bell shape log pattern interbeded with a thin layer of sandstone. The bell shape is dirty upwards with a minimum value intepreted as fluvial channel. Overlaying this bell shape are irregular alternations of shale/mudstone and sandstoneunits characterized by high and low gamma ray values within a short interval of vertical profile. Thisirregular pattern has no form and identified as turbidites fillassociated with sedimentation in a basin plain environment (Omoboriowo*et al*., 2012).

Intervalbetween 9810 ft – 10110 ft: This is the middle part of of Ore-1 well and defined by coarsening lithologies of repeated progradation interbeded with shale/mudstones. The interval recorded an average shale to sand ratio of approximately 7.0:19.7The shale/mudstone are grayish pink and pale gray in colour, fine to smooth and fissile in texture.The sandstone unit comprises of fine to medium grain sediments and occationally smooth. The colour of the sandstone unit ranges from pale orange to very pale orange and grayish orange pink in colour. The log motif in this intervalis blockyirregularly cylindrical and defined by both large and thin serrated funnel shapes indicating cleaning upward sequence. The funnel shapes with sharp top and base are interpreted asupper shore face sand, coastal barrier bar, channel/slope channel sand and offshore mudstone (Durogbitan, 2010).The interval is moderately rich in terrestrial palynomorphs, algal of *Botryococcusbraunii*and absence of marine forms.

The interval between 10110 ft – 10350 ft: This is the lower most part of Ore-1 well. This interval is characterized by thick layer of shale units. Theaverage shale to sand ratio recorded at this interval is approximately 30:19. This description agrees with the work of (Doust and Omatsola, 1990) who stated that the lower part of Agbada Formation is shalier than the upper part of the formation. The shale beds averages 60 ft in thickness with irregularly serrated log pattern associated with dirtying upward sequence. The shale units are dark gray to occasionally very dark gray in colour.The sandstone units within the shale/mudstone units has blocky cyclindrical, sharp base and thin funnel shape morphologies. The cylindrical log motif might have been form due to the presence of shale at the upper and lower boundaries of the well which display an abrupt truncation. Selly (1998) explain that this are distributary channel sand that were blocked by the action of stream water deposits which produces new distributaries. The sandstone units are coarse, fine to medium grain, pinkish to grayish colours.

4.1.1.1 Lithologic description of of Ore-2 well (9800 ft -10575 ft)

Ore-2 well have an average shale to sand ration of approximately57.3: 42.7. The regular pattern of alternation of sandstone, argillaceous sandstone and shale/mudstone beds units were also observed in the well. Based on the gamma ray log pattern Ore-2 well have been divided into three intervals. These are:

The interval between 9800 ft - 10240 ft: This interval recorded an average of shale to sand ratio of 27.7: 25.9 indicating more of shale than sand. The unit consists of stratified siltstone strata interpreted as coastal barrier bar and deltaic channel deposits associated with transgressive surface. Texturally the sandstone beds are fine to very fine, pinkish and grayish pink in colour. This sandstone beds most have been deposited in a high energy and interfringed with dark grayish mudstone/shale (Omoboriowo*et al*., 2012). The lithogy gradually thicking and cleaning upward with funnel shape log pattern.This is typical of coastal barrier bar deposit (Durogbitan, 2010). The interval is further characterized by abundance of freshwater algae of *Botryococcusbraunii* and moderate record of other freswater palynomorphs.

The interval between 10240 ft -10390 ft:This interval in Ore-2 well is characterized by a large set of deep dark gray marine shale. The ration of shale to sand averages 18.5:0.6 interbedwithin this interval is a thin unit of sanstone bed with funnel shape character. The deep marine shale is about 150 ft thick which infer increase in sea level and sedimentation within a marginal marine setting. The log pattern associated with this interval isirregulaly serrated blocky with high gamma ray values. Other characteristic found within this interval of shale strata isaboundance record of mangrovepalynomorphs.

The interval between 10390 ft -10575 ft: This is the lowermost part of this unit and is about 180ft thick. The base composedof a thinshalelithologyoverlained by a thick layer of coarsed grained, pinkish and pale orange sandstone bodies. The sandstone units clean upwards and defined by irregularly funnel and blocky cylindrical shape log pattern. The blocky cylindrical shape log pattern consists of fine and very fine cleansandstone units. The shaly units are grayishin color, moderately hard, fissile and interbeded by sandstone layers. The clean sandstone units within the shale are identified as channel sand in a progaradingdelta.

4.1.1.2 Lithologic description of Ore-3 well (9700 ft -10475 ft)

Sedimentation process within Ore-3 well is characterised by an erosive base unlike its other counterparts Ore-1 and 2 that lies on a thin bed of shale. Thesuccession has more of shale units in the upper part compare to the sand units in the lower part. Two bell shapes are recognisedwithin the intervals in Ore-3.One in the upper and the other in the lower section of the well. The bell shape morphology mostly designate fluvial-tidal channel sand (Durogbitan, 2010).The shale to sand ration in the entire interval recorded 45.8:54.2. The well was divided into three intervals. These are:

The interval between 9700 ft-9950 ft: This interval lies on erosional base of the prograding barrier sand and dirties upward into a uniform minimum valueof a thick shale bed of about 50 ft thick. The interval recorded more shale than sand with an average ratio of 24.8:9.2. The gamma ray log pattern of this thick shale beds has a bell shape indicating transgressive sand. Above this shale beds are irregular alternation of sandstone and shale strata that fines upward into a thin cylindrical and funnel shape morphology. More of the marine palynomorphs and algal of *Botryococcusbraunii*are found within this interval.

The interval between 9950 ft-10190 ft: This interval lies in the inner part of the well defined by progradation of silty sandstone strata interfringe with shale/mudstone. The shale to sand ratio average 20.9:13.1. It is underlained by a transgressive surface forming a thick irregular uneven funnel shape lithology that cleans gradually into a vertical profile indicating progradation of the delta. The interval is further defined by thin beds of cylindrical and funnel shape log pattern that fines finally into an erosive top. The shale are fissile, pale gray to grayish black, the sandstone beds have alternation of very fine, well to moderately sorted argillaceous sandstone and shaly sandstone facies.Increase in diversity of palynomorphs are observed at this interval.

The interval between (10190 ft - 10475 ft): This interval recorded a thickness of about 280 ft with more of argillaceous sandstone beds with an average of shale to sand ratio of 15.7: 16.3.Compared to Ore-1 and 2 wells texturally, the hethorolitic sandstone beds are fine to very fine grained, sub rounded to angular, pinkish and pale grayish pink coloration. The inteval is characterised by irregular blocky erosive base aggrading sandstone facies intercalated with siltstone and mudstone/ shale which progaraded vertically into a bell shape structure with high gamma value within the bell. The bell-shaped facies have thin sand units that are moderately sorted and fine. High gamma ray value within the bell shape structure suggests presence of micaceous minerals within these facies which might give a hint on the position of maximum sedimentation (Durogbitan, 2016).

Lithologic correlations of Ore-1, Ore-2 and Ore-3 wells were not possible.This may be due to variation in thichness, elevation or differences in depositional environmentof the wells. It could also be as a result of multiple faulting across the wells which is one of the major characteristics of the Niger Delta Basin.

4.2 Palynofacies

The results of palynofacies analysis of Ore-1, 2 and 3 wells are recorded in palynomorphs and palynomaceraldistribution charts in (Figure 4.4, 4.5 and 4.6). Includedin these charts are the lithology and different biostratigraphiczones encountered from the studied wells as the system tracts and their bounding surfaces. Different groups of terrestrial and marine palynomrphs were encountered from the studied section as well as four palynomaceral types. Palynomorphs recovery and diversity is moderate to low as palynomorphs increases downward the sequence.This concur with the work of (Adeonipekun and Oyebami, 2015; Adeigbe and Ochibo, 2017) on Paleocene-Eocene thermal maturation period. The low diversity and abundance may be as a result of green house global warming that took place in the Paleocene-Eocene period which led to extinction of some of these palynomorphs as reported by authors above. SimilarlyBarron (2015) reported low preservation of palynomorphs in the Middle to Late Eocene in the Gulf of Mexico.

Palynomorph assemblages in Ore wells were dominated by pollen, spores and algae of *Botryoccocusbraunii*with few dinoflagellates cysts. Palynomaceral 1 and 2 also recorded higher percentage from the wells compare with low record of palynomaceral 3and 4. Higher content of land derived palynomorphs and palynomaceral 1 and 2 suggest deposition not far from land (Shrank, 1984 and Oboh *et al.*, 2005).A total of501 palynomorphs specimen were recorded in Ore-1, 1191 in Ore-2 and 678 in Ore-3 wells respectively. Though none of the studied intervals were barren. The following palynomorphs were recorded from Ore-1, 2 and 3 wells:

Spores:*Acrostichumaureum, Laevigatosporites*sp,*Verucatosporites*sp,*Cyathidites*sp,*Verrucatosporitesusmensis*, *Pteris*sp, *Stereisporites*sp,*Cyathidites minor.*

Pollen:*Monoporitesannalatus, Zonocoastatitesramonae, Proxapertitescurus, Psilatricolporitescrassus, Retibrevitricolpitestriangulatus, Retimonocolpitesobaensis, Gardenia imperalis, Spinicolpitesechinatus, Racemonocolpiteshians, Psilamonocolpitesmarginatus,Doualaiditeslaevigatus,Psilatricolpitesoperculatus, Retitricolporitesirregularis, Sapotacea, Psilatricolporitescrassus,Grimsdaleapolygonalis, Milforda*sp,*Pachydermitesdiederixi,* *Ctenolophoniditescoastatus, Mauritiiditeslehmani, Germamonoporites*sp, *Elias guineensis,Longapertites*sp,*Praedapollis*sp,*PraedapollisflexibilisStriamonocolpitesrecto striatus, Pradopollis*sp,*Striatricolporitescatatumbus, Monocolpopollenitessphaeeroidites,Parchydermitesdiederixi, Striamonocolporitesundatostriatus,Retibrevitricolporitesprotrudens, Spinizonocolpites*sp,*Gemmate pollen*,*Spinizonocolpiteechinatus*and*Mauritiiditeslehmani*.

Algae:*Brotyococcusbraunii and Pediastrum* sp.

Dinocysts:*Lingulodinummachaerophorum, Polysphaeridiumzoharyi, Homotryblium*sp,*Spiniferitesramosus, Oligosphaeridium*sp,*Leiosphaeridia*sp,*Paleoperidium*sp, *Histrichokopolma, Operculodiniumcentracarpum, Homotrybliumsp*, *Spiniferites*sp,*Achomosphaeridia*sp and *Histrichokolpomarigaudiae.*

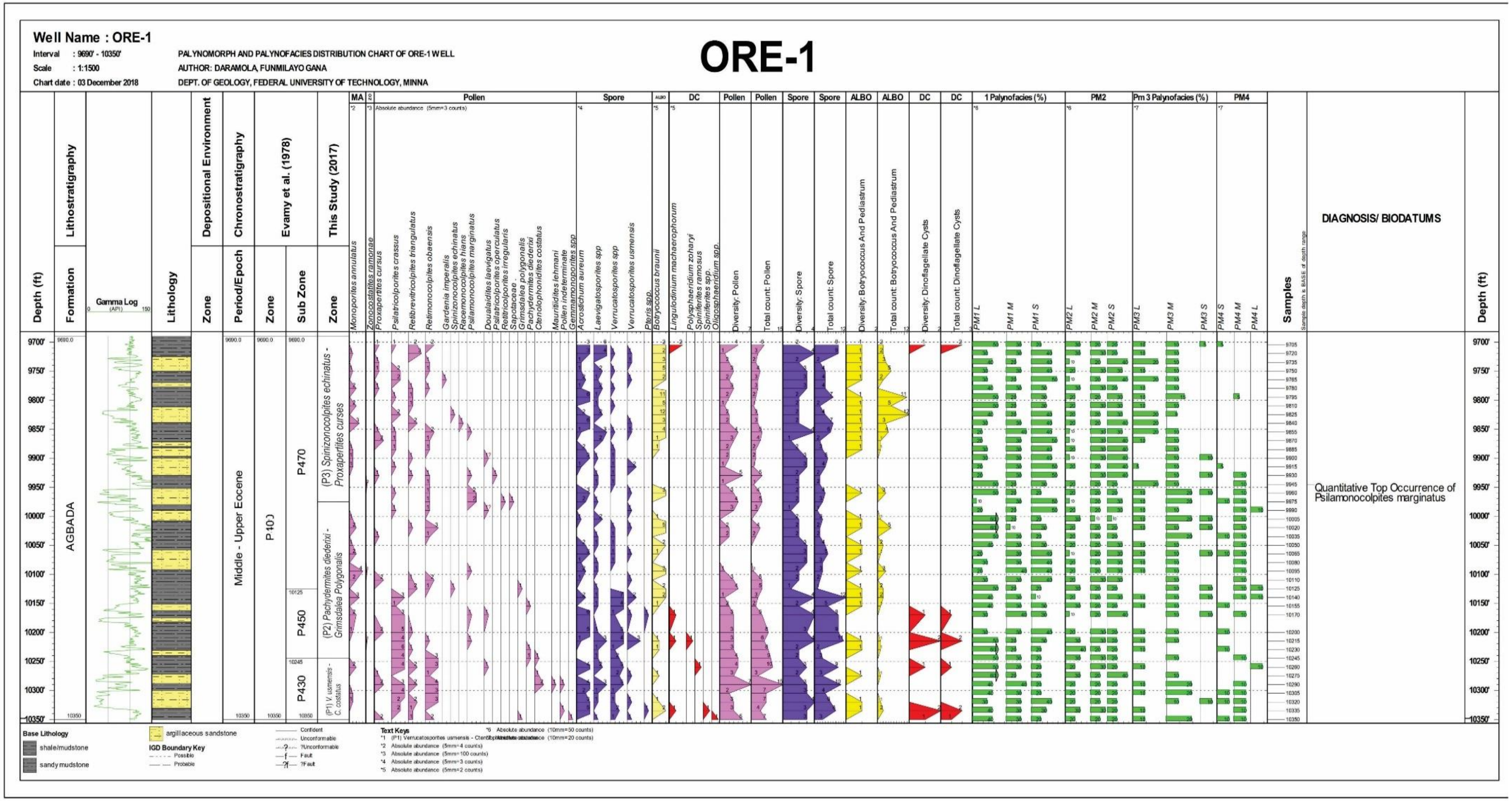


Figure 4.4: Lithology, palynomorphs and palynomacerals distribution chart of Ore-1 well

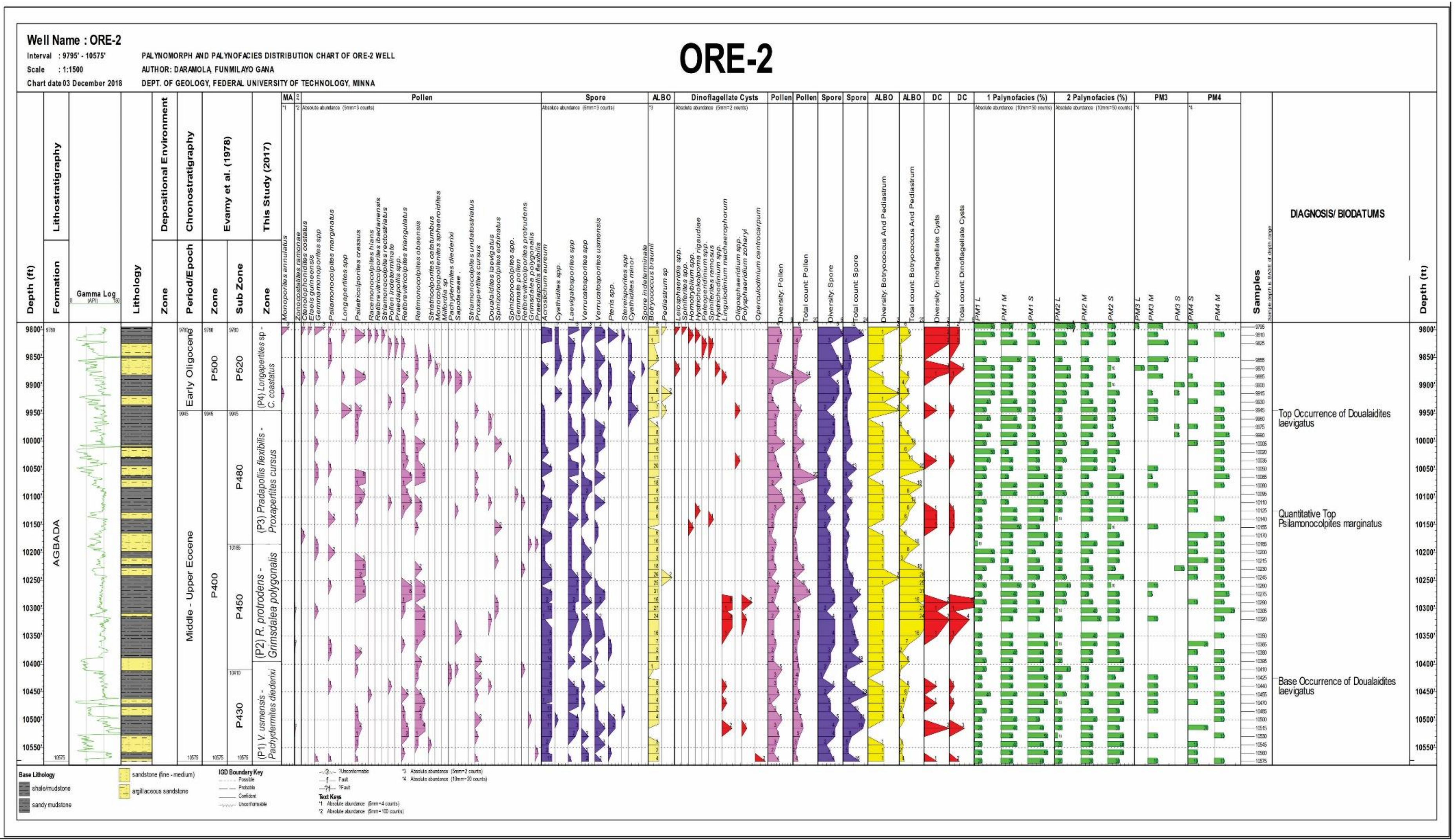


Figure: 4.5: Lithology, palynomorphs and palynomacerals distribution chart of Ore – 2

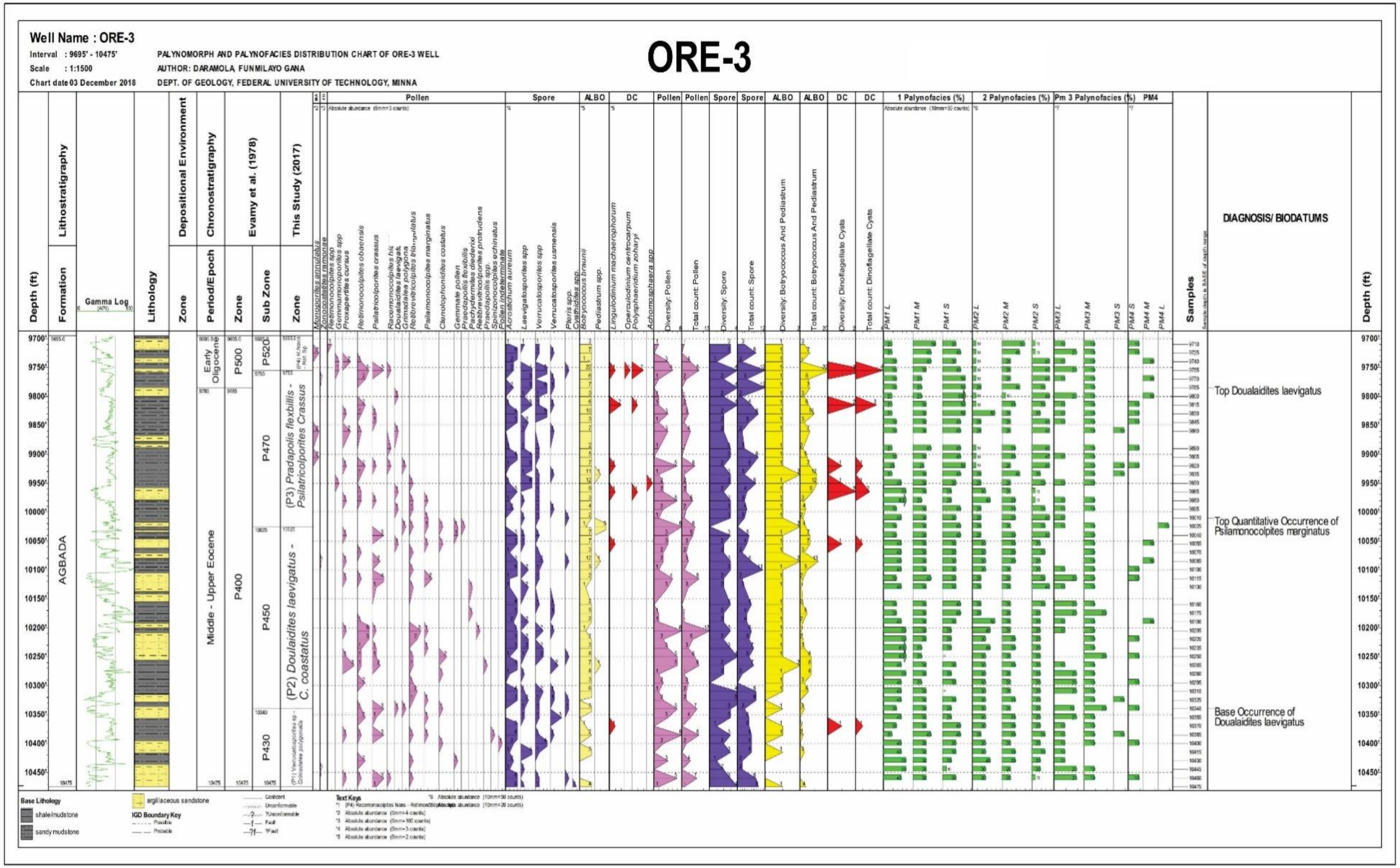


Figure: 4.6 Lithology, palynomorphs and palynomaceralsdistribution chart of Ore-3 well

4.2.1 Taxonomy

Systematic descriptions of palynomorphs follow the Centre for Botanical Nomenclature (CBN), 2018 using the size, shape, sculpture, exine ornamentation and number of aperture. Taxonomical identification wasperformed to generic and specie level. Palynomorph morphological description are centered on feature recognized at 600µm and photographs taken with the CIX 41 Olympius binocular transmitted light microscope. Each of the individual palynomorph type were identified and described with the aid of the palynological albums and other relevant published literature and atlas of palynomorphs. Common feature associated with spores are monolete, trilete and alete while pollen are linked with pores, colpi and sacci. All identified and described palynomorphs are showed in plate I to VI below (Magnification: X40, scale bar 600µm).

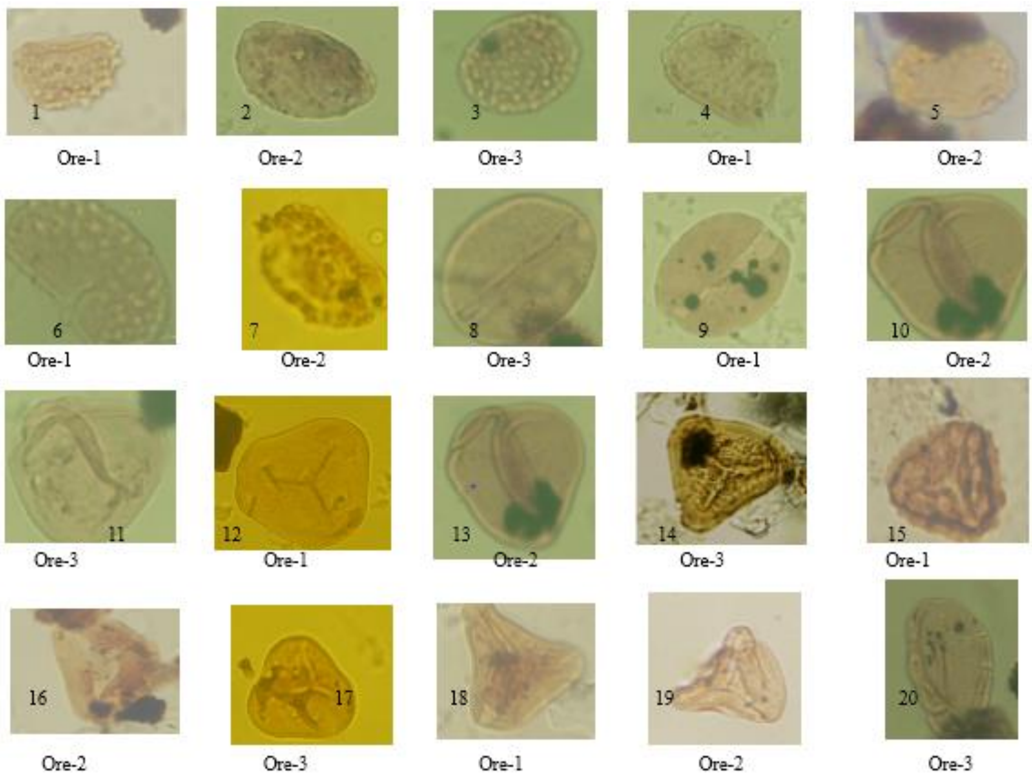


Plate I: Palynomorps recovered from studied wells (x600 µm)

Plate I

1-2. *Verrucatosporitesusmensis*(Van der Hammen, 1956).

