THE GEOLOGY OF THE AREA AROUND MAINAMAJI, ALKALERI LGA BAUCHI STATE, NIGERIA, SHEET 150 ALKALERI SE AND SW

BY

LONGMAAN NKUP BERNARD

JULY 1991

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JULY, 1991.

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DEDICATION:

This piece of work is dedicated to my Mother, Mrs. Epsan Eplong, who took all the pains to see that I complete my study, the whole Shinwul family and finally, to almighty God for making every thing possible for me during my study period.

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ABSTRACT

The area studied is located within latitudes $10^{0}00'N$ and $10^{0}34'N$ and longitudes $10^{0}04'E$ and $10^{0}06'E$ and it covers an area of about $33.0km^2$.

The area is underlain by both crystaline basement rocks and sedimentary rock. The Crystaline basement rocks consists of migmatitic gneiss complex, Granitic gneiss, Quartzites and Older Granite suite comprising of biotite granite, hornblende granite. The folding is dominant on the quartz ridges. The migmatituc . gneiss complex is thought to be the oldest group of rocks in the mapped area Brirrimian (2500m.y) or Liberian (2800m.Y) Cooray (1974).

The Older Granites in truded the migmatic gneiss complex during the pan African Orogeny (600 ± 150M.Y).

The sedimentary rock (Kerri-Kerri formation), is continental in Origin and is Paleocene in age. It overlies the Basement complex rocks unconformably. It is brown to buff in colour, angular to subangular grains, which suggest that the grains have not been transported far from the source, and is moderately sorted. It is also cross - bedded.

CHAPTER ONE

INTRODUCTION

1.1 Location, extent and Accessibility

The area mapped is bounded by longitudes $10^0 04'E$ and $10^0 06'E$ and latitudes 10°00'N and 10°34'N, and forms part of sheet 150 (SE & SW) of the Nigerian ordinaces surveys (Fig.I). It covers an area of about 33.0km². The are is fairly accessible and has a relatively good network of roads and foot paths. There is a tarred road in the area that stretches from Mainamaji - Duguri area. Another access road to the area is the Bauchi - Yankari tarred road. Also there are numerous foot paths in the are and this forms the major access roads in the mapped area. A number of cattle tracks also exist in the area, that give good access to the mapped AREA. The footpaths and cattle tracks were mostly used as traverse lines, while the Mainamaji - Duguri road formed the major acces road to the mapped area.

1.2 Relief and Drainage

The area is an undulating area lying between 370m and 400m above sea level, with isolating hills occuring in some places.

The farin Dutse hill is the highest peak in the area, about 480m above sea level.

The area is drained by many rivers and streams. Some of these rivers and streams are seeasonal, flowing in the rainy season and existing as gullies in the dry season. The drainage pattern is dendritic and cuts across the plains and hills.

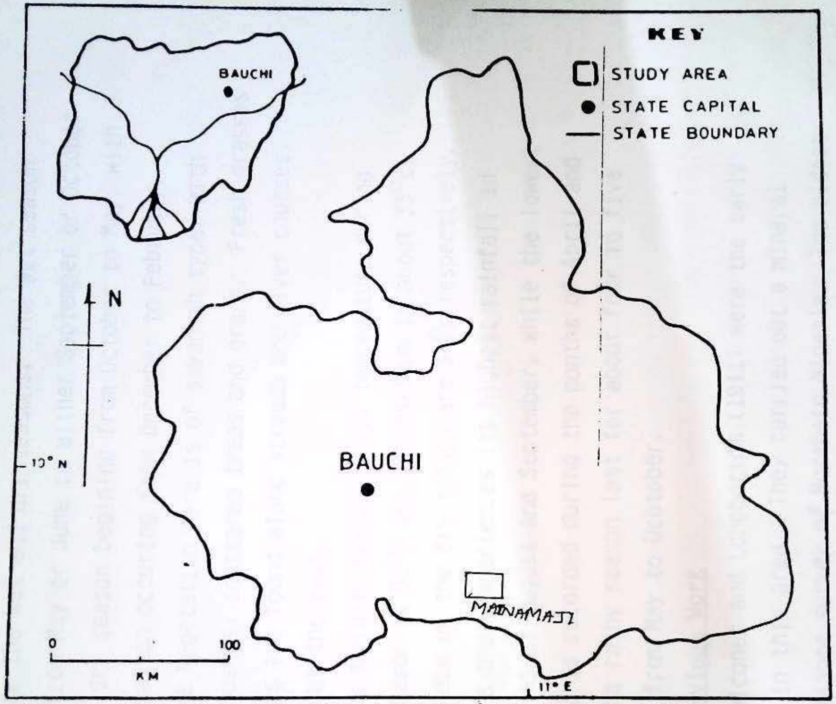


Fig. I. MAP SHOWING THE LOCATION OF STUDY AREA.

1.3 Climate and Vegetation.

The area is characterised by two distinct seasons. These are the wet and dry seasons. The wet season starts from May or June to either September or October and the dry season begining from October to May, with the Harmattan occuring from December to February.

The Vegetation here is of savannah type, with thorny bushes, scattered trees and grass. Fresh grasses and trees are found along streams and river courses, throughout the year.

The minimum average daily temperature during rainy season is 32^0c and the maximum is about 33^0c, while those of the dry season are 34^0c respectively.

The area experiences its highest rainfall in the months of August and September, while the lowest rainfall is recorded during the months of April and MAY. The rainy season last for about four to five months, from May to Ocotober.

1.4 Previous Work

Falconer and Longbottom (1911) were the early workers in this area. They carried out a mineral reconnaisance survey of Northern Nigeria. The oldest rocks recognised in Northern Nigeria was the Basement complex, which is made up of migmatites and gneiss intruded by the granitic rocks (Older Granites).

