LITHOLOG APPLICATION FOR DELINEATING AND ESTABLISHING LITHOFACIES (HYDROCARBON PLAY ELEMENTS) PRESENT IN WELL ‘X’, GREATER UGHELLI DEPOBELT, NIGER DELTA, SOUTHERN NIGERIA

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UNIVERSITY OF BENIN

BENIN CITY

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF SCIENCE LABORATORY TECHNOLOGY, FACULTY OF LIFE SCIENCES IN PARTIAL FULFILMENT OF THE REQUREMENT FOR THE AWARD OF BACHELOR OF SCIENCE (HONOURS) DEGREE (BSC.) IN SCIENCE LABORATORY TECHNOLOGY

OCTOBER, 2025

CERTIFICATION

This is to certify that this Project 'Litholog Application for Delineating and Establishing Lithofacies (Hydrocarbon Play Elements) Present in Well 'X', Greater Ughelli Depobelt, Niger Delta, Southern Nigeria' was carried out by Blessing SHEGUN of the Department of Geophysical Science Laboratory Technology, Faculty of Science Laboratory Technology, University of Benin, Benin City, Edo State, Nigeria.

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DEDICATION

This work is dedicated to The Almighty God, my helper, provider, protector and the sustainer of my soul.

ACKNOWLEDGEMENT

I give thanks to the God Almighty who stood by me from the beginning of this program to the end also for giving me this grand opportunity to be educated in the Department of Geophysical Science Laboratory Technology.

I appreciate the Head of Department of Science Laboratory Technology, Prof. J.O. Osarunmwense, and the entire academic and non-academic staff of the Faculty, for their support and training given me during this program.

Special thanks to my amiable Lecturer, Mr. P. Bassey for his patience, guidance, teachings and trainings he gave me during this program and for making this project work a success.

Special thanks to my wonderful parents, Mr. and Mrs. Shegun, and to my siblings for their prayers, support and advice they provide me during this program.

To my friends and classmates, I thank you all for your immense support for me during this program.

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ABSTRACT

This study was carried out with the aim of delineating and establishing the lithofacies present in the well. From a depth of 4,500 feet (4500 feet) to 11,500 feet (11500 feet) from the Well 'X' in the Greater Ughelli Depobelt, Niger Delta Basin, Southern Nigeria, 117 ditch cutting samples were taken from the Shell Petroleum Development Company (SPDC) and processed for sedimentological analysis. We created a lithostratigraphical map for the well that included lithofacies, lithofacies units, formations, and related minerals. Four lithofacies—sandstone, sandy shale, shale, and shale sand—are revealed by the sedimentological examination of the well (4500–11500 feet) in Southern Nigeria's Niger Delta Basin. Twenty-seven (27) lithofacies units were found in the well, including the following: the Sandy Shale lithofacies at units 2, 4, 6, 8, 10, 15, 17, 20, 22, and 26; the Shale lithofacies at units 1, 5, 23, and 25; the Sandstone lithofacies at units 11, 13, 18, and 27; and the Shaly Sand lithofacies at units 3, 7, 9, 12, 14, 16, 19, 21, and 24. In conclusion, the litholog application for studying Well 'X' was able to delineate and establishing the lithofacies (Hydrocarbon Play Elements) that are present, as the well under study has hydrocarbon play features such as source rock, reservoir rock, caprock, traps, and seals.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Petroleum remains a crucial source of energy and an essential driver of economic growth in both developed and developing nations. The Niger Delta Basin, located along Nigeria's western passive continental margin, is an extensional rift basin that stretches across the Niger Delta and into the Gulf of Guinea. With sedimentary deposits reaching depths between 9 and 12 km, it stands among the largest subaerial basins in Africa. Based on the scale of petroleum deposits, production levels, and the wide distribution of hydrocarbon resources across its offshore, continental shelf, and deepwater terrains, the Niger Delta represents Nigeria's most productive and economically viable sedimentary basin (Soronnadi-Ononiwu et al., 2021). Aizebeokhai and Olayinka (2010) further describe it as one of the most significant provinces along West Africa's continental margin and among the world's most prolific deltaic hydrocarbon regions.

Oil exploration in the Niger Delta began in 1958 following the discovery of the first commercial oil well. Since then, more than 3,000 wells have been drilled across the region, penetrating sedimentary layers where petroleum generation, migration, and accumulation processes have been identified. The resulting data have substantially enhanced understanding of the Niger Delta's regional geology and stratigraphy (Chukwu, 1991).

Short and Stauble (1967) identified three main subsurface stratigraphic formations within the Niger Delta: the Benin Formation, the Agbada Formation, and the Akata Formation. According to Reijers (2011), from the Cenozoic to the mid-Miocene period, the Niger Delta evolved through successive pulses of sedimentation over a seaward-dipping continental basement into the Gulf of Guinea. Subsequently, progradation occurred over a landward-dipping oceanic basement, producing a 12,000 m thick sequence of regressive, offlapping sediments that comprise three diachronous siliciclastic units: the deep-marine Akata Formation, the delta-front Agbada Formation, and the continental Benin Formation (delta top). The development of palynology in the 19th century has greatly advanced petroleum exploration, providing vital tools for stratigraphic correlation within these formations.

A complete petroleum system comprises five essential elements: a mature source rock, a migration pathway, a reservoir rock, a trap, and a seal. The proper timing and interaction of these components are necessary for hydrocarbons to form, migrate, accumulate, and be preserved. These relationships are often illustrated through petroleum system charts that correlate geologic time with the evolution of system elements.

The Niger Delta Basin's geological characteristics including its source rock composition, lithology, structural framework, and thermal history are favorable for hydrocarbon generation and accumulation (Whiteman, 1982; Stacher, 1995; Ekweozor, 2000). Exploration prospects are typically most successful in basins where a complete petroleum system is likely to exist. Given the success of lithostratigraphic techniques in oil exploration, a detailed lithostratigraphic analysis was conducted using ditch-cutting samples obtained from Well "X," located within the Niger Delta.

