INORGANIC GEOCHEMISTRY AS A TOOL FOR SEDIMENTOLOGICAL STUDIES: A CASE STUDY OF OSEDÉSTINY WELL, NORTHERN DEPOBELT, NIGER DELTA BASIN.

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SEPTEMBER 2023.

CERTIFICATION

This is to certify that **Destiny Osezele ALUEDE** with matriculation number **PSC1809007**, carried out this in fulfilment of the award for Bachelor of Science (B.sc) Degree in Geology.

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DEDICATION

I dedicate this project to the Almighty God, the creator of all things, the one who has enabled me to be here and also to my loving and supporting family, the source of my strength to keep pushing forward.

ACKNOWLEDGEMENT

Special thanks to Almighty God, the creator of all things and the giver of life, Also I cannot leave out the Immense contribution of my supervisor Dr. Nosa S. Igbinigie, who gave me all the support and guidance needed for the success of this project. I must also appreciate the head of department Dr. S. A. Salami for creating a better atmosphere for carrying out a great work. I must not must not fail to acknowledge my parents Mr. and Mrs. John Aluede, My loving siblings, also The Ogbemudia's and also my loving friends and my colleagues who has supported and played a vital role in this journey.

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ABSTRACT

The study incorporates inorganic geochemistry for a comprehensive stratigraphic analysis. To further elucidate sediment provenance, paleo-redox conditions, tectonic settings, and sandstone classification, ditch cutting samples were collected from the Osedestiny well in the Niger Delta Basin. The geochemical results revealed trace element ratios of V/Cr and U/Th, suggesting an oxic environment for deposition. The sediments' source was identified as felsic rock through bivariate plots of Ni vs Tio2, La/Sc vs Th/Co, and trace elemental ratios including Th/Sc, Th/Co, Cr/Th, and La/Sc. Graphical representations of K_2O/Na_2O versus SiO_2 and Log (K_2O/Na_2O) versus Log (SiO_2/Al_2O_3) predominantly fell within the passive margin zone. Various chemical sandstone classification systems classified the sediments as sublitharenite, Fe-rich sand, and with minimal content of quartzarenite. This comprehensive geochemical approach enhances the understanding of sediment characteristics and depositional environments in the Niger Delta Basin.

CHAPTER ONE

1.1 INTRODUCTION

In recent times, the surge in the global population and industrial growth in urban centers has led to a substantial increase in the demand for oil and gas. This heightened demand presents a formidable challenge for geoscientists, who must devise innovative solutions to enhance exploration and production. In the dynamic landscape of our economic and political environment, petroleum explorationists and field development geologists face significant responsibilities. It is crucial for geologists to introspect and discover ways to contribute value to the exploration and production sector. This necessity has spurred chemostratigraphers to pioneer novel techniques and approaches, challenging traditional methods and aligning scientific advancements with industry requirements. The Niger Delta stands out as a prominent center for hydrocarbon production on the West African Continental Margin, ranking among the world's most prolific petroleum-producing Tertiary Deltas. This distinction has prompted extensive geological investigations in the region, serving both academic and economic objectives. Since the identification of commercially viable oil in the Oloibiri-1 well in 1956, continuous exploration and exploitation of hydrocarbons have characterized activities in the basin. The hydrocarbon reservoirs within the Niger Delta Basin are commonly situated in regions with intricate structures and stratigraphy. Numerous fields encompass multiple reservoirs housing oil and gas of diverse compositions and gas/oil ratios. Notably, a substantial proportion of the world's hydrocarbon reservoirs exists in sequences with limited stratigraphic control. Establishing correlations in such sequences poses a challenge, often relying on similarities in lithological and petrophysical properties, although these can be precarious. To refine the stratigraphy of these sections, analysts frequently employ heavy mineral analyses and isotopic techniques. In this study, the variation in inorganic elemental geochemical values serves as a tool to determine the tectonic setting, provenance, and character of the strata, along with the paleo-redox conditions of the sediments. The application of inorganic geochemistry yields robust information about the studied well.

1.1.1 Background Of Study

Sub-surface uncertainties pose a major challenge in hydrocarbon exploration. To overcome this challenge, various tools can be applied. In this study, a chemostratigraphic approach was used, which involves analyzing variations in inorganic whole rock geochemistry to characterize and correlate sediments.

1.1.2 Location of Study Area

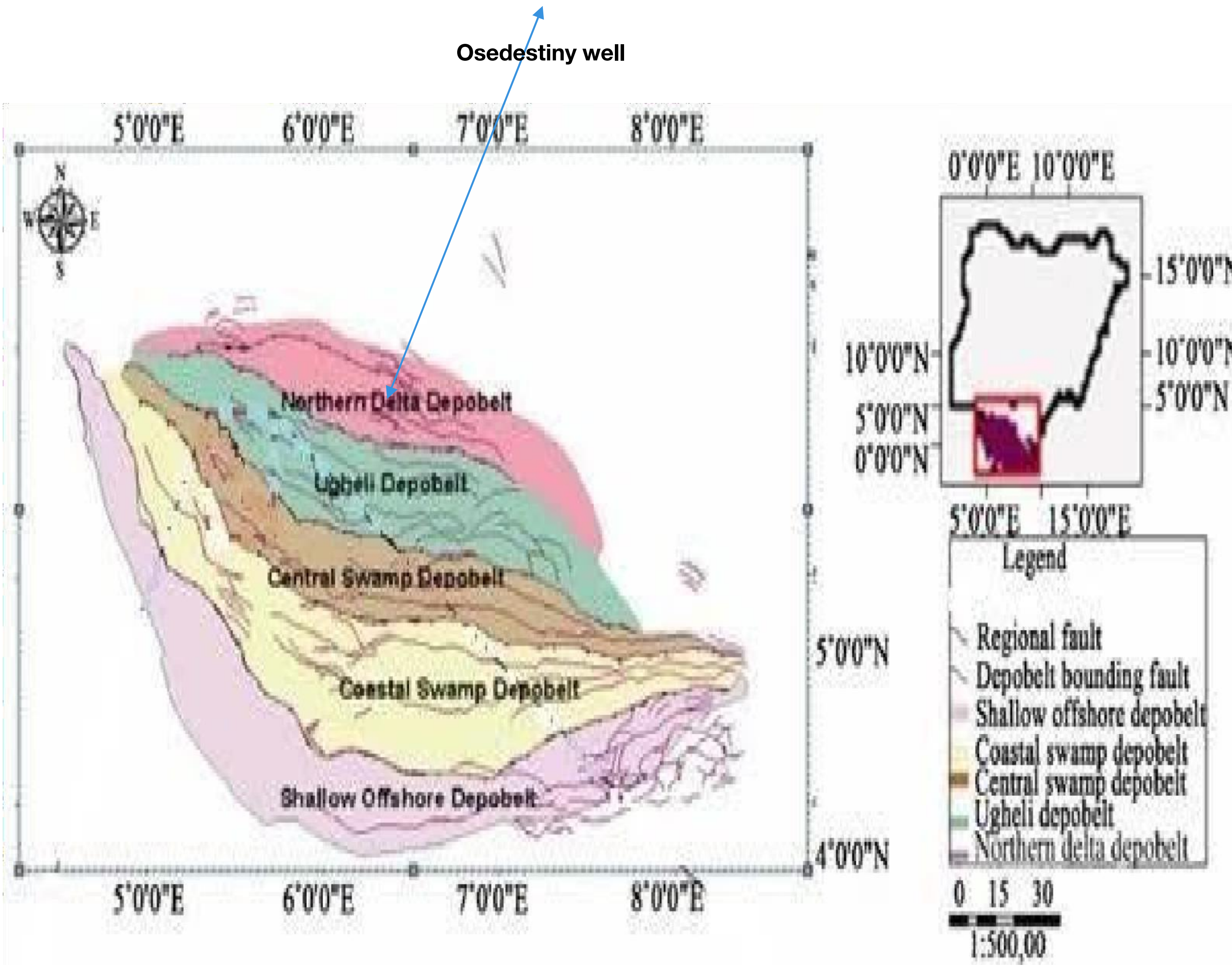


Figure 1.1 Map showing well location

1.1.3 Scope of Work

The scope of work includes:

1. To examine and describe the different types of rocks.
2. To create a record of the rock data collected.
3. The results will be documented using tables and charts.
4. To provide detailed findings and draw conclusions based on the data.
5. Finally, To present a report summarizing all the information gathered.

1.1.4 Aim and Objectives

The main goal of this study is to analyze the inorganic elemental geochemical data to understand the origin, tectonic setting, and paleo-redox conditions of the rocks penetrated by the well. The specific objectives of the study are:

1. Describe the types of rocks and sediments present.
2. Use inorganic geochemical ratios to determine the tectonic setting, origin, and paleo-redox conditions of the sediments.
3. Identify the tectonic setting of the rocks.
4. Establish the origin of the sediments.
5. Assess the paleo-redox conditions during the deposition of the sediments.
6. Characterize the sandstones in detail.

CHAPTER TWO

LITERATURE REVIEW

2.1 GENERAL OVERVIEW OF THE NIGER DELTA BASIN

The Niger Delta Basin stands out as a region renowned for its copious petroleum reserves, establishing its position as one of the world's most prolific Tertiary Deltas. Geographically situated along the Gulf of Guinea continental margin in equatorial West Africa, its coordinates range between Latitude 30°N and 60°N and Longitude 50°E and 80°E. The basin has undergone three distinct depositional cycles, commencing with a Middle Cretaceous marine incursion in the first cycle, culminating in Santonian time with mild folding. The second cycle witnessed the emergence of a Proto-Niger Delta during the Late Cretaceous, concluding with a significant Paleocene marine transgression. The third and ongoing cycle, spanning from Eocene to Recent times, has seen the continual expansion of the primary Niger Delta.

Numerous scholars have delved into the comprehensive study of the Niger Delta's stratigraphy, sedimentology, structural configuration, and paleo-environment concerning reservoir rocks. Pioneering research by Short and Stauble (1967), Weber and Daukoru (1975), Evamy et al. (1978), and Selley (1997) has significantly contributed to the understanding of this intricate geological setting. The northwest boundary of the Niger Delta is demarcated by the subsurface continuation of the West African Shield, recognized as the Benin Flank. Meanwhile, the eastern boundary aligns with the Calabar Flank, situated south of the Oban Masif. An examination of well sections within the Niger Delta reveals three distinctive lithostratigraphic subdivisions: the upper delta top facies, the middle delta front lithofacies, and the lower pro-delta lithofacies. These subdivisions correspond to the Benin Formation (Oligocene-Recent), Agbada Formation (Eocene-Recent), and Akata Formation (Paleocene-Recent) as classified by Short and Stauble (1967). The expansive reach of the Niger Delta Basin extends beneath the coastal plain, continental shelf, and slope of Nigeria and western Cameroon. Additionally, it encompasses the northern territorial waters of Equatorial Guinea west of Bioko Island, marked by seafloor escarpments overlaying oceanic crust. Covering an approximate area of 211,000km², the Niger Delta Basin originated and developed in a southwestward direction from the Anambra Basin and the Benue Trough.

