PALYNOFACIES AND PETROGRAPHY OF GBEKEBO WELL, DAHOMEY BASIN, NIGERIA

BY

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PSC2010346

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MARCH, 2025

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF GEOLOGY, FACULTY OF PHYSICAL SCIENCE UNIVERSITY OF BENIN, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF A BACHELOR OF SCIENCE DEGREE (B.Sc) GEOLOGY

MARCH, 2025

CERTIFICATION

This is to certify that this project was carried out by **Darlington IGBINOVIA** with matriculation number **PSC2010346** of the Department of Geology, University of Benin, Benin City.

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(Head of Department)

DEDICATION

This work is dedicated to my parents Mr and Mrs IGBINOVIA for their unwavering support, encouragement and prayers, to God almighty and everyone who supported me in this Journey of mine.

ACKNOWLEDGEMENT

My special thanks goes to GOD almighty for giving me strength and grace to finish this work. I also want to use this opportunity to acknowledge and thank my project supervisor, **Dr. N.S. IGBINIGIE** for his acceptance, encouragement, patience and also for providing me with the necessary information and advice required for making this project a success.

My acknowledgement also goes to the Head of the Geology Department, university of Benin **Dr S. A. SALAMI,** for his fatherly role in the department, and to the other lecturers for their teachings, corrections and advice to ensure my academic success – Professor, O. I. Imasuen, Dr A. Ogbamikhunmi, Dr (Mrs) O. Alonge, Dr (Mrs) Maju- Oyoviohikoude, Dr (Mrs) O. Andre. I also appreciate the support of the non-academic staff of the department.Finally, I want to appreciate my lovely Parents, siblings for their immense contribution, support and unending prayers and encouragement.

ABSTRACT

The palynofacies and petrography of the Gbekebo well in the Dahomey Basin are thoroughly examined in this project. Using petrographic analysis and palynological data (palynofacies), the study seeks to evaluate the well's depositional environment and examine its sedimentary components. Combining these methods has helped with oil and gas development in the Dahomey Basin by shedding light on the region's reservoir features and paleoenvironmental conditions.

In order to explore the region's hydrocarbon potential, the Gbekebo well was drilled in the Dahomey Basin. The palynofacies and petrographic examination of the well's sedimentary sequences are the main subjects of this investigation.

To identify and measure different organic matter components, such as terrestrial palynomorphs (pollen, spores, plant debris), marine palynomorphs (dinoflagellate cysts, acritarchs), amorphous organic matter (AOM), and inertinite, palynofacies analysis entailed the preparation and microscopic examination of palynological slides. Rebuilding the paleoenvironment, identifying the terrestrial versus marine origin of organic matter, and determining the degree of oxidation during deposition are all made possible by this research. Different palynofacies were identified based on the distribution and relative abundance of these elements, and these were subsequently connected with particular depositional environments.

Thin slices of rock samples were subjected to petrographic investigation in order to ascertain the sedimentary rocks' mineralogical composition and textural properties. This required utilising polarised light microscopy to identify and measure the framework grains, matrix and cement.

The findings will help to improve the stratigraphic framework and offer insightful information for upcoming hydrocarbon exploration projects in the area. Additionally, this research will improve our knowledge of the petrography, and palynofacies of the well.

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CHAPTER ONE

1.0 Introduction

1.1 General Statement

Nigeria's southwest coast is home to the significant sedimentary Dahomey Basin, which is well-known for its petroleum potential. The basin's Gbekebo well provides a singular opportunity to investigate the area's subsurface sedimentary features.

One of West Africa's most important sedimentary basins, the Dahomey Basin has demonstrated hydrocarbon potential. Studying the subsurface geology, with a focus on palynofacies and petrography to comprehend the depositional environment and hydrocarbon potential, is made possible by the Gbekebo well, which is situated within the basin. Pollen, spores, and other minute plant remains are studied in palynology because they are essential for reconstructing paleoenvironment. In contrast, petrography uses mineral composition and rock textures to evaluate reservoir properties. In order to obtain a thorough grasp of the geological context of the Gbekebo well, this study attempts to correlate the palynological data with petrographic features.

Numerous wells have been sunk in the region, including the Gbekebo well, which is well-known for its abundant hydrocarbon deposits. Palynofacies and petrographic analysis are crucial resources for comprehending the region's geological past.

1.2 Statement of the Problem

A thorough knowledge of the depositional conditions and reservoir properties of wells like Gbekebo is still lacking, despite the Dahomey Basin's substantial hydrocarbon reserves.

1.3 Aim and Objectives

Aim

The aim of this study is to carry out petrographic and palynofacies analysis on Gbekebo well , Dahomey basin.

Objectives

•To examine the Petrography of the Gbekebo well samples.

•To examine the Palynofacies of the Gbekobo well samples

•To interpret the paleoecological and depositional circumstances at the time of deposition..

•To evaluate the well's potential as a reservoir for hydrocarbons.

•To determine the mineralogical studies

1.4 Scope and Limitation of the Study Area

Scope of Study

The research of the Gbekebo well in the Dahomey Basin focuses on several geological features to understand its stratigraphy, depositional conditions, and hydrocarbon potential. The primary areas covered in the study include:

1. Stratigraphy Analysis

- correlation to create a regional stratigraphic framework with other wells in the Dahomey Basin.

2. Palynofacies and Paleoenvironmental Studies

- To ascertain the age and depositional environment, palynomorphs (pollen, spores, and dinoflagellates) are analyzed.
- analyzing sedimentary organic materials to determine the history of basins and historical climatic conditions.

3. Petrographic and Geochemical Analysis

- Rock sample thin-section petrography to determine reservoir quality, diagenesis, and mineral composition.
- Thermal maturity and source rock potential are evaluated by geochemical analysis, which includes Rock-Eval pyrolysis and Total Organic Carbon (TOC).

4. Hydrocarbon Prospectivity

- locating seal rocks, reservoirs, and possible sources.
- evaluation of hydrocarbon movement and generation using structural and geochemical data.

5. Tectonic and Structural Interpretation

- examination of the underlying features and faults that affect the buildup of hydrocarbons.
- Basin evolution and subsidence history are interpreted by combining seismic and well log data.

6. Economic and Engineering Applications

- assessment of reservoir characteristics for possible hydrocarbon exploitation, including permeability and porosity.
- Results are applied to reservoir modelling and petroleum exploration.

Limitation of Study Area

1. Limited Well Coverage

- Because the subsurface dataset from the Gbekebo well is limited, it is challenging to extrapolate results to the whole Dahomey Basin.
- The lateral differences in lithology, stratigraphy, and reservoir quality might not be adequately represented by a single well.

2. Insufficient Core and Cuttings Samples

- Comprehensive petrographic and geochemical investigations may be limited by the scarcity of core samples and cuts.
- Gaps in data interpretation may result from poor core recovery during specific intervals.

3. Thermal Maturity Constraints

- According to geochemical research, the organic-rich shales in the Gbekebo well are either immature or only slightly mature enough to produce hydrocarbons.
- This restricts the well's ability to produce hydrocarbons directly without the need for further burial or other heat sources.

4. Diagenetic Alteration

- Primary reservoir characteristics may have changed as a result of post-depositional procedures such cementation, compaction, and mineral replacement.
- Original depositional features may be obscured by diagenetic overprinting, making interpretation difficult.

5. Seismic Data Limitations

- It's possible that the resolution of the seismic data currently available is insufficient to precisely identify stratigraphic changes and underlying structures.
- Seismic resolution restrictions may result in an under-representation or incorrect interpretation of faults and stratigraphic traps.

6. Environmental and Accessibility Challenges

- Dense vegetation, swamps, or coastal conditions may make the study region inaccessible, which would restrict fieldwork and surface geology mapping.
- Direct geological observations might be challenging due to surface expressions being altered by coastal erosion and sedimentation.

1.5 Location of the Study Area

From southeast Ghana through Togo and the Republic of Benin to southwest Nigeria, the Dahomey Basin is a conglomeration of interior, coastal, and offshore basins. The Okitipupa Ridge is a subsurface basement high that divides it from the Niger Delta. It is unclear how far offshore it extends. The trend of sediment deposition is east-west. Geology is quite well known in the Republic of Benin (Billman, 1976; De Klasz, 1977). Cretaceous layers are roughly 200 meters thick onshore (Okosun, 1990). The Precambrian basement is covered by a non-fossiliferous basal sequence. Coal cycles, clays, and marls with fossiliferous horizons come after this. Black fossiliferous shales have been found near the top of a 1,000 m thick succession of sandstones offshore. Billman (1976) dated this as pre-Albian to Maastrichtian. North and South are the two geographic zones that make up the Cretaceous. A base sand that gradually grades into clay beds with lignite and shales intercalating is the sequence seen in the northern zone. Nearly all of the Maastrichtian's highest layers are argillaceous. The stratigraphy of the southern zone is more complex, with the main facies being beds of limestone and marl.