1.2 Aim and Objectives

Aim:

This study aims to identify and establish the lithofacies present in Well "X" of the Niger Delta Basin.

Objectives:

The specific objectives are to:

i. Conduct a detailed sedimentological study of ditch-cutting samples from Well "X."

ii. Perform a quantitative analysis of the sediment samples.

iii. Identify the hydrocarbon play elements within the well.

iv. Develop a litholog illustrating the sequence and arrangement of lithostratigraphic units in Well “X.”

1.3 Scope of the Study

This research covers the following:

i. Collection and identification of samples expected to contain organic material.

ii. Lithological description and classification of the collected samples.

1.4 Source of Data

Data for this study were provided by the Shell Petroleum Development Company (SPDC). The materials include ditch-cutting samples collected from predetermined depth intervals in Well “X,” which was drilled to a total depth of 11,500 feet. A total of 117 samples were obtained for analysis.

1.5 Location of Well

Well “X” is located within the Niger Delta Basin, Nigeria, between longitudes 4°E and 8.8°E and latitudes 3°N and 6°N. Nigeria itself lies between latitudes 4°N and 15°N and longitudes 3°E and 14°E, within the Pan-African Mobile Belt situated between the West African and Congo cratons (Figure 2). The country’s geology comprises nearly equal proportions of crystalline and sedimentary rocks (Woakes et al., 1987). Well “X” lies within the sedimentary rock province of the basin.

1.6 Previous Work

The earliest comprehensive geological study of the Niger Delta was conducted by Shell Petroleum Development Company (SPDC) in 1908, with Reyment (1969) providing an early focus on the region's geology. Subsequent research has covered various aspects, including basin structure, stratigraphy, hydrocarbon habitats, and sedimentology. Hospers (1965) examined the basin's gravitational field, noting a 40 mgal gravity minimum likely caused by crustal displacement and sedimentary density variations. Short and Stauble (1967) identified the three major formations Benin, Agbada, and Akata and Weber (1971) described the basin's sedimentology. Murray (1972) explored the stratigraphy and paleogeography of southern Nigeria, while Weber and Daukoru (1975) linked faulting at the basement to delta growth and reservoir productivity.

Avbovbo (1978) confirmed the tripartite lithostratigraphic structure of the basin and described deltaic progradation from the Akata through the Agbada to the Benin formations. Evamy et al. (1978) analyzed hydrocarbon distribution, while Ejedawe (1981) and Knox & Omatsola (1989) studied oil reserve patterns and the relationship between sedimentation and hydrocarbon occurrence.

Further contributions include Adesida et al. (1997) on sequence stratigraphy, Hooper et al. (2002) on structural deformation, and Owoyemi (2004) on sequence boundaries within the Agbada Formation. More recent studies (e.g., Reijers, 2011; Dim, 2017; Ikuoyomwen et al., 2022) have refined understanding of lithofacies, depositional environments, and hydrocarbon play elements within various wells across the Niger Delta.

1.7 Lithostratigraphy

Advances in exploration methods have demonstrated that improved lithostratigraphic analysis enhances petroleum delineation. Lithostratigraphy, which focuses on rock-unit subdivision based on stratigraphic sequences bounded by unconformities, plays a vital role in identifying both structural and stratigraphic traps. Sequence stratigraphy, which relates rock sequences to changes in sea level and sedimentation (Haq et al., 1988; Van Wagoner et al., 1990; Reijers, 1998), provides a temporal framework for understanding sedimentary processes.

In the Niger Delta, lithostratigraphic studies reveal diachronous sequences of continental Benin sands, paralic Agbada interbedded sands and shales, and pro-delta Akata marine shales a result of tectonic and eustatic interactions (Short and Stauble, 1967; Weber and Daukoru, 1975; White, 1982). The basin is characterized by growth faults whose complexity increases seaward (Merki, 1972; Doust and Omatsola, 1990).

1.8 Role of Lithostratigraphy in the Petroleum Industry

Lithostratigraphy integrates biostratigraphy, paleodepth data, and well-log signatures with seismic reflection profiles. This integration enables geologists to delineate stratigraphic sequences, correlate rock units regionally, and identify potential hydrocarbon-bearing zones.

1.9 Petroleum System

A petroleum system includes an active source rock and all related oil and gas accumulations. It comprises the geologic components and processes essential for hydrocarbon generation, migration, and entrapment. Hydrocarbon generation depends on the presence of organic-rich material, adequate temperature, and sufficient time for thermal maturity. Migration involves the movement of hydrocarbons from source to reservoir, while accumulation occurs when they are trapped and sealed within porous and permeable rocks.

Cap rocks (e.g., shale, mudstone, anhydrite, and salt) act as impermeable barriers, and traps either structural (folds and faults) or stratigraphic (pinch-outs, unconformities, or reefs) ensure hydrocarbons remain contained within reservoirs.

1.10 Sedimentology

Sedimentology examines the processes responsible for the formation, transport, and deposition of sediments in both continental and marine environments. These sediments eventually consolidate into sedimentary rocks through physical, chemical, and biological processes. The principles of superposition, original horizontality, lateral continuity, and cross-cutting relationships are fundamental to understanding sediment deposition and stratigraphic arrangement.

Sedimentological analysis typically includes studying grain size, shape, sorting, porosity, permeability, and matrix composition   all of which determine the potential of rocks to serve as hydrocarbon reservoirs.

