Global Scientific JOURNALS

GSJ: Volume 10, Issue 4, April 2022, Online: ISSN 2320-9186
www.globalscientificjournal.com

SHALE ORGANIC RICHNESS AND SEDIMENTATION OF ABAJI SECTION, PATTI FORMATION OF THE SOUTHERN BIDA BASIN

BY

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AUGUST, 2011

GSJ: Volume 10, Issue 4, April 2022
ISSN 2320-9186

CERTIFICATION

I hereby certify that this project work was carried out by **SOBOLA SUNDAY MICHAEL, (AGY/06/8420)** in the department of Applied Geology, The Federal University of Technology Akure, and to the best of my knowledge, it has not been submitted elsewhere for the award of any degree.

....

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(Project Supervisor/H.O.D Applied Geology)

DEDICATION

This report is dedicated to God Almighty, the giver of life and wisdom. He has been my help and everything.

ACKNOWLEDGEMENTS

My endless gratitude to God almighty for giving me life and strength through the thick and thin, making this project work a success.

I am so grateful to my supervisor, he is more than a supervisor but a father, looking at you reminds me of my late parents. Thanks so much for your support, advice, scolding when necessary, and taking the time out of no time to make this work a success and for bringing out the best in me. Thanks so much sir

I acknowledge my family, firstly the akinyemis, for being my parents supporting both financially and morally. I acknowledge the effort of the Oloyedes and my sisters; Sogo and Felicia. God bless u all.

I cannot be ungrateful to acknowledge the support from my colleagues, friends; Adeyemi, Mobolade Igbagbo, Ife adejuyigbe, Evo, Olorunfemi Michael, Olamide Johnson, Azike Chinyere, Dasabbath family and Rcfites. God bless u all

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ABSTRACT

Outcrops of Patti Formation occur between Lokoja and Abaji. The exposures encountered during the mapping exercise consist of sandstone beds, siltstones, mudstones, claystones and carbonaceous shale with lateral persistence. The outcrop of Abaji is full of clastic sediments with variations in primary structures and textural characteristics, which are indicators of the mode of deposition and depositional environment. The diagnostic structures observed on exposures are hummocky, herringbone, which indicate sediment deposition in the intertidal environment. Samples taken for grain size analysis gives the mean value ranging from 0.4ϕ to 2.63ϕ (average mean value of 1.4ϕ), which indicates that the sediments are medium grained, while the standard deviation range from 0.59ϕ to 1.40ϕ (total average value of 0.93ϕ), indicating moderately sorted sand. Skewness value ranges from -0.55ϕ to 0.16ϕ (with average of -0.16ϕ), this indicates coarse skewed while its distribution mesokurtic (kurtosis ranges from 0.94ϕ to 2.8ϕ averaging 1.09ϕ). The histogram plot shows that the sediments are unimodal, bimodal and polymodal which indicates that sediments are derived from one source (unimodal) and more than one parent material (bimodal, polymodal).

The average soluble organic matter concentration SOM (0.44wt. %) shows fair organic matter content for the generation of hydrocarbon.

The occurrence of primary structures such has hummocky, herringbone indicates sediment deposition in intertidal environment.

GSJ: Volume 10, Issue 4, April 2022
ISSN 2320-9186

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Statement

The Bida Basin is in the western section of central Nigeria. The basin is a NW–SE trending embayment, perpendicular to the main axis of the Benue Trough and the Niger Delta Basin (Fig.1). The basin is the least understood of Nigeria's sedimentary basin. This is, perhaps, because serious oil and gas exploration has not been undertaken in the basin.

Two major depositional systems characterized the Bida basin of Nigeria, and on this basis, the basin is divided into the Northern Bida basin and the Southern Bida basin

Attention in this study is focused on the southern part of the basin which is filled by sedimentary rocks of Campanian- Maastrichtian age.

Exposed rocks (road cuts) of the Patti formation within the Southern Bida basin were carefully examined, studied, and described along the highway between Lokoja and Abuja. Different structures were also described which are good pointers to ancient geological conditions that govern the deposition of the sediments.

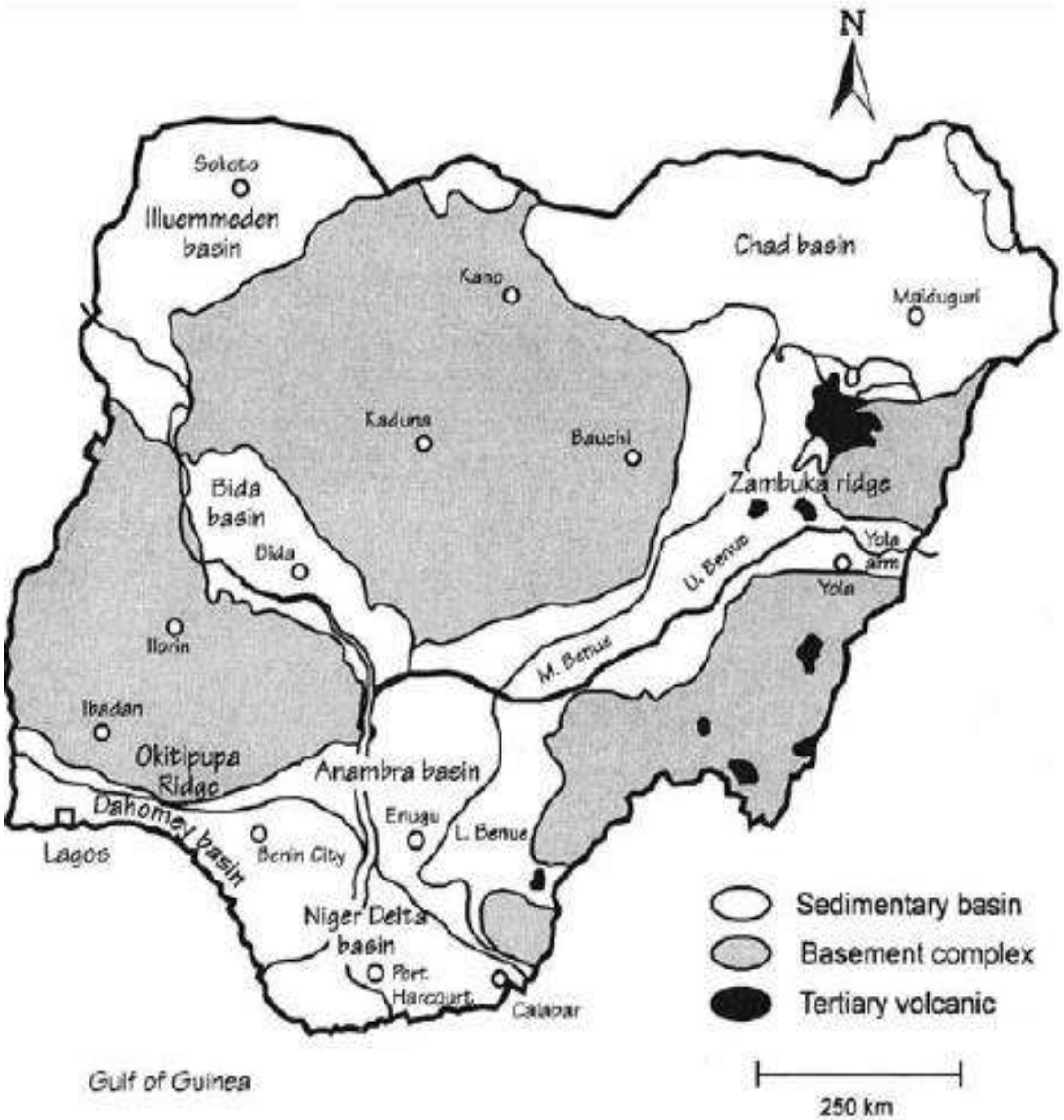

Fig.1: Geological map of Nigeria showing the study area

1.2 Aim and Objective of the Work

Attention of this project work is focused on the Patti formation of Southern Bida basin. The aim of this project is to estimate the Shale Organic Richness and Sedimentation of Abaji section, Patti formation of the Southern Bida basin. The main objectives are to:

a) Map the area around Ahoko-Ebira and Abaji

b) Describe the field relationship of the bed lithologies

c) Access the organic matter concentration from the shale samples encountered in the beds

1.3 Location

The study area lies within latitude $08^{o}18.831^{1}$N and longitude $006^{o}51.474^{1}$E, latitude $08^{o}19.217^{1}$N and longitude $006^{o}52.776^{1}$E. It extends precisely from AhokoEbira to Abaji. The outcrops studied are exposed by the road cut along Lokoja- Abuja highway

1.4 Geology of Bida Basin

The evolution of Bida basin is linked with geodynamic effect of the opening of the South Atlantic as the basin forms in NW-SE extension of Benue rift.

There are two major depositional systems characterized the Bida basin, and on this basis, the basin is divided into the Northern Bida basin and Southern Bida basin.

1.4.1 Stratigraphy

The stratigraphy and sedimentation of Upper Cretaceous succession of the BidaBasin have been documented by Adeleye and Dessauvagie (1972) in the centralparts of the basin around Bida. Four mappable stratigraphic unites are recognized inthis area, namely, the Bida Sandstone (divided into the Doko Member and the Jika Member), the Sakpe Ironstone, the Enagi Siltstone, and the Batati Formation. These are correlatable with the stratigraphic units in the Southern Bida Basin**.** In the southern Bida Basin, exposures of sandstones and conglomerates of the Lokoja Formation (ca. 300 m thick) directly overly the Pre-Cambrian to Lower Paleozoic basement gneisses and schists. This is overlainby the alternating shales, siltstones, claystones and sandstones of the Patti Formation (ca. 70–100 m) thick in the Koton-Karfi and Abaji axis and succeeded by the claystones, concretionary siltstones and ironstones of the Agbaja Formation.

1.4.1.1 Northern Bida Basin

The Bida Sandstone

The Bida Sandstone is divisible into two members, namely the Doko Member and the Jika Member. The Doko Member is the basal unit and consists mainly of very poorly sorted pebbly arkoses, sub-arkoses and quartzose sandstones. These are thought to have been depositied in a braided alluvial fan setting. The Jima Member is dominated by cross-stratified quartzose sandstones, siltstones and claystones. Trace fossils comprising mainly *Ophiomorpha* burrows have been observed. These were also observed in the overlying Sakpe Ironstone, suggesting a possible shallow marine subtidal to intertidal influence during sedimentation. The Jima Sandstone Member is thus considered as the more distal equivalent of the upper part of theLokoja Sandstone, where similar features also occur.

The Sakpe Ironstone

The Sakpe Ironstone comprises mainly oolitic and pisolitic ironstones with sandy claystones locally, at the base, followed by dominantly oolitic ironstone which exhibits rapid facies changes across the basin, at the top.

The Enagi Siltstone

The Enagi Siltstone consists mainly of siltstones and correlates with the Patti Formation in the Lokoja sub-Basin. Other subsidiary lithologies include sandstone, siltstone admixture with some claystones. Fossil leaf impressions and rootlets have been found within the formation. The formation ranges in thickness of between30 and 60 m. Mineral assemblage consists mainly of quartz, feldspars, and clay minerals.

The Batati Formation

This formation constitutes the uppermost units in the sedimentary sequence of the Bida Basin. The Batati Formation consists of argillaceous, oolitic and goethitic ironstones with ferruginous claystone and siltstone intercalations and shaly beds occurring in minor proportions, some of which have yielded near shore shallow marine to freshwater fauna (Adeleye, 1973).

1.4.1.2 Southern Bida Basin

The Lokoja Formation

Lithologic units in this formation range from conglomerates, coarse to fine grained sandstones, siltstones and claystones in the Lokoja area. Sub-angular to sub-rounded cobbles, pebbles and granule sized quartz grains in the units are frequently distributed in a clay matrix. Both grain supported and matrix supported conglomerates form recognizable beds at the base of distinct cycles at outcrop. The sandstone units are frequently cross stratified, generally poorly sorted and composed mainly of quartz plus feldspar and are thus texturally and mineralogically immature. The general characteristics of this sequence especially the fining upward character, compositional and textural immaturity and unidirectional paleocurrent trends, suggest a fluvial depositional environment dominated by braided streams with sands deposited as channel bars consequent to fluctuating flow velocity. The fine-grained sandstones, siltstones and clays represent flood plain over bank deposits.

The Patti Formation

Outcrops of the Patti Formation occur between Koton-Karfi and Abaji. This formation consists of sandstones, siltstones, claystones and shale interbedded with bioturbated ironstones. Argillaceous units predominate in the central parts of the basin. The siltstones of the Patti Formation are commonly parallel stratified with occasional soft sedimentary structures (e.g. slumps), and other structures such as wave ripples, convolute laminations, load structures. Trace fossils are frequently preserved. Interbedded claystones are generally massive and kaolinitic, whereas the interbedded grey shales are frequently carbonaceous. The subsidiary sandstone units of the Patti Formation are more texturally and mineralogically mature compared with the Lokoja sandstones. The predominance of argillaceous rocks, especially siltstones, shales and claystones in the Patti Formation requires suspension and settling of finer sediments in a quiet low energy environment probably in a restricted body of water (Braide, 1992). The abundance of woody and plant materials comprising mostly land-derived organic matter, suggests prevailing freshwater conditions.

The Agbaja Formation

This formation forms a persistent cap for the Campanian – Maastrichtian sediments in the Southern Bida Basin as a lateral equivalent of the Batati Formation on the northern side of the basin. It consists of sandstones and claystonesinterbedded with oolitic, concretionary and massive ironstone beds in this region. The sandstones and claystones are interpreted as abandoned channel sands and over bank deposits influenced by marine reworking to form the massive concretionary and oolitic ironstones observed. Minor Marine influences were also reported to have inundated the initial continental environment of the upper parts of the Lokoja Sandstone and the Patti Formation. The marine inundations appear to have continued throughout the period of deposition of the Agbaja ironstones in the southern Bida Basin.