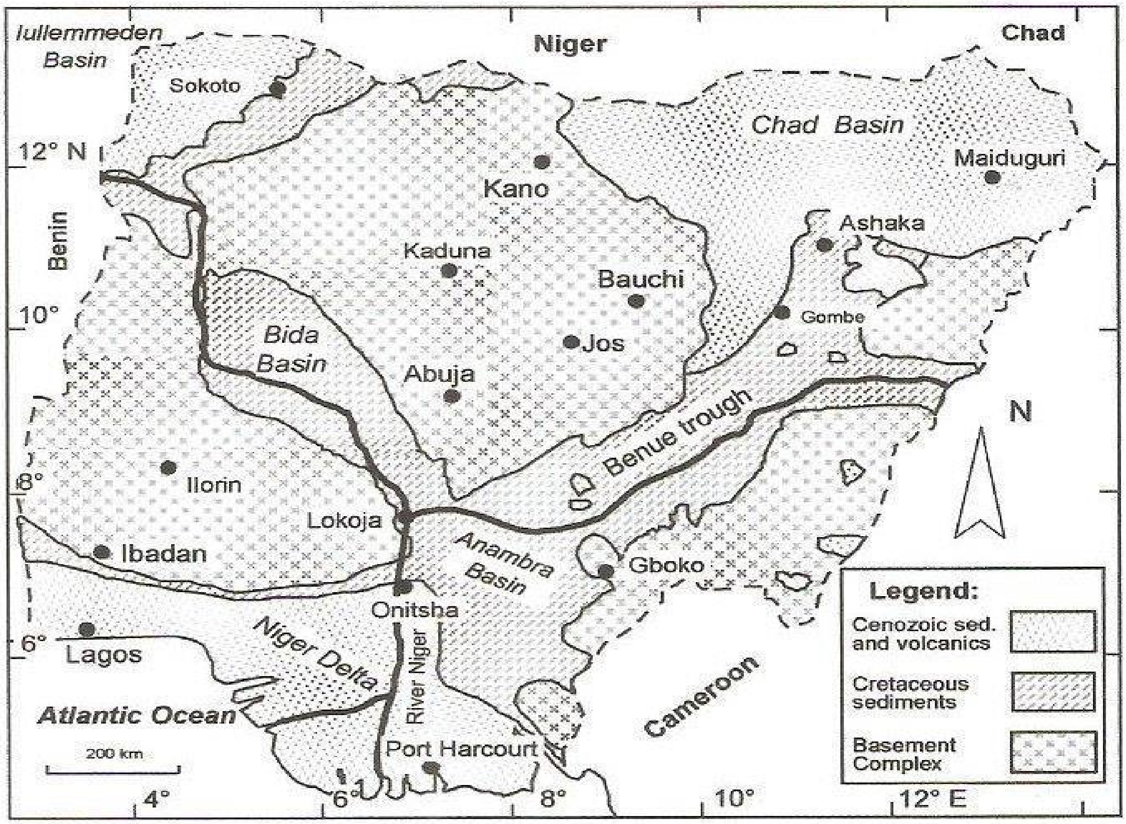


Figure 2.1 Generalized geological map of Nigeria including the basement complex and somesedimentary basins (Adelana et al., 2008).

2.2 REGIONAL TECTONIC SETTINGS OF THE NIGER DELTA BASIN

Tectonic processes in the West Coast of equatorial Africa have been elucidated by researchers such as Evamy et al. (1978), Ejedawe (1981), Knox and Omatsola (1989), and Stacher (1995). The overarching tectonic framework is influenced by Cretaceous fracture zones, manifested as trenches and ridges in the deep Atlantic, effectively dividing the margin into distinct basins. Within Nigeria, these fracture zone ridges serve as the boundary faults for the Cretaceous Benue-Abakaliki Trough, which extends into the West African shield. This trough represents an unsuccessful branch of a rift triple junction linked to the initiation of the South Atlantic opening. The rifting process initiated in the Late Jurassic and persisted until the Middle Cretaceous.

In the Niger Delta region, the cessation of rifting occurred in the Late Cretaceous, marking a shift in the paleogeography and the relative positions of the African and South American plates. Subsequent to the conclusion of rifting, gravity tectonics became the predominant deformational process in the Niger Delta. These gravity-driven tectonic activities, occurring prior to the deposition of the Benin Formation, led to the formation of intricate structures, including shale diapirs, roll-over anticlines, collapsed growth fault crests, back-to-back features, and steeply dipping, closely spaced flank faults. These faults primarily offset different sections of the Agbada Formation and transition into detachment planes near the top of the Akata Formation.

Situated at the southern extremity of the elongated Benue Trough, the Niger Delta Basin is demarcated from the Dahomey Basin by the Okitipupa basement high to the west. To the east, it is bounded by the Cameroun volcanic line. The northern margin intersects various older tectonic elements, such as the Anambra Basin, Abakaliki Basin, Afikpo Syncline, and the Calabar Flank. The interplay of these tectonic elements has played a crucial role in shaping the geological characteristics of the Niger Delta Basin.

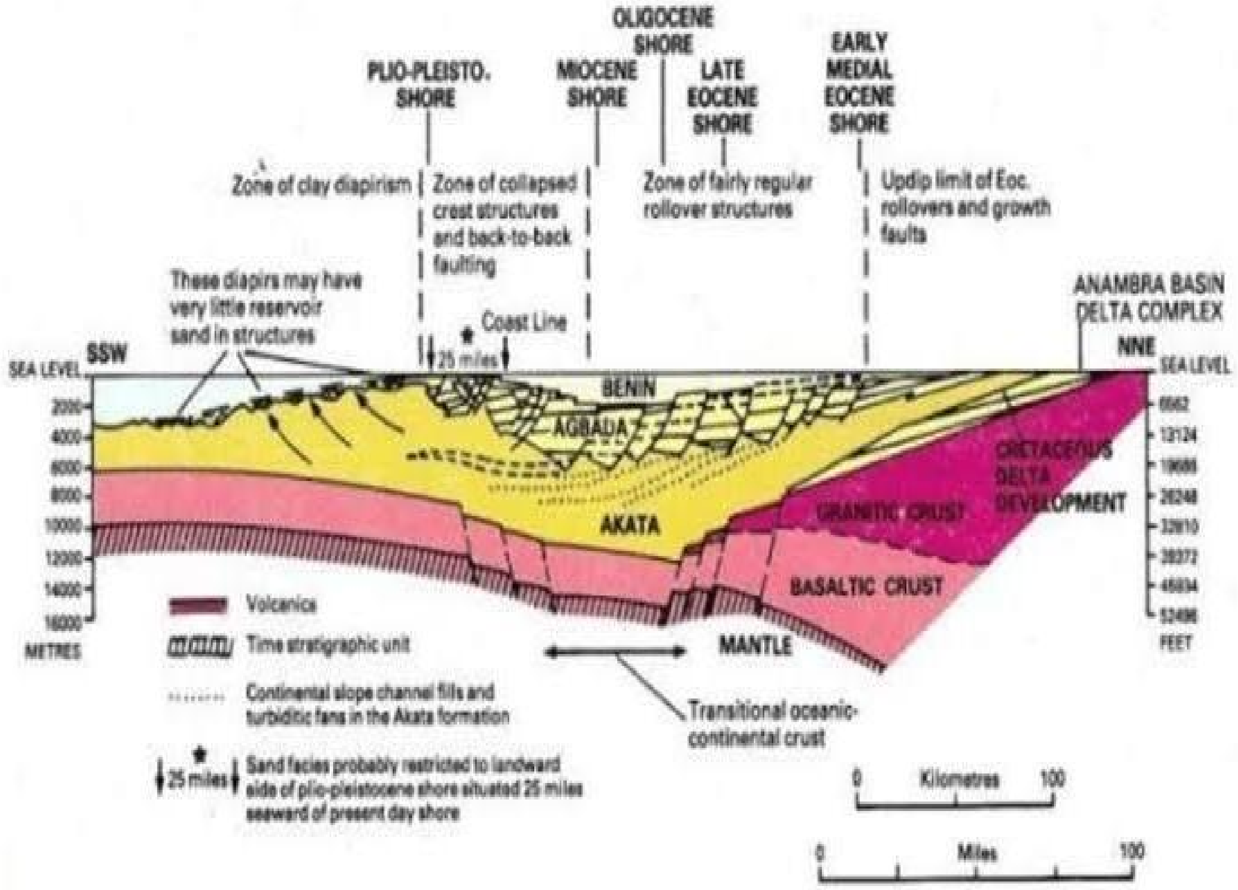


Figure 2.2 Structural units of the Niger Delta complex (Short and Stauble 1967)

The stratigraphic sequence of the Niger Delta encompasses a regressive arrangement of Tertiary clastics, reaching a thickness of up to 12 km. This sequence is categorized into three principal lithofacies. At the base, there are marine claystones and shales, succeeded by alternating sandstones, siltstones, and claystones with an increasing sand content as one moves upwards. The uppermost layer consists of alluvial sands. In terms of lithostratigraphic units, the subsurface of the Niger Delta identifies the Akata, Agbada, and Benin Formations, with the Akata Formation being the oldest and the Benin Formation being the youngest. It's noteworthy that these formations exhibit a considerable temporal gap between them, underscoring the evolutionary changes and sedimentary dynamics that have occurred over time in the Niger Delta.

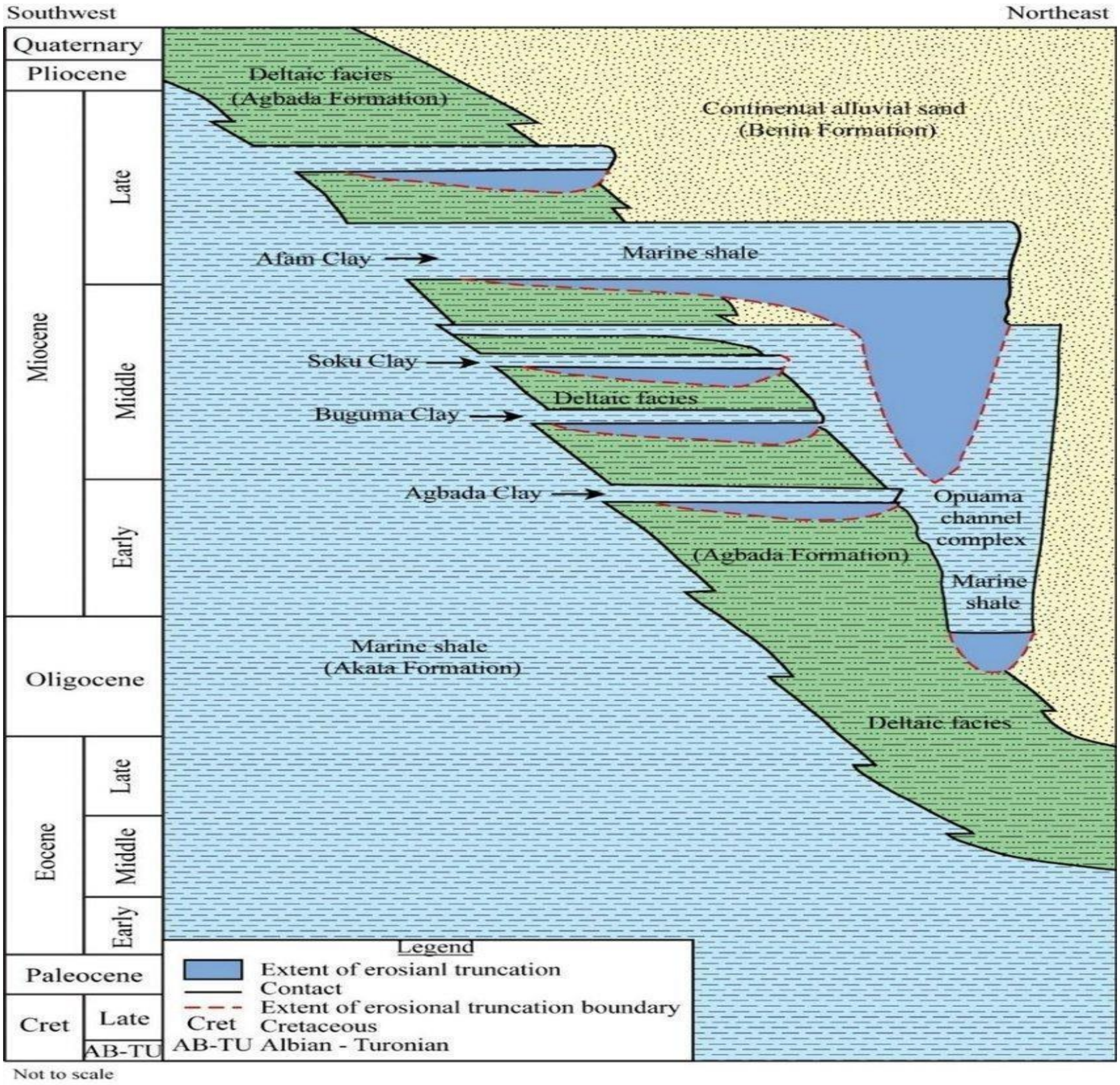


Figure 2.3 Schematic cross section of the Niger Delta showing the lithostratigraphic units (Akata, Agbada and Benin Formation. Also shown are some late Miocene canyons that incised Benin-Agabada Formation. (Redrawn from Shannon and Naylor (1989); Doust andOmatsola (1990).

