Depositional Processes And Paleoenvironment of The Cretaceous Bima Sandstone, At Wuyo Hina And Liji North-Eest Nigeria

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DEPOSITIONAL PROCESSES AND PALEOENVIROMENT OF THE CRETACEOUS BIMA SANDSTONE, AT WUYO,HINA AND LIJI. NORTH-EAST NIGERIA

BY

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A THESIS SUBMITTED TO THE GEOLOGY PROGRAMME, SCHOOL OF SCIENCE, ABUBAKAR TAFAWA BALEWA UNIVERSITY, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BARCHELOR DEGREE OF TECHNOLOGY (B-TECH)HONOURS IN APPLIED GEOLOGY.

APRIL 2009.

CERTIFICATION

This project entitled THE DEPOSITIONAL PROCESSES AND ALEOENVIROMENT OF THE CRETACEOUS BIMA ANDSTONE,UPPER BENUE TROUGH N-E NIGERIA. Meets the egulation governing the award of Bachelor of Technology Degree (B. 'ech) in Applied Geology of Abubakar Tafawa Balewa University Bauchi.

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External Examiner

DECLARATION

I hereby declare that this thesis was written by me. It is a record of my own research; it has not been presented in any previous application for a degree etc; to the best of my knowledge.

Sign:.. Date: 08/05/09

ABDULLAHI AHMED ISA

Sign:.. Date: 08/05/09

MAL. AHMADU TUKUR
RESEARCH SUPERVISOR

DEDICATION

I dedicated this project research to my beloved father late Alkali Ahmad Isa,and my mother Hajiya Fatima Magaji Isa,and my caring Uncle Alh Gambo Magaji con,(FNMGS).

ACKNOWLEDGEMENT

I must express my awesome thanks to Almighty ALLAH for his mercy and kindness, strength, wisdom and favour to undertake this project.

I must express my gratitude to my parents for their understanding and support toward my course of study, may Almighty ALLAH (Subhanahu wata'ala) bless them abundantly.

My sincere gratitude also goes to my supervisor Mallam Ahmadu Tukur, for the tireless support he has put in to this project and for the advice and guidance he has given to me. My sincere thanks goes to all members of staff Geology programme like Professor E.F.C Dike, Professor D.M Orazulike, my co'odinator Mallam A.S Maigari, Mr D.A Bassi, Dr M.B Abubakar, Mal M.T Isa, Dr N.K Samaila, Mr Timothy Bata and Mr A.I Haruna.

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ABSTRACT

The Bima Sandstone is the oldest cretaceous sedimentary sequence in the upper Benue Trough, which uncomformably overlies the basement rock. A sequence of three sub division has been recognized as: Lower (B1), Middle(B2) and Upper (B3).

Field studies and laboratory analysis were conducted to determine the lithology and depositional processes and paleoenviroment of the Bima sandstone. Based on lithology and sedimentary structures, four lithofacies were identified these are: Trough cross beddings, Planar beddings, Tabular planar cross beddings and Massive beddings.

The reference were made to other well studied lithostratigraphic locations by several workers who have brought a lot of emphasis on various fields of significant that may aid in arriving at logical conclusion. The logical conclusions are based on the fact that the Bima sand stone was deposited in continental environment and at high flow velocity. The Bima sand stone are said to be poorly sorted in general and the internal structures are believed to be extensively Trough cross bedded Facies.

CHAPTER ONE: INTRODUCTION

1.0 HISTORICAL BACKGROUNG OF SEDIMENTOLOGY

The sedimentology was first defined by Wandell, 1932 as the study of sediment, which has later been defined as anything settles at the bottom of a liquid dreg deposition. Similarly, the sedimentology is generally clear to embrace chemical precipitates like salt, as well as detrital deposit. The sedimentation take place in a fluid such as wind the abundant of sedimentation are thus pleasantly diffuse. It is difficult to discover the historical evolution of sedimentology. In fact among the first scholars must have been the stone age flint miners of nolfolk who as seen crime cave mined the stratified chart band to make flint artifacts shuttoms (1968). However, from the reference to the industrial revolution the foundation of modern sedimentology geology were laid by the Hutton, smith, and Leonardo Da Vinci. By the end of 19th century the law of uniformitarialism was established. The contribution of Lyell (1850) showed pre- ancient sedimentary textures and sedimentary structures. In 1960s the main focus of research was directed toward understanding sedimentary processes. By studying the depositional structures and bed forms of recent sediments either in laboratory or in the field which resulted the possibility to interprete accurately the environment of deposition of ancient sedimentary structures

The geologist first start to studied rocks in some details in the early eightees ago. In 1815, William smith published his" geological map of England Wales and parts of Scotland" The significant behind the map was absolutely based on the sequence of diverse rock types by which the strata had a lateral contuinity could be mapped and were characterized by different fossil assemblages.

As further process the stratigraphic paleontology become apparent that some fossils appeared to be restricted to certain geological time scale, while other were long ranging but they appeared to occur in certain rocks types of the fact were realized by provost (1838). He proposed the name formation or stratigraphic units, by using biostragraphy to established that difficult formation were formed in the some "epoch" and the similar formation could be formed in difficult epochs.

The Greasily (1538) working in the Alps reached a similar conclusion. He proposed the name facies as the as the unit of rock which characterized by similar lithological and paleontological cretaria. His definitions was translated by Teichert (1988) reads.

To start with two principal fact characterize the total sum of the modification which

i) Facies or aspect of stratigraphic units

ii) A certain lithological aspect of stratigraphic unit is linked with one another with the same paleontological assemblage.

iii) From each assemblage, fossil genera and common in other facies are invariably excluded.

Greessely took the word facies from word of Steno (1669) and which he was not aware of the distinction of zonal and facies fossils, he formulated a number of laws which govern a vertical and leteral transition of facies. In nineteen century it was established that the body rock could be defined and mapped with combination of paleontologic and lithologic criteria. These rock unit were called formation or facies by geologist.

Therefore, over several decades, these two terms as different meaning. "Formation" become more well defined while facies become widely used in a broad sense by several geologist. Lyell in (1665) was defined facies as expressed in geology by any assemblage of rock unit has some basic character in common weather by age origin or by composition which could be stratified, unstratified, marine fresh water, a gems and volcanic ancient and modern metalloferous and non-metalloferous formations.

1.1 AIMS AND OBJECTIVE OF THE STUDY

To determine depositional environment processes of Bima sandstone at selected sections of the formation in the Gongola arm. This will be achieve through

- **Logging of the selected samples**
- **Sieve analysis**
- **Petrographic studies**

1.2 LOCATION AND ACCESSIBILITY

The Bima sandstone was form an extensive part of the upper Benue Trough which drained by the River Benue and its major tributary is the Gongola. River which is located between latitude 8^0 45 and 10^0 45N and longitude 10^0 12 and 12^0 16E.