1.5 Previous Work

Early workers involved in basinal analysis have worked on the Bida basin suggested the origin ranges from sag, rift and shear related origin; Adeniyi(1985) suggests the sedimentary pile in the Bida Basin is about 3.5km thick.

Kogbe et al (1981) suggested rift origin. Other workers include Braide (1992), Akande and Ojo (1995), Ehinola et al (2005), Whiteman (1982), Kenedy (1995) and Agyingi (1991).

CHAPTER TWO

2.0 MATERIALS AND METHODOLOGY

The methodology of this project is in two parts: the field work and the laboratory work. The materials used depends on the scope and objectives of the project; shale organic richness and sedimentology of the Abaji section, Patti formation of the Southern Bida basin

The field work is carried out by traversing along the major road cuts within Lokoja-Abuja highway, observing and studying the sedimentary fill in the basin.

The laboratory work is carried out using two basic methods which are:

- Grain Size Analysis of sediments recovered from the section
- Soluble Organic Matter extraction of the Shale, found at Ahoko-Egbira and Idu bridge along Lokoja-Abuja highway, using Soxhlet Apparatus

2.1 Field Mapping

The field mapping involves traversing along the major road cuts within Lokoja-Abuja highway, observing and studying the sedimentary fill in the basin.

The appraisal of the exposures observed were done first during field mapping exercise. This helps in observing the lithofacies present in the exposures sequentially. Detailed study commences after this. The study entails taking a closer look at the characteristic features of the exposures which includes colour, texture, mineralogy, fissility, thickness and structures. The attitude of the beds, and the GPS reading were also taken and recorded.

Pictures, sketches of the exposures were taken, showing vividly their characteristic features. Lastly, samples were taken, labeled according to their point of collection, type of lithology and bed. They were collected in a sample bag and made ready for laboratory analysis.

The materials used during the field mapping include:

a) **Geological Hammer** – For breaking rock samples

b) **Sample bag**- For collecting samples

c) **Chisel**- For removing samples from the outcrops

d) **Masking tape**- For sample labeling

e) **Measuring tape**- For measuring the thickness of beds

f) **Camera**- For taking pictures

g) **Compass Clinometer**- For measuring the attitude of the beds

h) **Marker**- Also for sample labeling

i) **Global Positioning System (G.P.S)**- For measuring coordinates

j) **Field notebook**- For recording data

2.2 Laboratory Analyses

2.2.1 Extraction of Bitumen from Shale

The materials used in soxhlet extraction of soluble organic matter from the organic shale are:

i. **Moettler P161 electric balance**: For measuring the weight of samples

ii. **Extraction thimbles**: This is used for wrapping samples to prevent from staining of apparatus

iii. **Soxhlet**: It is made of transparent glass, used in extraction of the organic matter

iv. **Dichloromethane**: This is the solvent used for extracting the organic matter from the shale rock

v. **Electro-thermal heating system**: Used as a source of heat for the system.

Samples were crushed and pulverized. 100g of quantities were weighed using a Moettler P161 electric balance and the samples were placed in pre- weighed extraction thimbles.

The thimbles and samples were transferred to an array of transparent Soxhlet placed on an electrothermal heating system and extracted exhaustively for periods of 24 hours using 300ml each of Dichloromethane.

The extract (S.O.M) was subsequently separated from the Organic Solvent by evaporation. The Soluble Organic Matter (S.O.M) was transferred from the round bottom flask into the clean vials using syringe and stored.

The S.O.M was then transferred to sterilized pre-weighed vials and the remaining solvent was evaporated completely. The extract was weighed with the vials and the weights of the vials were extracted to obtain the weight of Soluble Organic Matter. The S.O.M content was computed relative to the initial weight of pulverized samples and expressed as parts per million.

2.2.2 Grain size Analysis

The aim of this analysis is to determine the distribution of sands in the sample collected on the field. The sand distribution enables us to determine

i. The environment of deposition of the samples

ii. The concentration of particles in the samples

iii. Determination of the different particle sizes in the samples

The materials used for this analysis include the Electric Sieve Shaker, Sets of Sieves with diameters,6.7mm, 2.36mm, 1.18mm, 850um,425um,300um,150um, 75um, Electric Weighing Machine, Brush.

The pulverized sample was weighed (500g), washed, dried, and poured into the topmost sieves in a set of sieves of known mesh sizes, the sieves are arranged in downward decreasing mesh diameter and mechanically vibrated for fifteen minutes, the weight of sediment retained in each sieve was measured, converted into percentage of the total sediment samples, weight percentage and cumulative percentage and were calculated for further statistical treatment.

Precaution Taken

i. the samples used were well pulverized
ii. The pulverized samples were dried samples.
iii. the samples were well shaken by the shaker for the duration of 15minutes
iv. Sample retained in each sieve was measured accurately without inclusion of impurities.

2.2.2.1 Statistical Measure of Grain Size Distribution

Folk and Ward, (1957) introduced the graphic method to estimate the various statistical parameters describing the grain size distribution using only percentile taken from cumulative frequency curve.

From the cumulative frequency curve, we can deduce the following.

Median (md) = $\phi 50$

Mean (m) = $\frac{\phi 16 + \phi 50 + \phi 84}{3}$ Friedman (1962, 1979)

Standard Deviation (σ)= $\frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$ Friedman (1962, 1979)

Skewness (Sk) = $\frac{(\phi84 + \phi16 - 2\phi50)}{2(\phi84 - \phi10)} + \frac{(\phi95 + \phi5 - 2\phi50)}{2(\phi95 - \phi5)}$ Friedman (1962, 1979)

Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44\,(\phi75 - \phi25)}$ Friedman (1962, 1979)

2.2.2.2 Values of Statistical Parameters Used for Interpretation

Median (MD)

Median of the distribution is read from cumulative curve, and it is the centre of particle size of the particle distribution. It is represented by the 50th percentile.

Mean (M)

It is the average size of the distribution. It represents the general grain size of the distribution. Graphically, it is calculated from the formula given in the previous page.

Significance:

- -1 to +1 represent a Coarse grain clast size
- 1 to 2 represent a medium grain sand size
- 2 to 4 represent a Fine grain sand size

The mean value is an indicator of the current energy, hence, a paleocurrent indicator, it could also indicate paleoscope.

Standard Deviation (σ)

This is the average spread of the curve. It is the measure of sorting. The units of sorting are phi units.

- When the **σ** is less than 0.350, the sand is very well sorted, and this is typical of beach and shallow marine shelves environment.
- Between 0.35 and 0.5, the sand is well sorted
- Between 0.5 and 0.81, it is moderately well sorted
- Between 0.81 and 1.4, it is moderately sorted
- Between 1.4 and 2.0, it is poorly sorted typical of fluvial environment
- Between 2.0 and 2.65, it is very poorly sorted
- Greater than 2.65, it is extremely poorly sorted

Sorting is a function of source and current energy at the depositional environment. It can also indicate the direction of current, density differential and rate of deposition.

Skewness

It is the measure of degree of symmetry of the curve and the direction of the tail. Normal distribution is zero skewed. Positive skewness makes excess of the fines while negative skewness makes excess of the coarse.

Kurtosis

This is the measure of degree of peakedness or flattening of a distribution usually taken relative to normal distribution. A distribution having relatively high peak is called Leptokurtic. A distribution which is flat topped is called Platykurtic. A distribution which is not very peaked or very flat topped like the normal is known as Mesokurtic. One measure of kurtosis that was the fourth moment of the mean is expressed in dimensionless form

CHAPTER THREE

3.0 DATA PRESENTATION AND INTERPRETATION

3.1 DATA PRESENTATION

3.1.1 Field Mapping and Description

LOCATION ONE

The outcrop is a road cut at Ahoko-Ebira along Lokoja-Abuja highway; it is made up of thirteen (13) beds. The outcrop is generally dipping in the direction of 140^0E (Fig. 2).

Bed 1 is carbonaceous grey shale which can be used to study the petroliferous attribute of the rock. The bed is 80cm thick overlain

Bed 2: This is bioturbated shale, also grey in colour, it is 10cm thick and it is fossiliferous (Bivalva) which depicts its condition of deposition.

Bed 3: this is grey shale, massive, fissile and it is 3m thick.

Bed 4: This bed is pinkish in colour and a fine-grained rock of siltstone. It is 46cm thick interbedded with grey shale. It is massive.

Bed 5: Grey shale, indurated, as it depicts the absence of water because of facies changes from the overlying bed due to low porosity and permeability. It is resistant to erosion compared to the other beds. It is 20cm thick

Bed 6: Another bed of grey shale, fissile and not as indurated as that of bed5 separated by an erosional surface from the underlying bed.

Bed 7: Ferruginised siltstone, reddish brown in colour and it is 123cm. it is fine-grained and gritty.

Bed 8: This bed is black, and the presence of hydrocarbon is suspected by the smell of the rock and the fact that it makes brown, oily stain on other materials. It is a dark shale bed which is

240cm thick, it is fissile, and it is terminated in the eastern direction forming a ledge and it is terminated at the top by an iron concretion. The concretion noodles separate this bed with the overlying bed 4 (Fig. 3). This bed is also associated with various joints (Fig. 4) cutting across the trend of the bed.

Bed 9: This is a bed of Mudstone, it is 80cm thick and creamy in colour, it is a massive bed but affected by a thrust fault cutting across the trend of this bed and bed 3. There is presence of normal fault with a throw of about 10cm (Fig. 5)

Bed 10: It is 126cm thick, siltstone belt, pinkish in colour and fine-grained

Bed 11: This is 170cm thick, yellowish in colour. It is mudstone composed of clay-size particles but lack stratified structure typical of shale.

Bed 12: This bed is 188cm thick, it is a highly bioturbated siltstone. It is highly concreted with ironstone. Highly ferruginised

Bed 13: It is ferruginised, made of mudstone of clay-size particles. It is 160cm thick.

Fig. 2: Outcrop of Ahoko-Ebira (location 1) showing the dipping direction

Fig. 3: Concretion nodules encountered at Location 1 (Ahoko-Ebira)

Fig. 4: Outcrop of Ahoko-Ebira, showing different joints.

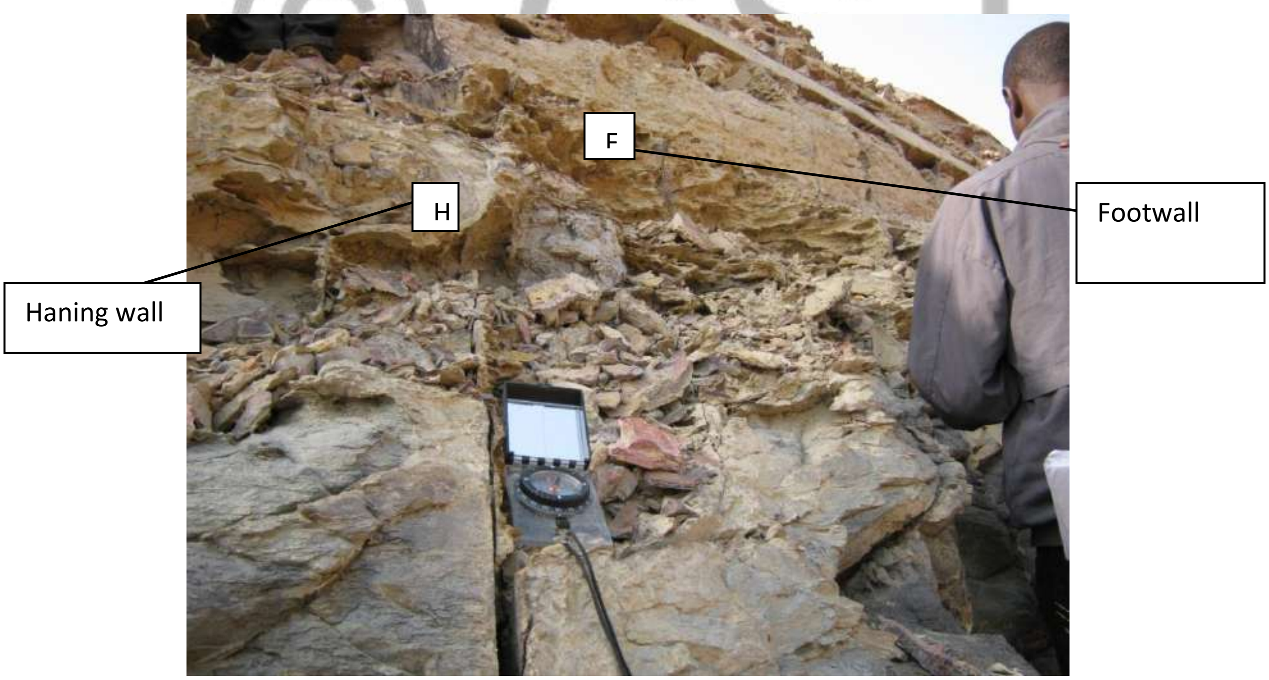

Fig. 5: Normal fault at location 1 (AhokoEbira)

LOCATION TWO

This is located at Idu Bridge along Lokoja-Abuja highway, the outcrop is a massive, structureless exposure, composed majorly of shale interbedded with siltstone. It is made up of six (6) different beds.

Bed 1: Grey shale bed, thinning out to the dipping direction. It is 35cm thick.

Bed 2: Siltstone bed, pinkish in colour and it is 115cm thick. It is massive and the clasts are fine-grained, about 0.002mm in diameter. It is separated from the overlying bed by two distinct erosional surfaces of about 0.2cm

Bed 3: This is 227cm in thickness and it is grey shale which is believed to have contained organic matter. It thins out at both directions, concentrated at the middle.

Bed 4: Siltstone bed, pinkish in colour and 117thick

Bed 5: Grey shale interbedded with siltstone, it is 110cm thick and massive.

Bed 6: Siltstone bed, it is indurated and about 20cm in thickness.

LOCATION THREE

It is about 1.5km from the main Abaji town at Abuja. The outcrop consists predominantly of Sandstone with different structures that mark the depositional environment. This exposure is made up of 10 beds capped by a lateritic layer, consisting of Iron which is believed to be of Lokoja formation.