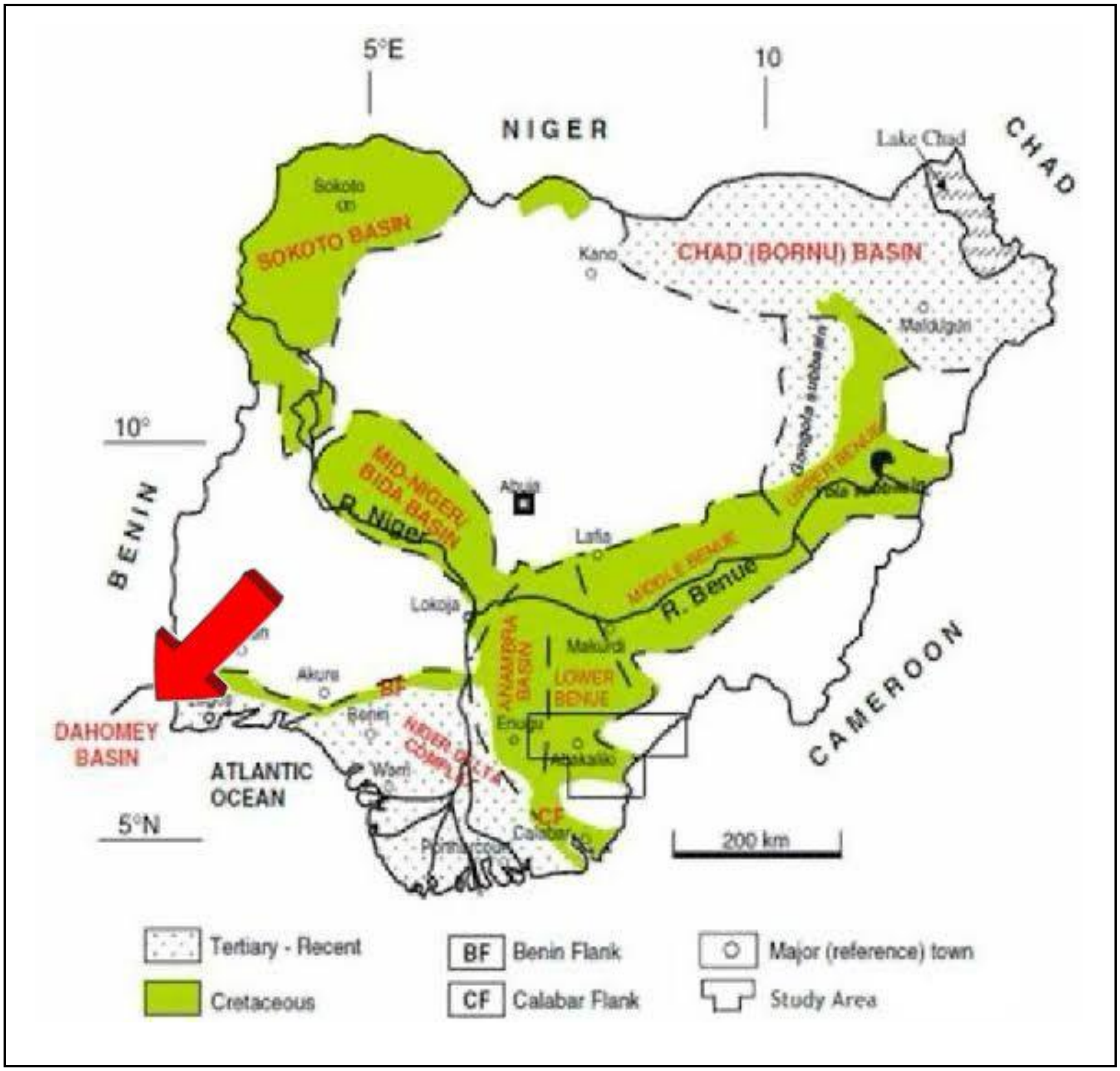


Fig1: Map of sedimentary basin of Nigeria showing the study area (After, Obaje 2009)

1.6 Geomorphology

Features arising from the region's geological past and sedimentary processes define the geomorphology of the region surrounding the Gbekebo well in the eastern Dahomey Basin of southwest Nigeria.

Topography and Surface Features

The area features a mix of gently rolling hills and coastal lowlands. Low-lying hills and ridges created by older sedimentary sequences can be found inland, while the coastal plains are mostly made up of recent alluvial deposits. The region's tropical environment has influenced the long-term weathering and erosion of sedimentary rocks, resulting in these landforms.

Drainage Patterns

A system of rivers and streams cuts through the region, exhibiting dendritic drainage patterns. By contributing to the deposition of alluvial deposits in the coastal areas, these watercourses have significantly shaped the landscape through fluvial processes.

Coastal Geomorphology

Barrier islands, lagoons, and estuaries are some of the distinctive coastal characteristics that have developed as a result of the area's proximity to the Gulf of Guinea. Because of tidal action, wave processes, and sediment delivery from terrestrial sources, these formations are dynamic and constantly changing.

Subsurface Geomorphology

The Gbekebo well's subsurface geomorphology shows a geological succession that shifts from continental to marine habitats. The existing surface geomorphological features are a result of this process, which is a reflection of past sea-level fluctuations and sedimentation patterns.

1.7 Palynofacies and Petrography

Two complimentary methods for examining sedimentary rocks are petrography and palynofacies.

Palynofacies

:The study of organic materials found in sedimentary rocks, including pollen, spores, and other palynomorphs, is known as Palynofacies. The kind and quantity of organic matter are revealed by this study, and this information can be utilized to:

1. Recreate ancient ecosystems and surroundings.
2. Determine possible hydrocarbon source rocks.
3. Establish a correlation between sedimentary rocks in various locations.

Palynofacies and their Uses

According to Tyson (1995), the main uses of Palynofacies include:

Determining the position and quantity of terrigenous inputs (i.e., proximal-distal connections with regard to source) is one of the primary purposes of palynofacies.

1. Identifying the onshore-offshore axes, or depositional polarity;
2. Finding regressive-transgressive and relative shallowing-deepening patterns in stratigraphic sequences (and consequently Flooding Surfaces and Sequence Tracts);
3. Determining and classifying sedimentologically homogeneous materials, particularly shales;
4. Assessing the potential for hydrocarbon source rocks and qualifying the geochemical properties of bulk rocks;
5. Calculating variations in water-mass stratification and primary productivity (using relative and absolute abundance of several kinds of organic-walled microplankton).
6. Differentiating between ecosystems, such as brackish freshwater, dysoxic-anoxic marine, and oxic open marine;

7. Calculating variations in water-mass stratification and primary productivity using the absolute and relative abundance of various organic-walled microplankton species.

Petrography

The study of the mineral makeup and texture of rocks is known as petrography. In order to determine the minerals present, their quantities, and their relationships, thin pieces of rocks are examined under a microscope. Petrography offers details on:

1.The rock's formation and change over its geological history.

2. Mineral identification and their paragenesis (formation sequence).

3. Restoring prehistoric habitats and depositional contexts.

Uses of Petrography

1. Rock Classification and Identification

- Based on their mineral makeup and structure, rocks can be categorised as igneous, sedimentary, or metamorphic using petrography.
- It facilitates the identification of various rock kinds and their geological backgrounds.

2. Sedimentary Basin Analysis and Depositional Environment

- Understanding porosity, permeability, and diagenetic changes is aided by petrographic research of reservoir rocks, such as carbonates and sandstones, in petroleum geology.
- It offers information about the depositional environment (deltaic, marine, and fluvial) based on grain properties and mineral assemblages.

3. Petroleum Exploration and Reservoir Characterization

- In hydrocarbon exploration, identifying source rocks, reservoir rocks, and cap rocks requires the use of petrography.

- By examining secondary mineral changes, cementation, and porosity, it aids in assessing the quality of reservoir rocks.

4. Economic Geology and Mineral Exploration

- It helps determine which minerals in rocks contain ore, which is essential for mining and mineral prospecting.
- Determining the economic feasibility of mineral resources is aided by petrographic investigations.

5. Construction and Engineering Geology

- When determining whether rocks are suitable for use as building materials (such as aggregates for concrete or materials for roads), petrography is employed.
- It aids in evaluating the weathering, strength, and durability of building stones.

6. Metamorphic and Igneous Rock Studies

- Through mineral assemblages and textures, petrography aids in the determination of the pressure-temperature history of rocks in metamorphic petrology.
- It sheds light on volcanic processes, cooling rates, and magma crystallisation in igneous petrology.

7. Environmental and Forensic Geology

- In environmental research, petrographic analysis is performed to evaluate the effects of pollution on rocks and sediments.
- It can assist in determining the provenance of materials used in crime scene investigations in forensic geology.

Researchers can obtain a more thorough understanding of sedimentary rocks and their geological history by combining petrography and palynofacies. This integrated strategy can offer insightful information about:

1.Sedimentary basin formation and evolution.

2. Hydrocarbon movement and formation.

3.The restoration of prehistoric ecosystems and surroundings.

1.8 Significance of study areas

The Gbekebo region is thought to be a possible exploration area, and the Dahomey Basin is a known hydrocarbon province. Because of its history of tectonic activity, sedimentation, and deformation, the Dahomey Basin is a complex geological setting. Researching the Gbekebo region can yield important information about the geological development of the basin. Significant economic ramifications for the region and the nation could result from the discovery of hydrocarbons in the Gbekebo area. Researchers have the chance to create and implement novel approaches and procedures for the exploration and production of hydrocarbons in the study region. In order to better understand the geological relationships between the various regions of the Dahomey Basin, the Gbekebo area can be a crucial site for regional correlation and mappin

CHAPTER TWO

2.0 Literature Review

2.1 Literature Review of Palynofacies and Petrography of the Gbekebo well, Dahomey Basin

Numerous geological investigations have examined the palynofacies and petrography of the Gbekebo well, which is situated in the eastern Dahomey Basin of southwest Nigeria. Understanding the region's stratigraphy, depositional settings, and hydrocarbon potential are the goals of these investigations.

Palynofacies Analysis

In order to assess depositional conditions and thermal maturity, palynofacies study entails analyzing sedimentary organic materials, including kerogen types and palynomorphs (pollen, spores, and dinoflagellate cysts). Important taxa like Proxapertites cursus, Verrucatosporites usmensis, and Spinizonocolpites echinatus have been found in the Gbekebo well through palynological investigations. These results, which correlate with miospore Zones E–G, point to the middle to late Paleocene age of the related strata. These palynomorphs' existence suggests a Paleocene coastal to marginal marine depositional environment.

Petrography and Source Rock Potential

The Maastrichtian Araromi Formation, regarded as a possible source rock in the Dahomey Basin, has been the subject of petrographic investigations of the Gbekebo well. Total organic carbon (TOC) concentrations in shale samples from this formation range from 0.5% to 4.78%, according to geochemical tests, indicating good to outstanding organic richness. According to results from Rock-Eval pyrolysis, Type II kerogen with the ability to produce oil is present, as evidenced by hydrogen index (HI) values that average 327 mg HC/g TOC. The organic matter is within the early to peak oil generation window, according to thermal maturity estimates based on Tmax values and biomarker tests.

Depositional Environment and Stratigraphy

Understanding the Gbekebo well's depositional history has been made possible by the combination of petrographic data and palynofacies. Deposition in a coastal to marginal marine environment, impacted by both terrestrial and marine inputs, is suggested by the identified palynomorph assemblages and organic matter types. This is in line with the stratigraphic framework of the eastern Dahomey Basin, where the Late Cretaceous to Paleocene saw the transgression sequence known as the Araromi Formation shift from continental to marine environments.

2.2 Overview of Palynofacies Analysis

Palynofacies is the study of sedimentary organic matter, particularly macerated plant and microbial waste and palynomorphs (pollen, spores, dinoflagellates, etc.). Understanding the history of deposition and the possibility of hydrocarbon source rocks depends on the examination of these organic components, which aids in the reconstruction of historical habitats and climatic circumstances. Key points from the literature on palynofacies analysis are summarised below:

Analyzing palynofacies focusses on the organic matter that is present in sedimentary rocks and sediments, including cuticles, wood fragments, amorphous organic debris, algae, and palynomorphs (such as pollen, spores, foraminiferal cysts, and dinoflagellate cysts). Palynofacies' composition offers crucial information about paleoenvironment by reflecting the organic material's source, deposition, and diagenesis. Moldowan et al. (1985) first proposed the idea of palynofacies after seeing its potential to comprehend source rock evaluation in petroleum systems. With many uses in the reconstruction of paleoenvironment, depositional settings, and biogeochemical cycles, palynofacies analysis has now developed into an essential stratigraphic tool. Over time, attempts to standardize procedures and enhance data interpretation have led to improvements in the classification of organic matter into categories known as palynofacies.

Usually, palynofacies are categorized according to the kind and proportion of organic materials present in a sample. The classification typically consists of: Pollen, spores, and dinoflagellate cysts are examples of the Palynomorph-rich facies, which are frequently linked to certain depositional habitats (such as coal swamps, floodplains, or lacustrine settings).

Degraded plant matter makes up Amorphous organic matter (AOM)-rich facies, which are frequently used to denote anoxic or low-energy depositional conditions.