The research work was carried out in wuyo, Hina, and liji near Gombe inlier where the Bima has been exposed in rock outcrops and stream channel in Borno and Gombe state within the Gongola arm of the upper Benue trough of North Eastern Nigeria the study minor road (mainly footpaths).

1.3 METHOD OF STUDY

The research work was carried out in the field to examined and observed the rock exposure as well as texture sedimentary structures, thickness of the bed colour and other physical properties. A general reconnaissance of the area was done on foot stop overs were made at localities outcrops which samples of visited outcrops were collected. The equipment that make up the gear used during the exercise were a geological hammer, a compass, field notepad, sample bag, measuring etc.

Sieve analysis was carried out in the laboratory on may return to the institution of the various rock samples collected and a petrographic studies were carried out. The resul is describe in detail in chapter four.

1.4 CLIMATE AND VEGETATION:

Nigeria located in the tropics; the studies are is located within the sub-Sahara climate condition and experiences two distinctive climate seasons. The dry season starts from November and continues until March, while the wet season which last from about the end of March to October with an average of 152 days duration. There are two continental winds blowing, the moisture laden South-West wind that originated from the Atlantic Ocean blows from April to October, while the dry North-East winds that originate from Sahara desert blow from November to March. It is semis arid region with sparse vegetation of which are scattered shrubs and bushed paratially independence of the climate.

1.5 SETTLEMENT AND LAND USE

The people living around the study area are Fulani, Tera, Kanuri, other ethnic group include, Hausa, Babur and other ethnic Minorities. The Major land used is farming. Most farmers practice substance farming and produce crops such as millet, guinea corn, maize beans, groundnut etc. the cattle rearing is also common amongst the Fulani.

TWO: LITERATURE REVIEW

2.0 GENERAL GEOLOGY OF THE BENUE TROUGH

The first geological frame in the upper Benue Trough was carried out by Falconer (1911) who mapped the area on a regional scale. However, the first major work on the Benue Trough was carried out by Caerter et al (1963) who described its structural stratigraphic framework.

The Bima sandstone was first discovered by falconer (1911). He applied the name Muri sandstone to similar rock in the muri area. He discovered a cretaceous sandstone formation which he called the upper grit, and he placed those rock above the cretaceous marine sediment of the Gongola valley. The rock outcrops near rimi and Bima sandstone of Hina and wuyo which is one of this studying are also include in the division. Re-examination of the sandstones at Rimi has shown that faulting and slumping disturbed the rocks and the grits and sandstones actually underlying the marine cretaceous sediments and grouped together with the Bima sandstone.

Carter et al (1963) did the first major study of the area In which he described the structural and sedimentological framework. His work was supported by the work of popoff et al (1983) and Allix (1983) which focused on the Aptian to lower Albian sedimentary sequence of the Bima sandstone. Raeborn and Brymnor (1954) gave the Bima formation and their group name and also classified the Gombe formation in the upper sandstone group.

Guiraund (1990), the present of early cretaceous syn-sedimentary tectonic in the upper Benue and secondly described the Bima formation as being deposited in a lacustrine deltaic environment.

Falconer (1911) assigned the Bima sandstone to an Eocene division. The work of carter et al (1963) showed that the Bima sandstone at Lamurde are under Turonian marine rocks. Carter et al (1963) studies the lithology of the Bima sandstone and concluded that it was derived from a graniterrain that also recognized detail and lacustrine depositional environment. This was based on structures observed.

Allix (1963) gave described of the sequence exposed at the lamurde anticline and recognized the following division.

The described of Bima was ask given by popoff (1983). The most detailed account was given by Guiraud (1991) who fully described as follows

- Upper Bima Sandstone B_3
- Middle Buma Sandstone B_2
- Lower Bima Sandstone B_1

Also Allix (1963) referenced the three parts of Bima sandstone in the lamurde area formation 1, 2,3,.

TABLE 6; SIEVE ANALYSIS RESULT FOR SAMPLE FIVE

Mesh Size (mm)	Ph(Ø)	Weight Retained (g)	Corrected Weight (g)	Weight %	Cumulative Weight %
1.18	-1.25	0.50	0.775	0.485	0.485
0.850	0.25	0.23	0.505	0.316	0.801
0.425	1.24	30.37	30.645	19.154	19.955
0.300	1.74	33.99	34.265	21.415	41.37
0.212	2.24	28.82	29.095	18.185	59.555
0.106	3.25	36.80	37.075	23.172	82.727
0.063	3.99	21.78	22.055	13.785	96.512
Pan	-	5.31	5.585	3.410	99.922

TABLE 7; SIEVE ANALYSIS RESULT FOR SAMPLE SIX

Mesh Size (mm)	Ph(Ø)	Weight Retained (g)	Corrected Weight (g)	Weight %	Cumulative Weight %
3.35	-1.75	3.08	2.917	1.823	1.823
2.36	-1.43	1.32	1.157	0.723	2.546
1.18	-0.25	2.51	2.347	1.4668	4.0128
0.850	0.25	7.31	7.147	4.4668	8.479
0.425	1.24	48.49	48.327	30.2043	38.684
0.300	1.74	22.68	22.517	14.073	52.757
0.212	2.24	18.34	18.177	11.360	64.117
0.106	3.25	39.46	39.297	24.560	88.677
0.063	3.99	13.59	13.749	8.695	97.269
Pan	-	4.69	4.527	2.829	100.0

TABLE 8; SIEVE ANALYSIS RESULT FOR SAMPLE SEVEN

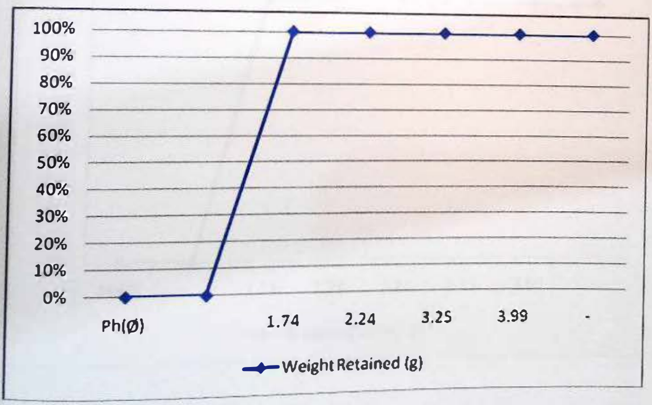
Mesh Size (mm)	Ph(Ø)	Weight Retained (g)	Corrected Weight (g)	Weight %	Cumulative Weight %
2.36	-1.43	10.34	10.692	6.6825	6.6825
1.18	-0.25	56.70	57.052	35.6575	42.34
0.850	0.25	29.80	30.152	18.845	61.185
0.425	1.24	39.27	39.622	24.7638	85.949
0.300	1.74	7.47	7.822	4.889	90.4908
0.212	2.24	4.19	4.542	2.8388	93.3296
0.063	3.99	1.36	1.712	1.07	99.3259
Pan	-	0.18	0.532	1.60	100.09