3-7. *Verrucatosporites*sp(Ibrahim, 1932).

8-9 *Steristosporites*sp (Plung, 1953).

10-13 *Acrostichumaureum*(Linneaus, 1953).

14-16 *Pteris*sp (Pontonie and Kremp, 1954).

17-19 *Cyathidites minor*(Couper,1953).

20*Laevigatosporites*sp (Ibrahim, 1933).

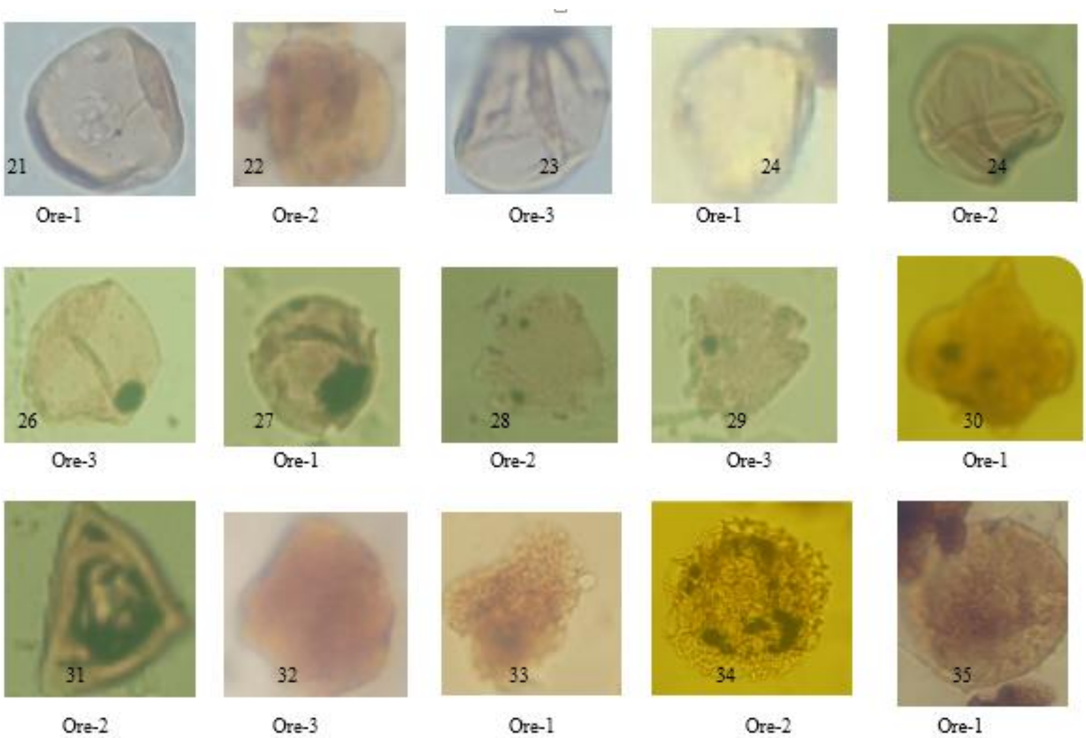


Plate II: Palynomorps recovered from studied wells (x600 µm)

Plate II

21 *Laevigatosporites*sp(Ibrahim, 1933).

22-26 *Monoporitesannulatus*(Van der Hammen, 1954 and Adojoh*et al*., 2019).

27-29*Retibrevitricolpitestriangulates* (Van Hoeken-Klinkenberge, 1966).

30-32 *Daoulaiditeslaevigatus*(Legoux, 1970).

33-35*Pradapollisflexibilis*(Legoux, 1978).

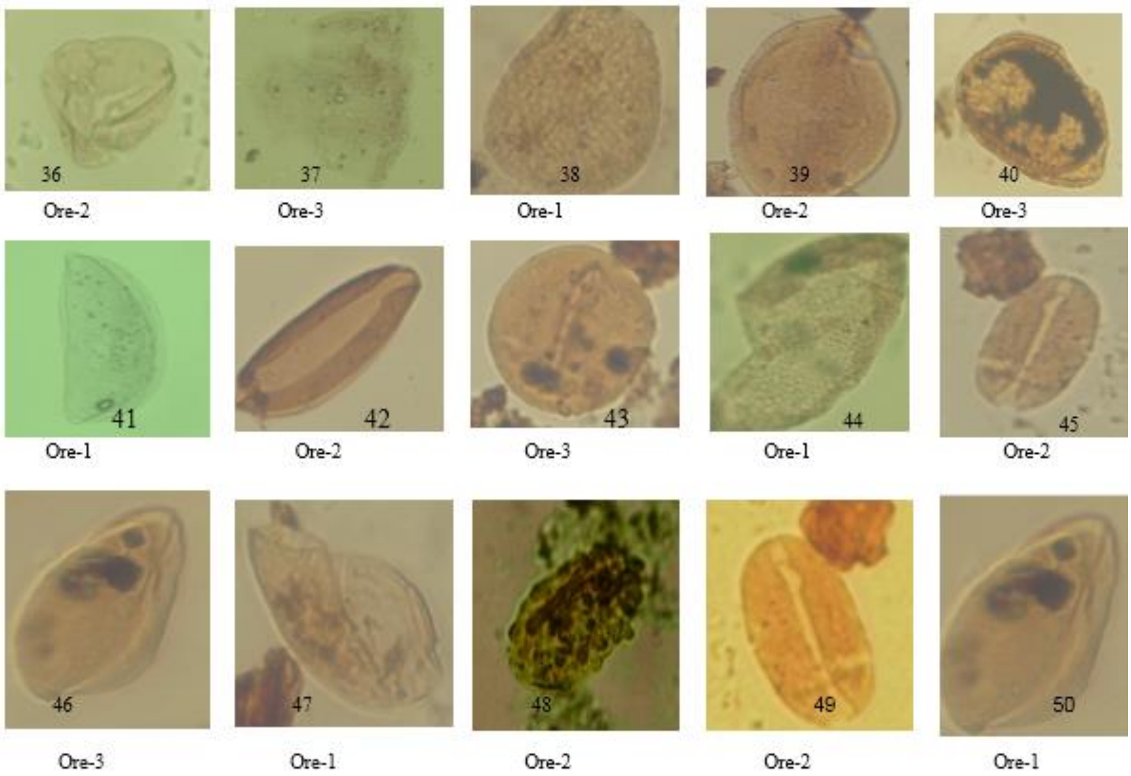


Plate III: Palynomorps recovered from studied wells (x600 µm)

Plate III

36-37. *Cyperacypollis* sp.

38-40*Proxapertites cursus*(Van Hoeken-Klinkenberge, 1966) (Oil immersion).

41. *Longapertites* sp.

42-43.*Monocolpollinites marginatus*(Van der Hammen,1954) (Oil immersion).

44. *Longapertites* sp.

45-46. *Retimonocolpites obaensis*(Oil immersion).

47-48. *Gemmamonoporites* sp (Vander Hammen and Garcia, 1965).

49-50. *Retimonocolpites obaensis*(Oil immersion).

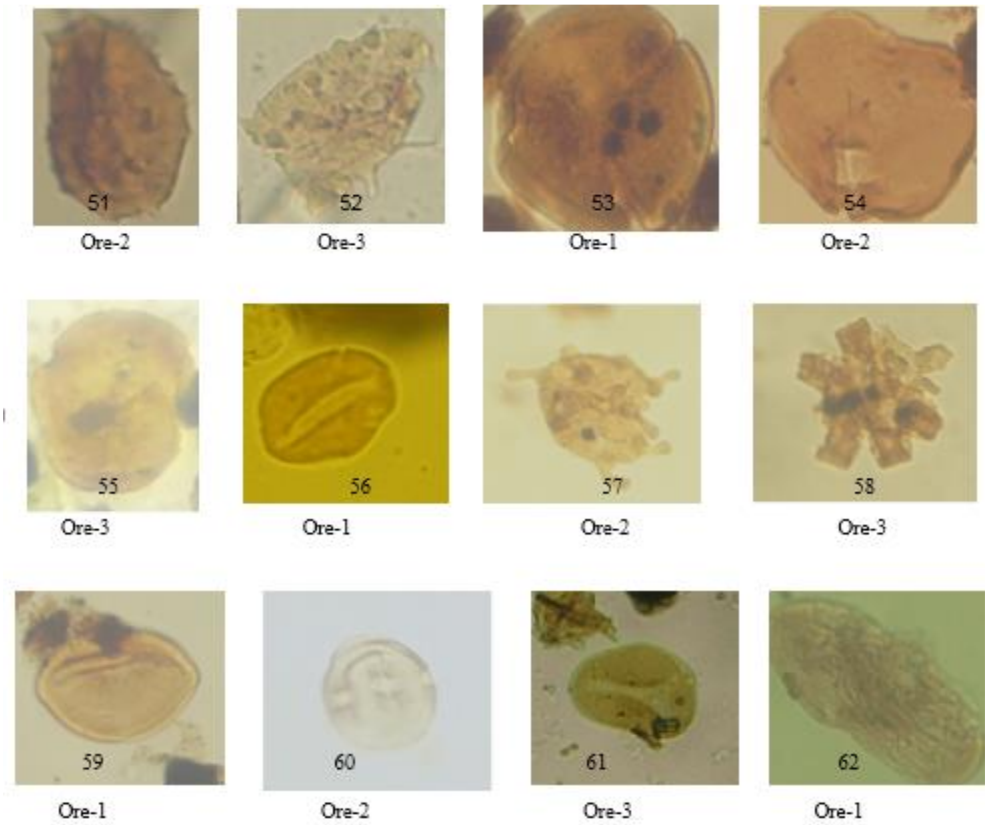


Plate IV: Palynomorphs recovered from studied wells (x600 µm)

Plate IV

51.*Mauritiiditeslehemani*Salard- Cheboldaeff, 1979 (Oil mimmersion).

52.*Spinizonocolpitesechinatus*(Muller, 1968) (Oil immersion).

53-55. *Psilatricolporitescrassus*(Van der Hammen et Whimstra, 1964).

56.*Psilamonocolpitesmarginatus*(Van HoekenKlinkenberge, 1964) (Oil immersion).

57.*Grimsdalea poligonalis*(JanduChene*et al*., 1978).

58. *Ctenolophoniditescoastatus*(Van HoekenKlinkenberge, 1966).

59-60. *Sapotaceae*(Oil immersion).

61. *Elaiseguneesis.*

62.*Striatricolpites catatumbus*(Gonzalez, 1967).

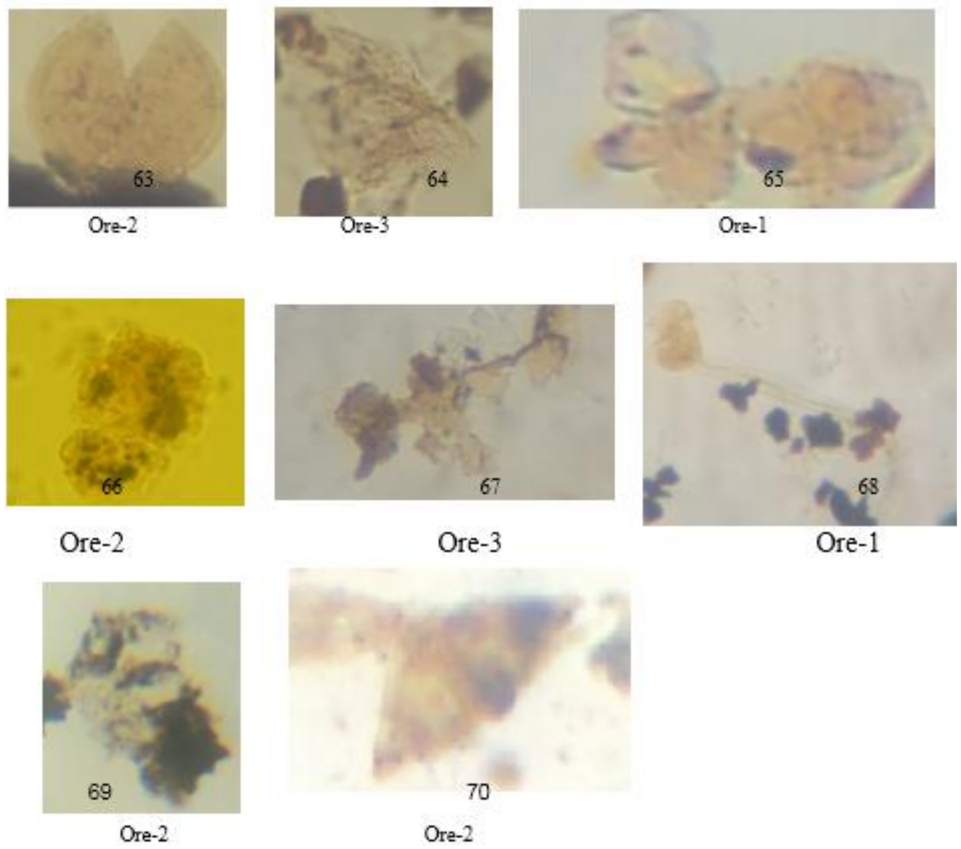


Plate V: Palynomorphs recovered from studied wells (x600 μm)

Plate V

63.*Monocolpollinitesspheroidites.*

64. *Pediastrum*sp(Gelorini*et al*., 2011).

65-66. *Botryoccocusbraunii*(Kuzing, 1849).

67-68. Fungi spore.

69. Uniserial foraminiferal lining.

70. Fungal sporel.

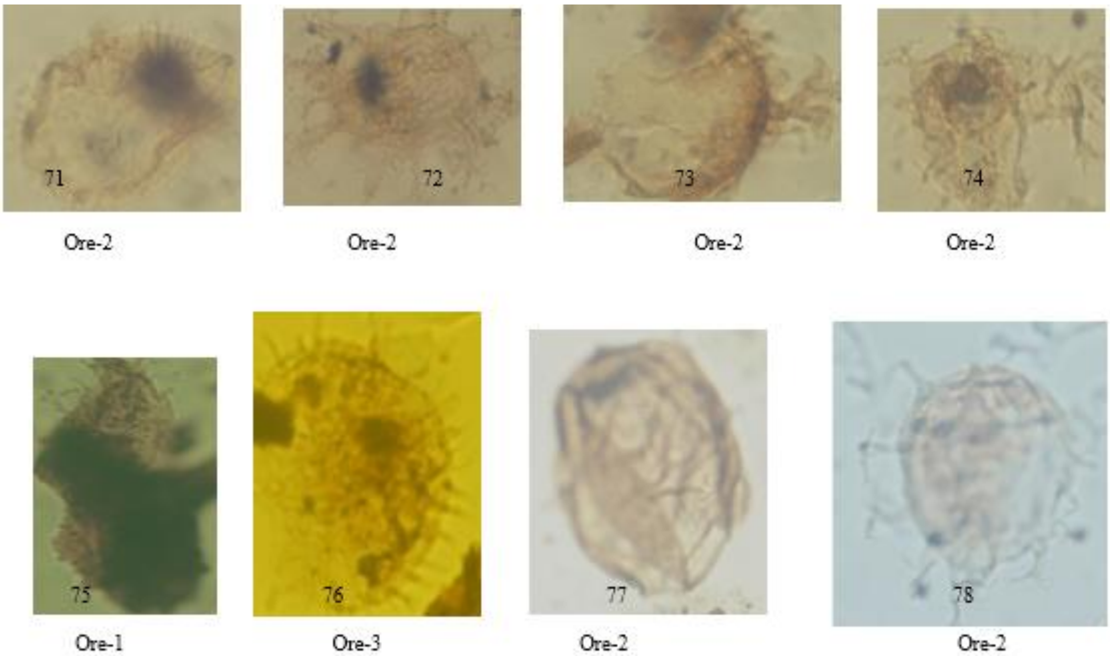


Plate VI: Palynomorphs recovered from studied wells (x600 µm)

Plate VI

71.*Polysphaeridium* sp(Bujak*et al*., 1980) (oil immersion).

72.*Achomosphseara*sp (oil immersion).

73.*Oligosphaeridia*sp (oil immersion).

74.*Spiniferites*sp(Deflandre and Cookson, 1955; Sargent Was, 1970) (oil immersion).

75-76. *Lingulodiniummachearaphorum*(Deflandre and Cookson, 1955)(oil immersion).

77.*Leiosphaerida*sp(Eisenack, 1958) (oil immersion).

78.*Spiniferitesramosus.*

Kingdom: Plantae (Pontonie and Kremp, 1954).

Division: Sporites(Pontonie and Gellectich, 1933).

Class: Monoletes (Ibrahim, 1932).

Genus: *Verrucatosporites* (Vander Hamman, 1956).

Species:*Verrucatosporitesusmensis*(Vander Hamman, 1956).

Description: A bilaterally symmetrical single grain spore with a reniform shape.Thelaesurais on the proximal face and situated at the central part of the pole. It has a warty (verrucate) surface that is round and very conspicuous with varying dimensions. Thelength measures 2.1 to 2.3 mm, width, 1.3 to 1.4 mm,(Plate I, Figure 1 and2).

Botanical affinity: Unknown.

Remarks: Occur in almost all intervals of the studied section.

Age: EocenetoPleistocene.

Genus: *Verrucatosporites*(Ibrahim, 1932).

Species: *Verrucatosporites*sp(Ibrahim, 1932).

Description: Monolete spore, bilaterally symmetrical, boat shape in equatorial view with verrucate to germinate sculpture. The length is 2.5 to 2.3 mm while the width measure 1.4 to 1 .7 mm.(Plate I, Figure 3 to 6).

Remarks: Common in all the wells and of different species.

Age: Eocene to Pleistocene.

Genus: *Laevigatosporites*sp (Ibrahim, 1933).

Species:*Laevigatosporites*sp (Ibrahim, 1933).

Description: A spore with a laevigate inner margin, amb is reniform (beans) shape, laesura situated at the concave side with a smooth (psilate) exine.Thespore measure 1.5 to 2.6mm in length and width between 0.9 to 1.5mm (Plate I, Figure 20, Plate II, Figure 21).

Botanical affinity:Polypodiaceae.

Remarks: Common in the studied section of the three wells.

Age: PaleocenetoPleistocene.

Class: Trilete spores.

Genus: *Acrostichum* (Linneaus, 1953).

Species:*Acrostichumaureum*(Linneaus, 1953).

Description: A tetrahedral spore commonly known a ‘golden leather fern’, the spore has a very clear and conspicuous and simplelaesura that are parallel, roundish triangular shape with a very distinct surface ornamentation. Surface is granulate with granules close to the commusurae, also associated with this golden leather fern is folding.

Dimension:Length 3 to 2.3mm, width varies between3.2 to 2.4mm,(Plate I, Figure 10 - 13).

Botanical affinity: Pteridaceae.

Remarks: Wellrepresented in the studied well.

Age: Paleocene toEocene.

Genus: *Pteris*(Pontonie and Kremp, 1954).

Species: *Pteris* sp(Pontonie and Kremp, 1954).

Description: A homosporus fern with a sub triangular amb, traditionally known as brake.Thebrownish and yellowish soriof the spore are marginally borne on the commisurae connected with veins on both sides, laesura are parallel and flange with coarse reticulate distal face and ornamentation is perine, thickening is also common in some of the general as seen in (Plate 1, Figure 14 to 16). The length of the different species are same with 1.3mm while a sight difference in width, the width measure 1.5 to 1.3mm

Botanical affinity: Polypodiaceae (Nagy, 1985).

Remarks: few appearances in wells of study.

Age: Oligoceneto Late Miocene.

Genus: *Cyathidites* (Couper, 1953).

Species:*Cyathidites minor* (Couper, 1953).

Description: Ambis sub triangular, exine is smooth, thick exine with granule at the surface, (Plate 1, Figure 16 to 19) the species in figure 16 have been recorded by Norris (1968), sizes of the species differs and measure between 1.3 to 1.8mm in length and 0.6 to 1.9mm in width.

Botanical affinity: Pteridopsida.

Remarks: Found at the interval of 9945 - 9625 ft in Ore-2 and absent in Ore-1 and 3 respectively, except for a lone occurrence of the species seen at 10475 ft in Ore-3.

Age: EocenetoMiocene.

Remarks:well represented in the upper part of Ore-2 well absent in Ore-1 well.

Genus:*Strereistosporites*(Thompson and Plung, 1953).

Species: *Stereistosporites*sp(Plung, 1953).

Description: The ambitusof this spore is prolate. Exine ornamentation is psilate, laesurae bold and covering three quarter of the radius Length,1.1mm and width,0.9mm (Plate 1, Figure 9).

Botanical affinity: Sphaghaceae.

Age: Eocene.

Remarks: This spore is only found in Ore-2 well at the interval of 9810 ft and10435ft.

Kingdom: Plantae (Pontonie and Kremp 1954).

Division: Pollenites (Pontonie and Kremp 1954).

Class:Alete.

Genus: *Grimsdalea*(JanduChene*et al.*, 1978).

Species:*Grimsdaleapolygonalis* (JanduChene*etal.*, 1978).

Description: A pollen without an aperture, nearly sphericalamb with fine baculate to scabrateexine (Plate IV, Figure 57). Length, 1.0mm, width,0.8mm.

Botanical affinity: Aracacae.

Age: Early Eoceneto Middle Eocene.

Remarks: Spot occurrence from the three wells of studied.

Class:Monoporatae (Iverson and Troels Smith, 1950).

Genus:*Monoporites* (Vander Hammen, 1954).

Species: *Monoporitesannulatus*(Germeraad *et al.*, 1968).

Description: Radially symmetrical, isopolar pollen with smooth ornamentation with a pore at the annulus, (Plate II, Figure 22 to 26). Length ranges from1.3 to1.1mm, width varies from 0.5 to 0.8mm.

Botanical affinity: Poaceae.

Age: EocenetoMiocene.

Remarks: Consistence occurrence in Ore-1 but rare in Ore-2 and 3, all species have been recorded by (Adojoh*et al*.,2019).

Genus: *Germmamonoporites*(Vander Hammen and Garcia, 1965).

Species:*Germmamonoporites*sp(Vander Hammen and Garcia, 1965).

Description: A gemmate pollen with globularoutline, gemmae is of different dimension. Length is between 1.6 to2.3mmand widthis0.5 to 1.3mm (Plate III, Figure 47 and 48).

Botanical affinity: Unknown.

Age: Earlyto MiddleMiocene.

Remarks: Consistence occurrence in Ore-2 but lone specie at 10350ft in Ore-1, two species at Ore-2 at the interval of 9740ft and 9755ft.

Class:Monocolpates (Inversen and Trols Smith, 1950).

Genus: *Psilamonocolpites*(Van Hoeken-klinkenberge, 1964).

Species:*Psilamonocolpitesmarginatus*(Van Hoeken-klinkenberge, 1964).

Description: Single colpus at the margin that is conspicuous,exine is psilate, ambisoblate. Lenghtvaries from 0.9 to 2mm, width, 0.7 to 1.5mm. (Plate I, Figure 8 and Plate IV, Figure 56).

Botanical affinity:Aracaceae.

Age: Paleocene to Eocene.

Remarks: Common in studied wells.

Genus: *Monocolpollinites*(Inversenand Troels Smith, 1950).

Species: *Monocolpollinitesmarginatus.*

Description: Single elongated colpus not reaching the pole, amb is circular and psilate.Length, width, mm (Plate III, Figure 43) but Figure 42 has a long broad colpus reaching the pole, amb is somewhat boat like.Length is 4.0mm and width is1.5mm.

Age: Maastrictian to Miocene.

Genus:*Proxapertites*(Vander Hammen, 1956).

Species:*Proxapertitescursus*(Van Hoeken-klinkenberge, 1966).