2.3 STRATIGRAPHY OF THE NIGER DELTA BASIN

2.3.1 Akata Formation (Marine Shales)

The Akata Formation, the earliest lithostratigraphic unit in the Niger Delta, has a temporal span extending from the Eocene to the present day. This marine sedimentary succession exhibits variable thickness ranging from 1,968 to 19,680 feet. Predominantly, the Akata Formation comprises consistently under-compacted shales, clays, and silts, constituting the foundational layer of the delta sequence. Towards the upper section, there are intercalations of sandstone characterized by unusually high pressure, potentially indicating a turbidite origin. These sandstone deposits originated in holomarine environments, encompassing settings from the delta-front to deeper marine realms. The shales within the Akata Formation harbor abundant planktonic and benthonic foraminifera, signifying deposition in both shallow and deep marine environments. Across various depobelts, these marine shales are situated at the base of the sequence, spanning the geological timeline from the Paleocene to the Holocene. In offshore areas, they manifest as diapirs along the continental slope, while onshore in the northeastern part of the delta, they are identified as the Imo Shale. This onshore manifestation highlights the dynamic geological features present in the Niger Delta, showcasing the adaptability and variability of the Akata Formation in different regions of the deltaic system.

2.3.2 Agbada Formation (Paralic Clastics)

Undoubtedly, the Agbada Formation plays a pivotal role in the hydrocarbon-prospective sequence of the Niger Delta. Comprising paralic interbedded sandstone and shale, this formation boasts a substantial thickness exceeding 3000 meters. These clastics underwent deposition in diverse deltaic environments, including the delta-front, delta-topset, and fluviodeltaic settings. The upper boundary of the Agbada Formation is characterized by shale containing marine fauna, coinciding with the inception of the continental-transitional lithofacies. Conversely, its lower boundary is distinguished by a significant sandstone body aligning with the upper limit of the Akata Formation. Initially perceived as potential source rocks, some shales within the Agbada Formation were thought to contribute to the hydrocarbon reserves. However, subsequent analysis has revealed that the primary source rocks for the Niger Delta are the shales within the Akata Formation. This realization underscores the complexity of the geological processes shaping the hydrocarbon reservoirs in the Niger Delta. This paralic sequence of the Agbada Formation is ubiquitously present in all depobelts and spans in age from the Eocene to the Pleistocene. Numerous exploration wells in the Niger Delta have successfully penetrated the entirety of this lithofacies, contributing valuable insights into the geological composition and hydrocarbon potential of the region..

2.3.3 Benin Formation (Continental sands)

The Benin Formation, the most recent unit within the Niger Delta, is of Miocene-Recent age and exhibits a minimum thickness exceeding 6000 feet. Predominantly composed of continental sands and sandstones, interspersed with shale layers, this formation features non-marine sand in its shallower sections. The sands are characterized by being coarse-grained, sub-angular to well-rounded, and poorly sorted. Deposition of the Benin Formation transpired in alluvial or upper coastal plain environments subsequent to the southward shift of deltaic deposition into a new depobelt. The oldest continental sands are inferred to be of Oligocene age, although direct dating poses challenges due to the absence of fauna suitable for such dating methods. In offshore areas, the sands progressively thin out and eventually vanish near the shelf edge, indicating variations in sedimentation patterns and highlighting the dynamic nature of the Niger Delta's geological history.

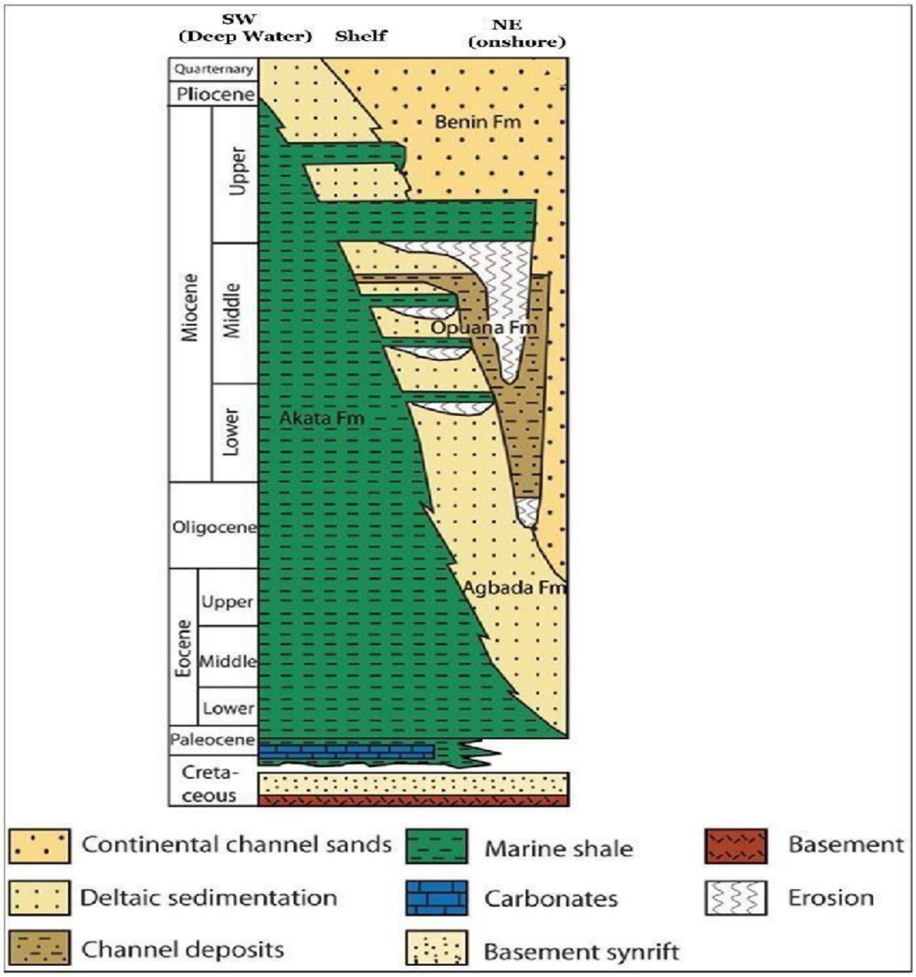


Figure 2.4 The regional stratigraphic column of the Niger delta Basin shows the three majorunits in the delta (Akata, Agbada, and Benin formations) (Doust and Omatsola 1990).

2.4 DEPOBELTS OF THE NIGER DELTA

The Niger Delta is characterized by distinct depobelts, including the Northern Delta, Greater Ughelli, Central Swamp, Coastal Swamp, and Offshore Depobelts, each demarcated by significant regional and counter-regional growth faults (Evamy et al., 1978; Doust and Omatsola, 1990). The evolution of these depobelts has unfolded over time and space, progressing south-southwestward through stepwise alluvial progradation. This progradation is facilitated by the withdrawal and forward movement of the underlying shale. The intricate interplay between subsidence and sediment supply rates has led to the formation of discrete depobelts.

As each depobelt reaches its subsidence limit, sediment deposition shifts seaward, initiating the formation of a new depobelt (Doust and Omatsola, 1990). The deposition of the three formations constituting the Niger Delta occurred within five offlapping siliciclastic sedimentation cycles, corresponding to these depobelts. These depobelts extend over 250 km into the Gulf of Guinea and are characterized by syn-sedimentary faulting (Stacher, 1995). The variable development of these depobelts is influenced by the interplay of subsidence and sediment supply rates (Doust and Omatsola, 1990). Each depobelt represents a distinct shallowing-upward depositional cycle, featuring marine, paralic, and continental deposits. These depobelts serve as markers for the progradation of the deltaic system, and as sediment loads increase, the underlying delta front and pro-delta marine shale move upward and basinward, perpetuating the dynamic geological processes shaping the Niger Delta.

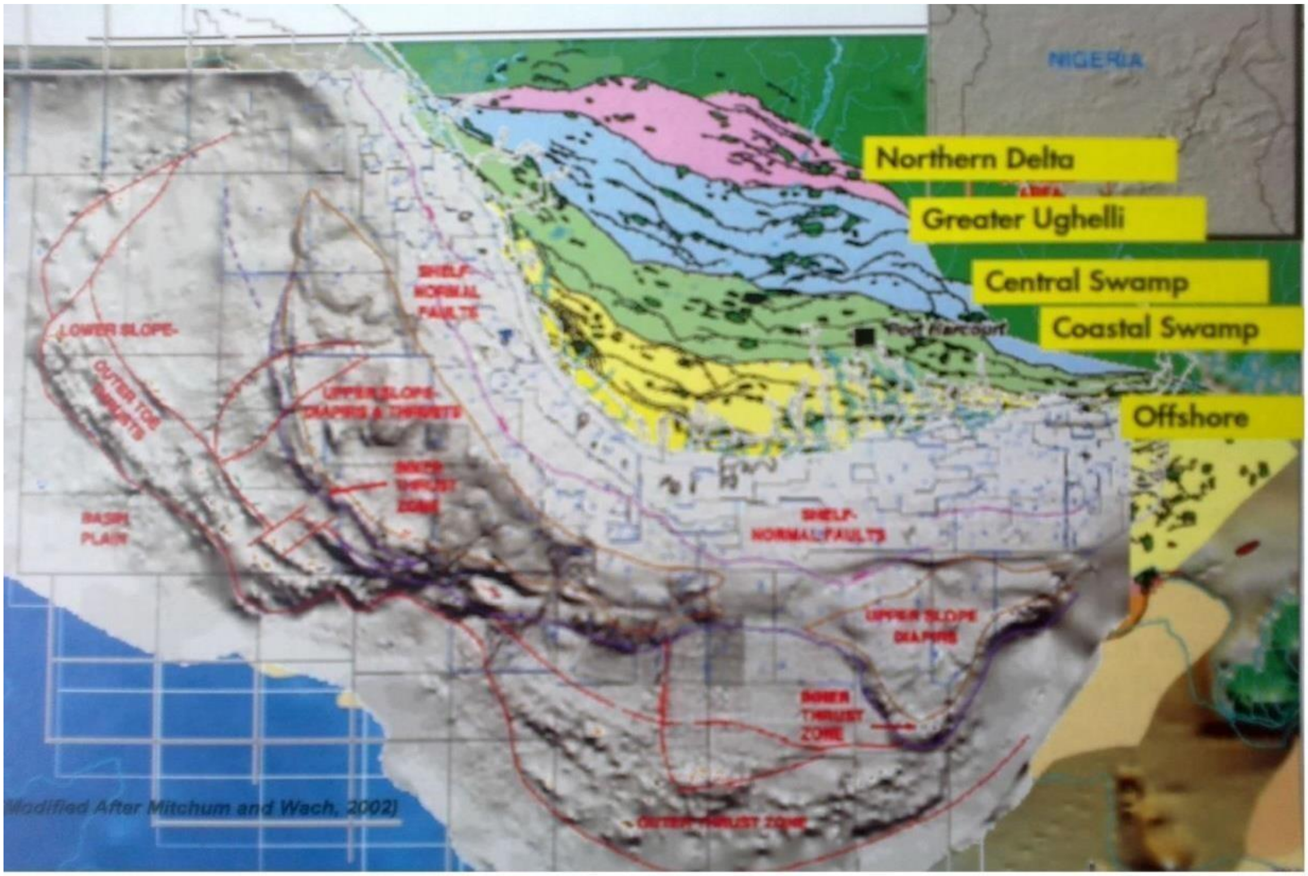


Figure 2.5: Niger Delta Depobelts (Modified after Weber and Daukoru, 1975

2.5 STRUCTURAL GEOLOGY OF THE NIGER DELTA

The Niger Delta is distinguished by prominent growth faults, integral geological features shaping the region's structure. These faults and folds exhibit an East-West orientation and are believed to be gravity faults formed concurrently with rapid sedimentation. The primary trigger for their formation is attributed to the differential loading of the laterally and vertically mobile under-compacted Akata Shales. This geological phenomenon results in the accumulation of thicker sediments on the down-thrown block compared to the up-thrown block due to sedimentation and gravity faulting. The rollover anticline structures within the delta play a crucial role in oil accumulation, where most of the oil reserves are concentrated. The oil and gas resources in these structures can be confined against synthetic or antithetic faults or within dip closures. The overall delta sequence undergoes additional deformation through syn-sedimentary faulting and folding, as elucidated by Evamy et al. (1978). This complex interplay of geological processes contributes to the unique structural characteristics of the Niger Delta, impacting the distribution and trapping of oil and gas reserves within the region.