1.11 Role of Sedimentology in the Petroleum Industry

Sedimentological studies of sands, silts, and clays provide critical insights into depositional environments, which directly influence reservoir quality and hydrocarbon distribution. By interpreting sedimentary structures and layering, sedimentologists can reconstruct past environments and predict the spatial distribution of petroleum deposits. Since most hydrocarbon accumulations occur in sedimentary rocks, sedimentology is a key discipline in petroleum exploration and reservoir evaluation.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Geology of the Niger Delta

The Niger Delta sedimentary basin, located between longitudes 4°E–8.8°E and latitudes 3°N–6°N, is recognized as one of the world's most productive hydrocarbon provinces. Geologically, it formed as a clastic wedge along a failed arm of a triple junction (aulacogen) that developed during the separation of the South American and African plates in the Late Jurassic period (Burke, 1972). While two of these arms evolved into passive continental margins along the southwestern and southeastern coasts of Nigeria and Cameroon, the third failed arm became the Benue Trough.

Other depocenters along the Atlantic margin of Africa also contributed to deltaic sediment accumulation. Syn-rift sediments comprising marine and marginal marine clastics as well as carbonates were deposited during the Cretaceous to Tertiary periods. The earliest sediments, dated to the Albian age, represent transgressive and regressive cycles that continued until the end of the syn-rift phase during the Santonian (Late Cretaceous) when the basin experienced inversion (Doust & Omatsola, 1989).

Subsequent continental separation and renewed subsidence allowed the sea to transgress the Benue Trough, facilitating continuous sediment accumulation. During the Middle Cretaceous, the Niger Delta clastic wedge prograded into a subsiding depocenter located above the collapsed continental margin at the triple junction. The sediments were primarily supplied from the north and east via the Niger, Benue, and Cross Rivers, with the latter two providing significant volcanic detritus from the Cameroon volcanic region beginning in the Miocene.

The deltaic progradation intensified during the Tertiary period, particularly from the Eocene onward, as sedimentation rates increased in response to higher sediment supply and ongoing subsidence of the continental margin. According to Doust and Omatsola (1989), normal faults caused by the movement of overpressured marine shales at depth deformed much of the Niger Delta clastic wedge. These syndepositional faults controlled sediment distribution and created structural complexity, including rollover anticlines, growth faults, and collapsed crest structures.

Structurally, the onshore Niger Delta is bordered in the north by the Benin flank, which marks a hinge line south of the West African basement massif, and in the northeast by the Abakaliki High and the Calabar Flank bordering the Precambrian basement. The basin's stratigraphy indicates a tripartite division of the Tertiary sequence each representing a distinct depositional environment differentiated by sand-to-shale ratios.

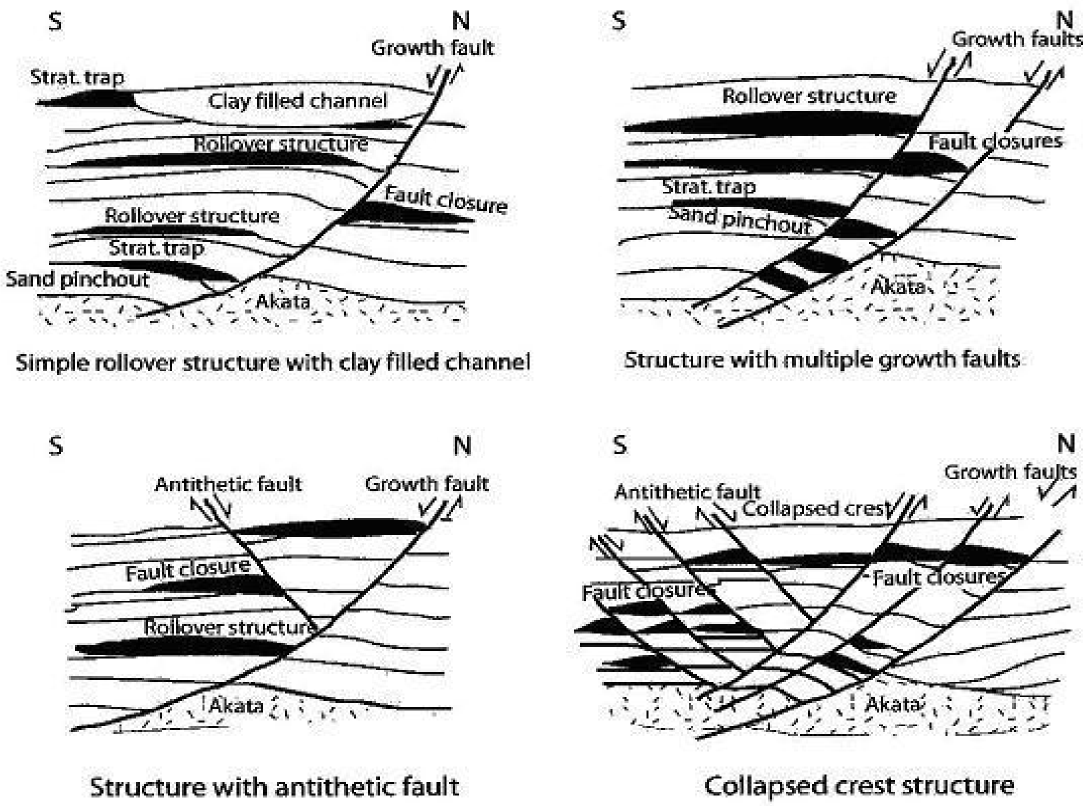


Figure 2: Niger Delta oil field structures and associated traps. Extracted from Doust and Omatsola (1990) and Stacher (1995)

2.2 Stratigraphy of the Niger Delta

The subsurface stratigraphy of the Niger Delta is divided into three major lithostratigraphic formations: **the Akata, Agbada, and Benin formations**. These represent a continuous depositional sequence from deep marine to continental environments.