Wood, leaves, and cuticles are examples of Material originating from terrestrial plants that are frequently used to indicate deposition sites where land plants predominate.

Dinoflagellates and marine algae are examples of Marine-derived facies, which are important markers of coastal or marine habitats.

palynofacies entails preparing and examining sediment samples under a microscope, frequently separating organic material from the sediment using methods like acid maceration. Visual examination, frequently with the aid of stereo-microscopy, light microscopy, or scanning electron microscopy, is then used to classify and quantify the organic matter. Palynofacies compositions can also be statistically analyzed and data visualize using a variety of methods and software.

2.2.1 Applications in Paleoenvironment and Stratigraphy

Reconstructing historical habitats is one of the primary uses of palynofacies study, especially in connection with:

• Paleoclimate: Based on the relative abundance of particular organic material types, paleoclimates can provide insight into past climates. High percentages of marine palynomorphs, for instance, indicate a warm climate with marine influences, whereas terrestrial plant material can represent more continental or temperate environments.

• Paleogeography: By distinguishing particular forms of palynofacies, one may ascertain how close depositional settings are to open sea or land and comprehend the dynamics of old shorelines, estuaries, and floodplains.

•Depositional Environments: Certain depositional environments are linked to specific organic materials. For instance, a high AOM concentration may indicate anoxic conditions that are common in lagoonal or deep marine habitats, however, a lot of pollen could be a sign of a forest-covered, terrestrial environment.

In petroleum geology, palynofacies are important, especially when assessing possible source rocks. The amount of organic matter in sediments can reveal information about the depositional history, hydrocarbon-producing potential, and thermal maturity of the parent rocks. This is particularly crucial for determining which source rocks are more likely to produce oil or gas and for determining when hydrocarbons will start to form. Palynofacies' function in evaluating the quality and maturation of source rocks is the subject of several research, as those conducted by Carter et al. (2000).

In recent advances the use of molecular biomarkers, which aid in identifying particular organic chemicals suggestive of particular types of organic matter (e.g., aliphatic and aromatic compounds), is one of the recent developments in palynofacies investigation. In order to supplement conventional palynological approaches and provide more in-depth understanding of the origin, alteration, and preservation of organic matter, geochemical techniques are also being used more and more. Recent research has concentrated on improving reconstructions of paleoenvironmental conditions by combining palynofacies with other data sources (such as sedimentology and isotopic data). Furthermore, studies have examined how the diagenetic mechanisms influencing palynomorph preservation impact the accuracy of palynofacies analysis.

2.3 Overview of Petrography analysis

A vital area of research in geology is petrography analysis, which focusses on the in-depth inspection and characterization of rock samples under a microscope. Reconstructing geological histories, analyzing rock attributes, and assessing possible resource deposits all depend on an understanding of the composition, texture, and structure of rocks. The main techniques, uses, and developments in the field of petrographic analysis are covered in the literature review that follows. By examining rocks under a microscope, petrography can provide information about their mineralogical makeup, texture, and structural characteristics. Petrographic analysis used to be based on thin section analysis using transmitted light microscopes, but more recent methods frequently incorporate cutting-edge imaging methods like X-ray diffraction (XRD) and scanning electron microscopy (SEM). Pioneers like Lazzaro Spallanzani and Gustav Rose established the groundwork for petrography in the 19th century by classifying minerals and rocks according to their visual characteristics. As the work of Adolf Knop and Alfred Lacroix led to the systematic classification of rocks based on mineral composition and texture, petrography gradually became a fundamental aspect of petrology, the study of rocks.

There are several methods in conducting Petrographic analysis;

Thin Section Petrography: To prepare a thin section, a rock sample is cut into incredibly thin slices, each 30 to 40 microns thick, and then placed on glass slides. To identify the minerals, textures, and structures present in the rock, these sections are inspected under a microscope. One of the most basic approaches to petrographic analysis is still this one.

• Scanning Electron Microscopy (SEM): SEM enables microscopic high-resolution imaging of rock materials. It offers comprehensive surface properties and mineral identification, which is particularly helpful when researching fine-grained rocks or minerals.

• X-ray Diffraction (XRD): XRD is a non-destructive technique that analyses the diffraction patterns of rocks to ascertain their mineralogical makeup.For a more thorough mineralogical investigation, it is frequently combined with petrography.

2.3.1 Applications of Petrography analysis

•Igneous and Metamorphic Petrology: Understanding the mechanisms that lead to the creation of igneous and metamorphic rocks requires a solid understanding of petrography. For instance, Winkler (1979) and McBirney (1993) investigated the application of petrography to examine mineral assemblages and magmatic textures, providing insight into the cooling and crystallisation history of igneous rocks.

Sedimentology: This field studies diagenetic processes and reconstructs previous depositional settings through petrographic examination of sedimentary rocks. Boggs (2009) emphasised the use of petrographic methods to categorize carbonate and clastic rocks, which shed light on source locations, post-depositional changes, and sediment transit.

• Evaluation of Hydrocarbon Reservoirs: In oil and gas exploration, petrographic analysis is crucial, especially for figuring out the mineralogy, permeability, and porosity of reservoir rocks. The evaluation of pore architecture and diagenetic alterations that impact hydrocarbon storage and migration is the main subject of studies such as Beard and Weyl (1973).

• Geotechnical Engineering: To determine the strength, durability, and appropriateness of rocks for construction projects, petrographic study of rock samples is essential in civil engineering. Tegeler et al. (2010) investigated the ways in which petrography aids in determining the durability of construction materials and the stability of rock slopes.

2.3.2 Textural analysis and Structural analysis

Miller and Strickland (2011) highlighted how the textural study of volcanic rocks, for example, can reveal information about the eruption dynamics and post-eruption alteration processes. Textural features provide insights into the cooling rate of igneous rocks, the depositional environment of sedimentary rocks, and the deformation history of metamorphic rocks. Textural analysis, which includes the study of grain size, shape, and arrangement of minerals, is central to petrography.

• Grain Size Distribution: The size distribution of grains in sedimentary rocks is determined by petrographic examination, which aids in determining the energy of the depositional environment (e.g., low-energy settings like deep seas vs. high-energy habitats like rivers).

• Porosity and Permeability: The quantity and distribution of pore spaces in sedimentary rocks affect the quality of reservoirs. To comprehend fluid flow characteristics in subterranean formations, petrographic examination of pore sizes and types is essential.

Recent developments in technology have greatly improved petrographic analysis:

• Automated Petrography: Thanks to developments in imaging methods and software, tiny slices of rock may now be automatically analysed, yielding quicker and more accurate findings. According to Schieber et al. (2010), tools such as image analysis software can now quantitatively analyze textural properties, grain morphologies, and mineral abundances across huge datasets.

• 3D Imaging and Visualization: Complex rock textures and structures may now be seen in three dimensions thanks to advancements in 3D imaging. The spatial distribution of minerals and pore networks can now be thoroughly analyzed thanks to techniques like micro-CT scanning, which is crucial for mineral exploration and reservoir characterization.

•Integration with Geochemical Data: To provide a more thorough picture of rock history, including age dating, source rock analysis, and temperature history, petrography is increasingly being combined with geochemical data, such as isotopic analysis. Studies of mineralization and geothermal systems benefit greatly from this integrated approach.

2.4 Geological settings of the Dahomey Basin

West Africa's Dahomey Basin is a sedimentary basin that mainly lies in southern Benin but also stretches into areas of Togo and western Nigeria. It is a component of the broader system of the Niger Delta Basin. The following is a description of the Dahomey Basin's geological setting:

1. Tectonic Setting

• The stable basement of most of West Africa is the West African Craton, which runs along the southern edge of the Dahomey Basin. The development of the basin is linked to the South Atlantic Ocean opening as a result of the breakup of the supercontinent Pangea during the Jurassic period, about 150 million years ago.

• Because of the rifting and separation of Africa from South America, the basin developed within a zone of tectonic stability, making it a passive continental border.

2. Sedimentary Characteristics

•The basin has a thick sequence of sedimentary deposits that began to accumulate during the Cretaceous period (approximately 100 million years ago) and continue into the present.

•Sedimentation is primarily made up of clastic materials such as sandstones, shales, and conglomerates, with a mix of marine and terrestrial deposits.

•These sediments were deposited in shallow marine, deltaic, and coastal environments, with increasing thickness and complexity toward the coast.

3.Stratigraphy

The Dahomey Basin's stratigraphy has a number of noteworthy formations. Marine shales are the earliest deposits; newer layers, which are frequently found in deltaic environments, are composed of sandstones and conglomerates.

- The following are typical formations found in the Dahomey Basin:

• The Dahomey Formation: Known for its clastic sediment mixture, this formation is frequently linked to the area's first marine transgressions.

• The Benin Formation: Sandstones and shales alternately formed in a deltaic environment.

• The Afowo Formation is well-known for its marine deposits, particularly shales, which are a sign of deeper water.

4. Hydrocarbon Potential

The deeper portions of the Dahomey Basin nearer the offshore Niger Delta are thought to have potential for gas and oil. The basin's sedimentary sequence, which is rich in organic material, is thought to be capable of producing hydrocarbons; some exploration has already been done. The basin shares many geological similarities with the prolific Niger Delta Basin, including possible source rocks, reservoir rocks, and trap formations.

5. Characteristics of Structure

•The basin displays a number of structural characteristics common to passive margin basins, including the formation of normal faults and extensive subsidence.

•The basin, which has a deeper offshore area and a relatively shallow shelf, is bordered to the north by the Atakora Mountains. The raised basement dominates the basin's northern region, which has affected the patterns of sediment deposition.

6 . Geological Evolution

After Pangea broke apart, the Dahomey Basin evolved through a series of rifting and thermal subsidence phases. The basin underwent several stages of development over time, including a post-rift thermal subsidence period that resulted in the buildup of significant sedimentary deposits. All things considered, the Dahomey Basin is a significant geological feature in West Africa that holds promise for additional research and resource development, especially in the field of energy.

