THE STRATIGRAPHY OF [illegible]
BAUCHI STATE.

BY

SALAMI JAMIU AJAYI

MARCH 1991

APPROVED BY

Supervisor:

Signature ----------

Name: Mr.A.W.MODE.

Date: 1-8-91

Programme Co- ordinator:

Signature ----------

Name: Dr. D.M.Orazulike.

Date: 1-8-91

Dean of School

Signature -----------

Name : Prof.S.O.Ale

Date: -------------

THE STRATIGRAPHY OF CHAM, BAUCHI STATE.

BY

SALAMI JAMIU AJAYI

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QUOTATION.

- GEOLOGY IS A CAPITAL SCIENCE TO BEGIN WITH, AS IT REQUIRES NOTHING BUT A LITTLE THINKING, READING AND HAMMERING.

CHARLES DARWIN.

1885.

DEDICATION.

THIS WORK IS DEDICATED TO THE SALAMI AND FATUGA FAMILIES.

LIST OF TABLES.

LIST OF PLATES.

LIST OF FIGURES.

ACKNOWLEDGEMENT.

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ABSTRACT.

The area around Cham town can be delianated into four lithologic units viz:

(i) The Bima Sandstones.

(ii) The Yolde Formation.

(iii) The Dukul Formation.

(iv) The Jessu Formation.

The Bima Sandstone comprises of medium to coarse grained, texturally and minerologically immature subarkosic sandstones.

The sandstones of the Yolde Formation are fine grained, texturally and minerologically mature quartz-arenites. The limestone of the Dukul Formation are highly fossiliferous yellow to dark brown with shell fragments of bivalves and ostracods in it. The Dukul limestone has a depositional texture of wackestone. The shales of the Dukul Formation are black and this tends to suggest anoxic conditions in the environment of deposition. The mudstones of the Jessu Formation have imprints of fossils while the shales are grey and gypsiferrous.

Compaction is the main diagenetic process that affects all four lithologic units; and this is more pronounced in the limestones of the Dukul Formation. Also affecting the limestone is dissolution and recrystallisation.

Varieties of structures abound in the sandstone units

with the Bima Sandstone having the highest number.

Sedimentologic and structural evidences suggests a continental environment for the deposition of the Bima Sandstones, a near shore shallow marine environment for the Yolde Formation and the Sandstones believed to be derived from pre existing sandbeds. Sedimentologic and faunal evidences suggest a low energy shallow marine depositional (inner shelf) environment for the Dukul and Jessu Formations.

TABLE OF CONTENTS.

CHAPTER ONE.

INTRODUCTION.

1.1. AIM OF THE PROJECT.

The purpose of this study is to investigate the stratigraphy and petrology of the area around Cham town. This includes the preparation of a detailed geological map of the area, differentiating the various lithologic units and to explain the depositional environment and their facie relationships.

1.2 LOCATION AND ACCESSIBILITY.

The project area lies within the upper Benue Trough. It is located at the eastern extreme end of Bauchi State close to its boundary with Gongola State (approximately 132Km from Gombe town) along Gombe-Yola road. It constitutes part of sheet 174 (Guyok S.W) and is bounded by Latitutes 11 40'N and 11 45 E and Longitudes 9 45'N and 9 40' 45"N.

Access within the area was by the trunk 'A' road that cuts across it , other minor roads and the numerous foot paths leading to settlement within and outside the area. Dry stream valleys were also used to gain access.

1.3. TOPOGRAPHY AND DRAINAGE.

The area is of moderate to high relief with the lowest point about 1400m (above sea level) in the northern part of the area; whilst the highest point about 1950m (above sea level) lies in the South-Western part of the area.

The area is drained by a few seasonal streams and the Perenial River Cham. The river Cham has a sinous course and it flows from the South east to the north of the area.

1.4. CLIMATE AND VEGETATION.

The climate in this area is of two seasons; a short rainy season and a long spell of dry season. The rainy season starts in May with an average annual rain-fall of 180mm-200mm and ends in late September. The dry season lasts for about seven months, from October to April. The period between late November and February is marked by the extremely dry and cold winds of the Hamattan which brings with it, high amount of dust particles that impairs visibility.

Vegetation of the area is of the Sudan Savannah type with large areas of tall grasses and the occassional thorny trees and scrubs. The thickest vegetations occur along the river banks.

1.5. PREVIOUS WORKS.

The sediments of the Upper Benue Trough was first described by J.D.Falconer and A.Longbottom (1911) on a reconnaissance basis during the Mineral Survey of Northern Nigeria. More systematic geological survey of the area was carried out by Carter et al (1963). They were able to delineate the various Stratigraphic units of the area.

1.6. METHODS OF INVESTIGATION.

The methods used during the field study was ground traversing which was done purely on foot. Traverses were made across the area using a grid system. Outcrops and observations made were plotted on the field map, and the recordings made, were noted in the field note-book.

Samples for sedimentological studies were collected at different points within the area. Thin sections were made for each of the lithologic units. Krumbien and Sloss' (1963) Chart was used to determine roundness and sphericity. Procedure given by R.L.Ingram (1970) was used for the size analysis of the sandstone samples, while interpretation was done using Folk and Ward's (1957) statistical parameters.

CHAPTER TWO

2. STRATIGRAPHY.

INTRODUCTION.

The Benue Trough in which the area of study is located, is a NE-SW trending sedimentary structure about 1000Km long, 50-100 Km wide (J.Benkhelil 1989). At the Northern end, It is Y-Shaped, with the E-W trending branch of Yola and the North trending arm of the Gongila basin.

The origin of the Benue Trough is quite controversial, some authors have proposed tensional movements resulting in a rift (King 1950, Cratchley and Jones 1965). Burke and Dewey (1974), Olade (1975), and Theissen (1979) believed it to be the third failed arm or aulacogen of a three arm rift system. However most recent works revealed that wrenching was a dominant tectonic process in the evolution of the Benue Trough, (Benkhelil (1982, 1986), Benkhelil and Robineau (1983), Maurin et al (1986)).

The depositional history of the Benue Valley can be discussed in the context of Murat's (1970) proposals of transgressive and regressive phases which corresponds to the depositional cycles. Dessauvagie, et al (1970) envisaged the deposition of Shales in both shallow and deep waters, while limestones and mudstones were deposited at the margins of the marine embayments mainly during transgressive phases. Three transgressive phases identified by Murat (1970) are said to be synchronous with the eustatic movements of Tethys (Offodile 1978).

2.1. REGIONAL STRATIGRAPHY.

Due to the differing lithostratigraphic records from North eastern Nigeria, Three different Paleogeographic areas were recognised. (Popoff et al 1986).

From South to North, they are:-

(a) The Upper Benue Trough

(b) The Zambuk Ridge (a Basement high in the Gongila Trough)

(c) The Chad Basin.

Cham lies within the northern margin of the Upper Benue Trough, the formations from top to bottom are as follows.

The Bima Sandstone (Late Aptian-Albian) Allix et al (1981) consisting of feldsparthic sandstones, medium to coarse grained, thick to massively bedded with interbeds of whitish and red siltstones and uncomformably overlies the Basement complex. The sediments are deposited in a continental environment.

