PETROGRAPHIC STUDIES AND STRUCTURAL ANALYSIS OF THE MIGMATITES AROUND GUBI AREA PART OF SHEET 149 BAUCHI NE

BY

ABDULLAHI SALISU ALI
13/32135/U/1

APRIL 2018

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A PROJECT SUBMITTED TO THE DEPARTMENT OF APPLIED GEOLOGY, FACULTY OF SCIENCES, ABUBAKAR TAFAWA BALEWA UNIVERSITY BAUCHI.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF TECHNOLOGY (B.TECH) HONOURS IN APPLIED GEOLOGY

SUPERVISOR:

MALLAM UMAR SAMBO UMAR

APRIL, 2019

DEDICATION

I dedicate this work to my parents Mr. and Mrs. Abdullahi Ali Danchua, and also AdamaAbdullahi.

DECLARATION

I solemnly declare that this work was solely done by me under the guidance of my supervisor and sources of information were duly acknowledged through references.

....
Abdullahi Salisu Ali
(Student)

....
Date

This declaration is confirmed by

....
Mal. Umar Sambo Umar
(Project Supervisor)

....
Date

Certification

I certify that this report is an original work done by .... (......................) under my supervision, and has met the requirement for the award of bachelor of technology (Applied Geology) of Abubakar Tafawa Balewa University, Bauchi.

Supervisor

Name....................................

Signature..............................

Date...

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Date........ 16/04/2019 ....

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Signature..................................

Date. 16 – 04 – 2019 ....

ACKNOWLEDGEMENT

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ABSTRACT

The study area lies between latitudes 10^0 26′ 00″ N to 10^0 29′ 00″N and Longitudes 9^0 47′ 00″E to 9^0 51′ 00″E, the minerals observed in the rocks in hand specimen are quartz, feldspar, biotite and plagioclase. Thin section study of the sample revealed quartz, plagioclase, biotite, microcline, are the essential minerals found associated with the rock. The minerals found in the granite are; quartz, orthoclase, biotite, microcline, plagioclase, are the essential minerals in the rock. The migmatite sample contained quartz, orthoclase, microcline, biotite, plagioclase, as essential minerals. Outcrops in the area ranged from high to medium to low levels and the rock types classified in the area are the intrusive granite and the metamorphic granite-gneiss and migmatites which is classified based on structural, petrogaphic and textural properties. Geological structures observed in the mapped area are joints, dyke and veins trending mostly in the NW-SE, NE-SW and N-S direction indicating the effect of pan African orogeny.

TABLE OF CONTENT

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: MATERIALS AND METHODS

CHAPTER FOUR

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

LIST OF TABLE

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The Study area falls within the Nigerian Basement Complex and also gives a Picture of an extension of the schist Belt of Nigerian. The area occupies part of Sheet 149 Bauchi NE within latitudes N 10° 26'00" and N10° 29'00" and Longitudes 9° 47'00"E and 9° 51'00."E. The area comprise of Migmatites as the Major rock type with lots of interesting structures, the migmatization has been dated at 580±100ma (Ferre C.E, 2006). At the end of this study more advances and conclusions as to their occurrences, field relations, structural interpretations as Well as petro graphical information of the various rocks encountered will be provided.

This study focuses on mapping, structural analysis and petrographic studies of the rocks in the study area and also focuses on adding to what is obtainable in the present geology of Nigeria as regards the geology of Bauchi State and the North-Western basement at large.

1.2 Aim and objectives

The aims of the project are to investigate, comprehend and reproduce a systematic description of the rocks in the study area using thin sections, hand specimens and structural analysis. This study includes analyzing their mineralogies, textures, structures, and origin and field occurrences.

Generally the objectives of the work are as follows:

i. To produce vital and useful information on the geology of the Area around Gubi, Bauchi state. This information includes the structures, geology, rock types, also to identify and distinguish rock types of study area using petrography, field relations, mode of occurrences, color and observable mineralogy of the rock samples.

ii. To improve and review earlier works done in the area in essence to build On existing facts and produce a geological map of the study area.

This study is also expected to contribute to the understanding on the Evolution of the Nigerian Basement Complex.

1.3 Statement of the Problem

The study area is part of the Northwestern basement, and also one of the least investigated in the geology of Nigeria. This work will attempt to use surface mapping, structural analysis and petrographic studies to classify, analyze and provide more information on the Migmatization in the area.

1.4 Justification for the Study

Haven known that the study area is one of the least investigated of the Northwestern basement complex, it gave a need for the area to be Investigated so as to know more about the rocks in the study area in terms of structures, minerals present and also know the level of deformation as to add to existing information on the Northwestern basement.

1.4 Location, Extent and Accessibility

The study area lies within latitudes N10° 26'00" and N 10° 29'00" and Longitudes 9° 47'00"E and 90° 51'00" as seen in figure 1. Even though the work was done in the rainy season the area was quite accessible and the study area falls within the sheet 149 NE of Bauchi State. The area is accessible by a major road linking Bauchi to Kano and numerous footpaths to access the remote areas within the study area. The study area covers approximately 2.7 by 3.5 rectangular kilometers. The tallest outcrop within this area has an elevation of about 657m above sea level.

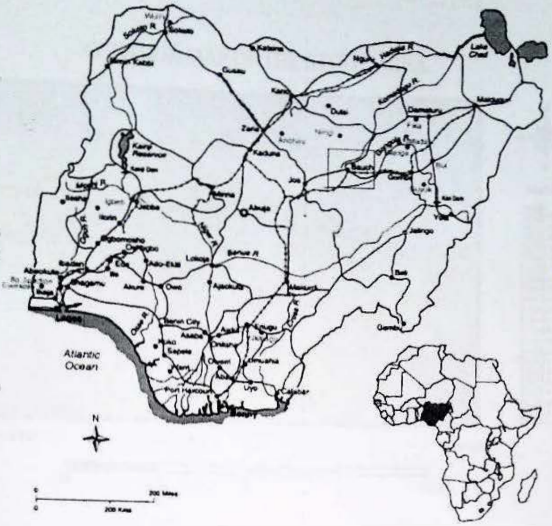


Fig. 1: Index Map of Nigeria showing Bauchi

1.6 Relief and Drainage

The area has appreciable relief and is characterized by high and low level outcrops. Most of the outcrops are conically shaped and have height ranges of 623 to 693 meters above sea level. The drainage pattern is dendritic (tree like) and the small streams in the area are controlled by the outcrops (structurally Controlled). The small streams empty their water into the Gubi River which forms a dam (Gubi dam) in the area.

