GEOLOGY AND X- RAY FLUORESCENCE OF THE ROCKS AROUND GUBI PART OF QUARTER DEGREE SHEET 149 BAUCHI NE

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JANUARY, 2018

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BY

ABDULMAJID AMINU JUNGUDO

12/29230/U/1

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

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

JANUARY, 2018

Declaration

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

.... 28/2/2018 ....

Full name of student   Date

The declaration is confirmed by

.... 28/3/18 ....

Full name of supervisor   Date

(Project supervisor)

Certification

I certify that this report is an original work done by Abdulmajid Aminu Jungudo (12/29230/u/1) under my supervision and has met the requirements for the award of bachelor of technology (Applied Geology) of Abubakar Tafawa Balewa University, Bauchi.

Supervisor

Name. Abdullahi A. M

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Date. 28/3/18

Head of department

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

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

Date..........................

External examiner

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

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

Date..........................

Dedication

This work is dedicated to my parents Alhaji Aminu Yahaya Jungudo and Hajiya Fatsuma Sale Dukku.

Acknowledgment

My immeasurable and immense gratitude to Allah (SWT) in whose unwavering bounties and mercies we all thrive. Through His guidance, support and protection today I am able to complete a smooth and hitch free project work.

A very principal and active personality worthy of acknowledgement is my supervisor Mal Abdullahi Adamu Abdullahi, without whose patience, perseverance, guidance, attention, this work would not have seen today. I take a very deep bow sir, for you have imparted in me not just academically but in all ramifications of life.

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Abstract

The mapped area occupies part of Sheet 149 Bauchi NE within latitudes 10°25'00"N and 10°28'00"N and longitudes 9°49'00"E and 9°50'00"E in Bauchi and part of Ganjuwa Local Government Area of Bauchi State. 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 petrographic and geochemical properties. The methods used include sampling and the samples were taken for petrographic and geochemical analysis. Petrographic results show that the dominant minerals were mostly Quartz, Plagioclase Feldspars and Orthoclase. This indicates that the rocks were original granites mostly monzogranites and quartz rich granitoids on the QAP plot. The geochemical analysis shows that the rocks in the study area are subaluminous-peralkaline and harker variation diagrams plotted shows that the rocks especially the granites have possibly come from the same magmatic chamber.

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CHAPTER ONE

1.0 INTRODUCTION

The study area falls within the Nigerian Basement Complex. The area lies within part of Sheet 149 Bauchi NE within latitudes 10°25'00"N and 10°28'00"N and longitudes 9°49'00"E and 9°50'00E". The study area comprises of Migmatites as the major rock type, 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, as well as petrographical information of the various rocks encountered will be provided. This study focuses on mapping, geochemical 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 to the geology of Bauchi State and the North Eastern Basement at large.

1.1 Statement of the problem

The study area is part of the North-Eastern Basement and also one of the least investigated in the geology of Nigeria, Oyawoye, (1964). This work will attempt to use surface mapping, geochemical analysis and petrographic studies to classify, analyze and provide more information on the mineralogy and origin of the magma that formed the rocks in the area.

1.2 Justification for the study

Haven known that the study area is one of the least investigated of the North-Eastern 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 minerals and to know the origin of these rocks as to add to existing information on the North-Eastern basement.

1.3 Location, extent and accessibility

The study area lies within latitudes 10°25'00"N and 10°28'00"N and longitudes 9°49'00"E and 9°50'00"E. The area was quite accessible and the study area falls within sheet 149 NE of Bauchi State. The area is accessible by a major road linking Bauchi to Ningi and numerous footpaths to access the remote areas within the study area. The highest elevation within this area is the Gubi hill.

1.4 Aim and objectives

The aim of the project is to investigate, comprehend and reproduce a systematic description of the rocks in the study area using thin sections, hand specimens examination and geochemical analysis. This study includes analyzing their mineralogy, textures, 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 geology, rock types and to also identify and distinguish rock types of the study area using petrography, 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.

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

1.5 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 elevations of 591 to 605 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.

1.6 Climate and Vegetation

The climate of the study area consists of a wet (rainy season) which extends from May/June to October with a temperature range of 25 to 37 degree Celsius and a dry season which is characterized by the Harmattan from November/December to April/May as with a temperature range of 29 to 45 degree. The vegetation type is the Sahel 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). The product of weathering of 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 villages in the study area are the Gubi village, Sabon Kaura and the Rudi Yusa villages.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Regional Geology

Nigeria lies approximately between latitudes 4^0N and 15^0N and Longitudes 3^0E and 14^0E within the Pan-African mobile belt in between the West African and Congo cratons. The geology of Nigeria is dominated by crystalline and sedimentary rocks; both approximately occurring in equal proportions (Woakes et al 1987). The crystalline rocks are made up of Precambrian basement complex and the Phanerozoic rocks which occur in the eastern region of the country and in the north central part of Nigeria. The Precambrian basement rocks in Nigeria consist of the migmatite – gneiss – quartzite complex dated Archean to Early Proterozoic (2700-2000 Ma). Other units include the NE-SW trending schist belts mostly developed in the western half of the country and the granitoid plutons of the older granite suite dated Late Proterozoic to Early Phanerozoic (750-450Ma).The basement complex is one of the three major lithological components that make up the geology of Nigeria.

The Nigerian Basement Complex (Fig. 1) forms a part of the Pan-African mobile belt which lies between the West African and Congo Cratons and south of the Tuareg Shield Obaje, (2006). It is the S•uthern elongation of the Morocco and

Algeria, Hogger and Aiir of Niger Republic. Further South, the Pan-African mobile belt of West Africa is considered to have continued in to the South American continent to form the Borborema province of North-Eastern Brazil before the separation of the African plate from the South American plate during the late Jurassic period (Oyawoye, 1964).

It is intruded by the Mesozoic calc-alkaline ring complexes (Younger Granites) of the Jos Plateau and is unconformably overlain by Cretaceous and younger sediments.