Carter et al (1963) also worked in Nothern Nigeria. They divided the Basement complex rocks into metasediments and Older Granites. Metasediments comprise rocks which are now transformed to migmatites and gneissis (anatectically), (Rahaman et al (1981) Onyeagocha (1984),these comprise of quartz - feldsparthic gneiss,biotite gneiss and hornblende ganites, and quartzites.

The Older Granites represent a cycle of granite evolution in which anatexis, granitization and migmatic actiVity are diaplayed. These include syntectonic granite, fine grained granite, coarsegrained granite, basic and intermadiate plutonic rocks and pegmatites Rahman et al (1981).

Carter et al (1963) also recognised that there is no record of sedimentation between precambrian and late mesozoic times. sedimentation started in the upper Cretacous in two basins; the Chad and Benue Basins, which are seperated by the Zambuk ridge.

Bima Sandstones are the oldest strata recorded, which are continental grits sandstones and clays, Carter et al)1963).

A wide spread marine transgression in the upper Benue trough during late Albian - Cenomanian times and this is characterised by thick Turonian marine shales. This led to the deposition of the Yolde, pindiga, Gongila and Fika shale formations, Carter et al (1963). Gombe sandstone was deposited in the Cretaceous, and the Kerri Formation which forms part of the maped area, was deposited in the paleocene Carter et al (1963), Wright (1976).

1.5 Methodology

The field work lasted from the 14th of April to 9th of June, 1991. The mapping was carried out using ground traversing with footpaths, cattle tracks, river channels and other paths forming the access routes into the project area. Stop - overs were made at all the exposures seen and structures such as foliations and lineations folds and joints were studied, with their strikes and dips taken. Samples were collected at each stop-over point, the location noted on the map and brief description of the rock made in the field note book. Any peculiar features seen in the field was also noted in the note book. Thin sections of the samples where prepared for detail petrographic studies in the laboratory.

The field equipment used were a geologist hammer, hand lens, a rock - sack for sample collection, eye goggle and a compass clinometer.

1.6 Aim of Project

The aim of the project is to produce an upto date geological map of the area by mapping the area in detail and delineating the contact between the different rock types. The lithologies, structural relationships and structures exhibited by the rocks are also to be studied. It is also aimed at training the student in the techniques of field mapping and accurate field reporting.

CHAPTER TWO

2.0 GENERAL GEOLOGY OF THE AREA

The area is underlain by both Crystalline and sedimentary rocks. The Crystalline rocks underlies most part of the mapped area, while the sedimentary rocks occupy only a small protion of the mapped area.

2.1 The Crystalline Basement Rock

The crystalline basement rocks consist of migmatite gneiss complex, Granites, Granite gneiss, Quartzites and pegmatites.

The migmatitic gneiss complex outcrops mostly along the streams and river channels. Some of these streams and rivers exist as gullies. The migmatitic gneiss complex comprise of biotite gneiss and magmatites. The granitic gneiss are found in the Southern part of the mapped area (around Tudun Wada). Biotite and hornblende granites make up the granitic rocks. The largest quartzite ridge is found in the Northern part of the mapped area. Also a small quartzite ridge about 0.5km in length is seen at lafiya , in the southwestern part of the mapped area.

The Crystalline basement rocks form the highest points in the mapped area. They occur as hills or inselbergs, and some are low lying. They are found extending from the northwestern to the southwestern part of the mapped area. These Crystalline basement rocks are termed the Older Granites, which intruded the basement complex. The migmatitic gneiss occur as low-lying hills and flatlying outcrops. The Crystalline rocks occupy about 70% of the mapped area. The contact between the quartzites and the gneisses is not exposed. The pegmatites have sharp contact with the crystalline rocks they invaded.

Joints, folds, foliations and lineations are seen in the crystalline basement rocks.

2.2 The Kerri Kerri Formation

The sedimentary rock in the mapped area is the Kerri Kerri Formation. It is deposited unconformably on the Crystalline basement rocks. The sedimentary rock extent from the Northeastern to the southeastern part of the mapped area and makes up the remaining 30% of the mapped area. In the field the outcrops occur as ridges which are disected forming large gullises in some localities. The Kerri Kerri Formation consist of sand with interbeds of clay. It is brown to buff in colour. Most of the exposures have been encrusted upon and have their structure destroyed. Few of the outcrops at Tudun Wada and Rapawa have cross-beeding,planar beddings and parallel laminations.
The Kerri Kerri is loosely pack with clay Matrix. The grains area angular to subangular, fine to medium grains in nauture. It forms the flat-lying portion of the mapped area (Fig.2).

CHAPTER THREE

FIELD GEOLOGY AND PETROGRAPHY

3.1 INTRODUCTION

The mapped area is underlain mostly by Crystalline basement rocks, consisting of migmatitic-gneiss, Granitic gneiss, granites and Quaratzites. These all together constitute about 70% of the studied area.

The migmatitic-gneiss complex occupy about 40% of the studied area. Granitic-gneiss account for about 10% of the whole area mapped. 15% of mapped area is underlain by Granitic rocks; with the Quartzites occupying about 5% of the area.

Kerri Kerri Formation is the sedimentary rock unit in the mapped area, and it accounts for the remaining 30% of the mapped area (Fig. 2).

3.2 Crystalline Rocks

3.2.1 Migmatitic Gneisses

These gneisses are the dominant Crystalline rocks in the studied area and occupy the greater part of the mapped area (Fig. 2). They occur as low-laying flatish exposures and hills in the north-western part of the area. The hills are highly weathered with the low flatish exposures fairly fresh. These gneisses consist of paleosome which are dark and fine-grained gneiss, and neosome, which is leucocratic with coarse-grains. The paleosome is highly foliated with flakes of biotite defining the foliations. The foliation strike in the NNW-SSE direction. The neosome consist of pridominantly quartz and feldspar, and is medium-grained. Some of the neosome are concordant to the banding in the paleosome, while others are discordant and cross-cut the banding in the paleosome.