2.2.1 The Akata Formation

The Akata Formation, which underlies the delta, consists primarily of marine shales and serves as the main source rock for hydrocarbons in the region. Deposition began in the Eocene and continues to the present day. The formation's lateral equivalent is the Imo Shale. Estimated to reach a thickness of up to 21,000 feet in the central portion of the basin (Doust & Omatsola, 1989), the Akata Formation comprises dark gray shales, silts, and occasional sand lenses deposited by turbidite flows. Marine planktonic foraminifera account for nearly half of its microfaunal content, suggesting a shallow marine shelf environment (Doust & Omatsola, 1989). Its age ranges from Paleocene to Recent, and it is interpreted as a deep-water lowstand deposit (Stacher, 1995).

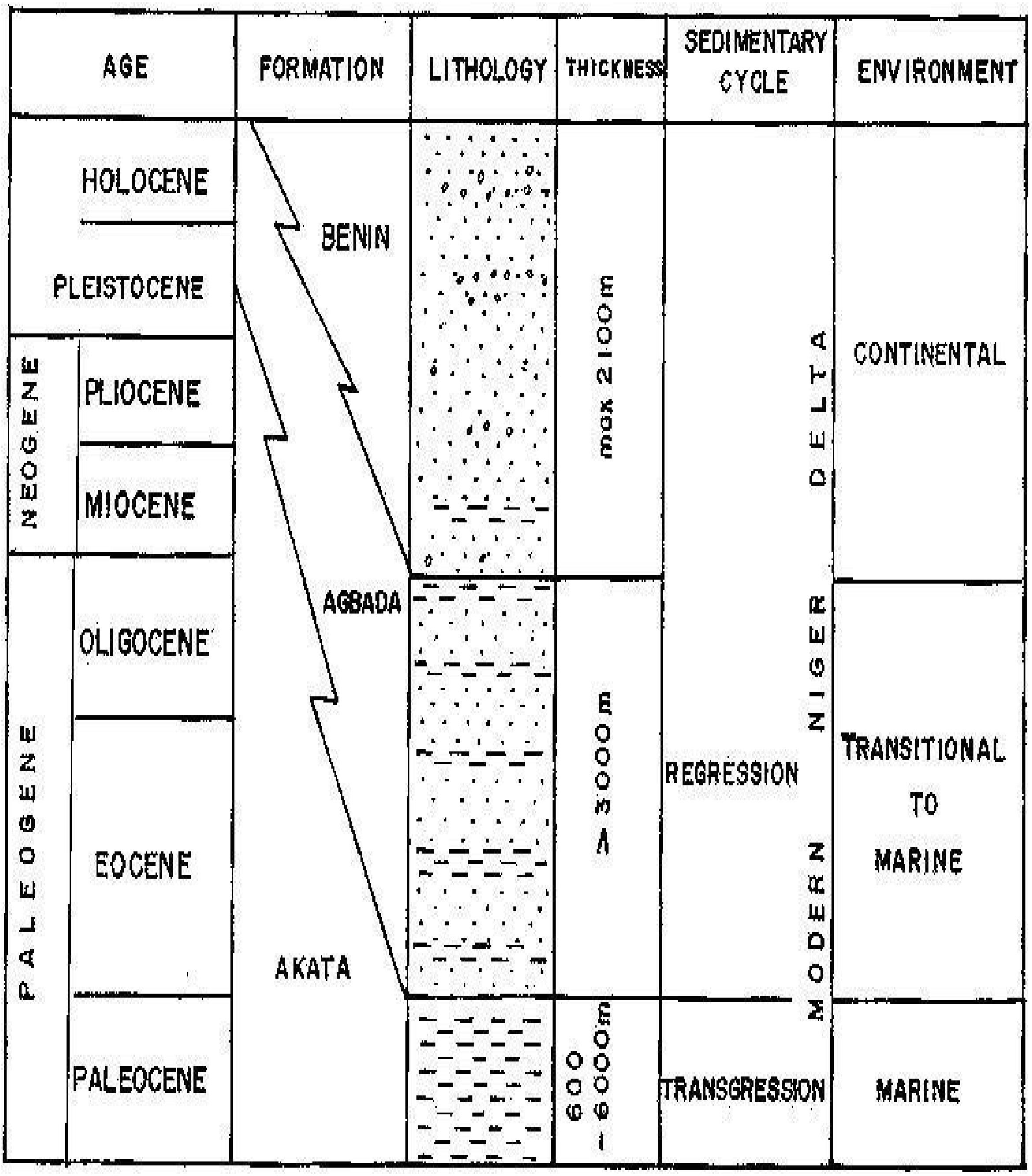
2.2.2 The Agbada Formation

The Agbada Formation represents the transition between marine and continental environments and serves as the principal reservoir unit of the Niger Delta. It consists of alternating layers of sand, silt, and shale organized in fining-upward sequences that indicate fluvial to deltaic deposition. The formation ranges in age from Eocene to Pleistocene and can reach thicknesses of approximately 13,000 feet. It overlies the Akata Formation and grades laterally into the Asaba and Ogwashi formations in the Anambra Basin (Doust & Omatsola, 1989). The sands of the Agbada Formation are typically well-sorted and moderately consolidated, making them ideal hydrocarbon reservoirs.

2.2.3 The Benin Formation

Overlying the Agbada Formation is the Benin Formation, which comprises predominantly continental sands. It forms the uppermost unit of the Niger Delta clastic wedge, extending from the Benin-Onitsha axis to the modern coastline (Short & Stauble, 1967). The formation, which is entirely non-marine, consists of coarse, unconsolidated sands deposited in alluvial and upper coastal plain environments during delta progradation (Doust & Omatsola, 1989). It ranges in age from Oligocene to Recent and thins basinward toward the shelf edge, terminating at depths of about 4,600 feet.