TABLE 9; SIEVE ANALYSIS RESULT FOR SAMPLE EIGHT

Mesh Size (mm)	Ph(Ø)	Weight Retained (g)	Corrected Weight (g)	Weight %	Cumulative Weight %
0.850	0.25	1.89	11.092	6.933	6.933
0.435	1.25	31.96	32.162	2.102	27.035
0.300	1.75	35.01	35.212	22.008	49.043
0.212	2.24	18.57	18.772	11.733	60.776
0.106	3.25	29.54	29.742	18.589	79.365
0.063	4.00	24.26	24,462	15.289	94.654
Pan	-	8.42	8.622	5.389	100.0

TABLE 10; SIEVE ANALYSIS RESULT FOR SAMPLE NINE

Mesh Size (mm)	Ph(Ø)	Weight Retained (g)	Corrected Weight (g)	Weight %	Cumulative Weight %
0.212	2.24	8.78	9.168	5.73	5.73
0.106	3.25	72.18	72.568	45.355	51.085
0.063	3.99	55.18	55.568	34.73	85.815
Pan	-	22.31	22.314	13.947	99.762



FIG;8 CUMULATIVE CURVE(SAMPLE 1)

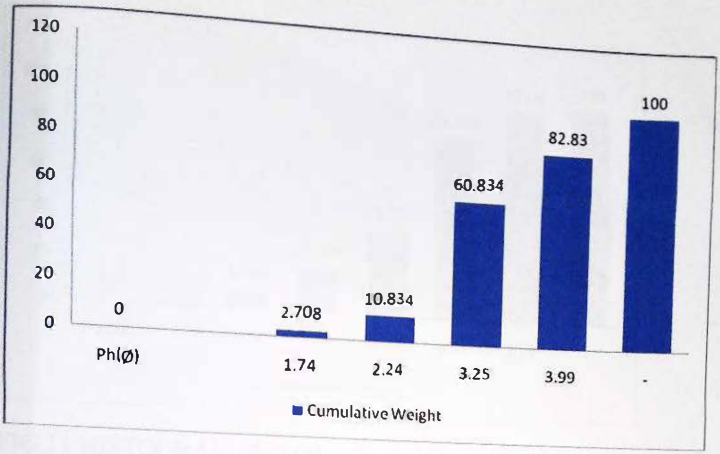


FIG 9:HISTOGRAM (SAMPLE1)

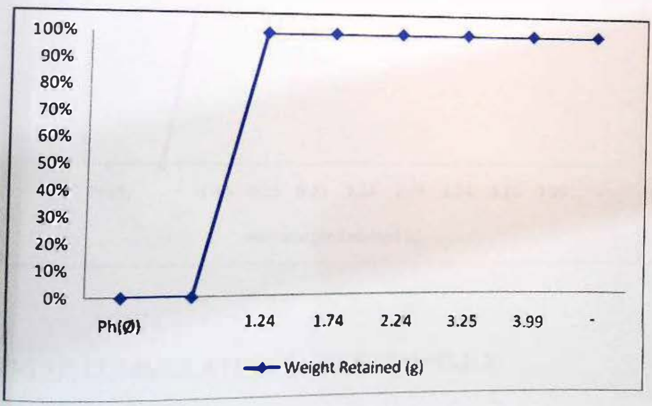


FIG 10: CUMULATIVE CURVE (SAMPLE 2)

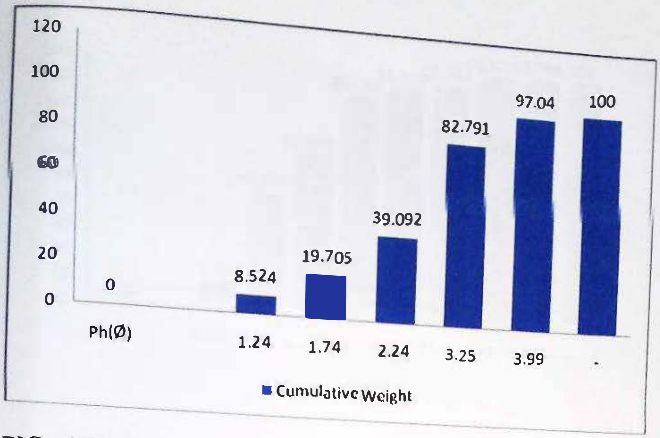


FIG 11:HISTOGRAM (SAMPLE 2)

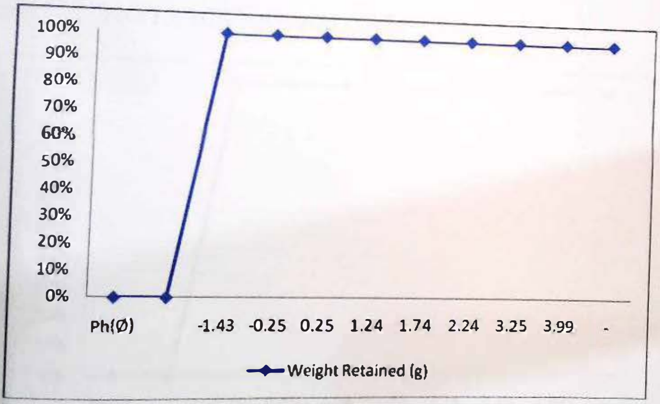


FIG 12: CUMMULATIVE CURVE (SAMPLE 3)

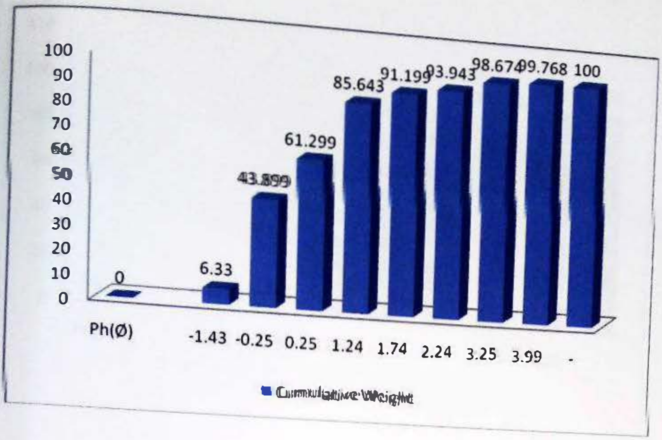


FIG 13: HISTOGRAM (SAMPLE 3).