In some places, there are alternating bands, of dark (melanocratic) and light (leucocratic) minerals. These bands vary in thickness from 1Cm - 15Cm. Augen structures are seen in other places. Augen gneiss is found in flat-lying exposures along streams around Rapawa.

3.2.2 Petrography

The migmatitic gneiss is medium to coarse-grained with alternating bands of dark (melanocratic) and light (leucocratic) minerals. The melanocratic band is made up of mafic minerals such as biotite and hornblende while the leucocratic band consist of felsic minerals which are mostly quartz and feldspar.

In thin section, the rock contains about 35% quartz, 55% feldspar, 7% biotite, 3% iron-oxide figure 3(a). The quartz occur as subrounded grains.

Some of them are polycrystalline. The quartz shows undulose extinction due to strain. Their diameter range generally from 0.5mm - 3mm.

Microcline account for about 40% of the rock and occurs as irregular grains and varies 0.3mm - 2mm in length. It shows cross-hatched twinning, with two cleavage directions and is seen to be undergoing alteration to sericite.

In thin section, it contains about 55% quartz, 25% microcline, 10% plagioclase and 7% biotite (Fig.3(b). The quartz displays undulose extyinction, indication of strain.

Quartz occurs both as large and small interstitial grains (about 0.3mm - 3mm in diameter). Most of the grains are subhedral, white some are embedded, others have tripple junctions, with some being polycrystall ine.

Microcline occurs as irregular sub-rounded grains; and it is perthitic as a result of cross-hatched twinning, with two cleavage directions. The plagioclase feldspar shows simple albite twinning with one cleavage dirction. The feldspar and quartz have low relief.

Biotite occurs as tabular (3mm in length), in the rock. It is pleochroic from yellow to brown, with parallel eetinction. It has high relief.

Iron-oxide is the accessory maneral in the rock and it account for about 3% of the rock volume. It is dark under plane polarised light and under cross-nicole.

3.2.5 Biotite granite

This rock type constitutes about 1.5% of the mapped area. Biotite granite occurs as hills and as flat-lying exposures. They occur in northwest of Kungibar and Gogo villages and around lafiya villages.

Quartz veins and pegmatite veins exploit the week zones. They veins and dyke have sharp boundaries with the host rock. It is highly weathered. The rock is leucocratic and medium to coarse-grained. It consist mainly of quartz, feldspar and biotite. In hand specimen , it contains about 60% feldspar, 30 % quartz, and 10% biotite. The grains are some what equigranular.

3.2.6 Hornblende Biotite granite

Hornblende - Biotite granite underlies about 5% of the studied area. It occurs mostly in the western part of the area, occuring as hills and some are flat-lying. It is greyish in colour, and consists of hornblende and feldspar, quartz with some biotite. It contains about 60% hornblende, 20% feldspar, 12% quartz and 8% biotite, in hand specimen. It is medium to coarse grained.

3.2.7 Pegmatites

They occur randomly in the Crystalline rocks and are very common. They are light coloured and have sharp boundaries with the host rocks, suggesting that they resulted from infiling of pre-existing fractures cross-cutting both migmatitic gneiss and the Older Granites. They are simple pegmatites containing mainly quartz and feldspar. Some of them are concordant while others are discordant. They concordant types are parallel to the pre-existing structures in the host rock, while they discordant types cross-cut pre-existing structures in the host rock. They are coarse-grained, with no trace of economic mineral in them. Their size range from 5cm to about 1.5m in width, while some could be as long as 5m.

3.2.8 Petrography

In hand specimen, the rock is coarse-grained. It consit of quartz and feldspar. It is leucocratic.

In thin section, it contains 80% feldspar, 15% quartz, 4% biotite and 1% iron-oxide figure 3(c). The feldspar occur as lenticular grains which are irregular. It is perthitic as a result of cross-hatched twinning, with two cleavage drections, and shows inclusion of quartz and biotite.

Quartz occurs as sub-rounded grains (about 0.2mm-2mmm in diameter).

Some of them are polycrystalline and are zoned, with inclusion of biotite. The quartz shows undulose extinction due to strain. The quartz and feldspar have low relief.

Iron-oxide is the major accessory mineral identified. It is dark under cross-nicol and plane polarised light.

3.2.9 Quartzites

Quartzite ridges are found in the western part of the studied area, occuring as northeast-southwest trending ridges. They occupy about 5% of the mapped area. They are intensively folded and fractured. The folds are both open and tight folds base on the interlimb angles and have conjugate fractures. The Farin Dutse hill is the highest point in the area, about 450m above sea level. The quartzite is witish in colour, hence the name Farin Dutse. This quartzite ridge is about 3.5KM long. The quartzite ridges are believe to have been sweated out a long fault zones or shear zones. They have been shattered and recrystallized. The grains have undergone melonifization as a result of dynamic Metamorphism. The grains have tripple juncture as a result of recrystallization under directed pressure and low temperature. TheKungibar quartzite ridge is highly deformed.

3.3.0 Petrography

In hand specimen, the rock is essentially quartz, with coarse-grains. The quartzite is extensively fractured. The inter-locking grains are white to light brown which is due to ferruginisation.

3.3.1 Petrogenesis of the Crystalline Rocks.

3.3.1.1 The Older Granites.

Carter etal (1963) believed that the Older Granites represent a cycle of granite evolution in which anatexis, granitization processes and magmatic activity are displayed. They opined that the intrusive rocks are products of the anatexis of the surrounding Metasedimentary country rocks due to high-grade metamorphism.