The succeeding Yolde Formation (U.Albian-Cenomanian) consists of sandstones, thinly bedded mudstones shelly limestone and shales. The formation is a transitional sediment between the underlying continental and overlying marine sediments. The Yolde is overlain by the Dukul Formation termed Limestone Shales Series in Lexique Stratigraphique International (1956). This formation consists of a sequence of black shales and thin limestones. The limestones are sometimes fringed with recrystallised calcite (Carter et al 1963).

The succeeding Jessu formation is an alternating sequence of grey, white and brown shales and light brown Sandy mudstones with subordinate sandstones (Carter et al 1963). The Sekule formation which is a sequence of Shales and limestones having thicker shale units than the limestones succeeds the Jessu formation. The lithology corresponds to that of the Dukul formation and is believed to be upper Turonian to Santonian in age (Carter et al 1963).

The Numanha Shales which succeeds the Sekule is composed of Shales with occassional bands of sandstones, nodular mudstones and limestones. The Numanha shales overlies beds of proven Coniacian-Santonian age and are tentatively assigned to the upper Senonian (Campanian ?).

The Lamja sandstones terminates the sedimentary successions in the region. It is a sequence of fine grained sandstones with carbonaceous streaks; shales and limestones (Carter et al 1963).

2.2. LOCAL STRATIGRAPHY.

The approximate percentages of the rocks in the area studied are :-

Bima Sandstones	28%
Yolde Formation	15%
Dukul Formation	10%
Jessu Formation	45%
Basalts	2%

2.2.1. Bima sandstones.

The Bima Sandstones in the studied area are light brown feldsphathic and cream coloured in some places. The texture ranges from being medium grained to very coarse grained sandstone.

Maximum thickness of the Bima Sandstone is estimated to be about 3.5-4 Km (Carter et al 1963).

However, the exposed thickness ranges from 50m-80m in Cham area. Most prominent are the hills closed to Gwa village, they extend West for about 4Km, though the height varies, but it averages between 40-50m. And also, the stream exposure of the Bima Sandstone along the banks of the River Cham shows an estimated thickness of 40 metres The Bima Sandstone shows varieties of sedimentary structures. In the studied area, it extends from the South to its boundary with Yolde Formation in the central part (which overlies it).

2.2.2. YOLDE FORMATION.

This is called " Transitional beds " by Carter et al (1963). The Yolde Formation contains fine to very fine grained sandstone and siltstone , cream coloured in most places and greenish in some parts of the mapped area.

The Yolde Formation in the east of the mapped area is a sequence of cream coloured fine grained flaggy sandstone and brown mudstone. A small exposed section measured in this area gave an estimated thickness of 4 metres with sandstone units ranging between 0.9-1.2 m and mudstones of 0.12-0.25m (Fig.4.). Towards Cham town from the east, the mudstone of the Yolde formation here is light grey in colour (Plate 2).

The Yolde Formation is flaggy in nature and has low angled cross laminations, however what is common to the sandstone of the Yolde formation is microcross laminations. Current ripple marks are also present in the Yolde Formation (Plate 4).

In the western part of the mapped area some of the structures of the Yolde Formation has been obliterated by Intense burrowing.

2.2.3. DUKUL FORMATION.

The Dukul Formation is a sequence of thin limestone and shales. The shales weather to form " cotton soil ", a black clayey soil with a high shrinkage capacity. The limestones appear as scattered surface debris , (Carter et al 1963).

Due to the fact that there was no presence of a surface section of Dukul Formation , The Dukul Formation was inferred from the occurence of " cotton soil " and limestone debris.

2.2.4. JESSU FORMATION.

The Jessu Formation is an alternating sequence of grey, white and brown shales, light brown and light green mudstones (Carter et al 1963) . In the north of Cham town, a man made irrigation canal has exposed a section consisting of seventeen beds of mudstones and marl and eighteen beds of shales (fig.2). Also at Kautare village, south-south-west of the mapped area, a stream section exposed 11.27 metres of alternating mudstone and shales (fig 3.). The thickest mudstone bed about 4m and shale of about 3.08m were recorded here. The shales of the Jessu Formation is fissile with light red staining and it is locally gypsiferrous. The beds of the Jessu Formation in the Canal Section are faulted (Plate 5). Also the mudstones contains casts and moulds of bivalves and molluscs.

2.2.5. BASALTIC INTRUSIONS.

The Basaltic intrusions in the area total eight and are intruded into the Jessu and Dukul Formations. Three are found in the Dukul while the Jessu Formation has five, scattered in different parts. The basaltic intrusions are hard resistants rocks and all are conical in shape.

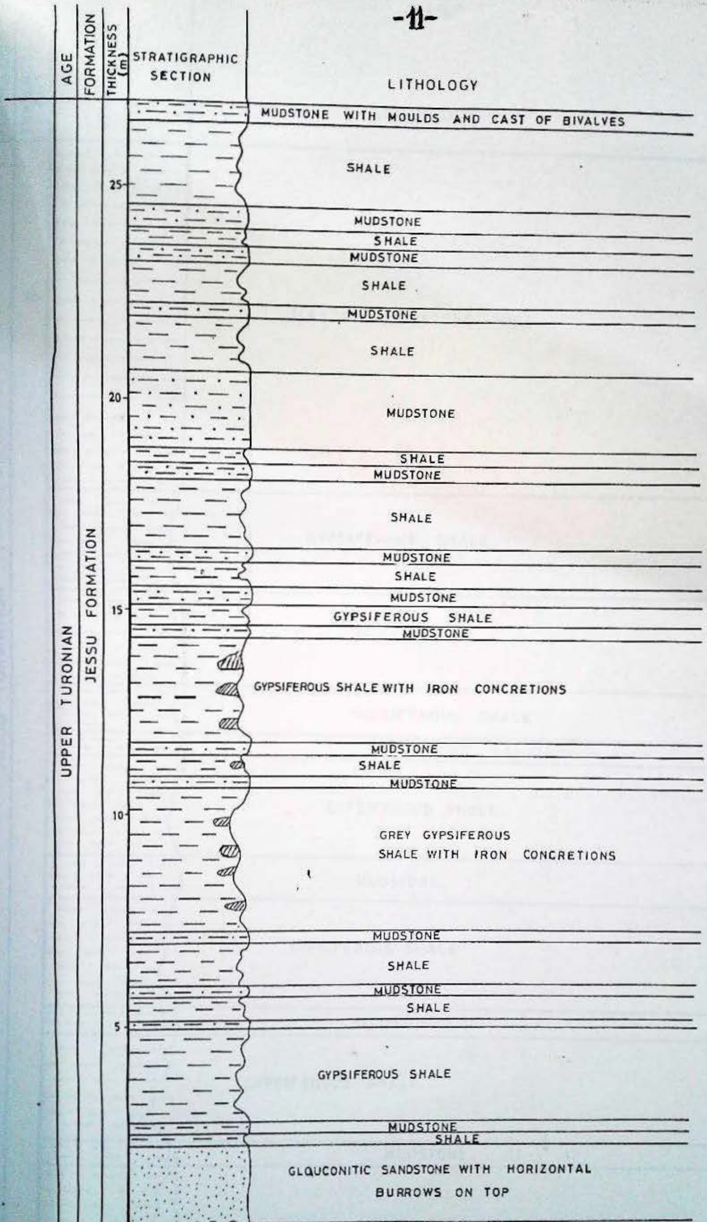


Fig. 2. STRATIGRAPHIC AND LITHOLOGIC SUMMARY OF THE CANAL SECTION OF JESSU FORMATION.