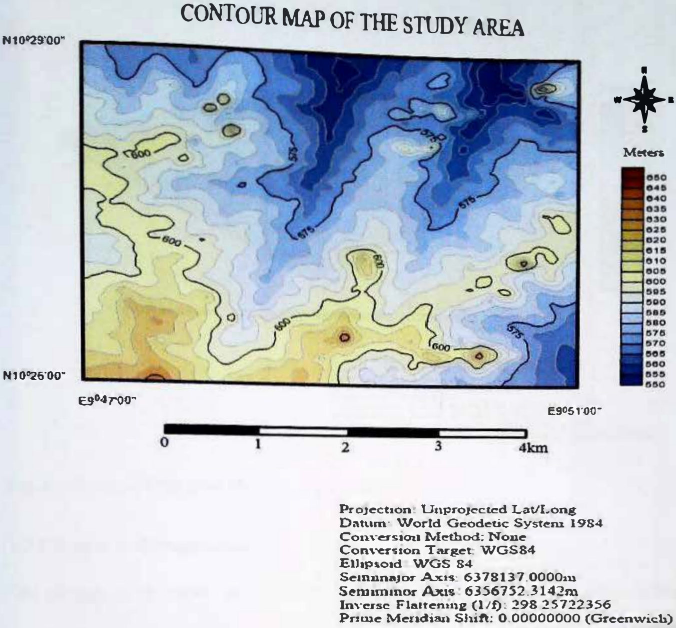


Fig.2:Contour map of the study area

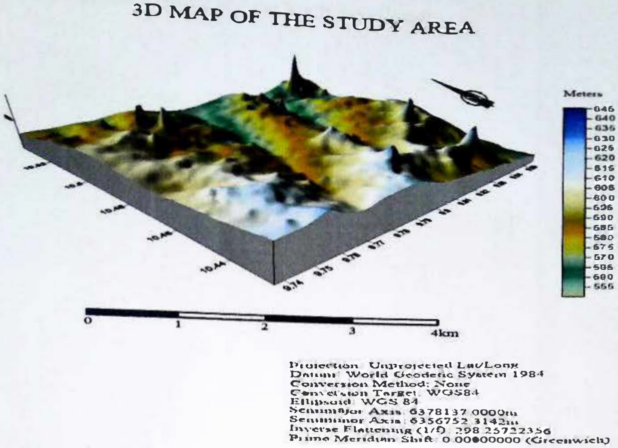


Fig.3: 3D map of the area showing elevations

1.7 Climate and Vegetation

The climate of the study area consists of a wet (rainy season) which extends FromMay/June to october with a temperature range of 25 to 37 degree Celsius (Data from NIMET 2004) and a dry season which is characterized by the harmattanform november/december to april/may as with a temperature range Of 29 to 45 degree (data from NIMET 2004).

The vegetation type is savannah and comprises of scattered trees, shrubs and mostly flat lying grasses as seen in the field.

1.7 Settlement and Land use

The major land use in the area is farming and Cattle rearing (Grazing) in some places not used for the farming purpose. The product of the weathering of the rocks in the area provides fertile soil for farming and the drainage systems provides soil moisture. These two factors make the area agriculturally viable.

The settlement here is mostly nucleated with scattered villages. The prominent village in the study area is the Gubi village and the Rudiyusa villages.

CHAPTER TWO

LITERATURE REVIEW

2.0 The Geology of Nigeria

Nigeria is situated in the West African sub-region and lies between longitudes 3^0 and 14^0 E and latitudes 4^0 and 14^0 N. It has a land mass of 923,768 km^2. It is bordered to the north by the Republics of Niger and Chad and to the west by the Republic of Benin. It shares the eastern boarders with the Republic of Cameroun down to the shores of the Atlantic ocean forming the southern limits of the Nigerian Territory. About 800km of coastline confers on the country the potentials of a maritime power. Arable land is in abundance in Nigeria for agricultural, industrial, domestic and commercial activities.

Although Nigeria is wholly within the tropics, its climate varies from the tropical at the coast to sub-tropical further inland. There are two marked seasons: The rainy season lasting from April to October and the dry season from november to march. The maximum temperature in the coastal areas of the south can go up to 37^0C while the approximate minimum temperature is 10^0C. The climate is drier further north where extremes of temperature may range from 40 to 50^0C.

The geology of Nigeria is made up of three major litho-petrological components, namely; the basement complex, younger granite, and sedimentary basins (Fig.).

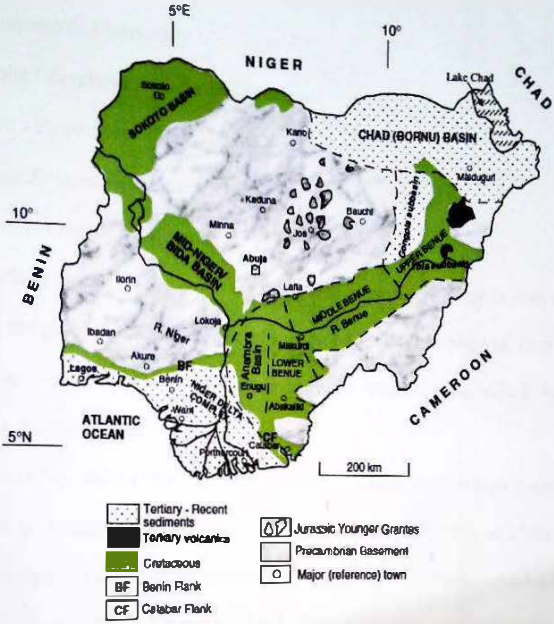


Fig. 4: Geologic Map of Nigeria Showing the Major Geological Components; Basement, Younger Granite, and Sedimentary Basins (Obaje, 2009).

2.1 General Geology of the Northern Nigeria Basement Complex

The Nigerian basement complex is situated in the pre-drift mobile belt defined by Kennedy (1964) east of the West African and Sao-Luis Cratons Northwest of the Congo and Sao-Fransciscocratons which was affected by the 550 ± 100 Ma Pan-African Orogeny. The entire belt lies in the reactivated margin of the West-African Craton and the active Pharusian Continental margin (Burke and Dewey, 1972; Black et al., 1972; Caby et al., 1981).

Northern Nigeria according to past literatures belongs to the Precambrian Basement Complex and is underlain by five major rock groups with the following relationships according to Olanrewaju (1976):

Volcanic: - Proterozoic-Quartenary

Younger Granite Complexes: - Triassic-Cretaceous

Older Granites: - Pan-African (550± 100 Ma)

Younger Metasediments: - (Schist-Belt)

Migmatite-Gneiss Complex: - Eburnean.

One of the earliest works on the basement complex of Northern Nigeria was done by Falconer (1911) during the general economic mineral survey of Northern Nigeria. During this survey he encountered the unusual Fayalite-uartz-Monzonite at Bauchi town which he described as a coarse-grained Augite Syenite.

Subsequent work by Bain (1926) established this unusual rock which belongs to the older grainite suites as Syenite. However, the distinctive feature of this unusual Fayalite-Quartz-Monzonite was first elaborated by Oyawoye (1978) and (1961) which named the unique Granitic rock as Bauchite after Bauchi town in 1965. Descriptions of the mineralogy of the normal Bauchite have been published by Oyawoye (1958, 1961 and 1962) and Oyawoye and Makanjuaola (1972).

Carter et al., (1963) discussed the older granites of Bauchi provinces of Northeastern Nigeria. He described veins of porphyritic biotite-hornblende-granite which cut and in places replaced fine-grained granites. He suggested that the fine grained granites are the oldest members of older-granite suite.

Marno (1971) however found Carter's suggestions as unusual. Furthermore, Carter (1963) also described Quartz-Diorite which belongs to the older-granite Series. Mac-Leod et al., (1971) compared the similarities between the Bauchi-quartz-diorite and the Toro- Hypersthene Diorite. They were all found to Possess similarities.

Eborall (1976) worked on the intermediate rocks from the older granite complex of Bauchi Area, Northern Nigeria. She recognized porphyritic Biotite-Hornblende granite, quartz, Hypersthene Diorite, migmatites and gniesses. She also suggested that the complex grades outward into a less mafic rock.

Kogbe (1989) worked on the geology of the northern part of Nigeria. He described the northern Nigerian as underlain by gneisses, migmatites and metasediments of Precambrian age which have been intruded by a series of granite rocks of late Precambrian to lower Paleozoic age. The oldest rocks are represented by series of older metasediments and gneisses believed to be of Birrimian and older ages. The rocks have been variably metamorphosed and granitised through at least two tectono-metamorphic cycles. They have been largely converted to migmatites and granite-gneisses.

Younger metasediments believed to be Upper Proterozoic in age were deposited in this granitic basement and folded along with it during the Pan-African orogeny. They are of low metamorphic grade and are now represented as synclinal troughs among older rocks in the North-west Nigeria (Rahaman, 1989).

Intrusive in the basement rocks and the younger supracrustal cover are series of basic, intermediate and acidic plutonic rocks known as the older granites. The youngest rocks in the area belong to a suite of volcanic rocks intruded into older granite bodies during the lower Paleozoic epeirogenic uplift following the Pan-African orogeny.