2.5.1 Growth Faults

In the Niger Delta, growth faults arise due to the swift deposition of sediments along the delta edge, particularly atop under-compacted clay. These faults are distinctive for featuring thicker sediment layers on the downthrown block compared to the upthrown block. Referred to as contemporaneous faults, they play a pivotal role in facilitating the migration of hydrocarbons from the marine shale of the Akata Formation to the reservoir sand of the Agbada Formation. The accelerated deposition of sand along the delta edge on the under-compacted clay gives rise to the development of numerous syn-sedimentary gravitational faults, commonly termed as growth faults. Interestingly, similar growth faults are also observed in the U.S. Gulf coast. This shared geological feature underscores the broader implications of such fault systems in diverse deltaic environments.

2.5.2 Rollover Anticlines

Rollover anticlines in the Niger Delta take shape through a reversal of the dip section, typically instigated by the rotation of a block due to sliding along a curved fault plane. These fault planes, often associated with gravity faulting, align with the deposition of sediments in the region. The reversal of the dip direction is a consequence of the rotation of a curved (listric) fault plane, occurring simultaneously with sediment deposition. This dynamic geological process is instrumental in giving rise to rollover anticlines within the Niger Delta.

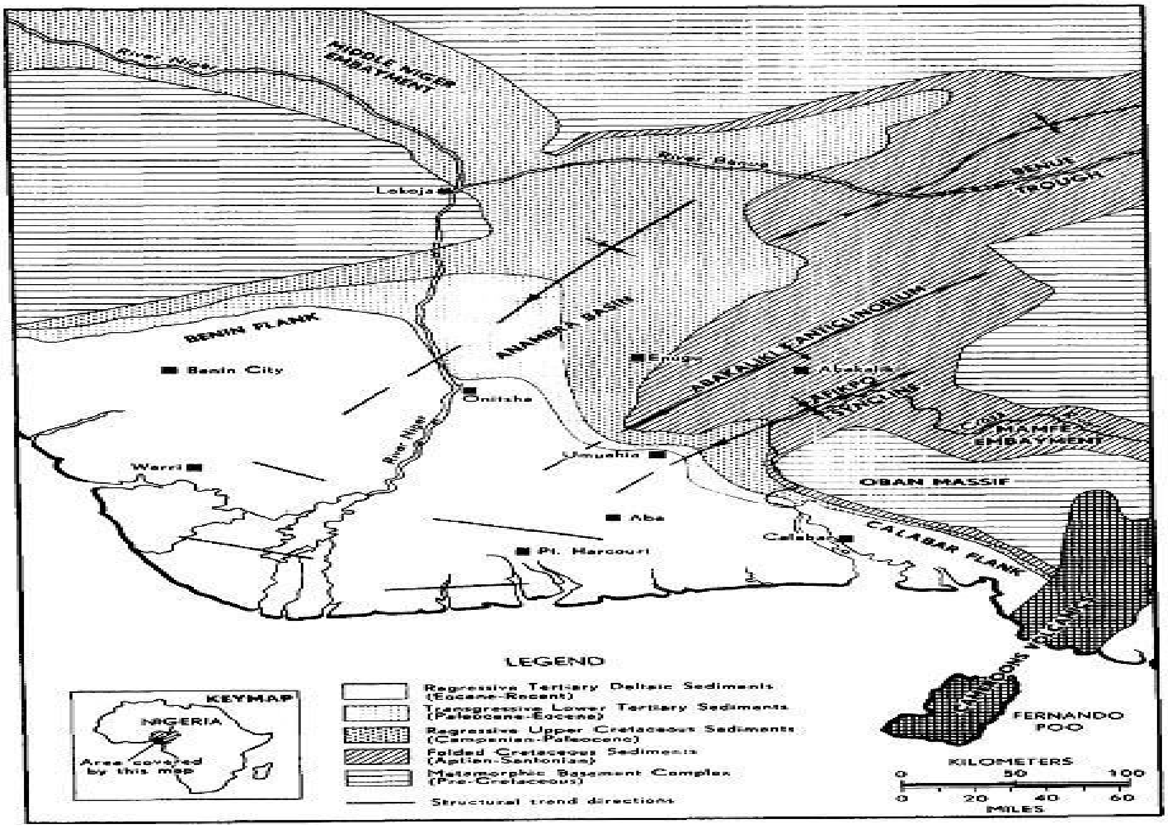


Figure 2.6: Structural units of the Niger Delta Basin (Short and Stauble, 1967).

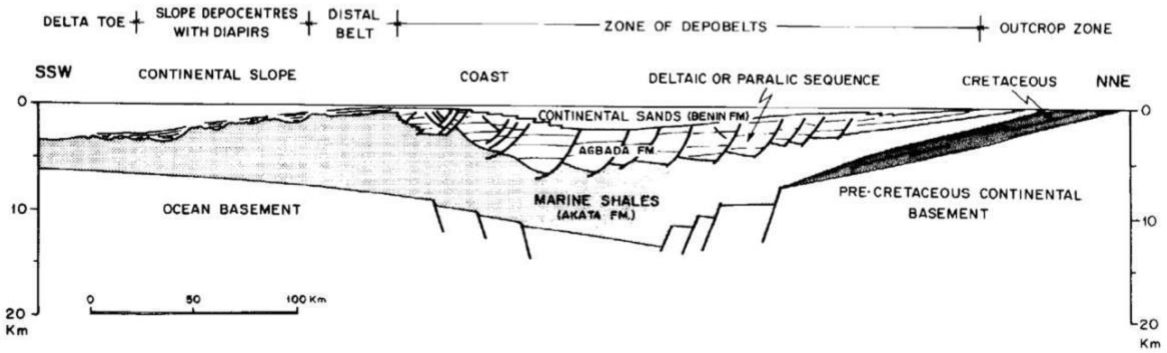


Figure 2.7: Schematic dip section of the Niger Delta Basin (Doust and Omatsola, 1990)

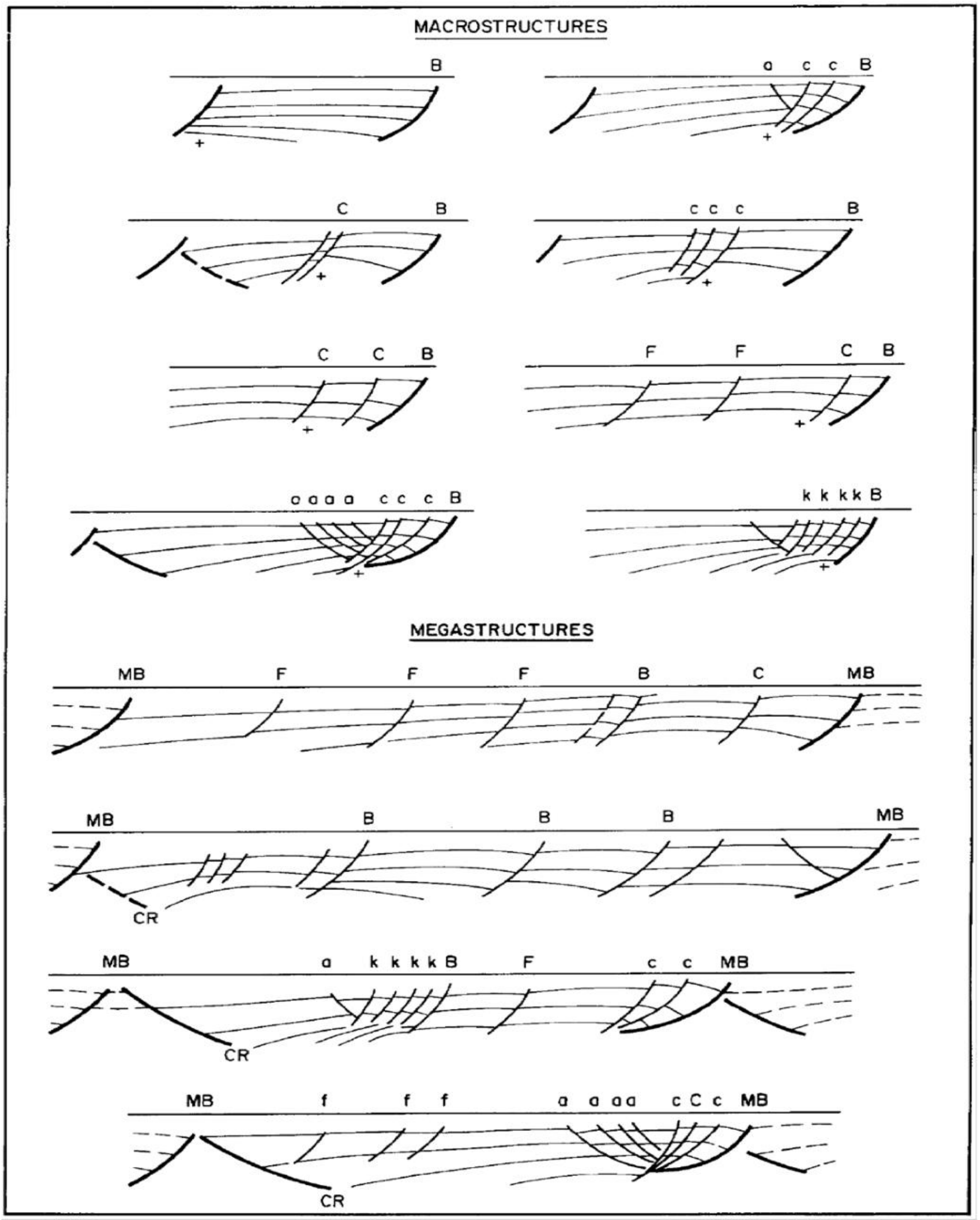


Figure: 2.8: Macrostructures and Megastructures showing A: antithetic fault, B: structure building or boundary faults, MB; if major C: Crestal fault; CR: Counter- regional faults; F:Flank faults and K: k-type faults (Evamy et,.al 1978)

2.6 TRAP AND SEALS

In the Niger Delta Basin, structural traps, illustrated in Figure 2.10, predominate as the most common trapping mechanisms. Although stratigraphic traps are also observed, they are not as prevalent as their structural counterparts. These structural traps originate during the syn-sedimentary deformation of the Agbada paralic sequence. Notably, the structural complexity tends to escalate from the northern region, where earlier depobelts formed, to the southern areas, where later depobelts developed. This heightened complexity is a direct response to the increasing instability of the undercompacted, over-pressured shale in the geological formations.

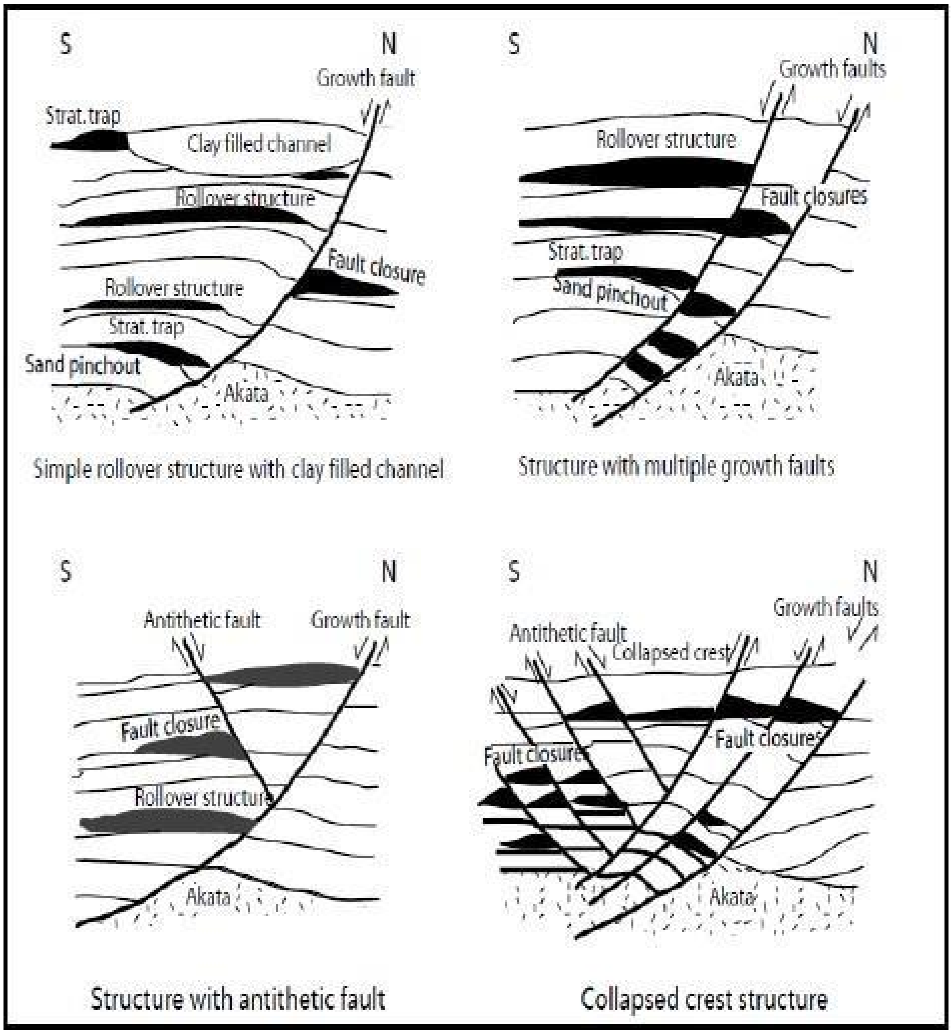


Figure 2.9: Niger Delta oil field structures and associated trap types (Modified from Doustand Omatsola, 1990 and Stacher, 1995

2.6.1 STRUCTURAL TRAPS

In the Niger Delta Basin, the prevalent traps result from the syn-sedimentary structural deformation of sediments in the region. However, solely relying on folding as a guide in the search for hydrocarbon pools may prove challenging. The shape, size, and amplitude of folds can undergo alterations in depth, as well as in their lateral position, making it intricate to accurately determine these changes at the surface. Furthermore, folding and faulting occurring beneath buried unconformities may go unnoticed at the surface. In the context of hydrocarbon pools trapped by normal faulting, they are typically situated on the upper side of the fault. This positioning arises because oil and gas tend to escape up-dip around the end of the fault. Conversely, finding pools on the lower side of the fault is rare, if such occurrences are identified at all. This underscores the complexity of the subsurface structures and the nuanced nature of hydrocarbon trapping mechanisms in the Niger Delta Basin.

