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GEOLOGICAL MAPPING OF DIFFERENT ROCKS UNITS IN BOKOKO AREA, KEFFI LGA, NASARAWA STATE, NIGERIA

HASSAN A. MOHAMMED[1], ILIYASU M. ANZAKU[2], ANYAKU D. OVYE[3] , NASIRU UMARU[4]

[1]Department of Geology, School of Physical Science, Federal University of Technology, Owerri, Imo State. [2]Department of Science, School of Continuing Education, Bayero University, Kano. [3&4]Department of Geography, Faculty of Environmental Science, Nasarawa State University, Keffi, Nigeria.

Abstract

An independent geologic field mapping of the area around Bokoko, part of Keffi Sheet 208NE, which covered an area extent of about 25Km^2 was carried out on a scale of 1:12,500. The area lies within Latitudes: 8^{0}47'25"N and 8^{0}50'10"N, and longitudes 7^{0}57'15"E and 8^{0}00'00"E. The research was aimed at producing a geologic map of the study area such that it will contribute to knowledge and better understanding of the regional geology of Nigeria. Method of study involved field work to identify mappable rock units as well as structural features. Petrographic analysis was done to identify megascopic and microscopic properties of the rocks so as to ascertain the identities of these rocks. The different rocks identified in the study area are granite-gneiss, banded gneiss and schist. Structures such as joint, quartz vein and foliation were observed. The rose plot of these structures revealed that foliation is trending NE-SW while joints and quartz veins had various trend. Economic minerals in the study area include; construction materials such as granite and sand, and industrial minerals such as quartz, mica and feldspar.

Keywords: *Geological, Mapping, Rocks, Unit, Topography, Minerals.*

Introduction

Nigeria lies approximately between latitudes 4ºN and 15ºN and longitudes3ºE and 14ºE, within the Pan African mobile belt in between the West African and Congo cratons (figure 2.1). The Geology of Nigeria is dominated by crystalline and sedimentary rocks both occurring in approximately 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-gneissic –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).

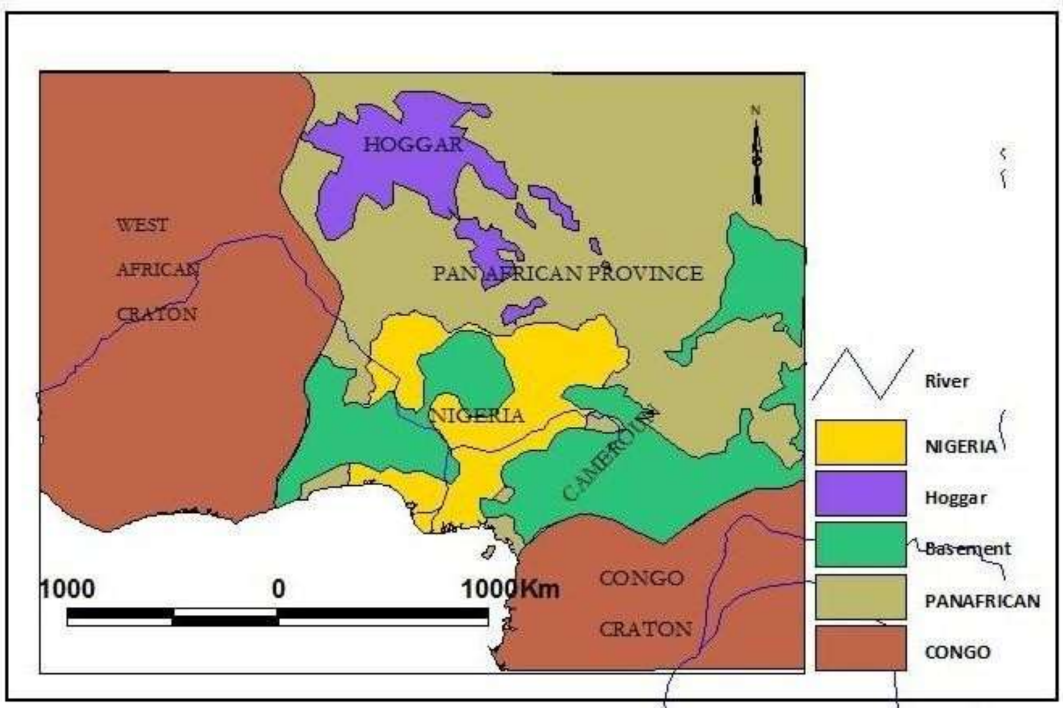

Fig 2.1: Location map of the Nigerian sector of the Pan-Africa mobile belt of West Africa (Turner, 1983)

Results and Discussion

Geological Mapping of the Study Area

Geological mapping of the area around Bokoko was done on a scale of 1:12,500. The study was undertaken with the aim of identifying different rock units and delineating boundaries between the various rock units and in so doing, produce an updated map of the area. Topographic map of Keffi Sheet 208NE was used to extract the base map for the study which covers an area of about 25Km^2 and lies within latitudes 08°47' 25'' N to

08°50'10'' N, and longitudes 7°57'15'' E to 8°00'00'' E. Surface traversing method was adopted. Three rock units were identified and samples were taken for further analysis. Thin sections of the rock samples collected from the area were prepared and analyzed in the Geology laboratory of Nasarawa State University Keffi (NSUK). Structural elements were also identified and their orientation were measured. The Geo rose computer software was used to plot the orientations of these structural features.
Lithologic and structural data were then superimposed on the blown base map to produce a geologic map and a cross-section was then produced.