BED 1: It is whitish sandy clay bed, and forms the basal bed.It is sticky when wet and this reflects its clayey content. It is 50cm thick

BED 2: It is 70cm thick; ferruginised sandstone coarsening upwards with pebbles imbedded in the sandstone. It is relatively gritty which differentiates it from the basal bed

BED 3: Floodplain deposition of kaolinic clay forming an over bank deposit within the sandstone, it varies in thickness, thinning towards the Toe. It is massive with no structure. It is 70cm thick,

BED 4: Sandstone bed forming a gutter cast over the softer clay because of overburden pressure exerted on the clay by the sandstone bed. This bed is 98cm thick. The clayey portion is very fissile.

BED 5: This is an argillaceous sandstone bed with lenses of clay as result of overbank deposition. There is a presence of fading hummocky structure (Fig. 7) within the bed, which is an indication of tidal deposition. The bed is about 3.3m thick.

BED 6: It is 68cm thick; this is a sandstone bed containing sub-rounded and sub-angular pebbles of quartz and granites. It is a channel deposit or infill.

BED 7: Coarse sand, fining upwards, forms a cross-bedding structure with BED 8 because of channel switching. It is 1.42m thick.

BED 8: This bed is dipping towards the Toe which marks the direction of movement of the channel. Epsilom cross-bedding is present which depicts channel switching. It is 1.38m thick.

BED 9: This is a sandstone bed which is 20cm thick. There is presence of parallel lamination structure (Fig. 6)

BED 10: Ferruginised sandstone, 20cm thick and possesses parallel bedding concretion of ferruginised capping, having a sharp contact with the wedge of the epsilom stratification. It has an erosional surface which indicates a fluvial depositional environment.

Fig 6: Parallel lamination observed on Abaji section (Location 3)

Fig 7: Hummocky structure observed in location 3 (Abaji)

3.1.2 Laboratory Analyses

Laboratory analyses include Extraction of Soluble Organic Matter from the Shale rock for location 1 and location 2, Grain-size analysis for location 3. The laboratory analysis is done to corroborate the field mapping exercise.

3.1.2.1 Soluble Organic Matter (S.O.M) Extraction

The Shale (100.88g for Ebira-Ahoho and 109.5g for Idu) was Soxhlet extracted with 300ml of Dichloromethane for 24hrs. Two Soxhlet extractions were carried out to afford total yield of shale bitumen (Soluble Organic Matter).

3.1.2.2 Grain Size Analysis

Grain size analysis is done to confirm the grading of the bed and infer mode of deposition. Data below show the result from the grain size analysis.

Table 1: Data obtained from sieve analysis of Location 3, bed 1

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	0	0	100	0	0
1.18	-0.239	0	0	100	0	0
0.85	0.234	0.67	0.13	99.87	0.34	0.34
0.425	1.234	12.33	2.47	97.4	6.25	6.59
0.3	1.737	38.67	7.73	89.67	19.59	26.18
0.15	2.737	118	23.6	66.07	59.8	85.98
0.075	3.737	27.67	5.53	60.53	14.02	100
Base pan		302.67				

Table 2: Data obtained from sieve analysis of Location 3, bed 2

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	10	2	98	2	2
1.18	-0.239	11	2.2	95.8	4.22	6.22
0.85	0.234	11.67	2.33	93.47	4.48	10.7
0.425	1.234	130.33	26.07	67.4	50	60.7
0.3	1.737	67	13.4	54	25.7	86.4
0.15	2.737	28.33	5.67	48.33	10.87	97.27
0.075	3.737	2.33	0.47	47.87	0.9	98.16
Base pan		239.33				

Table 3: Data obtained from sieve analysis of Location 3, bed 3

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	2.33	0.47	99.53	0.47	0.47
1.18	-0.239	9	1.8	97.73	3.29	3.76
0.85	0.234	20.67	4.13	83.6	7.55	11.31
0.425	1.234	144.33	28.87	64.73	52.74	64.05
0.3	1.737	63	12.6	52.13	23.02	87.07
0.15	2.737	26	5.2	46.93	9.5	96.57
0.075	3.737	8.33	1.67	45.27	3.05	99.61
Base pan		226.33				

Table 4: Data obtained from sieve analysis of Location 3, bed 4

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
6.7	-2.740	5	1	99	1.42	1.42
3.35	-1.740	19.33	3.87	95.13	5.47	6.89
2	-1.000	18.67	3.73	91.4	5.28	12.17
1.18	-0.239	32.67	6.53	84.47	9.25	21.42
0.85	0.230	27.33	5.47	79.4	7.74	29.15
0.425	1.230	88.67	17.73	61.67	25.09	54.25
0.3	1.740	55	11	50.67	15.57	69.81
0.15	2.740	77.67	15.53	35.13	21.98	91.79
0.075	3.74	29	5.8	29.33	8.21	100
Base pan		171				

Table 5: Data obtained from sieve analysis of Location 3, bed 5

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
3.35	-1.737	7	1.4	98.6	2.14	2.14
2	-1.000	9.33	1.87	96.73	2.86	5
1.18	-0.239	24.33	4.87	91.87	7.45	12.45
0.85	0.234	23	4.6	87.27	7.04	19.49
0.425	1.234	75	15	72.27	22.96	42.45
0.3	1.737	56.67	11.33	60.93	17.35	59.8
0.15	2.737	90.33	18.07	42.87	27.65	87.45

0.075	3.737	41	8.2	34.67	12.55	100
base pan		180.33				

Table 6: Data obtained from sieve analysis of Location 3, bed 6

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	0	0	100	0	0
1.18	-0.239	0	0	100	0	0
0.85	0.234	2	0.4	99.6	1.77	1.77
0.425	1.234	7	1.4	98.2	6.19	7.96
0.3	1.737	5	1	97.2	4.42	12.39
0.15	2.737	24	4.8	92.4	21.24	33.63
0.075	3.737	75	15	77.4	66.37	100
Base pan		387				

Table 7: Data obtained from sieve analysis of Location 3, bed 7

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
6.7	-2.737	5	1	99	2	2
3.35	-1.737	18.33	3.67	95.33	7.32	9.32
2	-1.000	15	3	92.33	5.99	15.31
1.18	-0.239	28	5.6	86.73	11.19	26.5
0.85	0.234	35	7	79.73	13.98	40.48
0.425	1.234	86	17.2	62.53	34.35	74.83
0.3	1.737	29.33	5.87	56.67	11.72	86.55
0.15	2.737	30.33	6.07	50.6	12.12	98.67
0.075	3.737	3.33	0.67	49.93	1.33	100
Base pan		273				

Table 8: Data obtained from sieve analysis of Location 3, bed 8

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	7.33	1.47	98.53	2.48	2.48
1.18	-0.239	17.33	3.47	95.07	5.86	8.33
0.85	0.234	49.33	9.87	85.2	16.67	25
0.425	1.234	145.67	29.13	56.07	49.21	74.21
0.3	1.737	46	9.2	46.87	15.54	89.75
0.15	2.737	27.33	5.47	41.4	9.23	98.99
0.075	3.737	3	0.6	40.8	1.01	100
Base pan		204				

Table 9: Data obtained from sieve analysis of Location 3, bed 9

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	-1.000	7	1.4	98.6	4.09	4.09
1.18	-0.239	9	1.8	96.8	5.26	9.36
0.85	0.234	7.5	1.5	95.3	4.39	13.74
0.425	1.234	19	3.8	91.5	11.11	24.85
0.3	1.737	16.5	3.3	88.2	9.65	34.5
0.15	2.737	96	19.2	69	56.14	90.64
0.075	3.737	16	3.2	65.8	9.36	100
Base pan		329				

Table 10: Data obtained from sieve analysis of Location 3, bed 10

Particle size (mm)	Particle size (phi)	Mass Retained (g)	Percent Retained (%)	Percent Passing (%)	Recalculated Percent Retained (%)	Recalculated Cumulative Mass Retained (%)
2	**-1.000**	**2.67**	**0.53**	**99.47**	**0.6**	**0.6**
1.18	**-0.239**	**7.67**	**1.53**	**97.93**	**1.73**	**2.33**
0.85	**0.234**	**16**	**3.2**	**94.73**	**3.61**	**5.94**
0.425	**1.234**	**110**	**22**	**72.73**	**24.79**	**30.73**
0.3	**1.737**	**153.67**	**30.73**	**42**	**34.64**	**65.36**
0.15	**2.737**	**144.33**	**28.87**	**13.13**	**32.53**	**97.9**
0.075	**3.737**	**9.33**	**1.87**	**11.27**	**2.1**	**100**
Base pan		**56.33**				

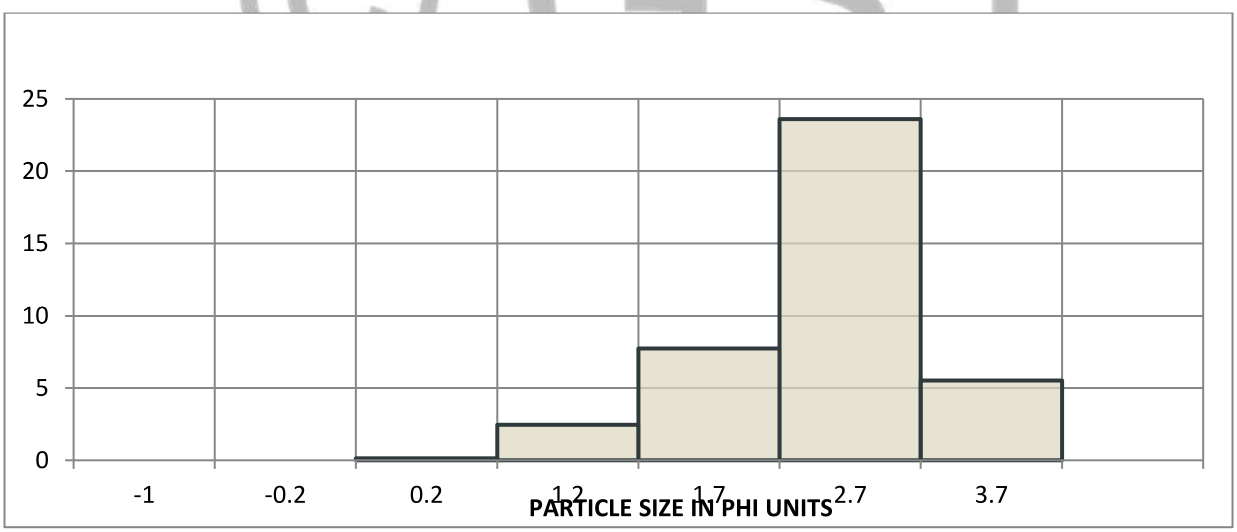

Plate 1: Histogram graph deduced from grain size analysis of Location 3, bed 1

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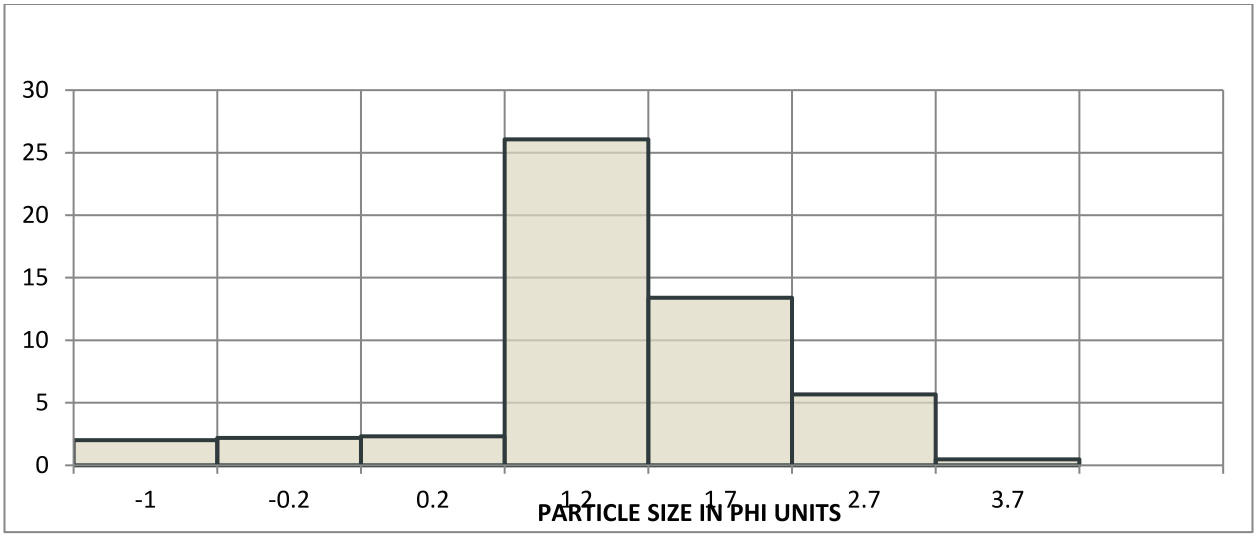