The Nigerian basement was affected by the 600 Ma Pan-African orogeny and it occupies the reactivated region which resulted from plate collision between the passive continental margin of the West African craton and the active Pharusian continental margin (Burke and Dewey, 1972 and Dada, 2006). The basement rocks are believed to be the results of at least four major orogenic cycles of deformation, metamorphism and remobilization corresponding to the Liberian (2,700 Ma), the Eburnean (2,000 Ma), the Kibaran (1,100 Ma), and the Pan-African cycles (600 Ma). The first three cycles were characterized by intensive deformation and isoclinal folding accompanied by regional metamorphism, which was further followed by extensive migmatization. The Pan-African deformation was accompanied by a regional metamorphism, migmatization and extensive granitization and gneissification which produced syntectonic granites and homogeneous gneisses (Abaa, 1983). Late tectonic emplacement of granites and granodiorites and associated contact metamorphism accompanied the end stages of this last deformation. The end of the orogeny was marked by faulting and fracturing (Gandu et al., 1986).

The Basement Complex of Nigeria is made up of four major rock groups;

i. The Migmatite – Gneiss complex (MGC)

ii. The Schist Belt (Metasedimentary and Metavolcanic rocks)

iii. The Older Granites (Pan-African Granitoids)

iv. Undeformed Acidic and Basic Dykes.

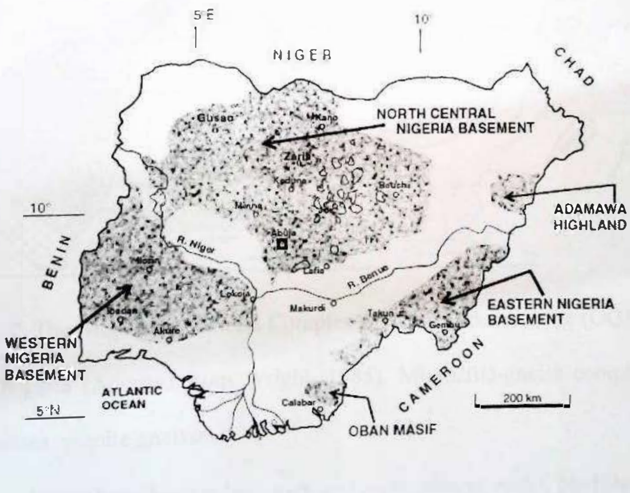


Fig 1: Basement Geology of Nigeria (Adapted from Obaje, 2006).

2.1.1 Migmatite-Gneiss complex

The migmatite-gneiss complex also termed by some workers as the migmatite gneiss-quartzite complex or the Basement Complex *sensu-stricto* makes up about *60%* of the surface area of the Nigerian basement Rahaman (1988); the earliest, at 2500ma, involved initiation of crust forming processes (e.g. the branded Ibadan grey gneiss of mantle origin), and of crustal growth by sedimentation and orogeny; next came the Eburnean, 2000 ±200 ma, marked by the Ibadan type granite gneisses; this was followed by ages in the range of 4500±900ma which represent the imprint.

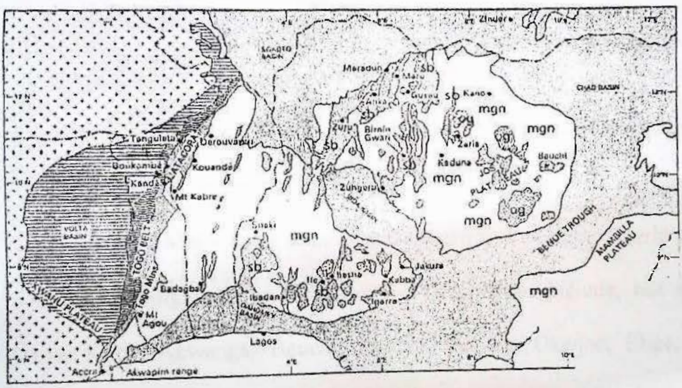


Fig 2: The Migmatite- Gneiss Complex (MGN), Older Granite (OG) and Schist Belt of Nigeria (Adopted from Wright, 1985). Migmatite-gneiss complex (migmatites, gneisses, granite gneisses)

- Schist belt (Metasedimentary and metavolcanic rocks, phyllites, schist, pelites, quartzite, marble, amphibolites).

- Older granite (Pan-African granitoids, granites, granodiorites, syenites, monzonites, gabbro, charnockite.
- Undeformed acid and basic dykes (Muscovites, and syenite dykes; basaltic, doleritic and lamprophytic dykes).

The close analogy in time with the development of the Birrimian of West African craton is striking. However, although gold, manganese and iron mineral deposits are associated with Birrimian rocks, the same age rocks in Nigeria are very sparsely, if at all, mineralized. The extent of Eburnean and older rocks in Nigeria is not known. Definite geochemical evidence for the existence of these rocks exists for the area south of latitude 9°N Rahaman, (1988). Lithologically, similar rocks in other parts of Nigeria, especially in the northeast and southeast, have given only Pan- African ages (Turner, 1983). Many areas in northern, eastern and western Nigeria are covered by rocks of the migmatite-gneiss complex. These areas include, but not limited to; Abuja, Keffi, Akwanga, Bauchi, Kaduna, Funtua, Okenne, Ebge, Ajaokuta (in northern Nigeria) Ibadan, Ile-ife, Akure, Ikerre (in western Nigeria), and Obudu and Oban massif areas (in eastern Nigeria).

2.1.2 The Older Granites (Pan African Granitoids)

The term "Older Granite" was introduced by Falconer (1911) to distinguish the deep-seated, often concordant or semi-concordant granites of the Basement Complex from the high-level, highly discordant tin-bearing granites of Northern Nigeria. The Older Granites are believed to be pre-, syn- and post-tectonic rocks which cut both the migmatite-gneiss-quartzite complex and the schist belts. They range widely in age (750–450 Ma) and composition. They represent a varied and long lasting (750–450 Ma) magmatic cycle associated with the Pan-African orogeny. The rocks of this suite range in composition from tonalites and diorites through granodiorites to true granites and syenites. Charnockites form an important rock group emplaced during this period. They are generally high level intrusions and anataxis has played an important role (Rahaman, 1981). The Older Granites suite is notable for its general lack of associated mineralization although the thermal effects may play a role in the remobilization of mineralizing fluids. The Older Granites are the most obvious manifestation of the Pan-African orogeny and represent significant additions of materials (up to 70% in some places) to the crust (Rahaman, 1988). Attempt to classify the Older Granites with respect to timing during an orogenic event are valid over only short distances. Contact features between members of the Older Granites suite suggest the coexistence of several magmas. Compositionally, the granites plot in the field of calc-alkaline rocks on the AFM diagram and although they contain significant amount of alkalis, are also often slightly corundum normative.