Description: A zonoaperturate (single aperture at the equator), oblate to prolate in shape with irregular elliptic equatorial outline, ornamentation is coarse and reticulate (Plate III, Figure 38 to 40). Length varies from 2.6 to3.2mm, width ranges from 1.9 to 2.5mm.

Botanical affinity:Nypa.

Age:PaleocenetoEocene.

Remarks: Rare in the wells.

Class:Trichotomonosulcate.

Genus: *Elais.*

Species:*guineesis.*

Description: A trichotomonosulcate pollen commonly called Africa palm, exine is finely reticulate with elliptical shape (Plate IV, Figure 61). Length, 1.1mm, width, 0.9mm.

Botanical affinity: Palm (Aracaeceae).

Age: Middle toLate Miocene.

Remarks:Present only in Ore-2 well.

Class:Tricolporatae (Inverson and Troels, 1950).

Genus:*Psilatricolporites*(Vander Hammen, 1954).

Species:*Psilatricolporitescrassus* (Vander Hammen and Wijstra, l964).

Description: one grain, outwardly even, sphere-shaped to subangular. Grain is tricolporatecolpi with straight forward edges and pointy ends, ora is stretched out equatorially. Exine is psilate and perforated (Plate IV, Figure 53to 55). Length, 1.9mm, width, 1.9mm.

Botanical affinity: Euporbiaceae.

Age: Early MiddletoLate Midlle Eocene.

Remarks: The length and width are equal and the other two most have been affected by burial pressure due to there shapes.

Genus:*Brevitricolporites*(Anderson, 1960).

Species:*Retibrevitricolpitestriangulatus*(Vander Hamman andWystra, 1964).

Description:ambitus is subtriangular, reticulate surface, furrow is coastae, tricolpate pollen (three colpi with the pores on the surface of the colpi. Length ranges between 1.0 to 1.6mm, width is between 1.1 and 1.2mm(Plate II, Figure 27 to 29).

Botanical affinity:Euphorbiaceae.

Age: Middle Eocene.

Class: Tricolpate(Inversenand Troels Smith, 1950).

Genus:*Doulaidites*(Legoux, *et al*, 1970).

Species:*Doualaiditeslaevigatus* (Legoux,*et al*., 1970).

Description:Amb is arched triangular, exine ornamentation is psilate with two opeanings. Length, 0.9mm width, 0.7mm (Plate II, Figure 30 to 32).

Remarks: This particular pollen is a marker of P450 (Figure 30 and 31) and must have been affected by burial pressure.

Age: Eocene to Miocene.

Genus:*Striatricolpitescatatumbus*(Gonzalez, 1967).

Species:*Striatricolpitescatatumbus*(Vander Hammen, 1956) ex Gonzalez, 1967.

Description: this tricolpites pollen grain has long colpi reaching the poles with exine ornamentation is striate (Plate IV, Figure 62).

Remarks: This pollen grain is only seen in Ore-2 well at an interval of 9850ft and 10550ft.

Age: Eocene to Miocene.

Genus: *Pradapollis*(Boltengen and Salard, 1973).

Species:*Pradapollisflexibillis*(Legoux, 1978).

Description: Ambitus iscircular, coarsely reticulate exine, length, 1.5mm and width, 1.3mm (Plate II, Figure 34) while *Pradapollis*sp(Figure 33) length measured3.6mm, width1.6mm.

Age: Eocene to Miocene.

Remarks: *Pradapollis*sp is some what elongated with very coarse reticulate sculpture compare with *Pradapollisflexibillis.*

Class: Stephanocolpate (Inverson and Troels Smith, 1950).

Genus:*Ctenolophonidites* (Germeraad*et al*., 1968).

Species:*Ctenolophoniditescoastatus* (Germeraad*et al*., 1968).

Description: A ring like structure with sixcolpi that fuse together, the pore is in the centre (Plate IV, Figure 58).

Botanical affinity: Ctenolophonaceae.

Age:Paleoceneto Middle Miocene.

Remarks: Consistence in Ore wells.

Division: Pyrhophyta (Mantell, 1850).

Class: Dinophyceae.

Genus: *Spiniferites* (Mantell, 1850; Sarjeant Was 1970).

Species:*Spiniferites*sp (Mantell, 1850; Sarjeant Was, 1970).

Description: Sphere-shaped to ellipsoid dominantform, well-definedarrangement, gonal – intergonal processes remain furcatedby the apexes (Plate VI, Figure 74).

Age: Eocene to Recent.

Remarks: Rare in the three studied wells.

Genus: *Leiospheridia*(Eisenack, 1958).

Species: *Leiospheridia*sp(Eisenack, 1958).

Description: Spherical to ovaidal shape. Cell wall is thin and without tubes, surface is psilate with slight ornamentation (Plate VI, Figure 77).

Age: Eocene to Recent.

Remarks: Rare in the wells.

Genus: *Lingulodinum*(Wall, 1967).

Species:*Lingulodinummachaerophorum*(Deflandre and Cookson, 1955).

Description:Chorate is spherical in shape with spines, surface are granulated (Plate VI, Figure 75-76).

Age: Eoceneto Recent.

Division: Chlorophyta/Algae.

Class: Acanthophyceae.

Genus:*Botryococcus.*

Species:*Botryococcusbraunii* (Kutzing, 1849).

Description: Algae, radially symmetrical and isopolar, flat and irregularly shaped.Surface is perforated around the pores (Plate V, Figure 65 and 66).

Age: Eocene to Recent.

Remarks: Abundant from in the three wells.

4.2.1.1 Stratigraphic age range of some recovered palynomorphs in Ore wells

Stratigraphic age range ofsomerecovered palynomorphs (pollen and spores) are presented in (Figure 4.7). Most of the recovered palynomorphs have been recorded byGermmeraald*et al;* 1968;Ige (2009, 2011), Bankole (2010) and Niger Delta Palynological Consortium Biostratigraphic Sub-Committee (2000).

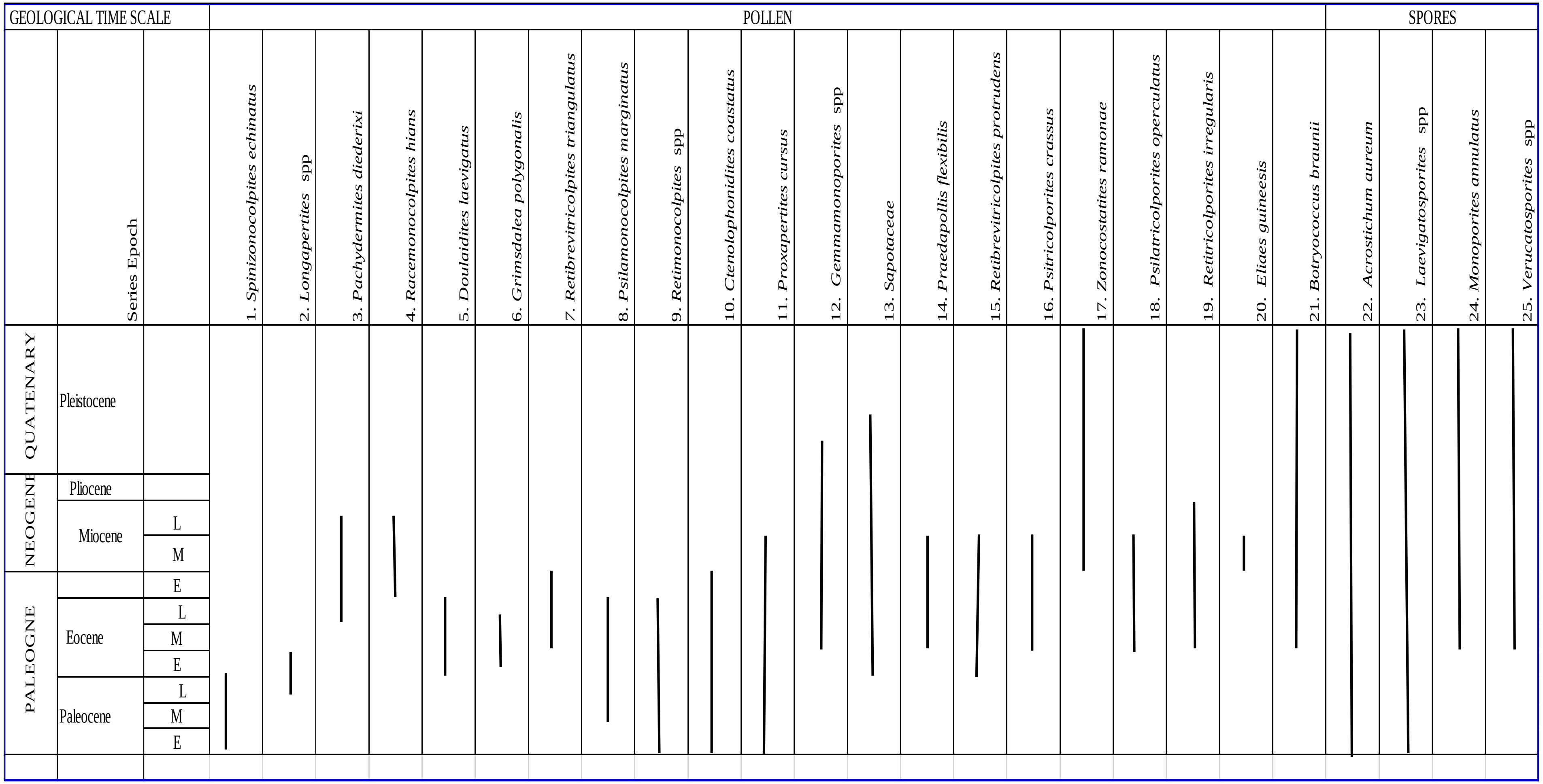


Figure 4.7: Stratigraphic age range of palynomorphs recovered from Ore wells (Niger Delta Palynological Consortium Biostratigraphic Sub-Committee, 2000)

4.2.1.2Palynostratigraphiczonationsof Ore wells

Accurate dating of stratigraphic successions based on their fossils contents (palynomorphs) is referred to as palynostratigraphy. Asuccessful palynostratigraphiczonations based on fossil floras allows subdivision of stratigraphic column into smaller scale or units irrespective of lithology.This will allow the recognition and understanding of short time events going on in the stratigraphic column and establishment of correlation between time equivalents.This is because fossil floras are great indicator of time ranges due to theirrapid evolutionary trend.Thepalynostratigraphic zones established in this study was based on the concept of Oppel (1856), the International Stratigraphic Guide an edited version of Murphy and Salvador (1999) and the North American Stratigraphic Code (Boggs,2006).Oppel (1856) was the first to introduce the concept of zonation, the author noted that some species of fossils taxa exists for a short time while some are long ranging others overlapping another. Based on unique assemblage of fossils from the studied section the interval range zone has been established, using the first appearance datum (FAD) and last appearance datum (LAD).

The interval range zone is defined as a body of strata between two definitepalynostratigraphic horizons.The limits of the Interval zone are characterized by two taxa recognized at the lowermost and uppermost section within a specific horizon.

4.2.1.3Palynostratigraphiczonationof Ore-1 well

Zone-1:***Verrucatosporitesusmensis–Ctenolophoniditescostatus*Zone (Interval Zone)**

Stratigraphic interval: 10350ft-10245ft.

Definition:The zone is marked at the base by first appearance datum (FAD) of*Verrucatosporitesusmensis* and on top by thelast appearance datum (LAD) of*Ctenolophoniditescoastatus*.

Characteristics: The zone is characterised bytheappearance of*Doulaiditeslaevigatus*a pollen thatmark the base of the P450 zone and *Monoporitesannulatus* an index pollen of P420 and P430 zone belonging to the Niger Delta Palynological Consortium BiostratigraphicSub-Committee (2000). Other characteristics palynomorphs found in the zone are *Monoporitesannulatus, Proxerpertites cursus, Psilamonocolpitescrassus,Retimonocolpitesobaensis, Retibrevitricolpitestriangulatus, base rich continuous Accrostichumaureum*, *Laevigatosporites*sp, *Verucatosporites*sp, *Verucatosporitesusmensis, Pteris*sp, *Lingulodiniummachaerophonum, Polysphaeridiumzohayi*and fresh water algae *of Botryoccocusbraunii*. Also characterising the zone are single occurrence of*Germmamonoporites*sp, *Mauritiditeslehmani,Spiniferites*sp,*Polysphaeridiumzohayi, Spiniferitesramosus*and*Oligosphaeridium*sp.

Age: The zone is datedMiddle Eocene (Lutetian) due to the presence of*Retimonocolporitesirregularis, Pachydermitesdiederixi,Retimonocolpitesobaensis*and first appearance of*Daoulaiditeslavigatus*purely Eocene taxa that mark the base of the P450.

Remark: The zone is equivalent to the P400 and P430 sub zone of Evamy*et al*., (1978).The zone is rich in *Acrostichumaureum, Psilatricolporitescrassus*and*Retimonocolpitesobaensis*.Also characterising the zone is a lone occurrence of *Germmamonoporites*sppollen belonging purely to the Miocene age and *Maritiiditeslehimani*. The presence of *Gemmamonoporites*spin this zone may be as a result of caving in the process of drilling or mixingof the ditch cuttings from the field during drilling operations and the indeterminate may be reworked taxa due to improper storage.This is because *Gemmamonoporites*sp is of much younger age than the Eocene which may also be considered as part of the limitations ofbiostratigraphy.

Zone- 2:***Pachydermitesdeiderixi- Grimsdaleapolygonalis*****Zone(Interval Zone)**

Stratigraphic interval:10245ft-10125 ft.

Definition: The zone is defined at the base by the first appearance datum (FAD) of *Pachydermitesdiederixi* and at the top by last appearance datum (LAD) of *Grimsdaleapolygonalis.*

Characteristics:The group palynomorphs found in this zone are base rich of *Psilamonocolpitescrassus*and*Verucatosporites*sp,*Monoporitesannulatus, Proxerpertites cursus,Retimonocolpitesobaensis, Retibrevitricolpitestriangulatus, base rich continuous Acrostichumaureum,Laevigatosporites*sp, *Psilamonocolpitesmarginatus,Daoulaiditeslavigatus,Pachydermitesdiederixi,Ctenolophoniditescoastatus, Acrostichumaureum, Laevigatosporites*sp, *Verrucatosporitesusmensis, Pteris*sp, *Botryoccocusbraunii,Lingulodiniummachaerophonum*and*Polysphaeridiumzohayi.*

Age:Assigned to this zone is MiddletoUpper Eocene age (Bartonia) due to the presence of *Psilamonocolpitesmarginatus* a pollen use to define the top of the P450 subzone of the P400 pollen and spores zonation scheme.The presence of*Daulaiditeslaevigatus* a pollen that exists only in the Eocene and used to mark the base of the P450 zone has its first appearance in this zone.

Remark: Thezone corresponds to the P450 subzone of P400 ofEvamy*et al*., 1978, Shell Petroleum Development Company (SPDC) and the Niger Delta Palynological ConsortiumBiostratigraphic-Sub Committee Zone (2000). The zone recorded high occurrence of *Psilamonocolpitescrassus, Verrucatosporites*spand*Verrucatosporitesusmensis.*

Zone- 3:***Spinizonocolpitesechinatus* - *Proxapertitescursus*Zone(Interval Zone)**

Stratigraphic interval:10125 ft – 9705ft.

Definition: The base of the zone is defined by last appearance datum of *Spinizonocolpitesechinatus*(LAD) top defined by first appearance datum (FAD) of *Proxerpertites cursus.*

Characteristics: Characteristic palynomorphs found within the zone are single occurrence of *Sapotaceae,Retitricolporitesirregularis,Racemonocolpiteshians and Gardenia imperelis.* Other palynomorphs are*Psilamonocolpitesmarginatus,Doualaiditeslaevigatus,Psilatricolpitesoperculatus,Monoporitesannulatus,Zonocoastitesramonae,Proxapertites curses,Psilamonocolpitescrasus,Retibrevitricolpitestriangulatus,Acrostichumaureum,Laevigatosporites*sp, *Verrucatosporitesusmensis,Botryococcusbraunii, Sapotaceae* and *Lingulodiniummachaerophorum.*

Age:The zone is dated Upper Eocene (Bartonia) based on the presence of *Grimsdaleapolygonalis*,*Psilamonocolpitesmarginatus*and top rich *Retibrevicolpitestriangulatus*which suggest that the interval is of Early Eocene sediment(Jan Duchene *et al*., 1978).

Remark: The zone corresponds to the P470 zone subzone of Evamy*et al*. (1978).

4.2.1.4 Palynostratigraphiczonation of Ore-2 well

Zone - 1:***Verrucatosporitesusmensis –Pachydermitesdeiderixi*Zone (Assemblage Zone)**

Stratigraphic interval:10575ft – 10410ft.

Definition: The zone is defined as assemblage zone becausethezone is marked at the topbythree taxa with shared characteristics. These taxa are *Sapotaceae, Pachydermitesdiederixiand Retibrevitricolpitesprotrodens.*

Characteristics: Other characteristic palynomorphs in the zone are*Doulaiditeslavigatus*,*Racemonocolpiteshians*,*Pradapollisflexibilis*,*Grimdaleapolygonalis*,*Proxapertitescursus*,*Pachydermitesdiederixi*,*Striatricolporitescatatumbus,Retibrevitricolpitestriangulatus*,*Pradapollis*sp,*Psilatricolporitescrassus,Germmamonoporites*sp, *Zonocoastitesramonae,Acrostichumaureum, Cyathidites*sp, *Leavigatosporites*sp, *Verrucatosporitesusmensis*,*Pteris*sp, *Stereisporites*sp, *Botryoccocusbraunii*,*Lingulodiniummachearophorum*,*Operculodiniumcentrocapum*and *Oligosphaeridium* sp.

Age: The zone is dated Middle Eocene based on palynomorph assemblages of Dauladites*lavigatus,* *Pradapolisflexibilis*,*Psilatricolporitescrassus*,*Grimsdaleapolygonalis*,*Psilatricolporites marginatus*,*Pradapolis*sp,*Perchydermitesdiederixi*, *Verrucatosporites*sp and*Racemonocolpiteshians*.

Remark: Immediately at the base of the zone lays *Daoulaiditeslavigatus* a marker species that marks the First Appearance Datum of theP430 sub zone. The zone is equivalent to P430 subzone of Evamy*et al*.(1978). The baseis rich in*Acrostichumaureum*andconsistence frequency in *Retimonocolpitesobaensis* and scanty occurrence of dinocysts.

Zone-2:***Retibrivitricolporitesprotrudens - Grimsdaleapolygonalis*****Zone(Interval Zone)**

Stratigraphic interval: 10410ft-10185ft.

Definition: Thezone is defined at the base by first appearance datum (FAD) of*Rtibrvitricolporitesprotrudens*and on top by last appearance datum (LAD) of*Grimsdaleapolygonalis.*

Characteristics:Diagnostic palynomorphs found within the zone include the zone are *Doualaiditeslaevigatus*, *Psilatricolporitescrassus,* *Racemonocolpiteshains*, *Monocolpitesmarginatus*, *Monoporitesannulatus*, *Gemmamonoporites*sp, *Psilamonocolpitesmarginatus*, *Sapotaceae*, *Spinizonocolpitesechinatus, Lingulodiniummachearophorum*,*Polysphaeridiumzohazyi*.*Acrostichumaureum*, *Verrucatosporitesusmensis*,*Verrucatosporites*,*Laevigatosporites*sp, *Retibretricolpitestriangulatus*, *Botryococcusbraunii*, *Pediastrum*sp, *Retimonocolpitesobaensis* and *Proxapertites cursus*.

Age: The zone is dated MiddletoUpper Eocene (Bartonian) due to the presence of *Doualaiditeslaevigatus*, *Psilamonocolpitesmarginatus* and

*Retibrevicolpitestriangulatus*whichsuggest penetration of the basal Eocene sediments (Salard, 1979).

Remark: The zone correspondsto the P450 subzone of the P400 ofEvamy*et al*., (1978). The zone is extremely rich in the spore of *Acrostichumaureum*and fresh wateralgae of*Botryoccocusbraunii.*

Zone -3:***Pradapollisflexibillis–Proxapertitescursus* Zone (Interval Zone)**

Stratigraphic interval: 10185 ft-9945ft.

Definition: This zone was established based on last appearance datum (LAD) of *Grimsdaleapolygonalis*at the base andfirst appearance datum (FAD) of*Proxapertitescursus*atthetop.

Characteristics: The interval is marked by consistence high frequency of fresh water algae (*Botryoccocusbraunii*), sparse distribution of marine dinoflagellates of *Spiniferites*sp, *Histrichokolpomarigaudiae, Lingulodiniummachearophorum,Operculodiniumcentrocapum* and *Oligosphaeridium* sp.

Age: The intervalis dated UppertoLate Eocene based on the presence of *Grimsdaleapolygonalis,Doualaiditeslaevigatus* and *Psilamonocolpitesmarginatus.*

Remark: The base of this zone is placed 10200ft defined by*polygonalis* and top occurrence of *Proxapertites cursus*. The base is defined by quantitative occurrence of *Psilatricolpritescrassus.* The subzone boundary between the P470 and P480 could not be asserted due to the absence of the marker specie (*Cinctiperiporitesmulleri*)in this subzone. This missing subzone which could not be asserted may suggest a fault or unconformity. The zone is further characterised by the presence of *Doualaiditeslaevigatus*,*Verrucatosporitesusmensis* and *Psilamonocolpitesmarginatus*.

Zone- 4:***Longapertites*****sp-*****Ctenolopniditescostatus* Zone (Interval Zone)**

Stratigraphic interval: 9945ft – 9795ft.

Definition: The zone is defined by first appearance datum (FAD) of *Longerpertites*sp at the base and last appearance datum (FAD) of *Ctenolopniditescoastatus*at thetop.

Characteristics: The zone is characterised by the presence of *Racemonocolpiteshians, Germmamonoporites*sp, *Psilamonocolpitesmarginatus*,*Pradapollis*sp,*Retibrevitricolpitesibadanesisand Striamonocolpitesundatostriatus*. Base rich*Cyathiditesminor* and more diversity in the marine dinofllagellates.

Age: The zone is dated LowerOligocene based on*Striamonocolpitesundatostriatus*and *Racemonocolpiteshians*marker specie belonging to the P520 zone.

Remark: This is the youngest of the zone identified in the intervals studied in Ore-2 well. The zone falls within the P500 zone and a subzone ofP520 of Evamy*et al.*(1978).

4.2.1.5Palynostratigraphic zonation of Ore-3 well

Zone-1:***Verrucatosporites*****sp -*****Grimsdaleapolygonalis*****Zone (Interval Zone)**

Stratigraphic interval: 10450ft -10340ft.

Definition: The zone is defined by first appearance datum (FAD) of *Verrucatosporites*sp at the base and on top by the appearance of *Grimsdaleapolygonalis.*

Characteristics: The zone is characterised by the presence of*Doulaiditeslaevigatus,Spinizonocolpitesechinatus,Ctenolophoniditescoastatus,Germate*pollen,*Psilamonocolpitesmarginatus,Retibrevicolpitestriangulatus,Retimonocolpitesobaensis, Proxapertites cursus, Ctenolophoniditescoastatus,Lavigatosporites*sp, *Verrucatosporitesusmensis, Lingulodiniummacherophorum* and *Botryoccocusbraunii*. Rich in *Psilatricolpritescrassus*and the spore of*Acrostichumaureum*.

Age:Assigned to this zone is Middle Eocene age. The presence of species*Ctenolophoniditescoastatus*, top occurrence of *Doualaditeslaevigatus* suggest that the the interval is of Middle Eocene. Although the base which is marked by*Margocolporitesfoveolatus* was not encountered in the studied section.

Remark: The zone match with the P400 zone and P430 subzone of Evamy*et al*.(1978).

Zone-2:***Doulaiditeslaevigatus-Ctenolophoniditescoastatus* Zone (Interval Zone)**

Stratigraphic interval: 10340ft-10040ft.

Definition: The zone is marked at the base by first appearance datum (FAD) of *Doualaiditeslavigatus*and on top by last appearance datum (LAD) of *Ctenolophoniditescoastatus.*

Characteristics: The zone is rich in the algae of *Botryoccocusbraunni*,*Acrostichumaureum*. Consistence record of*Verrucatosporites*sp, *Laevigatosporites*sp,*Lingulodiniummachearophorum*. Furthermore, the zone is characterised by the presence of gemmate pollen, lone occurrence of *Spinizonocolpitesechinatus*, *Pradapollis*sp is observed in this zone.

Age: The zone is dated Middle to Upper Eocene.

Remark: The zone is equivalent to P400 zone and a sub zone of P450 of Evamy*et al*.(1978).