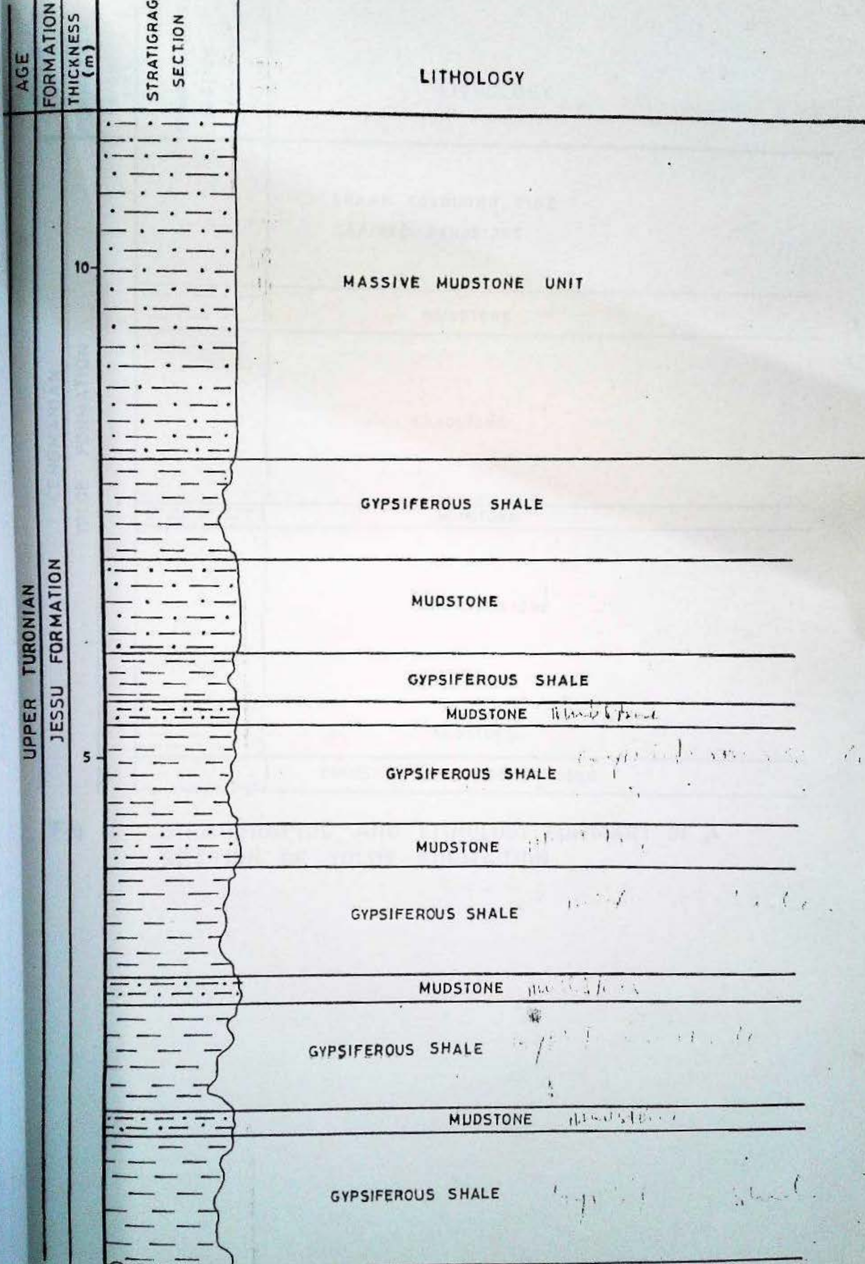


Fig. 3. STRATIGRAPHIC AND LITHOLOGIC SUMMARY OF A STREAM BANK SECTION OF JESSU FORMATION.

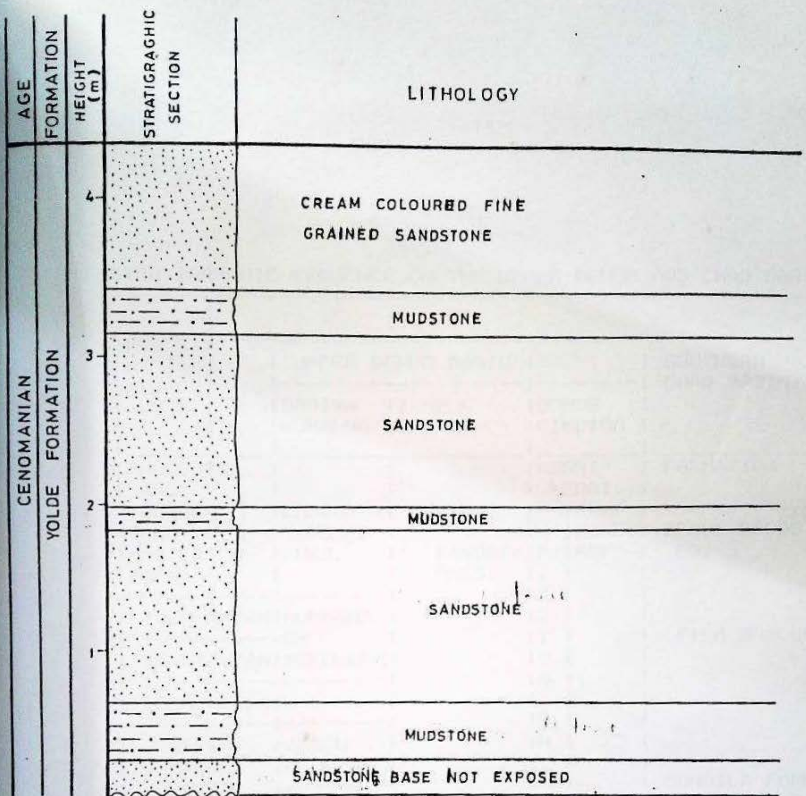


Fig. 4. STRATIGRAPHIC AND LITHOLOGY SUMMARY OF A SECTION OF YOLDE FORMATION.

TABLE 1.

STRATIGRAPHIC SEQUENCE OF THE UPPER BENUE AND CHAD BASINS.

AGE	UPPER BENUE BASIN: DADIYA NUMANHA	UPPER BENUE BASIN: ZAMBUK GULANI	GOMBE PINDIGA		SOUTHERN CHAD BASIN.
PALEOCENE AND YOUNGER	LAMJA SANDSTONES.	GULANI SANDSTONES.	KERRI-KERRI.		FORMATION
MAASTRICHTIAN			PINDIGA FM	GOMBE SST	GOMBE SANDSTONES.
CAMPANIAN	NUMANHA SH				FIKA SHALES.
SANTONIAN	SEKULE FM				
CONIACIAN					
T. UPPER MIDDLE LOWER	JESSU FM				GONGILA FORMATION.
	DUKUL FM				
CENOMANIAN	YOLDE FM	BIMA SANDSTONES			BIMA SST
MID-LATE ALBIAN.	BIMA SST				
PRE-CAMBRIAN	BASEMENT COMPLEX				

(AFTER C.O.OFOEGBU 1986).