Olarewaju and Rahaman (1981) suggested that the intrusive rocks were derived from sources other than anatexis of metasediments. Fitches et al (1985) described the Older Granites as high-level, I-typed intrusiond and suggested that they are the product of collisional processes related to subduction at the eastern margin of the West African Craton.

Mc Curry (1976) believed that the Older Granites intruded the Metamorphic basement of Nigeria during the Pan African Orogeny (600 ± 150 MY). Ajibade and Fitches, (1985) said that the major collisional event in the frontal region betweeen the passive margin of the West African Craton and the active margin of a continent to the east during the Pan African led to the widespread reactivation of the internal region and the emplacement of large volumes of granites.

Major rock types belonging to the Older Granites suite in the mapped area are biotite granite, hornblende-biotite granite and the pegmatites.

3.3.1.2 <u>The Migmatitic-gness complex</u>

The migmatitic gneiss is belief by some workers on the Nigerian basement complex, such as Olariwaju and Rahamen (1981), Carter et al (1963) as comprising largely of sedimentary series with associated ignous rocks which were altered by metamorphic, migmatitic and granitic processes. Mc Curry (1976) believed that these Older metasediments belong to the Brirrimian (2500MY), while Cooray (1974), believed that they are of Liberian (2800MY).

Similarity in the orientation of the fold axial plane and dip, with the foliation in the migmatitic gneiss complex, suggest a sedimentary origin for the biotite gneiss and the paleosome unit of the migmatite. On the other hand, an intrusive origin could be suggested for the migmatites; for the neosome components where the contact between the granitic neosome and the gneissic paleosome are some what sharp.

3.3.1.3 Quartzites

The quartzites are generally massive. It has been suggested that they may have probably resulted from the metamorphism of sandstone (Mbonu, 1974).This is supported by the open to tight folds with schistosity, found on the quartzites. It has also been suggested that they have been 'sweated' out along fault zones or shear zones (MC Curry 1970, 1973; Phillips, 1965), in the process, they have been shattered and recrystallised.

The similarity in the orientation of the axial plane of the folds and that of the foliation in the migmatitic gneiss complex shows that the structures may have been formed by the same phase of deformation. If this is so, the quartzites are probably meta-sedimentary relicts, which were resistant to migmatization processes.

In conclusion the origin of the different Crystalline rocks proposed by the different workers that have worked on the Nigerian basement complex, are in agreement with the field observations and the field studies that have been carried out.

The 'sweated' out along fault or shear zones model for the origin of the quartzites by MC Curry, (1970,73), Phillips, (1965), Ajibade and Mbanu, is most suitable. The various field observations made on the quartzites, support this fact. These quartzites are massive, they are schistose and mylonites were also seen. These observations are in agreement or the same with what was observed by MC Curry, (1970,73), Ajibade and Mbanu on the Malumfashi quartzite and that made by Phillips (1965) on a quartzite ridge in Central Uganda.

3.4 Sedimentary Rock

3.4.1 Kerri Kerri Formation.

The Kerri Kerri Formation is the sedimentary rock in the mapped area. It constitutes about 30% of the studied area (Fig.2). In the mapped area, it overlies the Basement complex uncomformably. This formation is generally believed to be low Tertiary (Paleocene) age and is continental in origin deposited under a wide range of conditions (fluvial and Lacustrine environments). The formation consist of Sandstone with interbed of mudstone. The sandstones are brown to buff in colour. It is fine to medium-grained. Grain size increases from bottom to the top. The sandstone is loosely packed and is friable and the grains are supported by clay matrix. It is restricted to the Southeastern part of the area. It occurs mostly as low hills (exposures). The grains are angular to subangular and it consist of quartz embedded in clay matrix. Cross-beddings, gradded beddings and parallel laminations are structures found in the sandstones. Most of the structures have been destroyed by organic activity, which have encrusted and burrowed the sandstone.

Carter et al (1963) are of the view that the sandstone must have been derived from a terrain of cretaceous sedimentary rocks. He reasoned that the similarities in lithology and sedimentary structures between the Kerri Kerri Formation and the Bima Sandstone support his suggestion, even though Bima Sandstone is coarser and is characterised by feldspartic sediments.

From the results of my work, I observed that there is no feldspar in Kerri Kerri Formation. The sandstone contains only quartz and iron oxide in thin section. The absent of feldspar may be attributed to the fact that feldspar is an unstable mineral, thus, get weathered easily.

Difference in mineral grain size between Bima sandstone and Kerri Kerri Formation, may not be used to disproof the derivation of the Formation (Kerri Kerri) from the Creataceous sedimentary rocks, as grain size also vary in same rock type. This fact may be due to the reduction in strength of current that deposited them. The similarity in structures can be sued to support the suggestion, with these observations, the derivation of the sandstone from a terrain of Creaceous sedimentary rocks, is supported.

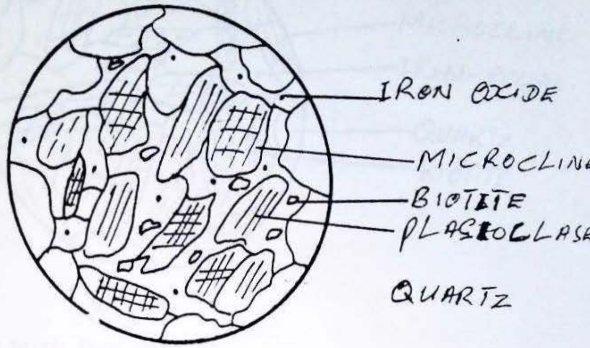
3.4.2 Petrography

In hand specimen, it is fine to medium-grained and is brown or buff in colour. The grains are angular to subrounded and the sands are moderately sorted. The mudstone is whitish in colour and is fine-grained. It contains clay, silt, fine sand, with Kaolinite as the dominant clay.