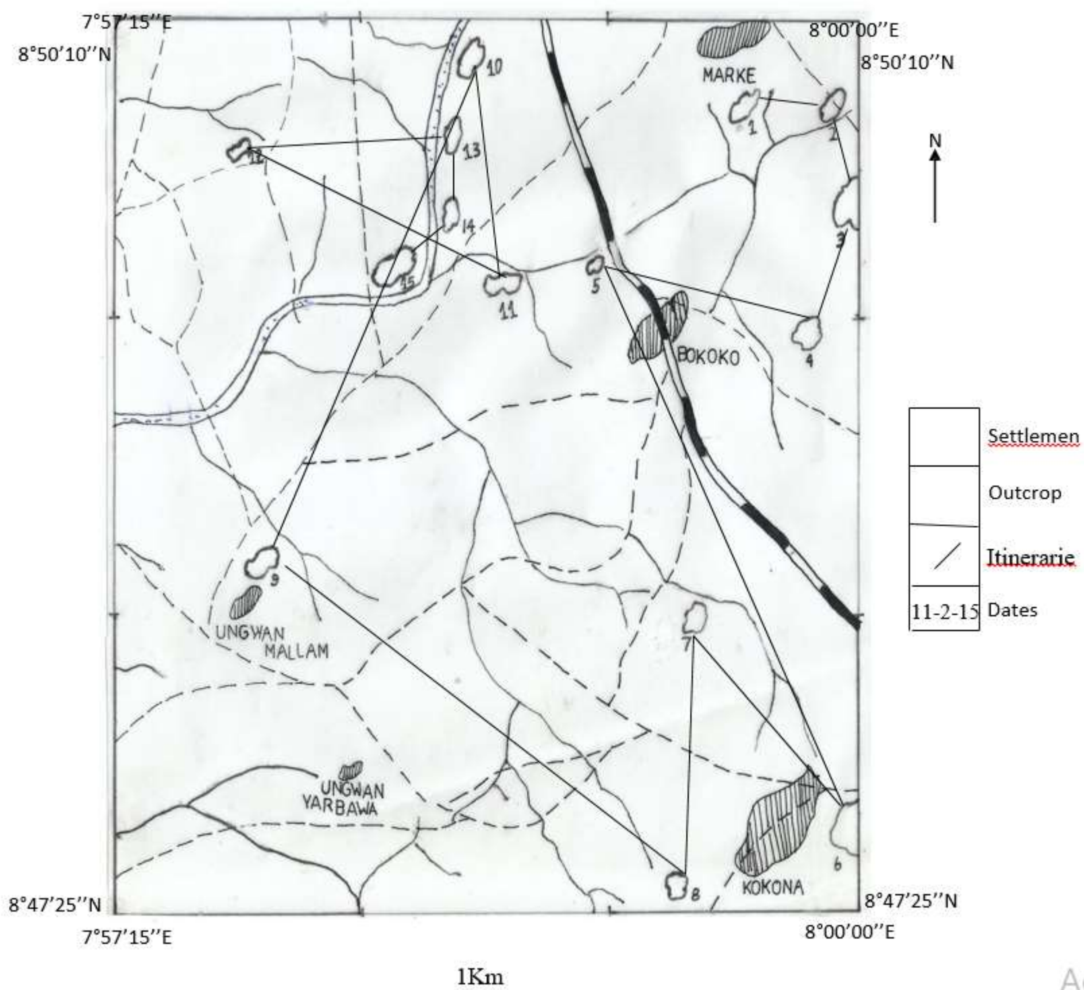

Fig 3.1: Mapping Itineraries and outcrop locations in the study area. Outcrops indicated as shaded shapes with number and dates of visit (Extracted and modified from Keffi Sheet 208 NE, Federal Survey of Nigeria 1972)

Petrography

This involved megascopic and microscopic studies of the mapped rocks. The megascopic studies involved the study of the physical properties of rock in hand specimen (Appendix A contain list of outcrops and their description). Figure 3.1 shows outcrop locations. Microscopic studies involved the use of a microscope to identify the constituent minerals in a rock sample in thin section, as well as their properties in the cross polarized light (XPL) and plane polarized light (PPL). The percentage composition of minerals was deduced by point counting each mineral present. The counting is done at least three times, rotating the stage in each case, the average of the three counts is then taken and the percentage composition was calculated relative to other minerals (see tables 3.1, 3.2, and 3.3). Based on the mineral assemblage, texture, and structures the identities of these rocks were confirmed.