Zone- 3:***Pradapollisfl*****exibilis-** ***Psilatricolporitescrassus*****Zone (Interval Zone)**

Stratigraphic interval: 9950ft – 9755ft.

Definition: The zone is defined at the base by first appearance datum (FAD) of*Pradapollisflexibilis* and last appearance datum (LAD) of *Psilatricolporitescrassus*which concedes with the base of the overlying subzoneatthetop.

Characteristics: The zone ischaracterised by scarce distribution of fossil flora (palynomorphs) and lumped together to form this subzone. Characteristic palynomorphs encountered in the subzone are *Pteris*sp, *Proxapertites cursus*,*Zonocoastiteramonae*, *Monoporitesannulatus*, *Gemmamonoporite*ssp, *Daoulaiditeslaevigatus*,*Grimsdaleapolygonalis*, persistence and high record of*Botryoccocusbraunii*. Also, consistencerecord of *Laevigatosporites*sp, *Acrostichumaureum* and *Retimonocolpitesobaensis* and dinocysts of *Operculodinumcentrocarpum*, *Lingulodinummachrorophorum*,*Polysphaeridiumzoharyi* and *Achomosphaera*sp was recorded at this zone.

Age: The zone is dated Upper to Late Eocene (Bartonian and Priabonian).

Remark: The zone relates to the P400 and subzone of P470 and P480 of (Evamy*et al*., 1978).

Zone-4:***Retimonocolpites*****sp-** ***Racemonocolpiteshians*****Zone (Interval zone)**

Stratigraphic interval: 9755ft – 9710ft

Definition: The zone is defined by the first appearance datum (FAD) of*Retimonocolpites*spat the base which concedes with the top of the zone below it and on top by last appearance datum (LAD) of *Racemonocolpiteshians.*

Characteristics: The zone is characterised by *Monoporitesannulatus*,*Accrostichumaureum*,*Laevigatosporites*sp, *Verrucaosporitesusmensis*,*Verrucaosporites*sp, *Pteris*sp and *Botryoccocusbraunii*.

Age: Assigned to this zone is Early Oligocene (Rupelian).

Remark: The zone relates to the P500 and a subzone of P520 of Evermy*et al*.(1978).

4.2.1.6Palynostratigraphic correlation of Ore-1, 2 and 3 wells

Palynostratigraphic correlation across Ore -1, 2 and 3 wells are carried out acrossOre-wells based on similar palynomorphs recovered from the wells (Figure 4.8). Correlation was not fair enough because of different intervals have different taxa, even though the three wells belong to similar age group.This may be due to internal or local processes operating within the basin itself. These processes include channel meandering and delta avulsion which led to redistribution of energy.Retreat and repeated progradation must have also prevented lateral continuity between the three wells of studied.

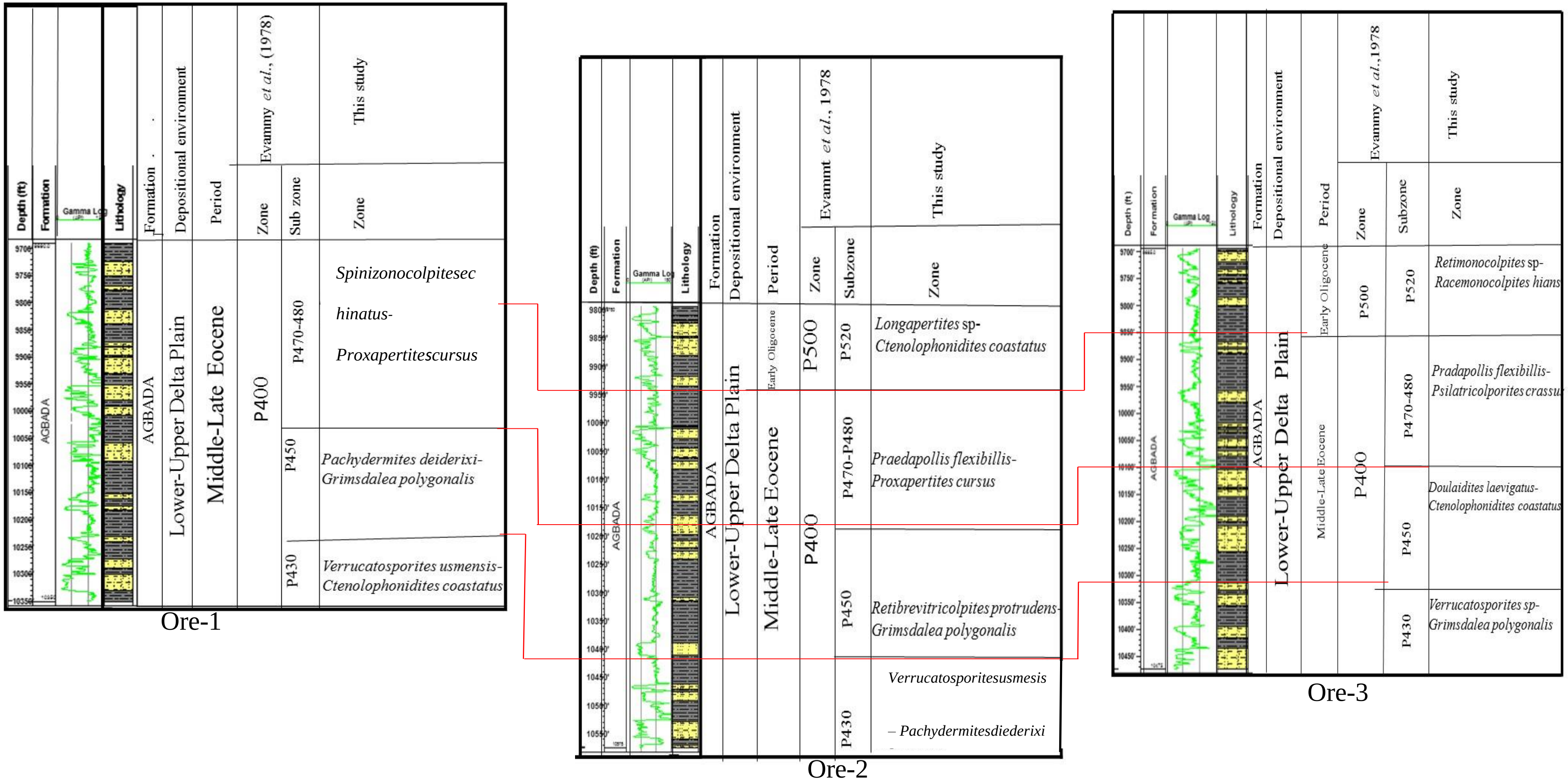


Figure 4.8: Palynostratigraphic correlation of Ore-1, 2 and 3wells

4.3 Palynomacerals

Palynomacerals analysis from the three wells followed the classification of Whitaker *et al*. (1992).Palynomaceral were grouped into four different classes; palynomaceral-1, 2, 3 and 4 based on their appearance, shape, structure and type. The studied section yielded abundant records of palynomaerals1 and 2 and few occurrences of palynomaceral 3 and 4 (Plate VII, Figure 4.4, 4.5 and 4.6) respectively. Structureless organic matter (SOM) was not considered in these studies because only one of such was recovered between the intervals of 9810 ft-9825 ft in Ore-1 well.

4.3.1 Palynomaceral 1 (PM 1) of Ore-1, 2 and 3 wells

Palynomaceral1 recovered from this study have dense appearance, variable shapes (structured or unstructured) and of orange-brown or dark brown colouration (Plate VII). Palynomaceral of this kind consists of alginate material of higher plant origin mainly resinous cortex material which is considered structured materials (Oyede, 1992; Whitaker *et al*., 1992; Batten and Stead, 2005). Also included in this class are algal remains of *Botryoccocus*sp with high specific gravity and large size humic gel like substances. Palynomaceral 1 are considered to be of the lowest buoyancy compared to the other three classes also found in this class is chlorococcale algae of *Botryoccocusbraunii*as stated in Whitaker *et al.* (1992). The palynomaceral of this type is referred to as maceral (PF1) and concomitant to PF 1 of (Tyson, 1995) classification.This is because it is made up of over 90% of palynomaceral I, none recovery of sedimentary organic matter (SOM) and marine taxa ranges between 2-5%.

4.3.1.1 Palynomaceral 2 (PM 2) of Ore-1, 2 and 3 wells

Palynomaceral 2 observed in this study is of brownish-orange colouration of lath (lathy) shape material in structure (Plate VII). Oyede(1992); Whitaker *et al*. (1992); Batten andStead, (2005) described PM 2 as exinite of structureless or structured irregular shape materials of rootlet relics, stem, leaf and relics of algae. PM 2 is considered of higher buoyancy than PM 1 and of lesser degree of gelifiedhumic and resinous substances due to their lathy structure (Oyede, 1992; Whitaker *et al*., 1992; Batten & Stead 2005; Thomas *et al.,* 2015).

4.3.1.2 Palynomaceral 3(PM 3) of Ore-1, 2 and 3 wells

Palynomaceral 3 as observed in this study has a skinny, pale brown colour and irregular shape of plant debris (Plate VII).Oyede (1992); Whitaker *et al*., (1992); Batten and Stead (2005); Thomas *et al.* (2015) specified that palynomaceral 3 are cutinite (leaf cuticle, irregular relics of plants and consists of stomata. It is the more buoyant than palynomaceral 3.

4.3.1.3 Palynomaceral 4 (PM 4) of Ore-1, 2 and 3 wells

Palynomaceral 4 from the studied sediments are variable dark equidimensional blade and needle like shape material with intermittent cellular structure (Plate VII). Whitaker *et al*. (1992) described palynomaceral of this kind as opaque equidimensional material of variable origin. The authors also added that palynomaceral 4 constitute inertinite highly degraded plant material and humic gel.Palynomaceral 4 are also considered as product of forest fires (charcoal) and fossilised material. The blade shapes are extremely buoyant, resistant and transported over long distances. They are also concentrated in high energy and offshore environment.

Generally, PM1, 2, 3 and 4 are primarily of terrestrial origin and their abundance decreases from the shore and water depth as sedimentation rate increases, PM1 and PM 2 are mainly from land plant.

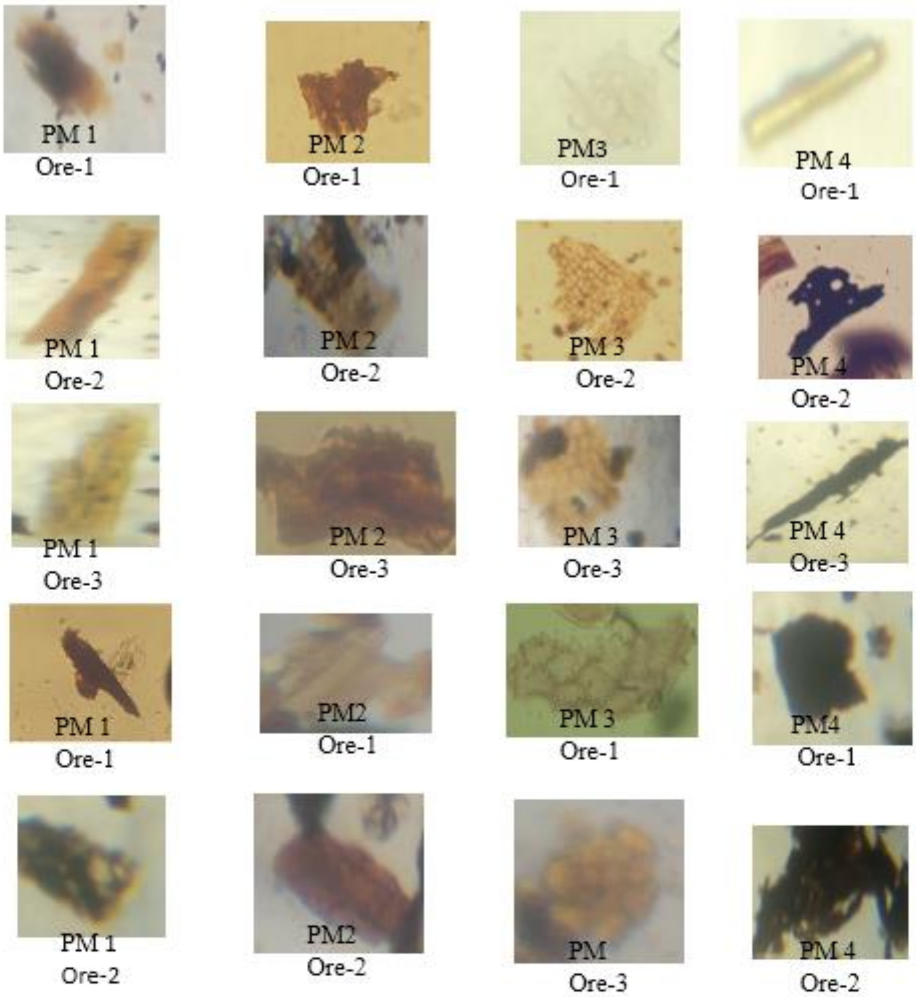


Plate VII: Types of palynomacerals recovered from Ore wells

4.4 PaleoenvironmentalInterpretation of Ore-1, 2 and 3 wells

Paleoenvironment is a periodic time in depositional environment in the geological past. It is very significant to investigate past environment of deposition because different environment implies different reservoir qualities in terms of architectural style, porosity, permeability and connectivity. Four parameters have been integrated to determine the paleoenvironment in which Ore wells have been deposited. These are:

1. The percentage of the recovered palynomacerals and palynomorphs are plotted in (Figure 4.9, 4.10 and 4.11).Each environment be it terrestrial or marine have their own characteristic in which they can be identified (Oyede, 1992). The terrestrial environment is defined by unevenly sorted palynomacerals. Similarly, Tyson (1993) stated that over 90% of PM1 and over 80 % of PM2over 90-80 % and less than 5% of palynomorphs with low values of PM3 and PM4 infer a terrestrial environment with rare dinocysts vice-versa (Figure 4.9,4.10 and 4.11).High value of palynomorphs are common interrestrial and coastal origin (Thomas *et al.*, 2015 andTyson, 1993). The marine counterpart have good sorted palynomacerals with predorminately small and medium PM1 and PM2. Also associated with the marine environment are lathy,tube, needle shape PM4 and dinoflagelates cysts and foraminiferal lining. The dominace of PM1 and PM2 suggest that organic matter from the studied wells is from higher plants. Abundance record of algal of *Botryoccocusbraunii* typified by incursion of fresh water (Bustin,1988).Therefore, palynofacies of this kind infer sedimentation processes in a terrestrial and coastal environment in a reduced salinity.

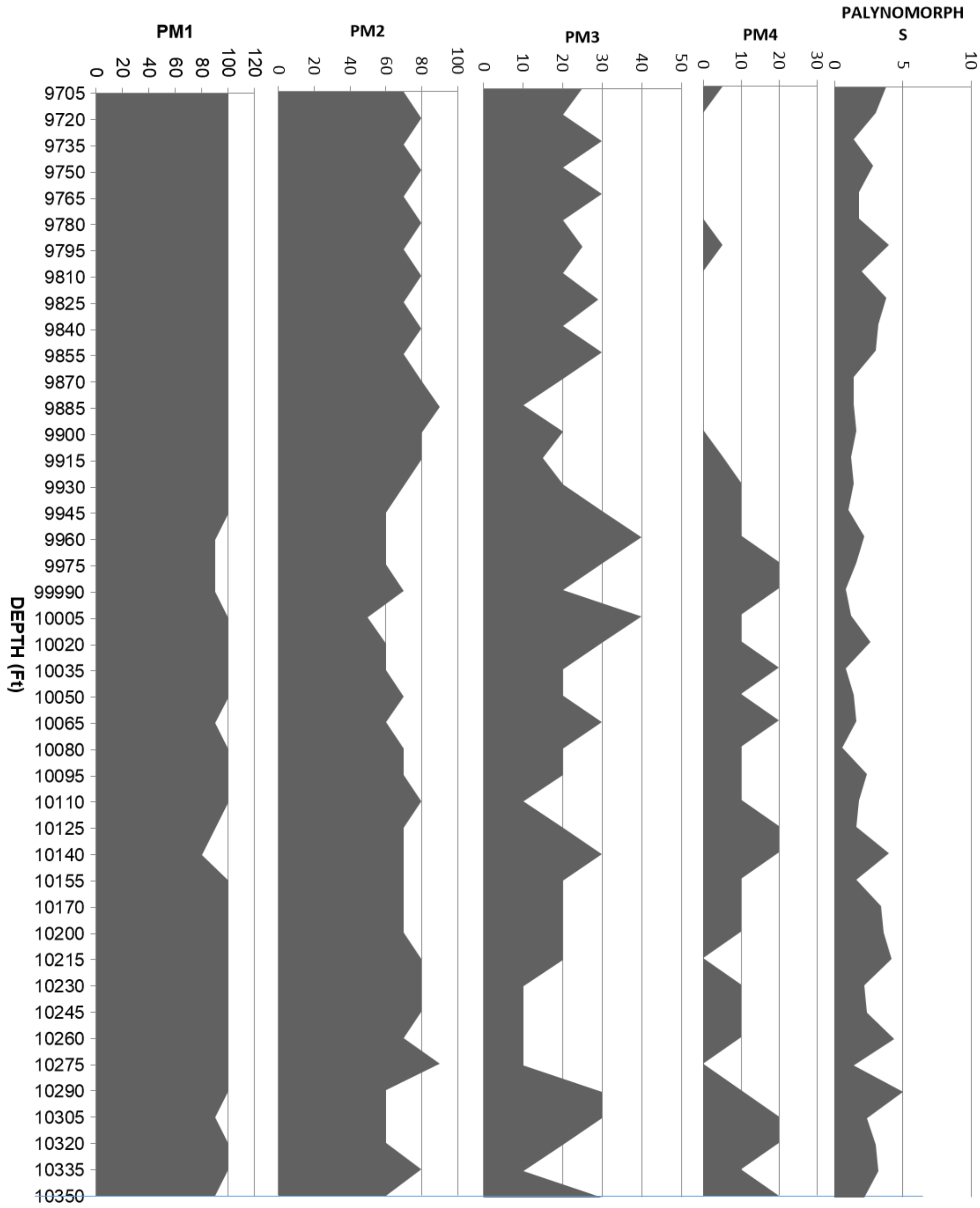


Figure 4.9: Percentagepalynomaceral and palynomorpsof Ore-1 well

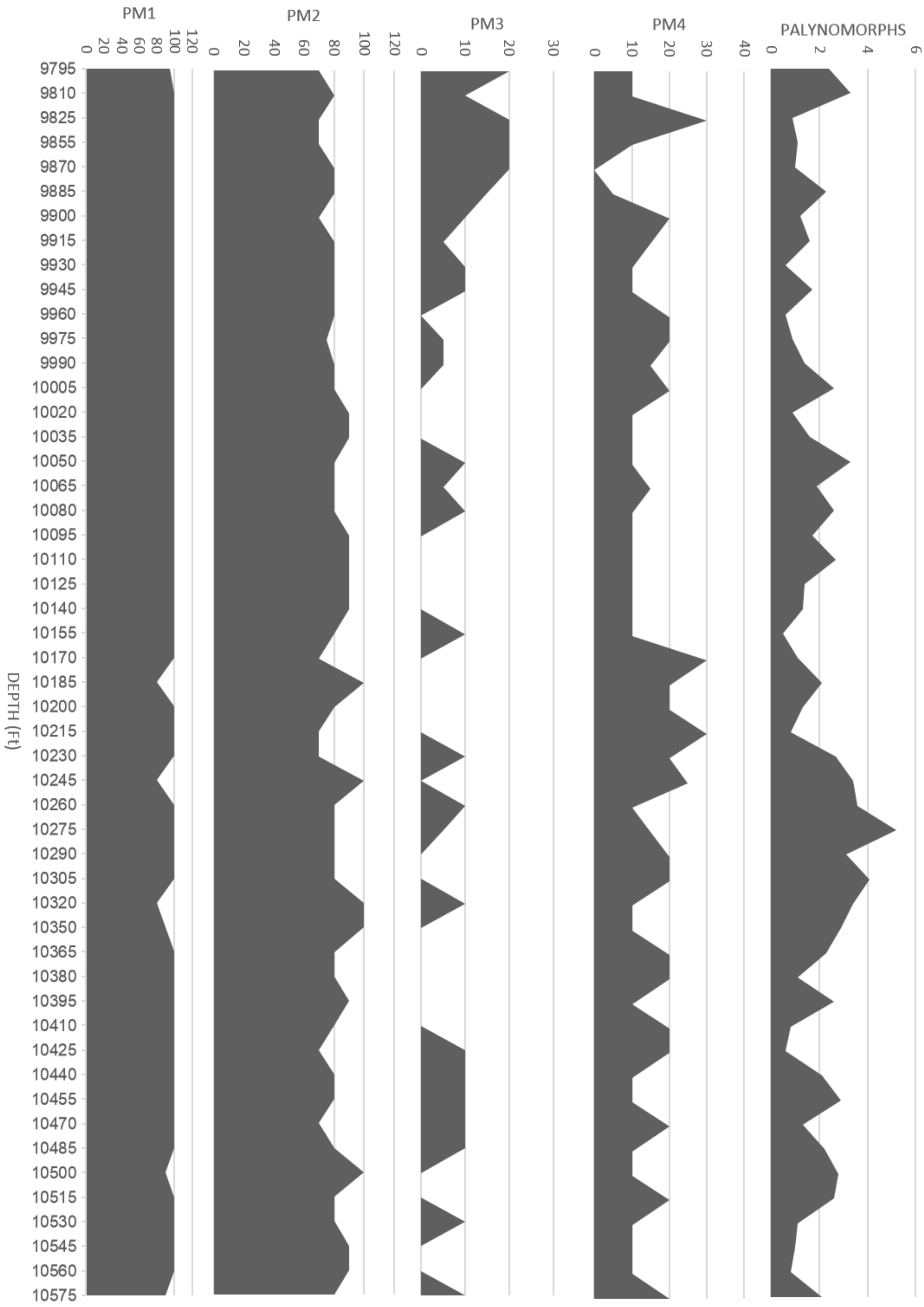


Figure 4.10: Percentage palynomaceralandpalynomorphsof Ore-2 well

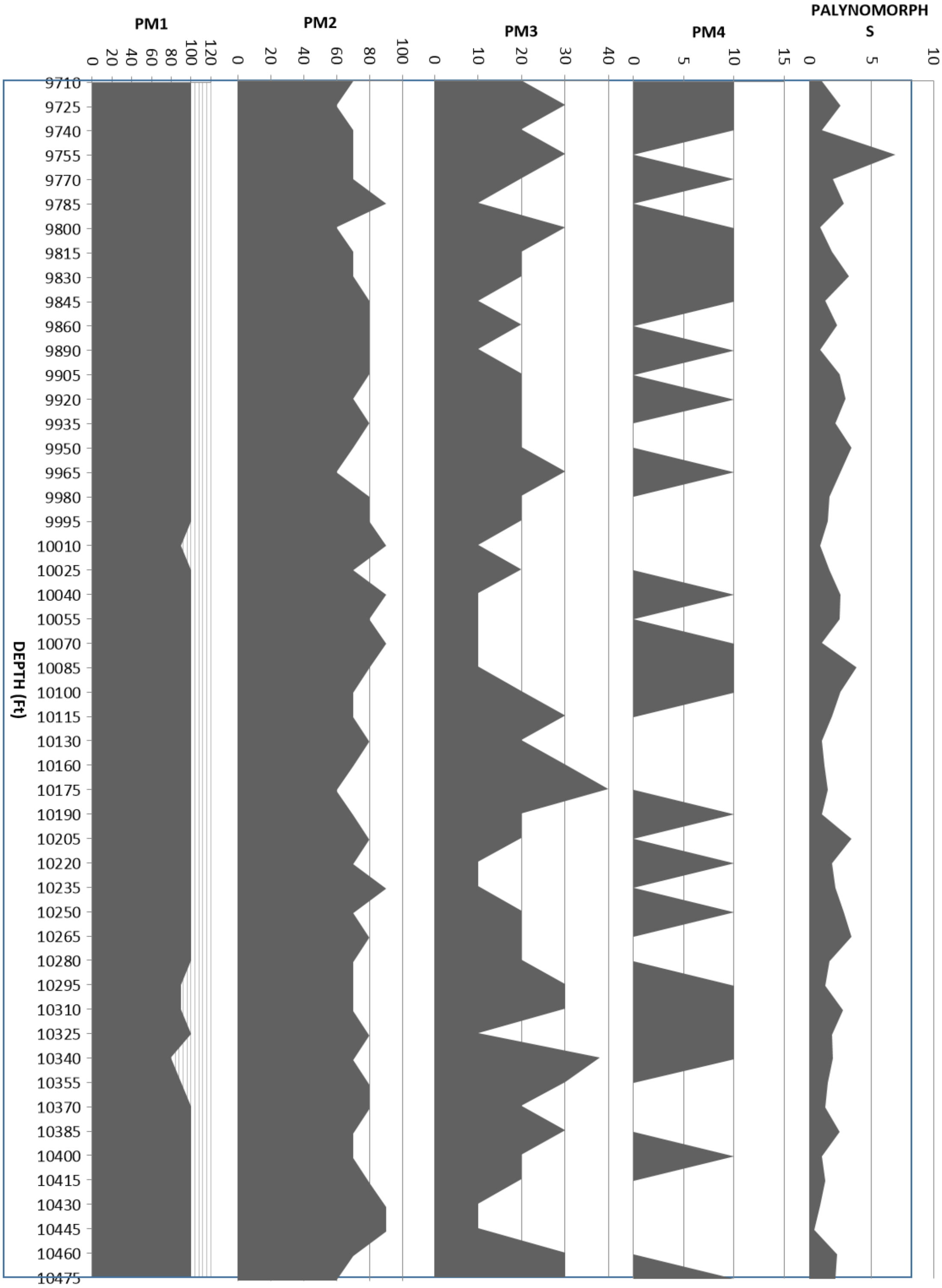


Figure 4.11: Percentage palynomaceral and palynomorphs of Ore-3 well

2. Thepaleoecological groupings of the recovered palynomorphs in the Ore wells are also put into consideration (Appendices A,B and C).Paleoecologicalplotingsfrom the studied intervals reveal that the fresh water palynomorphs recorded the highest values (Figures 4.12, 4.13 and 4.14). The algae of *Botryoccocusbraunii*recorded the highest value amongthe freshwater taxa and as a whole from the studied wells. *Botryoccocusbraunii* have been known to be an important marker for hydrocarbon generation.This is followed by the mangrove, the savanna, rainforest,marineand montane. However there was no record of montane palynomorphs in Ore-1.