Plate 2: Histogram graph deduced from grain size analysis of Location 3, bed 2

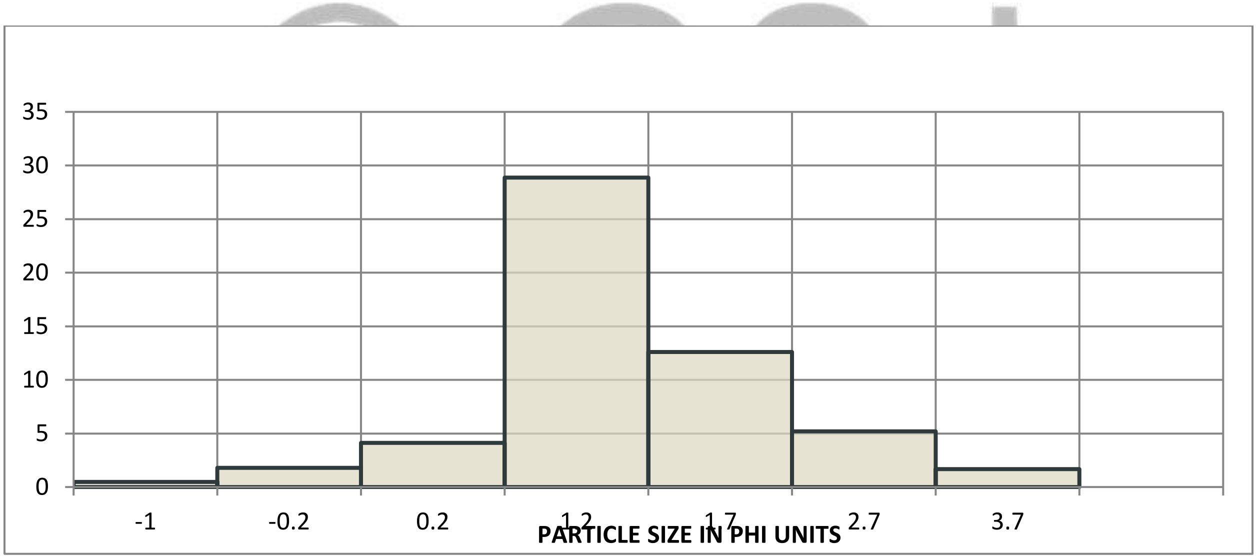

Plate 3: Histogram graph deduced from grain size analysis of Location 3, bed 3

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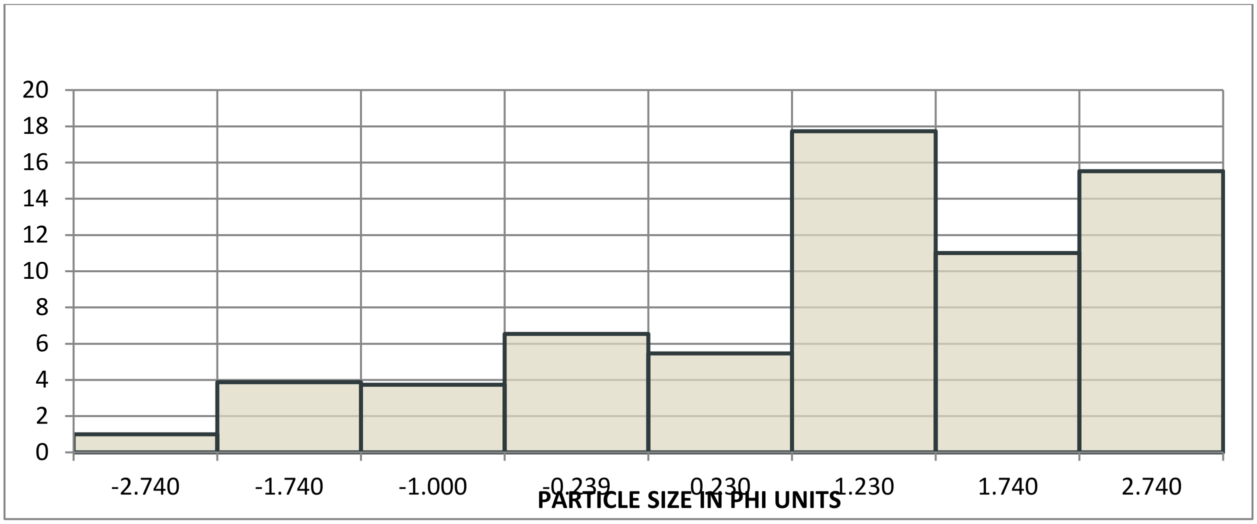