2.6.2 STRATIGRAPHIC TRAPS

Traps in the Niger Delta Basin emerge from both lateral and vertical variations in the lithology of reservoir rocks, coupled with interruptions in their continuity. These variations stem from the unique characteristics of the material and the conditions of its deposition. The transformation of a permeable reservoir rock into a less permeable or impermeable rock contributes to the creation of traps, showcasing the fascinating interplay of geological processes. Stratigraphic traps can materialize when a reservoir rock is truncated by an unconformity or when strata, such as channel sandstone or lift bar, is deposited, introducing variations in lithology and stratigraphy. These alterations can induce local fluctuations in porosity or result in the termination of reservoir rock up-dip. It's worth noting that stratigraphic traps may not be as readily discernible as structural traps on seismic sections, primarily due to the limited contrast in acoustic impedance between the elements that constitute the trap. This underscores the intricacy involved in identifying and understanding the diverse trapping mechanisms in the Niger Delta Basin.

2.6.3 COMBINED STRUCTURAL AND STRATIGRAPHIC TRAPS

Traps in the Niger Delta Basin that showcase both structural and stratigraphic characteristics are commonly known as combination traps or hybrid traps. These intricate traps result from a combination of structural and stratigraphic mechanisms that contribute to their formation. Several examples of combination traps include faulted diapiric stratigraphic traps, salt dome overlying domes and faults, compaction anticlines, and salt dome-cap rock in reservoir. The complexity of these traps makes them some of the most robust and effective trapping systems in the geological setting of the Niger Delta Basin.

2.7 RESERVOIR AND SOURCE ROCKS

The question of the primary source rock in the Niger Delta Basin has been a topic of debate among researchers, leading to various perspectives. Weber and Daukoru (1975) assert that the Akata Formation serves as the sole source rock, while Short and Stauble (1967) and Lambert-Aikhionbare et al. (1990) advocate for the Agbada Formation as the primary contributor. Ejedawe and Okoh (1981) propose that both the Akata and Agbada Shales are source rocks, with the former playing a more dominant role. Evamy et al. (1978) and Ekweozor and Okoye (1980) support a combination of both the Akata and Agbada Formations as the source rock. Doust and Omatsola (1990) introduce environmental factors as influencers in the distribution of source rock in the Niger Delta Basin. They suggest that coastal, swampy conditions, including forest swamps, fresh water swamps, and mangrove swamps, may have provided conducive settings for the deposition of rich source rock beds. Nwachukwu and Chukwura (1986), Knox and Omatsola (1989), Shannon and Naylor (1989), and Reijers (1996) align with the idea that the Agbada Formation hosts the majority of the reservoir rocks in the Niger Delta. The alternating layers of fine and coarse clastics within the Agbada Formation create numerous reservoir-seal couplets, enhancing its significance in the hydrocarbon system of the region.

2.8 PREVIOUS WORK IN THE NIGER DELTA

Indeed, Short and Stauble (1967) and Frankl and Cordry (1967) played pioneering roles in the study of the Cenozoic Niger Delta, making significant contributions to our understanding of the deposits and subsurface stratigraphy in the Niger Delta Basin. Short and Stauble (1967) specifically focused on the framework of the Niger Delta, emphasizing the importance of the shales in the Agbada Formation as major source rocks. Their work laid the foundation for subsequent research and exploration efforts in the region. Burke (1972) and Whiteman (1982) expanded on this knowledge by proposing that the clastic segment of the Niger Delta Basin formed along an aulacogen during the disintegration of the South American and African plates in the Late Jurassic. This tectonic framework added valuable insights into the geological evolution of the Niger Delta. Kulke (1995) and Ekweozor and Daukoru (1994) identified the Tertiary Niger Delta (Akata-Agbada) Petroleum System as the sole petroleum system in the Niger Delta Province. According to their findings, this petroleum system extends to the boundaries of the province, highlighting its comprehensive influence on the hydrocarbon resources in the region. The collective work of these researchers has significantly advanced our understanding of the geological and petroleum aspects of the Niger Delta.

2.8.1 Palynology

Germeraad et al. (1968) conducted a comprehensive palynological study on Tertiary sediments, encompassing tropical South America, Asia, and West Africa, including the Niger Delta Basin. This research contributed valuable insights into the palynology of the region. Building on this foundation, Evamy et al. (1978) established a formal palynological zonation for the Niger Delta using alpha-numeric nomenclature, further refining our understanding of the region's geological history. Durugho (2013) focused on the potential of dinoflagellate cyst abundance and diversity in marking maximum flooding surfaces and sequence boundaries in the Niger Delta. This investigation identified seven maximum flooding surfaces and six sequence boundaries, enhancing our knowledge of the delta's stratigraphy. Legoux (1978) made notable contributions by discovering new types of organisms for classifying parts of the Neogene Niger Delta. Additionally, Biffi and Grignani (1983) studied sediments from the Oligocene period in the Niger Delta Basin, identifying different groups of dinoflagellate cysts and uncovering new species within the Lejeunecysta, Pheiodinium, and Selenopemphix groups.

Oloto (2014) determined the age of the Igbomotoru-1 Well in the Niger Delta Basin using dinoflagellate cysts. Soronnandi-Ononiwu et al. (2014) conducted palynological and paleoenvironmental studies on the Akukwa-1 Well in the Anambra Basin, providing valuable insights into the ancient environment and age of these areas. Collectively, these palynological studies have significantly enriched our understanding of the geological history, environmental conditions, and age determinations of the Niger Delta and surrounding regions.

2.8.2 Paleoecology

Several authors like Sowunmi (1981b), Poumot (1989), Samant and Phadtare (1997), Bankole (2010), and Dupont and Agwu (1991) have used palynofloral analysis to understand the ancient environment in sedimentary deposits. Bankole (2010) specifically identified five important palynomorph ecological groups in the Neogene Agbada Formation in the Niger Delta.

2.8.3 Paleoenvironment

Odedede and Lucas (2014) studied the Benin West-1, ANL-1, and E-12 wells and determined that the sediments in those wells were deposited in a distributory channel, marine shelf, and marine environment. They used sedimentary facies, chemostratigraphy, and palynoflora to establish the paleoenvironment. Boboye et al. (2017) found that the Olure-1 well had an inner neritic to coastal deltaic paleoenvironment, while the Abigboro-1 well showed a broad grouping of intervals as inner to middle neritic. Chukwu et al. (2012) identified littoral to marine environments of deposition in the Oloibiri-1 well based on the presence of specific benthonic foraminiferal taxa. Obaje and Okosun (2013) indicated a shelf paleoenvironment of deposition using foraminiferal morphogroups and biometric analysis. These studies provide valuable insights into the ancient environments of these wells. Basically, the P/B ratio and the average percentage ratios of calcareous benthic to arenaceous benthic foraminifera in the five wells (Tomboy-1, Tomboy-2, Tomboy-4, Tomboy-5, Tomboy-6) indicate that the environment was shallow marine in the past. Petters (1995) came up with a way to categorize different depths in the Niger Delta based on foraminifera, which is helpful for quickly identifying marine environments in oil well samples. Okosun et al. (2012) found evidence of deposition in littoral (deltaic) to marine (outer neritic) settings in four wells (Akata 2, 4, 6, and 7) based on specific foraminiferal species. Ajayi and Agboneni (2016) studied deep-water wells in the Niger Delta Basin and determined different bathyal environments based on benthic agglutinated foraminifera.

2.8.4 Micropaleonthology (Foraminefera)

Obaje and Okosun (2013) studied the Tomboy Field in the Offshore Western Niger Delta and determined that it was a shelf environment for deposition based on various factors like the ratios between Textularina, Miliolina, and Rotalinna, the P/B ratio, presence of indicator fossils, lithofacies, and the FOBC/FOBA ratio. It's fascinating how they were able to infer the shallow marine paleoenvironment based on these findings. Ajayi and Okosun (2014) focused on planktonic foraminifera in four offshore wells in the Niger Delta Basin. They identified 42 foraminifera species and three foraminifera zones, assigning a Late Miocene to Early Pliocene age to the sedimentary succession. Nwaejije et al. (2017) studied Well 5 in OML 34, Niger Delta and identified three planktonic foraminiferal zones: Catapsydrax dissimilis, Praeorbulina glomerosa, and Orbulina universa, which correspond to the N6-N7, N8-N9, and N9 zones respectively. They also determined that the age of the well is Miocene based on the marker species recovered. Ifeoluwadun and Saka (2018) focused on the Opolo-5 Well in the Western

Niger Delta and established two informal planktonic foraminiferal zones (Globoquadrina dehiscens and Globigerinoides ruber) and four informal benthonic foraminiferal zones (Cyclamina cancellata, Lenticulina inornata, Marginulina costata/Quinqueloculina microcostata, and Heterolepa Pseudogeriana) through foraminiferal biostratigraphy. The age of the wells can vary between Late Miocene-Early Pliocene. Okosun et al. (2012) identified three planktonic and benthonic foraminiferal zones in the Akata field, while Ozumba and Amajor (1999) proposed six foraminiferal zones for the Middle to Late Miocene in the western Niger Delta Basin. Fadiya et al. (2014) established four informal benthonic and younger planktic foraminiferal assemblage zones in the AM-2 well. Chukwu et al. (2012) used foraminifera to determine the Miocene age and inner neritic-middle neritic depositional environment of the sediments in the Oloibiri-1 well.

2.8.5 Sequence Stratigrapghy

Foraminiferal abundance and diversity have been successfully used by several authors to characterize sequence stratigraphy in the Niger Delta Basin. Okengwu and Amajor (2015) identified three sequences in the Biwa Field using wireline logs and high-resolution biostratigraphic tools. The sequence boundaries and maximum flooding surfaces were interpreted to have geologic ages ranging from 23.7Ma to 32.4Ma. Samuel et al. (2012) analyzed depositional systems in the XB Field using well logs and biostratigraphic data, identifying four depositional sequences and their accompanying systems tracts. Armentrout et al. (1999) conducted a high-resolution sequence stratigraphic study of the Oso Field using biostratigraphic data. Boboye et al. (2017) integrated wireline log and biostratigraphic data to characterize the sequence stratigraphy of Olure-1 Well in the Niger Delta Basin. They identified two maximum flooding surfaces and one sequence boundary. Odedede and Lucas (2014) also identified two sequence boundaries, one maximum flooding surface, and six systems tracts in the upper Miocene sediments of the ANL-1 well offshore. Ojo and Gbadamosi (2013) found one sequence boundary and three systems tracts in the investigation of the Del-2 well southwest of the Niger Delta Basin. And Chima et al. (2017) conducted sequence stratigraphic and structural studies of the Southern Coastal Swamp of the Niger Delta. Alege (2017) studied the Sequence Stratigraphy of wells 007, 009, and 013 in the Akos Field of the Coastal Swamp Depobelt of the Niger Delta. They identified four major sequence boundaries (SBs) and maximum flooding surfaces (MFSs), represented by markers like Dodo shale, Nonion-4, and Uvigerina-8. They established three depositional sequences and identified different parasequence stacking patterns.