Dada (2006) was of the opinion that the term "Pan African Granitoids" be used for the Older Granites not only on the merit of age which was not available at the time they were named Older Granites, but because it covers several important petrologic groups formed at the same time. The granitoids which outcrop with the schist belts in northwestern and southwestern Nigeria biotite granites, biotite muscovite granites, syenites, chanockites, serpentinites and anorthosites. Rahaman (1988) discarded the earlier classification of members of the Older Granites suite on the basis of their texture, mineraological composition and the relative timing of their emplacement. In its place, members of the Older Granite suite were classified as follows, based mainly on the textural characteristics:

1. Migmatitic granite;
2. Granite gneiss;
3. Early pegmatites and fine-grained granite;
4. Homogeneous to coarse porphyritic granite;
5. Slightly deformed pegmatite aplites and vein quartz; and
6. Undeformed pegmatites, two-mica granites and vein quartz.

In northern Nigeria, the abundance of Pan-African granites appears to increase eastward. In the area west of Zaria these occur as isolated intrusions (McCurry, 1973), whereas in the region between Rahama and the Mesozoic-Cenozoic cover the intrusive granites and related rocks envelope remnants of Migmatites. McCurry (1973) working mainly west of Zaria divided the granites into two main groups according to their field relationships. The first "syntectonic"group comprised of elongate batholithic sheets that is partly concordant and foliated. The second group "late tectonic" are made up of poorly foliated discordant bodies, rich in mafic xenoliths and having a lower proportion of potash feldspar. The late granites are considered to be the products of wide spread mobilization and reactivation of older basement rocks during the Pan-African orogeny. The Older Granites occur intricately associated with the Migmatite-Gneiss Complex and the Schist Belts into which they generally intruded. Older Granite rocks therefore occur in most places where rocks of the Migmatite-Gneiss Complex or of the Schist Belt occur. However, Older Granites are particularly noteworthy in and around Wusasa (Zaria), Abuja, Bauchi, Akwanga, Ado-Ekiti and Obudu areas. In Bauchi area and some parts of southwestern Nigeria, most of the Older Granite rocks occur as dark, greenish-grey granites with significant quantities of olivine (Fayalite) and pyroxene occurring with quartz, feldspars and micas. For this unusual composition, the Older Granites in these areasare termed Bauchite (in Bauchi area) and Oyawoyite (After Professor Oyawoye who first mapped them) in southwestern Nigeria. For uniformity of terminology, both the Bauchites and Oyawoyites constitute the charnockitic rocks (*Charnockites*) of the Basement Complex.

Charnockitic rocks constitute one of the important petrological units within the Precambrian Basement Complex of Nigeria. They are generally characterized by their dark greenish to greenish grey appearance which makes them easily recognizable in hand specimen. They usually contain quartz + plagioclase + alkali feldspar +orthopyroxene+ clinopyroxene+ hornblende ± biotite± fayalite. Accessory minerals are usually zircon, apatite, and iron ores. Apart from Toro, other localities of charnockite occurrence include Bauchi, Ado-Ekiti, Ikere (Ekiti), Akure, Idanre, and in the Obudu Plateau.

2.1.3. Undeformed Acid and Basic Dykes

The undeformed acid and basic dykes are late to post-tectonic Pan African. They cross-cut the Migmatite-Gneiss Complex, the Schist Belts and the Older Granites. The undeformed acid and basic dykes include:

a. Felsic dykes that are associated with Pan African granitoids on the terrain such as the muscovite, tourmaline and beryl bearing pegmatites, microgranites, aplites and syenite dykes (Dada, 2006)

b. Basic dykes that are generally regarded as the youngest units in the Nigerian basement such as dolerite and the less common basaltic, felsite and lamprophyric dykes.

The age of the felsic dykes has been put at between 580 and 535 Ma from Rb-Sr studies on whole rocks Dada, (2006), while the basic dykes have a much lower suggested age of ca. 500 Ma (Grant, 1970). The structural and geochronological importances of this suite of rocks, which have been put to immense chronological use elsewhere (Dada, 2006) are often overlooked in Nigeria. When they cross-cut basement, they could be used to infer relative age of metamorphic structures and rock suites and could also suggest the existence of older basement windows in the Nigerian schist belts, apart from the immense guide they provide in sampling for isotope geochemistry, analysis and interpretation (Dada, 2006).

Table 1: Summary of the General Succession of Paleozoic to Precambrian Rocks of Northern Nigeria Adapted from Kogbe, (1989).

AGE	SUCCESSION	ROCK TYPES
Ordovician-Cambrian	Marandun and Burashi group	Granites, Porphyries, Tuffs, Agglomerates, Rhyolites, Dacites, Andesites, Basalts
Cambrian-Upper Proterozoic	Older Granites	Granites, Granodiorites, Syenites, Migmatites, Acidic – Basic Complexes, Pyroxene, Diorites, Gabbro
Upper Proterozoic	Younger Metasediments	Phyllites, Schists, Quartzites, Conglomerates, Interbedded Volcanics
Older Precambrian	Older Metasedimenhts and Gneisses	Quartzites, Marbles, Basic Calcareous Schist, Biotites and Hornblende Gneisses and Granulites.

2.2 General geology of the Gubi area

The study area (Gubi, Sabon Kaura and Rudi Yusa) is part of the north-eastern basement rocks emplaced during Neoproterozoic (Pan African orogeny 600±150 Ma) in Bauchi, Bauchi state, Nigeria. It comprises of three rock types which are granites, gneisses and migmatites. All those rocks found poses a granitic composition, the migmatite in the area are granitic in composition, Ferre (2006).

The area consists of the hills range from 591m to 606m, hills in the area include; gubi hill, they are mainly granites. The study area provides evidence that high grade metamorphic conditions and anatexis are met by the combination of widespread regional amphibolites facies conditions and local contact metamorphism due to pluton emplacement. Most basement of the study area shows the 550±100 Ma ages (Ferre and Caby. 2006). 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). The structure such as vien, fractures, joints and dyke on the rock in the area are dominantly trending in the NE-SW direction which is part of the general trends of Pan-African structures.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Introduction

Topographic map and base map were 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 for fresh samples of important rocks, photographs of important outcrops and samples were taken.

3.2 Materials

The apparatus used in the course of the field work and lab work includes:

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. Pencils and Eraser

10. Masking Tapes

11. Rotring pens and ruler

12. Calculators

13. Field book

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

3.3 Methods

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

3.3.1 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, after the fresh sample had 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 traversing 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 eld and physical properties of samples taken.