Plate 4: Histogram graph deduced from grain size analysis of Location 3, bed 4

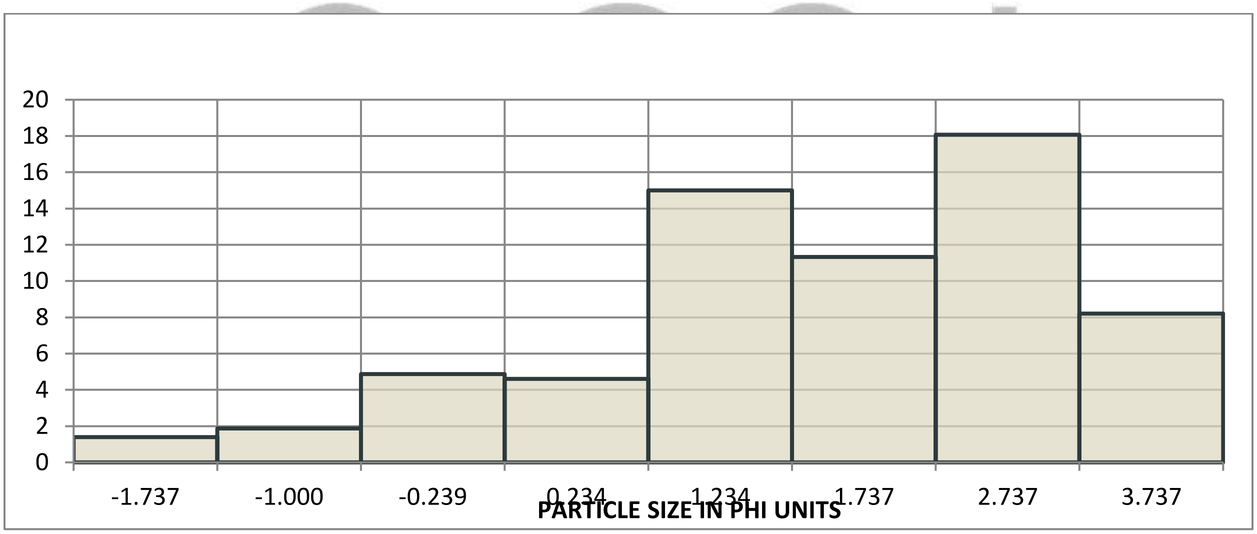

Plate 5: Histogram graph deduced from grain size analysis of Location 3, bed 5

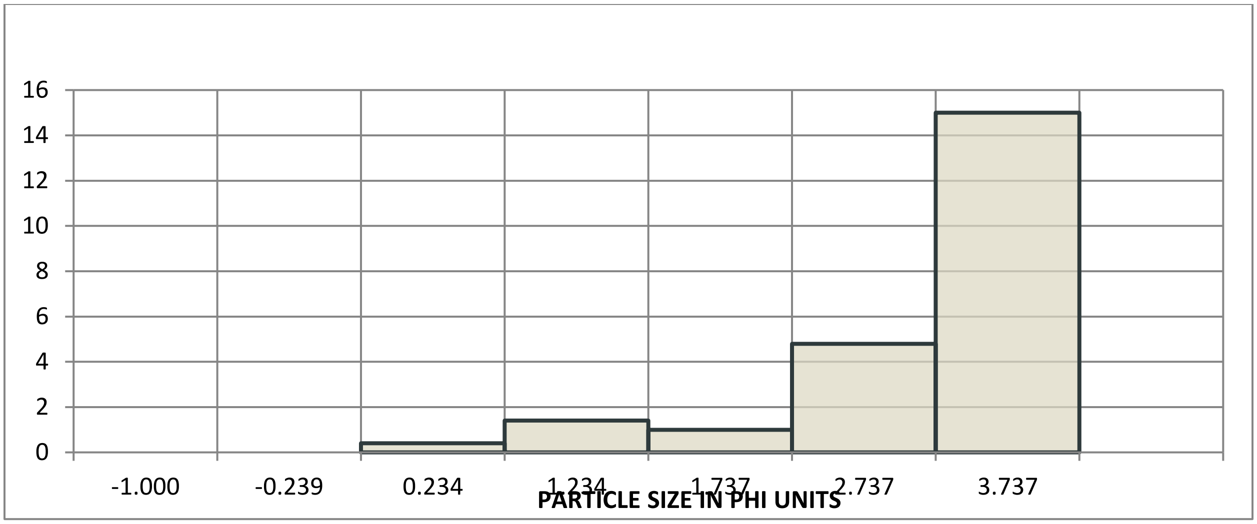

Plate 6: Histogram graph deduced from grain size analysis of Location 3, bed 6

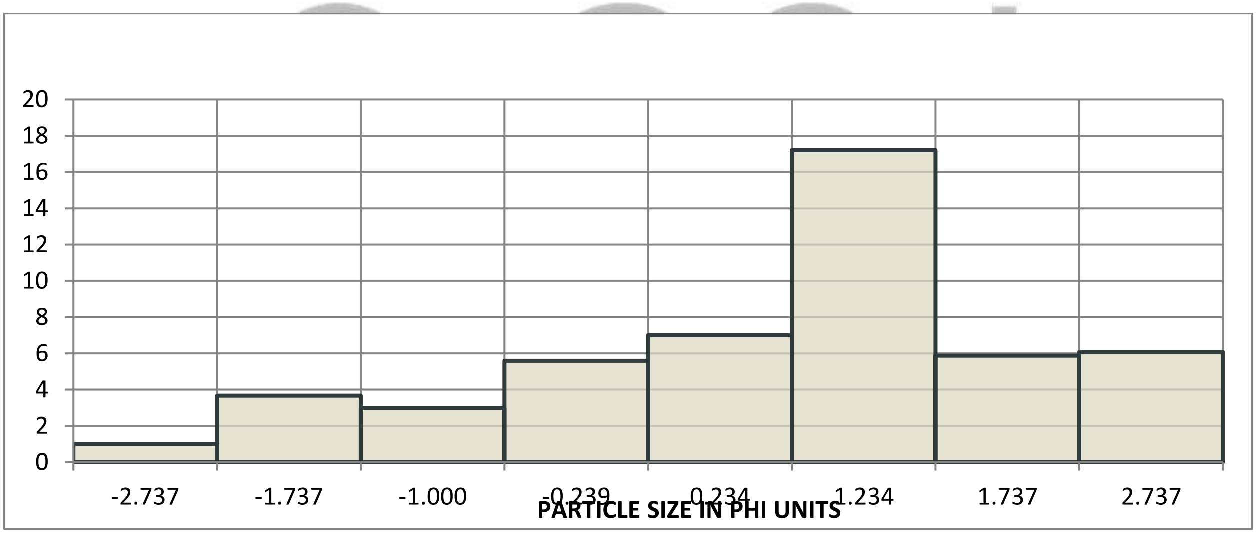

Plate 7: Histogram graph deduced from grain size analysis of Location 3, bed 7

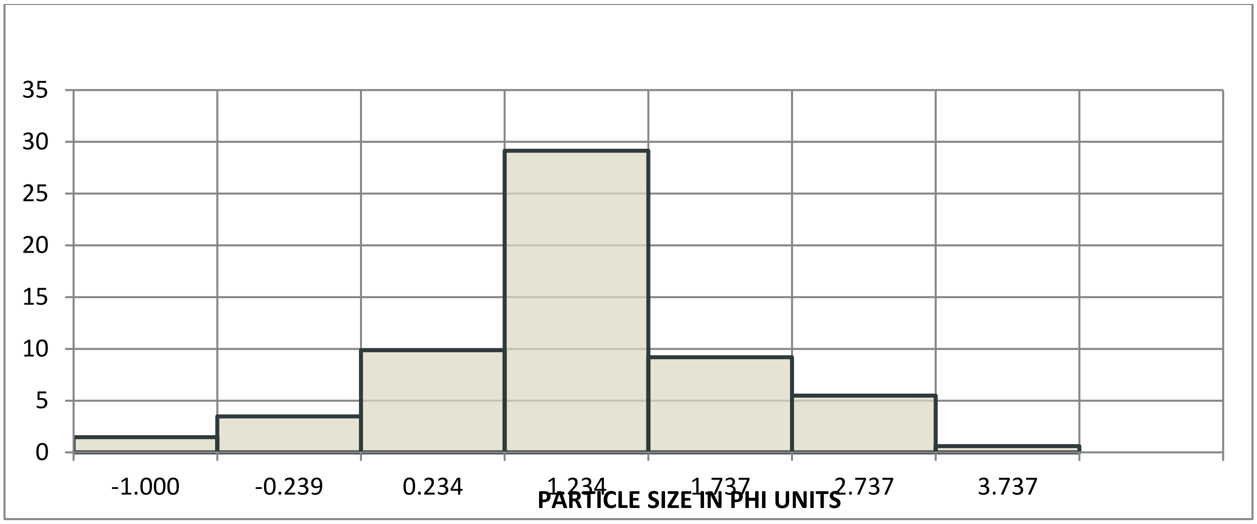

Plate 8: Histogram graph deduced from grain size analysis of Location 3, bed 8

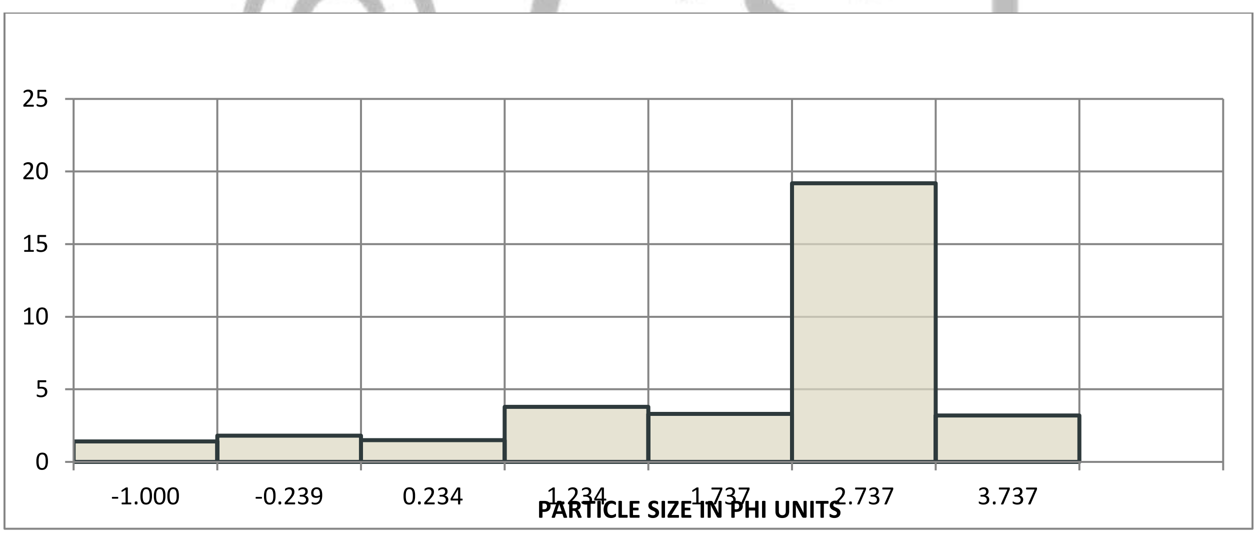

Plate 9: Histogram graph deduced from grain size analysis of Location 3, bed 9

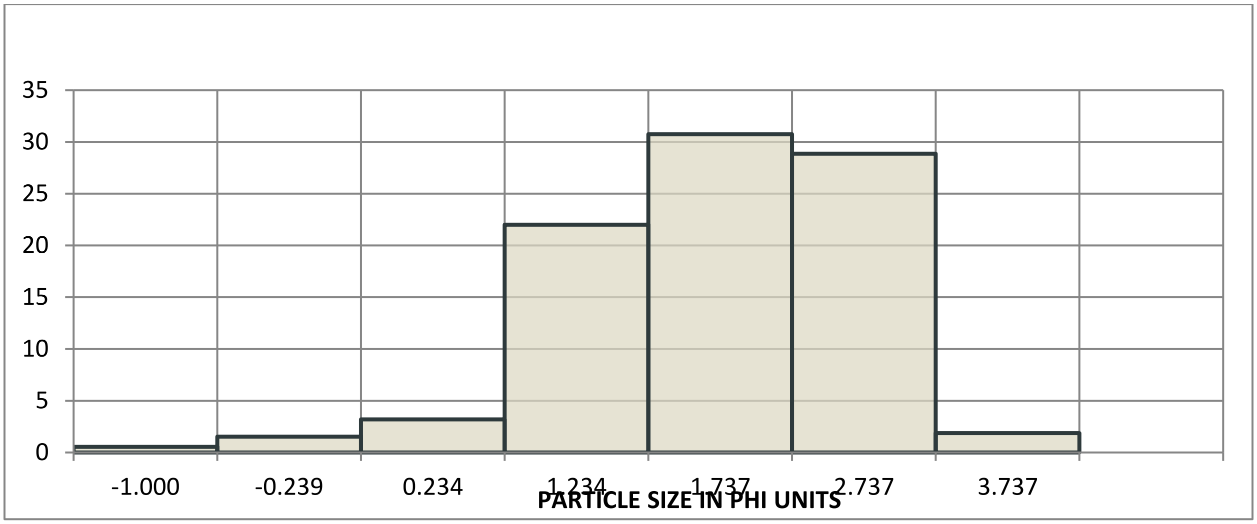

Plate 10: Histogram graph deduced from grain size analysis of Location 3, bed 10

3.2 Data Interpretation

3.2.1 Interpretation of Soxhlet extracted S.O.M

Soluble Organic Matter for Ahoko-Ebira Shale

Initial weight of Shale (g) = 100.88

Weight of oven dried Shale after extraction (g) = 99.0

Weight of S.O.M (g) = 100.88-99.0 = 1.88

Weight of S.O.M extracted with Dichloromethane = 0.8ml

Weight of Solvent (Dichloromethane) = 300ml

Percent weight of S.O.M = 0.8/300 * 100 = 0.27%

Soluble Organic Matter for Idu Shale

Initial weight of Shale = 109.5g

Weight of oven-dried Shale after extraction = 105.8g

Weight of S.O.M = 109.5 – 105.8 = 3.7g

Weight of S.O.M extracted with Dichloromethane = 1.8ml

Weight of Solvent (Dichloromethane) = 300ml

Percent weight of S.O.M = 1.8/300 * 100 = 0.60%

Table 11: Soluble Organic Matter concentration in the Organic Shale

Location	S.O.M (ml)	S.O.M (wt. %)
Ahoko- Ebira	0.8	0.27
Idu Bridge	1.8	0.6
Average	1.3	0.44

3.2.2 Interpretation of Grain size Analysis

3.2.2.1 Deduction from the Histogram plot

Table 12: Deductions made from the histogram plots

Sample code	Interpretation	Source
Location 3, bed 1	Formed from one parent material. The mode occurs at the particle size of 2.7**ϕ**. The histogram has extent from maximum to minimum size of 3.74ϕ to -1.00ϕ, it's shows that it is coarsing upward	Unimodal
Location 3, bed 2	Sediments are derived from one source. The mode occurs at a particle size of 1.23ϕ	Unimodal
Location 3, bed 3	It is derived from one parent material. The mode occurs at the particle size of 1.23ϕ as bed 2, but it is finer when compared to bed 2 because it has higher amount of mass of grains retained than bed 2	Unimodal
Location 3, bed 4	Sediments derived from more than one source because it has	Bimodal

	two peaks. The mode occurs at particle size of 1.23ϕ. The histrogram has extent from -2.74ϕ to 3.74ϕ	
Location 3, bed 5	The sediments are formed from more than one parent material. It has three peaks. The mode occurs at the particle size of 2.74ϕ with a percentage retained of 27.65%.	Polymodal
Location 3, bed 6	Formed from one parent material. The mode occurs at particle size of 3.74ϕ	Unimodal
Location 3, bed 7	It is formed from more than one parent material. The mode occurs at the particle size of 1.23ϕ	Bimodal
Location 3, bed 8	Sediments are derived from one source. It has one peak. Mode is 1.23ϕ	Unimodal
Location 3, bed 9	The sediments are formed from more than one. The	Polymodal

	mode occurs at particle size of 2.74ϕ	
Location 3, bed 10	It is formed from one parent material because it has one peak. The mode occurs at particle size of 1.74ϕ	Unimodal

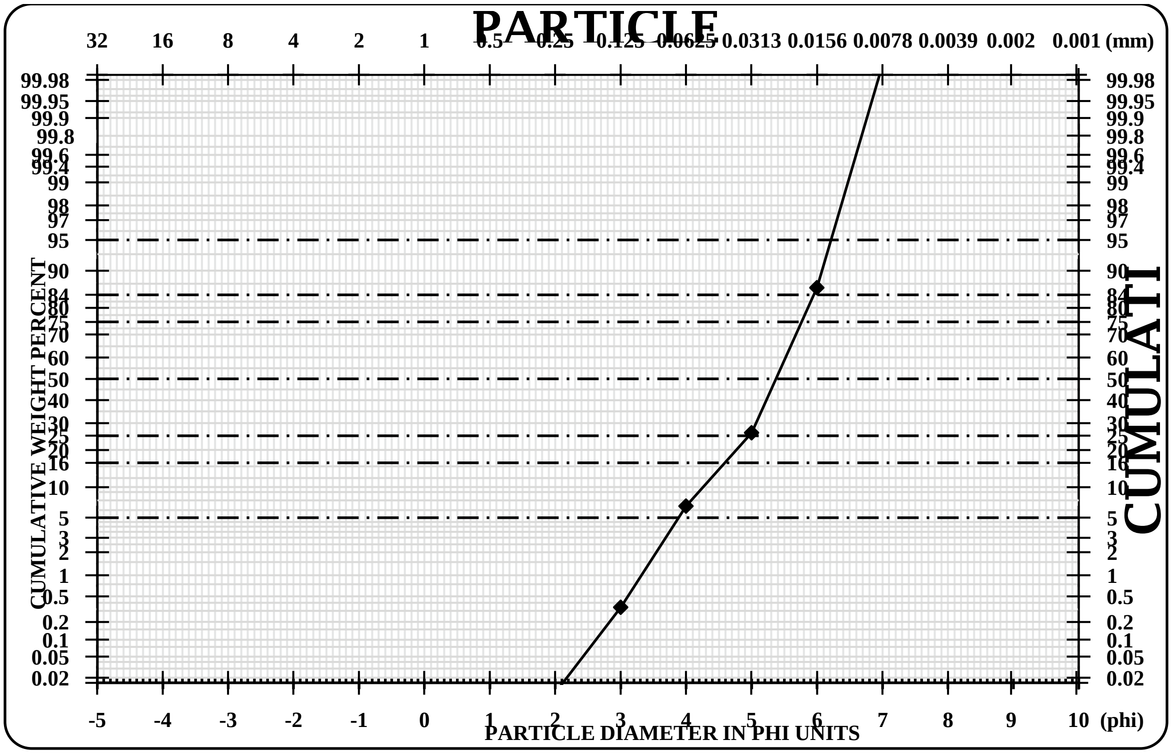

Plate 11: Cumulative frequency curve of grain size analysis for Location 3, bed 1

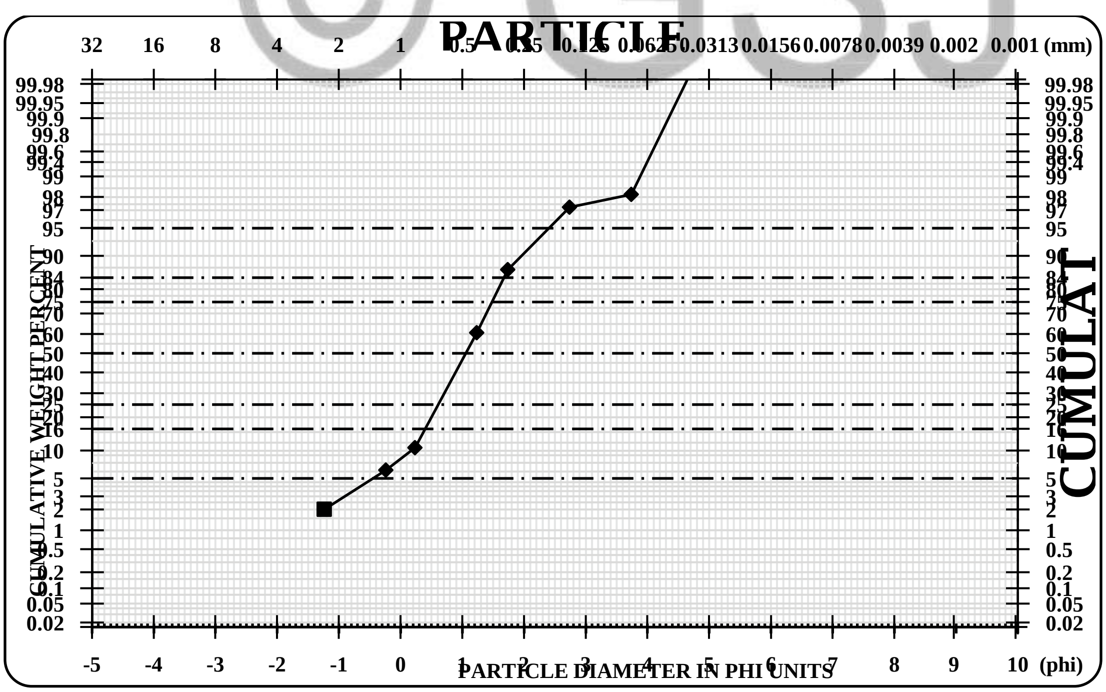

Plate 12: Cumulative frequency curve of grain size analysis for Location 3, bed 2

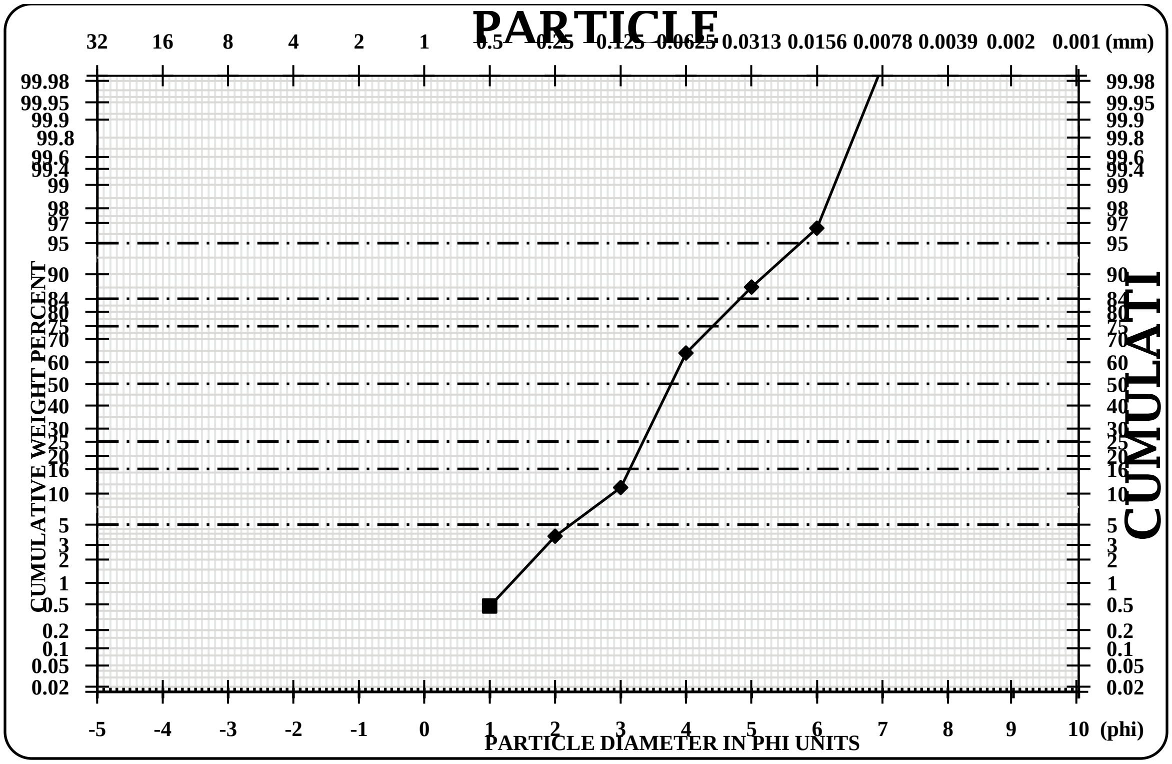

Plate 13: Cumulative frequency curve of grain size analysis for Location 3, bed 3