Okosun et al. (2012) also found third-order maximum flooding surfaces in wells Akata-2, Akata-4, Akata6, and Akata-7 in the Akata Field. Durugho et al. (2013) investigated dinoflagellate cyst abundance and diversity in two wells, identifying seven MFSs and six sequence boundaries. These studies provide valueable insights to the Niger Delta.

2.8.7 Chemostratigraphy

Chemostratigraphy, a valuable method employed in this study, utilizes major and trace element geochemistry to characterize and correlate strata. Ratcliffe et al. (2007) and Adebayo et al. (2016) conducted geochemical characterization and palynological studies of deposits in the Agbada Formation within the Niger Delta Basin. Their findings indicated that the sediments were derived from felsic source rocks, as discerned through trace metal ratios and rare earth element patterns. This information contributes to our understanding of the composition of the source rocks in the region. Odedede et al. (2014) delved into the inorganic geochemistry of Upper Miocene sediments from the ANL-1 well in the Offshore Niger Delta Basin. Their analysis revealed that the sediments originated from granitic and metamorphic rocks within a passive tectonic setting. Similarly, Madukwe and Bassey (2016) analyzed the geochemistry of the Ogwashi-Asaba Formation, classifying it as continental sandstones derived from mafic igneous rock in a passive tectonic setting. Adebayo et al. (2016) further noted that trace metal ratios suggested the sediments originated from felsic source rocks, while ratios such as U/Th, Ni/Co, Cu/Zn, and V/Sc indicated well-oxygenated bottom water conditions. The integration of chemostratigraphy into these studies provides essential insights into the provenance, depositional environments, and tectonic settings of the sediments within the Niger Delta Basin.

CHAPTER THREE

MATERIALS AND METHOD

AVAILABLE DATA

1. Ditch cutting samples for the well.

3.1 MATERIALS USED

1. The chart for assessing the texture and grading the sorting was useful. (Jerram 2001).
2. The grain images chart for estimating the roundness of sedimentary particles (powers 1953).
3. A Mettler PC 440 digital balance was used as the sample scale.
4. To describe the sediments, different reflected light microscopes like the Zeiss binocular 475022 model, wild Heerbrugg M5 - 81796 model, and B-Bran Binocular was used.
5. Picking trays and brushes were used for handling the samples.
6. I employed X-ray fluorescence (XRF) to investigate the major oxides and trace elements in the sediments.

3.2 METHOD

By combining sedimentological and inorganic geochemical tools, I was able to achieve some great outcomes. I successfully reconstructed the sediment's provenance, determined its tectonic setting, classified the sandstone, and assessed the paleo-oxygenation condition. The integration of these methods allowed for a strong and comprehensive research approach, resulting in the successful accomplishment of the aims and objectives.

3.2.1 Sedimentological Analysis

To describe the samples from the two wells, I followed the Shell Petroleum Development Company lithofacies description guide to generate lithology and lithologic/lithofacies. I also followed detailed sedimentological sample preparation procedures.

3.2.1.1 Sedimentological sample preparation procedures

1. The samples were organized in a specific order.
2. The samples underwent a washing process to remove any additional substances.
3. The Wet samples were dried on a hot plate at a temperature of 80°C.
4. Dilute hydrochloric acid was used to identify the presence of carbonates in the samples.
5. The samples were handled in batches of no more than twenty at a time to prevent contamination, starting with the deepest sample and working towards the shallowest.
6. Sample description was carried out by visually inspecting the samples and using a reflected light binocular microscope for assistance.

3.2.1.2 Shell Petroleum Development Company Lithofacies Description Guide

1. The samples were moistened with water to reveal rock characteristics that may not be visible in dry samples.
2. The lithology of the samples was determined.
3. The color of the samples was noted.
4. The texture of the samples, including grain size, grain shape, and sorting, was assessed using a photograph of a standard comparator based on Jerram (2001) and Powers (1953).
5. Fossils and additional constituents such as mica flakes, carbonaceous detritus, ferruginous material, glauconite, shell fragments, and calcite were identified.
6. Sedimentary structures were not identified due to the type of sample (ditch cutting) used.
7. Dilute hydrochloric acid was applied to the samples to test for the presence of carbonate, and effervescence indicated the presence of carbonate in the sediments.

3.2.2 Chemostratigraphy

A chemostratigraphic analysis of the well was conducted by examining major and trace elements. The elemental content of the pulverized ditch cutting samples was determined using X-Ray Fluorescence (XRF) spectrometry, which allowed for the investigation of major oxides and trace elements.

3.2.3 List of plates;

1. XRF(X-ray Fluorescence) machine
2. Microscope
3. Picking brush and trays

Plate 1: XRF (X-ray Fluorescence) machine

Plate 2: microscope

Plate 3: picking brush and picking tray

CHAPTER FOUR

RESULTS AND DISCUSSION

The study focused on analyzing sedimentological and inorganic geochemical data (Major and Trace elements). The inorganic geochemical results were used to understand various aspects such as sedimentological characteristics, identification of petroleum system play elements, sequence stratigraphic framework, tectonic setting, paleo-redox conditions, and provenance.

4.1 LITHOLOGIC DESCRIPTION/LITHOFACIES STUDIES

The studied interval of Osedestiny well penetrated sedimentary succession from 1025 to 1325ft. The main lithofacies identified in Osedestiny well were shaly sands and sandy shales.

4.2 CHEMOSTRATIGRAPHY

For this study, a set of eight samples comprising shaly sands and sandy shales were carefully selected using the methods outlined in chapter three. These samples were subjected to detailed analysis, providing crucial information for the geochemical characterization of the wells under investigation. The analytical methods employed yielded results for ten major elements, reported as oxide percentages by weight (SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, P_2O_5, K_2O, MnO, MgO, Na_2O). This process involves measuring the weight change of a sample after it has been subjected to high temperatures, causing some of its content to burn or volatilize.

Additionally, results for twelve trace elements (Ba, Cu, Cr, Ni, Zn, Co, Th, Pb, Sc, La, V, U) were recorded in parts per million (ppm). These comprehensive analyses contribute to a detailed understanding of the geochemical characteristics of the wells, providing valuable insights into the elemental composition and potential environmental factors influencing the studied samples.

4.2.1 INORGANIC GEOCHEMICAL RESULTS

Table 4.1; Major oxides(%) of the selected sandy shale and shaly sand from Osedestiny well

S/n	SiO_2	AI_2O_3	Fe_2O_3	TiO_2	Cao	P_2O_5	K_2O	Mno	Mgo	Na_2O
1	76.80	6.98	4.65	1.50	0.87	0.40	0.79	0.06	0.77	0.17
2	90.55	2.45	3.75	0.20	0.19	0.08	0.40	0.09	0.14	0.85
3	89.50	3.50	4.50	0.70	0.25	0.06	0.37	0.07	0.28	0.49
4	88.70	4.22	3.06	0.19	0.19	0.04	0.31	0.09	0.24	0.44
5	87.50	3.25	4.18	0.50	0.30	0.06	1.45	0.06	0.17	0.95
6	88.20	3.75	4.68	0.15	0.14	0.08	1.40	0.06	0.21	0.65
7	86.75	3.56	4.20	0.30	0.19	0.06	0.40	0.05	0.17	0.45
8	88.10	3.56	4.30	0.20	0.19	0.07	0.38	0.05	0.19	0.47

4.2.1.1 Major Elements Discussion

Tables 4.1 present the inorganic geochemical results of the analyzed sandy shale and shaly sand samples. In the Osedestiny well, the SiO_2 content is much higher compared to the other oxides. For example, it ranges from 76.80 wt.% to 90.55 wt.%. The sandy units have higher values, while the shaly units have lower values. The composition of SiO_2 reflects the nature and composition of the source area, as well as the maturity of the sandstone. Al_2O_3 content ranges from 2.45 wt.% to 6.98 wt.%, and it is lower in sands than in shales. This suggests the presence of clay minerals formed from the weathering of ferromagnesian minerals. The Fe_2O_3 content ranges from 3.06 wt.% to 4.68 wt.%, and it is generally higher in shales. The low values of MnO, MgO, CaO, and Na_2O may be due to post-depositional processes or the sediment source.

Table 4.2.2: Trace Elements(ppm) Result for Osedestiny well

S/N	Ba	Cu	Cr	Ni	Zn	Co	Th	Pb	Sc	La	V	U
1	871.0	26.30	95.0	37.0	89.7	17.8	15.70	40.7	16.6	57.4	15.6	3.91
2	780.50	30.32	55.70	20.65	45.25	4.50	4.45	40.45	1.90	18	39.50	1.65
3	766.40	27.22	36.20	23.60	40.45	3.15	6.28	30.13	3.5	0.82	19.00	0.70
4	662	27.32	40.20	19.60	48.25	6.15	5.13	28.35	5.44	0.92	22.5	2.52
5	695.50	27.32	47.70	22.65	60.25	6.15	4.13	35.24	2.74	0.62	19.5	0.63
6	788.50	43.32	40.70	25.65	48.25	8.15	5.43	35.24	1.75	19	25.50	1.65
7	650.50	25.20	39.20	23.45	35.50	53.0	5.15	28.30	2.90	19.4	18.00	0.97
8	620.50	25.20	37.20	53.45	34.50	54.0	5.15	28.30	2.95	19.4	18.00	0.95

4.2.2.1 Trace Elements Discussion

Trace elements found in sedimentary rocks offer valuable insights into the paleoenvironmental conditions during deposition and the origin of the rocks. The behavior of trace elements throughout sedimentary processes, including fractional crystallization, weathering, and recycling, aids in understanding the tectonic setting and crustal evolution. Rare earth element (REE) patterns, a specific focus, are frequently utilized for provenance determination.

Vanadium (V), known for its sensitivity to redox conditions, tends to be enriched in sediments beneath anoxic or near-anoxic waters. The V/Sc ratio is commonly employed to indicate the degree of enrichment. Strontium (Sr) is prone to loss during chemical weathering, with the amount lost proportional to the degree of weathering. Barium (Ba) serves as a proxy for biotic paleo productivity in oceans due to its strong correlation with settling biogenic matter. Elevated Ba concentrations, especially in association with a high palynofloral content, suggest a connection to bio-productivity. Zirconium (Zr), Hafnium (Hf), and Niobium (Nb) concentrations are enriched in both wells compared to PAAS, reflecting their association with heavy minerals and greater abundance in felsic rocks than mafic rocks. The depletion of Scandium (Sc) in both wells indicates a felsic source. Titanium (Ti) also exhibits high values in both wells. Krejci-Graf (1972) contributed valuable insights into the trace element content of sediments in different depositional environments, highlighting how continental sediments with prolonged subaerial weathering typically contain trace elements like titanium and thorium. These trace element analyses enhance our understanding of the environmental conditions and geological history of the studied wells.