TABLE 2.

STRATIGRAPHIC SEQUENCE OF THE MAPPED AREA.

AGE			
TERTIARY			VOLCANIC INTRUSIONS
CRETACEOUS.	TURONIAN	U	JESSU FORMATION.
		M	
		L	DUKUL FORMATION.
	CENOMANIAN.		YOLDE FORMATION.
	U-APTIAN (?) ALBIAN		BIMA SANDSTONES.
PRECAMBRIAN.			CRYSTALLINE BASEMENT

CHAPTER THREE.

3. PETROLOGY

3.1. BIMA SANDSTONE: PETROGRAPHY.

The composition of the Bima Sandstones was established on the basis of several hand specimens studies and thin section analysis. The colour of the Bima sandstones ranges from cream white to light brown. Grain size ranges from medium to very coarse grained, friable in some specimens while compact in others. The minerals in hand specimen are quartz and feldspars.

Thin section analysis shows the Bima to contain about 50-60% quarts, 10-25% feldspar, 2-5% mica and clay as the void filling matrix. The sandstone is classified as Subarkose (Pettijohn 1975). The quartz grains are sub angular to sub-rounded and are polycrystalline and monocrystalline possesing undulose extinction of various intensity. The feldspar in the specimen consists of plagioclase and microcline. They show various degrees of alterations, noticeably at the edges. The mica presents are thin flakes showing various degrees of deformation.

3.1.1. DIAGENESIS AND ITS EFFECTS.

Diagenesis is the post depositional changes that occurs in sediments (Krumbien and Sloss 1963). It may express itself in a number of ways.

There are several diagenetic effects present in the Bima sandstones, but the most common is compaction.

Compaction is the reduction in bulk volume of the sediments caused mainly by the vertical forces exerted by an increasing overburden. Compaction due to compressional forces (i.e. reduction in bulk) in the Bima sandstone was observed by the deformation of mica flakes which were bent.

3.1.2. TEXTURAL ANALYSIS.

The major objective of the textural analysis is to determine the grain size of the sand particles. From the parameters obtained from this analysis a better description of the grain sizes can be made and depositional processes, and environment of deposition and the mode of transportation of the sediments can be inferred.

Though there are various methods used in the determination of grain sizes, sieve analysis was used in this study, while the roundness and sphericity estimates was determined by microscopic studies.

Samples of the Bima-Sandstone were disaggregated into the individual grains by use of pestle and mortar. The samples were later divided using the coning and quartering method (Ingram 1971). The quartered samples were weighed and placed in a mechanical sieve shaker using standard sieve openings between 0.63mm-4.75mm. The shaker was

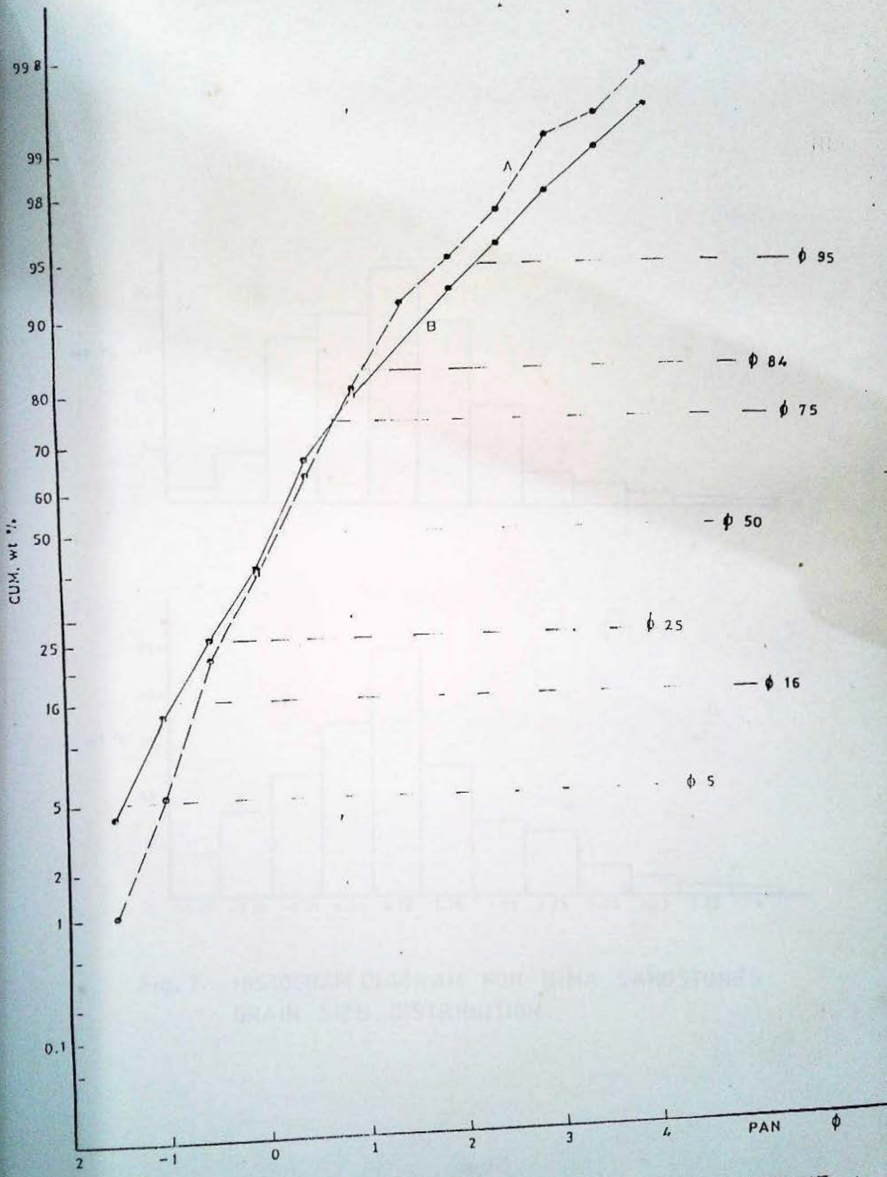


Fig. 6. CUMMULATIVE FREQUENCY PLOT FOR BIMA SANDSTONE.