Table 1: Sequence Stratigraphy of Niger- Delta. According to Ajibola 2004



2.3 Geomorphology of the Niger Delta

Geomorphologically, the Niger Delta is characterized by a flat, low-lying terrain that is heavily dissected by a dense network of rivers, creeks, and distributaries (Dickenson & Kekwaru, 2021). Akpokodje (2001) identified five major geomorphic zones within the delta:

i. **Dry Flatlands and Plains:** Elevated and relatively well-drained areas forming the northern boundary of the delta.

ii. **Sombreiro–Warri Deltaic Plains:** Extensive lowlands with numerous freshwater backswamps.

iii. **Freshwater Swamps and Meander Belts:** Regions characterized by fluvial deposition and active sediment transport.

iv. **Mangrove or Saltwater Swamps:** Coastal zones influenced by tidal processes and saline intrusion.

v. **Active and Abandoned Coastal Ridges:** Sand ridges and barriers formed by marine and fluvial interactions during different transgressive and regressive cycles.

These geomorphic divisions reflect the complex interplay of sedimentation, hydrology, and tectonic activity that have shaped the modern Niger Delta.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Materials

A total of one hundred and seventeen (117) ditch-cutting samples were obtained from Well "X," drilled by the Shell Petroleum Development Company (SPDC). The samples were collected from depths ranging between 4,500 feet and 11,500 feet within the Niger Delta Basin.

To conduct the sedimentological analyses, the following materials and equipment were used:

i. Ditch-cutting samples

ii. Set of sieves

iii. Microscope

iv. Hand lens

v. Sample bowls and pans

vi. Glass slides

vii. Distilled water

viii. Water jet

ix. Kerosene

x. Dilute hydrochloric acid (HCl)

xi. Hot plate

xii. Aluminum bowls

3.1.1 Ditch-Cutting Samples

The ditch-cutting samples used in this study were provided by SPDC and represent depth intervals from 4,500 ft to 11,500 ft in Well "X." A total of 117 samples were systematically collected at predetermined depths for laboratory analysis. These samples served as the primary materials for sedimentological description, textural evaluation, and lithologic interpretation.

5	**4740**	**1445**
6	**4800**	**1463**
7	**4860**	**1481**
8	**4920**	**1500**
9	**4980**	**1518**
10	**5040**	**1536**
11	**5100**	**1555**
12	**5160**	**1573**
13	**5220**	**1591**
14	**5280**	**1609**
15	**5340**	**1628**
16	**5400**	**1646**

17	**5460**	**1664**
18	**5520**	**1683**
19	**5580**	**1701**
20	**5640**	**1719**
21	**5700**	**1737**
22	**5760**	**1756**
23	**5820**	**1774**
24	**5880**	**1792**
25	**5940**	**1811**
26	**6000**	**1829**
27	**6060**	**1847**
28	**6120**	**1865**
29	**6180**	**1884**
30	**6240**	**1902**
31	**6300**	**1920**
32	**6360**	**1939**
33	**6420**	**1957**
34	**6480**	**1975**
35	**6540**	**1993**
36	**6600**	**2012**
37	**6660**	**2030**
38	**6720**	**2048**
39	**6780**	**2067**
40	**6840**	**2085**
4	**6900**	**2103**

1		
4 2	**6960**	**2121**
4 3	**7020**	**2140**
4 4	**7080**	**2158**
4 5	**7140**	**2176**
4 6	**7200**	**2195**
4 7	**7260**	**2213**
4 8	**7320**	**2231**
4 9	**7380**	**2249**
5 0	**7440**	**2268**
5 1	**7500**	**2286**
5 2	**7560**	**2304**
5 3	**7620**	**2323**
5 4	**7680**	**2341**

5 5	**7740**	**2359**
5 6	**7800**	**2377**
5 7	**7860**	**2396**
5 8	**7920**	**2414**
5 9	**7980**	**2432**
6 0	**8040**	**2451**
6 1	**8100**	**2469**
6 2	**8160**	**2487**
6 3	**8220**	**2506**
6 4	**8280**	**2524**
6 5	**8340**	**2542**
6 6	**8400**	**2560**
6 7	**8460**	**2579**
6 8	**8520**	**2597**
6 9	**8580**	**2615**
7 0	**8640**	**2634**
7 1	**8700**	**2652**
7 2	**8760**	**2670**
7 3	**8820**	**2688**
7 4	**8880**	**2707**
7 5	**8940**	**2725**
7 6	**9000**	**2743**
7 7	**9060**	**2762**
7 8	**9120**	**2780**
7	**9180**	**2798**

9		
80	9240	2816
81	9300	2834
82	9360	2853
83	9420	2871
84	9480	2890
85	9540	2908
86	9600	2926
87	9660	2944
88	9720	2963
89	9780	2981
90	9840	2999
91	9900	3018
92	9960	3036

93	10020	3054
94	10080	3063
95	10140	3091
96	10200	3109
97	10260	3127
98	10320	3146
99	10440	3182
100	10500	3200
101	10560	3219
102	10620	3237
103	10680	3255
104	10740	3274
105	10800	3292
106	10860	3310
107	10920	3328
108	10980	3347
109	11040	3365
110	11100	3383
111	11160	3402
112	11220	3420
113	11280	3438
114	11340	3456
115	11400	3475
116	11460	3493
117	11500	3505

3.2 Methodology

The methodology adopted for this study comprised the following stages:

i. **Collection of Ditch-Cutting Samples**

ii. **Sedimentological Analysis**

iii. **Sedimentological Description of Samples**

3.2.1 Collection of Ditch-Cutting Samples

One hundred and seventeen (117) ditch-cutting samples were systematically collected from Well "X," drilled by Shell Petroleum Development Company (SPDC). Each sample was carefully labeled according to its depth interval to ensure accurate depth correlation during analysis.