In thin section, it contains 85% quartz, 15% iron-oxide grains figure 3 (d). The quartz grains are subangular to angular. They show undulose extinctin, due to strain. The quartz have high relief.

The iron-oxide grains occur as angular to subangular grins. They are dark in plane polarised light and under cross nicol. The iron oxide and fine quartz grains form

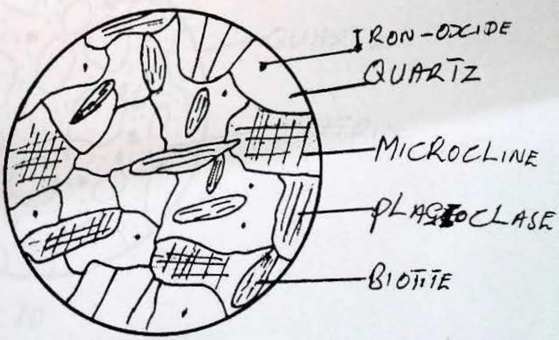
Fig. 3(a)



X 10

Migmatic gneiss in thin Section.

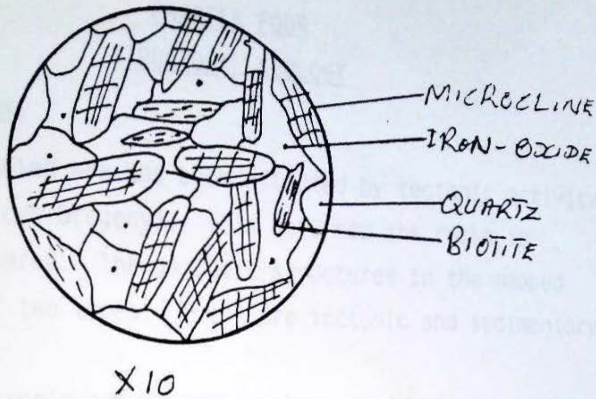
Fig. 3(b)



X 10

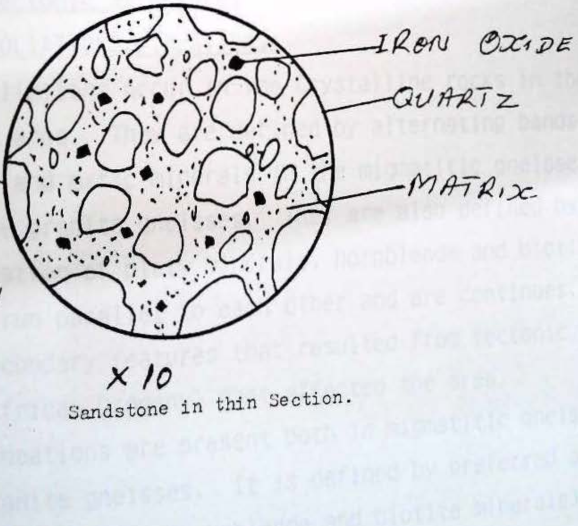
Granite gneiss in thin Section.

Fig. 3(c)



Pegmatite in thin Section.

Fig. 3d



Sandstone in thin Section.

CHAPTER FOUR

STRUCTURAL GEOLOGY

INTRODUCTION:

The studied are has been affected by tectonic activity (Pan - African Orogeny). This deformed the rocks in the mapped area. The geologic structures in the mapped area are of two types. These are tectonic and sedimentary structures.

The tectonic structures in the mapped area are; Fold; Joints, foliations/lineations and dykes/vein. The sedimentary structures include cross-bedding, graded - bedding, parallel bedding and massive bedding.

4.0 Tectonic Structures

4.1 FOLIATIONS/LINEATIONS

Foliations occur in the Crystalline rocks in the mapped area. They are defined by alternating bands of felsic and mafic minerals in the migmatitic gneisses and the granite gneisses. They are also defined by parallel orientation of platy minerals, hornblende and biotite, which run parallel to each other and are continues. Foliations are secondary features that resulted from tectonic activity (Pan-African Orogeny) that affected the area.

Lineations are present both in migmatitic gneisses and granite gneisses. It is defined by preferred alignment of mafic minerals (hornblende and biotite minerals). (Plate: 5).

4.2 FOLDS

Small scale folds are seen to occur in the quartzites at Kungibar and Southwestern part of Farin Dutse. They are open to tight folds with steeply punging axis. The folds seen in Farin Dutse is not as prominent as that of Kungibar quartzite. The Kungibar quartzite ridge have mean axial plane of 30%/178^{0}E. The Farin Dutse quartzite have mean axial plan of 59^0/153^0.

The Farin Dutse and the Kungibar quartzite ridges have similar fold orientations and may have been affected by the same phase of deformation. The folds are formed because of differences in response to the stress field by the quartzite ridges and also due to the intensity of the deformative force. Plasticity of the rocks also play important role in the formation of the folds, as another quartzite ridge in the southwestern part of the mapped area is not folded. This may be due to difference in response, plasticity of the quartzite ridge to the deformative force (Plate 6).

4.3 JOINTS

These are present in all the rock types in the studied area. Some occur as micro joints, while others are well developed joints. They have a dominent northwest - southeast, trend. These joint joints are secondary features which probably have been formed by techtonic activity, such as surface movement of rock or contraction due to shrinkage because of cooling. The joints are prominent in the quartzite ridges than in other rock types, due to their response to the deformative force. The quartzite ridges are highly fractured, especially the Kungibar ridge. The quartzite ridges have conjugate joints. Some of the joints are in the 285°WNW and 225° SW directions (fig. 4 e).