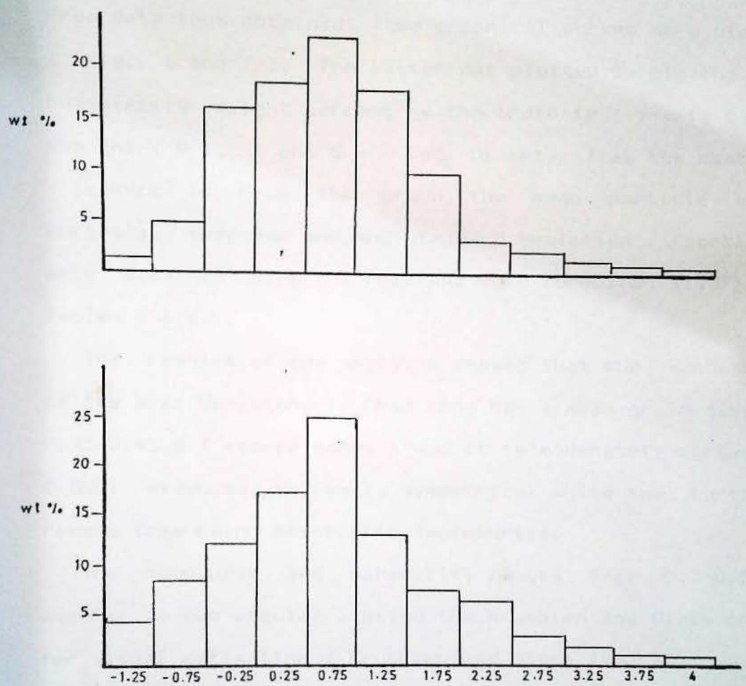


Fig. 7. HISTOGRAM DIAGRAM FOR BIMA SANDSTONES GRAIN SIZE DISTRIBUTION.

switched on for 30 minutes. After which the seperated grains retained in each sieve was collected and weighed. From data thus obtained, two graphical curves were plotted (fig. 6 and 7). The latter was plotted by placing the cummulative weight percent as the ordinate (y-axis) and the phi (Ø), (phi Ø = - $\log_2$ Diameter) as the abscissa (x-axis). From the graph the mean particle size, Kurtosis, skewness and and standard deviation (sorting) were obtained using the Folk and Ward formulae (1957). (Tables 5 & 6).

The results of the analysis showed that the sandstones of the Bima Sandstone in Cham area has a mean grain size of 0.35-0.45 Ø (coarse sands) and it is moderately sorted (0.890) skewness is nearly symmetrical while the kurtosis ranges from being mesokurtic-leptokurtic.

The roundness and sphericity ranges from 0.3-0.5 (angular to sub angular) using the Krumbien and Sloss'chart for visual estimation (Krumbien and Sloss 1963).

3.2. YOLDE FORMATION (SANDSTONE PETROGRAPHY).

Composition of the sandstone of the Yolde Formation was done by the use of hand specimen and thin section studies.

The hand specimen studies showed the sandstone to be medium to very fine grained and the colour varies from cream brown to green. The only mineral noted in hand specimen are quartz grains. The rock samples are loosely compacted.

Thin-section studies shows that the sandstone contains about 70% - 80% quartz minerals, 3-5% calcite crystals, 10% glauconites and 5% mica flakes. The quartz minerals are sub rounded to rounded (Plate 7).

The sandstone is a quartz-arenite Pettijohn (1963) based on its framework composition.

3.2.1. DIAGENESIS AND ITS EFFECTS.

Diagenetic effects observed in the sandstone of the Yolde formation are compaction and cementation.

Evidence of compaction was shown by the presence of deformed mica flakes within the rock. Cementation of the rock was by quartz and calcite crystals.

Authigenesis, the development of a new mineral within a a sediment (Krumbien and Sloss 1963) is believed to be responsible for the glauconite present in the rock; which is believed to form in a variety of ways; by subaqueous alteration of biotite, formed from diatom tests and by replacement of feacal pellets (Moorhouse 1959).

3.2.2. TEXTURAL ANALYSIS.

The same procedures used in the sieve analysis of the Bima sandstones were used for the Yolde sandstones.

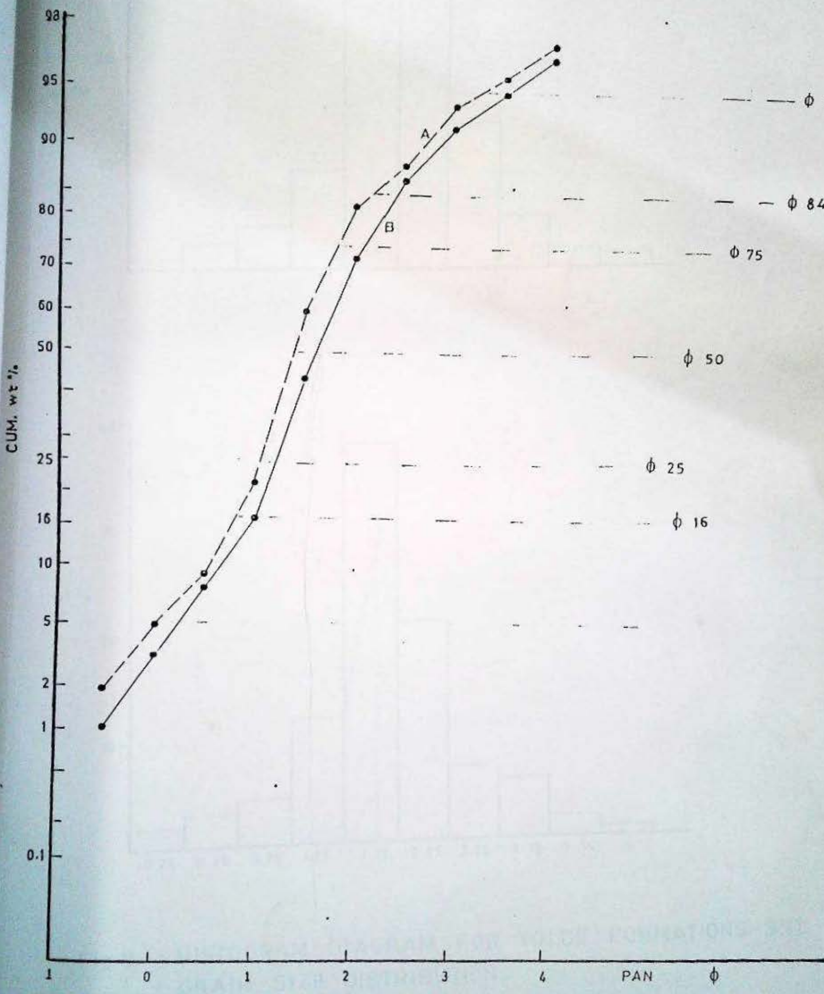
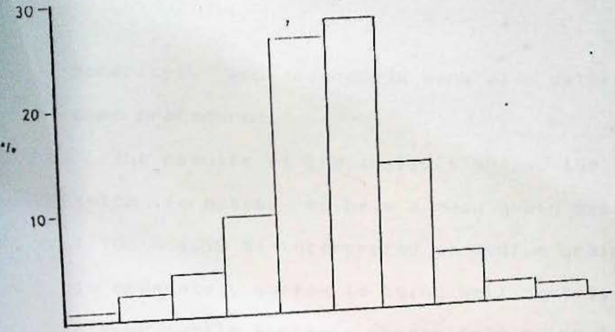


Fig. 8. CUMMULATIVE FREQUENCY PLOT FOR YOLDE FORMATION'S SST.