The test of the hypothesis in the laboratory using 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 and steel measuring tapes.

e. Line of zero dip:

This is to get the accurate dip and strike of the various structures in the field, this 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

3.3.2 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 following

a. **Petrographic study**:

etrographic analysis involves the description of a rock sample in thin section sing 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 polarised lights. Properties analysed under PPL are colour, pleochroism, relief, and cleavages shape, alterations while those analyzed under XPL are birefringence, interference colours, and extinctionanglesexsolution.

3.3.2.1 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:

- Using rock cutting machine, cut side of interest from the rock sample.
- Using carborandum powder, thin the rock chip.

- Mark the glass slide using a diamond pen.
- Place the thinned rock and glass slide on heat source for 2-5 minutes.
- Using glass rod, mix araldite to equilibrium.
- Gum rock chip and glass slide using the araldite.
- Ensure removal of bubbles by carefully heating the slide after pressing out air bubbles using forceps.
- Dry for about 3-5 minutes; allow cooling for about 5-10 minutes.
- Damp slide and the rock chip on the grinding machine and grind gently.
- Thin carborandum powder, after grinding while observing on petrographic microscope.
- Take thinned glass slide to hot plate to be scrapped to the size of thecover clip.
- Gum the glass slide to the cover clipusing Canada balsam.
- Eliminate air bubbles by gently rubbing the surface using mounting pin.
- Keep to dry for two days.
- Wash slide using detergent and methylated spirit and allow to dry.
- 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.

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

Take care of overheating as it causes cracking of glass.

3.2.2 Slide viewing technique under the optical microscope

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

a. Colour

b. Pleochroism

c. Form

d. Cleavages

e. Relief

f. Alteration

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

a. Interference colors

tinction angle

vinning

refringence.

r which the mineral counts in various slide positions are made and the required e pictures are taken using the USB PC thin section camera.

.2.3 Laboratory procedures for geochemical analysis

e X-Ray fluorescence (XRF) was employed to analyze for major oxides in the mples.

3.2.4 Sample preparation

he samples were crushed using crushing machine at Ashaka Cement Company, fter crushing for size reduction. It was pulverized into powdered form using Herzurg milling machine. 0.1g of each sample was measured and 4.0ml nitric acid, 6.0ml Hf acid and 1.0ml perchloric acid were added on each of the sample measured to dissolve it. It was then heated to dryness on a sand bath inside fume cupboard for about 6 hours and then allowed to cool. Then 2.0ml of nitric acid and 2.0ml of distilled water was further added on each of the dried samples and boiled. It was then removed and allowed to cool and filter using 100ml volumetric flask.

Pressed pellet preparation procedure

0.400+/- 0.001g of stearic acid was accurately weighed into a clean dry weighing boat.

20.000+/- 0.001g was accurately weighed and added to the stearic acid.

The grinding vessel was clean using brushes.

The grinding vessel was set, the sample plus the stearic acid was poured into the grinding vessel, and the lid was properly covered and ensured the O-ring on the lid was in place and ok.

5. The grinding vessel was placed in the Herzurg mill (Plate 1) and covered.

6. The appropriate grinding time of 100 second for clinker and gypsum was selected.

7. The mill started by pressing the start button and allowed to run till expiration of the set time.

8. The Herzurg mill was opened, and the grinding vessel was brought out, the ground sample on top of a clean paper was cleaned out using brushes and ensured that no part of the brush was entrained in the sample.

9. The sample on the paper was thoroughly mixed and the stearic acid was put into aluminum cup to a maximum of one third of the cup's volume.

10. The ground sample was filled and the excess materials were leveled out.

11. It was carefully inserted in the pressed pellet machine and the screw on top of the damp was turned to hold the lid.

The screw was then unturned through a quarter of a turn and the pressing was started.

At stop of the press, the lids of the press were held firmly with one hand and with the other hand, the damp was unscrewed and released and the pressed pellet was brought out by pressing the start button.

4. The surface of the pellet was examined properly to detect any possible effect. The pellet was properly labeled with a marked and no defect was detected.

15. The pellet was inserted into XRF analyzer. The XRF pc was used to select the program. The sample was identified, the analysis starts and elapsed for about 3 minutes and the result was displayed on the pc's screen.

3.3.2.5 X-ray Fluorescence Spectrometry (XRF)

Wavelength- dispersive X-ray fluorescence- WDXRF is a non-destructive analytical technique used to identify and determine the concentrations of elements and oxide present in solid, powdered and liquid sample at trace levels often below one part per million, and up to 100% wide application in industry and research derives from the ability to carry out accurate, reproducible analysis at very high speed with modern computers controlled systems, operation is fully automatic and result are typically delivered within minutes, or even seconds.

.6 Working principle of X-ray Fluorescence Spectrometer (XRF)

F method depends on fundamental principles that are common to several istrumental methods involving interaction between electron beams and X-ith samples. When samples atoms are irradiated with high energy primary photons electrons are ejected in the form of photo electrons. This creates ons "holes" in one or more of the orbital's, converting the atoms into ions are unstable. To restore the atoms to a more stable state, the holes in inner al are filled by electrons from outer orbital's such transitions may be mpanied by an energy emission in the form of a secondary X-ray photons- a omenon known as fluorescence. The various electrons orbital is called KLMN , where k is closest to the nucleus each corresponds to a different energy level – the energy (E) of emitted fluorescent photons is determined by the difference nergies between the initial and final orbital for the individual transition.

analysis of major and trace elements in geological materials by X-ray rescence is made possible by the behaviors of atoms when they interact with iation when materials are excited with high energy short wavelength.

diation (e.g. X-Rays), they can become ionized. If energy of the radiation is ficient to dislodge a tightly held inner electron, the atom becomes unstable and outer electron replaced the missing inner electron. When this happens, energy is due to the decreased binding energy of the inner electron orbital compared outer one. The emitted radiation is of lower energy than the primary X-rays and is termed fluorescent radiation. Because the energy of the photons is characteristic of a transition between specific electron orbital in cular element, the resulting fluorescent X-rays can be used to detect the nces of elements that are present in the sample.