At least two phases of light isoclinal folding have been recognized in both the younger metasediments and the basement gneisses. These deformational episodes were accompanied by progressive regional metamorphism and followed by phases of static metamorphism. Pressure-temperature conditions remain essentially constant throughout both deformations. Accompanying migmatisation and granitisation of the basement gneisses is the intrusion of a suite of syn to late tectonic granites. The closing stages of the orogeny were marked by cooling uplift and fracturing and by the intrusion of high level volcanic Rocks.

Finally, Olanrewaju and Rahaman (1982) worked on the petrology and geochemistry of older granites from some part of northern Nigeria of which Bauchi State is part. They recognized four main petrographic varieties of granites which includes coarse porphyritic Biotite-Hornblende-granite, medium- coarse grained biotite-hornblende- granite, medium grained biotite and leucocratic granite (dababe granite) and fine grained leucogranite and biotite granite.

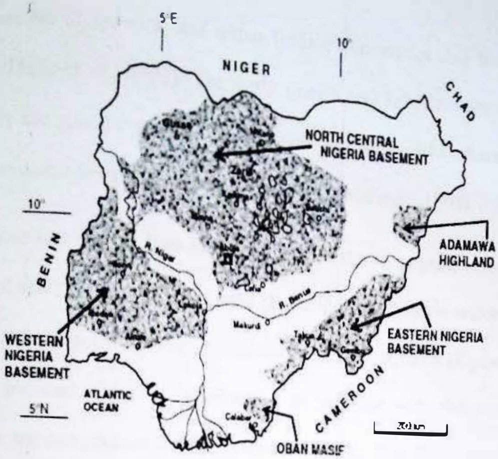


Fig: 5.Map showing Basement Geology of Nigeria (Adopted after Obaje 2009)

2.2 Review of Recent Works of the Study Area

The Bauchi area is underlain by migmatite-gneiss which is the oldest rock in the Nigerian basement complex (Rahaman, 1988). The relationship of the present rocks can be defined in that the effect of metamorphism of the gneiss that resulted into schist and was later intruded by older granites (Bauchite). The heat from this intrusion led to a metamorphism that formed the later gneiss showing a polycyclic cycle of metamorphism (Bruguier et al., 1994).

However according to Oyawoye (1965) who said much work has not been done in the area as quoted "I share the reluctance of modern petrologists to propose new variety names for rocks".

The result of works on the migmatite gneiss in the Bauchi area shows their nature to be that of Agmatite (Mehnert, 1968).

Agmatites are of sporadic and rather limited occurrence and the isotope count in them shows 618Ma (Dada et al., 1993). The early gneiss and other ultramafic rock are cut into irregular blocks by the granitic component. In areas around Bauchi where they are well developed they show dikyonitic structure (Oyawoye, 1964 and Mehnert, 1968).

In a discussion on the Bauchite-Biotite hornblende granite transition by ●yawoye (1961) he suggested that the charnockitic rocks (Bauchite) are formed under local pyroxene-hornfelsfacies conditions in regions of amphibolitesfacies metamorphism (Oyawoye, 1965). These conditions may be induced either by a reduction in pressure with the concomitant rise in temperature and/orby the introduction of hydrothermal fluids. It is also conceivable as suggested by some field evidence that such areas represent minor intrusions of rocks of charnockitic affinity which because of low PH20 have managed to retain their premetamorphic high temperature low PH20 (Winkler, 1967) mineral assemblages.

Bowden (1969) suggested that bauchite was melted by a linear zone of high heat flow from the mantle during the disruption of Gondwanaland. Bauchite happens to be part of theEastern Nigeria's terrane which according to Ferre et al, 1993, has U and W (isotopes) deposits (Woakes et al., 1987). It is implaced in metamorphic rocks which are a part of those in Northern Nigeria which consist mainly of granite-high-grade gneisses and migmatites which are cut by large Pan-African monzogranite plutons (Djouadi et al., 1997).

This eastern domain stretches from the Cameroon line to the area between Kaduna and Jos (Ferre and Caby, 2006). This Jos-Bauchi transect situated to the east of the main terrain boundary includes mostly gneisses and anatexites of metasedimentary origin (Ferre et al., 1998, 2002). The depositional age of the sediments is poorly constrained and no basement-cover relationships have been identified. The use of U-Pb Zircon isotopes to determine the ages of the syn-kinematic and late kinematic plutons suggests that most of the outcrop found in the study area irrespective of the composition are 638 + 3ma and 585 + 7 Ma (Dada and Rerpant, 1989; Dada et al., 1989; Ferre et al., 1993). The close relationships between the regional anatexis and emplacement of syn-kinematic plutons from the monzodiorite-charnockite association strongly suggest that this area underwent a monocyclic metamorphic history (Ferre et al., 1989). This is in agreement with model ages of 1.8Ga obtained on Tilde Fulani migmatitic metasedimentary rocks by Dada (1998). It further establishes that the source of the sedimentary rocks is younger than Late Palaeoproterozoic, and strengthens the case for a single monocyclic Pan-African evolution.

Bauchite is a part of the Neoproterozoic belt (Pan African) of Northern Nigeria where there is a distribution of metamorphic facies (Mac-Leod et al., 1971; Deleris et al., 1996). High grade metasedimentary rocks reached granulite facies condition and survived as large lenses and pendants interlayered within anatexites and migmatitic granites as seen in the Toro area of Northern Nigeria.

Mineral assemblages in both rock types could be used to determine magmatic and metamorphic thermo barometric conditions and it was shown to be of the Barrovian type metamorphism (medium temperature) by Ferre and Caby (2006).

The Bauchi area has foliations running through it, these was deduced from field data, SLAB images and previous maps (Wright, 1971). It has in place biotite-muscovite granite which form elongated plutons parallel to the regional structures suggesting a syn-tectonic emplacement, and biotite-hornblende granites which have more rounded shapes molded by country rock structures in conformity envelopes, suggesting a late tectonic emplacement (Ferre et al., 1998).

The Neoproterozoic Trans-Saharan Belt in which the study area falls within was suggested to be formed between 700Ma and 580Ma by accretion of terrains between the converging West African Craton, the Congo Craton and East Saharan Block, which was probably a craton until 700Ma (Black and Liegeois, 1993) when it was widely and largely reactivated, except in few areas.

Extensive sampling of metasedimentary gneisses of the Bauchi area (Jos-Bauchi transect) has revealed several occurrences of granulite facies rocks within high temperature amphibolitesfacies rocks and anatexites (Ferre and Caby, 2006

2.3Summary

In summary it is deduced from the literature that

1. The Archean basements of this area as sighted by previous work underwent high grade metamorphism and anatexis during the Pan-African Orogeny and hence show a Pan-African age.

2. The Jos-Bauchi transect is a representation of the Neoproterozoic (Pan African) Belt of Northern Nigeria as it exposes high-grade metamorphic rocks of contrasted character depending on their distance from Neoproterozoic monzonitic plutons (Ferre and Caby, 2006).

3. The distribution of granulite facies rocks in the Neoproterozoic Belt appears to be wide but may reflect a constant granulite facies conditions.

4. The Bauchi area provides evidence that high grade metamorphic conditions and anatexis are met by the combination of widespread regional amphibolitesfacies conditions and local contact

metamorphism due to pluton emplacement. Hence most basement if not all of the study area shows the 550±100 Ma ages (Ferre and Caby, 2006).

CHAPTER THREE:

MATERIALS AND METHODS

3.0 Introduction

Topographic map and base map was used to conduct the desk study from which the coordinates of the study area were calculated. During the course of the field work, samples were taken using the geologic hammer of fresh samples of important rocks, also photographs of important structures and outcrops were taken. The altitude values (Statement of dip and strike) of the various structures in the field were taken and the stereographic projection of the strikes and dips were plotted.