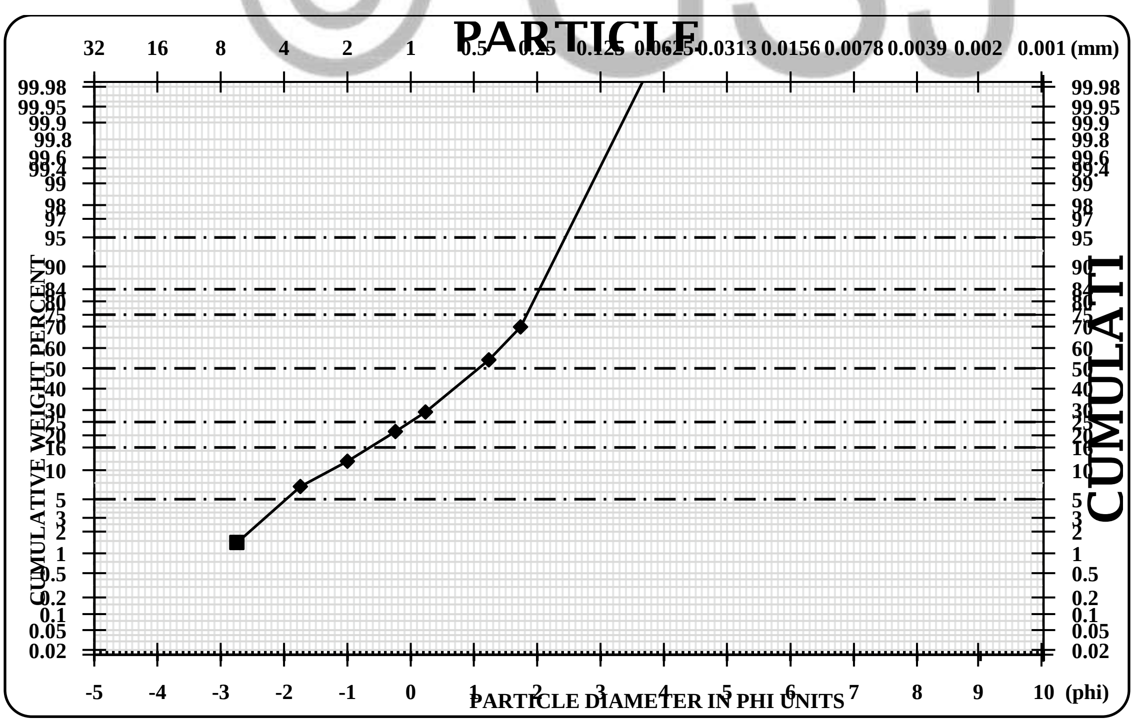

Plate 14: Cumulative frequency curve of grain size analysis for Location 3, bed 4

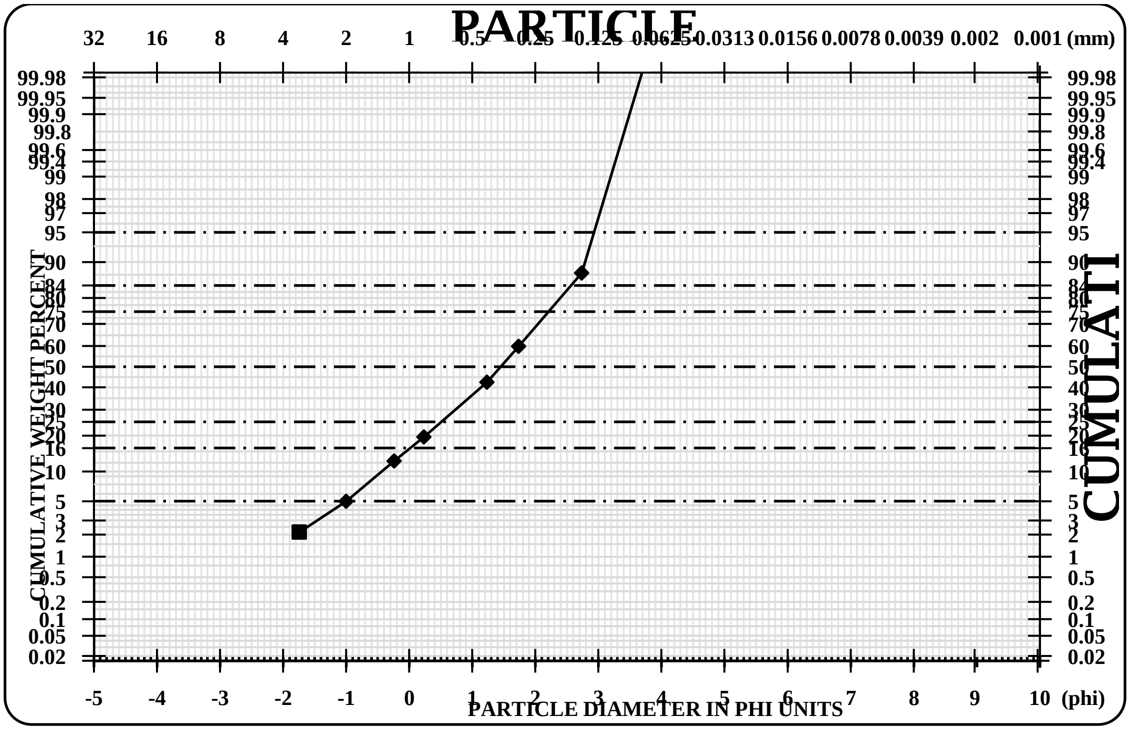

Plate 15: Cumulative frequency curve of grain size analysis for Location 3, bed 5

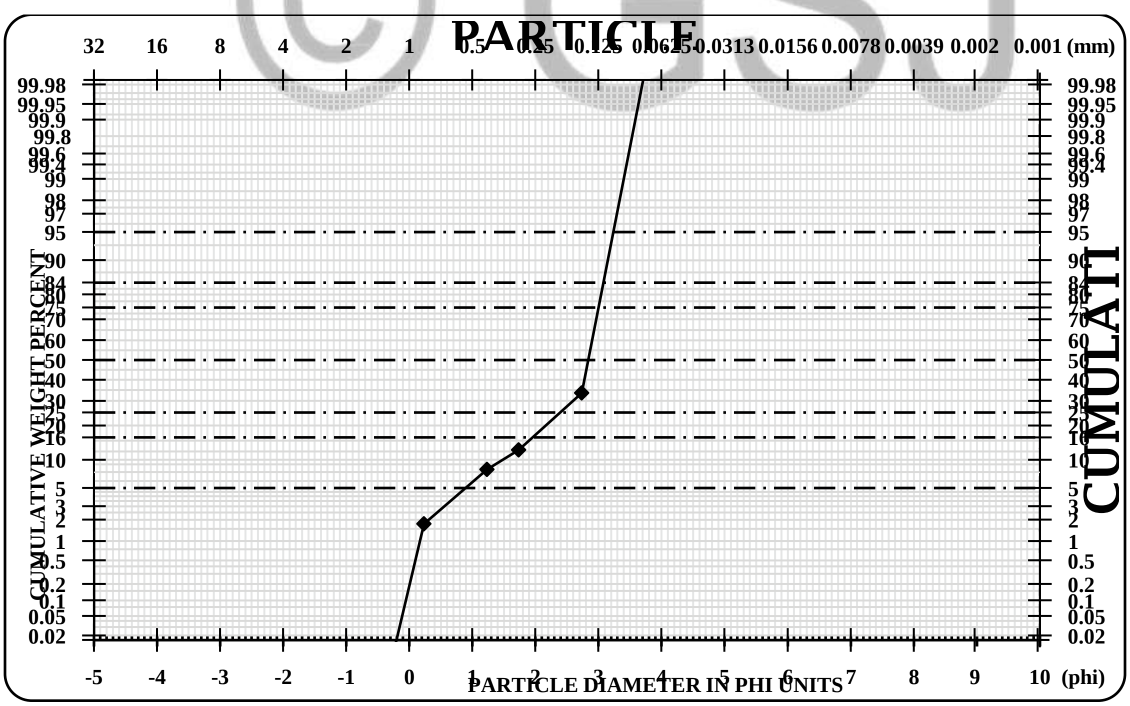

Plate 16: Cumulative frequency curve of grain size analysis for Location 3, bed 6

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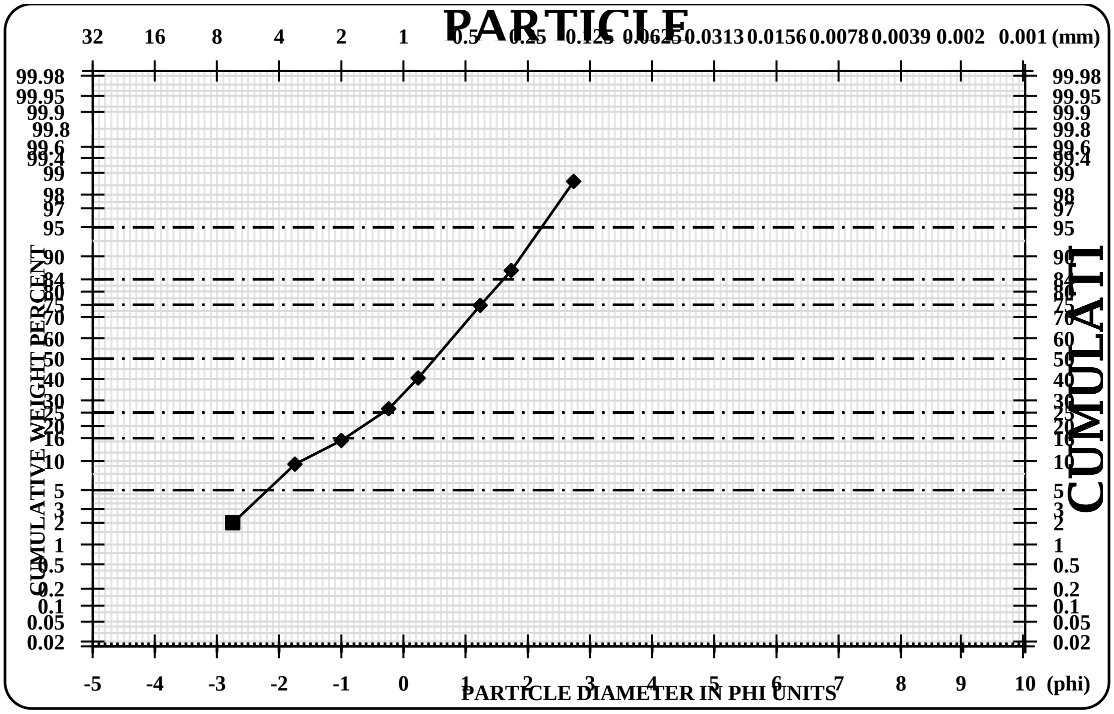


Plate 17: Cumulative frequency curve of grain size analysis for Location 3, bed 7

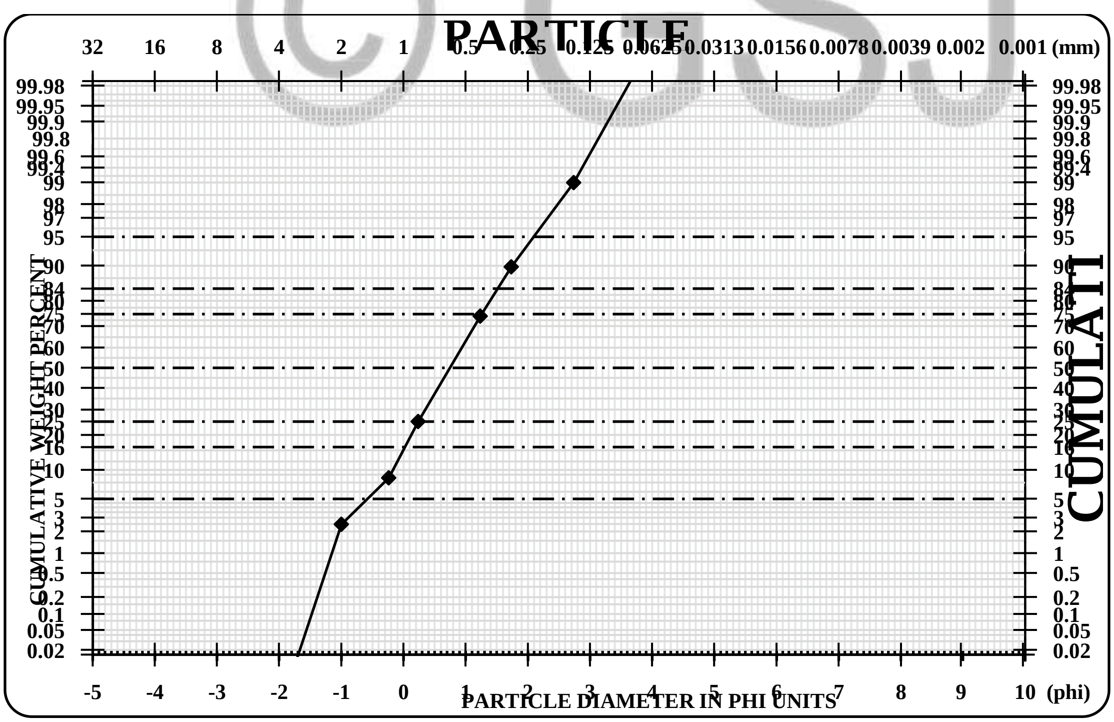


Plate 18: Cumulative frequency curve of grain size analysis for Location 3, bed 8