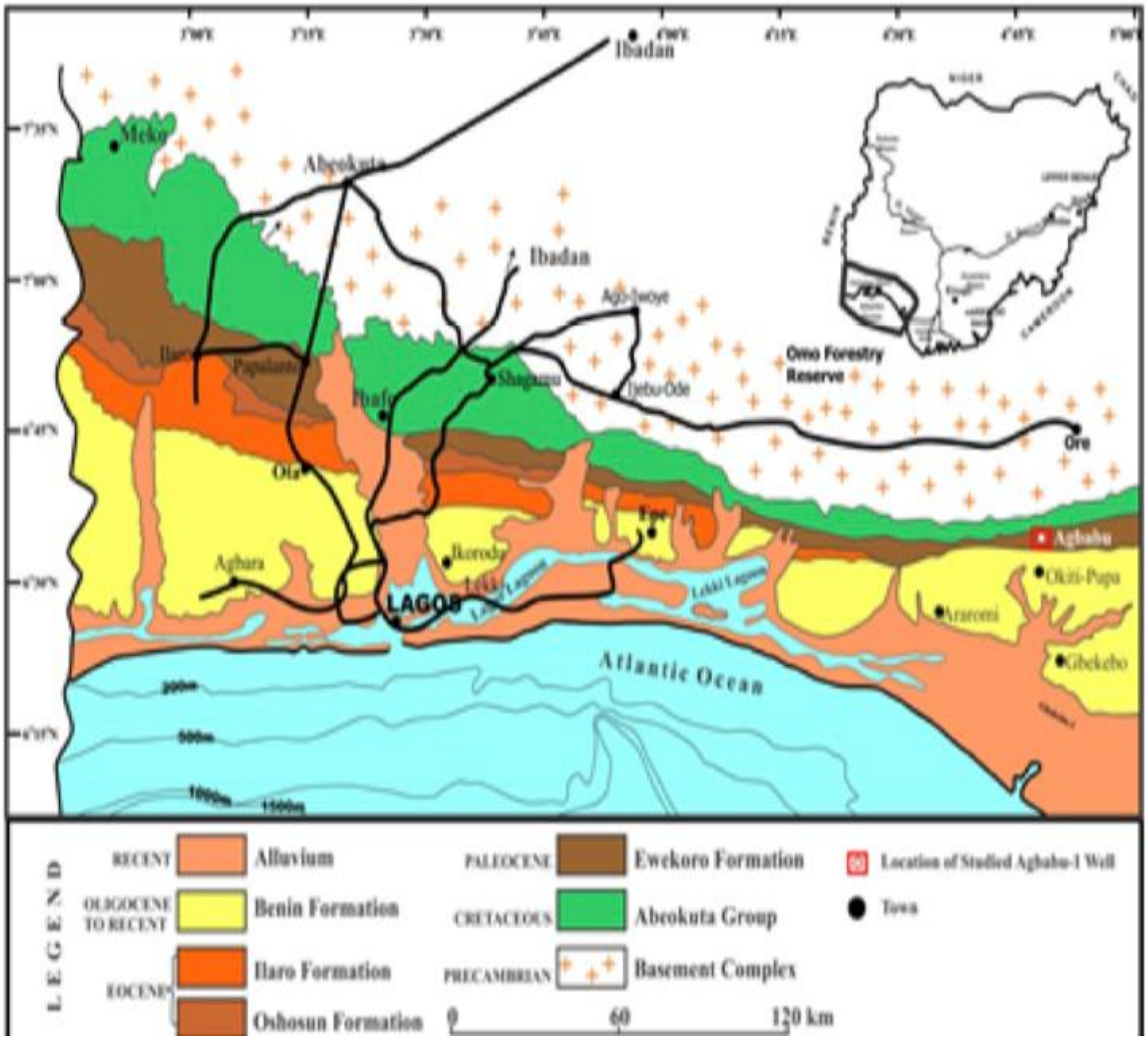


Fig2: **The outline geological map of Dahomey Basin (Modified after Adekeye et al., 2019)**

2.5 Previous studies on Gbekobo well and Dahomey Basin

Numerous geological and geochemical investigations have been conducted on the Gbekebo Well in the southwest region of Nigeria's Dahomey Basin with the goal of comprehending its stratigraphy, hydrocarbon potential, and depositional environment.

Geochemical and Stratigraphic Assessments

In order to describe provenance, paleogeography, source area weathering, and tectonic settings, research has concentrated on the geochemical composition of Cretaceous-Tertiary shales from the Gbekebo-1 well. With high chemical index of alteration (CIA) values indicating severe chemical weathering under a humid tropical climate, these findings imply that the shales were deposited in a passive margin setting.

Subsequent geochemical logging of the Gbekebo well has revealed two organic-rich periods, designated A and B, which are crucial for hydrocarbon development.

Potential for Hydrocarbons

Examining the Maastrichtian Araromi Formation's possible source rocks in the Gbekebo well has shown that marine algae are present in deeper portions, as evidenced by the presence of C30 24-n-propyl cholestane. In order to assess the basin's hydrocarbon potential, this biomarker indicates a significant marine influence.

Studies in Palynology

To determine the age and paleoenvironmental circumstances of the sedimentary sequences in the Gbekebo-1 well, palynological studies have been carried out. The stratigraphy of the basin and its relationships with adjacent areas are better understood thanks to these investigations.

Geological Context in the Region

The Dahomey Basin stretches from southeast Ghana to southwest Nigeria via Togo and the Republic of Benin. It is distinguished by a blend of coastal, offshore, and interior habitats. The Mesozoic epoch, when the African and South American plates separated, is when the basin's formation started.

The geological features, hydrocarbon potential, and depositional history of the Gbekebo Well within the Dahomey Basin have all been well investigated. These studies offer insightful information for the region's future resource management and exploitation.

CHAPTER THREE

3.0 Material and Methods

Samples were selected at different points in time to gather more accurate information about the well and its contents. The basic procedures carried out during the study, from data collection to intervention.

3.1 Materials

Below are some of the equipment used in carrying out the Palynofacies and petrographic analysis In the sedimentary lab

Plate 1: Microscope

Plate 2: Weigh balance

Plate 3: Sieve shaker

Plate 4 Sieve

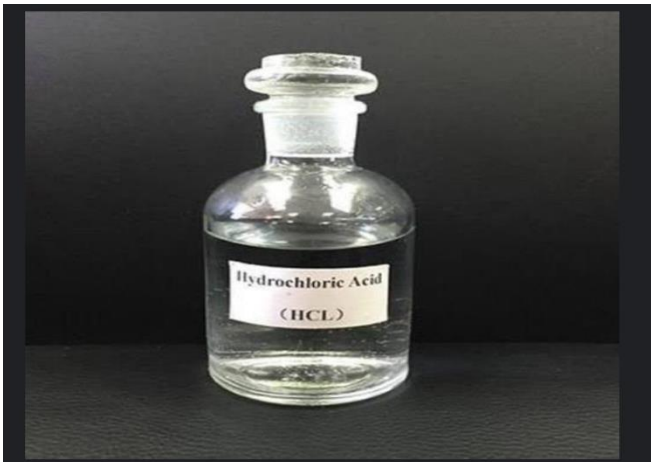


Plate 5: Hydrochloric Acid

3.2 Samples Collections and Preparation

Accurate palynofacies and petrographic analyses depend on the collection and preparation of samples from the Gbekebo Well in the Dahomey Basin. These procedures guarantee the accuracy and consistency of the data used to evaluate hydrocarbon potential, age dating, and depositional settings.

Samples Collection

Standardized protocols are followed while collecting samples from the Gbekebo Well in order to guarantee the accuracy of petrographic and palynological examinations.

a. Core and Cutting Samples for Palynofacies

- Core Samples: obtained from drilled parts that were maintained, guaranteeing low levels of contamination.

- Cutting Samples: collected to examine changes in the organic materials and depositional environment at regular depths intervals

- Preservation: To stop oxidation and microbiological deterioration, samples are enclosed in airtight bags or vials.

b. Core Samples for Petrography

- Rock Core Samples: chosen for thin-section processing from notable lithologic intervals.

Samples Preparation

a. Palynofacies analysis Preparation

Analyzing paleofacies entails examining different kinds of organic materials in order to decipher source rock potential and depositional conditions.

1. Crush and Acid Treatment

- Crushed samples (~10g) reveal interior stuff.
- Carbonates were eliminated by treating with HCl (10–15%).
- digested further in 40% HF to break down silicates.

2. Residue Washing and Sieving

- To concentrate organic materials, residues are rinsed with distilled water and sieved (10–15 μm)

3. Microscopic and image analysis

- used to categorize organic materials (such as spores, pollen, and amorphous organic material) using fluorescence microscopy and transmitted light.

b. Petrographic Analysis Preparation

To ascertain the mineralogical composition and diagenetic characteristics, petrographic study entails the fabrication of thin sections and microscopic inspection.

1. Samples Cutting and Polishing

- With a diamond saw, core samples are sliced into 2-4 cm pieces.

• To get rid of saw marks, it was polished to a smooth surface.

2. Thin Section Preparation

- Epoxy resin was used to adhere slices to glass slides.
- ground using silicon carbide abrasives to a thickness of around 30 µm.
- final polishing for clarity of vision.

3. Microscopy and Staining

- thin sections examined for mineral identification using polarized light microscopy (PLM).
- Alizarin Red-S staining was used to distinguish between dolomite and calcite.

Sample logging

Samples were laid down sequentially in batches.

Sample were prepared as per the supplied spot samples provided

1. Pre-treatment operations

Sample Treatment: 1. Maceration/Decarbonation

36% Hydrochloric acid (HCl) was added to cover sample.

The sample was left for about 20 – 30 minutes to allow for the total dissolution of carbonates.

Spent Hydrochloric acid (HCl) was decanted.

Beaker containing sample was topped with distilled water.

Allowed to settle and then decanted.

Process repeated three times (i.e. topping up and decanting). This is to remove any remaining calcium ions which could produce a precipitate when HF is added.

Sample treatment 2: Removal of Silicates

Enough Hydrofluoric acid (HF) was added to cover samples.

The samples were soaked in HF and left for 12 hrs (or overnight).

Material in the beaker was then topped up with distilled water, allowed to settle and decanted.

The above process was repeated three times to remove HF completely.

(HF + Silicates produces Silicofluoride gels which mar the production of quality palynological slides and therefore should be removed.)

Sample Treatment: 3. Removal of Silico fluoride gel

Residue was transferred into 150/100mlpyrex glass beaker after HF has been removed by decanting three times in step, 50 % HCl (40 ml) was added to residue and boiled down to 20 ml. On cooling, material was topped up with distilled water, allowed to settle and decanted.

Separation of organic from inorganic material is effected by using Zinc bromide solution or by swirling.

I.Separation of Organics from Inorganic Materials:

The residue from section (I)was transferred into 15 ml test tube.

Topped up with 10 % HCl.

Centrifuged at 2000 Revolutions Per Minute (RPM) for one minute.

Decanted and a little Zinc Bromide solution added, stirred and then topped up with approximately 25 ml of Zinc Bromide up to ¾ full.

Centrifuged at 2000 RPM for 10 minutes. This was done until there exist a good separation.

The dark organic portion was then transferred into another test tube using a pipette.

This was then topped up with 10 % HCl, centrifuged at 2000 RPM for 2 minutes.

This was decanted, topped up with distilled water, and centrifuged for 2 minutes and decanted.

II. Mounting of unoxidized residue: The residue is mixed thoroughly and a little pipetted out into a glass slide and examined under the microscope. This is to determine the level of oxidation required.

III. Oxidation: Cleaning of the Palynomorphs

Concentrated Nitric acid (HNO_3) was added to residue and left for about 10minutes.

Topped up with water and centrifuged at 2000 RPM for 2 minutes and decanted.

The last step was repeated until residue is neutral.

Residue was poured into glass beaker and sieved through the required nylon sieve mesh size with the aid of sonifier.

IV. Treatment with KOH: Removal of Humic Acid (Alternate to step 1.3.9)

A little of the residue was pipetted into another 100 ml beaker.