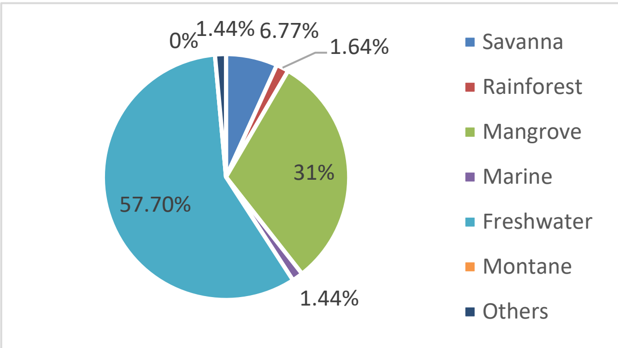


Figure 4.12: Paleo-ecological ploting of palynomorphs from Ore-1 well

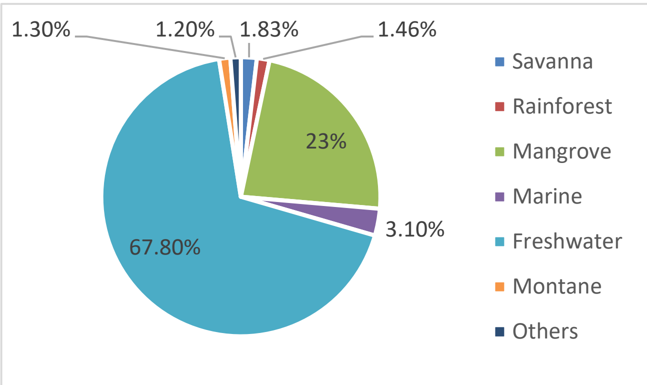


Figure 4.13: Paleo-ecological plotings of palynomorphs from Ore-2 well.

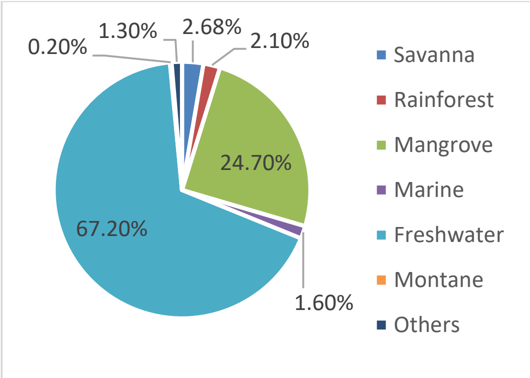
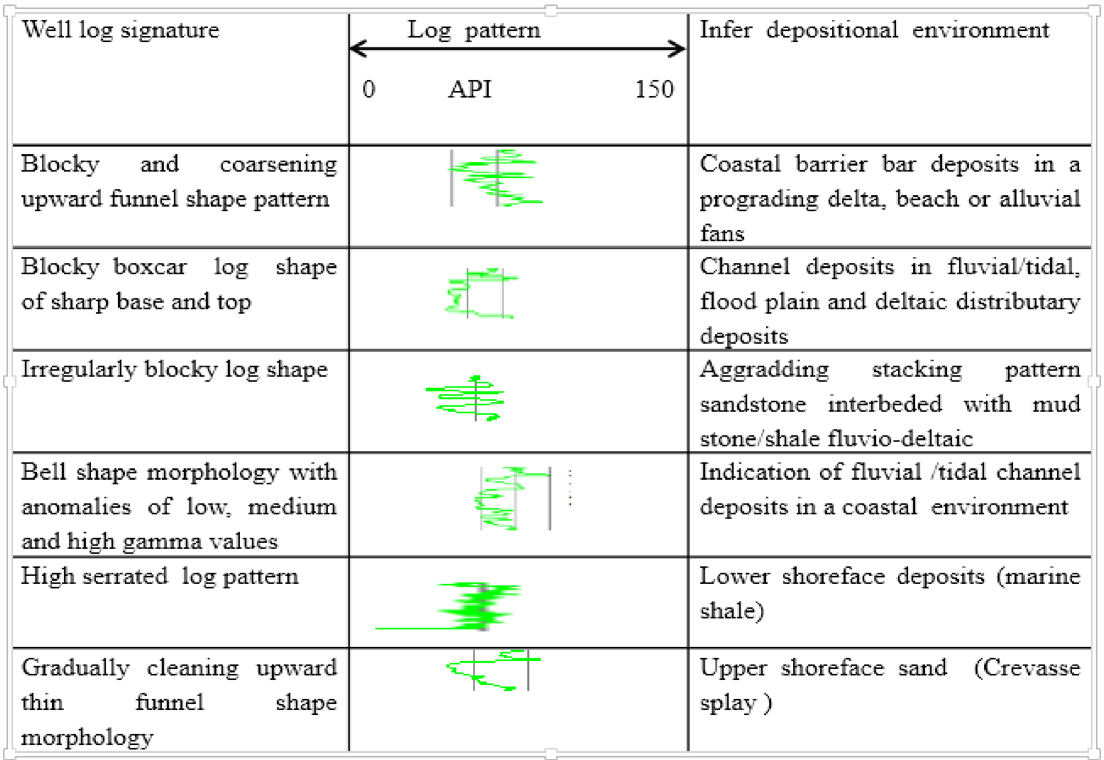


Figure 4.14: Paleo-ecological plotings of palynomorphs from Ore-3 well

According to the principle of sedimentation there is enrichment of the mangrove, coastal swamp plants, algae, spores and other marine palynomorphs during the sea level rise. In this period there is largeextension of the coast and sedimentation takes place in the subaerial delta plain (Sowunmi, 1981 and Adojah*etal*., 2015). Similarly, during the period of fall in sea level, area of the land that was submerged before are now expose to erosive activities by fluvial processes and sedimentation takes place in the subaqueousdelta plain environment. Subaqueous environment are defined chiefly by savanna and montane palynomorphs (Olayinwola and Bamford, 2016).Furthermore, the downward increase in palynomorphs further suggest that depositional environment of Ore-1,2 and 3 are from upper to lower delta plain environment which is in agreement with the previous work workof (Iyang*etal*.,2016).

3. The gamma ray log motifsand lithology were consider and also used inpaleoenvironmental deductions. Six major gamma ray log pattern was identified in Ore wells namely, highly serrated, irregular, blocky and cleaning upward trend, blocky and dirtying upward, blocky and sharp base and top(Figure 4.15). Thisconformsto the works of (Durogbitan, 2010;Omoboriowo, 2012).



Well log signature	Log pattern 0 API 150	Infer depositional environment
Blocky and coarsening upward funnel shape pattern		Coastal barrier bar deposits in a prograding delta, beach or alluvial fans
Blocky boxcar log shape of sharp base and top		Channel deposits in fluvial/tidal, flood plain and deltaic distributary deposits
Irregularly blocky log shape		Aggradding stacking pattern sandstone interbeded with mud stone/shale fluvio-deltaic
Bell shape morphology with anomalies of low, medium and high gamma values		Indication of fluvial /tidal channel deposits in a coastal environment
High serrated log pattern		Lower shoreface deposits (marine shale)
Gradually cleaning upward thin funnel shape morphology		Upper shoreface sand (Crevasse splay)

Figure 4.15: Different gamma ray log motifs observed in Ore-wells

4. Palynomorph marine index (PMI)was further put into consideration to further have a clear understanding of paleoenvironment in which Ore wells are deposited. PMIis a mathematical model presented by Helene de-Guerra and Vasquez (1998) to simplify interpretation of depositional environment which provides information on palynomorph diversity in both marine and terrestrial environmental setting, thus the formula is given as

$$PMI= (RM/RT+1)100 \qquad \text{Equation 1}$$

Where, RM= richness in marine palynomorphs (dinoflagellates, acritarchs and foraminiferal lining).

RT= richness in terrestrial palynomorphs.

High readings of PMI are interpreted as marine, low values are taken as brackish and null values are indicated as freshwater environment.

The PMI calculations for Ore-1 and graphical plot is obtained in (Table 4.1, Figure 4.16) with PMI values between0-13%.The interval between 9700 ft to 10155 ft is freshwater environment while interval between 10155 ft to 10350 ft is brackish.

Table 4.1: Palynological Marine Index in Ore-1

S/No	Depth (ft)	M	RT	PMI (%)
1	9705	2	17	11
2	9720	0	15	0
3	9735	0	7	0
4	9750	0	14	0
5	9765	0	9	0
6	9780	0	9	0
7	9795	0	20	0
8	9800	0	10	0
9	9825	0	19	0
10	9840	0	16	0
11	9855	0	15	0
12	9870	0	7	0
13	9885	0	7	0
14	9900	0	8	0
15	9915	0	6	0
16	9930	0	7	0
17	9945	0	5	0
18	9960	0	11	0
19	9975	0	8	0
20	9990	0	4	0
21	10005	0	6	0
22	10020	0	13	0
23	10035	0	4	0
24	10050	0	7	0
25	10065	0	8	0
26	10080	0	3	0
27	10095	0	12	0
28	10110	0	9	0
29	10125	0	8	0
30	10140	0	20	0
31	10155	0	8	0
32	10170	1	16	6
33	10200	0	18	0
34	10215	2	19	10
35	10230	0	11	0
36	10245	0	12	0
37	10260	1	21	5
38	10275	0	7	0
39	10290	0	25	0
40	10305	0	12	0
41	10320	0	15	0
42	10335	2	14	13
43	10350	1	10	9

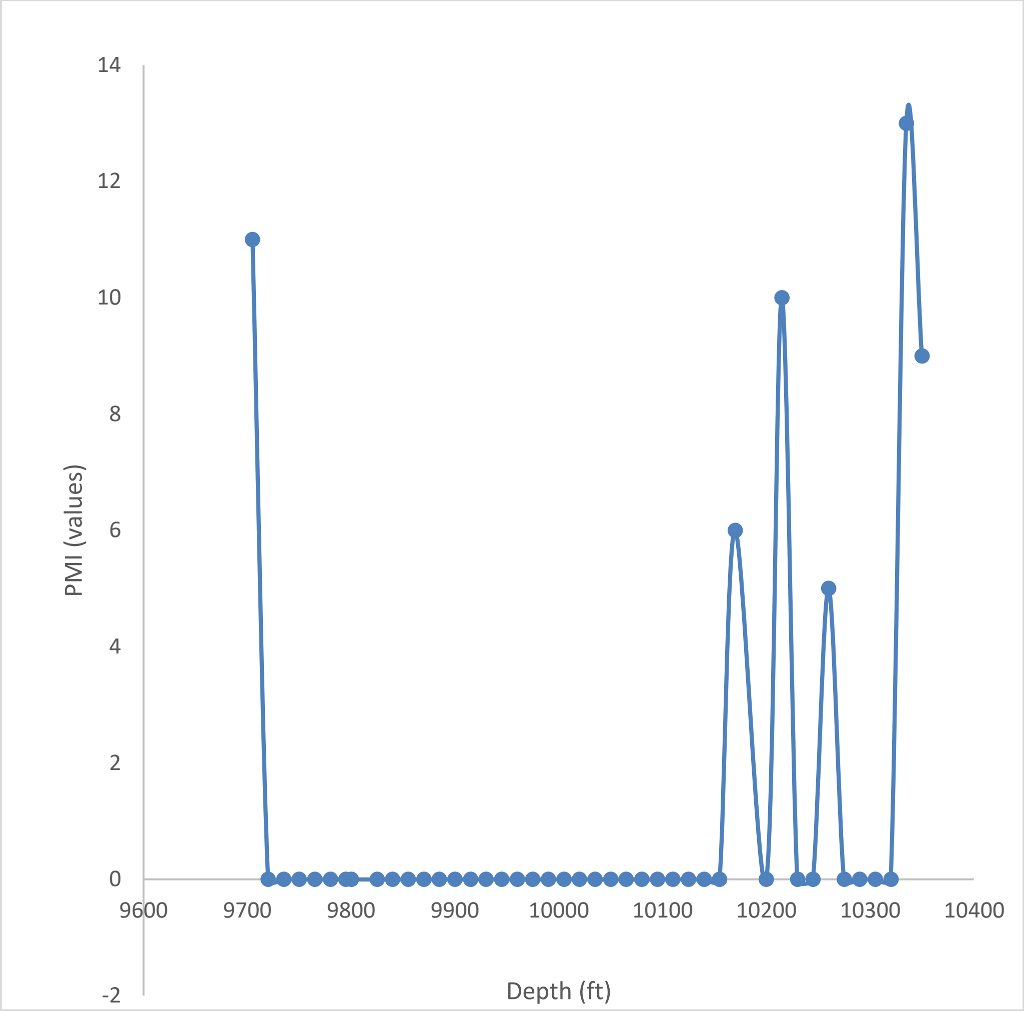


Figure 4.16: PMI against depth in Ore-1well

The PMIresult of Ore-2 is presented in (Table 4.2 and Figure 4.17). The PMI values ranges from 0-35% indicating deposition of sediments in brackish environment. This is characterized by intermittent rise and fall of the sea level sea. The higher the ratio of marine, the higher the marine condition and vice-visa.

The PMI value of Ore-3 was calculated in (Table 4.3) and ploted in (Figure4.18). The values range between 0-30%. Observed in this well is a sequencetial reverse of environmentdeposition with the brackish environment at the upper part and freshwater below. The sediments in the upper part of the well infer in a period of marine regression defined by fluctuating salinities into a very nearshore marine condition.

Table 4.2: Palynological Marine Index in Ore-2

S/No	Depth	RM	RT	PMI (%)
1	9795	1	29	3
2	9810	2	36	5
3	9825	2	9	20
4	9855	0	13	0
5	9870	3	9	30
6	9885	1	26	4
7	9900	0	14	0
8	9915	0	19	0
9	9930	0	7	0
10	9945	1	19	5
11	9960	0	7	0
12	9975	0	11	0
13	9990	0	17	0
14	10005	0	31	0
15	10020	0	11	0
16	10035	1	18	5
17	10050	0	39	0
18	10065	0	23	0
19	10080	0	31	0
20	10095	0	20	0
21	10110	0	32	0
22	10125	1	16	6
23	10140	1	15	6
24	10155	1	5	17
25	10170	0	13	0
26	10185	0	25	0
27	10200	0	16	0
28	10215	0	10	0
29	10230	0	32	0
30	10245	0	40	0
31	10260	0	43	0
32	10275	0	62	0
33	10290	10	27	35
34	10305	1	48	2
35	10320	4	37	11
36	10335	0	0	0
37	10350	1	34	2.9
38	10365	0	27	0
39	10380	0	13	0
40	10395	0	31	0
41	10410	0	10	0
42	10425	0	7	0
43	10440	1	24	4
44	10455	0	35	0
45	10470	1	15	6
46	10485	0	26	0
47	10500	0	33	0
48	10515	1	30	3
49	10530	0	13	0
50	10545	1	11	8
51	10560	0	9	0
52	10575	2	23	8

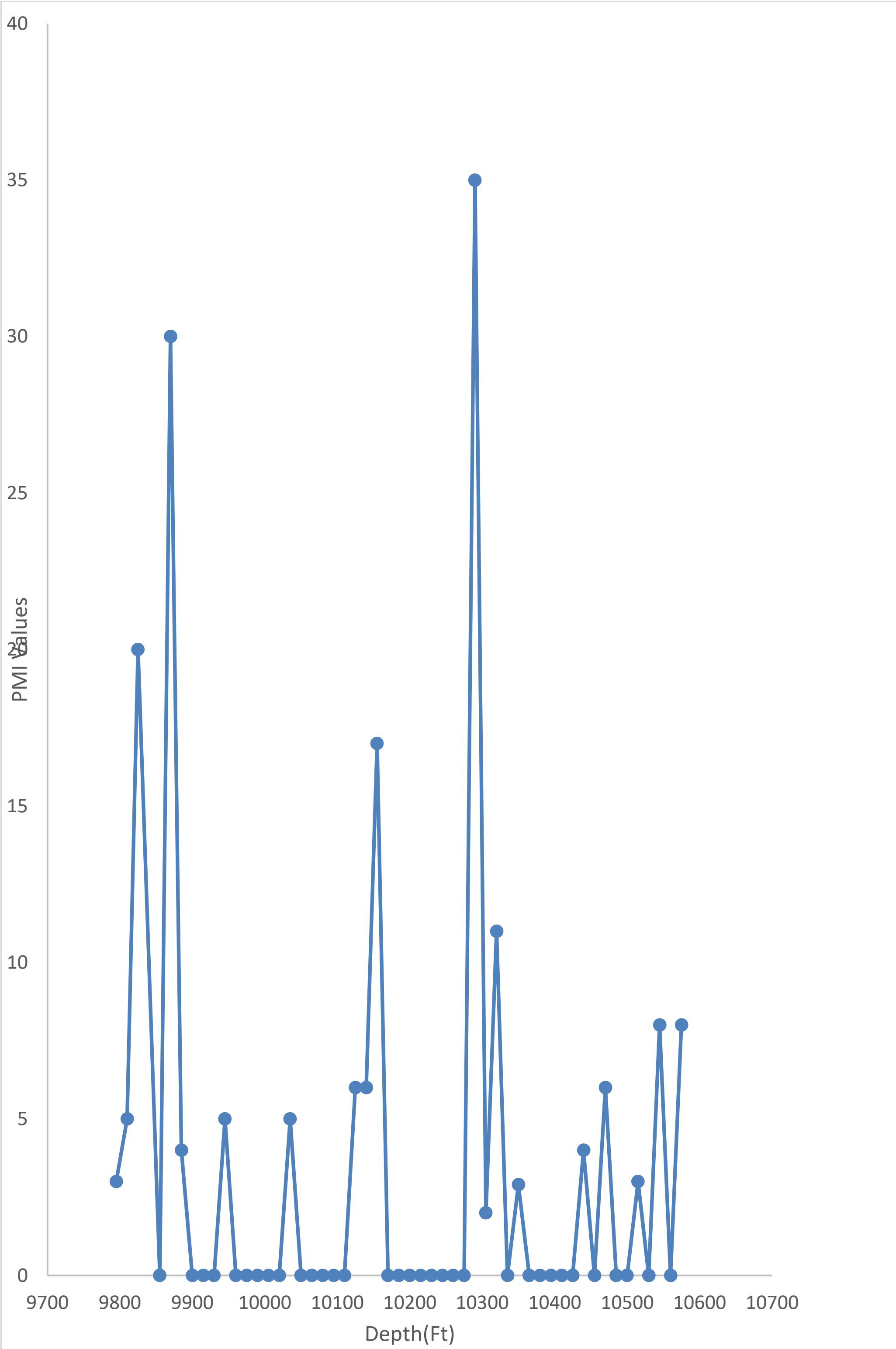


Figure 4.17: PMI against depth in Ore-2 well

Table 4.3: Palynomorph Marine Index in Ore-3 well

S/No	Depth(ft)	RM	RT	PMI (%)
1	9710	0	7	0
2	9725	0	17	0
3	9740	0	7	0
4	9755	4	43	9
5	9770	0	13	0
6	9785	0	19	0
7	9800	0	6	0
8	9815	3	9	30
9	9830	0	22	0
10	9845	0	9	0
11	9860	0	15	0
12	9890	0	6	0
13	9905	0	16	0
14	9920	1	19	5
15	9935	0	14	0
16	9950	1	22	4
17	9965	2	15	12.5
18	9980	0	11	0
19	9995	0	10	0
20	10010	0	6	0
21	10025	0	11	0
22	10040	0	17	0
23	10055	1	15	6
24	10070	0	7	0
25	10085	0	26	0
26	10100	0	17	0
27	10115	0	12	0
28	10130	0	7	0
29	10160	0	8	0
30	10175	0	10	0
31	10190	0	7	0
32	10205	0	23	0
33	10220	0	12	0
34	10235	0	14	0
35	10250	0	19	0
36	10265	0	23	0
37	10280	0	11	0
38	10295	0	9	0
39	10310	0	18	0
40	10325	0	12	0
41	10340	0	13	0
42	10355	0	10	0
43	10370	0	9	0
44	10385	0	16	0
45	10400	0	9	0
46	10415	0	9	0
47	10430	0	6	0
48	10445	0	3	0
49	10460	0	15	0
50	10475	0	14	0

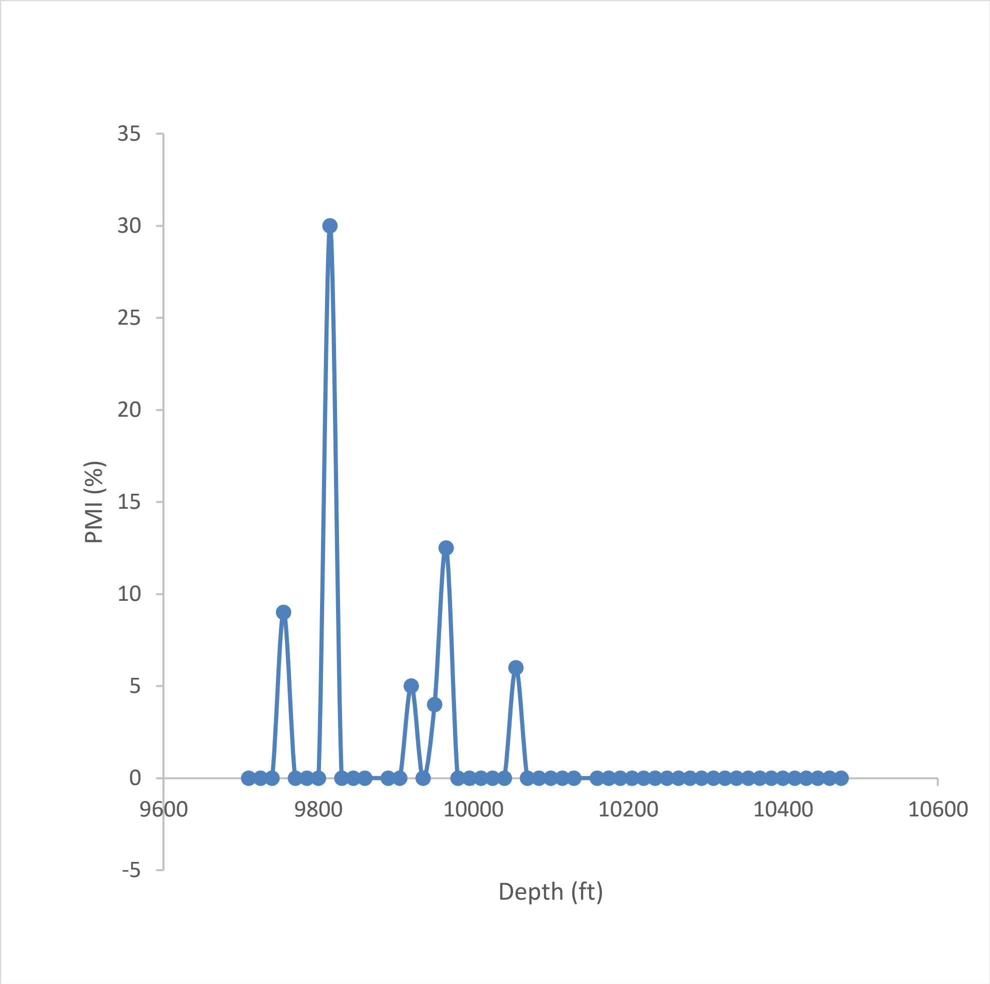


Figure 4.18: PMIplotted against depth in Ore-3

High readings are interpretated as marine, low values are taken as brackish and null values interpreted as freshwater environment. Based on the above stated conditions the freshwater (upper deltaic plain) and brackish (lower deltaic plain) environment have been deduced for Ore-1, 2 and 3 wells and summerised in (Table 4.4, Figure 4.19).