ULTS

duction

phy deals with the Macroscopic and Microscopic descriptions of various the study area. The rocks studied in the area include; migmatites and gneisses. The major oxides geochemistry carried out is aimed at classifying k types of the study area are SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, TiO_2 and P_2O_5 (Table 2). Effort was made to understand the possible geologic sses that led to the formation of the various rock types of the study area by ng reference to the various classification schemes used.

Geochemical analysis

total of seven (7) samples were analyzed in weight percent (wt. %) of major lements. Below is a table showing the major oxides that were analyzed.

oxides in wt% that were analyzed

RD6A	GB3B	SQ5B	GB4	GB1A	GB6B	GB6A
53.39	63.55	101.75	65.35	61.72	53.96	62.70
12.00	13.12	2.36	12.41	12.40	12.07	12.64
4.93	1.18	1.21	1.54	1.99	4.32	1.70
10.31	8.76	8.73	9.15	9.84	10.73	9.78
1.93	0.25	0.40	0.40	0.43	1.56	0.38
0.60	0.60	0.60	0.60	0.60	0.60	0.60
1.68	6.21	0.21	3.47	3.24	1.39	2.17
2.17	1.58	0.25	2.26	2.31	2.27	2.85
0.23	0.00	-0.01	0.04	0.08	0.22	0.00
0.21	0.01	0.01	0.02	0.05	0.18	0.03
0.82	0.09	0.10	0.16	0.20	0.70	0.16
10.22	7.15	7.30	7.62	8.20	10.13	8.09
98.50	102.49	122.91	103.01	101.06	98.12	101.10
3.15	4.45	28.49	4.68	4.29	3.29	4.37
2.43	11.13	1.96	8.05	6.24	2.79	7.44
6.18	4.51	3.03	4.60	5.22	6.38	5.10
-502.87	-578.50	-814.82	-589.94	-561.12	-504.87	-570.22
18.40	15.63	15.58	16.32	17.57	19.15	17.45

above table, the following indices were plotted;

otal alkali silica.

luminium saturation index.

Harker variation diagram.

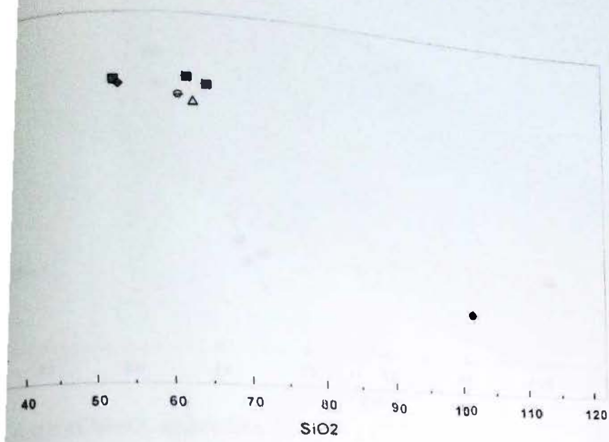
AFM diagram.

alkali silica: this defines the suite of the rocks (Fig 4).

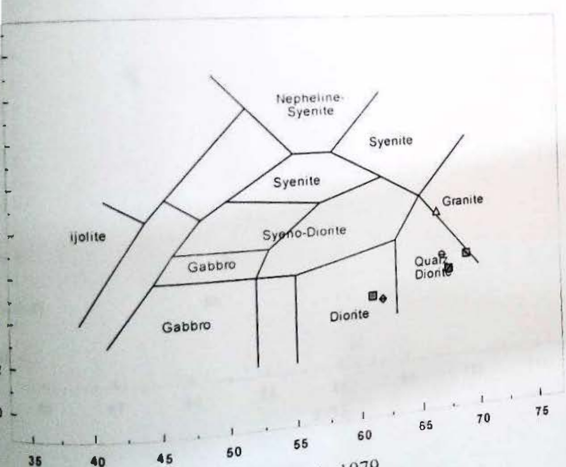
inium saturation index: this classifies the rock samples into Metaluminous, uminous or Peralkaline (Fig 3).

ker variation diagram: this defines and tells the origin of the magma as either ntle origin or crustal origin (Fig 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14).

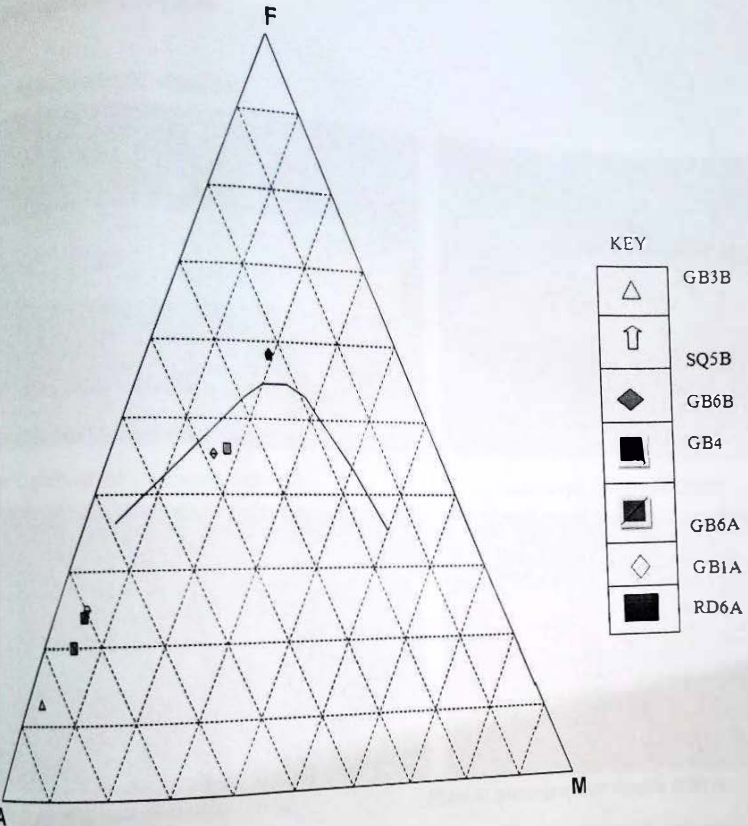
M: this classifies rock samples into either tholeiitic or calc-alkaline (Fig 15).