3.2.2 Sedimentological Analysis

Sedimentological analysis was carried out using a binocular microscope to examine and describe the textural and compositional features of the samples. Each sample was analyzed for key characteristics such as:

- **Grain size**
- **Grain shape and roundness**
- **Sorting**
- **Grain color**
- **Presence of calcareous materials**

Chemical testing using dilute hydrochloric acid (10% HCl) was also performed to detect the presence of carbonate minerals and to identify calcareous materials within the sediments.

3.2.3 Sedimentological Description of Samples

Each of the 117 ditch-cutting samples was described based on its physical and textural characteristics. The description included observations of color, texture, hardness, fissility, and rock type.

The lithofacies interpretations were guided by established sedimentological and lithostratigraphic models for the Niger Delta Basin (Weber & Daukoru, 1975; Whiteman, 1982). Grain composition, sorting, and degree of roundness were used to differentiate between lithofacies such as sandstone, shaly sand, sandy shale, and shale.

3.2.4 Analytical Approach

1. **Sample Preparation:**
   - Samples were washed with distilled water to remove drilling mud residues.
   - Each sample was then oven-dried and sieved to separate different grain sizes.
2. **Microscopic Examination:**
   - Under a binocular microscope, grain composition and texture were examined in detail.
   - Particular attention was given to the presence of quartz, feldspar, mica, and iron oxide.
3. **Chemical Testing:**
   - A 10% dilute HCl solution was applied to test for effervescence, which indicates the presence of carbonate cement.
4. **Data Recording:**
   - Observations were systematically tabulated for each depth interval.
   - A litholog was generated to illustrate the vertical distribution of the various lithofacies and sediment types within the well.

CHAPTER FOUR

RESULTS AND INTERPRETATION

4.1 RESULTS

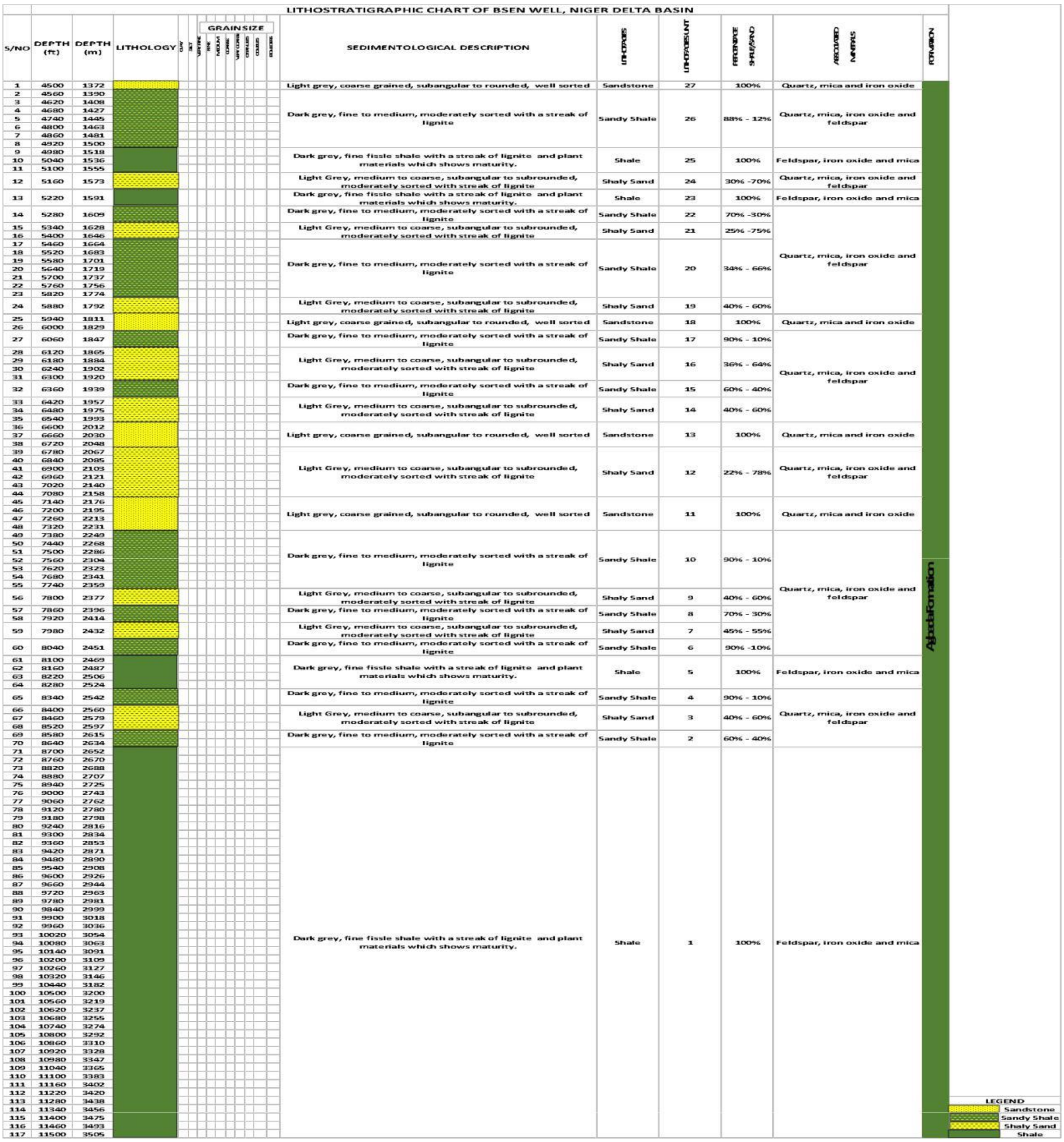


Figure 3: Lithostratigraphic chart of Well 'X' (4500ft – 11500ft), Niger Delta Basin.