Table 4.4: Inferred paleoenvironment of deposition in Ore wells

Ore-1 well Interval (ft)	Ore-2 well Interval (ft)	Ore-3 well Interval (ft)	Inferred environment
9700 – 10170		1055 - 10475	Upper deltaic plain (freshwater)
10170 – 10350	9800 -10575	9700 – 1055	Lower deltaic plain

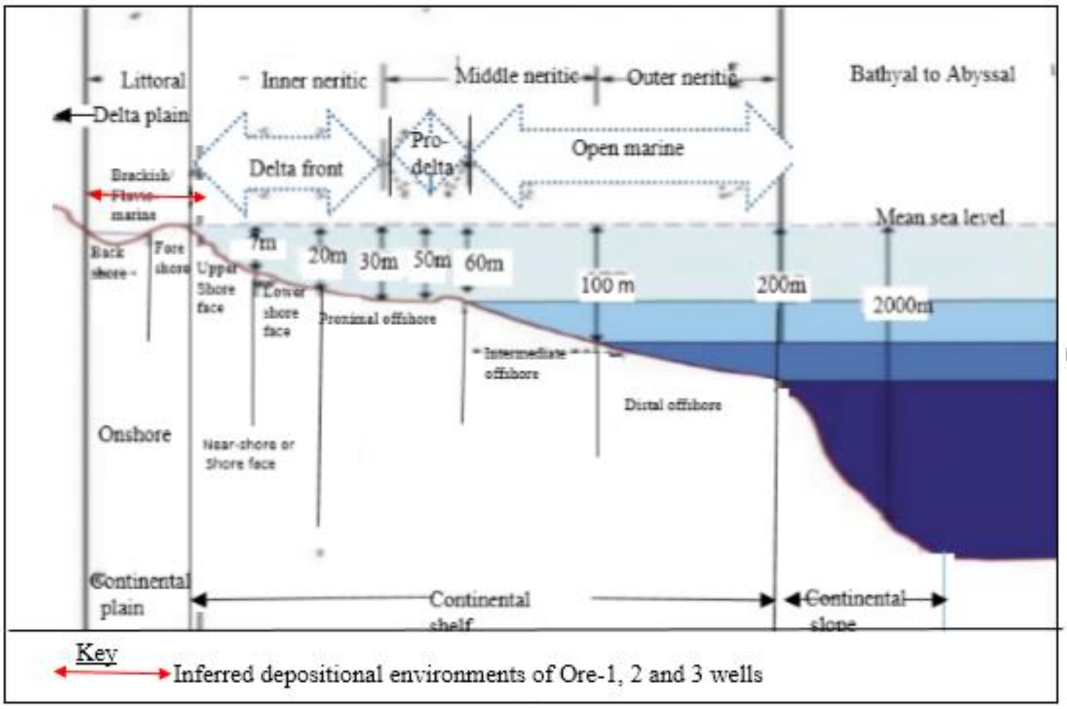


Figure 4.19: Depositional environments and bathymetric ranges used in paleoenvironmental interpretations (Ijomah*et al.*, 2016)

Theintervalsof 9700 ft -10170 ft in Ore-1 and intervals between 10170 ft -10475 ft in Ore-3 have been deduced to be deposited in the upper delta plain environment (freshwater). The reasons are:

i. This is define by high representation offreshwater (*Botryoccocusbraunii*, *Verrucatosporites*sp, *Retitricolporitesirregularis*), rainforest taxa

(*Pachydermitesdeiderixi*, *Pteris*sp),minimal representation of the mangrove,rare to spot occurrence of dinoflagellates cyst (*Spiniferites*sp, *Lingulodinummachaerophorum*), poor record of savvana (*Monoporitesannulatus*,fungal spore).

ii. PM1,PM2 and PM3 (large, medium and small)which are poorly sorted are recorded in this interval with little record of PM4.Tyson, (1993) stated that over 90% of PM1 and 80% PM2 and than 5% recovery of palynomorphs infer sedimentation in a coastal- deltaic setting andthis agrees with palynofacies 1 of (Tyson, 1993).

iii. The lithology was characterized by blocky and cleaning upward sequence funnel shape (coastal barrier)serated alternation of sand and shale (fluvio-deltaic), blocky sharp base with irregular anomally of shale and sand interbeds.

iv. The PMI values recored at these intervals are null values which agree with the mathematical model of Helen de - Guerra and Vasquez (1998).

None of the intervals in Ore-2 belong to upper deictaicplain environment the well must have been deposited in the brackish (lower detaic plain) environment. The intervals between 10170 ft -10350 ft in Ore-1, 9800 ft- 10575 ft in Ore-2 and 9700 ft – 10055 ft in Ore -3 have been deposited in the lower delta plain (brackish water) environment with srong incursion of freshwater element. This strong incursion of freshwater palynomorphs must have taken place when the fluvial current becomes unconfined in the mouth of the river due to decrease in energy which led to deposition of sediment in the lower deltaic plain environment through a narrow channel where the fluvial current is strong even though tidal current is still the most dominate sedimentation processes within this region. The reasons are:

i. The intervals recorded higher percentage of mangrove (*Acrostichumaureum, Psilatricolporitescrassus*) followed by freshwater swamp (*Botryococcusbraunii, Verrucatosporitessp*) dinocysts (*Polysphaeridiumzoharyi, Spiniferites*sp),few rainforest taxa(*Pachydermitesdiederixi*) and few savvana (*Monoporitesannulatus, Pteris* sp)and montane (*Cyathidites*sp). The presence of marine palynomorphs indcicate sedimentation in a fluvio-marineenvironment (lower deltaic plain) (Adejoh*et al*., 2015; Olayinwola and Bamford, 2016).

ii. Large quantity of PM1 and 2 are also recorded in this intervals but unevenly sorted with influx of the algal of *Botryoccocusbraunii* that is also tolerable to slight saline environment

iii. Prominent in these intervals are shallowing upward trend indicated by irregularly blockysharp base and top, blocky and dirtying upward, blocky and cleaning upward, high serrated log pattern.This suggest channel bar /coastal barrier bar sedimentation in a delta plain environment as posited byDurogbitain, (2010)and Nazeer *et al.,* 2016). The lithology is poorlybeded, sandstone units characterised by very fine, grayish pink, well to moderately sorted, angular to subangular and rounded. The shale units are dark gray to blackish, fissile and moderately hard.

iv. The PMI values recorded at this interval are also very low. All these artributes defined the lower delta plain environment.

4.5 Paleoclimatic Interpretation of Ore-1, 2 and 3 Wells

Palynomorphs are powerful indicators of past climate; because modern climate distribution of extant species mirrors that of their co-generics in earlier geological epochs as posited by (Ghazoul, 2012). Palynomorphs respond to any slight change in climate as such they can providequantitative and qualitative informations about aceint vegetations which is a reflection of climate (Sowumi, 1981).Based on relative abundance of ecological grouping of recovered palynomorphs in Ore wells the wet and temperate climatic cycles have been established (Appendice D, E and F). Where in the wet climate signifies a rise in sea level and temperate climate suggest a stable sea level defined with aggradational phase. The wet climatic cycle is associated with marine facies of mud stone (shale) which concede with the transgressive system tracts (TST) in the lower deltaic plain. The highstand system tract (HST) correspond with the temperate climatic cycle in the upper deltaic plain as posited by (Bankole, 2010, 2016; Adebayo and Ojo, 2014;Adejohet *al*., 2015 andOnigbo*et al*., 2015). The mangrove and freshwater communities are mostly affected by sea level oscillations which make them an excellent indicator of sea level changes while the rainforest and savannah are influenced by climatic factors (Chukwuma-Orji *et al.*, 2017).

4.5.1 Wet climatic zones

The interval between 10350ft -10205 ft in Ore-1 well was delineated to have been deposited under wet climatic conditions (Figure 4.11). In Ore-2 well, the interval of 10575ft- 10275ft was delineated to have been deposited under wet climatic conditions (Figure 4.12) and in Ore-3 the interval betweenthe intervals of 10475 ft - 10025 ft were delineated to have been dposited under a wet climatic condition as well (Figure 4.13). This is because the intervals are defined by increase of the mangrove communities(*Acrostichumaureum*and*Psilamonocolpit*es*crassus*), freshwater swamp (*Lavigatosporites*sp, *Retimonocolpitesobaensis* and *Verrucatosporitesusmensis*) andrainforest taxa (*Pachydermitesdiederixi and Sapotac*eae). This is also typified by the freshwater algal of *Botryococusbraunii*and further supported by few occurrences of savannah (*Monoporit*es*annulatus*) and montanecommunities. Furthermore,few and rare occurrence of the grass pollen (*Monoporitesannulatus*). High representation of spores also suggest warm humid wet climatic condition of deposition in Ore wells and vice-versa (Morley, 1981).High representations of mangrove, freshwater swamp and marine forms (*Acrostichum*aureum, *Leavigatosporites*sp,and *Polysphaeridiazoharyi*) with few representation of the savannah, especially the grass pollen of *Monoporitesannulatus*and montane vice-visa are associated with transgressive system tracts deposition system. This is capped by the maximum flooding surface (MFS) which marks the peak of wet climate(AdeonipekunandOyelami, 2015; Adojah, *et al*., 2015;Olayinwola and Bamford, 2016).High specie diversity of palynomorphs within these intervals further suggests predorminately wet climatic condition of the sediments. The wet climatic zones in this study agree with the work of previous aurthors in the basin (Adebayo *et al*., 2014; Bankole, 2010).

The presence of *Pachydermitesdeiderixi* a wet climate indicator found to inhabitthe coastal swamps Africa including Nigeria was seen at these intervals at 10125 ft in Ore-1, in Ore-2 at this 9670ft and in Ore-3 between10160 ft-10115ft. Also, the presence of*Pteris*sp and *Cyathidites*within these intervalsinfer closed, thick tropical climate (Sammant andPhadtare, 1997;Graham, 1988) in coastal wet and humidenvironment. Other elements of mangrove found in Ore wells that are indicators of wet climate are *Mauritiditeslehimani*, *Proxapertitescurssus* and *Longapertites* sp.

4.5.1.1 Temperate climatic zones

The intervals 10205 ft- 10700 ft, 10275ft- 9800 ft and 10025 ft- 9700 ft were delineated to have been deposited under a temperate climatic conditionsin Ore-1, 2and 3 wells respectively (Figure 4.21, 4.22 and 4.23). This is because the intervals recorded a decrease in the mangrove communities and characterized by increase in the freshwater swamp communities. The flooding of*Botryococcusbraunii*at these intervals point to deposition ofsediment under a temperate climatic condition; associated with the highstand system tracts (HST) which might be due to intermittent rise and fall of the sea level, a change from progradational to retrogradational (Odededee*t al*., 2012).*Botryococcusbraunii*are commonly found in the freshwater and brackish environment and distributed in reservoirs under temperate climatic conditions (Tyson, 1995).

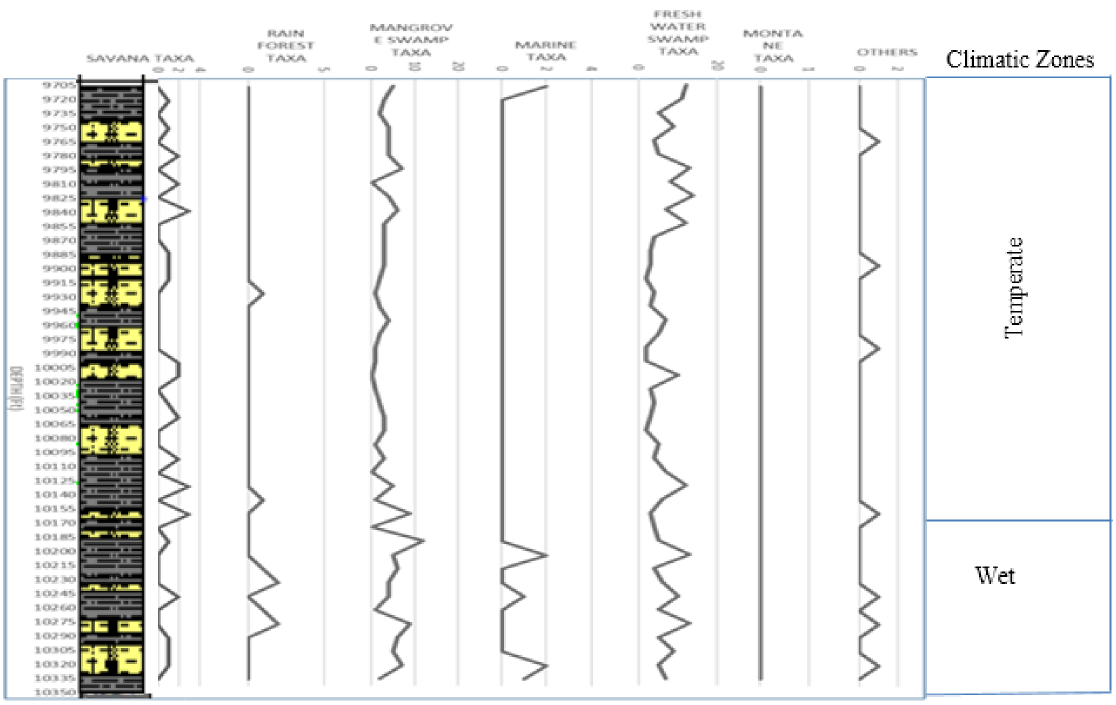


Figure 4.20: Abundance population count andpaleoecological grouping of Ore-1 well

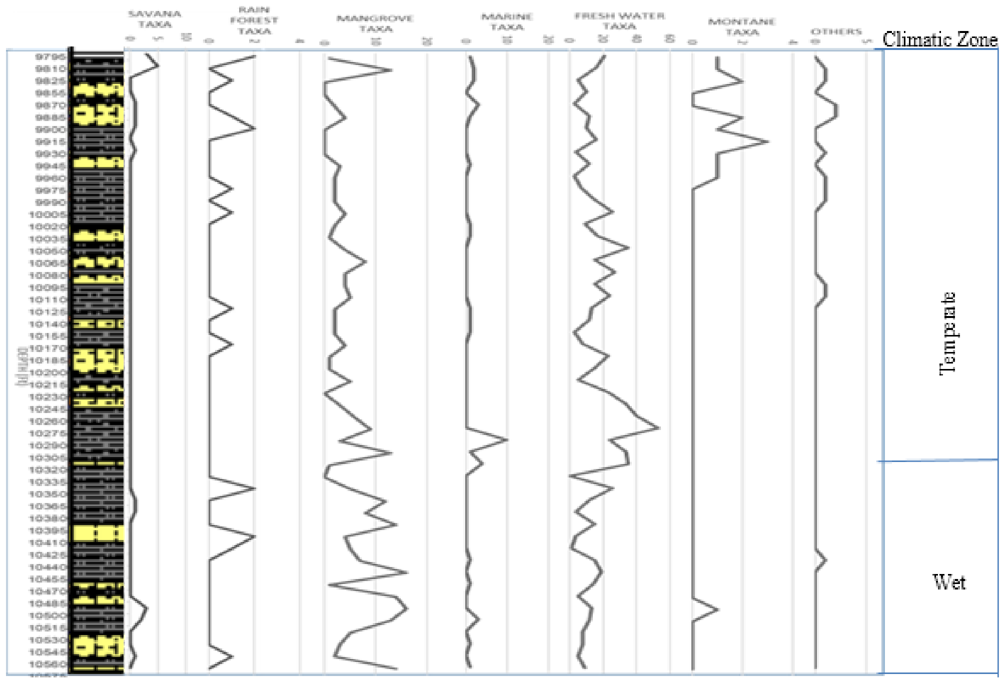


Figure 4.21: Abundance population count and paleoecological grouping of Ore-2 well

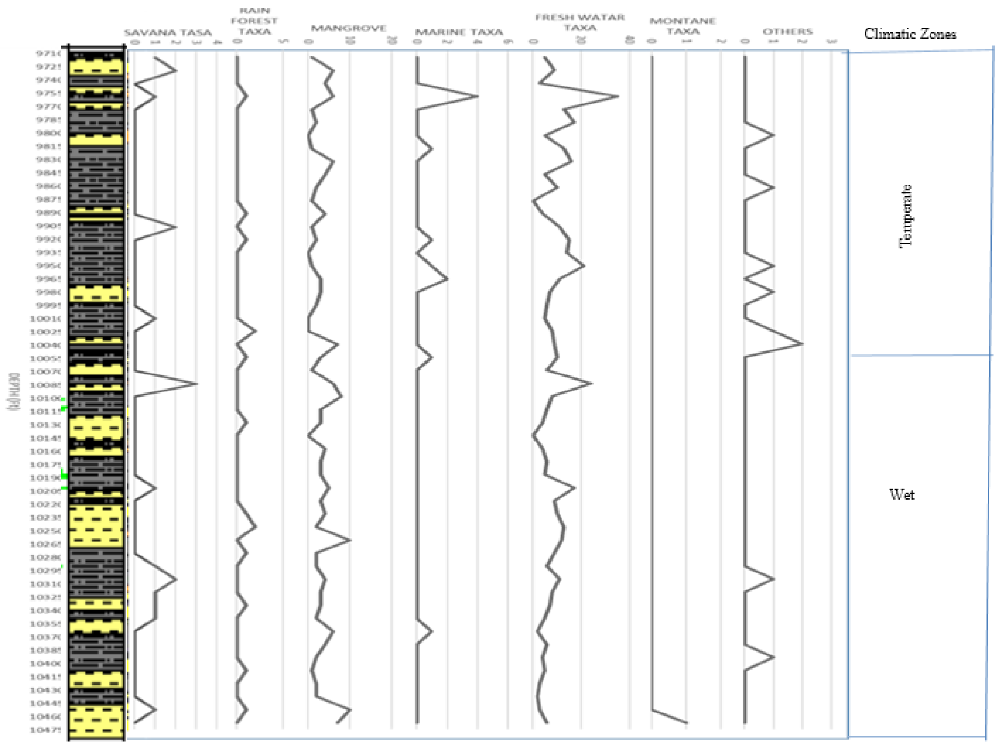


Figure 4.22: Abundance population count and paleo-ecological grouping of Ore-3 well

4.6 Sequence Stratigraphic Interpretation of Ore-1, 2 and 3 Wells

Sequence stratigraphic interpretationof Ore wells are presented in (Figure 4.23, 4.24 and 4.25) below. The identified system tracts from the studied wells follow the procedure of model dependent. The method allows the mapping of all the sequence stratigraphic units based on diversity and abundance of fossils, palynomacerals in conjunction with gamma ray log and seismic. In this study the seismic data was not provided as such iswas not included in the sequence stratigraphic interpretation.

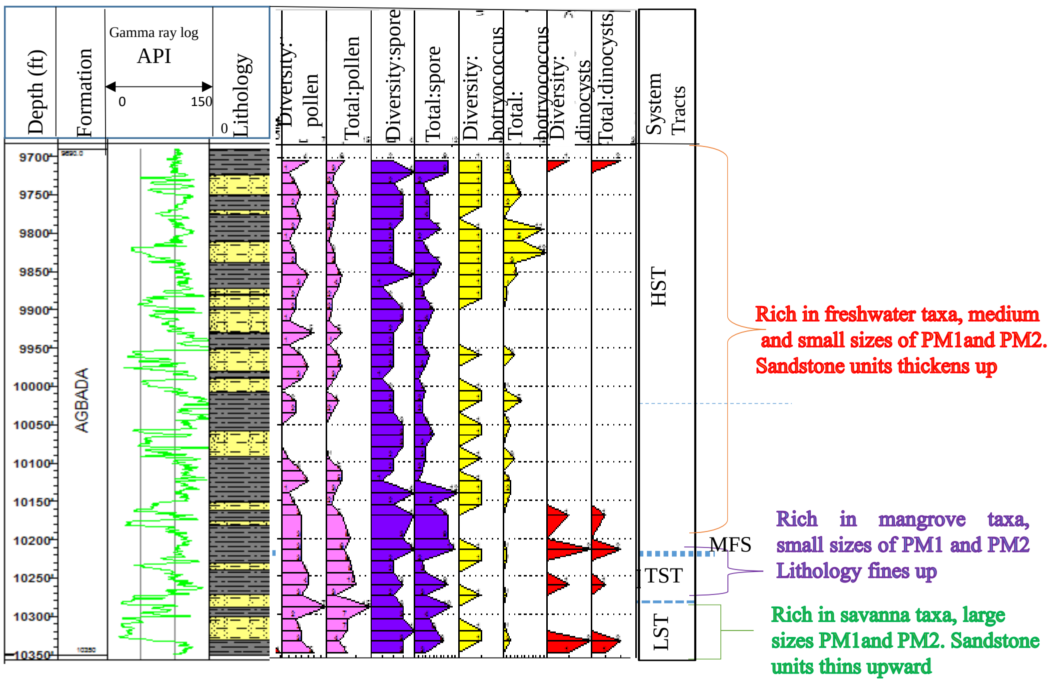


Figure 4.23: Sequence stratigraphic interpretation of Ore-1 well

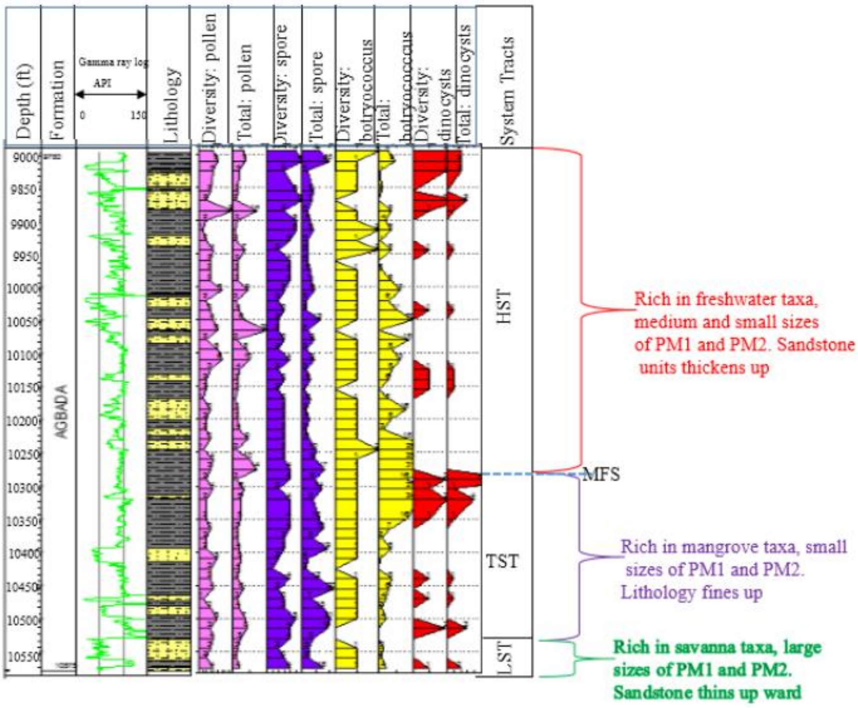


Figure 4.24: Sequence stratigraphic interpretation of Ore-2 well

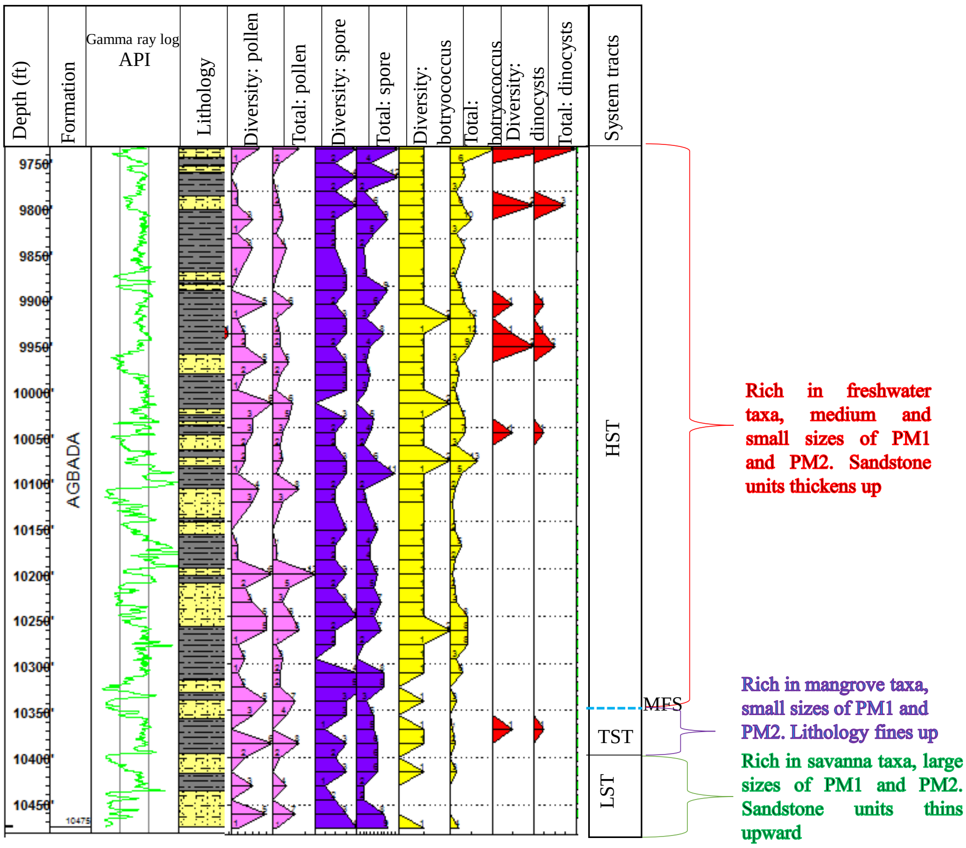


Figure 4.25: Sequence stratigraphic interpretation of Ore-3

4.6.1 Condensed sections (CS) and maximum flooding surfaces (MFS)

Condensed sections are stratigraphic intervals of thin marine unitsconsisting offine grained organic rich sediments accumulated at a very slow rate(Vail *et al*., 1984). Being the most significant surfacethey are use as paleomaker of timeindelineating sequence boundaries and system tracts.The upper layer of the transgressive system tract forms the condensed section associated with the maximum flooding surface (MFS) (Vail *et al*., 1984).Condensed sections are highly fossilliforus with high gamma ray signatures formed at the time of final transgression (Bernard, 1990). Maximum floodingsurface (MFS) is a correlative surface within the nonmarine setting. This surface marks the final stage of shorelinetransgression (condensed section) separating the transgressive system tracts (retrograding strata) from the high stand system tract (prograding strata). It lies at the heart of aerially extensive condensed section when the shoreline reaches the apex of landward position (Posamenteir and Allen, 1999). It is further characterised by hard ground rich in organic shale that are starved of sediments from the continentalmargin. The hard ground allowsfossils to be accumulated within these surfaces recording the highest diversity of fossil flora and fauna at these intervals.