Table 4.2.3 Major Elements Ratios of Osedestiny well

S/N	Depth interval	Na_2O / TiO_2	K_2O /Na_2O	AI_2O_3/ TiO_2	Log(SiO_2/ AI_2O_3)	Log(K_2O / Na_2O)	Log(Fe_2O_3/ K_2O)	Log(Na_2O / K_2O)	TiO/ Ni
1	1025-1040	0.113	4.64	4.65	1.04	0.66	0.77	-0.66	0.0 4
2	1070-1085	4.25	0.52	12.25	1.57	-0.33	0.97	0.36	0.01
3	1100-1115	0.7	0.76	5	1.41	-0.12	1.09	0.12	0.03
4	1130-1145	2.31	0.7	22.21	1.45	-0.15	0.99	0.15	0.01
5	1175-1190	1.9	1.52	6.5	1.43	0.18	0.46	-0.18	0.01
6	1220-1235	4.33	2.15	25	1.37	0.33	0.52	-0.33	0.005
7	1265-1280	1.5	0.88	11.8	1.39	-0.05	1.02	0.05	0.01
8	1310-1325	2.35	0.81	17.8	1 39	-0.09	1.05	0.02	0.004

Table 4.2.4 Trace Elements Ratios of Osedestiny well

S/N	Depth Interval	Ni/ co	Co/ Th	La/ Sc	Ni/ Cr	U/ Th	V/ Sc	Cu/ Zn	Cr/ Th	Th/ Co	Th/ Sc	La/ Th
1	1025-1040	2.08	1.13	3.46	0.38	0.25	0.94	0.29	6.05	0.88	0.95	3.66
2	1070-1085	4.59	1.01	1.47	0.37	0.37	20.79	0.67	12.52	0.99	2.34	4.04
3	1100-1115	7.49	0.50	0.23	0.65	0.11	5.42	0.67	5.76	1.99	1.79	0.13
4	1130-1145	3.19	1.19	0.17	0.49	0.49	4.13	0.57	7.83	0.83	0.94	0.18
5	1175-1190	3.68	1.49	0.23	0.47	0.15	7.11	0.45	11.55	0.67	1.5	0.15
6	1220-1235	3.15	1.5	10.86	0.63	0.30	14.57	0.89	7.49	0.67	3.10	3.49
7	1265-1280	0.44	10.29	6.69	0.59	0.19	6.20	0.71	7.61	0.09	1.76	3.76
8	1310-1325	1.99	10.48	6.57	1.43	0.18	6.10	0.73	7.22	0.09	1.75	3.76

4.3. PALEOREDOX STUDIES

According to Calver and Pedersen (1993), Jones and Manning (1994), Crusius et al. (1996), and other studies, concentrations or ratios of redox-sensitive trace elements are commonly utilized as indicators of redox conditions in sedimentary deposits. For instance, Jones and Manning (1994) observed that a Ni/Co ratio below 5 suggests oxic environments, while ratios between 5 and 7 indicate dysoxic environments. Ratios greater than 7 imply suboxic to anoxic environments. In the Osedestiny well, the Ni/Co ratio ranges from 2.38 to 5.26, suggesting oxic environments during deposition. Similarly, the U/Th ratio is used as an indicator, where a ratio below 0.75 suggests an oxic environment, ratios between 0.75 and 1.25 indicate a dysosic environment, and ratios above 1.25 imply a suboxic to anoxic environment. In the Osedestiny well, the U/Th ratio ranges from 0.19 to 0.28, indicating an oxic environment.

Additionally, the V/Cr ratio is employed, with a ratio less than 2 indicating an oxic environment, ratios between 2 and 4.25 suggesting a dysosic environment, and ratios above 4.25 implying a suboxic to anoxic environment. In the Osedestiny well, the V/Cr ratio ranges from 0.53 to 2.68, indicating an oxic environment during the deposition of sediments. These redox-sensitive trace element ratios provide valuable information about the prevailing redox conditions in the studied sedimentary deposits.

Table 4.3.1 Elemental ratios to evaluate the paleo-redox condition of sediments after Jonesand Manning (1994).

Elements Ratios	Oxic	Dysoxic	Sub-oxic to anoxic
Ni/Co	<5	5-7	>7
V/Cr	<2	2-4.25	>4.25
U/Th	<0.75	0.75-1.25	>1.25

Table 4.3.2 Ni/Co, V/Cr and U/Th ratios for X-well for the determination of Paleoredox condition of deposition

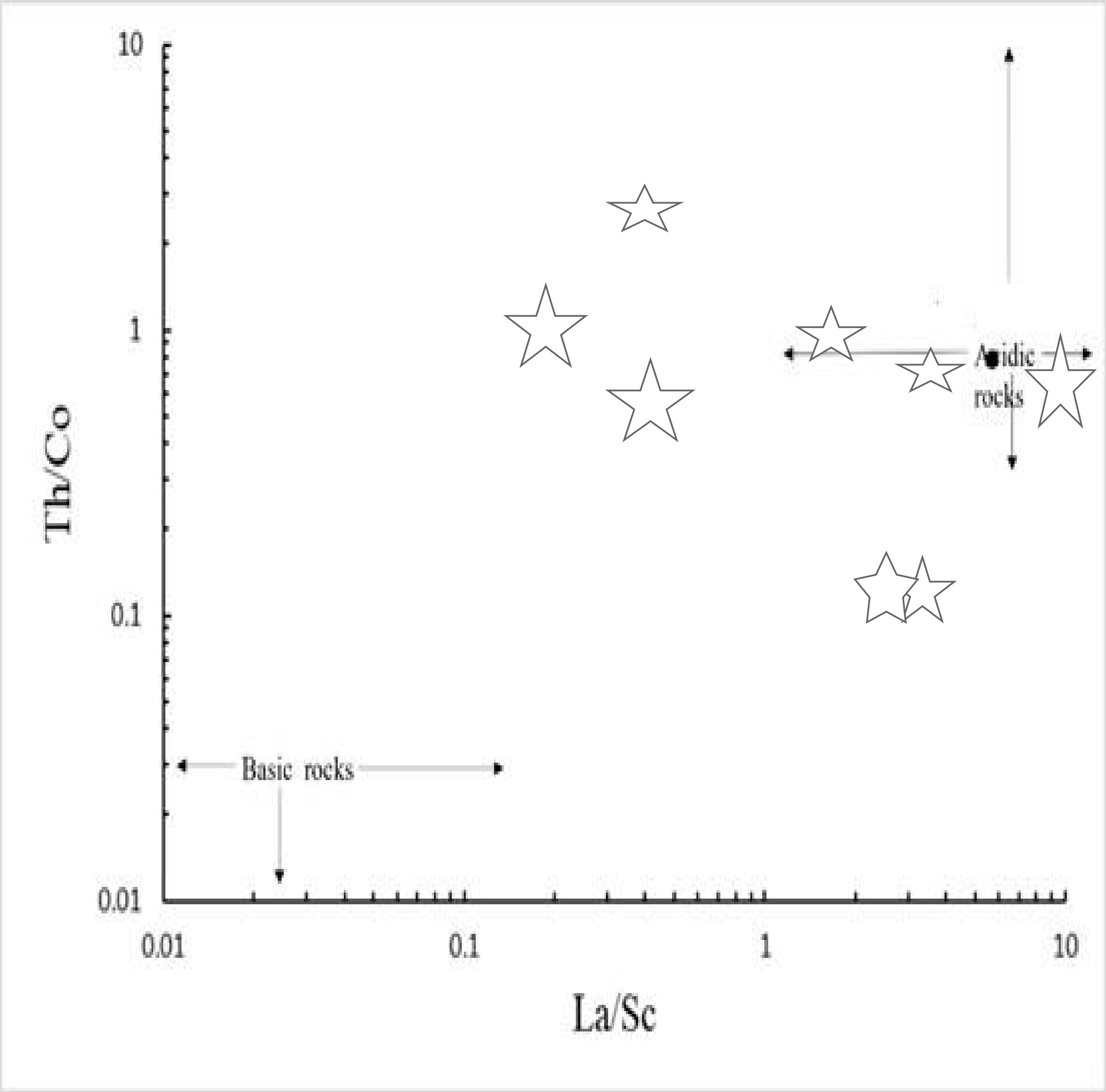
Sample Number	Ni/Co	V/Cr	U/Th
1	2.08	0.16	0.25
2	4.59	1.30	0.37
3	7.49	0.52	0.11
4	3.19	0.56	0.49
5	3.68	0.40	0.15
6	3.15	0.62	0.30
7	0.44	0.46	0.19
8	1.99	0.48	0.18

4.4 PROVENANCE STUDIES

Provenance studies play a crucial role in reconstructing the sediment supply history, encompassing erosion of parent rocks to the burial of detritus, ultimately determining the geographic location and characteristics of the source area. Various factors, including the source area's location, drainage pattern, sediment transfer pathways, relief, climate, and tectonic setting, undergo evolution over time. These changes leave imprints in the characteristics of sediments deposited in the basin (Davies and Pickering, 1999).

Rare earth elements have proven valuable in deciphering the origin and evolution of rocks across diverse rock types (Bhatia, 1985). Additionally, Cullers (2002) suggested using the Th/Co versus La/Sc plot as a tool for determining provenance. In the case of the Osedestiny well, the rocks exhibit characteristics indicative of acidic rocks. Provenance studies, guided by such geochemical analyses, contribute to unraveling the complex geological history of sedimentary basins and understanding the dynamics of sediment transport and deposition..

Figure 4.1: Th/Co versus La/Sc diagram for Osedestiny well. (After Culler, 2002)



Key: Osedestiny well = ★

Also, the concept of Floyd et Al (1989) to establish the source of the sediments in the Osedestinywell was adopted. Through the use of TiO2 versus Ni bivariate plot, it was discovered that the sediments in the well are predominantly of acidic nature.