4.4 DYKES/VEINS

Veins occur both in the migmatitic gneisses, granite gneisses and the granites. They occur as quartz and pegmatite veins exploiting weak zones in the rock types. Quartz veins which are micro in size have sharp boundaries with the host rocks. Their sizes ranges from 5cm to 10cm in length, and 2cm to 3cm in width. They veins consist mainly of quartz. Pegmatite veins are the most dominant veins in the migmatitic gneisses. They have sharp boundaries with the host rocks. They consist mainly of quartz and feldspar and have coarse grains and are light coloured, some of the veins are discordant, while others are concordant. They result from infiling of pre-existing fractures. The concordant type are parallel to the pre-existing structures, while the discordant type cut across pre-existing structures in the host rocks, in different direction some of which are being NW-SE, NE-SW with the dominant direction being NW - NE

Dykes occur in the migmatitic gneisses and biotite granites. The dykes in the migmatitic gneiss are light coloured having sharp boundary with host rock. It is about 4m in width, while the one in biotite granites is about 5cm in width, and it consist of mafic minerals, which are fine grained.

These pegmatite veins are infiling of pre-existing fractures because their aporphysis are not found anywhere within the host rocks.

The pegmatite veins that are concordant with the regional trend are said to be older generation of pegmatites, based on the fact that they may have been formed at the time the rocks in the studied area were deformed. The discordant ones, which out across the regional trend are the younger generation of pegmatites. They may have been formed by letter phase of deformation that affected the area. (Plates 1, 2 and 7).

4.5 RAFT

Raft structure is found in the migmatitic gneiss. It is one in which the neosome is the dominant part of the rock and the paleosome floating on top of it (Plate 3)

4.6 Sedimentary Structures

These structures are related to the process that took place before, during or immediately after the deposition of the sedimentary rocks in the mapped area, they are not well expose, apart from the exposures at Tudun Wada and near Rapawa. Most of the exposures, along the river banks are seriously weathered. The sedimentary structures in the mapped area are cross-bedding, parallel bedding, graded-bedding and planar bedding. These structures are useful indications of environment of deposition, as they throw light on the depth factor, and the energy state of the environment, and paleocurrent direction of transporting media.

4.6.1 Cross Bedding

Cross - bedding is common in Kerri - Kerri sandstone. They are trough and planar cross-beddings and vary in size.

The trough and planar cross-beddings show that the transporting current was strong (allen, 1963). These cross beddings are found in coarse grain sands.

Carter et al (1963) is of the view that the cross-beddings found in Kerri Kerri sandstone is an indication of fluviatile and or deltaic conditions of the environment of deposition. Dike (1991) is of the view that, the sandstone is a braided river deposits, with the fining sequence formed in meandering river (figure 4 a' b').

4.6.2 Parallel Bedding

Bedding, layering or stratification is the most fundermental and diagnostic feature of sedimentary rocks (Selley, 1968). This is as a result of vertical variations in lithology, packing, orientation or grain size. Beds having different thickness, textures were observed in the Kerri Kerri formation.

The differences between beds may be attributed to the differences in grain size, due to the decrease or reduction in current strength.

4.6.3 Graded - Bedding

Graded-bedding was observed in the Kerri Kerri Formation, near Tudun Wada. It is due to the upward decrease in grain size in a bed; and is a shallow water deposit.

Formation of graded bedding could be attributted to gradual reduction in current strength (figure 4d)

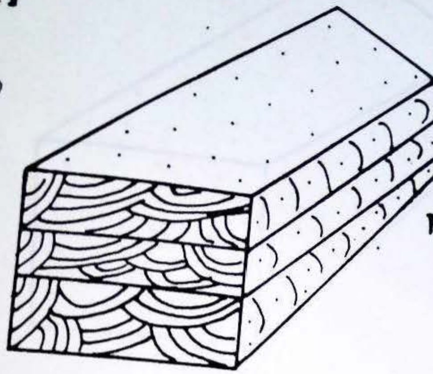
4.6.4 Massive bedding

In the mapped area, massive bedding were observed mostly in the river banks and in the gullies.

This occur where the sandstones are generally devoid of structures, that is the structures originally present have been destroyed. (fig. 2c)

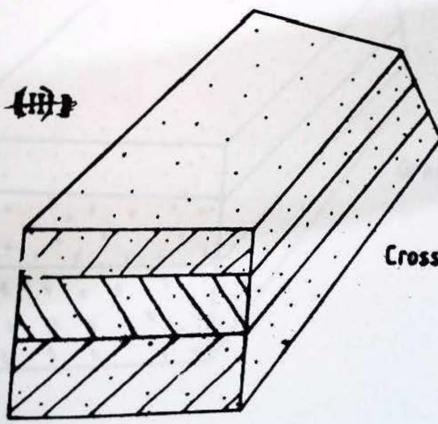
SEDIMENTARY STRUCTURES

Fig 4 (a)



Trough cross-bedding

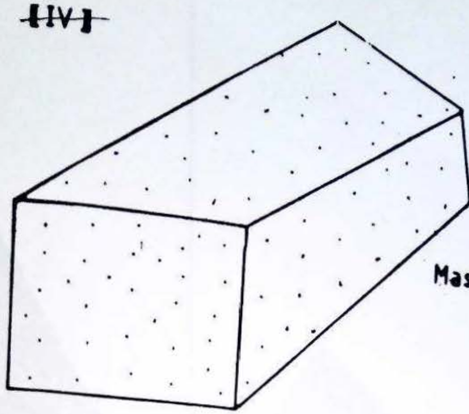
Fig.4 (b)



Cross-bedding

(IV)