3.1 Materials

The apparatus used in the course of the field work and lab work include

Laboratory Apparatus

1. Global positioning system (G.P.S)
2. Compass clinometers
3. Hand lens
4. Masking tape
5. Measuring tape and Rulers
6. Topographic map
7. Geologic Hammer
8. Permanent Markers
9. Optical microscope

Field Apparatus

1. Schmidt net
2. Counting Net

3. Over Lay tracing sheets

4. Pencils and Eraser

5. Plane sheets

6. Office pins

7. Masking Tapes

8. Rotring pens and Ruler

9. Calculators

Plate: 1: Ruler

Plate: 2: Geologic Hammer

Plate:3:Global Positioning System (GPS)

Plate:4:Compass clinometre

These materials were all utilized in various processes in the field and laboratory as well in desk study to analyses the rocks of the area.

3.2 Methods

Methods employed in the course of the work can be broadly divided into two, which are field methods and the laboratory Methods.

3.3 Field Methods

These are the various methods employed in the field to acquire data, take samples and also interpret in the field. These include the following:

a. Direction And Bearing: The bearing of various outcrops were measured using the compass and the location, elevation, coordinates in terms of longitude and latitudes using the GPS(Global Positioning system) usually in the Mini datum configuration mode. Compass alongside the Clinometers is used in taking the dips and strike of the beds. the clinometers give the dip angles and the compass gives the Strike angles.

b. Distance: Distances between one location and another is taken using the GPS (Global positioning system) in terms of latitude and longitudes and usually recorded for further references

c. Rock Sampling: Rock samples are taken using the geologic harmer, afterthe fresh sample might have been taken It is labeled and later described in terms of lithology as well as in their mineralogy, textures and relationship between them are also analyzed from the samples gotten from the field.

Ground transversing was the method that was adopted and the following steps were applied:

- The investigators first observed and collected data.

- Then formulate a hypothesis to explain the collected data using structures seen on field and physical properties of samples taken.

- The test of the hypothesis in the laboratory using the microscope.

- The end result of the test or adoption of another before conclusion and inferring of the sample unit.

d. Measurement: The measurements were taken using rulers, ropes and steel measuring tapes.

e. Line Of Zero Dip: These is to get the accurate dip and strike of the various structures in the field, these is done by setting the compass to a 270-90 position such that the clinometers is on zero to get the strike line, the line perpendicular to these strike line is the dip, and the amount is measured.

3.4 Laboratory Method

Knowing that the results collected from the field are tentative and are inferred there is need for them to be confirmed using the appropriate methods in the laboratory, this studies involved the

Petrographic Study: Petrographic analysis involves the description of a rock sample in thin section using the optical microscope in the lab. This is more detailed than the macroscopic study, which involves looking at the rock sample with naked eye or through a hand lens to observe the color, texture, mineralogy and composition. This is known as hand specimen study, the structures can also be seen such as foliation, banding, cross bedding etc. Under the microscope the sample is viewed both under plane and cross polarized lights. Properties analyzed under PPL are color, pleochroism, relief, and cleavages shape, alterations while those analyzed under XPL are twinning, interference colors, and extinction angles resolution.

3.5 Laboratory Procedure for Thin Sectioning

Firstly, the sample to be used for the thin section is selected. In selection finer samples are chosen so as to give more information of the rock rather than coarse samples, also representative samples are taken such that is shows all or almost all of the minerals assemblages for each rock type. After selecting the samples then it is taken to the lab where the following processes are conducted to produce the thin section:

1 Using rock cutting machine, cut side of interest from the rock sample.

2 Using carborandum powder, thin the rock chip.

3 Mark the glass slide using a diamond pen

4 Place the thinned rock and glass slide on heat source for 2-5 minutes.

5 Using glass rod, mix araldite to equilibrium.

6 Gum rock chip and glass slide using the araldite.

7 Ensure removals of bubbles by carefully heating the slide after pressing out air bubbles using forceps

8 Dry for about 3-5 minutes; allow cooling for about 5-10 minutes.

9 Damp slide and the rock chip on the grinding machine and grind gently.

10 Thin carborandum powders, after grinding while observing on petrographic microscope

11 Take thinned glass slide to hot plate to be scrapped to the size of the cover clip.

12 Gum the glass slide to the cover clip using Canada balsam

13 Eliminate air bubbles by gently rubbing the surface using mounting pin

14 Keep to dry for two days

15 Wash slide using detergent and methylated spirit and allow it to dry

16 Label slide ready for further studies.

Precautions to be taken in thin section production include:

1. Take care not to break the glass slides when thinning and grinding.

2. Ensure to remove all air bubbles in the slide.

3. Take care in applying the gum not to affect the important features of the section.

4. Take care of overheating as it causes cracking of glass.

3.6 Slide Viewing Techniqque under the Optical Microscope

The thin section of a sample is to be viewed in two modes the first with the Analyzer out to produce or give the plane polarized light in this mode you can view the following properties:

a. Color

b. Pleochroism

c. Form

d. Cleavages

e. Relief

f. Alteration

After the above method you now view same slide these time with the analyzer in producing the cross-polarized Light, you can see the following properties of the minerals in these mode:

a. Interference colors

b. Extinction angle

c. Twinning

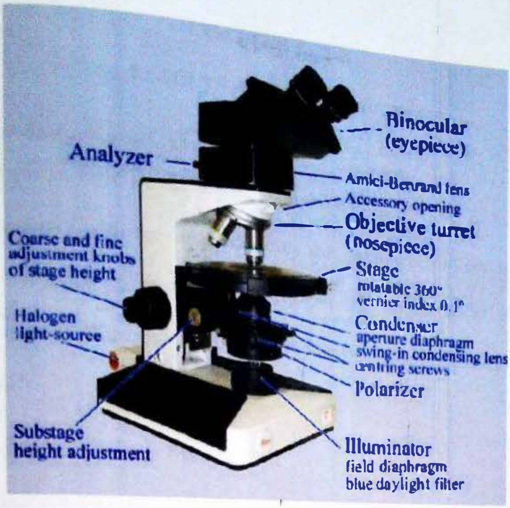


Fig.6: Design of polarized-light microscopes

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Background

The various rocks gotten from the field were grouped into samples A, B, C, and D, and were analyzed macroscopically with the aid of the eyes and hand-lenses to see minerals which are visible and later subjected to thin-section (Petrographic) studies under the microscope to ascertain the minerals and other important attributes like twinning as well as presence or absence of certain structures.

4.1 Macroscopic and Microscopic Studies

The macroscopic and microscopic studies are outlined below for each of the samples and also the mineral percentages are gotten from the various slide stage rotation. The rocks with migmatitic structures are analyzed as thus:

SAMPLE A

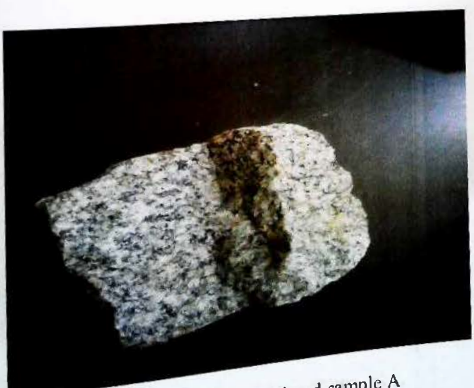


Plate.5: Photograph of hand sample A

The sample suspected to be granite gneiss, its alight colour mineral with some dark mineral interclation indicating presence of biotite . Foliation is observed on the rock (that is minerals are trending in a particular direction).

Sample A

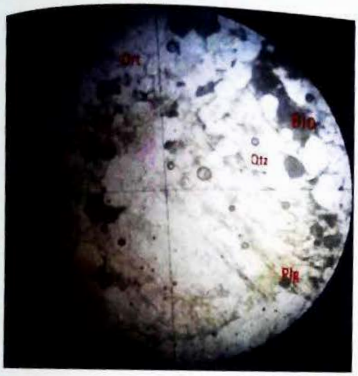


Plate.6a: Photomicrograph of sample A under PPL.