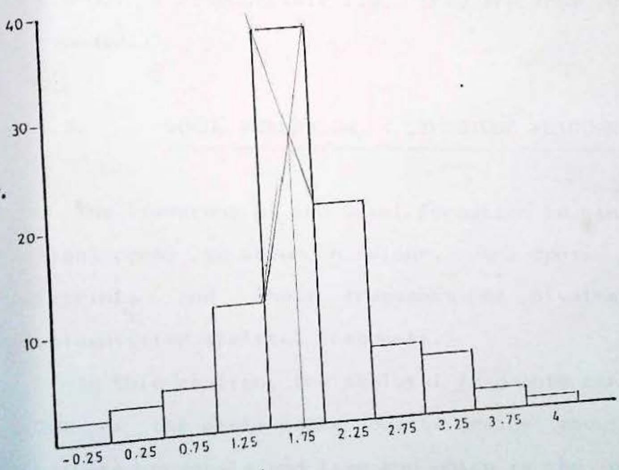


Fig. 9. HISTOGRAM DIAGRAM FOR YOLDE FORMATION'S SST. GRAIN SIZE DISTRIBUTION.

Sphericity and roundness were also determined using the same procedures.

The results of the analysis showed the sandstones of the Yolde formation to have a mean grain size ranging from (1.70 - 1.90 Ø) interpreted as medium grained sands and it is moderately sorted to being well sorted, it is positively skewed while kurtosis ranges from being leptokurtic - very leptokurtic. (Tables 3 & 4) (Figs. 8 & 9).

Roundness and sphericity ranges between (0.3-0.5) and (0.5-0.7) respectively i.e. they are from subangular to rounded.

3.3. DUKUL FORMATION (LIMESTONE PETROGRAPHY).

The limestone of the Dukul Formation in hand specimen is light grey to brown in colour, very dense and contains imprints and shell fragments of bivalves and some unidentified skeletal fragments.

In thin-section, the skeletal fragments constitute about 30% of the whole rock, quartz grains about 1%, Sparry calcite crystals and lime-mud which is the ground matrix about 50%. There is the presence of ostracod shells which are infilled with sparry calcite and micritic calcite.

The limestone is classified as Wackestone (Dunham 1962) or Biomicrite (Folk 1959).

3.3.1. LIMESTONE DIAGENESIS.

The limestone lithofaces have been variously affected by diagenetic process of recrystallization, compaction and dissolution.

Recrystallization has altered part of both the matrix and the shell fragments, they are transformed to sparry calcite in some places. However, the recrystallization was brought about by compactional stress and pressure of overburden. This was observed by the sparry-calcite appearing as fillings along lines of fracture that extends from the matrix into the shell fragments.

Dissolution effect is common in skeletal grain cavities. These include ostracod shells infilled with sparry-calcite crystals. Compaction however, is the most common diagenetic effect in the limestone. Though the rock is dense without presence of pore spaces, compaction is observed by the splitting into complimentary parts of a single shell that has been fractured and displaced and also in the compression of ostracod shells. (Plate 8)

.4. JESSU FORMATION (MUDSTONE PETROGRAPHY).

The mudstone of the Jessu Formation are light green to rown in colour. Some of the hand specimens show casts and oulds of bivalves and other skeletal fragments. Apart from he shell fragments, the mineral grains are too fine to be dentified in hand specimen.

However, thin section analysis shows the rock to contain 0% quartz minerals which are subangular to subrounded and rains are quite small about 0.075mm . Calcite crystals resent in the thin section is about 10%, glauconite about % which are rounded and the colour is green to light rown. Clay is the matrix material. Also present within the lay are ostracod shells infilled with clay.

.5. INTRUSIONS (BASALT PETROGRAPHY).

The basalts in hand specimen is flinty, and hard. They re black in colour, fine grained with phenocrysts of livine.

In thin section,the basalts shows phenocrysts of olivine nd pyroxene (augite variety) and iron oxides. The livine occurs also as small, rounded crystals.

The pyroxene is an augite variety and it is weakly oned.

TABLE 3a.

SIEVE ANALYSIS DATA FOR THE SANDSTONE OF YOLDE FORMATION.

SAMPLE A.

Phi (Ø)	weight	cumm.weight	cumm.percentage
-0.25	0.95	0.95	0.95
0.25	2.36	3.31	3.31
0.75	4.53	7.84	7.84
1.25	9.61	17.45	17.45
1.75	26.86	44.31	44.31
2.25	28.04	72.35	72.35
2.75	14.19	86.54	86.54
3.25	5.18	91.72	91.72
3.75	2.21	93.93	93.93
4.00	1.81	96.74	96.74
PAN	3.22	99.96	99.96

TABLE 3b.

SAMPLE B.

Phi (Ø)	weight	cumm.weight	cumm.percentage
-0.25	1.91	1.91	1.91
0.25	2.79	4.7	4.7
0.75	4.38	9.08	9.08
1.25	12.29	21.37	21.37
1.75	38.13	59.5	59.5
2.25	21.51	81.0	81.0
2.75	6.87	87.88	87.88
3.25	5.87	93.75	93.75
3.75	2.18	95.93	95.93
4.00	1.35	97.28	97.28
PAN	2.72	100.00	100.00

TABLE 4.

SUMMARY OF SIZE STATISTICS FOR THE SANDSTONE OF YOLDE FORMATION SAMPLES.

	SAMPLE A	SAMPLE B
MEDIAN (Ø50)	1.65	1.85
MEAN (Mz)	1.72	2
	medium sands	fine grained sands
SORTING (σ)	0.85	0.83
verbal term	moderately sorted	moderately sorted
SKEWNESS (SK)	0.147	0.165
verbal term	positively skewed	positively skew-ed
KURTOSIS (KG)	1.69	1.46
verbal term	very leptokurtic	leptokurtic

TABLE 5a.

SIEVE ANALYSIS DATA FOR BIMA SANDSTONE.

SAMPLE A.

Phi (Ø)	weight	cumm.weight	cumm. percentage
-1.25	1.1	1.1	1.13
-0.75	4.46	5.56	5.73
-0.25	15.94	21.5	22.13
0.25	18.25	39.75	40.83
0.75	22.64	62.39	64.13
1.25	17.74	80.13	82.33
1.75	9.94	90.07	92.53
2.25	2.90	92.97	95.53
2.75	2.20	95.17	97.83
3.25	1.18	96.35	99.03
3.75	0.46	96.81	99.5
4	0.24	97.05	99.75
PAN	0.1	97.15	100.00

TABLE 5b.

SAMPLE B.

Phi (Ø)	weight	cumm.weight	cumm.percentage
-1.25	4.26	4.26	4.3
-0.75	8.56	12.8	12.95
-0.25	12.1	24.92	25.17
0.25	17.3	42.22	42.65
0.75	24.3	66.52	67.2
1.25	12.46	78.98	79.79
1.75	7.5	86.48	8.37
2.25	5.94	92.42	93.37
2.75	2.84	95.26	96.24
3.25	1.93	97.19	98.19
3.75	0.91	98.1	99.11
4	0.61	98.71	99.73
PAN	0.24	98.95	100.00

TABLE 6.

SUMMARY OF SIZE STATISTICS FOR BIMA SANDSTONE SAMPLES.