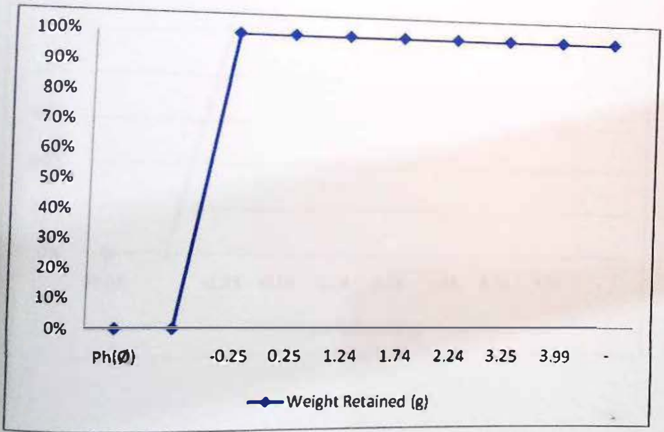


FIG 14: CUMMULATIVE CURVE (SAMPLE 4)

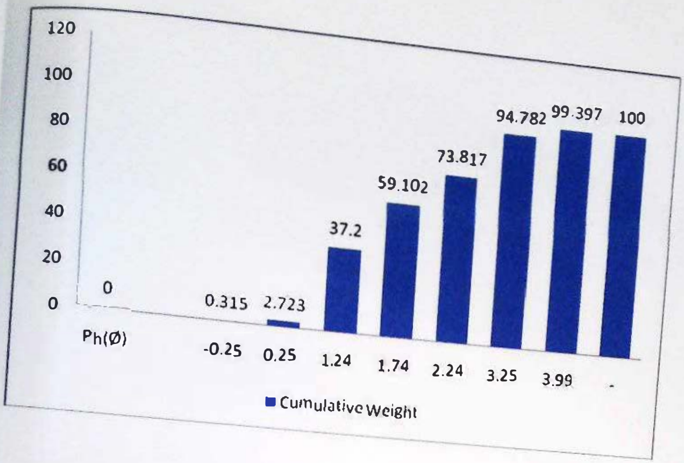
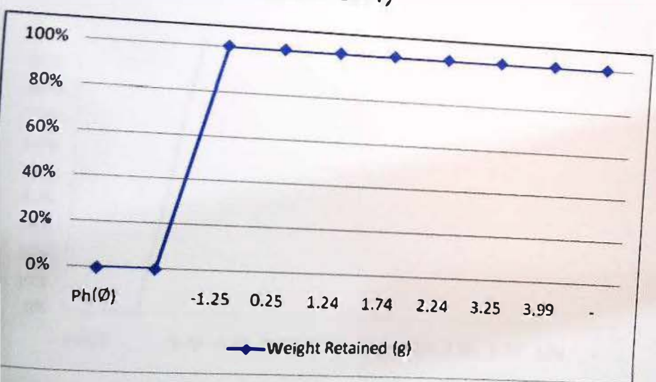


FIG 15: HISTOGRAM (SAMPLE 4)



G 16: CUMMULATIVE CURVE (SAMPLE 5)

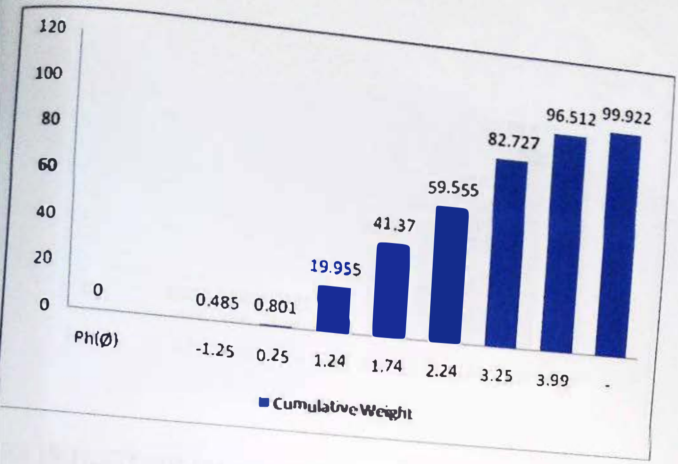
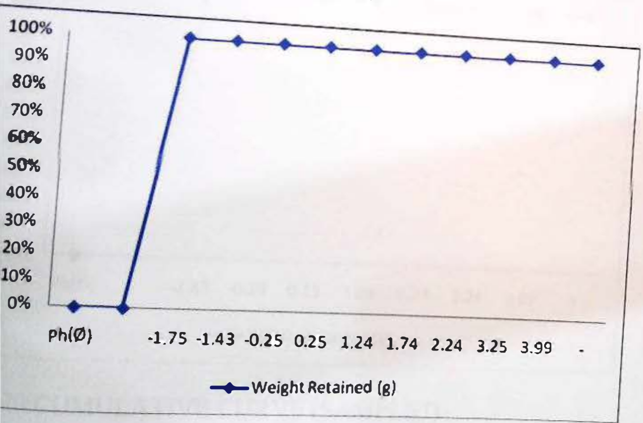


FIG 17: HISTOGRAM (SAMPLE 5)



18: CUMMULATIVE CURVE (SAMPLE 6)

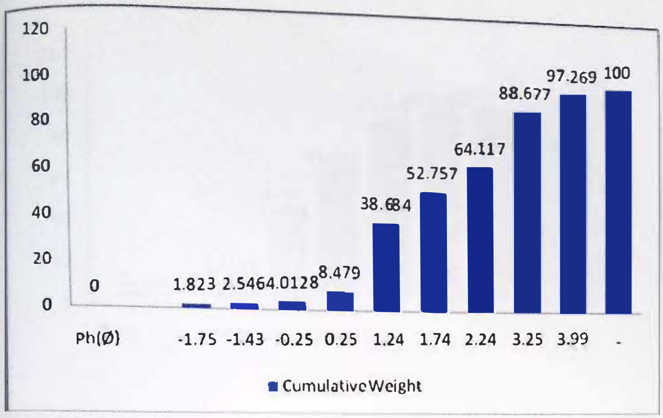


FIG 19:HISTOGRAM(SAMPLE 6)

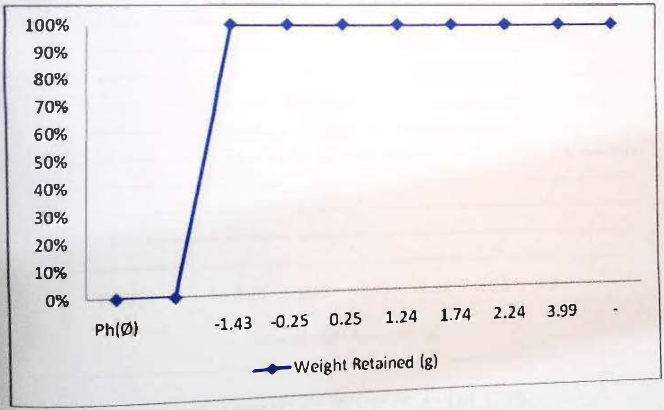
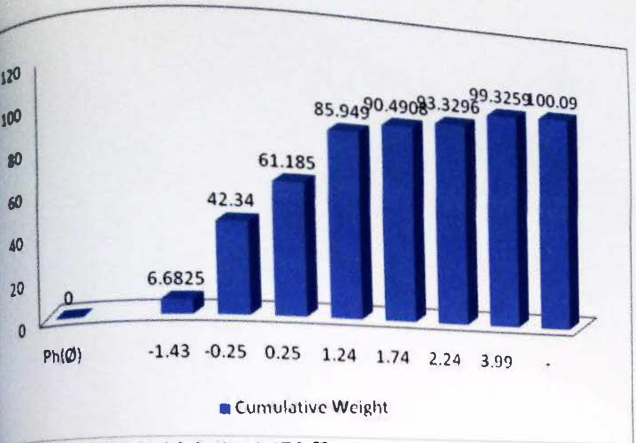