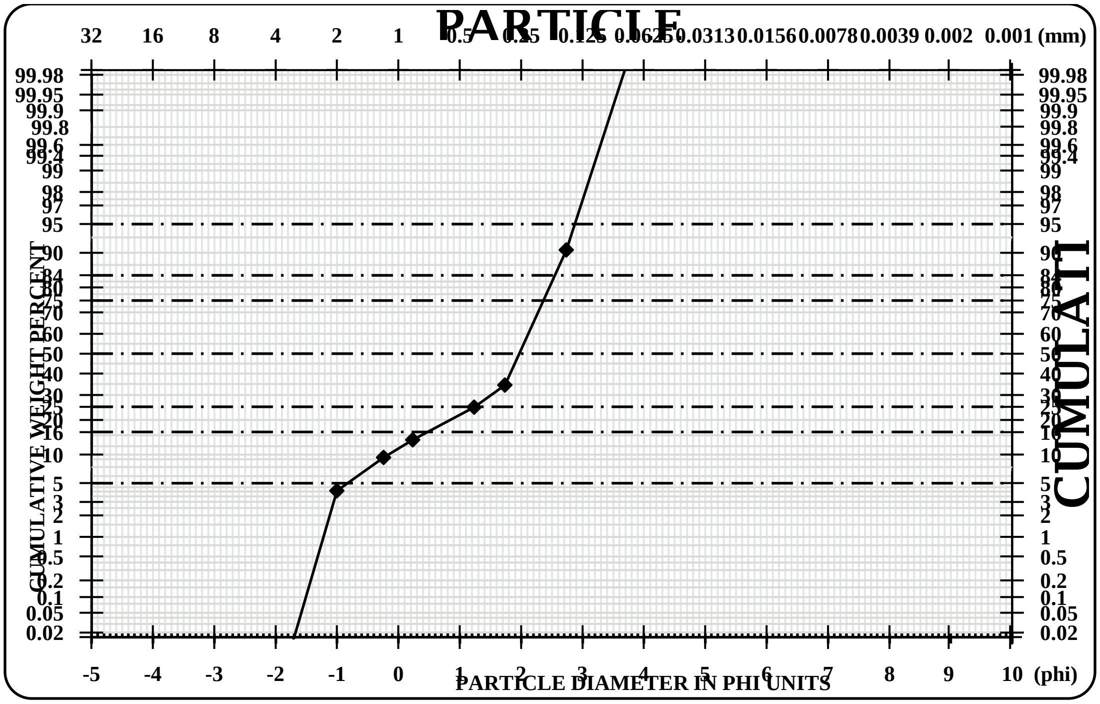


Plate 19: Cumulative frequency curve of grain size analysis for Location 3, bed 9

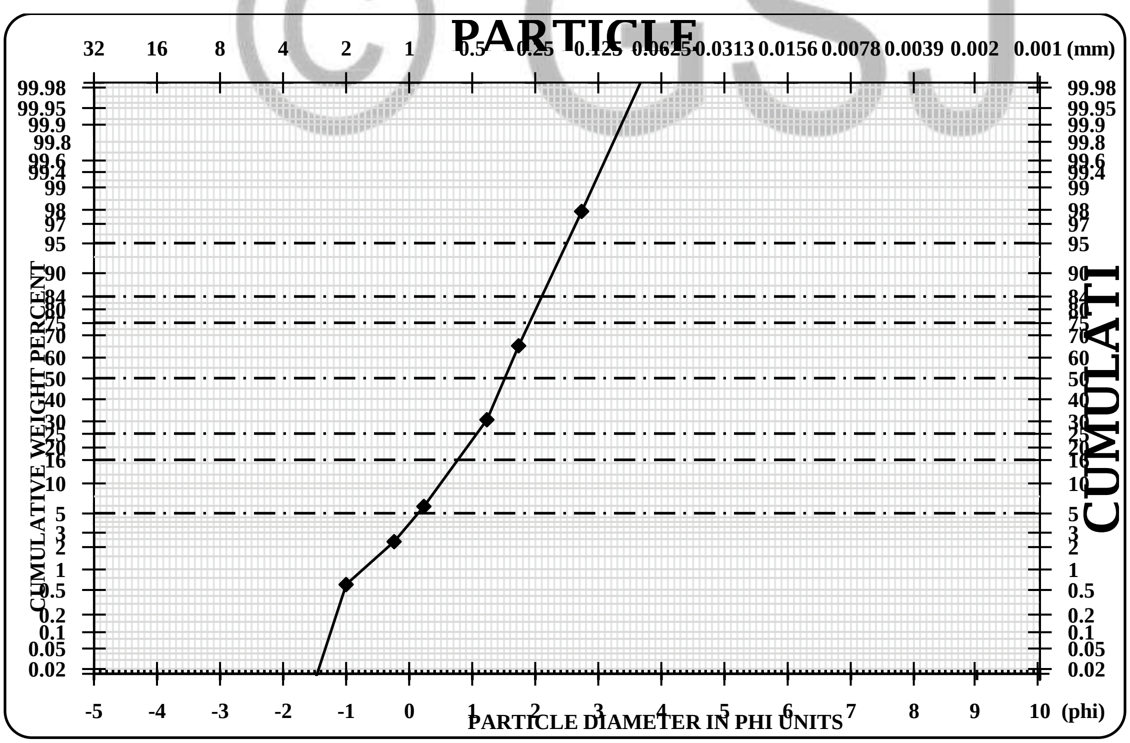


Plate 20: Cumulative frequency curve of grain size analysis for Location 3, bed 10

3.2.2.2 Deduction from Cumulative Frequency Curve

The significant values in 25^{th}& 75^{th} segments represent central portion of distribution, 15^{th}& 85^{th}percentile also represent point of inflexion, and 5th & 95th percentiles represent very coarse to coarse and very fine to fine distribution.

Calculation from Cumulative Frequency curve

Result for Location 3, bed 1, from the cumulative frequency curve;

95^{th} percentile = 3.00

84^{th} percentile = 2.28

75^{th} percentile = 2.60

50^{th} percentile = 2.20

25^{th} percentile = 1.80

16^{th} percentile = 1.60

5^{th} percentile = 1.10

1) Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{1.60 + 2.20 + 2.8}{3} = \mathbf{\underline{2.20}}$

2) Standard Deviation = $\frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{2.8 - 1.60}{4} + \frac{3.0 - 1.10}{6.6}$

$= 0.30 + 0.29 = \mathbf{\underline{0.59}}$

3) Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

$= \frac{2.8 + 1.60 - 2(2.20)}{2(2.8 - 1.60)} + \frac{3.0 + 1.10 - 2(2.20)}{2(3.0 - 1.10)} = \mathbf{\underline{-0.08}}$

4) Kurtosis (K) = $\frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)} = \frac{3.0 - 1.10}{2.44(2.60 - 1.80)} = \underline{\mathbf{0.97}}$

Result for Location 3,bed 2 from cumulative frequency curve

$\phi 95 = 2.50$

$\phi 84 = 1.90$

$\phi 75 = 1.70$

$\phi 50 = 1.10$

$\phi 25 = 0.80$

$\phi 16 = 0.50$

$\phi 5 = -0.30$

- Mean (m) = $\frac{\phi 16 + \phi 50 + \phi 84}{3} = \frac{0.5 + 1.10 + 1.90}{3} = \underline{\mathbf{1.17}}$

- Standard Deviation = $\frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6} = \frac{1.9 - 0.50}{4} + \frac{2.5 - (-0.3)}{6.6}$

  $= 0.35 + 0.42 = \underline{\mathbf{0.77}}$

- Skewness (SK) = $\frac{\phi 84 + \phi 16 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$

  $= \frac{1.90 + 0.5 - 2(1.10)}{2(1.90 - 0.5)} + \frac{2.5 + (-0.3) - 2(1.10)}{2(2.5 - (-0.3))} = \underline{\mathbf{0.07}}$

- Kurtosis (K) = $\frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)} = \frac{2.5 - (-0.3)}{2.44(1.7 - 0.8)} = \underline{\mathbf{2.8}}$

Result for Location 3, bed 4 from cumulative frequency curve

ϕ95 = 2.90

ϕ84 = 2.40

ϕ75 = 2.00

ϕ50 = 1.20

ϕ25 = 0.00

ϕ16 = -0.30

ϕ5 = -1.90

- Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{-0.3 + 1.2 + 2.4}{3} = \mathbf{\underline{1.10}}$

- Standard Deviation = $\frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{2.4 - (-0.3)}{4} + \frac{2.90 - (-1.90)}{6.6}$

  $= 0.68 + 0.73 = \mathbf{\underline{1.41}}$

- Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

  $= \frac{2.4 + (-0.3 - 2(1.20)}{2(2.40 - (-0.3)} + \frac{2.6 + (-0.9) - 2(1.2)}{2(2.9 - (-0.9))} = \mathbf{\underline{-0.21}}$

- Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.90 - (-1.9)}{2.44(2.0 - 0.0)} = \mathbf{\underline{0.98}}$

Result for Location 3, bed 5 from cumulative frequency curve

ϕ95 = 2.90

ϕ84 = 2.60

$\phi75 = 2.20$

$\phi50 = 1.40$

$\phi25 = 0.50$

$\phi16 = 0.00$

$\phi5 = -1.00$

- Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{0.0 + 1.40 + 2.60}{3} = \mathbf{1.33}$

- Standard Deviation = $\frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{2.60 - 0.00}{4} + \frac{2.9 - (-1.0)}{6.6}$

  $= 0.65 + 0.59 = \mathbf{1.24}$

- Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

  $= \frac{2.60 + 0.0 - 2(1.40)}{2(2.60 - 0.0)} + \frac{2.9 + (-1.0) - 2(1.40)}{2(2.9 - (-1.0))} = \mathbf{-0.15}$

- Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.9 - (-1.0)}{2.44(2.20 - 0.5)} = \mathbf{0.94}$

Result for Location 3, bed 6 from cumulative frequency curve

$\phi95 = 3.20$

$\phi84 = 3.10$

$\phi75 = 3.00$

$\phi50 = 2.80$

$\phi25 = 2.50$

ϕ16 = 2.00

ϕ5 = 1.00

- Mean (m) = $\frac{\phi 16 + \phi 50 + \phi 84}{3} = \frac{2.0 + 2.80 + 3.10}{3} = \mathbf{\underline{2.63}}$

- Standard Deviation = $\frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6} = \frac{3.10 - 2.00}{4} + \frac{3.20 - (-1.0)}{6.6}$

  $= 0.28 + 0.33 = \mathbf{\underline{0.61}}$

- Skewness (SK) = $\frac{\phi 84 + \phi 16 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$

  $= \frac{3.10 + 2.0 - 2(2.8)}{2(3.10 - 2.0)} + \frac{3.20 + 1.00 - 2(2.80)}{2(3.2 - 1.0)} = \mathbf{\underline{-0.55}}$

- Kurtosis (K) = $\frac{\phi 95 - \phi 5}{2.44(\phi 75 - \phi 25)} = \frac{3.2 - 1.0}{2.44(3.0 - 2.5)} = \mathbf{\underline{1.80}}$

Result for Location 3, bed 7 from cumulative frequency curve

ϕ95 = 2.30

ϕ84 = 1.70

ϕ75 = 1.30

ϕ50 = 1.60

ϕ25 = -0.20

ϕ16 = -1.10

ϕ5 = -2.10

- Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{-1.10 + 0.6 + 1.70}{3} =$ **0.40**

- Standard Deviation = $\frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{1.70 - (-1.1)}{4} + \frac{2.3 - (-2.10)}{6.6}$

  $= 0.70 + 0.67 =$ **1.37**

- Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

  $= \frac{1.70 + (-1.1) - 2(0.60)}{2(1.70 - (-1.1)} + \frac{2.3 + (-2.1) - 2(0.6)}{2(2.3 - (-2.1))} =$ **-0.22**

- Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.3 - (-2.1)}{2.44(1.3 - (-0.2)} =$ **1.20**

Result for Location 3, bed 8 from cumulative frequency curve

$\phi95 = 2.20$

$\phi84 = 1.60$

$\phi75 = 1.30$

$\phi50 = 0.8$

$\phi25 = 0.30$

$\phi16 = 0.10$

$\phi5 = -0.50$

- Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{0.1 + 0.8 + 1.60}{3} =$ **0.83**

- Standard Deviation $= \frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{1.6 - 0.10}{4} + \frac{2.2 - (-0.5)}{6.6}$

$= 0.38 + 0.41 =$ **0.78**

- Skewness (SK) $= \frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

$= \frac{1.60 + 0.1 - 2(0.8)}{2(1.60 - 0.1)} + \frac{2.2 + (-0.5) - 2(0.8)}{2(2.2 - (-0.5))} =$ **0.05**

- Kurtosis (K) $= \frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.2 - (-0.5)}{2.44(1.3 - 0.3)} =$ **1.11**

Result for Location 3, bed 9 from cumulative frequency curve

ϕ95 = 2.80

ϕ84 = 2.60

ϕ75 = 2.40

ϕ50 = 2.0

ϕ25 = 1.3

ϕ16 = 0.50

ϕ5 = -0.80

- Mean (m) $= \frac{\phi16 + \phi50 + \phi84}{3} = \frac{0.5 + 2.0 + 2.6}{3} =$ **1.70**

- Standard Deviation $= \frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{2.6 - 0.50}{4} + \frac{2.8 - (-0.8)}{6.6}$

$=$ **1.07**

- Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

$$= \frac{2.60 + 0.5 - 2(2)}{2(2.60 - 0.5)} + \frac{2.8 + (-0.8) - 2(2)}{2(2.8 - (-0.8))} = \mathbf{-0.49}$$

- Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.8 - (-0.8)}{2.44(2.4 - 1.3)} = \mathbf{1.34}$

Result for Location 3, bed 10 from cumulative frequency curve

$\phi95 = 2.60$

$\phi84 = 2.30$

$\phi75 = 2.10$

$\phi50 = 1.60$

$\phi25 = 1.20$

$\phi16 = 0.80$

$\phi5 = 0.20$

- Mean (m) = $\frac{\phi16 + \phi50 + \phi84}{3} = \frac{0.8 + 1.60 + 2.3}{3} = \mathbf{1.57}$