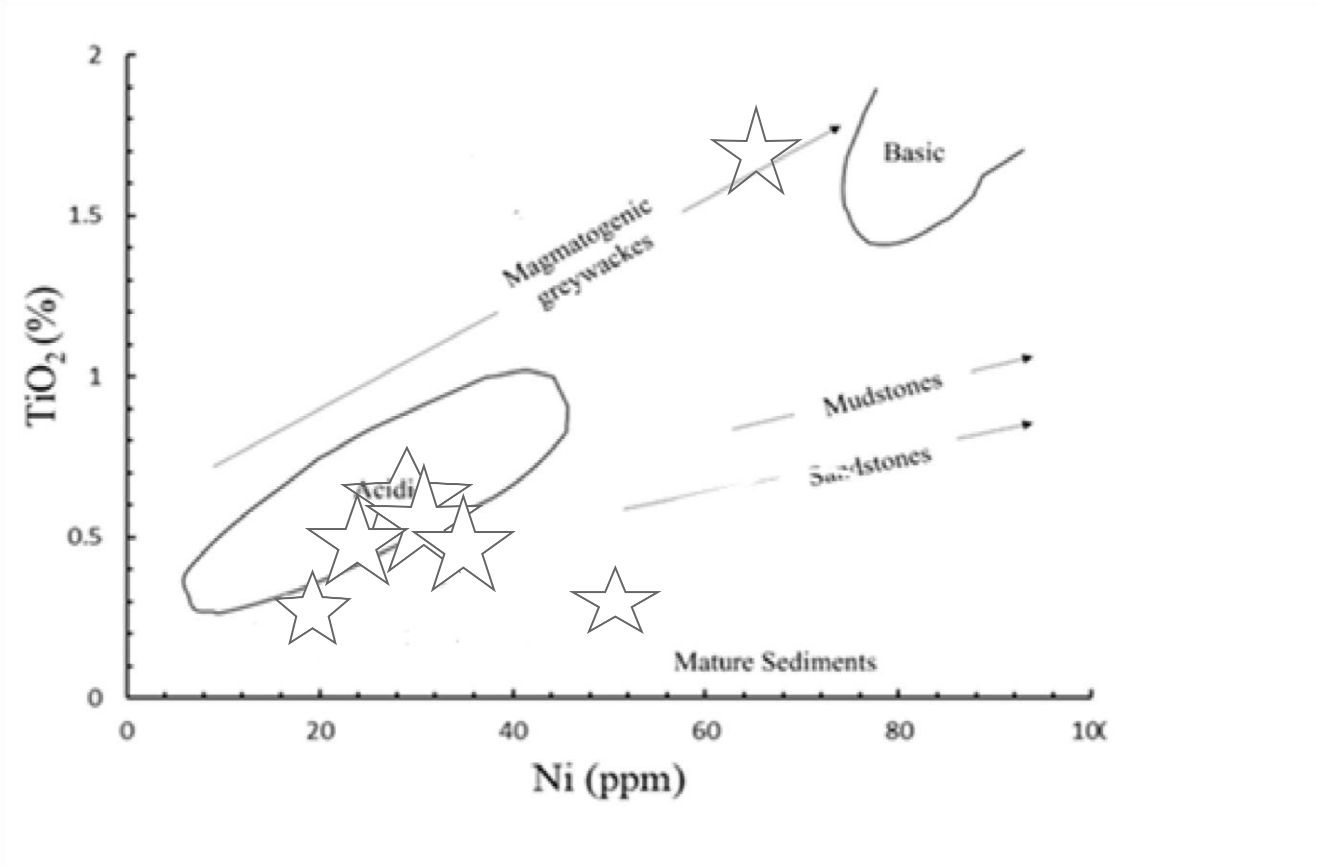


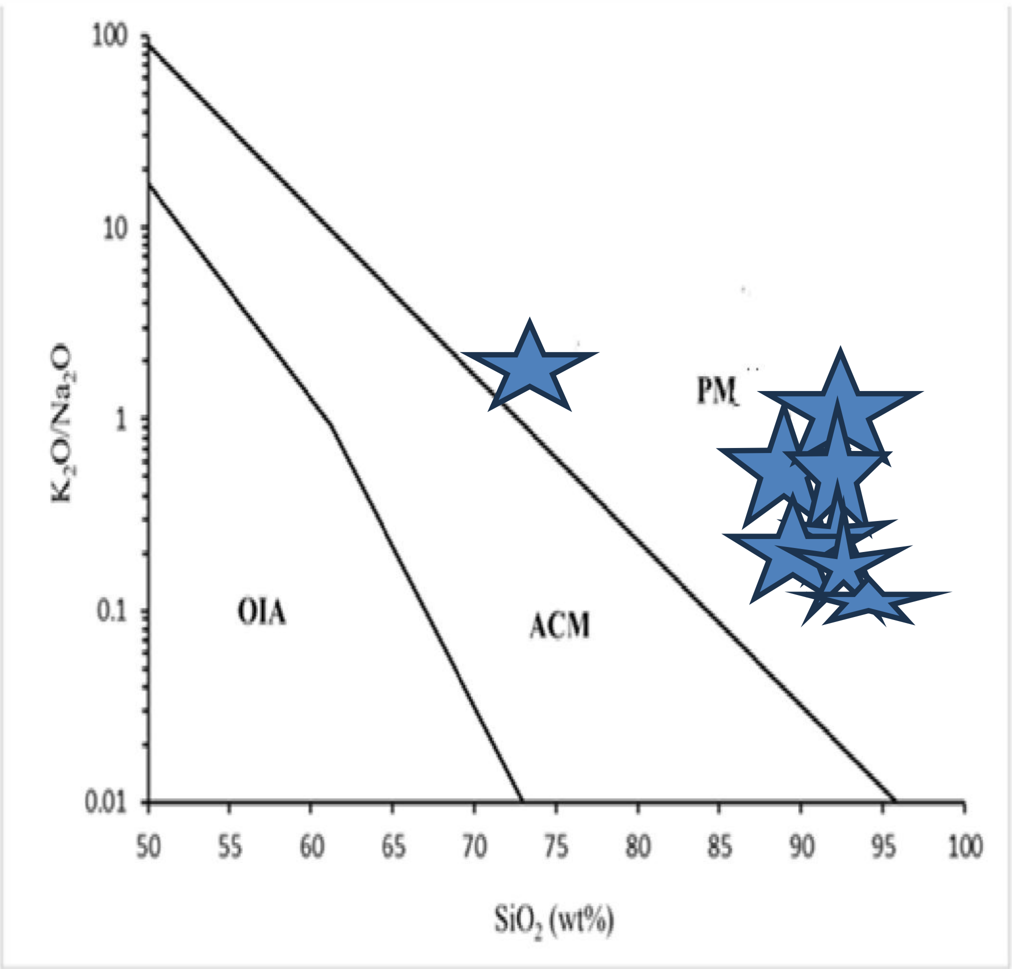
Figure 4.1 TiO$_2$ versus Ni bivariate data of the Osedestiny well After Floyd et Al 1989)

Key: ☆ **= Osedestiny well**

4.5 TECTONIC SETTINGS

Plate tectonic processes leave distinctive geochemical signatures on sediments in two primary ways. Firstly, different tectonic environments exhibit unique characteristics that dictate the origin of sediments. Secondly, these environments also involve specific sedimentary processes. As highlighted by Bhatia (1985) and Roser and Korsch (1986), the chemical compositions of clastic rocks are significantly influenced by the plate tectonic settings of their sources.

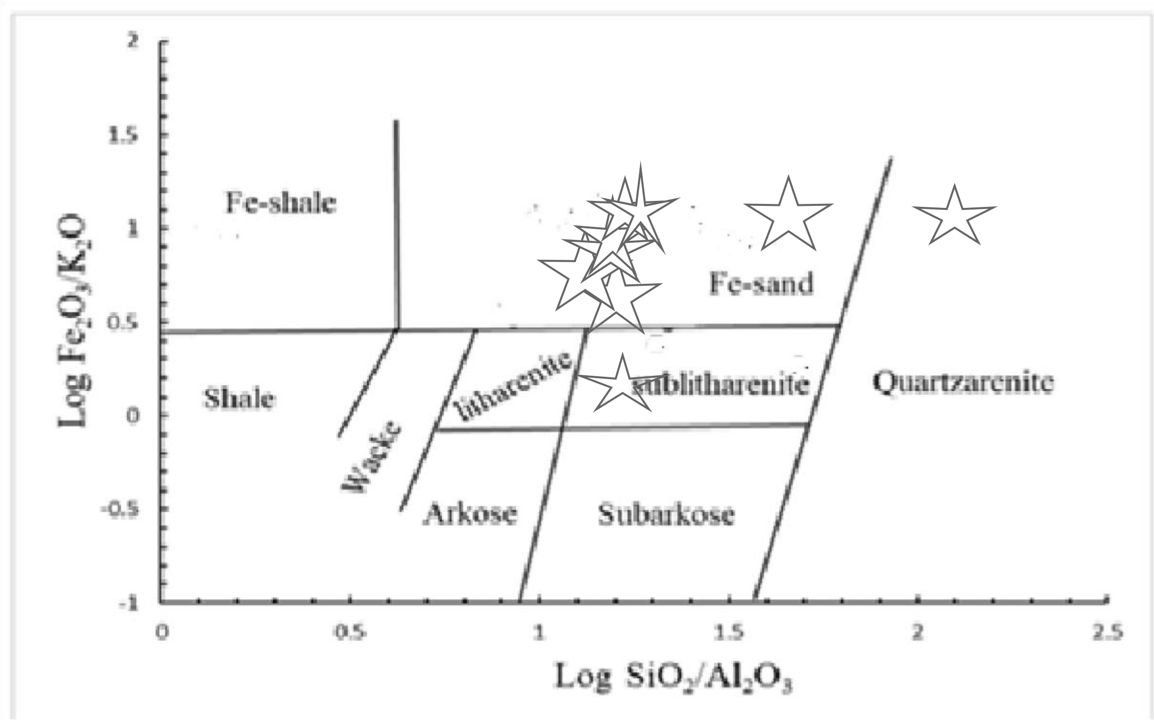
Clastic rocks originating from different tectonic settings bear distinct geochemical signatures, a concept elucidated by Roser and Korsch (1986). To determine the tectonic setting of the Osedestiny well, a discrimination diagram was employed based on the K2O/Na2O versus SiO2 plot. This approach identifies different tectonic settings, such as passive continental margin (PCM), active continental margin (ACM), and oceanic island arc (OIA). Analyzing the samples from the Osedestiny well revealed that they predominantly plotted in the passive continental margin zone. This inference indicates that the tectonic setting for the facies in the Osedestiny well aligns with a passive continental margin.



Key: ★ = Osedestiny well Figure 4.5.1 Tectonic discrimination plot for Osedestiny well.After Roser and Korsch (1986)

4.6 SANDSTONE CLASSIFICATION

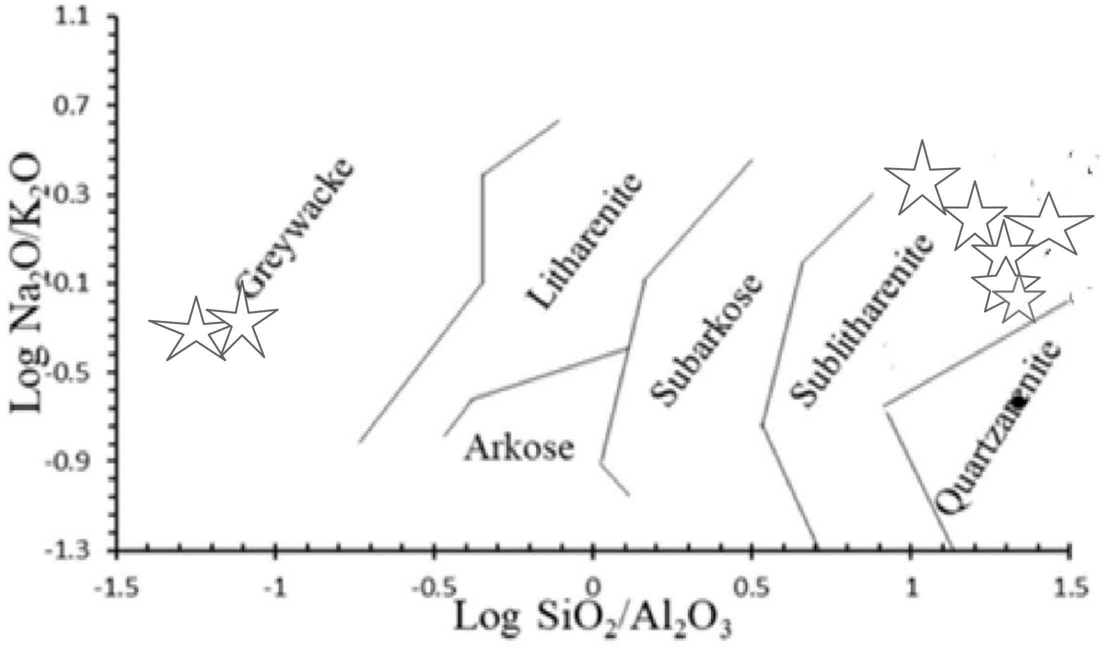
Boggs (1967) proposed that the classification of sandstone can provide valuable insights into its origin. It also helps in understanding the paleogeography and tectonic background of the provenance. Herron(1988) developed a classification scheme using log (SiO2/Al2O3) plotted against Log(Fe2O3/K2O). When this scheme was applied to the Osedestiny well, it was discovered that most of them fell with the Fe sand domain and one sample fell into the Sublitharenite and Quartzarenite each.



Key: ☆ = Osedestiny well

Figure 4.6.1 Chemical Classification of the samples of the Osedestiny well based on Log (SiO_2/Al_2O_3) vs Log (Fe_2O_3/K_2O). After Herron(1988)

Pettijohn (1972) propose day classification in which log(SiO_2/Al_2O_3) is plotted against Log(Na_2O/K_2O). By adopting pettijohn's concept in this work, the samples penetrated by Osedestiny well was plotted mainly in Sublitharenite and Greywacke domain.



Key: ☆ = Osedestiny well Figure 4.6.2 Classification of Osedestiny well sample facies based on Log(SiO_2/Al_2O_3) vs Log Na_2O/K_2O). After Pettijohn(1972)

CHAPTER FIVE

SUMMARY, CONCLUSION, FUTURE RECOMMENDATIONS

5.1 SUMMARY

The sedimentological analysis of twenty (20) samples from the Osedestiny well in the Northern depobelt of the Niger Delta, coupled with chemostratigraphic studies on eight (8) selected samples, yielded the following key findings:

1. The sedimentological analysis identified the lithology as primarily sandy shale to shaly sand consistently throughout.

2. Grain sizes in the sedimentological analysis ranged from fine to coarse, with the samples exhibiting poor to moderate sorting and grain shapes varying from sub-rounded to angular.

3. Chemostratigraphic characterization using major oxides on the selected eight (8) samples highlighted that the percentage composition of SiO2 was notably higher than that of other oxides, indicating the duration and intensity of weathering.

4. The chemostratigraphic characterization, employing major oxides and trace elements, provided insights into the paleo-redox environment, provenance studies, tectonic setting, and sandstone classification of the sediments in the Osedestiny well.

This comprehensive analysis enhances our understanding of the sedimentary characteristics and depositional history in the specified region of the Niger Delta.

5.2 CONCLUSION

Sedimentological analysis of the Osedestiny well revealed a predominant composition of sandy shale and shaly sand. Chemostratigraphic characterization, utilizing major oxides and trace elemental ratios, suggested that the sediment source for the Osedestiny well originated from felsic rock within a passive margin zone. The trace elemental ratios of U/Th and V/Cr further indicated that the deposition of sediments in the Osedestiny well occurred in an oxic environment. Various chemical sandstone classification schemes employed in the study characterized the sediments as sublitharenite, Fe-rich sand, and quartzarenite. This comprehensive analysis contributes to a deeper understanding of the sediment characteristics and environmental conditions in the Niger Delta Basin.

5.3 SUGGESTIONS FOR FURTHER STUDIES

Biostratigraphy should be carried out to effectively infer the age, environment of deposition and paleobathymetry of the sediments.

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