uminium saturation index after Le ba se et al, 1986



: Total alkali silica after Cox-Bell Pank, 1979



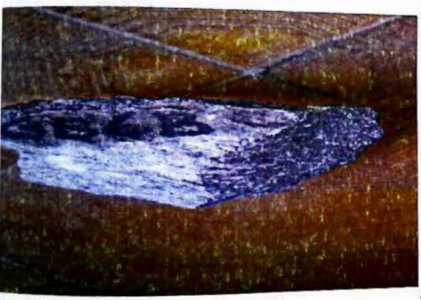
g 15: AFM ternary plot after Irvine Barager, 1971 {A=Al_2O_3 + Fe_2●$_3$ −(N_2● + K_2Owt.%)},
=total Fe as Fe_2O_3wt% and M = MgOwt%

?etrographic studies

| Macroscopic studies

: 1: photograph of sample GB6BA

Plate 2: photograph of sample GB3B



e 3: photograph of sample GB6B

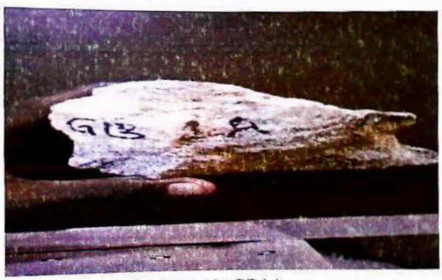
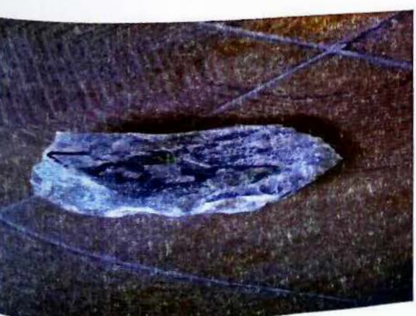


Plate 4: photograph of sample GB1A



e 5: photograph of sample SQ5B

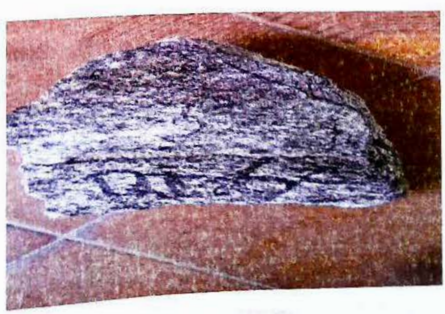


Plate 6: photograph of sample RD6A

ic properties of sample GB6B

It is a melanocratic rock material with high leucocratic mineral content

Clear aligning of both the light and dark colored minerals in the form of bands.

Sample GB6B is inferred to be granite gneiss (Plate 3).

sic properties of sample SQ5B

It is a fine grained leucocratic material

Sample SQ5B is inferred to be a felsic dyke

Basic properties of sample RD6A

i. It is melanocratic rock material with high leucocratic mineral content.

i. Clear aligning of both the light and dark colored minerals in the form of bands.

i. Sample RD6A is inferred to be granite gneiss (Plate 5).

asic properties of sample GB3B

i. It is a combination of two rock types.

i. The leucocratic part has coarse grains

ii. The melanocratic part has medium grains

v. Sample GB3B is inferred to be a migmatite (Plate 2).

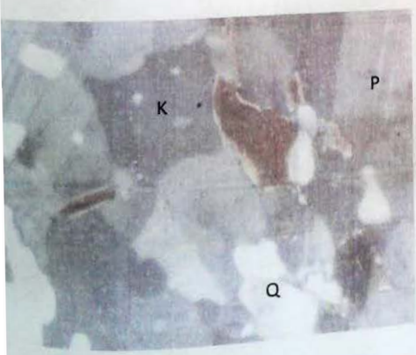
c properties of sample GB1A

- It is a combination of two rock types.
- The leucocratic part has coarse grains
- The melanocratic part has medium grains
- Sample GB1A is inferred to be a migmatite

ic properties of sample GB6A

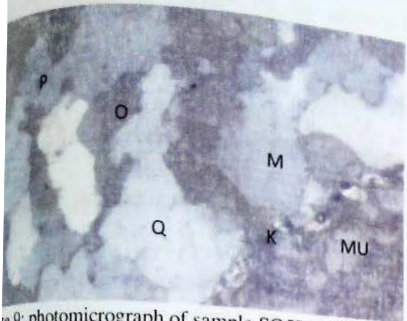
- It is a combination of two rock types.
- The leucocratic part has coarse grains
- The melanocratic part has medium grains
- Sample GB6A is inferred to be a migmatite

.2 Microscopic examination



late 7: photomicrograph of sample GB6B in CPL

Plate 8: photomicrograph of sample GB6B in PPL



te 9: photomicrograph of sample SQ5B in CPL

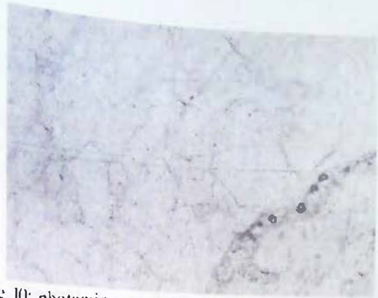
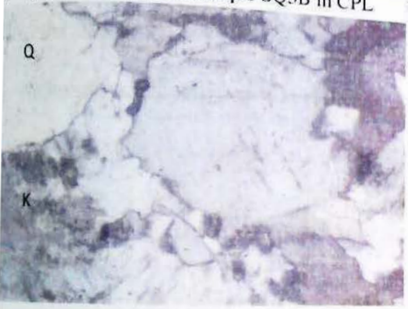
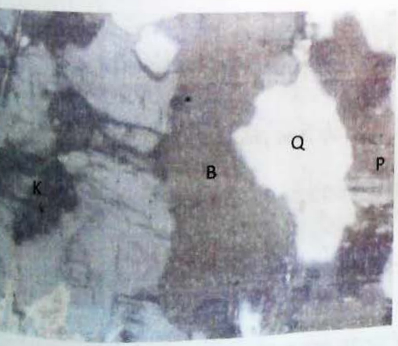


Plate 10: photomicrograph of sample SQ5B in PPL



te 11: photomicrograph of sample RD6A in CPL

Plate 12: photomicrograph of sample RD6A in PPL



e 13: photomicrograph of sample GB3B in CPL

Plate 14: photomicrograph of sample GB3B in PPL

quartz, M= microcline, O= olivine, K= orthoclase, P= plagioclase, MU= muscovite, B=biotite

Properties observed under CPL for sample GB3B

i. Dark colored minerals were identified
ii. Light colored minerals were also identified
iii. Poly synthetic twinning was observed (Plate 13)

Properties observed under PPL for sample GB3B

i. Few patches of brownish coloration observed indicating biotite
ii. Abundant colorless minerals
iii. Most of the crystals show subheral to anhedral form (Plate 14).