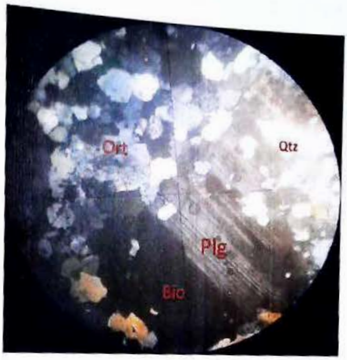


Plate.6b: Photomicrograph of sample A under XPL

TABLE 1.MICROSCOPIC STU●Y OF SAMPLE A

S/N	MINERAL SEEN	MICR●SC●PIC VIEW ●F SAMPLE A	
		PPL	XPL
1	**Plagioclase**	-Un●er plane polarised light; the plagioclase phenocryst is zoned. -It has low relief and is colourless in PPL. It occurs as euhedral crystals, colorless and low relief with perfect cleavage in plane polarized light.	• The biotite is also light brown with perfect basal cleavage. • This mineral is strongly pleochroic, as the stage is rotated. • It is euhedral in form with high relief in plane polarized light.
2	**Orthoclase**	• It is as anhedral to subhedral crystal. • It is colourless with low relief in plane polarized light. • It occurs as dark grey in colour.	• It has a low birefringence (first order) in cross polarized light. It constitutes about 10% of the entire mineral observed in the slide.
3	**Quartz**	• It is monocrystalline in nature. • It is clear, anhedral in form, low relief, fractures, display no pleochroism, alteration and cleavage in plane polarized light. • It is colourless in color.	• It exhibits a characteristics phenomenon known as undulose extinction in cross polarized light. It constitute about 45% of the total mineral present in the slide.
4	**Biotite**	• The biotite is also light brown with perfect basal cleavage. • This mineral is strongly pleochroic, as the stage is rotated. • It is euhedral in form with high relief in plane polarized light.	• It exhibits a high birefringence in cross polarized light. It occurs in traces; occupy about 20% of the entire mineral composition of the rock.

Table 2: Table showing the counts from the various slide positions for Sample A

SLIDE POSITION	1	2	3	4	5	TOTAL
QUARTZ	3	4	0	2	6	15
ORTHOCLASE	2	0	0	0	2	4
MICROCLINE	0	0	1	2	3	6
ALBITE	3	4	1	0	1	9
BOITITE	2	4	1	2	2	11

Below are the normalized values of the minerals in percentage

Quartz=15/34 * 100%=44%

Plagioclase=9/34* 100%=26%

Alkaline Feldspar=10/34 *100%=29%

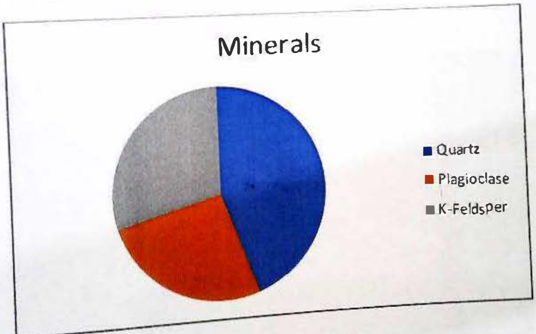


Fig.7: A pie chart showing mineral percentage of sample A

Relating to Q A P the initial Quartz, Alkaline Feldspars and Plagioclase are 15, 10 and 9 respectively. Normalizing it to 100% we have 44% Quartz, 29% Alkaline Feldspar and 26% Plagioclase and are presented in the QAP diagram below and these showed that the rock is granitic (granite) in composition.

Fig.8: QAP diagram of Sample A naming its composition as that of Granite.

Sample B

Plate.7: Photographof hand sample B

The rock was suspected to be a Migmatite with a light Granitic part with coarse grained (Pegmatitic texture) minerals mainly Quartz and Feldspars and a dark gneissic part with high content of biotite as evidenced from the foliation planes which are so many in the mother Rock.

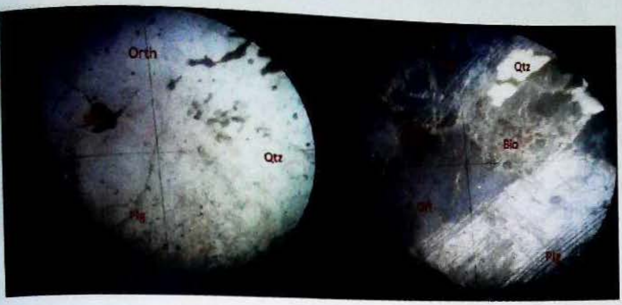


Plate.8a: Photomicrograph of sample B under PPL   Plate.8b: Photomicrograph of sample B under XPL

TABLE 3: MICROSCOPIC STUDY OF SAMPLE B

S/N	MINERAL SEEN	MICROSCOPIC VIEW OF SAMPLE A	
		PPL	XPL
I	**Plagioclase**	• The plagioclase phenocryst is zoned. • It has low relief and is colourless in PPL. • Cleavage is poor in PPL.	• It displays polysynthetic-twinning and. It constitutes about 45% of the mineral composition of the entire rock.
2	**Orthoclase**	• Orthoclase is the main phenocryst. • The feldspars are severely altered to places for orthoclase and plagioclase feldspars respectively. It is grey, low relief and anhedral crystal in PPL.	• It has oblique extinction, and display a simple Carlsbad twinning in XPL. It constitutes about 20% of the entire mineral composition.
3	**Quartz**	• It constitute about 25% of the total mineral present in the slide. • It is colorless, anhedral in form, low relief, fracture, displays no pleochroism and cleavage in PPL.	• It exhibits undulose extinction.
4	**Biotite**		• The biotite is brown color with moderate relief and perfect basal cleavage. However, some biotite grains did not exhibit cleavage. It constitutes about 10% of the entire minerals observed in the slide.

Table 4: Table showing the counts from the various slide positions for Sample B

SLIDE POSITION	1	2	3	4	5	TOTAL
QUARTZ	11	15	18	13	5	62
ORTHOCLASE	4	0	3	2	1	10
MICROCLINE	0	0	6	0	2	8
ALBITE	2	4	6	4	4	20
BOITITE	10	4	6	0	1	21

Below are the normalized values of the minerals in percentage

Quartz=62/100 * 100%=62%

Plagioclase=18/100 * 100%=18%

Alkaline Feldspar=20/100 *100%=20%

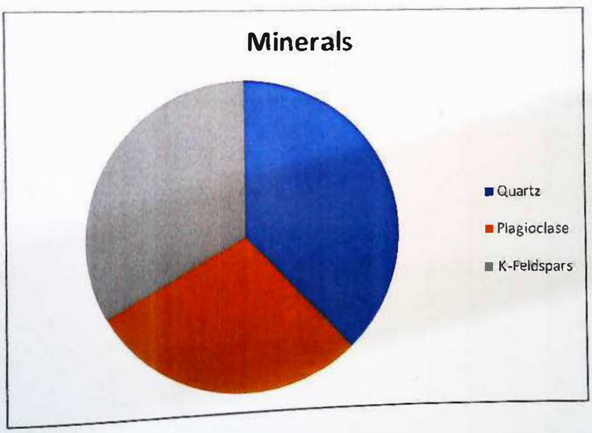


Fig.9: A pie chart showing mineral percentage of sample B

Relating to Q A P the initial Quartz, Alkaline Feldspars and Plagioclase are 62, 20 and 18 respectively. Normalizing it to 100% we have 62% Quartz, 20% Alkaline Feldspar and 18% Plagioclase and are presented in the QAP diagram below and these showed that the rock is granitic (Quartz-Rich Granitoid) in composition.