Two pellets of Potassium Hydroxide (KOH) pellets was added the to residue in water bath and watched closely.

Data Interpretation

The following data interpretation was provided with the aim of optimizing stratigraphic control of the sample(s) involved. The major interpretation items are

Biozonation

Palynological zonation based on the distribution of the recovered palynomorphs

Time-Stratigraphic Interpretation

This is provided on a per sample basis, where possible.

Environments of Deposition

Paleoecological interpretation was provided for each sample or set of samples. Palynological Simple Preparation Procedures

3.3 Palynofacies Analysis Techniques

In sedimentology and petroleum geology, palynofacies analysis is a technique used to examine organic materials in sedimentary rocks. It aids in determining source rock potential, evaluating thermal maturity, and reconstructing depositional settings. The following are the main methods used in palynofacies analysis:

1. Samples Preparation Techniques

a. Acid Digestion Method (Chemical Processing)

• Carbonates are eliminated from the sample by treating it with hydrochloric acid (HCl).

• Organic stuff is left behind when silicate minerals are dissolved by hydrofluoric acid (HF).

• Neutralization: Distilled water is used to wash away the residue after it has been neutralized with diluted HCl.

• To concentrate the palynological material, the sample is run through a fine mesh sieve, such as one with a mesh size of 10 to 15 µm.

b. Density Separation ($ZnCl_2$ or NaCl solution)

• To separate organic matter from heavier mineral particles, a heavy liquid (such as sodium chloride or zinc chloride) is utilized.

• For analysis, the floating fraction—which includes kerogen, palynomorphs, and amorphous organic matter—is kept.

2. Microscopic and Imaging Techniques

a. Transmitted Light Microscopy

• On slides, organic particles are adhered with Canada balsam or glycerin jelly.

• observed to categorize kerogen kinds (Type I, II, III, and IV) using a transmitted light microscope.

• Identification of amorphous organic matter (AOM) and palynomorphs (pollen, spores, and dinoflagellates).

b. Scanning Electron Microscope (SEM)

• offers photos of organic particles at high resolution.

• used to thoroughly characterize palynomorphs morphologically.

3. Quantitative and Statistical Analysis

a. Point Counting Method

• The relative abundance of various organic components (AOM, phytoclasts, and palynomorphs) is estimated by counting a predetermined number of points (e.g., 200–500) on each slide.

b. Organic Matter Classification

• Marine-derived organic matter, or amorphous organic matter (AOM), is crucial for the production of oil.

• Terrestrial plant fragments known as phytoclasts are linked to gas-prone kerogen.

• Palynomorphs: Indicators of the depositional environment and age dating include pollen, spores, dinoflagellates, and fungal remnants.

3.4 Petrographic Analysis Techniques

A key technique in geology for examining the mineralogical makeup, texture, and diagenetic history of rocks is petrographic analysis. It is extensively used in investigations of sedimentary, igneous, and metamorphic rocks as well as in the characterization and evaluation of the quality of petroleum reservoirs.

1. Microscopy Techniques

a. Polarized Light Microscopy (PLM)

• uses light that is both plane-polarized and cross-polarized in a petrographic microscope.

• uses extinction angles, pleochroism, birefringence, and color to identify minerals.

• aids in identifying the diagenetic characteristics, grain size, and rock fabric.

b. Fluorescence Microscopy

• used to find minerals that contain oil and organic substances.

• Under UV light, minerals containing hydrocarbons glow, signifying the presence of petroleum.

c. Reflected Light Microscopy

• utilised in the study of opaque minerals, such as oxides and sulphides.

• needed for coal and ore petrography.

2. Advanced Analytical Techniques

a. Scanning Electron Microscopy SEM) with Energy Dispersive X-ray Spectroscopy (EDS)

• gives high-resolution pictures of pore structures and minerals.

• Minerals' elemental composition is ascertained by EDS analysis.

• used to determine the porosity of reservoir rocks and identify diagenetic minerals.

b. X-ray Diffraction (XRD)

• determines the phases of crystalline minerals by examining diffraction patterns.

• Used to quantify clay mineral content in shales and sandstones.

c. Raman Spectroscopy

• uses vibrational spectra to determine the composition of minerals.

• Useful for detecting carbonaceous material, fluid inclusions, and diagenetic minerals.

3. Quantitative Petrography Techniques

a. Point Counting Method

• mineral counts using a narrow section grid (e.g., 300–500 points per sample) in a statistical approach.

- establishes the percentage of each mineral in rocks, or its modal composition.

b. Grain Size analysis

- uses image analysis software to determine the average grain size and sorting.
- aids in reservoir quality assessment and sedimentary rock classification.

c. Porosity and Permeability Estimate

- Cementation effects, secondary porosity, and inter-granular porosity can all be measured using thin-section analysis and image processing software.

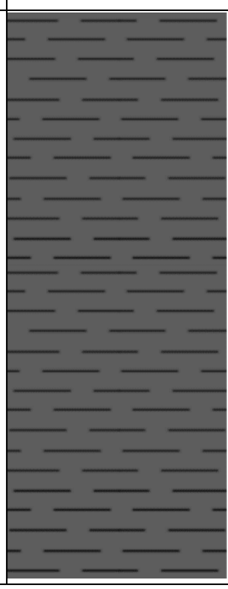
CHAPTER FOUR

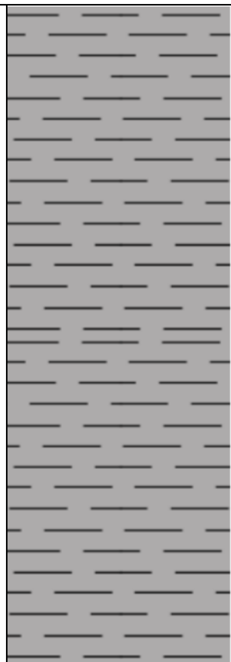
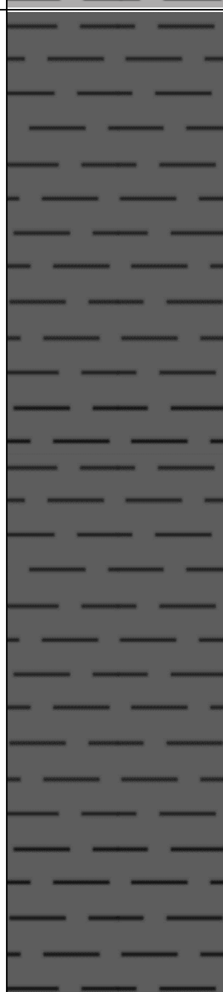
4.0 Results and Discussion

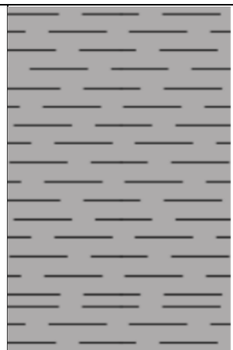
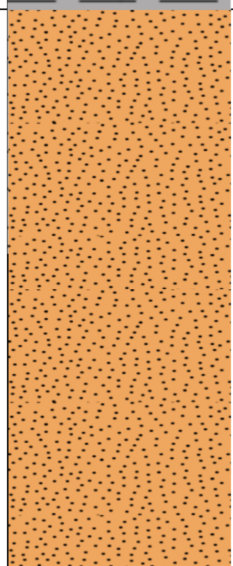
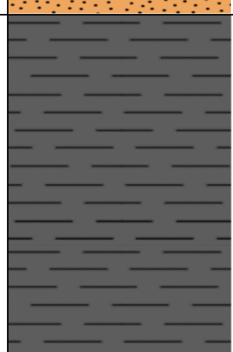
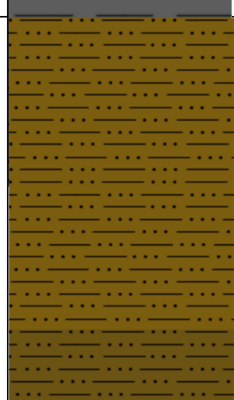
4.1 Lithostratigraphy

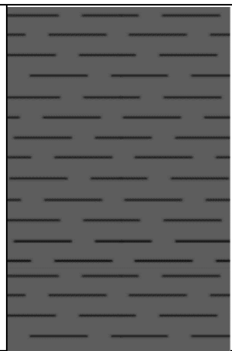
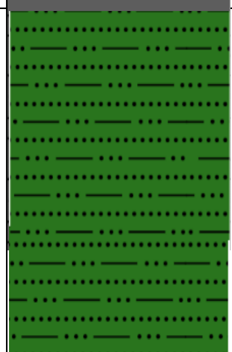
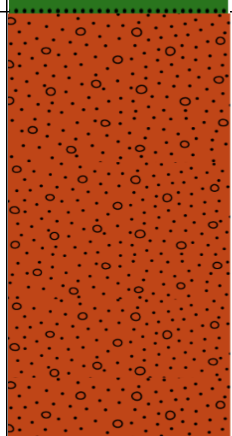
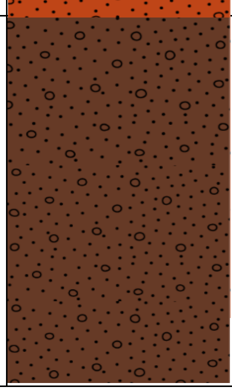
The Lithostratigraphic description of the samples recovered from Gbekebo well was done from top to bottom of the well. A total of 47 samples was described based on color, grain size mineralogical composition from 300ft -3200ft. Three major lithofacies types were identified in the well. A lithologic log of the well is shown in Table 4.1 below.