SAMPLE NO	SAMPLE A	SAMPLE B.
MEDIAN (Ø)	0.45	0.35
MEAN (Mz)	0.45 coarse sands	0.383 coarse sands
SORTING (σ) verbal term	0.89 moderately sorted	1.04 moderately sorted
SKEWNESS (SK) verbal term	0.086 nearly symmetrical	0.083 nearly symmetrical
KURTOSIS (KG) verbal term	0.990 mesokurtic	1.17 leptokurtic

Plate 1. Planar Cross beds of the Bima Sandstone

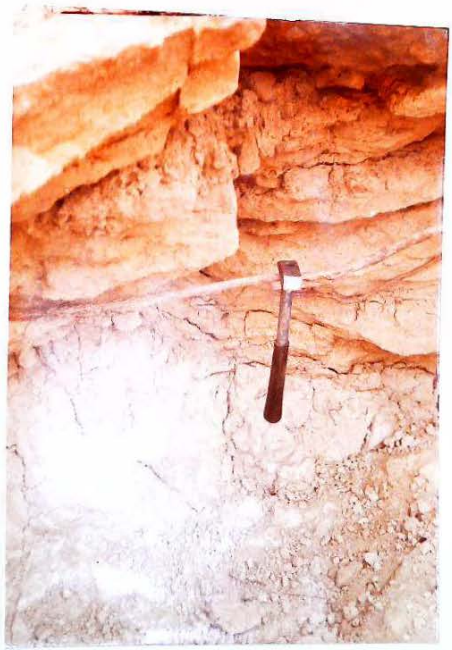


Plate 2. Mudstone bed Overlain by Sandstone in Yolde Formation

Plate 3. Alternating mudstone and Shale Sequence of Jessu formation

Plate 4. Current ripple Marks of the Yolde Formation

Plate 5. Fault Plane in Jessu Formation Showing the displaced mudstone beds.

Plate 6. Current ripple-Marks of the Basal Sandstones in Jessu Formation showing horizontal burrows.

Plate 7. Quartz Minerals in the thin Section of the Yolde sand stone.

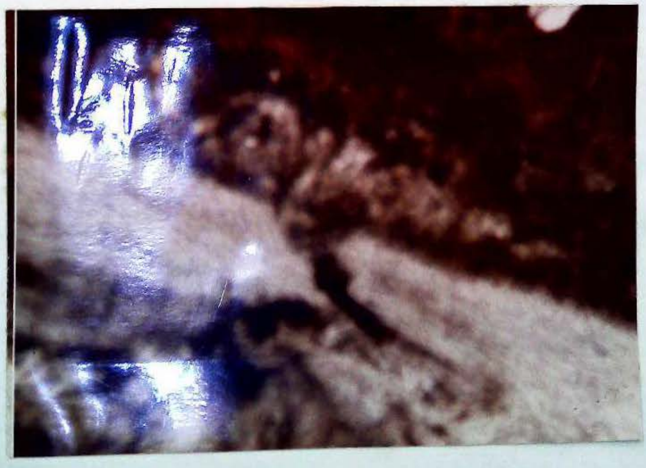


Plate 8. Evidence of Compaction in the Limestone of Dukul Formation, Show fractures of skeletal fragments.

CHAPTER FOUR.

4. STRUCTURAL GEOLOGY.

INTRODUCTION.

The observed structures in the area are both tectonic and sedimentary. However, the dominant structures are sedimentary while the tectonic structures are minor.

4.1. SEDIMENTARY STRUCTURES.

Sedimentary structures can be reffered to as those structures in sedimentary rocks formed either contemporaneously with deposition as primary structures or after deposition as secondary structures. Sedimentary structures are useful indicators of environments of deposition. They shed light on the energy state and depth factor of the environment as well as the paleocurrent directions.

Sedimentary structures found in the area include :-

4.1.1. GRADED BEDS.

There is a textural gradation in the materials;

In this type of structure, each individual laminae has a coarse detritus at the base and finer materials at the top and this is repeated for subsequent stratum. This type of structure abounds in the South western part and other parts of the South of the mapped area (Bima Sandstone). Thickness ranges between 9-15cm.

This type of structure is probably due to seasonal waning of current flow.

4.1.2. PLANAR BEDS.

Stratification or layering is probably the most fundamental and diagnostic feature of sedimentary rocks, (Selley,, 1978).

The difference between the beds in the field were easily seen due to the flaggy nature of the sandstones of the Yolde formation in which this type of bed is common. The thickness of the beds ranges between 6-12cm.

4.1.3. CROSS BEDS.

Cross beds are found to be common in the Bima sandstones. They vary in sizes and are of two types; trough and planar cross beds (Plate 1).

This type of large scale cross beds implies that the transporting current was strong. This inference was drawn on the basis of Allen's (1963) view that angular or tangential forsets are characteristic of fast flowing river currents. This inference was supported by feild evidences in which large scale crossbeds occurred in the coarse grained sands of the Bima sandstone.

Micro-cross laminations was observed in the sandstones of the Yolde formation. The thickness of these beds ranges between 6-7cm while the thickness of individual laminae is between 3-6mm.

The paleocurrent direction of the Bima sandstone using the crossbeds is found to trend in 2 major directions W.N.W. and S.W. (fig.5).

4.1.4. RIPPLE MARKS.

The ripple marks observed in the mapped area are in the Bima sandstones, sandstones of the Yolde formation and the basal sandstones of the Jessu formation (Plates 4 and 6).

The ripple marks observed common to all is a type of assymetrical ripple mark. Tanner's (1967) parameters for distinguishing ripple marks was used to distinguish them. The results showed their continuity index (CI) which is the crest length divided by the mean spacing between crest to be between 5.215 and 6.74 and the interpretation according to Tanner is about 85% current formed.

4.2. TECTONIC STRUCTURES.

The tectonic structures give indication of the deformational forces which may have influenced the rocks in the mapped area. The tectonic structure noticed was only minor faults.

4.2.1. MINOR FAULTS.

The fault displacements was noticed in the beds of the Jessu formation and it is a normal fault.

The fault shows a predominant E-W direction and the displacement is between 18-24cm (Plate 5).

TABLE 7.

FREQUENCY TABLE FOR THE PALEOCURRENT DIRECTION FOR BIMA SANDSTONE.

CLASS	FREQUENCY	PERCENTAGE	SCALE 5° = 1cm.
0 – 30	3	13.5	2.7
31– 60	2	9	1.8
61– 210	–	–	–
211– 240	7	32	6.4
241–270	–	–	–
271– 300	7	32	6.4
301–330	3	13.5	2.7
331–360	–	–	–

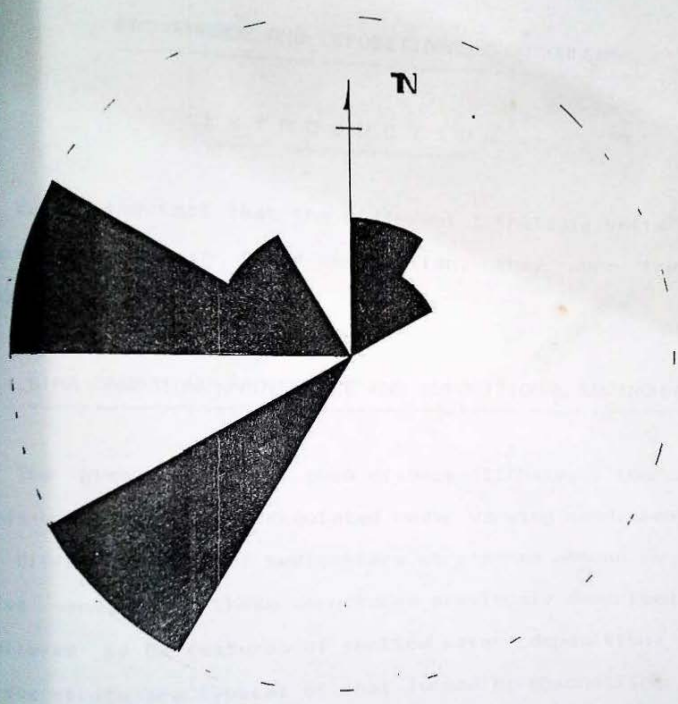


Fig. 5. Paleocurrent direction for Bima Sandstones.