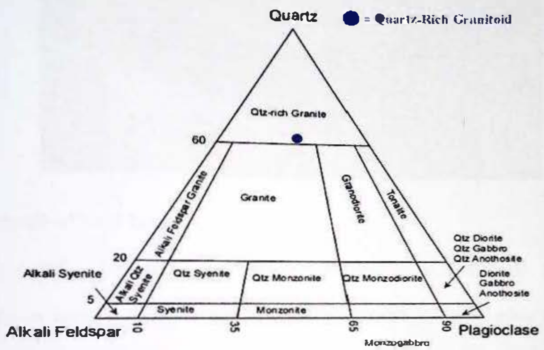
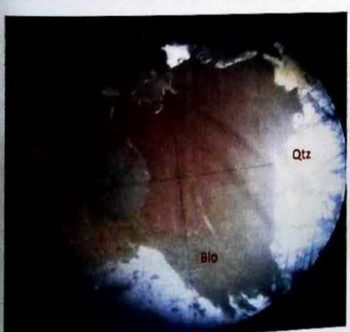


Fig.10: QAP diagram of sample B Showing its composition as that of Quartz-rich granitoid

SAMPLE C

Plate.9 photograph of hand Sample C

It is a light colored, it has traces of brown and few dark colored minerals. The rock is fine-medium grain in texture. Feldspar crystals form the porphyroblastic grain and it constitute dominantly in the groundmass. The rocks compose of feldspar, quartz and biotite in order of abundance. Foliation is observed at the surface of the rock.



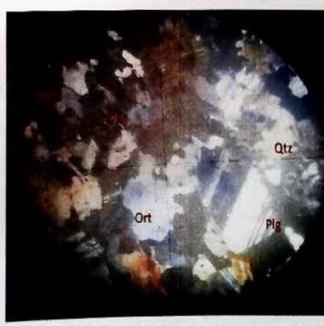


Plate.10a: Photomicrograph of sample C under PPL Plate.10b:Photomicrograph of sample C under XPL

TABLE 5: MICROSCOPIC STUDY OF SAMPLE C

S/N	MINERAL SEEN	MICROSCOPIC VIEW OF SAMPLE A	
		PPL	XPL
1	**Plagioclase**		• It has polysynthetic twinning.
2	**Orthoclase**	• It is grey in color. • It has low relief. • It constitutes about 15% of the mineral present in the slide.	• Orthoclase is colourless. • Pleochroism is absence. • Cleavage is absent. • The form is subhedral and relief is low.
3	**Quartz**	• It is clear, anhedral in form, low relief, fractures, display no pleochroism, alteration and cleavage in plane polarized light. • It is colourless in color.	• It exhibits a characteristics phenomenon known as undulose extinction in cross polarized light. It constitute about 30% of the total mineral present in the slide.
4	**Biotite**	• It is clear, anhedral in form, low relief, fractures, display no pleochroism, alteration and cleavage in plane polarized light. • It is colourless in color.	• It exhibits parallel extinction.

Table 6: Table showing the counts from the various slide positions for Sample C

SLIDE POSITION	1	2	3	4	5	TOTAL
QUARTZ	4	6	5	3	7	25
ORTHOCLASE	3	5	1	3	6	18
MICROCLINE	4	3	3	6	1	17
ALBITE	4	3	4	5	3	19
BOITITE	12	4	3	3	2	24

Below are the normalized values of the minerals in percentage

Quartz=25/79 * 100%=32%

Plagioclase=19/79* 100%=24%

Alkaline Feldspar=35/79 *100%=44%

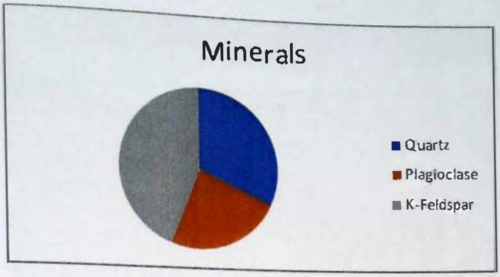


Fig.11: A pie chart showing mineral percentage of sample C

Relating to Q A P the initial Quartz, Alkaline Feldspars and Plagioclase are 25, 35 and 919respectively. Normalizing it to 100% we have 32% Quartz, 44% Alkaline Feldspar and 24% Plagioclase and is presented in the QAP diagram below and these showed that the rock is granitic (granite) in composition.

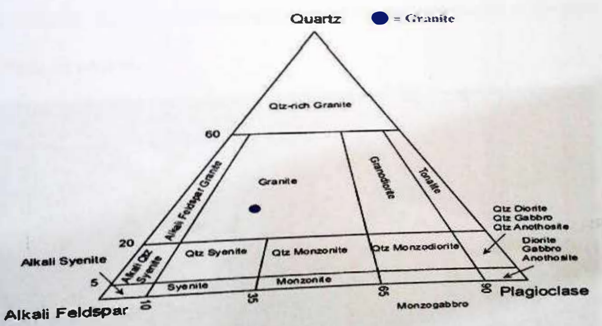


Fig.12:QAP diagram of sample C Showing its composition as that of a granitic rock

SAMPLE D

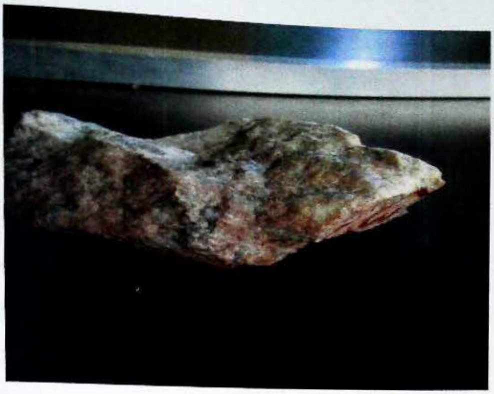
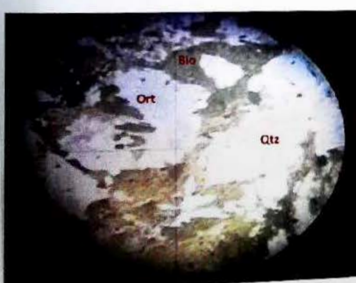


Plate.11 :Photographs of hand sample D

The rock is the granitic-Pegmatitic part of the migmatite found in the area, it shows a coarse-grained to medium-grained in some parts, it has less biotite and has feldspars and quartz as the dominant minerals, the rocks coexist together with the main migmatite in the area, and are hard to differentiate or separate.



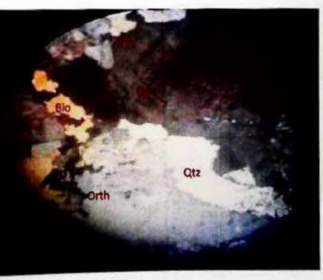


Plate.12a: Photomicrograph of sample D under PPL Plate.12b:Photomicrograph of sample D under XPL

TABLE 7: MICROSCOPIC STUDY OF SAMPLE D

S/N	MINERAL SEEN	MICROSCOPIC VIEW OF SAMPLE A	
		PPL	XPL
1	**Orthoclase**		• It constitutes about 15% of the entire mineralogy observed in the slide.
2	**Quartz**	• It is monocrystalline in nature, and it constitutes about 30% of the total mineral present in the slide. • It is colourless, pleochroism is absent. • Cleavage is also absent. • The form is anhedral and the relief is high.	
	Biotite	• This mineral is strongly pleochroic in shades of brown to dark brown, as the stage is rotated. • It occurs in traces, occupying about 20% of the entire mineral composition of the rock.	• This mineral is strongly pleochroic in shades of brown to dark brown, as the stage is rotated. • It occupies about 20% of the entire mineral composition of the rock.
	MICROCLINE		• Under crossed polarized light, interference colour is grey to white of the first order. Exticion is parallel and twinning is Carlsbad. It constitutes about 10% of the entire mineral composition of the rock.