Table 4.1 LITHOLOGIC DESCRIPTION

S/N	COLOUR	DEPTH INTERVAL	LITHOLOGY	DESCRIPTION
1		300FT-400FT	DARK GREY SHALE	Samples In this interval are dark grey shale mainly composed of clay size minerals, quartz and feldspar

2		500FT	LIGHT GREY SHALE	A light grey shale with clay, quartz and feldspar as the mineral present in it.
3		600-1114FT	DARK GREY SHALE	Dark grey shale composed of clay quartz

4		1145-1163FT	LIGHT GREY SHALE	light grey shake which composed of fine clay particles and mica particularly Muscovite
5		1183-1186FT	FINE GRAINED SAND	fine sand composed of small grain particles ranging from 0.0075-20 in diameter
6		1220FT	DARK GREY SHALE	A very dark shale with organic matter present and clay, quartz identified to be the minerals present in it
7		1350-1353FT	SILTSTONE	A brownish siltstone with silt-sized grains, Quartz is identified

8		1377FT	DARK GREY SHALE	A dark shale with mainly of mica, quartz, clay and feldspar
9		1383-1386FT	SILTY SANDSTONE WITH PLANTS MATTER	A sandstone with lots of silt In it and plant matter mainly of high percentage of quartz.
10		1398-1404FT		Sand which particles (silt size or sand size) are average between 1/2 and 1/4 mm in diameter
11		1419FT	DARK MEDIUM-COARSE SANDY UNITS	A dark medium-coarse grained sand with particles size average of about 1/2 and 1/4 mm in diameter

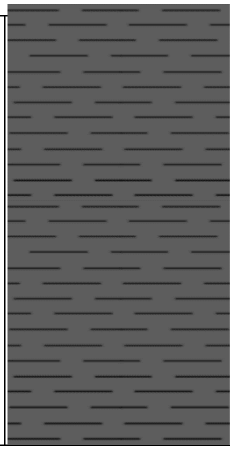
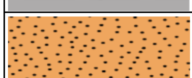
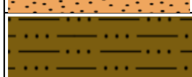
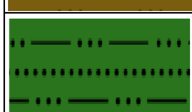
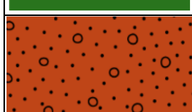
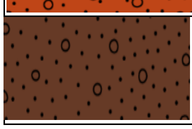
12		2022-3220FT	DARK GREY SHALE	minerals in this shale are quarts , feldspar and clay size minerals

FIG 3: LITHOLOGY OF THE SAMPLED GBEKEBO WELL

LEGEND

	DARK GREY SHALE
	LIGHT GREY SHALE
	FINE-GRAINED SAND
	SILTSTONE
	SILTY SANDSTONE WITH PLANT MATTER
	MEDIUM-COARSE DARK GRAINED SAND UNITS
	DARK MEDIUM-COARSE SANDY UNITS

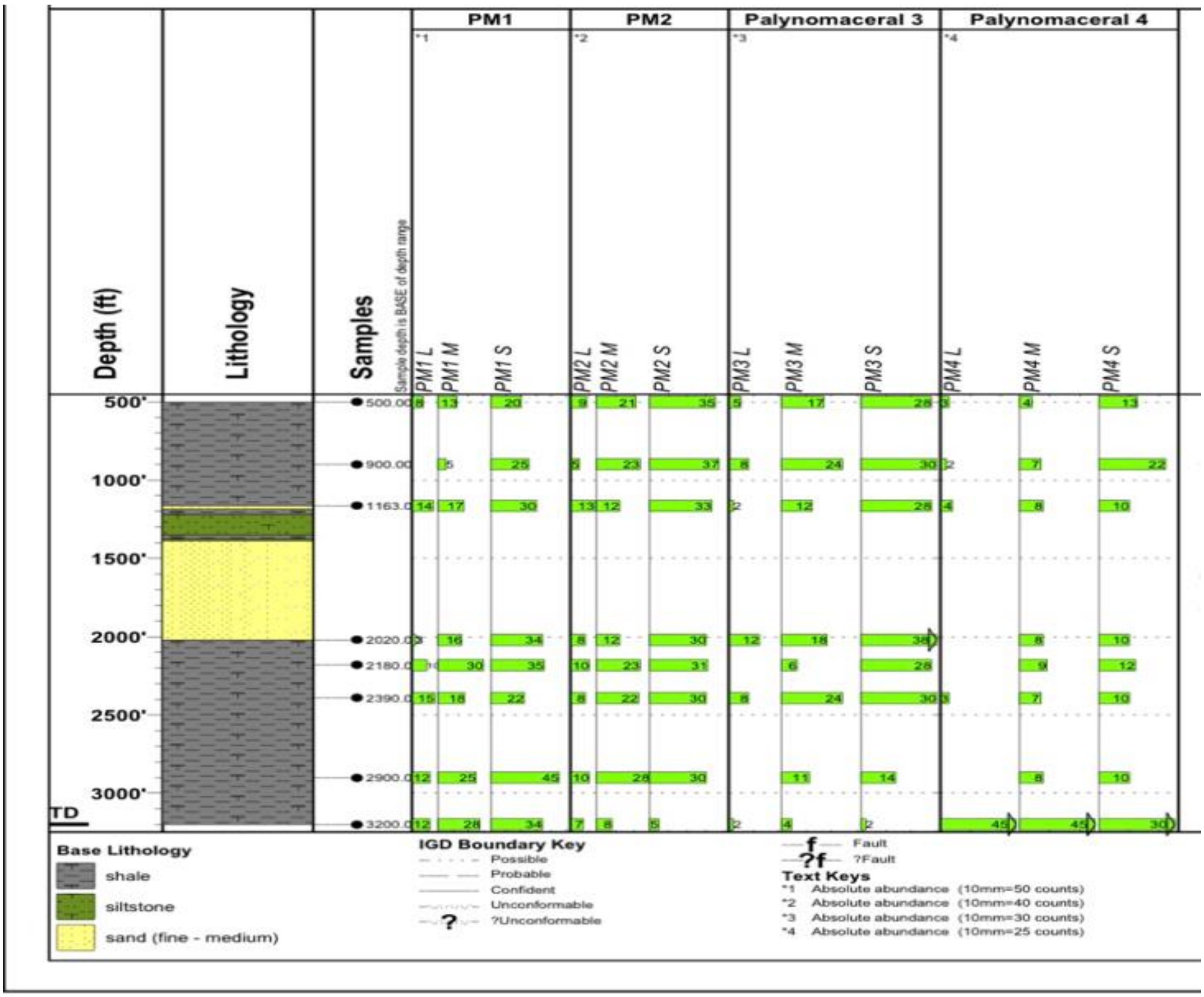
4.2 Palynofacies Study of Gbekebo Well

Eight core samples were selected and analyzed for palynofacies studies. The eight core samples show predominance of medium and small structured palynomeceral (PM3) and PM2 with common records of PM1 and low counts of palynomaceral (PM4) & SOM. This admixture suggests a predominantly continental (terrestrial) environment of deposition.

Palynofacies processing and analysis were carried out on eight (8) core samples of the Gbekebo-1 well (500-3000 ft). Unoxidized slides were produced and routine microscopic identification of plant materials were carried out in order to decipher the possible paleoenvironment of deposition of the samples. Varying sizes and abundances of Palynomaceral (PM1-PM4) types as well as Structureless Organic Matter (SOM) were recorded.

A total of 200 counts were made per type of palynomaceral (PM) per slide to determine for abundance of various size fractions of each PM group. The percentage of the counts is computed to determine the percentage dominance of the palynomaceral type.

Table 4.2: Distribution of organic matter present in Gbekebo well interval 300- 3000 f



4.2.1 Palynofacies interpretation

The interpretation of the palynofacies is based on the model erected by Oyede (1991). The palynofacies assemblage is quantitatively dominated by medium and small sized structured PM2 and PM3 with common records of PM1, low counts of PM4 and SOM. Based on the abundance of PM2 and PM3 types with common records of PM1 type, the paleoenvironment of deposition is interpreted to be predominantly terrestrial. The colour of the kerogen types (palynofacies) is predominantly black with few brownish colouration of PM3. The details of the abundances of the palynomacerals are shown below.

Table 4.3: Palynofacies Type, Counts, Colour and Interpretation of Gbekebo-1

Samples (ft)	**Palynofacies / Counts of size fraction.**			**Counts of each PM**	**% Ct.**	**Color**	**Interpretations**
500	**PMI1**	**L**	**8**	**41**	**20.5**	The samples are predominantly black with few brownish colouration	The eight ditch cuttings of Gbekebo-1 samples show predominance of medium and small structured palynomaceral (PM) 3 and PM2 with common records of PM1 and low counts of palynomaceral (PM) 4 and SOM. This admixture suggests a predominantly continental (terrestrial) environment of deposition.
		M	**13**				
		S	**20**				
	PM2	**L**	**9**	**65**	**32.5**		
		M	**21**				
		S	**35**				
	PM3	**L**	**5**	**50**	**25**		
		M	**17**				
		S	**28**				
	PM4	**L**	**3**	**20**	**10**		
		M	**4**				

		S	1 3				
	SOM 10.5 CGC 1.5				21 3		
900	PM1	L	-	30	15		
		M	5				
		S	25				
	PM2	L	5	65	32. 5		
		M	23				
		S	37				
	PM3	L	8	62	31		
		M	24				
		S	30				
	PM4	L	2	31	15. 5		
		M	7				
		S	22				
	SOM:			12	6		
1163	PM1	L	14	61	30. 5		
		M	17				
		S	30				

	PM2	**L**	**13**	**58**	**29**		
		M	**12**				
		S	**33**				
	PM3	**L**	**2**	**42**	**21**		
		M	**12**				
		S	**28**				
	PM4	**L**	**4**	**22**	**11**		
		M	**8**				
		S	**10**				
	SOM: 17 **8.5**						
2020	**PM1**	**L**	**3**	**53**	**26.** **5**		
		M	**16**				
		S	**34**				
	PM2	**L**	**8**	**50**	**25**		
		M	**12**				

		S	**30**				
	PM3	**L**	**12**	**68**	**34**		
		M	**18**				
		S	**38**				
	PM4	**L**	**-**	**18**	**9**		
		M	**8**				
		S	**10**				
	SOM **11** **5.5**						
2180	**PM1**	**L**	**10**	**70**	**35**		
		M	**30**				
		S	**35**				
	PM2	**L**	**10**	**64**	**32**		
		M	**23**				
		S	**31**				
	PM3	**L**	**-**	**34**	**17**		
		M	**6**				

		S	28				
	PM4	L	-	21	10.5		
		M	9				
		S	12				
	SOM: 11 5.5						
2390	PM1	L	15	55	27.5		
		M	18				
		S	22				
	PM2	L	8	60	30		
		M	22				
		S	30				
	PM3	L	8	62	31		
		M	24				
		S	30				
	PM4	L	3	20	10		
		M	7				
		S	10				
	SOM			3	1.5		
2900	PM1	L	12	82	41		
		M	25				
		S	45				

	PM2	**L**	**10**	**68**	**34**		
		M	**28**				
		S	**30**				
	PM3	**L**	**-**	**25**	**12.5**		
		M	**11**				
		S	**14**				
	PM4	**L**	**-**	**18**	**9**		
		M	**8**				
		S	**10**				
	SOM			**7**	**3.5**		
3200	**PM1**	**L**	**12**	**74**	**37**		
		M	**28**				
		S	**34**				
	PM2	**L**	**7**	**62**	**31**		

		M	**8**				
		S	**5**				
	PM3	**L**	**2**	**24**	**12**		
		M	**4**				
		S	**2**				
	PM4	**L**	**45**	**30**	**15**		
		M	**45**				
		S	**30**				
	SOM			**10**	**5**		

The abundance of medium to small sized palynomaceral (PM) 2 and PM3 types with common records of medium to small sized PM1 type indicate a predominantly terrestrial paleoenvironment of deposition.

Palynomaceral 1 (PM1): These are dense black, dark brown and or orange-brown, largely irregular in shaped plant materials. Its origin may include plant debris such as resinous cortex materials as well as gel like substances. They are easily degraded by physical abrasion or high energy oxidizing environments.

Palynomaceral 2 (PM2): they include brown to orange structured plant materials e.g. leaf, algal detritus stem or small rootlet debris. It is less dense compared to PM2.

Palynomaceral 3 (PM3): This is pale coloured, structured material occasionally bearing stomata. It is cuticular in origin and degraded plant material.