FIG 20:CUMULATIVE CURVE (SAMPLE7)



G 21: HISTOGRAM (SAMPLE 7)

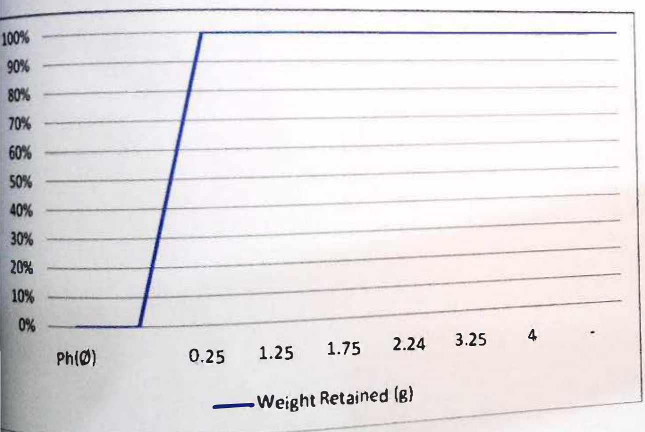
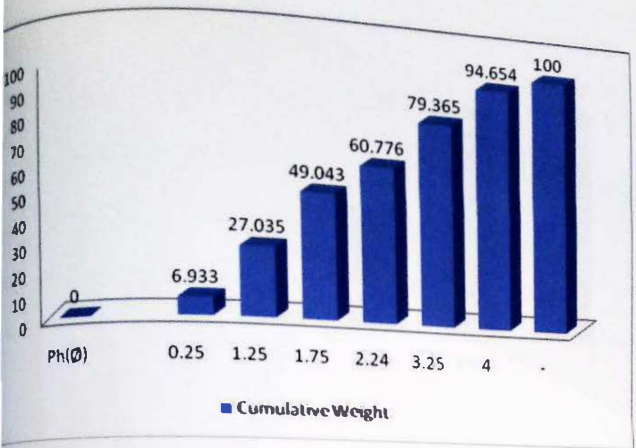
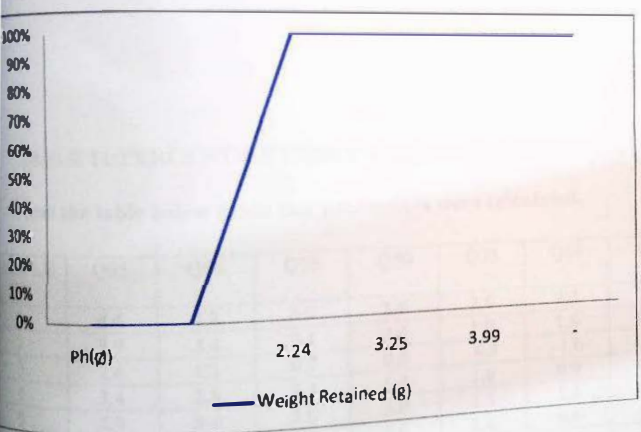


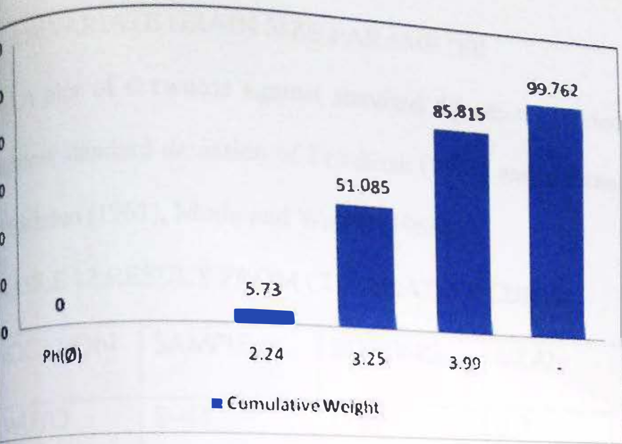
FIG 22: CUMMULATIVE CURVE (SAMPLE 8)



G 23: HISTOGRAM (SAMPLE 8)



IG 24 : CUMMULATIVE CURVE (SAMPLE 9)



G 25: HISTOGRAM (SAMPLE 9)

TABLE 11:PERCENTILE DEDUCATION FROM CUMMULATIVE CURVES

From the table below grain size parameters were calculated.

AMPLE NO	Q95	Q84	Q75	Q50	Q25	Q16	Q5	
1	4.4	4.2	3.9	2.9	2.6	2.2	2.0	
2	3.9	3.4	3.1	2.4	1.8	1.6	0.7	
3	2.6	1.1	0.7	0.0	-0.8	-1.0	-1.4	
4	3.4	2.8	2.3	1.4	1.0	0.9	0.8	
5	3.9	3.4	3.0	2.0	1.5	1.3	0.6	
6	3.8	3.0	2.7	1.6	1.1	0.6	-0.2	
7	2.7	1.1	0.9	0.5	-0.9	-1.1	-1.4	
8	4.1	3.5	3.0	1.8	1.1	0.6	0.1	
9	4.3	3.9	3.7	3.2	2.6	2.4	2.2	

4.6 BIVARIATE GRAIN SIZE PARAMETER

A plot of skewness against standard deviation of Friedman (1967) and mean against standard deviation of Friedman (1961) and skewness against mean size of Friedman (1961), Moila and Weiser (1968).

TABLE 12:RESULT FROM CUMULATIVE CURVE

LOCATION	SAMPLE	SORTING	MEAN	REMARK
WUYO	Swl1	0.87	3.1	Very fine sand,moderately sorted
	Swl2	0.93	2.47	Fine sand, moderately sorted
	Swl3	0.43	0.04	Coarse sand,well sorted
HINA	SHI1	0.87	1.7	Medium sand,moderately sorted
	SHI2	1.03	2.24	Fine

				sand,poorly sorted
	SHI3	1.45	1.74	Medium sand,poorly sorted
LUI (Gombe inlier)	SL1	0.197	-0.9	Very coarse sand, very well sorted
	SL2	1.34	1.97	Medium sand,poorly sorted
	SL3	0.69	3.17	Very fine sand,moderately sorted.