Table 8: Table showing the counts from the various slide positions for Sample D

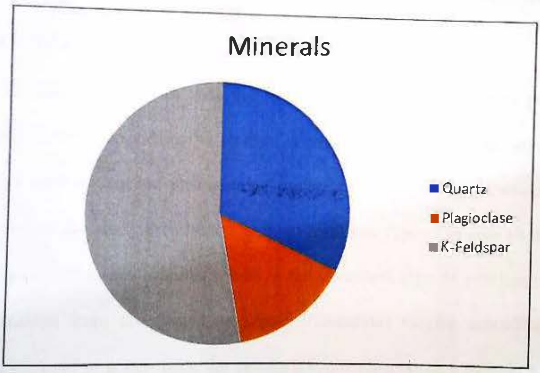
SLIDE POSITION	1	2	3	4	5	TOTAL
QUARTZ	11	5	7	4	5	32
ORTHOCLASE	2	5	7	4	6	24
MICROCLINE	2	8	12	5	4	30
ALBITE	3	2	2	5	3	15
BOITITE	2	0	0	1	2	5

Below are the normalized values of the minerals in percentage

Quartz=32/101 * 100%=32%

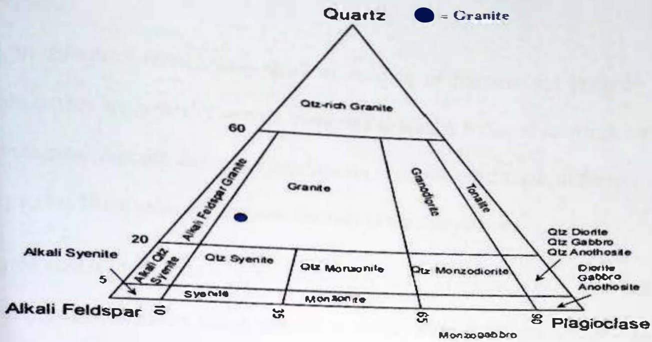
Plagioclase=15/101 * 100%=15%

Alkaline Feldspar=54/101 *100%=53%



.13: A pie chart showing mineral percentage of sample D

ating to Q A P the initial Quartz, Alkaline Feldspars and Plagioclase are 32, 54 and 15 ectively. Normalizing it to 100% we have 32% Quartz, 53% Alkaline Feldspar and 15% ioclase and is presented in the QAP diagram below and these showed that the rock is granitic ite) in composition.



ig.14:QAP diagram of sample D Showing its composition as that of a granitic rock

.2 SUMMARY OF PETROGRAPHIC STUDIES

ı summary, it could be deduced that the migmatitic rocks in these area poses a granitic operties suggesting and supporting the work of Ferre and Caby (2006) that says the migmatite the study area are Pan-African posing same properties as those of the Pan-African granites. l the migmatites of the study area hence tends to form one type of granite or the other and in nposition it gives the monzogranites which is the dominant type of granites in Bauchi Area : to contamination from the quartz monzonite (Bauchite) magma according to Oyawoye '65). All the information gotten from the petrographic studies opens a thought to suggest these gmatites as different from the Eburnean Migmatites since they somehow poses the granitic perties of the 550±100 MA granites hence suggests same age.

Structural Geology

ctural geology is essentially the study of the geometry of geologic structures, how these ctures were formed, their significance to the geologic study of an area, as well as their elationship to plate tectonic motions. These structures include veins, joints, faults, intrusive odies, and xenolith (Ragan, 1969a).

3.1 Veins

iese are structures formed as a result of infilling of fractures and joints by later formed nerals, or they are generally narrow, elongated or tabular bodies of economic minerals formed hydrothermal deposits due to the deposition of hydrothermal fluids in fissures and cracks of ıntry rocks. These veins are common features of the mapped area.

ing the course of the fieldwork, veins of different set of minerals were observed. These set of erals appeared as fissure filling deposits on a rock. Vein are tabular or sheet-like body of one ore minerals deposited in openings of fissures, joints or faults, sometimes with associated cement of the host rock. They are believed to form when aqueous solutions migrate through es in rock and deposit minerals onto the fissure walls. The newly mineral species ›itated onto rock walls thereby leaving the wall rock unaltered.

filling of quartz or aplite sometimes protrudes above the rock containing them , this could to differential weathering showing that quartz is more resistant than the other minerals in :t rock. In some place they occur in large boulders, some measure up to 3cm wide and cm long, they are sheared, scattered and disintegrated and have undergone significant ing .The composition is mainly quartz.

plate.13: Vein in migmatite N-E direction.

plate.14: vein in Migmatite N-W direction

Table.9: Strike Measurements of Veins on Migmatite.

S/N	Strike Reading	Back Azimuth	S/N	Strike Reading	Back Azimuth
1	28	208	23	4	184
2	2	182	24	10	190
3	42	222	25	47	227
4	52	232	26	55	235
5	11	191	27	22	202
6	14	194	28	45	225
7	16	196	29	66	246
8	78	258	30	140	320
9	150	330	31	135	315
10	30	210	32	115	295
11	4	184	33	16	196
12	20	200	34	16	196
13	24	204	35	46	226
14	33	213	36	34	214
15	35	215	37	28	208
16	29	209	38	26	206
17	14	194	39	27	207
18	6	186	40	24	204
19	20	200	41	55	235
20	26	206	42	16	196
21	27	207	43	40	220

Rose Style of vein

Style – Wedges

Class Size - 15^0

Mode –Bidirectional

Type - Equal Area

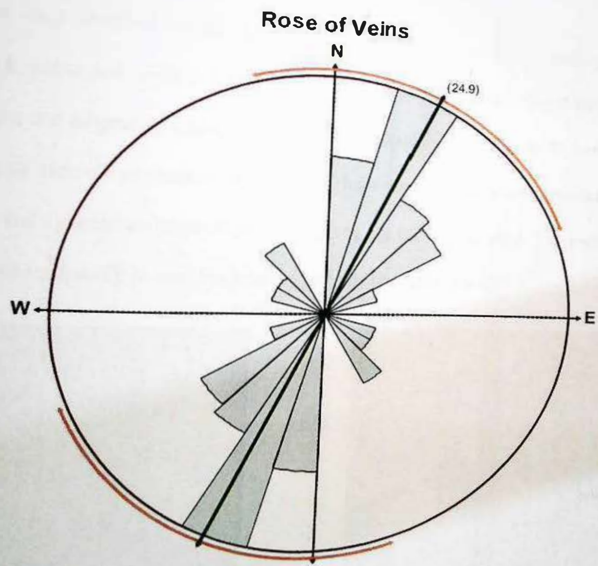
Grid – None

Radial Grid Interval – 15

Circular Grid Interval – 5

Max Percent – 38

Axes Label – N. E. S. W.



The trend is NNE-SSE direction.

Fig.15: Showing Rose Plot of Veins on Granite

4.3.2 Joint

Joints are fractures in rock along which there has been little or no observable movement of one side of the r●ck relative to the other parallel to the joint surface (Plate 15-and 16). Joint in a rock is as a result of many geological processes. They could be due to shrinkage as a result of emplacement and cooling of igneous pluton. While some could be as a result of stresses developed by unload of near surface rocks or over-burden. Joint can therefore, be said to act as a records of past events that took place in a ge●logical environment, hence help in interpreting rock history. Joints in the study area are present in all the rock types encountered in the study area.

These joint were observed on the coarse grained porphyritic granites trending between the granitic rock quartz and apalitic fillings some of the joints. The jointing and fracturing on the granite gneiss and migmatite could be as a result of intrusion of later rocks in form of dyke and shear stress by tectonic movement. It is noticed that mostly all the varied granites in the study area are severely jointed and type of joints observed are the tension joint. The rock in the study area is sometimes heavily jointed but jointing patterns are rather poor.

Plate.15: Joint in granite.