Palynomaceral 4 (PM4): This is black almost equi-dimensional, blade or needle shaped material which is uniformly opaque, black and structureless. It may include coal, charcoal or geothermally fusinized material. They are very buoyant, resistant to degradation and transported over long distances. Unlike the other palynomacerals, the PM4 general indicate brackish water swamp and fluvio marine environment.

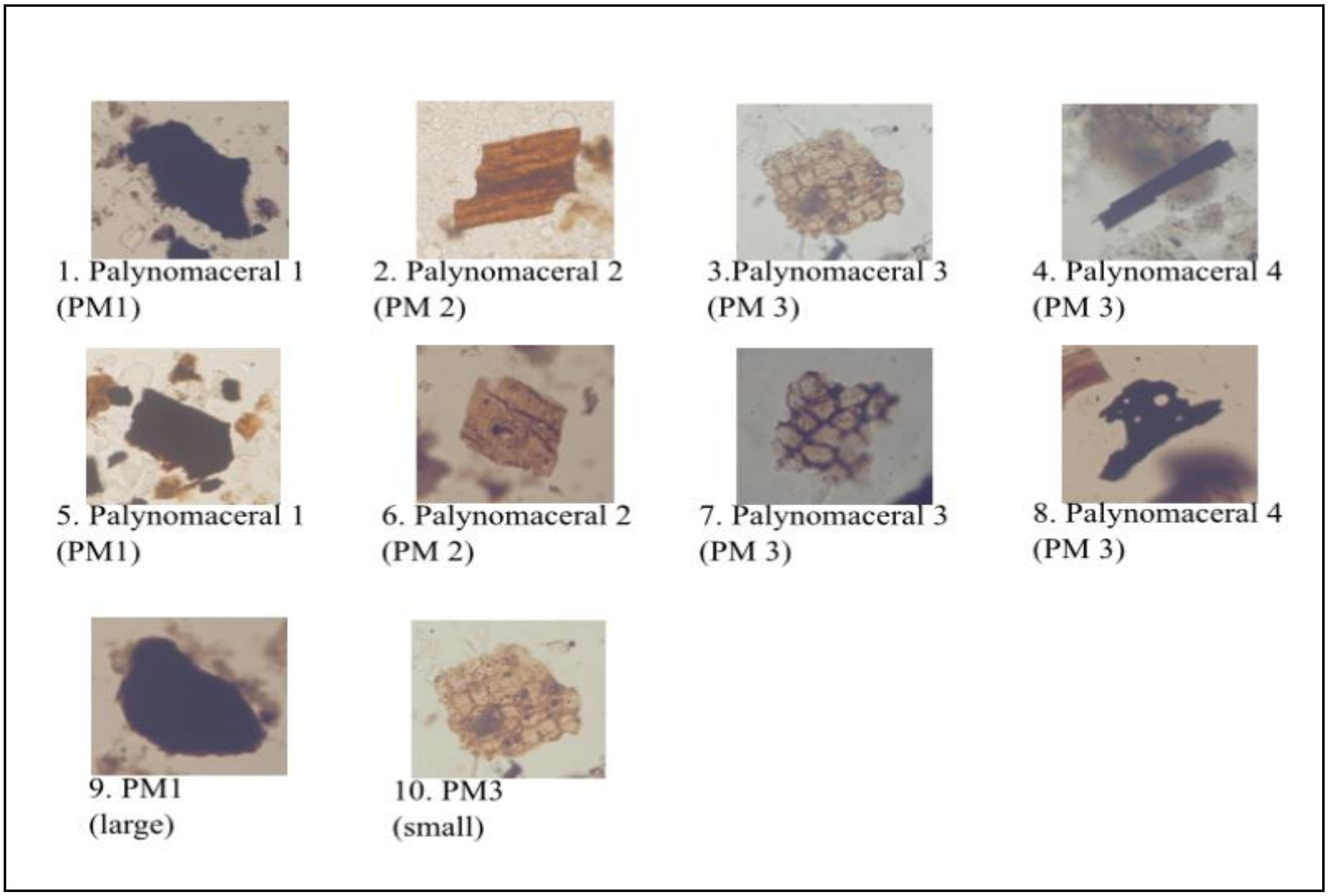


Plate 6, 4.1:Photomicrograph of important Palynofacies species in Gbekebo well

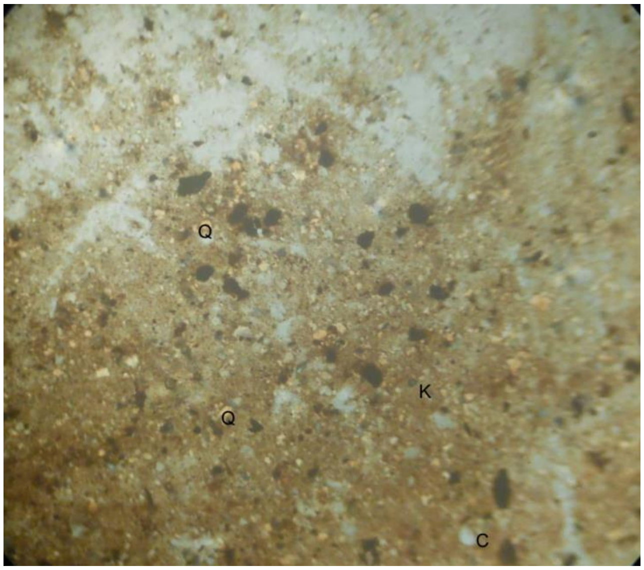
4.3 Petrographic Studies of Gbekebo Well

The result of the petrographic studies for Gbekebo well is shown below:

Table 4.4: Petrographic Distribution of minerals component in Gbekebo well

SAMPLE NO	QUARTZ	KAOLINITE	FELDSPAR	DOLOMITE	PYRITE	CALCITE	ORGANIC MATTER
GBEKEBBO 300	21	50	8	5	3	7	6
GBEKEBB0 750-790	16	62	4	3	2	6	7
GBEKEBBO 1183-1186	26	52	4	4	3	3	8
GBEKEBBO 1419	30	53	3	3	2	3	6
GBEKEBBO 2155-2180	15	66	4	2	2	4	7
GBEKEBBO 2300-2320	16	67	3	3	2	4	5
GBEKEBBO 2500-2520	18	63	2	2	3	5	7
GBEKEBBO 32000	14	65	3	3	2	5	8

4.3.1 IMAGES OF SOME DIFFERENT MINERALS COMPONENT FOUND IN THE SAMPLED SLIDE



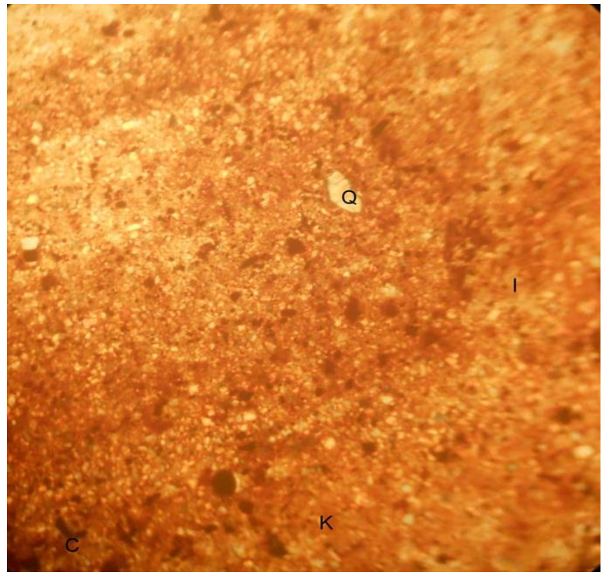
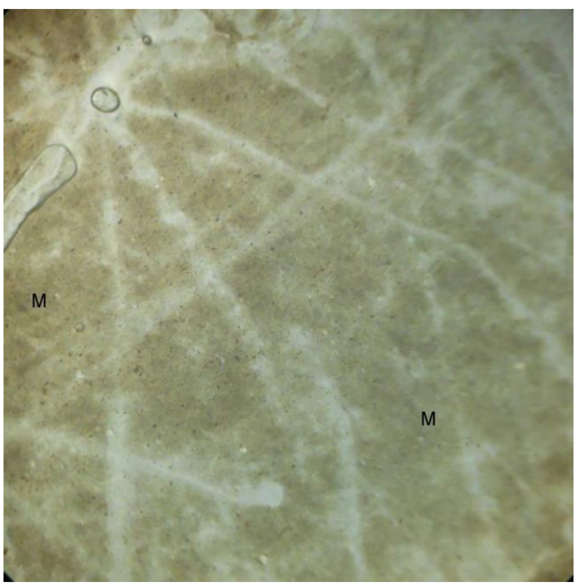


Plate 7 **Table 8**



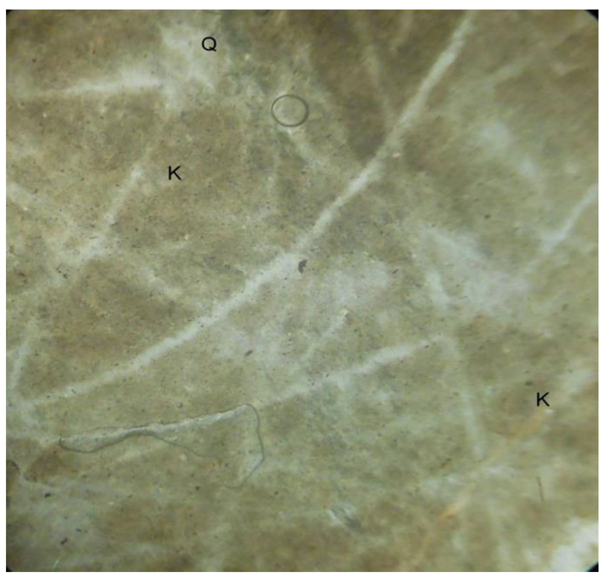
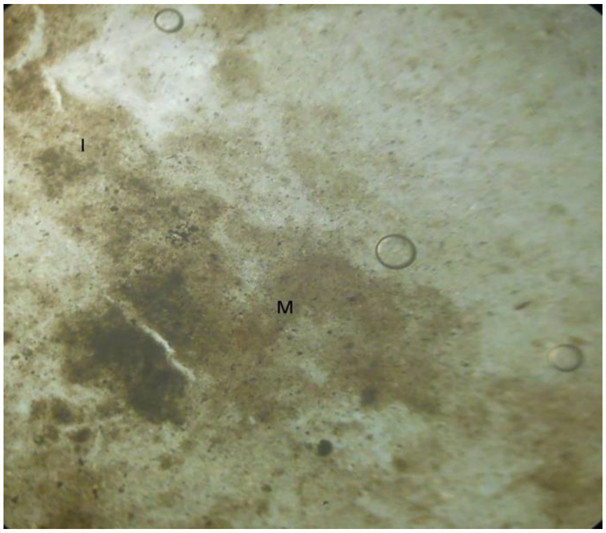