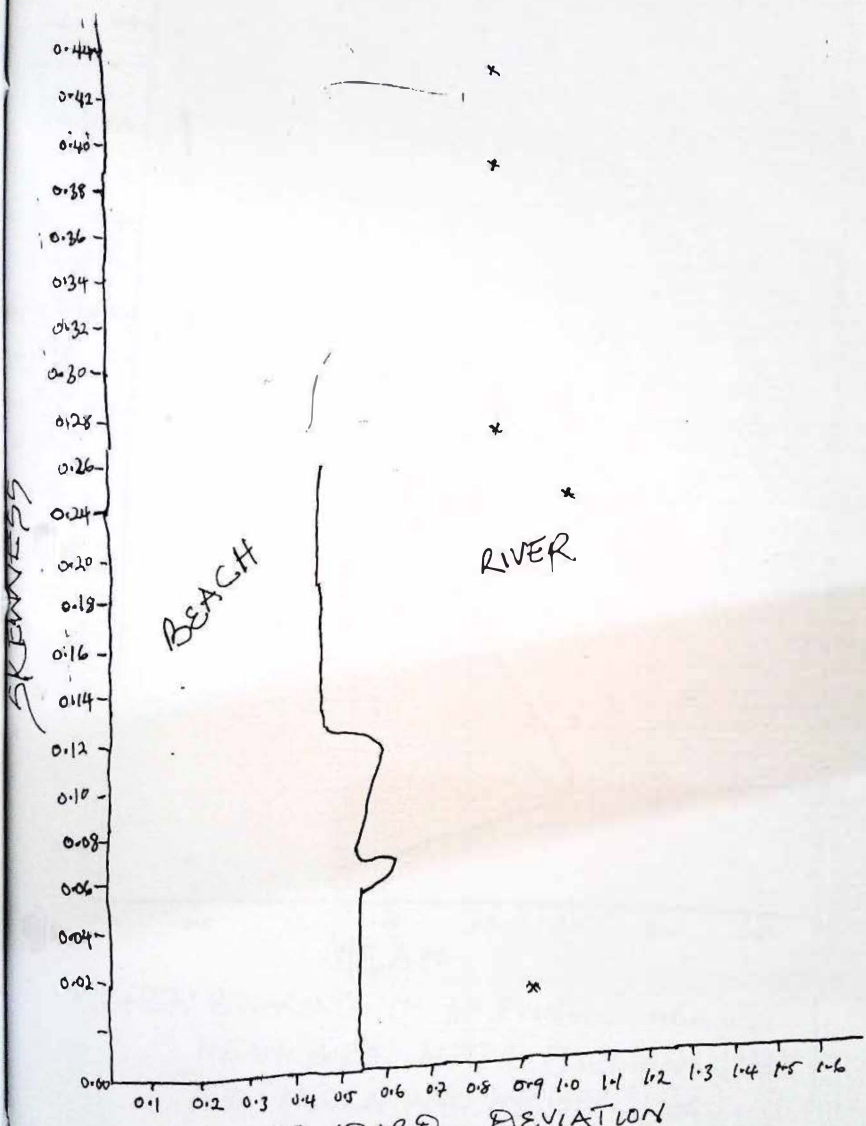


FIG 26: BIVARIATE PLOT OF SKEWNESS AGAINST STANDARD DEVIATION AFTER FRIEDMAN (1967)

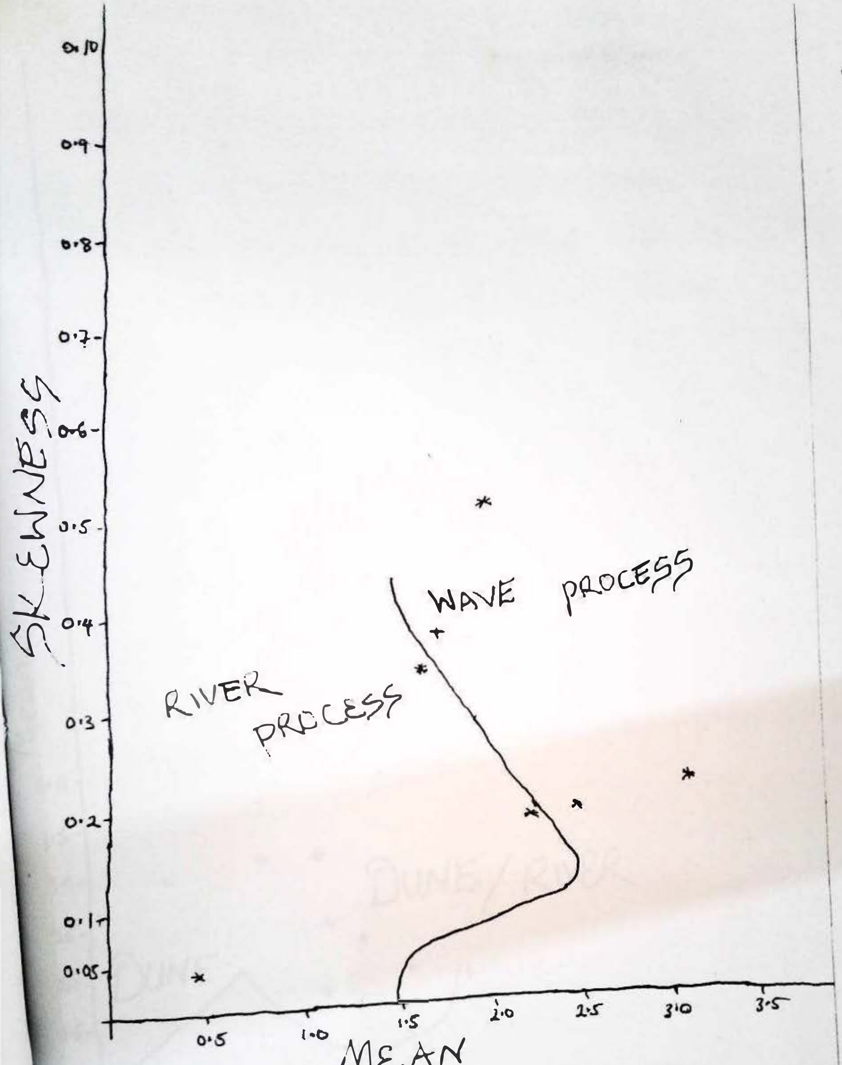


FIG.27: BIVARIATE OF SKEWNESS AGAINST MEAN SIZE AFTER FRIEDMAN (1961) AND MIOLA AND WEISER (1968).