Properties observed under CPL for sample GB6B

i. Poly synthetic twinning was observed to identify plagioclase
ii. Dark colored minerals were observed (Plate 7)

Properties observed under PPL for sample GB6B

i. Colorless, light brown and dark colored minerals
ii. The brown minerals have one perfect cleavage (Plate 8).

Properties observed under CPL for sample SQ5B

i. Light colored minerals were observed
ii. Poly synthetic twinning evident

Interference colors observed (Plate 9).

...perties observed under PPL for sample SQ5B

- Abundant light colored minerals observed
- Cleavage lines evident from muscovite (Plate 10).

...operties observed CPL for sample RD6A

i. Poly synthetic twinning was observed
ii. Light colored minerals were observed
iii. Dark colored minerals were also observed (Plate 11).

...roperties observed under PPL for sample RD6A

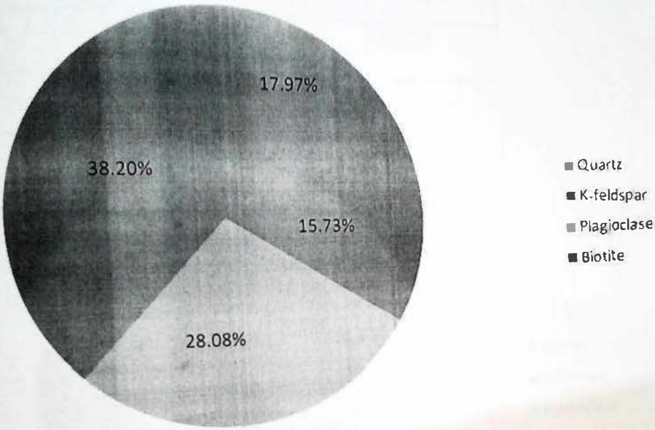
i. Colorless, light brown and dark colored minerals
ii. The brown minerals have one perfect cleavage (Plate 12).

...4 Modal classification

...able 3: mineral count for sample GB3B

Inferred Minerals	Quadrants				Total	Percentage
	1st	2nd	3rd	4th		
Quartz	5	3	2	6	16	17.97

ldspar	4	3	5	2	14	15.73
ioclase	6	7	8	4	25	28.08
ite	10	8	11	5	34	38.20
					89	99.98



16: A pie chart showing the percentage composition of minerals in sample GB3B

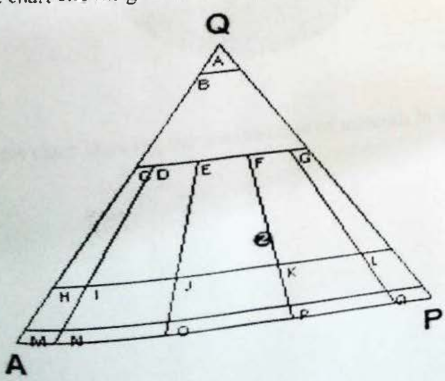
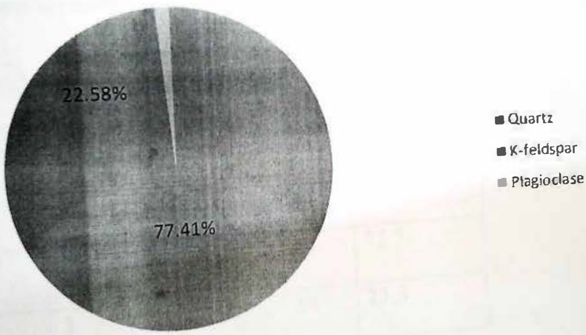


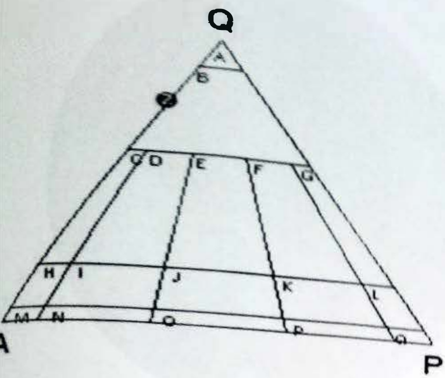
Fig 17: QAP plot for sample GB3B

: mineral count for sample RD6A

red eral	Quadrant				total	Parcentages
	1st	2nd	3rd	4th		
tz	15	9	13	11	48	77.4
dspar	5	3	2	4	14	22.58
ioclase	-	-	-	-	-	-
					62	99.98



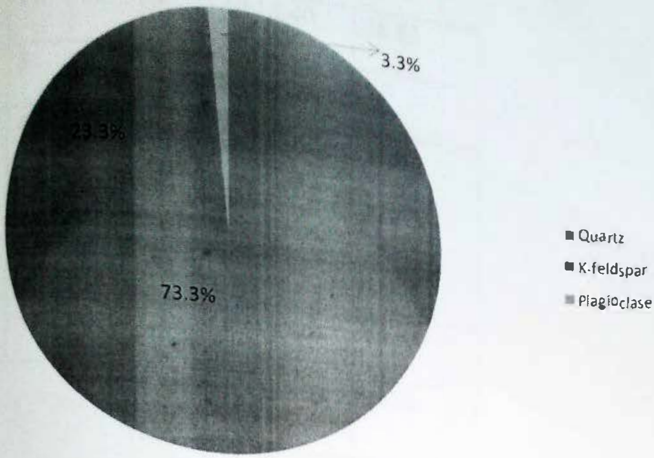
ig 18: A pie chart showing the composition of minerals in sample RD6A