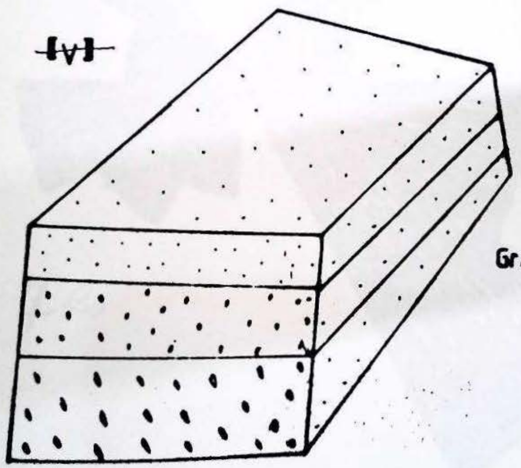
Fig. 4 (c)



(V)

(D)

Fig 4 (d)



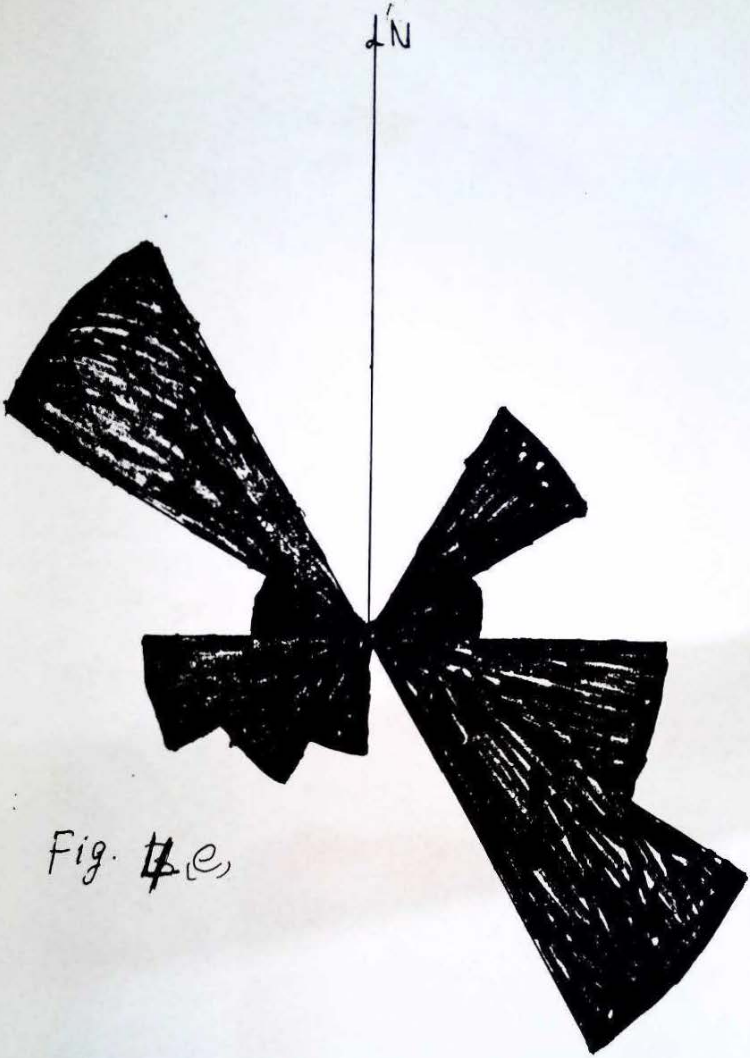


Fig. 4(e)

Rose diagram of Joint readings from Migmatitic gneiss complex and Granite gneiss Showing a dominant NW - SE trend.

Plate 1: showing pegmatite veins in granite gneiss

Plate 2: showing pegmatite vein in migmatitic gneiss.

Plate 3: showing Raft structure in migmatitic gneiss.

Plate 4: showing ~~massive~~ parallel Lamination in Kerri Kerri sandstone.

Plate 5: showing foliation in Migmatitic gneiss

Plate 6: showing Close Fold in Kungibor quartzite ridge

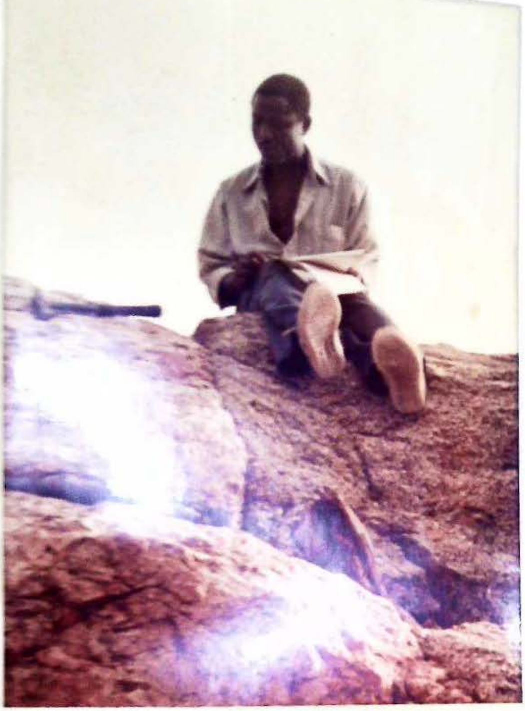


Plate 7: Showing pegmatite dyke in migmatitic gneiss

5.0 ECONOMIC GEOLOGY AND HYDROGEOLOGY

5.1 ECONOMIC GEOLOGY

5.1.1 MINERAL POTENTIALS.

In the mapped areathere is no occurence of mineral of economic importance, in the rocks. The pegmatites which suppose to have contain economic minerals, are simple pegmatites. Minerals of economic importance are found only in complex pegmatites if the fractionation path of the magma leads to its formation, also the composition of the magma, is very important in the occurence of the minerals. Because of their simple nature. They contain no economic minerals. Simple pegmatites are quartz-feldspar rocks, thus have no ore-bearing potential. The pegmatites in gneisses resulted from segregations from metamorphic fuilds, while those in migmatites are from rocks which are non-ore-bearing and therefore not mineralised. The pegmatites occuring in granites are magmatic in origin and could have bear ore minerals, but this is not the case in the studied area. This could be attributed to the composition of the original magma; which may have no ore minerals. Also, the fractionation path of the magma did not allow for ore-bearing. The fractio-nation path seem towards quartz enrichment, which led to the formation of simple pegmatites, which are barren.