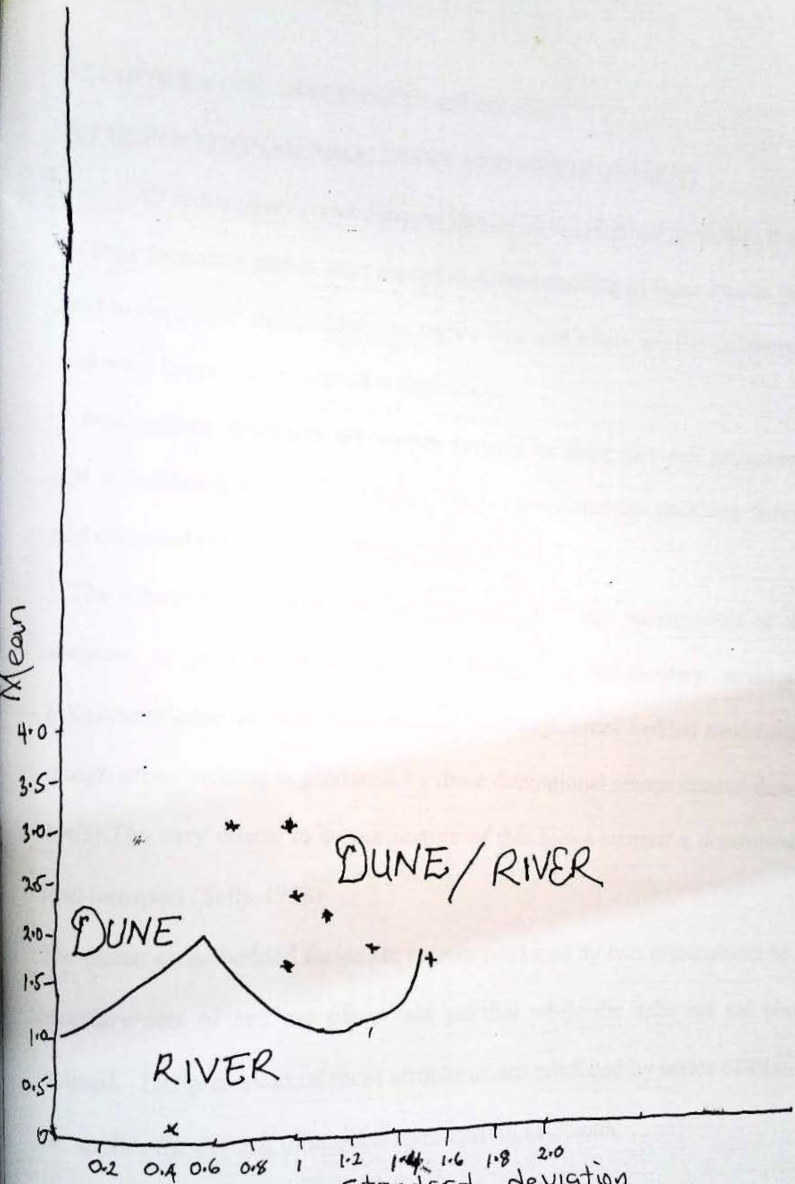


FIG.28: BIVARIATE PLOT OF MEAN SIZE AGAINST STANDARD DEVIATION AFTER FRIEDMAN (1961) AND (1967).

CHAPTER FIVE: DISCUSSION OF RESULT

5.1 DEPOSITIONAL PROCESSES AND ENVIRONMENT

All sedimentary rocks carry an inprint of the physical processes that resulted to their formation and or later alteration. Understanding of these inprint in the field lead to the proper interpretation as regard how and where are the sediments formed and what happened to them after deposition.

Sedimentary structures are mainly formed by these physical processes during and immediately after sedimentation, while those structures resulting from organic and chemical processes formed much later.

The interpretation of the depositional processes and environment of the three sections is principally based on textures and sedimentary structures. All lithostratigraphic sections is dominated by trough cross bedded sandstone facies, trough cross bedding is produced by three dimentional sinous crested dunes(Allen 1963).The very coarse to coarse texture of this facies suggest a deposition by bed load transport (Selly 1988)

The planar cross bedded facies are mostly produced by two dimensional beds. The boundary sets of bed are planer aid parallel while the subs set are planer and inclined. The presences of these structures are produced by series of stratification that applies the deposit of braided river system.Friedman.

Planer bedded sandstone facies is also common but less abundant in all the sections.It represented in all three sections. The planer bedded sandstone has been described as the most fundamental diagnostic feature of sedimentary rocks. It is generally considered that they are deposited horizontal, flat bedding, grades via sub-horizontal bedding, into cross bedding which also attributed to sedimentation from planer bed forms.

Massive bedding are only found in lithosection at Hina. The massive bedding are sedimentary rock features used to describe sediments devoids of sedimentary structures. It was observed in the Bima sandstone that the overall lithosections at all point are braided river system and individual lithofacies are help in identifying the different sub environment within the mega braided river system, they include, bars, debris flow deposit, linguiod bars,planar bed deposit,dunes of the lower flow regimes.

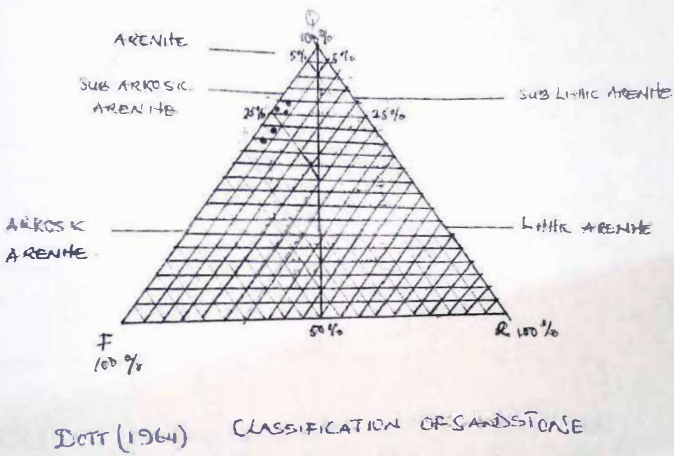
5:2 PETROGRAPHIC ANALYSIS

The frame work elements (minerals) from the petrographic analysis data of the sectioned sample are used to classify the sediments into various units of sedimentary rocks by using Dott (1964) classification. From the result, various samples were plotted on a triangular diagram

Based on the result of the Dott triangular classification for siliciclastic sedimentary rocks, all the samples have been found to range from sub-Arkosic to Arkosic

Arenite. The Arkoses are sand which are relatively mature in texture (i.e. low in clay matrix and are immature in mineralogy as shown by the abundance of feldspar. The clay content must generally

FIG29: Dott (1964) triangular classification of sand stone.



be less than 15% and feldspar more than 25%.