A detailed sedimentological and lithologic analysis was conducted on Well "X," which penetrates formations between depths of 4,500 ft and 11,500 ft in the Niger Delta Basin. The analysis was based on microscopic observations and laboratory testing of ditch-cutting samples.

From the examination, four (4) major **lithofacies** were identified:

- **Sandstone**
- **Sandy shale**
- **Shaly sand**
- **Shale**

In total, twenty-seven (27) informal lithofacies units were delineated throughout the studied interval. Additionally, five (5) hydrocarbon play elements reservoir, source, cap, seal, and trap were recognized in the well.

4.2 Sedimentological Description

Sedimentological descriptions were made through microscopic examination of grain characteristics such as texture, color, shape, sorting, and composition. Calcareous materials were identified by the reaction of 10% HCl on carbonate-bearing samples.

Summary of Key Observations:

- The **Sandstone facies** consist mainly of light-gray, fine- to coarse-grained quartz and feldspar with angular to subangular grains. They are well sorted and lack calcareous material, with quartz overgrowth serving as the main cement.
- The **Sandy shale facies** are medium- to coarse-grained, brownish-gray in color, and moderately sorted. They contain mica, feldspar, quartz, iron oxide, and variable amounts of calcium carbonate as cement.

- The **Shale facies** are dark-gray, fine-grained, fissile, and often contain streaks of lignite and plant remains indicating organic maturity.
- The **Shaly sand facies** display characteristics between sandstone and shale moderately sorted with mixed proportions of quartz, feldspar, and mica, and sometimes contain carbonate cement.

4.2.1 Lithofacies Units in Well "X"

A total of **27 lithofacies units** were identified and categorized as follows:

- **Shale facies:** Units 1, 5, 23, and 25
- **Sandy shale facies:** Units 2, 4, 6, 8, 10, 15, 17, 20, 22, and 26
- **Shaly sand facies:** Units 3, 7, 9, 12, 14, 16, 19, 21, and 24
- **Sandstone facies:** Units 11, 13, 18, and 27

4.2.2 Lithofacies Unit Descriptions and Interpretations

The following interpretations summarize the identified lithofacies from the bottom to the top of the well:

Unit 1 (8700–11500 ft) – Shale

Dark-gray, fissile shale containing lignite and plant remains. Fine-grained and compact, with calcium carbonate ($CaCO_3$) as cement. Represents a probable **source rock**.

Unit 2 (8580–8640 ft) – Sandy Shale

Medium to coarse, moderately sorted, dark-gray shale with feldspar, mica, and carbonate cement. Interpreted as a **potential source rock** and **seal**.

Unit 3 (8400–8520 ft) – Shaly Sand

Fine to medium, moderately sorted grains composed of feldspar and quartz. Carbonate-cemented; forms a **potential reservoir rock**.

Unit 4 (8340 ft) – Sandy Shale

Dark-gray, poorly sorted, mica-rich shale with carbonate cement. Acts as a **cap rock** overlying the reservoir below.

Unit 5 (8100–8280 ft) – Shale

Fine, dark-gray fissile shale with organic streaks. Represents another **source rock** interval.

Unit 6 (8040 ft) – Sandy Shale

Poorly sorted, dark-gray shale with mica and carbonate cement. Interpreted as a **seal**.

Unit 7 (7980 ft) – Shaly Sand

Moderately sorted, quartz–feldspar mixture; carbonate-cemented. Serves as a **potential reservoir rock**.

Unit 8 (7860–7920 ft) – Sandy Shale

Moderately sorted dark-gray shale with mica and carbonate cement. Functions as a **seal and cap**.

Unit 9 (7800 ft) – Shaly Sand

Fine- to medium-grained, angular to subangular quartz and feldspar; carbonate-cemented. **Reservoir unit**.

Unit 10 (7380–7740 ft) – Sandy Shale

Medium- to coarse-grained brownish shale; moderately sorted with carbonate cement. Serves as **cap rock**.

Unit 11 (7140–7320 ft) – Sandstone

Light-gray, coarse-grained, poorly sorted sandstone dominated by feldspar and quartz with siliceous cement. Acts as a **primary reservoir rock**.

Unit 12 (6780–7080 ft) – Shaly Sand

Moderately sorted, fine- to medium-grained quartz–feldspar mixture; carbonate-cemented. Represents **reservoir facies**.

Unit 13 (6600–6720 ft) – Sandstone

Light-gray, coarse-grained sandstone; quartz-cemented. **Reservoir rock.**

Unit 14 (6420–6540 ft) – Shaly Sand

Fine- to medium-grained dark-gray sandstone–shale mix; carbonate-cemented. **Reservoir unit.**

Unit 15 (6360 ft) – Sandy Shale

Moderately sorted dark-gray shale with carbonate cement. **Seal and cap rock.**

Unit 16 (6120–6300 ft) – Shaly Sand

Fine- to medium-grained, feldspathic sandstone with carbonate cement. **Reservoir unit.**

Unit 17 (6060 ft) – Sandy Shale

Dark-gray, moderately sorted, carbonate-cemented shale. **Seal rock.**

Unit 18 (5940–6000 ft) – Sandstone

Light-gray, coarse-grained, well-sorted quartz and feldspar sandstone. Quartz-cemented and interpreted as a **probable reservoir rock.**

Unit 19 (5880 ft) – Shaly Sand

Moderately sorted dark-gray sandstone–shale mixture. **Reservoir unit.**

Unit 20 (5460–5820 ft) – Sandy Shale

Medium- to coarse-grained, moderately sorted dark-gray shale with carbonate cement. **Cap and seal.**

Unit 21 (5340–5400 ft) – Shaly Sand

Fine- to medium-grained feldspathic sandstone. **Reservoir facies.**

Unit 22 (5280 ft) – Sandy Shale

Moderately sorted dark-gray shale with carbonate cement. **Seal rock.**

Unit 23 (5220 ft) – Shale

Fine-grained fissile shale containing lignite streaks and plant material. **Source rock.**