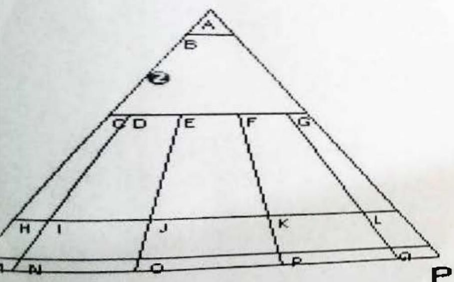
QAP plot for sample RD6A

mineral count for sample GB6B

	Quadrant					
l	1st	2nd	3rd	4th	total	Parcentages
	14	8	12	10	44	73.3
ar	5	3	2	4	14	23.3
ase	-	-	2	-	2	3.3
					60	99.9



pie chart showing mineral composition in sample GB6B

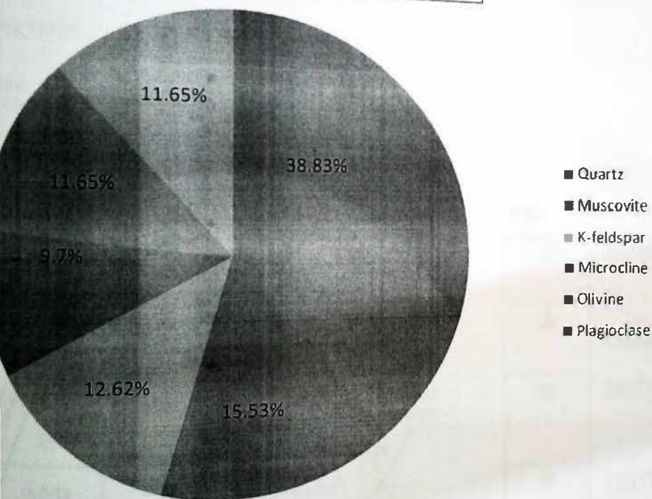


AP plot for sample GB6B

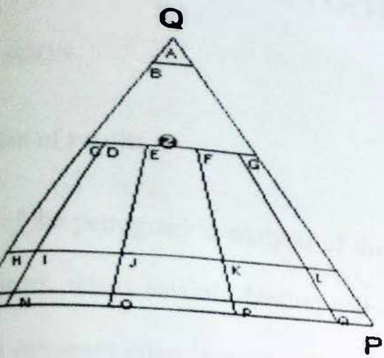
neral count for sample SQ5B

Quadrants				total	percentage
1st	2nd	3rd	4th		

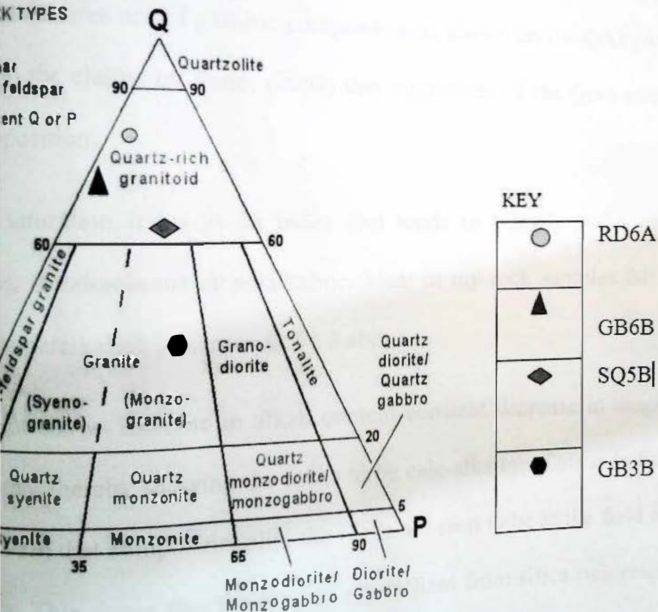
11	10	9	10	40	38.83
3	2	3	2	10	9.7
4	2	3	3	12	11.65
3	4	3	3	13	12.62
4	2	2	4	12	11.65
4	3	5	4	16	15.53
				103	99.98



ie chart showing mineral composition for sample SQ5B



lot for sample SQ5B



: Tenary plot showing the various rock samples.

CHAPTER FIVE

SSION

ion of results

of the petrographic analysis of the Gubi rocks shows a dominance of spars, micas (mainly biotite) and opaque minerals and also the QAP a dominant granitic composition which support the claims by Oyawoye the rocks of the Bauchi area are of granitic composition and the in the area are of granitic composition as shown on the QAP plot. This th the claims by Ferre, (2006) that migmatites of the Gubi area are of nposition.

saturation index is an index that tends to classify rocks as either us, metaluminous or peralkaline. Most of my rock samples fall within us-peralkaline as shown in fig 3 above.

plot shows increase in alkali content constant decrease in magnesium ntent thereby showing the rocks to be calc-alkaline. This is in line with 1988) that compositionally; the rocks are seen to be in the field of calc-ks. This shows that the magma crystallizes from silica rich magma on agram as shown in fig 15 above.

plot is a plot that classifies rocks into suites. From the plot, a Diorite-Diorite- Granite suite is given for the different rock samples. It means that na was fractionated while crystallization of the rock.

Harker variation diagrams above, the high temperature oxides as shown 10, 11, 12, and 14 are decreasing as the silica content is increasing the low temperature oxides as seen in fig 7 and 8 are increasing with g SiO_2 content suggesting the magma is possibly of mantle origin.

omic geology of the Gubi area

i area has enormous economic potentials, here are but a few:

ne rocks if properly harnessed would provide source materials for tile oduction which can serve as a great source of income to both the state and e country at large.

ne Gubi dam also provides a source of water for the Bauchi metropolitan habitants and also a source of water for irrigation and fishery activities.

ne area provides fertile grounds for agricultural activities such as farming, e to the weathering of the rocks with high biotite, ferromagnesian and dspar content which provides the necessary nutrients for plant growth and velopment.

CHAPTER SIX

ONCLUSION AND RECOMMENDATION

nclusion

ea is underlain by rocks of the basement complex mainly the migmatite complex which was intruded by rocks of the Older-Granite suite at syn on to post-orogenic episodes with respect to the Pan-African orogeny. These s were intruded by basic dykes and other intrusives (pegmatites, dolerite and quartz veins). The geochemical characteristics of the rocks have shown e magma from which the rock fractionated is of mantle origin.

commendation

on the Research conducted and fieldwork, I strongly recommend the ing:

re research should be carried out on the Geology of Nigerian Basement lex as to make some amendments to the old researches that confuses in the a situation where you see something different and you are made to believe it 'as and not what you see in reference to literatures.

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

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The area is underlain by rocks of the basement complex mainly the migmatite gneiss complex which was intruded by rocks of the Older-Granite suite at syn collision to post-orogenic episodes with respect to the Pan-African orogeny. These granites were intruded by basic dykes and other intrusives (pegmatites, dolerite dykes. and quartz veins). The geochemical characteristics of the rocks have shown that the magma from which the rock fractionated is of mantle origin.

6.2 Recommendation

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

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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