The condensed sections acknowledged in Ore-1,2 and 3 wells from the studied intervals are between 10200ft-10215ft, 10095ft–10110ftand 10370ft-10385ftrespectively based on the following criteria:

i. There are rich and diverse palynomorphs recorded within the intervals.

ii. There are more of small and medium sized palynomacerals1 and 2 with scanty large sizes of PM1 and PM 2with little PM 3 and 4 within the intervals.

iii. Lithologically the intervals are made of thick shale as observed from the ditch cuttings and gamma ray log signatures which indicate maximum flooding with minimal sediment being deposited.

The maximum flooding surface (MFS) is a correlative surface within the nonmarine setting that marks the final stage of shoreline transgression (condensed section) separating the transgressive system tracts (retrograding strata) from the high stand system tract (prograding strata). It lies at the heart of aeriallyextensive condensed section when the shoreline reaches the apex of landward position (Posamenteir and Allen, 1999). It is a hard ground rich in organic shale that are starved of sediments from the continental margin and considered as the deepest paleowater depth within the vertically deepening upward succession. These hard ground intervalsallows fossil palynomorphs to be accumulated within these surfaces recording the highest diversity of fossil flora and fauna (Loutit *et al*., 1988) and mark by the peak of gamma ray value at these intervals.

The MFS recognised within the studied intervals were at 10215ft, 10105ft and 10370ft respectively. The mode of identification and chronology were based on:

i. Theshaliest point within the condensed sections as deduced from the gamma ray log signatures of API 125,107 and 100 respectively. Associated with the MFS arerich intervals of palynomorphs, more of small and mediumsizes of PM1and PM2 with fewoccurrences of large sizes of PM1 and PM2.
ii. The ages of 41,38.6 and 41 Ma was assigned to the MFS and was confirmed by the Niger Delta Cenozoicchronosratigraphy chart. Furthermore, the MFS fall within the pollen zones of P430 and P450 of(Reijers, 2011) (Figure: 4.26).

4.6.1.1 Sequence boundaries (SB)

Sequence boundary (SB) Sequence boundaries are erosional unconformity surfaces that separate two cycles of depositional sequences separating the younger from the older cycle (www.glossary.oilfield.slb.com). They are product of sea level fall which erodes the earlier subaerieally sediments that have been exposed. They are easily recognised as a sharp lithology contact between the dirtying upward pattern of the TST and cleaning and dirtying upward pattern (funnel shape) of the HST. The interval comprising of scarce,reworked and poorlypreserved microfossils.

From the studied sections, the sequence boundaries were recognised at 10310ft, 10520ft and 10390ft respectively and dated 44.4 Ma, due to the following reasons:

i. The sections are low in fossil palynomorphs and palynomacerals.
ii. From the gamma ray log signatures there is a sharp lithologic contact between the dirtying upward sequence of theTST and cleaning upward sequence of the HST.
iii. The surface is dated 44.4 Ma because it is directly overlain directly by the MFS which is dated 38.6 Ma and41Ma.

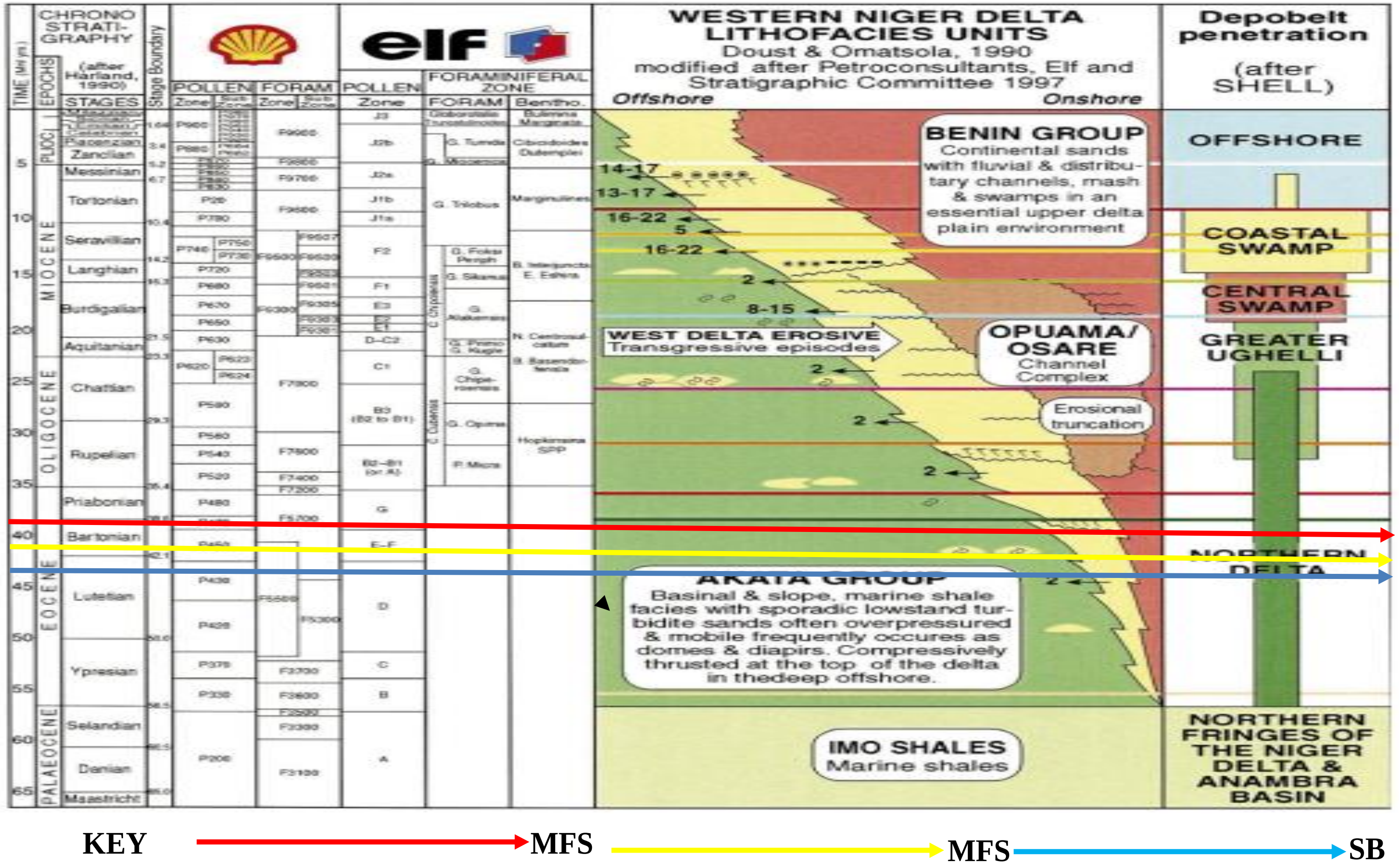


Figure 4.26: Age correlation of the established palynostratigraphic zones in Ore-1, 2 and 3 wells (Reijers, 2011)

4.6.1.2 System tracts (ST)

System tracts are defined as different package of distinctive sediment types that are deposited during different phases of sea level change. They are made up of parasequences and bounded at the base and top by major stratigraphic surfaces and recognised on the basis of the geometric pattern and position within the sequence. The following system tracts are recognised within the studied sections in Ore wells.

4.6.1.3 Lowstandsystem tracts (LST)

The LST are progradationalparasequence that are deposited during regression period of the sea level when deposition exceeds accommodation. It may also be deposited by turbidite current produced on the continental shelf and associated with shallow water deposition and acknowledge as channel sand. The LST is separated by the Transgressive surface (TS) and below it is the Sequence Boundary (SB). The aggradational pattern of the LST suggest that this system tract is of incised fill (Mode *et al*., 2017) and cut into the Highstand System Tracts (Cataneanu*et al*., 2011).

The LST are recognisedwithin the following intervals of the studied sections10270ft– 10340ft, 10520ft– 10560ft and 10390ft -10475ft respectively due to the following reasons:

i. The interval recorded high PM1 and PM2 of large and medium sizes which is concomitant with (Batten and Stead, 2005).

ii. The interval recorded poor fossil contents (palynomorphs) and dorminated by the savannah and montane palynomophs and a decrease in the freshwater, rainforest and mangrove taxa.

iii. From the gamma raylog it shows a blocky cleaning upward sequence which indicates they are incised valley fills with API reading of 20, 30 and 20respectively.

iv. It is bounded on top by a Transgressive Surface and at the base by a Sequence Boundary.

4.6.1.4Transgressive system tracts (TST)

The transgressive system tracts are deposits that accumulated from the beginning of a coastal transgression until the final stage of transgression. It is the middle system tract of both type-1 and type-2 sequences (Kendall and Schlager, 1981) and lies on the transgrssive surface (Catuneanu*et al*., 2011).Mode *et al*. (2017) stated that the TST is associated predominatelywith shale lithology and little streaks of sand associated with dirtying upward sequence.Also the TST comprises of sediments of the shoreface sand deposited in shelf region during the rising sea level. The sediments of the TSTare rich in the pollen of pinaceae since they are lighter and can be transportd far away from deposition area. Enrichment in mangrove, brackish and coastal palynomorphs due to increase in marine sediments (Morley, 1995) further defined the TST. Dominating the TST also are small sizes of PM1 and PM2 (Batten and Stead, 2005). The TST from the studied sectionfallwithin the intervals of 10215ft-10275ft, 10105ft-10525ft and 10080ft-10390ftrespectivelybasedon the following creteria:

i. It is made up of the basal shore face sand of coarse grained fluvio-deltaic sandstone.

ii. It is capped by the maximum flooding surface (MFS).

iii. It is overlain by the high stand system tract (HST).

iv. It is dominated by the mangrove, brackish and coastal palynomorphs.

v. Abundant of small and medium sizes PM1 and PM2 are found within the section.

vi. The log pattern associated with the TST indicates fining upward sequence (retrogradational) signifying deepening in marine sediment as the sea level rise (Adoja*et al*., 2015).

4.6.1.5 Highstandsystem tracts (HST)

The Highstand system tracts are sediment accumulation that takes place at the upper deltaic plain at the initial stage of the sea level fall due to flooding (Tyson, 1995).During the development of the HST the fresh water palynomorphs dominate the upper deltaic plain.It is associated with progradational andaggradationallogpatterncharactersignifyingsporadic rise and fall in sea level (Catanue*et al*., 2011; Odedede*et al*., 2012, Alege, 2017). The progradational pattern of the HST is further defined by irregular high gamma ray log values characterised by high fossil palynomorphs content under the wet to temperate climatic condition (Adojoh, *et al*., 2015). It is a surface that shows clear evidence ofsubarieal exposure indicating a shift in facies from proximal offshore setting to shoreface parasequence indicating a minimum fall in base level as sediment supply outpacesaccommodation. Marking the base of the HST is the maximum flooding surface and at the top capped by the sequence boundary indicating deposition in a fluvial, coastal plain environment (Catanue*et al*., 2011). From the studied interval the HST were recognised at 10205ft – 9700ft, 10105ft-9800ft and 10370ft – 9700ft respectively based on the following assumptions:

i. The interval was dominated by freshwater palynomorphs and algal (*Botryococcusbraunii* and *Laevigatosporites*sp).

ii. The gamma ray log pattern exhibits a progradational and aggradational pattern and compose of shale bedsinterveningwith sandstone units of about 505ft, 305ft and 665ft thick respectively.

iii. Palynomacerals found within the HST are not degraded (Thomas *et al*., 2015). Also, more of PM 1 and 2 of both medium and small sizes were recorded within the HST which may be due to sporadic rise and fall in sea level.

4.6.1.6 Sequence stratigraphic correlation of Ore-1, 2 and 3 wells

Sequence stratigraphic surface of Ore-1, 2 and 3wells were carried out based on the identified system tracts identified from the studied intervals (Figure 4.27). This was done using gamma ray log signatures of the three studied wells and the lithology. The well logs of the three wells are placed side by side and correlated to determine stratigraphic units that are of same age.

4.7 Hydrocarbon implication

Proper identification of system tracts will provide an insight into the regressivebarrier sandstone and transgerssive mudstone (shale units) of the studied intervals which will enable understanding of reservoirs within Ore wells. More accumulation of gas and oil are found within the channel sandstone units of the lowstand system tracts compared to that of the highstand system tracts. This is because sandstone units within the lowstand system tracts are concentrated near the source rock and have a better seal associated with it compare with the sandstone units of the highstand system tract and transgressive system tracts. In the highstand system tracts there are large bodies of sandstone units but lack proper seal while that of the transgressive system tracts are little.

The established chronostratigraphic units, palynostratigraphic zones, lithofacies subcycles, paleoclimate cycles as well as the system tracts identified could provide a guide in correlating other similar wells around Ore wells which could aid in optimising hydrocarbon exploration and exploitation.

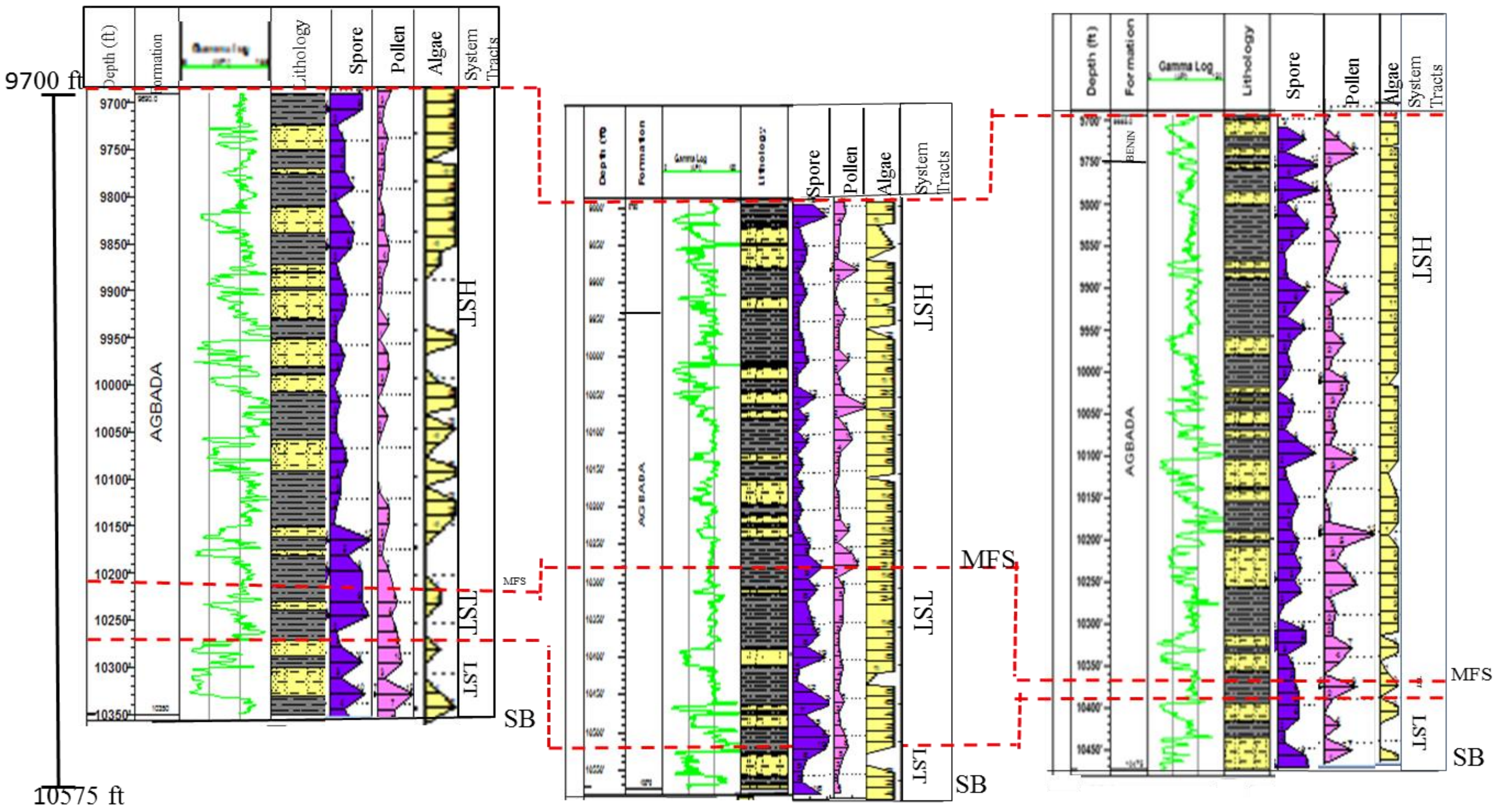


Figure 4.27: Sequence stratigraphic correlation of Ore-1, 2 and 3 wells

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Taxonomy, palynofacies and gamma ray log data were integrated to carryout sequence stratigraphy analysis of Ore-1, 2 and 3 with the aim to erect taxonomical classes of the palynomorphs, paleoenvironment, correlation, biozonation, and paleoclimatic studies of the sequence penetrated by Ore wells. 143 dicth cuttings samples within the range of 9700ft– 10350ft, 9700ft -1450 ftand 9800ft – 10575ft in Ore-1, 2 and 3 wells were analysed using the standard acid method for palynofacies laboratory preparation.Palynofacies assemblage yielded abundance of large and sizes of PM1 and PM2, few occurrences of PM3 and PM4 from the studied intervals.Amorphus organic matter was excluded from this studied because of its rareoccurrence from the studied intervals. The palynofacies assemblage yielded more of coastal palynomorphs with the freshwater dominating the assemblage, especially the algal of*Botryoccocusbraunii*, followed by the mangrove, savanna, rainforest, marine and the montane.

The lithology of Ore-wells indicates alternation of argillaceous sandstone beds and shale with thin layer of sandstone units. Variable colourssuch as pinkish, grayish pink were associated with the argillaceous sandstone beds while the shale aredark grayish to grayishcolours. Texturally the argillaceous sandstone beds are fine to medium and occationallycoarsed3 wells belong to Agbda Formation.

The studied sections were dated Middle, Middle to Upper and Late Eocene respectively based on the stratigraphic age range of the recovered maker species. The presence of*Daulaiditeslaevigatus* a marker used to mark the base of the P450 is purely an Eocene taxa according to the (Niger Delta Palynological Consortium Biostratigraphic Sub-Committee, 2000). Similarly, the occurance of other marker species such as*Grimsdaleapolygonalis*,*Psilamonocolpitesmarginatus* and top rich *Retibrevicolpites triangulates* suggest that Ore-1, 2 and 3 wells sediments are ofMiddle, Middle to Upper and Late Eocene.

Three palynostratigraphiczonations have been proposed for Ore-1, four for Ore-2 and 3 based on the international stratigraphic guide. *Verrucatosporitesusmensis-Ctenolophoniditescoastatus*, *Pachydermitesdeiderixi–Grimsdaleapolygonalis* and *Spinizonocolpitesechinatus- Proxapertites cursus* zone were established for Ore-1 well. In Ore-2 are *Verrucatosporitesusmensis- Pachydermitesdeiderixi, Retibrvitricolporitesprotrudens -Grimsdaleapolygonalis,Pradapolisflexibillis-Proxapertites cursus* and *Longapertites*sp- *Ctenolophoniditescoastatus* zones. Lastly Ore-3*Verrucatosporites*sp-*Grimsdaleapolygonalis,Doualaditeslaevigatus-Ctenolophoniditescoastatus*, and *Racemonocopiteshians- Retimoncolpites*sp zones. These zones belong to the P430, P450, P470 - P480 and P520 respectively.

The lower (brackish) and upper (freshwater) delta plain environments have been proposed for Ore wells based on the palynofacies assemblages and the gamma ray log patterns in the wells. The paleoecologicalgroupings of the palynomorphs revealthat the wells were deposited under wet and temperate paleoclimatic conditions. The temperate climate was inferred for the upper deltaic plain environment while the wet climate was inferred for the lower delta plain respectively.

Based on the gamma ray log patterns, lithology and palynofacies data recorded from the studied sections a type (iv) depositional system comprising of single highstand system tracts, transgressive system tracts and lowstand system tracts have been recognized from Ore -1, 2 and 3 wells respectively. The maximum flooding surfaces were dated 41, 38.6 and 41 Ma while the sequence boundaries were dated 44.4 Ma by correlation with the Cenozoic chart andglobalsequence cycle of Hag*et al*. (1988).

The coastal barrier, crevasse splay and the transgressive sandstone could be the main reservoirs for hydrocarbon generating units within the studied intervals as suggested by Chow*etal*. (2005).

5.2 Recommendations

This research work was carried out to logical conclusion and reasonable success and findings but not without some challenges especially in the area of sample preparation and analysis. On this basis of the experience gathered from this research, the following recommendations are offeredfor future guidance and improvement.

The proprietaries of oil companies should be encouraged to patner with the academics of the universities in area of research to afford students with easy access to well samples and equipped laboratories.Also the discrepancies between ditch cuttings samples and wire line logs are obvious atimes as such it is recommended that core samples should be considered when carring out biostratigraphic studies. This is because they are less affected by contamination due to caving of strata during drilling operetions and caution during preparations.

It is further suggested that the well of study be further subjected to other micropaleontological entities such as calcareous nannofossils and foraminiferas for better characterization in terms of their biozonation, age, paleoecology and paleoenvironmental studies.Furthermore, the studied wells should be subjected to seismic and sedimentological analysis to provide a better correlation of the wells.