Unit 24 (5160 ft) – Shaly Sand

Medium-grained sandstone–shale mix. **Reservoir unit.**

Unit 25 (4980–5100 ft) – Shale

Fine-grained, fissile dark-gray shale with organic inclusions. **Source rock.**

Unit 26 (4560–4920 ft) – Sandy Shale

Medium- to coarse-grained shale with carbonate cement. **Seal rock.**

Unit 27 (4500 ft) – Sandstone

Light-gray, coarse-grained, quartz-feldspar sandstone with quartz overgrowth cement. **Reservoir rock.**

4.3 Hydrocarbon Play Elements in Well "X"

The five major hydrocarbon play elements identified in Well "X" include:

1. Source Rock

Source rocks are organic-rich formations capable of generating hydrocarbons under suitable temperature and pressure conditions.

- **Probable source rocks:** Units 1, 5, 23, and 25
- **Potential source rocks:** Units 2, 4, 6, 8, 10, 15, 17, 20, 22, and 26

2. Reservoir Rock

Reservoir rocks are porous and permeable formations capable of storing and transmitting fluids.

- **Probable reservoirs:** Units 11, 13, 18, and 27
- **Potential reservoirs:** Units 3, 7, 9, 12, 14, 16, 19, 21, and 24

3. Cap Rock

Cap rocks are impermeable layers that prevent fluid migration from underlying reservoirs.

- Identified cap rocks occur in units 4, 8, 10, 15, 17, 20, 23, and 25.

4. Seal Rock

Seal rocks are impermeable strata located beneath reservoirs that prevent downward migration of fluids.

- Seal rocks were identified in units 2, 6, 8, 10, 15, 17, 20, and 23.

5. Trap

Traps are geological configurations that enclose hydrocarbons within reservoirs. Both structural and stratilgraphic traps were recognized.

Eight major traps were identified between the following units:

(2 & 4), (6 & 8), (8 & 10), (10 & 15), (15 & 17), (17 & 20), (20 & 22), and (23 & 25).

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary

This study focused on the **lithostratigraphic and sedimentological analysis of ditch-cutting samples from Well "X"**, located in the Niger Delta Basin, Nigeria. The well was drilled to a total depth of **11,500 feet**, and a total of **117 ditch-cutting samples** were collected and analyzed.

Sedimentological analysis was conducted to identify the lithofacies, interpret depositional environments, and evaluate the presence of hydrocarbon play elements such as **source, reservoir, seal, and cap rocks**, as well as **traps**.

Microscopic examination and field descriptions revealed four main lithofacies within the well interval:

- **Sandstone**
- **Sandy shale**
- **Shaly sand**
- **Shale**

Twenty-seven (27) lithofacies units were identified and characterized based on texture, sorting, color, cement type, and mineral composition. These were further classified according to their hydrocarbon potential and stratigraphic significance.

The study identified five essential hydrocarbon system elements in Well "X":

1. **Source rocks** rich in organic material and mainly represented by dark-gray shale units.
2. **Reservoir rocks** consisting primarily of well-sorted sandstones and shaly sands.

3. **Cap rocks** serving as impermeable barriers, mainly composed of sandy shale and shale units.
4. **Seal rocks** impermeable formations located above and below reservoirs, preventing fluid leakage.
5. **Traps** formed by both stratigraphic and structural controls, providing potential accumulation sites for hydrocarbons.

The lithostratigraphic succession shows alternating sandstone and shale intervals typical of the **Agbada Formation**, with deeper units likely correlating with the **Akata Formation**, which serves as the primary source rock in the Niger Delta.

5.2 Conclusion

The lithostratigraphic and sedimentological interpretation of Well "X" has provided valuable insights into the subsurface geology of the Niger Delta Basin. The identified lithofacies sandstone, sandy shale, shaly sand, and shale represent depositional cycles characteristic of deltaic environments.

The occurrence of organic-rich shale units confirms the presence of potential **source rocks**, while the interbedded sandstones and shaly sands act as **reservoir facies** with adequate porosity and permeability. The associated sandy shale and shale layers function as **effective seals** and **cap rocks**, essential for hydrocarbon entrapment.

Furthermore, the recognition of **structural and stratigraphic traps** between alternating facies suggests that Well "X" possesses a **complete petroleum system**. This implies favorable conditions for hydrocarbon generation, migration, and accumulation within the studied depth interval.

In conclusion, the sedimentological and lithostratigraphic characteristics of Well "X" align with those commonly observed in productive sections of the Niger Delta Basin. Therefore, the well has **high hydrocarbon potential**, particularly within sandstone intervals that serve as prime reservoir targets.

5.3 Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. **Further Geophysical and Geochemical Analysis:**

   Conduct detailed geophysical logging and geochemical maturity studies to confirm hydrocarbon potential and evaluate the thermal maturity of identified source rocks.

2. **Core Sample Examination:**

   Where possible, obtain core samples to complement ditch-cutting data. Core analysis will improve understanding of porosity, permeability, and sedimentary structures.

3. **3D Seismic Interpretation:**

   Integrate 3D seismic data with lithologic and well-log information to delineate structural traps and identify optimal drilling targets.

4. **Petrophysical Evaluation:**

   Perform quantitative petrophysical analysis to estimate reservoir properties such as porosity, saturation, and permeability.

5. **Further Exploration Drilling:**

   Given the favorable stratigraphic and structural conditions observed in Well "X," additional exploratory drilling in nearby locations is recommended to assess continuity and reservoir extent.

6. **Regional Correlation:**

   Compare lithofacies and stratigraphic units from Well "X" with other wells within the Niger Delta Basin to establish regional stratigraphic correlations and improve petroleum system modeling.

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