- Standard Deviation = $\frac{\phi84 - \phi16}{4} + \frac{\phi95 - \phi5}{6.6} = \frac{2.3 - 0.80}{4} + \frac{2.6 - 0.2}{6.6}$

$$= 0.38 + 0.36 = \mathbf{0.74}$$

- Skewness (SK) = $\frac{\phi84 + \phi16 - 2(\phi50)}{2(\phi84 - \phi16)} + \frac{\phi95 + \phi5 - 2(\phi50)}{2(\phi95 - \phi5)}$

$$= \frac{1.90 + 0.5 - 2(1.10)}{2(1.90 - 0.5)} + \frac{2.5 + (-0.3) - 2(1.10)}{2(2.5 - (-0.3))} = \mathbf{0.07}$$

- Kurtosis (K) = $\frac{\phi95 - \phi5}{2.44(\phi75 - \phi25)} = \frac{2.6 - 0.2}{2.44(2.1 - 1.2)} = \mathbf{1.09}$

Table 14: Deductions from the cumulative frequency curve of the sieve analysis

Sample Code	ϕ5	ϕ16	ϕ25	ϕ50	ϕ75	ϕ84	ϕ95
BED 1	1.1	1.6	1.8	2.2	2.6	2.8	3
BED 2	-3	0.5	0.8	1.1	1.7	1.9	2.5
BED 3	-0.1	0.4	0.7	1	1.5	1.8	2.6
BED 4	-1.9	-0.3	0	1.2	2	2.4	2.9
BED 5	-1	0	0.5	1.4	2.2	2.6	2.9
BED 6	1	2	2.5	2.8	3	3.1	3.2
BED 7	-2.1	-1.1	-0.2	0.6	1.3	1.7	2.3
BED 8	-0.5	0.1	0.3	0.8	1.3	1.6	2.2
BED 9	0.2	0.8	1.2	1.6	2.1	2.3	2.6
BED 10	-2.2	-1.5	-1.1	0.3	1	1.3	2

Table 15: Deduction from the statistical analysis

SAMPLE CODE	MEAN (MZ)	STANDARD DEVIATION (σ)	SKEWNESS (SK)	KURTOSIS (K)
BED 1	2.2	0.59	-0.08	0.97
BED 2	1.17	0.77	0.07	2.80
BED 3	1.07	0.76	0.16	1.38
BED 4	1.1	1.4	-0.2	0.98
BED 5	1.33	1.24	-0.15	0.94
BED 6	2.63	0.61	-0.55	1.84
BED 7	0.4	1.37	-0.22	1.20
BED 8	0.83	0.78	0.05	1.11
BED 9	1.7	1.07	-0.49	1.34
BED 10	1.57	0.74	-0.12	1.09

Table 16: Average distribution and interpretation

Samples Codes	Graphic mean	Standard Deviation (σ)	Skewness	Kurtosis
Bed 1	Mean is 2.2, therefore it is a fine grained sand	The standard deviation is 0.59; therefore it is moderately well sorted.	-0.08 is the skewness, so it is near symmetry	0.97 Mesokurtic
Bed 2	1.17 Medium grained	0.77 Moderately well sorted	0.07 Near symmetry	2.8 Leptokurtic
Bed 3	1.07 Medium grained	0.76 Moderately well sorted	0.16 Finely skewed	1.38 Leptokurtic
Bed 4	1.10 Medium grained	1.40 Moderately sorted	-0.20 Coarse skewed	0.98 Mesokurtic
Bed 5	1.33 Medium grained	1.24 Moderately sorted	-0.15 Coarse skewed	0.94 Mesokurtic
Bed 6	2.63 Fine grained	0.61 Moderately well sorted	-0.55 Very coarse skewed	1.80 Leptokurtic
Bed 7	0.40 Coarse grained	1.37 Moderately sorted	-0.22 Coarse skewed	1.20 Leptokurtic
Bed 8	0.83 Coarse grained	0.78 Moderately well sorted	-0.05 Near symmetry	1.11 Leptokurtic
Bed 9	1.07 Medium grained	1.07 Moderately sorted	-0.49 Very coarse skewed	1.34 Leptokurtic
Bed 10	1.57 Medium grained	0.74 Moderately well sorted	-0.12 Coarse skewed	1.09 Mesokurtic
AVERAGE	**1.4 Medium grained sand**	**0.93 Moderately sorted**	**-0.16 Coarse skewed**	**1.06 Mesokurtic**

CHAPTER FOUR

4.0 DISCUSSION AND CONCLUSION

4.1 DISCUSSION

In the mapping exercise, the lithologies encountered were sandstone beds, claystones, siltstone, mudstone, and carbonaceous shale. The sandstone beds were characterized by various sedimentary structures that give a clue about the depositional environment. Diagnosed sedimentary structures such as parallel lamination, hummocky, herringbone, trough festoon, wave ripples and epsilom crossbedding, are indication of sediment deposition in intertidal environment.

From the grain size analysis, the mean grain size value of the sediments depicts that it is of Medium grained sand size, with the mean size ranging from 0.40ϕ to 2.63ϕ and the total average value of 1.4ϕ. Sorting is the description of the distribution of clasts sizes present derived from the Standard Deviation of the distribution which ranges from 0.59ϕ to 1.40ϕ with the total average value of 0.93ϕ, therefore, indicating moderately sorted sand. Skewness value ranges from -0.55ϕ to 0.16 having a total average value of -0.16, which indicates coarse skewed sand, having excess of the coarse.

The value ranges from 0.94ϕ to 2.8ϕ with the total average value of 1.09ϕ, therefore the sand is Mesokurtic which depicts that the sediments are derived from different source. The histogram plot shows that some of the sediments are unimodal, which is an indication that they are derived from only one source. Bed 4 and Bed 7 are bimodal, while Bed 5 and Bed 9 are polymodal, indicating that the sediments are derived from more than one source.

The Soluble Organic Matter (S.O.M) concentration in the Organic Shale of Patti formation gives an average value of 0.44wt.%, which is an indication of low or fair organic richness in the shale rock.

4.2 CONCLUSION

Interpretation of textural parameters of the sediments derived from Abaji section give a clue about the environment of deposition.

Medium grained sand and moderately sorted sand are indication of fluvial environment. Some of the sediments are derived from different parent materials which could have been transported and deposited by fluvial system.

The Organic Shale richness with the average S.O.M value of 0.44wt. % shows that the shale has a fair organic content suitable for hydrocarbon generation.

REFERENCES

Adeleye DR, Dessauvagie TFJ (1972) Stratigraphy of the Mid-Niger Embayment near Bida, Nigeria. In: Dessauvagie TJF, Whiteman AJ (eds) Proceedings of the Conference on AfricanGeology, Ibadan University Press, Ibadan, pp 181–186

Adeleye DR (1973) Origin of ironstones: an example from the Mid-Niger Basin, Nigeria. J Sediment Petrol 43:709–727

Adeniyi JO (1985) Ground total magnetic intensity in parts of the Nupe Basin and the adjacent basement complex, Niger State, Nigeria. Niger J App Sci 3:67–78

Akande SO, Ojo OJ (2000) Organic petrology and Rock-Eval studies on source rocks faciesof theCampanian-Maastrichtian Patti Formation, Southern Bida Basin, Nigeria. NAPE Bull 16:22–38

Agyingi, C.M. (1990) Geology of the Upper Cretaceous Rocks in Eastern Bida, Central Nigeria. Geological Survey of Nigeria Bulletin. Pp7-35

Braide SP (1992b) Syntectonic fluvial sedimentation in the central Bida Basin. J Mining Geol 28:55–64

Ehinola et al (2005) Organic Geochemistry and Biomarker Evaluation of Shale units of the Maastrichtian Patti Formation, Bida Basin, Nigeria, pp 78- 84

Friedman, G.M. (1962) Sorting coefficient and the lognormality of grain size distribution of Sandstone. Jour. Geology, Vol. 70, pp. 737-753

Friedman, G.M. (1979) Differences in size distributions of population of particles among sands Of various origins. Sedimentology, Vol. 26, pp.3-32

Folk, R.L and Ward W.C. (1957): Brazos River Bar: A study in the Significance of grain size Parameters. Journal of Sedimentary Petrology, Vol 27(1). Pp 3-26

Folk, R.L., (1996): A review of grain size parameters. Sedimentology, Vol 6, pp. 73-93

Kogbe CA, Ajakaiye DE, Matheis G (1983) Confirmation of rift structure along the Mid-Niger Valley, Nigeria. J Afr Earth Sci 1:127–131

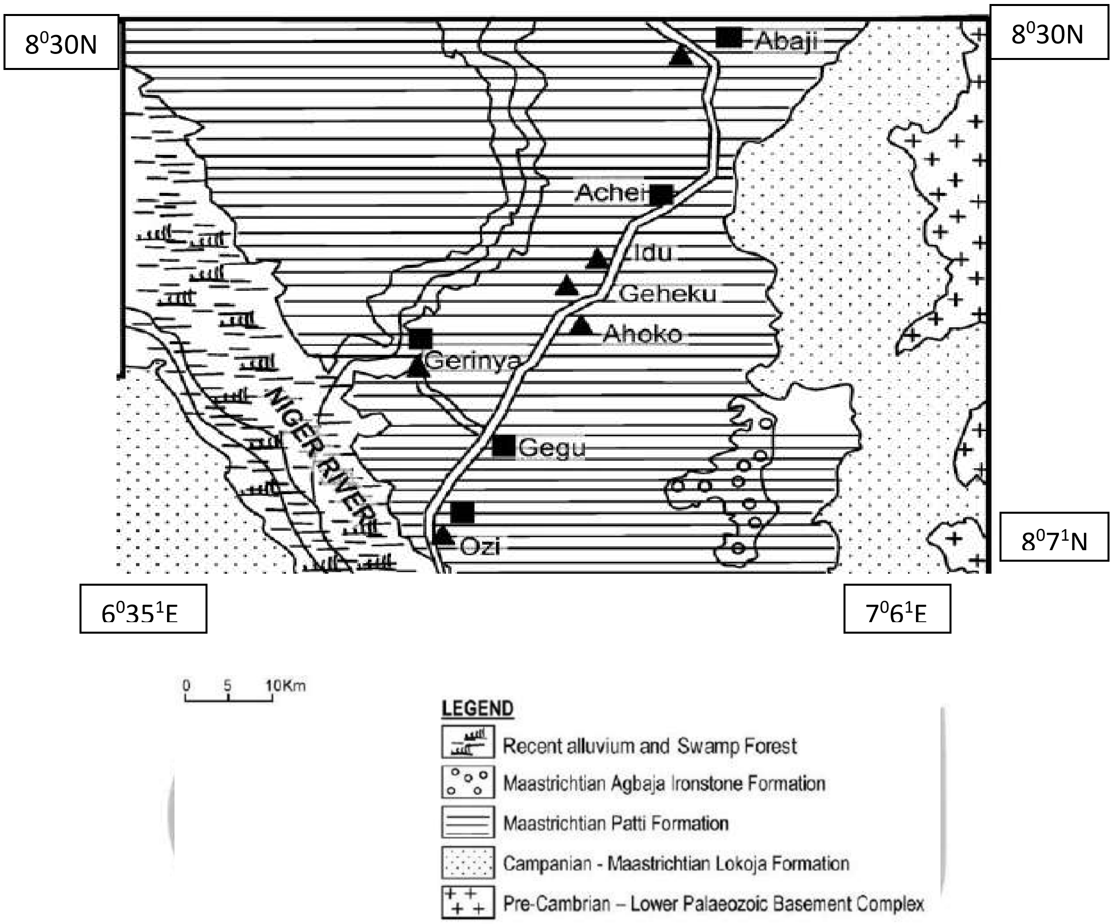
Kogbe CA (1989) Geology of Nigeria, 2nd Edition.RockviewNige Ltd, Jos, 538pp

Sneed, E.D and Folk, R.L. (1985). Pebbles In The Lower Colorado River, Texas : A Study In Particle Morphogenesis. Jour. Geol. Vol. 66, pp. 114-150

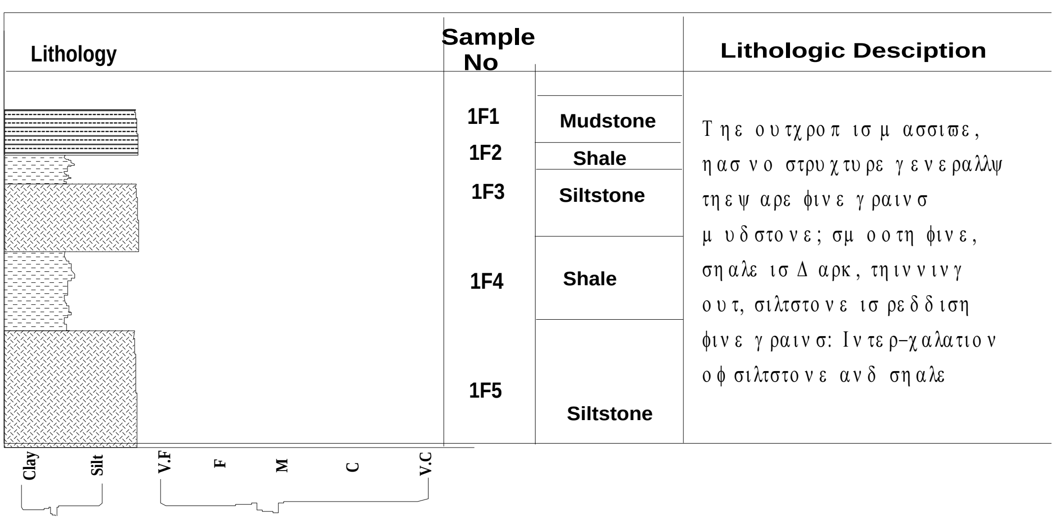
Visher, G.S (1969) Grain size distribution and deposition processes. Journal of Sedimentary Petrology, Vol. 33. Pp.1074-1106

GSJ: Volume 10, Issue 4, April 2022
ISSN 2320-9186

APPENDIX



Appendix 1: Geological map of study area showing locations of studied sections. (Agyingi 1991)



Appendix 2: Litholog for exposed rock at Idu Bridge