The Kaolin-rich clay stone and Kaolinite bands of the Kerri-Kerri formation, may be useful raw materials in industries depending on its grade. The clay of the Kaolinites is used for stone ware, white ware, sewer s and refractories. Pure Kaolinite is used for ting ink, . paper, leather paint, plastics and rubber m 1962).

2 Construction/Building Materials

The jointed nature of the Crystalline rocks, makes loitation easier and they can be used for construction poses. For example, the medium-grained and coarse ined granite can be quarried and used for side walls, arkment for dams, railway blast, for road and building truction, in making concrete blocks (the sand dust). e large quantities of river sands along the rivers n be used for packing bore holes and also for concrete xtures, for plastering due to their rounded surfaces. ey could also be used in the glass industries, if ean.

The quartzites, could be quarried and used as abrassive. ne Kerri - Kerri is used for building hots and the lluvium in the area is used for farming.

An important point to bear in mind is that the ine-grained granite is preferable for construction ork over the coarse-grained granites, this is because the coarse-grained grainite have cleavages thus, can not withstand pressure because of the lines of weakness so developed. Also, the felsic granitic rocks are preferred over mafic ones, because the mafic minerals are easily weathered to clay minerals. Because of this, they can not withstand changing conditions and pressure.

5.2 HYDROGEOLOGY

The mapped area is underlain by Crystalline basement rocks and sedimentary rocks Areas underlain by the crystalline rocks are poor in ground water storage. In the crystalline rocks, water is stored in the weathered, fractured, fissures and brecciated zones.

Kerri - Kerri Formation is known to form good aquifers with variable transmissivity (Dupreez & barber (1965), Dike and Danhassan, (1990), Dike (1988) and yields depending on the degree of sorting and thickness of the sands, laterisation, clay content, and degree of ferruginous cementation.

The depth of weathered zone in the basement complex varies depending on the composition of the parent rock.

The studied area is drained by seasonal streams which over-flows their banks only in the rainy season, and dry up during the dry season. In the course of the field work, a part from the sluggish flow observed in some of the rivers, other streams were dried up.

In the dry season, water is obtained from small pools and pits sunk along dry stream channels, and from boreholes constructed by the government.

CHAPTER SIX

6.1 Summary and conslusion

The mapped area is underlain by two main rock types; these are the Crystalline basement rocks and sedimentary rock. The Crystalline basement rocks consists of the migmatitic gneiss, Granitic gneiss quartzites and older granite. The sedimentary rock in the area is the Kerri - Kerri Formation (Fig. 2).

The migmatitic - gneiss complex and quartzite are of sedimentary origin. Also, it has been suggested by MC Curry, (1970, 73); Phillips (1965) that the quartzites have been sweeted out along fault zones or shear zones; while the Older Granites are said to be intrusive rocks.

Foliations, folds and joints which are tectonic in origin are common in the Crystalline rocks. They suggest that the area have been metamorphosed and deformed by the Pan-African Orogeny.

The folding on the two quartzite ridges are probaly due to the same deformational phase. In the mapped area, the relationship between the rock units of the basement complex is not certain.

The sedimentary rock (Kerri - Kerri Formation), derived its source from the underlying basement rocks (Older Granites). The angular to subangular shape of the grains shows that its source is close by, that is the grains have not been transported far from its source.

Because the clay unit of Kerri Kerri Formation is easily eroded when high current regime is re-established in the depositional environment, it is less extensive compare to the sandstone.

In conclusion, a more detailed geological mapping of the area should be done. This will go a long way to solving the unclear relationship between the different rock types, in the mapped area; especially the age relationship between the quartzites and the migmatitic gneiss complex.

FOLIATION READINGS IN GRANITE GNEISS

DIP	STRICKE
71^0SE	029
67^0NE	335
75^0SW	131
81^0NW	254
77^0NW	243
80^0SE	040
76^0SE	030
86^0SE	304

FOLIATION READINGS IN MIGMATITIC GNEISS

DIP	STRICKE
55^0NE	277^0
51^0NE	288^0
50^0NE	283
45^0NE	310
52^0NE	335
40^0SE	321
81^0SE	319^0
80^0NW	219^0
75^0NE	343
70^0NW	200

JOIN READINGS IN MIGMATITIC GNEISS COMPLEX

CLASS	FREQUENCY
0 - 30	0
30 - 60	5
60 - 90	2
90 - 120	6
120 - 150	9
150 - 180	0
180 - 210	2
210 - 240	3
240 - 270	4
270 - 300	2
300 - 330	8
330 - 360	1

FARIN DUTSE QUARTZITE RIDGE FOLD AXIS READINGS.

DIP	STRIKE
61^0 SE	006^0
72^0 SE	007^0
70^0 NE	331^0
59^0 NE	312^0
70^0 SE	057^0
60^0 NE	310
56^0 SE	032^0

KUNGIBAR QUARTZITE RIDGE FOLD AXIS READINGS.

DIP	FREQUENCY
24° SE	135°
08° SE	130°
30° NE	250°
25° NE	302°
28° NE	349°
10° NE	275°
20° SE	070°
60° SE	053°
69° SE	018°

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