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APPENDIX A

Sample depth (ft)	Lithology	Description
9700 – 9725	Shale	5yr/8/1, dark ash and laminated
9725 – 9750	Sandy	10yr/8/2, fine grain, round, well sorted. Thin beded sand and shale alternating
9750 – 9810	Shale	5r/8/2, powdery, very smooth
9810 – 9835	Sand	5yr/7/2, fine, well rounded and well sorted
9835 – 9875	Shale	5r/8/2 , fine and laminated
9875 – 9930	Sand	10yr/8/2, fine to medium grain, moderately sorted
9930 – 9950	Shale	10yr/8/2, grayish ash
9950 -10010	Sand	10r/8/2, medium to fine grain, moderately sorted
10010 – 10060	Shale	5r/8/2
10060 -10090	Sand	5r/ 8/2, mediun to fine grain, moderately sorted
10090 – 10150	Shale	5r/8/2, powdery and very fine
10150 – 10185	Sand	10yr/8/2, silty sand stone
10185 -10280	Shale	5r/8/2, fine, powdery, laminated, with thin interbed of sand
10280 – 10330	Sand	10yr/8/2, thick beds of coarse grain sand with thin laler of mud/shale in between,moderately sorted
10330 – 10350	Shale	5r/8/2, fine, powdery, laminated

APPENDIX B

Sampledepth(ft)	Lithology	Description
9780 – 9795	Shale	5r 8/2
9795–9885	Sand	10yr 8/2 sandy sandstone beds with thin layer of mudstone, medium grain, rounded and well sorted
9885 – 9930	Shale	5r8/2, dark grayish pink, laminated
9930 - 10005	Shale	5r8/2, dark grayish pink
1005 - 10090	Sand	10yr8/2, thick beded fine sand stone with thin intercalation of mudstone, rounded to subrounded and moderately sorted.
10090 - 10170	Shale	5r8/2 dark grayish pinkish marine clay
10170 - 10240	Sand	10yr8/2, thick beded, fine sandy mudstone, moderately sorted, rounded to subrounded
10240 - 10385	Shale	5r8/2, highly thich marine shale beds, dark and grayish colouration
10385 - 10425	Sand	10yr8/2, medium to fine grain sand, rounded to subrounded, moderately sorted,
10425 - 10470	Shale	5r8/2, marine shale, dark and grayish
10470 - 10520	Sand	10yr8/2
10520 - 10545	Shale	5r8/2, marine shale grayish dark
10545 - 10560	Sand	10yr8/2, very fine sand,well sorted and well rounded
10560 - 10575	Shale	5r8/2, marine shale grayish dark

APPENDIX C

Sampledepth (ft)	Lithology	Description
96695 -9760	Sand	5yr 6/4, sandy mudstone light brown, medium to coarse grain well to moderately sorted, rounded
9760–9780	Shale	Sub fissile, milky, grayish and dark brown
9780– 9800	Sand	Fine grain, grayish brown, well rounded and sorted
9800– 9860	Shale	Fissile, milky, dark grayish and dark brown
9860 -9890	Sand	Sandy mudstone, dark brownish, fine grain, well sorted
9890 - 9960	Shale	Dark grayish and milky
9960– 9980	Sand	Angular to sub angular, fine grain, brownish,milky, well sorted
9980– 10010	Shale	Fissile, milky gray
10010 -10090	Sand	5yr 6/4,sandy mudstone, medium to fine grain, angular to subangular, moderately sorted
10090 -10100	Shale	Sub fissile, dark brown
10100 -10160	Sand	Thick beded, fine to medium grain sand, light brown, coarse to medium grain, moderately sorted angular to subangular
10160 -10190	Shale	Dark grayish and fisissle
10190 -10260	Sand	Fine to medium grain, dark to pale brown, medium to fine gain, angular and well sorted
10260 -10320	Shale	Dark grayish, fissile
10320 -10350	Sand	Medium to fine grain sand, dark grayish brown sandstone, moderately sorted, subangular
10350– 10400	Shale	Dark grayish marine shale
10400 -10420	Sand	Fine grainsandstone, dark grayish brown, well sorted and rounded
10420 -10440	Shale	Dark grayisk, laminated marine shale
10440– 10475	Sand	Coarse to medium grain sand stone,grayish brown, well sorted and rounded

APPENDIX D

S/N		Savana Taxa				Rainforest swamp Taxa					Mangrove swamp Taxa							Marine Taxa						Freshwater Swamp Taxa												Others			
	Sample depth (ft)	*Fungal spore*	*Pteris spp*	*Monoporites annulatus*	Total	*Psilatricolporites operculatus*	*Sapotaceae*	*Pachydermites diederixi*	*Ctenolophonidites coostatus*	Total	*Proxapertites cursus*	*Psilatricolpites crassus*	*Acrostichum aureum*	*Zonocoastites ramonae*	*Spinicolpites echinatus*	*Mauritidites lehmani*	Total	*Lingulodinium machaerophorum*	*Polysphaeridium zohayi*	*Spiniferites ramosus*	*Spiniferites spp*	*Oligosphaeridium spp*	Total	*Brotryococcus braunii*	*Laevigatosporites spp*	*Retibrevitricolpites triangulatus*	*Retimonocolpites obaensis*	*Verrucatosporites spp*	*Verrucatosporites usmensis*	*Racemonocolpites hians*	*Psilamonocolpites marginatus*	*Retitricolporites irregularis*	*Grimsdalea polygonalis*	*Gemmamonporites spp*	*Total*	*Doaulaidites laevigatus*	Gardenia imperelis	*Pollen indeterminate*	Total
1	9705	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0	5	2	0	0	0	0	2	2	6	2	2	0	0	0	0	0	0	0	12	0	0	0	0
2	9720	0	0	1	1	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	2	4	3	0	1	1	0	0	0	0	0	11	0	0	0	0
3	9735	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	3	0	0	1	0	0	1	0	0	0	0	5	0	0	0	0
4	9750	0	0	1	1	0	0	0	0	0	1	2	1	0	0	0	4	0	0	0	0	0	0	5	2	0	1	1	0	0	0	0	0	0	9	0	0	0	0
5	9765	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	4	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	0	0	4	0	1	0	1
6	9780	0	0	2	2	0	0	0	0	0	1	0	1	0	0	0	4	0	0	0	0	0	0	0	2	1	1	1	0	0	0	0	0	0	5	0	0	0	0
7	9795	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	7	0	0	0	0	0	0	11	1	1	0	0	0	0	0	0	0	0	13	0	0	0	0
8	9810	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	1	0	1	0	0	0	0	0	0	8	0	0	0	0
9	9825	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	4	0	0	0	0	0	0	12	2	0	0	0	0	0	0	0	0	0	14	0	0	0	0
10	9840	0	0	3	3	0	0	0	0	0	0	0	6	0	0	0	6	0	0	0	0	0	0	3	0	2	0	0	1	1	0	0	0	0	7	0	0	0	0
11	9855	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	3	0	0	0	0	0	0	4	3	0	2	1	1	0	1	0	0	0	12	0	0	0	0
12	9870	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3	0	0	0	0	0	0	1	2	0	1	0	0	0	0	0	0	0	4	0	0	0	0
13	9885	0	0	1	1	0	0	0	0	0	0	1	2	0	0	0	3	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	3	0	0	0	0
14	9900	0	0	1	1	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	3	1	0	0	1
15	9915	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0
16	9930	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	4	0	0	0	0
17	9945	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	3	0	0	0	0
18	9960	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	4	0	0	0	0	0	0	3	0	0	1	0	1	0	2	0	0	0	7	0	0	0	0
19	9975	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	2	1	0	0	5	0	0	0	0
20	9990	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2	1	0	0	1
21	10005	1	0	1	2	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0
22	10020	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	3	1	1	0	0	0	0	0	10	0	0	0	0
23	10035	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	3	0	0	0	0
24	10050	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	2	1	0	0	1	0	0	0	0	0	0	4	0	0	0	0
24	10065	0	0	2	2	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	3	0	0	0	0
25	10080	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2	0	0	0	0
27	10095	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	3	1	0	0	0	0	0	1	0	0	0	5	0	0	0	0
28	10110	0	0	2	2	0	0	0	0	0	2	0	1	0	0	0	3	0	0	0	0	0	0	0	0	1	2	0	1	0	0	0	0	0	4	0	0	0	0
29	10125	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1	2	1	0	0	0	0	0	1	0	7	0	0	0	0
30	10140	0	0	3	3	0	0	0	0	0	0	3	2	0	0	0	5	0	0	0	0	0	0	2	1	0	0	7	2	0	0	0	0	0	12	0	0	0	0
31	10155	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	4	0	0	0	0	0	0	6	0	0	0	0
32	10170	0	1	2	3	0	0	0	0	0	0	3	6	0	0	0	9	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	3	1	0	0	1
33	10185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	3	0	0	0	0	0	0	4	0	0	0	0
34	10200	0	0	1	1	0	0	0	0	0	2	5	5	0	0	0	12	0	0	0	0	0	0	0	1	1	0	3	0	0	0	0	0	0	5	0	0	0	0
35	10215	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	5	1	1	0	0	0	2	1	3	0	1	4	3	0	1	0	0	0	13	0	0	0	0
36	10230	0	0	0	0	0	0	1	0	1	0	6	0	0	0	0	6	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	4	0	0	0	0
37	10245	0	0	0	0	0	0	1	1	2	0	4	0	0	0	0	4	0	0	0	0	0	0	0	1	0	3	2	0	0	0	0	0	0	6	0	0	0	0
38	10260	0	0	2	2	0	0	0	0	0	0	4	0	0	0	0	4	0	0	1	0	0	1	0	2	2	3	3	0	0	0	0	0	0	10	1	0	0	1
39	10275	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0	0	0	5	0	0	0	0
40	10290	0	0	0	0	0	0	0	2	2	2	3	4	0	0	1	9	0	0	0	0	0	0	0	3	2	4	3	0	0	0	0	0	0	13	0	0	1	1
41	10305	0	0	1	1	0	0	0	0	0	0	4	2	0	0	0	6	0	0	0	0	0	0	0	1	0	3	1	0	0	0	0	0	0	5	0	0	0	0
42	10320	0	0	1	1	0	0	0	0	0	0	2	3	0	0	0	5	0	0	0	0	0	0	1	1	2	3	1	1	0	0	0	0	0	9	0	0	0	0
43	10335	1	0	0	1	0	0	0	0	0	0	2	5	0	0	0	7	1	0	0	1	0	2	2	0	1	0	2	0	0	0	0	0	0	5	0	0	1	1
44	10350	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	1	1	0	1	1	2	1	1	0	0	0	0	1	7	0	0	0	0

APPENDIX E

		Savanna Taxa						Rainforest Taxa							Mangrove Taxa					Marine Taxa													Freshwater Taxa																		Montane			Others							
S/N	**Sample depth(ft)**	***Monoporites annulatus***	***Retibrevitricolpotites ibandanensis***	***Stereisporites sp***	***Pteris spp***	***Fungal spore***	**Total**	***Elaies guineensis***	***Ctenolophonidites coastatus***	***Pradapollis spp***	***Sapotaceae***	***Pachydermites diederixi***	***Praapollis flexibillis***	**Total**	***Acrostichum areuem***	***Psilamonocolporites crassus***	***Proxapertites curssus***	***Spinicolpites echinatus***	**Total**	***Spiniferites spp***	***Hystrichokolpoma rigaudiae***	***Homotryblium spp***	***Spiniferites ramosus***	***Paleoperidinum spp***	***Leiosphaeriadia spp***	***Hysrichodinium spp***	***Lingulodinium machaerophoum***	***Oligosphaeridium spp***	***Operculodium centrocarpum***	***Polysphaeridium zohayi***	***Microforaminiferal wall linining***	**Total**	***Laevigatosporites spp***	***Botryococcus braunii***	***Padiastrum***	***Gemmamonosporites spp***	***Verrucatosporites spp***	***Verrucatosporites usmensis***	***Psilamonocolpites marginatus***	***Racmonocolpites spp***	***Retibrevitricolpites trangulatus***	***Striatricolpites catatumbus***	***Retimonocolpites obaensis***	***Longapertites sp***	***Monocolpites marginatus***	***Retibrevitricolporites protrudens***	***Grimsdalea polygonalis***	***Stereisporites spp***	***Racemonocolpites hians***	**Total**	***Cyathidites spp***	***Cyathidites minor***	**Total**	***Pollen indeterminate***	***Striamonocolpites rectostriatus***	***Monocolpopollenites sphaeroidites spp***	***Spore indeterminate***	***Milforda spp***	***Daulaidites laevigatus***	***Gemmate pollen***	**Total**
1	9795	3	0	0	0	0	3	1	1	0	0	0	0	2	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	6	5	1	3	3	2	1	0	0	0	0	0	0	0	0	0	0	21	1	0	1	0	0	0	0	0	0	0	0
2	9810	0	1	1	3	0	5	0	0	0	0	0	0	0	10	3	0	0	13	0	1	1	0	0	0	0	0	0	0	0	0	2	0	9	0	0	1	4	0	0	0	0	0	1	0	0	0	0	1	16	1	0	1	0	1	0	0	0	0	0	1
3	9825	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2	2	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	5	1	1	2	1	0	0	0	0	0	0	1
4	9855	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	3	1	0	0	1	1	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
5	9870	0	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	2	0	1	1	0	0	1	0	0	0	0	0	0	3	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	1	1	0	0	0	2
6	9885	0	0	0	1	0	1	0	0	0	1	0	0	1	4	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	1	0	8	0	1	0	1	0	0	2	0	0	1	0	0	0	0	0	12	1	1	2	0	1	0	0	1	0	0	2
7	9900	0	0	0	1	0	1	0	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	2	2	0	0	0	0	1	0	0	0	0	0	0	10	0	1	1	0	0	0	0	0	0	0	0
8	9915	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	2	0	3	1	0	0	1	0	0	0	1	0	0	0	0	16	2	1	3	0	0	0	0	0	0	0	0
9	9930	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	4	0	1	1	1	0	0	0	0	0	0	0
10	9945	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	3	0	0	0	0	0	0	0	0	1	0	0	0	1	0	7	1	1	0	0	0	0	0	0	0	3	0	0	0	0	0	12	0	1	1	0	0	0	0	0	0	0	0
11	9960	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	3	0	1	1	0	0	0	0	0	1	0	1
12	9975	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	1	0	1
13	9990	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	15	0	0	0	1	0	0	0	0	0	0	1
14	10005	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4	13	0	1	0	4	0	0	1	0	3	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0
15	10020	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	6	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
16	10035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	11	0	0	1	1	0	0	2	0	1	0	0	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0
17	10050	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	9	20	0	1	0	0	1	0	1	0	3	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0
18	10065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	4	0	6	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
19	10080	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	18	0	0	0	5	0	0	1	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0
20	10095	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	9	0	0	2	0	1	0	2	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	1	1
21	10110	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0	0	1	3	0	0	3	0	2	0	0	1	0	0	0	24	0	0	0	1	0	0	0	0	1	0	1
22	10125	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	9	0	0	1	0	0	0	1	0	2	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0
23	10140	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	1	3	6	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
24	10155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
25	10170	0	0	0	0	0	0	0	1	0	0	0	0	1	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0
26	10185	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	23	0	0	0	0	0	0	0	0	0	0	0
27	10200	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	1	3	0	2	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
28	10215	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
29	10230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	18	0	0	1	0	0	0	0	0	2	0	0	1	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0
30	10245	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	26	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0
31	10260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	7	24	0	0	1	1	1	0	3	0	3	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0
32	10275	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	7	31	0	0	1	4	0	0	6	0	4	0	0	0	0	0	0	53	0	0	0	0	0	0	0	0	0	0	0
33	10290	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	3	0	0	0	0	0	0	0	8	0	0	2	0	10	2	16	0	0	3	2	0	0	1	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0
34	10305	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	1	13	0	0	0	0	0	0	0	1	0	0	0	0	1	2	27	0	1	0	0	0	0	1	0	3	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	0	0
35	10320	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	3	0	0	1	0	4	3	24	0	0	2	2	0	0	0	0	4	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0
36	10335	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	10350	0	0	0	0	0	0	0	0	0	2	0	0	2	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16	0	0	3	3	0	0	0	0	3	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0
38	10365	0	0	0	1	0	1	0	0	0	0	0	0	0	12	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
39	10380	0	0	0	1	0	1	0	0	0	0	0	0	0	6	2	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
40	10395	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	0	0	3	0	0	0	0	0	2	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
41	10410	0	0	0	0	0	0	0	0	0	1	1	0	2	3	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
42	10425	0	0	0	0	0	0	0	0	0	0	1	0	1	3	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
43	10440	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7	0	0	0	0	0	0	0	1	0	0	0	0	1	2	8	0	0	1	3	1	0	0	0	0	0	0	0	0	0	0	15	0	0	0	1	0	0	0	0	0	0	1
44	10455	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	1	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	8	6	0	0	0	0	0	0	2	0	2	0	0	0	0	0	1	19	0	0	0	0	0	0	0	0	0	0	0
45	10470	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	6	4	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0
46	10485	0	0	0	0	0	0	0	0	0	0	0	0	0	13	1	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	1	0	2	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0
47	10500	0	0	0	2	1	3	0	0	0	0	0	0	0	13	1	2	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	1	0	0	1	0	2	0	0	0	1	0	0	13	1	0	1	0	0	0	0	0	0	0	0
48	10515	0	0	0	2	0	2	0	0	0	0	0	0	0	11	2	0	0	13	0	0	0	0	0	0	0	2	0	0	1	0	3	3	0	0	0	0	3	0	0	2	0	4	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	1
49	10530	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	1	0	0	2	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0
50	10545	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3	0	0	0	3	0	0	0	1	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0
51	10560	0	0	0	1	0	1	0	0	0	0	0	1	1	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
52	10575	0	0	0	0	0	0	0	0	0	0	0	0	0	11	1	1	1	14	0	0	0	0	0	0	0	0	0	1	0	0	1	1	4	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0

APPENDIX F

		Savanna Taxa					Rainforestswamp Taxa						Mangrove Taxa					Marine Taxa					Freshwaterswamp Taxa												Montane Taxa		Others			
S/N	Sample depth (ft)	*Retimonocolpites spp*	*Monoporites annulatus*	*Pteris spp*	*Fungal spore*	Total	*Racemonocolpites hians*	*Ctenolophonidites coastatus*	*Pachydermites dirderixi*	*Pradapollis flexibilis*	*Pradapollis spp*	Total	*Acrostichum aureum*	*Proxapertites cursus*	*Psilatricolporites crassus*	*Zonocoastites ramonae*	Total	*Operculodinium centrocarpum*	*Lingulodinium machaerophorum*	*Polysphaeridium zohayi*	*Achomosphaera spp*	Total	*Verrucatosporites spp*	*Laevigatosporites spp*	*Botryococcus braunii*	*Verrucatosporites usmensis*	*Gemmamonoporites spp*	*Retimonocolpites obaensis*	*Grimsdalae polygonalis*	*Padiastrum*	*Retibrevitricolpites triangulatus*	*Psilamonocolpites marginatus*	*Retibrevitricolporites protundens*	Total	*Cyathidites spp*	Total	*Doualaidites laevigatus*	*Gemmate pollen*	Pollen indeterminate	Total
1	9710	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
2	9725	0	2	0	0	2	0	0	0	0	0	0	6	0	0	0	6	0	0	0	0	0	1	0	7	1	0	0	0	0	0	0	0	9	0	0	0	0	0	0
3	9740	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	4	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	3	0	0	0	0	0	0
4	9755	0	0	1	0	1	1	0	0	0	0	1	2	0	4	0	6	1	1	2	0	4	5	4	22	0	1	3	0	0	0	0	0	35	0	0	0	0	0	0
5	9770	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	7	1	0	2	0	0	0	0	0	13	0	0	0	0	0	0
6	9785	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	6	3	7	1	0	0	0	0	0	0	0	17	0	0	0	0	0	0
7	9800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	5	0	0	1	0	0	1
8	9815	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1	3	6	1	0	2	0	0	0	0	0	13	0	0	0	0	0	0
9	9830	0	0	0	0	0	0	0	0	0	0	0	4	1	1	0	6	0	0	0	0	0	5	0	10	0	0	1	0	0	0	0	0	16	0	0	0	0	0	0
10	9845	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	4	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
11	9860	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	1	7	1	0	1	0	0	0	0	0	10	0	0	1	0	0	1
12	9875	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	9890	0	0	0	0	0	1	0	0	0	0	1	4	0	0	0	4	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
14	9905	0	2	0	0	2	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	4	5	1	0	0	0	0	0	0	0	11	0	0	0	0	0	0
15	9920	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	2	0	1	0	0	1	0	5	7	0	0	2	1	0	0	0	0	15	0	0	0	0	0	0
16	9935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	9	1	0	1	0	1	0	0	0	14	0	0	0	0	0	0
17	9950	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	6	12	0	1	0	0	0	1	0	0	21	0	0	1	0	0	1
18	9965	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0	1	1	0	2	1	0	9	0	0	1	0	0	0	0	0	11	0	0	0	0	0	0
19	9980	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	3	0	0	0	0	0	1	1	3	0	0	1	0	0	1	0	0	7	0	0	1	0	0	1
20	9995	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	1	0	4	1	0	0	0	0	1	0	0	6	0	0	0	0	0	0
21	10010	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0
22	10025	0	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	3	1	2	0	8	0	0	0	1	0	1
23	10040	0	0	0	0	0	0	0	0	0	0	0	3	1	3	0	7	0	0	0	0	0	1	1	7	0	0	0	0	0	0	0	0	9	0	0	1	1	0	2
24	10055	0	0	0	0	0	0	1	0	0	0	1	3	0	0	0	3	0	1	0	0	1	0	2	7	0	0	0	0	0	0	1	0	10	0	0	0	0	0	0
25	10070	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	3	0	0	1	0	0	1	0	0	6	0	0	0	0	0	0
26	10085	0	0	1	2	3	0	0	0	0	0	0	3	1	0	2	6	0	0	0	0	0	2	0	12	0	0	0	0	10	0	0	0	24	0	0	0	0	0	0
27	10100	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	8	0	0	0	0	0	1	1	5	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0
28	10115	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	3	0	0	0	0	0	1	0	2	0	0	1	0	0	0	2	0	6	0	0	0	0	0	0
29	10130	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	3	0	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0
30	10145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	10160	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4	0	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0
32	10175	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	6	0	0	0	0	0	0
33	10190	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	0	2	2	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0
34	10205	0	0	0	1	1	0	0	0	0	0	0	3	1	1	0	5	0	0	0	0	0	2	0	2	1	0	6	0	0	3	1	2	17	0	0	0	0	0	0
35	10220	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	2	2	0	0	3	0	0	2	0	0	9	0	0	0	0	0	0
36	10235	0	0	0	0	0	0	0	0	0	1	1	3	0	1	0	4	0	0	0	0	0	2	2	3	0	0	1	0	0	0	2	0	10	0	0	0	0	0	0
37	10250	0	0	0	0	0	0	2	0	0	0	2	1	1	1	0	2	0	0	0	0	0	2	1	8	0	0	1	0	0	1	0	0	13	0	0	0	0	0	0
38	10265	0	0	0	0	0	0	0	0	0	0	0	5	3	2	0	10	0	0	0	0	0	0	0	7	2	0	1	0	1	1	0	0	12	0	0	0	0	0	0
39	10280	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	2	0	0	0	0	0	0	1	8	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0
40	10295	0	0	0	1	1	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	3	0	0	2	0	0	1	0	0	6	0	0	0	0	0	0
41	10310	0	0	2	0	2	0	0	0	0	0	0	4	0	0	0	4	0	0	0	0	0	2	1	5	1	0	0	0	0	2	0	0	11	0	0	1	0	0	1
42	10325	0	0	1	0	1	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	1	2	0	1	0	1	0	0	1	2	0	8	0	0	0	0	0	0
43	10340	0	0	1	0	1	0	1	0	0	0	1	0	0	3	0	3	0	0	0	0	0	1	1	3	0	0	1	1	0	0	0	0	7	0	0	0	0	0	0
44	10355	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	3	1	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0
45	10370	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	6	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
46	10385	0	0	0	0	0	0	0	0	0	0	0	4	1	3	0	4	0	0	0	0	0	1	0	2	1	0	1	0	0	1	0	0	6	0	0	0	0	0	0
47	10400	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	1
48	10415	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
49	10430	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	3	0	0	0	0	0	0
50	10445	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
51	10460	0	0	1	0	1	1	0	0	0	0	1	6	1	3	0	10	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	3	0	0	0	0	0	0
52	10475	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	7	0	0	0	0	0	1	1	4	0	0	0	0	0	0	0	0	6	1	1	0	0	0	0