Plate.16 Joint in migmatite

Table. [illegible] Strikes of Joints on migmatite

S/N	Strike Reading	Back Azimuth	S/N	Strike Reading	Back Azimuth
1	135	315	22	166	346
2	40	220	23	158	338
3	166	346	24	160	340
4	168	348	25	71	251
5	82	262	26	130	310
6	150	330	27	60	240
7	152	332	28	78	258
8	88	268	29	10	190
9	87	267	30	92	272
10	89	269	31	136	316
11	161	341	32	64	244
12	154	334	33	12	192
13	155	335	34	10	190
14	154	334	35	76	256
15	155	335	36	66	246
16	162	342	37	90	270
17	161	341	38	72	252
18	168	348	39	150	330
19	160	340	40	76	256
20	152	332	41	46	226
21	150	330	42	54	234

Rose Style of Joint

Style – Wedges

Class Size - 15^0

Mode –Bidirectional

Type – Equal Area

Grid – None

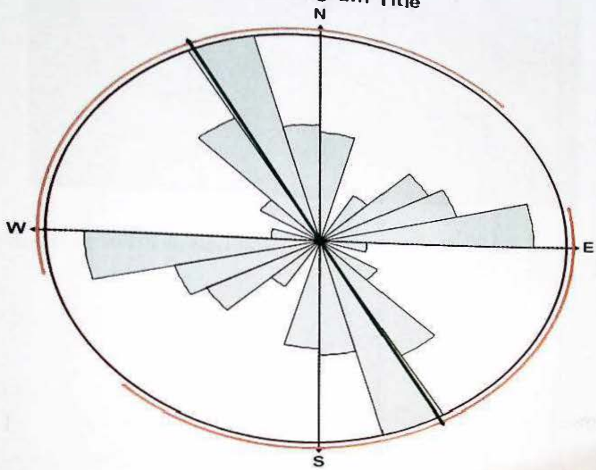
Radial Grid Interval – 15

Circular Grid Interval – 5

Max Percent – 38

Axes Label – N, E, S, W.

Rose Diagram Title



Thetrend is NW-SE direction

Fig.16: Showing the Rose Plot of Joints on granodiorite.

4.3.3 Dykes

. The dyke structures observed in the study area are mostly dolerite in origin or composition. It exhibit fine-grained texture, and dark coloured mineral, forced through the vertical or near vertical cracks or fissures at the surface of low lying graniteoutcrop inthe study area as seen in plate (17). The Dolerite dyke was found about 10-30m length that range in thickness from 12cm to 23.1cm, and is trending NW-SE direction.

Plate.17: Basalticdyke within an outcrop migmatite.

GEOLOGIC MAP OF THE STUDY AREA

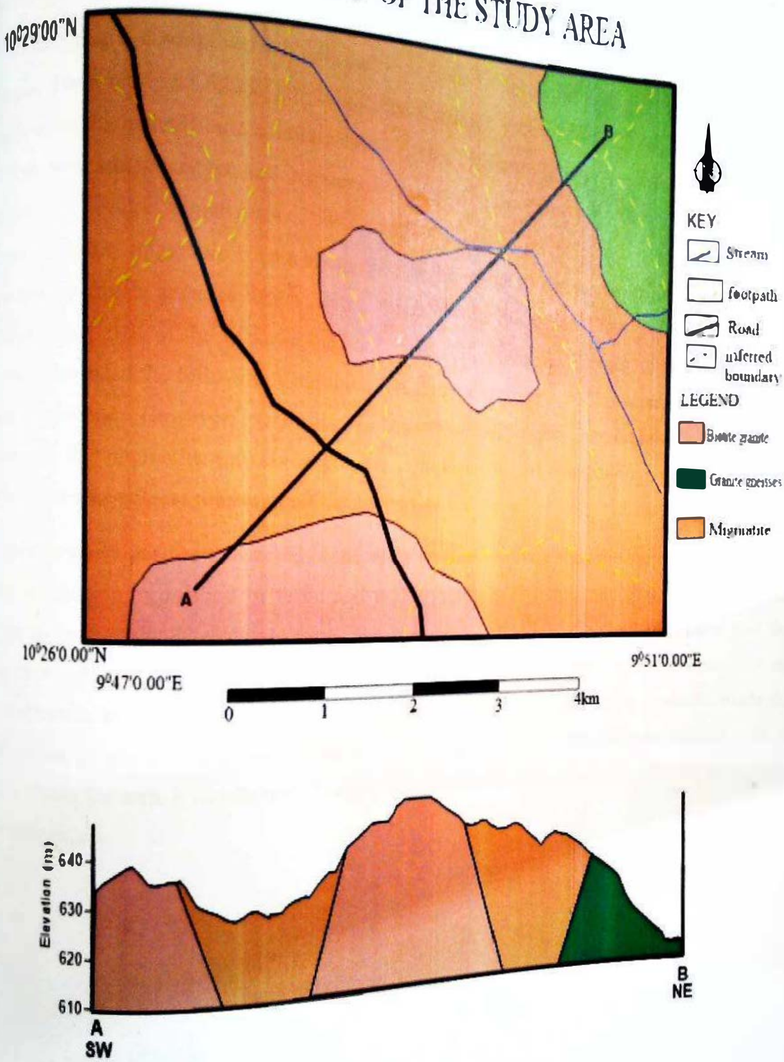


Fig.17Geological map of the study area with cross section

4.3.4 Discussion

The study area (Gubi and its environs) is a part of the north-eastern basement rocks emplaced during upper proterozoic (Pan African orogeny 600±150 Ma) in Bauchi, Bauchi state, Nigeria. The microscopic descriptions with photomicrographs of the major rock units are shown in this chapter. These represent rocks from areas where studies were performed. These four (4) major rocks units(Migmatite,Biotite granite,Granite gneisses,Biotite granite gneisses) existing in the studied area are described and explained in detail with respect to their macroscopic and microscopic features which shows the respective minerals present in each of the above rock types. Therefore, migmatite covers about 60% of the mapped area and are the highest abundant, followed by granite gneisses which covers about 30% in abundance, Then biotite granite covers the remaining 10% of the rocks in the study area. The petragraphic study of the rock samples collected revealed the following essential minerals such as quartz, biotite, microcline, orthoclase and plagioclase. However, according to quartz alkali-felspar plagioclase diagram (QAP Diagram) the migmatite possess a granitic composition (manzogranite), biotite granite and granite gneisses possess monzogranitic composition.

Metamorphism has been observed in the study area and is evident by the presence of structures such as foliation, separation of felsic and mafic minerals. Microscopic studies show that the rocks have undergone metamorphism. The undulose extinction exhibited by quartz and the inclusions of tiny quartz and Biotite particles in feldspar proved the phenomenon of re-crystallization and rearrangement of minerals. The lack of diagnostic index minerals made the recognition of metamorphic zones and facies difficult. From these evidences and the type of rocks within the area, it can therefore be established that the study area was affected by regional metamorphism.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 Conclusion

In conclusion as deduced from the Petrographic studies and the structural analysis, it is seen that the Pan-African Migmatite in the area was formed as a result of the reaction between the granitic material that intruded the schist in the area and led to metamorphism forming granite-gneisses and migmatite structurally. In fact the structural analysis, Petrographic studies and field studies supplement each other. I conclude based on the data gotten in this research that:

1. The Pan-African migmatite are in most cases formed by alteration of schist belt by granitic material as the study area has some indication of schist extension confirming this possibility and also the trend of foliations confirms these.

2. The reactions between the Schist and the magma locally give complex migmatic structures which might look like the Eburnean migmatite but compositionally and structurally Pan-African as its field relation distinctively shows it as Pan-African after some work of prominent researchers like Eric Ferre (2006).

3. The banding which is convolute confirms the rock to be migmatite and also structural and textural analysis showed the rocks to be low- medium grade metamorphism and also the structural analysis shows slightly folded, bent layer at 450 (from Donal Ragan Structural geology 2009)which coincide with a low – medium grade metamorphism the rocks thus named in the area are intrusive granitic rock (which underlies the area and also intrudes the schist to form migmatite), metamorphic granite gneiss and the migmatite.

5.1 Recommendations

Based on the Research conducted and fieldwork, I strongly recommend the following:

1. More research should be carried out on the geology of Nigerian basement complex as to make some amendments to the old researches that confuses in the field, a situation where you see something different and you are made to believe it as it was and not what you see in reference to literatures.

2. The study area is a very good potential for polished stone value, and also the rocks could be used to make tiles, hence the government or private sector should invest productively into these.

3. Although no mineral of economic value was encountered in the work, but there are prospects of such and further studies of the study area should be conducted for any existence of such.

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