plate 9 **Plate 10**



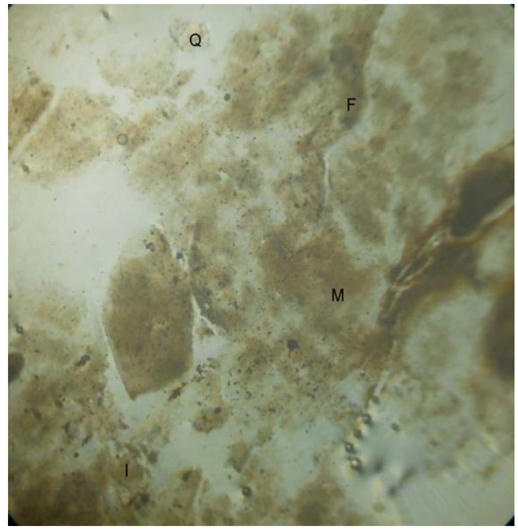
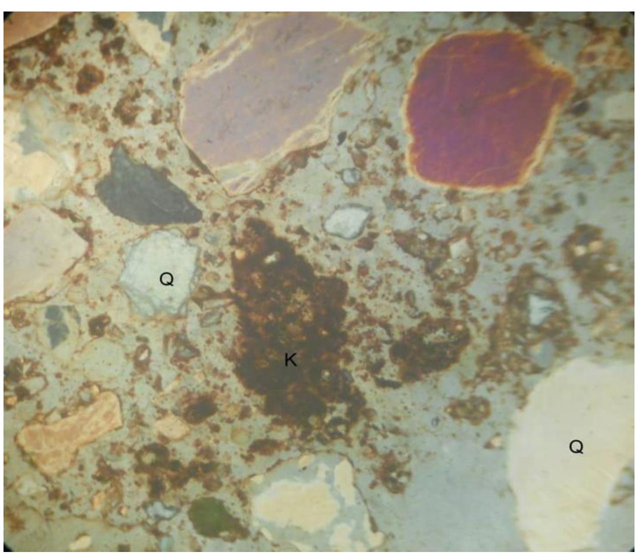


Plate 11

plate 12



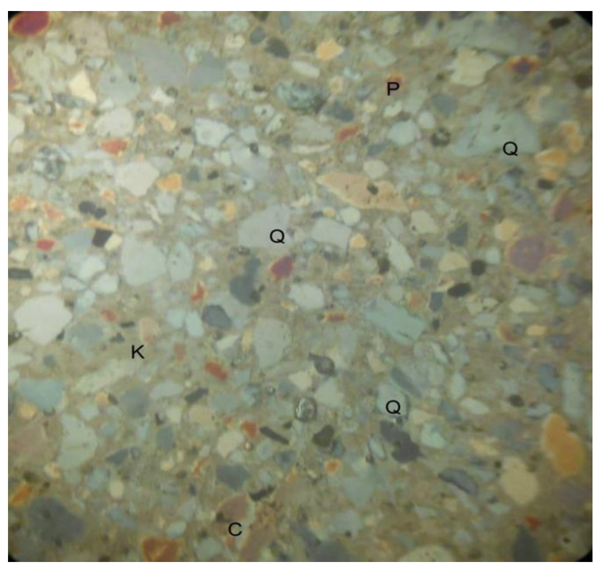


Plate 13

Plate 14

plate 7 indicate mineral components like Q(Quartz) a common mineral in sandstones, K (K-feldspar) another mineral in sandstones often indicating felsic source.

The above Plate appears to be a poorly sorted sandstone with mix of angular to sub - rounded grains of different minerals composition.

Plate 8 The labeled minerals shows the rock suck as Quartz, iron oxide and clay, the above plate image suggests a fine- grained sedimentary rock known to be a siltstone .

Plate 9 Matrix or Micrite is observed from the above plate and also veins (the white cross cutting features)

The presence of micrite indicates that the rock is likely a carbonate-rich mudstone

Plate 10: Quartz and k- feldspar is present in this plate . The rock contains quartz and k- feldspar suggesting it could be sandstone

Plate 11: Matrix or micrite which is the dominant component indicating a fine- grained carbonate and also iron oxide . The rock is likely a micritic limestone since it contains a micrite

Plate 12: Quartz grains are present in the rock indicating a silicicclastic influence and then micrite, the presence of micrite calcite suggests a carbonate-rich environment . F which represents fossil fragments or bioclast , I which is iron oxide

The combination of micrite, quartz, and fossil fragments suggests that this rock is likely a fossiliferous limestone

Plate 13: The labeled quartz grains (Q) are angular to sub-rounded, varying in size and shape, The brownish, rusty-looking areas labeled "K" suggest cementation or kaolinite clay mineral presence.The multicolored grains (pink, purple, and dark-colored clasts) suggest lithic fragments, which may be feldspar or metamorphic rock fragments.

The dominance of quartz and iron-rich cement suggests that this rock could be an iron-cemented sandstone

Plate 14: Q in the above plate is Quartz grains , the presence of quartz (Q) suggests a dominant siliciclastic composition. The labeled feldspar (P) indicates the presence of plagioclase feldspar, which is common in arkosic sandstones. The brownish to reddish patches labeled “K” could indicate iron oxide cementation or kaolinite clay minerals. Possible carbonate cementation or carbonate clasts are indicated by the presence of a labelled carbonate (C). This rock appears to be a feldspathic wacke (arkosic wacke) or lithic wacke based on the presence of quartz, feldspar, and lithic pieces.

CHAPTER FIVE

5.0 Conclusion and Recommendations

5.1 Conclusion

This study demonstrates the following transdisciplinary scope:

1. Lithologic Description
2. Palynofacies Studies
3. Petrographic Studies

That the Gbekebo well was mostly deposited in a terrestrial environment, with signs of slight marine impact at some depths, according to the integration of petrographic investigations and palynofacies. A fluvio-deltaic environment is supported by the preponderance of structured organic matter (PM2 and PM3), although low counts of PM4 suggest sporadic brackish water conditions. Intense weathering in humid circumstances, which are typical of tropical or subtropical paleoenvironments, is further supported by the high kaolinite content.

5.2 Recommendations

1. Detailed organic studies should be done to establish the hydrocarbon generation of the sediment.
2. Foraminifera studies should be done to establish age, depositional environment and biozones

REFERENCES

Akinwunmi, A. (2010). The Dahomey Basin: A Study of Sedimentary Facies and Hydrocarbon Potential. Nigerian Journal of Petroleum Geology7(4), 45–59.

Adekeye O. A., Ogundipe O., Adeoye J. A., Adeyilola A., Samuel O.,& Akande S. O.,(2021). Paleoenvironments and Hydrocarbon Potential of Upper Cretaceous Shales in Agbabu-1 Well, Dahomey Basin SW Nigeria European Scientific Journal, ESJ, 17(43), 194.

Batten, D. J. (1982). Palynofacies, palaeoenvironments and petroleum. Journal of micropalaeontology, 1(1), 107-114.

Boggs, S. (2009). Petrology of Sedimentary Rocks. Cambridge University Press. (A comprehensive guide to sedimentary petrology and petrographic analysis).

Bolaji, T. A., Ndukwe, O. S., Oyebamiji, A. R., & Ikegwuonu, O. N. (2020). Palynological age control and paleoenvironments of the Paleogene strata in Eastern Dahomey Basin, southwestern Nigeria. Scientific Reports, 10(1), 8991.

Billman, H.G. (1976). Offshore stratigraphy and paleontology of the Dahomey Basin. Journal of Mining and Geology, 12(1-2), 1-10.

Ben-Shlomo, D., & Gorzalczany, A. (2010). Petrographic analysis. Yavneh I: The excavation of the 'Temple Hill'repository pit and the cult stands, 148-166.

De Klasz, I. (1977). The Dahomey Basin: A review of its geology and hydrocarbon potential. Bulletin des Centres de Recherches Exploration-Production Elf-Aquitaine, 1(2), 147-160.

Falufosi, M. O., & Osinowo, O. O. (2021). Geology and hydrocarbon potential of the Nigerian sector of Dahomey Basin. Journal of Sedimentary Environments, 6(3), 335-358.

Folk, R.L. (1980). Petrology of Sedimentary Rocks. Hemphill Publishing

.**Okosun, E.A. (1990).** A review of the Cretaceous stratigraphy of the Dahomey Basin, Nigeria. Journal of African Earth Sciences, 10(1-2), 151-160.

Graz, Y., Di-Giovanni, C., Copard, Y., Laggoun-Défarge, F., Boussafir, M., Lallier-Vergès, E., ... & Simonneau, A. (2010). Quantitative palynofacies analysis as a new tool to study transfers of fossil organic matter in recent terrestrial environments. International Journal of Coal Geology, 84(1), 49-62.

Isabel, S. R. (2012). Organic petrology: an overview. Petrology: new perspectives and applications, 199.

Iserlis, M., & Thareani, Y. (2011). Petrographic analysis. Tel 'Aroer. The Iron Age II Caravan Town and the Hellenistic e Early Roman Settlement. The Avraham Biran (1975e1982) and Rudolph Cohen (1975e1976) Excavations. Annual of the Nelson Glueck School of Biblical Archaeology, 8, 179e187.

Jerram, D. A., & Kent, A. J. (2006). An overview of modern trends in petrography: Textural and microanalysis of igneous rocks. Journal of Volcanology and Geothermal Research, 154(1-2), vii-ix.

Njoku, J. O., Okeke, O. C., Opara, K. D., Okeke, H. M., & Okonkwo, S. I. (2021). A Review Of the Geology And Hydrocarbon Potential Of The Dahomey Basin. Inter. Jour. of Innov. Environ. Stud. Res., 9(1), 58-71.

Okeke, O. C., Abiahu, C. M. G., Anifowose, F. A., & Fagorite, V. I. (2019). A review of the geology and mineral resources of Dahomey Basin, Southwestern Nigeria. Int J Environ Sci And Nat Resour, 21(1), 1-5.

Obaje, N.G. (2009). Geology and Mineral Resources of Nigeria. Springer, Dordrecht. (Provides a comprehensive overview of the sedimentary basins in Nigeria, including the Dahomey Basin).

Oluwajana, O. A., Opatola, A. O., Adamolekun, O. J., Ndukwe, O. S., Olawuyi, G. T., Ofiwe, C. U., ... & Oluwajana, O. O. (2021). Sedimentation, depositional environments, and hydrocarbon potential of the Maastrichtian-Paleocene Araromi Formation, eastern Dahomey (Benin) Basin, southwestern Nigeria. Journal of Petroleum Exploration and Production Technology, 11(11), 3917-3934.

Oyede, A.C., (1991). Palynofacies in Deltaic Stratigraphy. Paper presented at the 1991 NAPE Conference. November, 1991.

Smith, D., & Jones, A. (2002). Palynological Approaches to Hydrocarbon Exploration

Schieber, J., and Zimmerle, W. (1998). Petrography of shales: A review of techniques and applications. Earth-Science Reviews, 44(1-2), 1-26.

Tyson, R. V. (1993). Palynofacies analysis. In Applied micropalaeontology (pp. 153-191). Dordrecht: Springer Netherlands.

Tyson, R.V. (1995). Sedimentary Organic Matter: Organic Facies and Palynofacies. Springer.