5.3 GRANULOMETRIC ANALYSIS

The results of the sieve analysis are interpreted in the table below:

GROUNLOMETRIC RESULT INTERPRETATION

SAMPLE NO	MEAN SIZE (M_2)	STANDARD DEVIATION
1	Very fine sand	Moderately sorted
2	Fine sand	Moderately sorted
3	Coarse sand	Well sorted
4.	Medium sand	Moderately sorted
5.	Finely sand	Poorly sorted
6.	Medium sand	Poorly sorted
7.	Very coarse sand	Very well sorted
8.	Medium sand	Poorly sorted
9.	Very fine sand	Moderately sorted

SAMPLE 1:- Is a very fine grain sand stone, moderately, sorted.

SAMPLE 2: Is a fine sand stone, moderately sorted.

SAMPLE 3: Is a coarse grain sand stone, well sorted.

SAMPLE 4: Is a medium grain sand stone, moderately sorted.

SAMPLE 5: Is a fine grain sand stone, poorly sorted.

SAMPLE 6: Is a medium grain sand stone, poorly sorted.

SAMPLE 7: Is a very coarse sand stone, very well sorted.

SAMPLE 8: Is a medium grain sand stone, poorly sorted.

SAMPLE 9: Is a very fine sand stone, moderately sorted.

5.4 BIVARIATE INTER PRETATION

The plot of skewness against mean of Friedman (1968) technique indicates the sand to be deposited in a river system.

However, by using Friedman (1967), a plot of skewness again standard deviation confirm the sand to be fluvial and may supported the braided river system in the environment of deposition for the Bima sandstone.

The plot of mean against standard deviation Friendman (1961) also suggest a fluvial river system deposit for the Bima sand stone.

5.5 HISTOGRAMS

The plot of individual weight percentages against the phi size of various samples in the figure 1, 2 are bimodeal, 3, 4 polymodal, 5 bimodal, 6,7,8 are poly modal while figure 9 is bimodal patern perhaps suggesting that more than one sourse for the sediment of Bima sandstone

CHAPTER SIX

SUMMARY AND CONCLUSION

6.0 Summary

The term facies is broadly used in both descriptive and interpretive terms and the word it self may have a singular or plural meaning. The descriptive facies include both lithefacies and bio facies, both of which are used to term a certain observable attributes of sedimentary rocks that can be interpreted interms of biological or depositional processes.

An individual litho facies is a rock unit defined on the basis of its distinctive lithologic features including grain size, bedding characteristics, compositions ad sedimentary structures, with each litho facies representing and individual depositional episode. Based on sedimentary structures and lithology, the Bima sand stone may be described as contain of the following litho facies below:-

1 - Trough Cross bedded sandstone

2 - Planer bedded standstone

3 - Tabular planer cross bedded sanstone

4. - Massive bedded sandstone

But, in the studied area most of the sedimentary structures recognized are mostly trough cross bedded sandstone and some few with planer bedded sand stone,massive bedded sandstone,and Tabular planar cross bedded sandstone been recognized in the studied area.

Also, based on litho facies, the following may be recognizable as environment of deposition:

- Linguoid or transverse bars
- Debris flow deposit
- Dunes

The bivariate indicate depositions is mainly in a fluvial environment, the histogram is mostly bimodal hence indicating more than one soruce for the Bima stand stone. From the Granulometric and petrographic analysis, the Bima sand stone is generally sub-Arkosic to Arkosic arenite, that are poorly to moderately sorted and little fine sorted. The presence of rock fragment suggest both metamorphic and ingneous recycled source for the Bima sandstone.

6.1 CONCLUSION

With reference to observation and the analysis that have been carried out on the Bima sandstone with respect to the various parameters that were put into consideration, the Bima sandstone can be inferred to have been deposited in a fluvial environment during a braided river flow.The textural appearance of the studied sandstone ranges in size from coarse to very coarse grain and most significantly the sandstone is extensively endowed with the Trough cross bedded facies and minor occurance of planar beds,massive bed and Tabular planar cross bedded facies.

It is recommend that further research be carried out on the Bima sandstone on a much regional scale to establish its environment of deposition, will also build more ideas on different lithofacies that mainly characterized the entire Bima stand stone

REFERENCES

Abubakar M.B (2006) Biostratigraphy,paleoenviroment and organic Geochemistry of the Cretaceous sequence of the Gongola Basin, upper Benue Trough, Nigeria. P 49-57.

Adegoke O.S, Agumanu. A.E,Benkhelil M.J and Ajayi P.O (1986). New stratigraphic, sedimentological data on the Keri-Keri formation, Bauchi and Borno state Nigeria. Journal of Africa Earth sciences. Vol 5 P-249-277.

Allen J.R.L (1963),The classification of cross stratified unit with note of their origin, sedimentology Vol 2 P 93-114

Allen (1965). A review of the origin and characteristics ofresources of alluvial sediment; sedimentology. Vol 5, P 89-191.

Allen J.R.L, AND leeder, M. R(1980). Cretaria for the instability of the upper stage plane bed; Sedimentology,Vol 27, P 209-217.

Benkhelil J. I (1989). The origin and Evolution of Benue Trough(Nigeria) Journal of African Earth Sciences, Vol 8 P 281-282.

Benkhelil J. I (1992). Workshop on cretaceous Geology of the upper Benue Trough and field trip. P 16-20,April 1992. The university of Jos.

Dike E.F.C (1993). Stratigraphy and structure of the Keri-Keri Basin North-Eastern Nigeria,journal Of Mining and Geology. Vol 29,p 77-93.

Friedman G.M (1961). Distinctive between dune beach, river sand from textural characteristics. Journal of sedimentary petrology,Vol 31 P 514-529.

Friedman G.M (1967).Dynamic processes and statistical parameters compared from size, frequency distribution of beach and river sand. Journal of sedimentary petrology. Vol 37, P 327-354.

Folk R.L(1951). Stages of textural maturity in sedimentary rocks.Journal of sedimentary Petrology, Vol 21

Folk R. L and Ward W.C (1957).Brazos river bars, a study in significance of grain size parameters,Journal of sedimentary petrology,Vol 31, P 514-529.

Guiraud M.(1990).Tectono-sedimentary Framework of the early cretaceous continental Bima formation (upper Benue Trough N-E Nigeria).Journal in science.Vol 10,P 341-353.

Kogbe C.A Geology of Nigeria. Elizabethan publishing company lagos.

Moila R.J and Weiser D. (1968). Textural parameters.

Selly R. C (1978). Ancient sedimentary environment, Chapman and Hall.London, p 287.

Selly R.C (1988). Applied sedimentology. P 79-86,107-108,120-132.

Singh S.P (1983). Fluvial sedimentation of the proterozoic Alwar group in the lalgahr Graben,. Northwestern India. Sedimentary Geology. Vol 39, p95-119.

Zaborsky P; Ugodulunwa F; Idornigie. A. (1997). Stratigraphy and structure of the cretaceous Gongola Basin N-E Nigeria-Bull centre Reach ELF Exploration production. Vol 21, No 1, p 153-185.