CHAPTER FIVE.

5. PROVENANCE AND DEPOSITIONAL ENVIRONMENTS.

INTRODUCTION.

Due to the fact that the different lithologic units are quite diverse in their composition, they were treated individually.

5.1.BIMA SANDSTONE:PROVENANCE AND DEPOSITIONAL ENVIRONMENTS

The Bima Sandstones show diverse lithology therefore this unit must have accumulated under varying conditions.

Different types of sedimentary structures abound in the Bima sandstone, these structures previously described are believed to be features of shallow water deposition. The cross strata are typical of that formed by channelling and steady deposition in point-bars, likewise the graded beds. Since the ripple marks are current formed, they are believed to be of river flood plains. From the above, it is highly probably that fluviatile conditions predominated in the greater parts of the deposition of the Bima sandstones.

With the high feldspar content, and the angular to sub angular nature of its quartz mineral, it is believed that the sediments had travelled a short distance and must have been derived from a nearby source. Since the paleocurrent direction of the Bima Sandstone is predominantly West-North-West and South-West Fig.5, the source is likely to be from the basement rocks of the Bamenda massif to the west.

5.2. YOLDE FORMATION: PROVENANCE AND DEPOSITIONAL ENVIRONMENT

The sandstones of the Yolde Formation is flaggy and interbedded with mudstones. Two sets of micro laminations are present in the sandstone in the eastern margin and Cham town. Biogenic activities is common in the western parts and also in that part, glauconitic sandstones abound.

The above description of the Yolde Formation tends to lead into concluding that it is of a near shore shallow marine environment.

With the lack of feldspars and its relatively good rounding,

it is believed the sediments must have travelled far and in that process, the feldspars were removed due to weathering and however, since it is of a near shore environment, constant action of the waves in that type of environment would have helped removed the feldspars. Since the rounding of quartz grains which are hard resistant rocks cannot be achieved in one sedimentary cycle, it is believed that the sandstones of the Yolde formation were derived from pre-existing sand beds, possibly the Bima Sandstone.

5.3. DUKUL FORMATION.

The Dukul Formation is made up of an alternating sequence of shales and fossiliferous limestone which contains bivalves, ostracods and other skeletal fragments. The alternating sequence of shales and limestones presumably represents a slow deposition of terrigenous clastic influx into a restricted low energy shallow marine environment. The black shales represents anoxic bottom conditions and low energy.

The abundance of lime-mud and the presence of unbroken shell fragments indicates low energy and sheltered marine depositional environment. In the open marine or high energy marine environment, Winnowing effect of the waves would eliminate the lime mud present in the matrix of the limestone, and the shells would be broken.

5.4. JESSU FORMATION.

This is a lithologic unit with basal sandstones and alternating sequence of shales and mudstones.

The basal sandstones exposed in the canal section north of Cham town (fig.2) is fine grained and glauconitic containing horizontal trace burrows as well as associated current ripple marks (Plate 6). The mudstones are fossiliferous and contains poorly preserved. moulds of bivalves.

The basal sandstones represents deposition in a near shore marine environment, while the sequence of shale and mudstone is of a restricted low energy marine environment. The presence of gypsum in the shale might indicate high salinity conditions of the environment.

CHAPTER SIX.

6. ECONOMIC GEOLOGY AND HYDROGEOLOGY.

6.1. HYDROGEOLOGY.

The major and only perenial stream in the area is the river Cham and its tributaries and other rivers in the area, however, these are effemeral.

Presently under construction in the area is an artificial dam, it is the catchment area for the river Cham and the other streams draining the northern parts.

The Bima sandstone in the area provides considerable unconfined ground water reservoir. A borehole constructed by B.S.A.D.P. in 1982 taps water from the Bima Sandstone at 20-40 metres depth with modest yields. The permeability of the Bima sandstone is low due to the clay content of its matrix. However good water yield can be expected in the Bima Sandstone if major fractures caused by Tertiary tectonics in the basement can be intercepted (Wadrop report 1983).

6.2. ECONOMIC GEOLOGY.

The rocks of the Bima sandstone as well as the mudstones of the Jessu formation are widely used as building materials in the area.

Due to its lack of clay content, the sandstone of the Yolde formation is suitable for glass making and the mixing of concrete for construction purposes.

The limestone is very important in the construction industry as a building stone, for use as aggregate and road metal. It is much sort after in the metallugical industries. Limestone is also used as a fertilizer in the neutralizing of acid soil. And finally, it is invaluable for the manufacture of Portland cement.

Gypsum present is not in commercial quantity, but it is an important raw material in the manufacture of Portland cement. The shales of the Jessu formation are being used for brick production.

The basalts are used in the construction industries as road aggregate and for the earth filling of dams by the construction firm building a dam within the area.

CHAPTER SEVEN.

7. CONCLUSION.

The results of the present work has led to the following conclusions :-

The area around Cham town can be divided into four lithologic units.

(I) The Bima Sandstone.

(II) The Yolde Formation.

(III) The Dukul Formation.

(IV) The Jessu Formation.

The Bima Sandstones is medium to coarse grained subarkosic sandstones, it is texturally and minerologically immature.

It covers 28% of the mapped area. The Yolde Formation covers 15% of the mapped area. It comprises of medium to fine grained (quartz arenite) sandstone. The sediment is both texturally and minerologically mature. The sandstone is highly biotubated in some areas and locally glauconitic.

The Dukul and Jessu Formations which both make up over 50% of the mapped area are marine sediments. With the Dukul formation being a sequence of limestone and shales, while the Jessu comprises of basal sandstone, mudstones and shales. The limestone of the Dukul Formation is highly fossiliferous with the major diagenetic process affecting it being compaction and recrystallization. The mudstones of the Jessu Formation is fossiliferous containing poor casts and moulds of bivalves. The limestones and mudstones both contain varying amount of ostracods in their thin sections.

The depositional environment of the Bima Sandstone is of continental origin and it is believed to be derived from the basement rocks from the Bamenda massif due to its paleocurrent directions.

The Yolde Formation is believed to be deposited in a shallow marine environment, evidence supporting this, like biogenic activities, glauconitic sandstones abound in the Yolde Formation of the mapped area.

The Dukul and Jessu Formations are both restricted low energy shallow marine deposits.

After the deposition of the Dukul Formation there was a return to the type of transitional environment that formed the Yolde Formation and evidence for this was seen in the basal sandstones of the Jessu Formation.

The youngest rock in the area are the intrusive basalts which total eight in the mapped area and intrude only into the Dukul and Jessu Formations.

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