Granite Gneiss

Megascopic description

The granite-gneiss was seen as massive exposures dominantly in the south-eastern part of the mapped area. It is medium to coarse grained, light coloured and intruded by quartz and quartzo-feldspathic veins. Structures such as joints and foliation surfaces were associated with the granite- gneiss in the mapped area. Minerals present include: feldspar, quartz, muscovite and biotite.

Microscopic description

Thin section, minerals present include**:** quartz, biotite, muscovite, orthoclase feldspar, plagioclase feldspar and microcline. The texture of the rock sample in thin section is relatively coarse grained, showing foliation. Muscovite has sharp contact with other minerals.

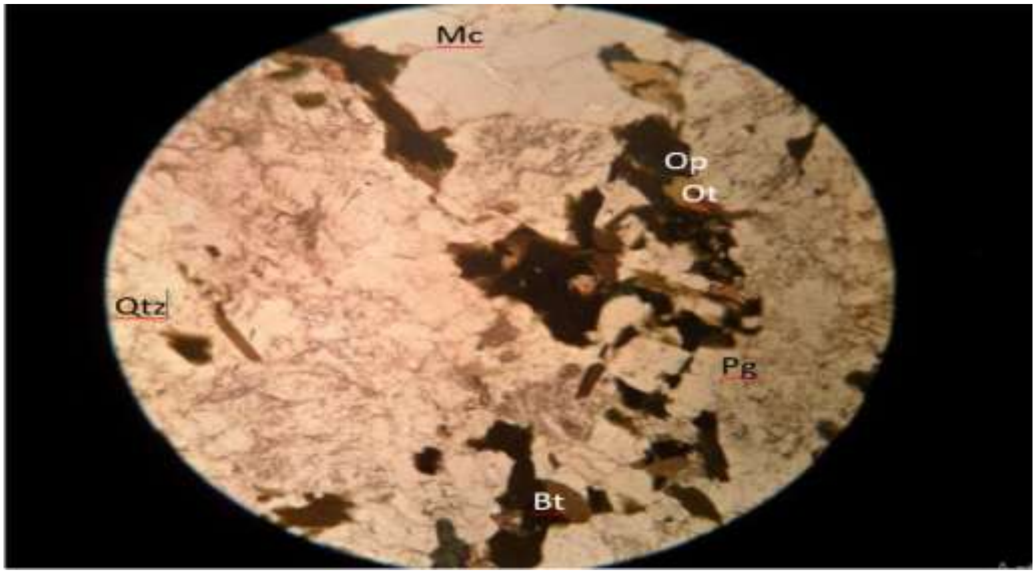

Plate 3.2a: Photomicrograph of foliation in granite gneiss under plane polarized light (Magnification X40)

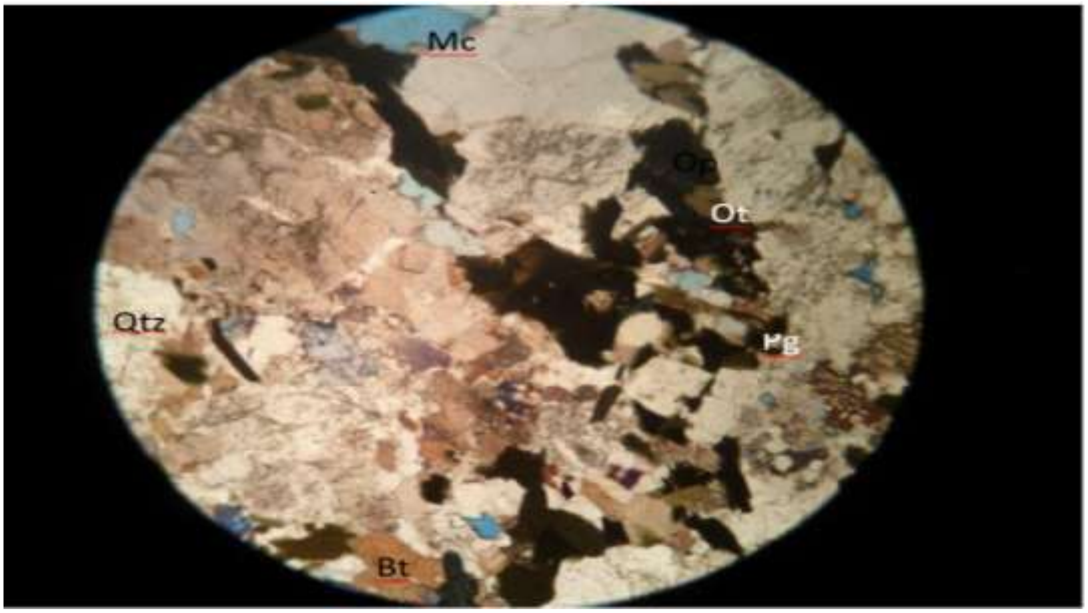

Plate 3.2b: Photomicrograph of foliation in granite-gneiss under cross polarized light (Magnification X40)

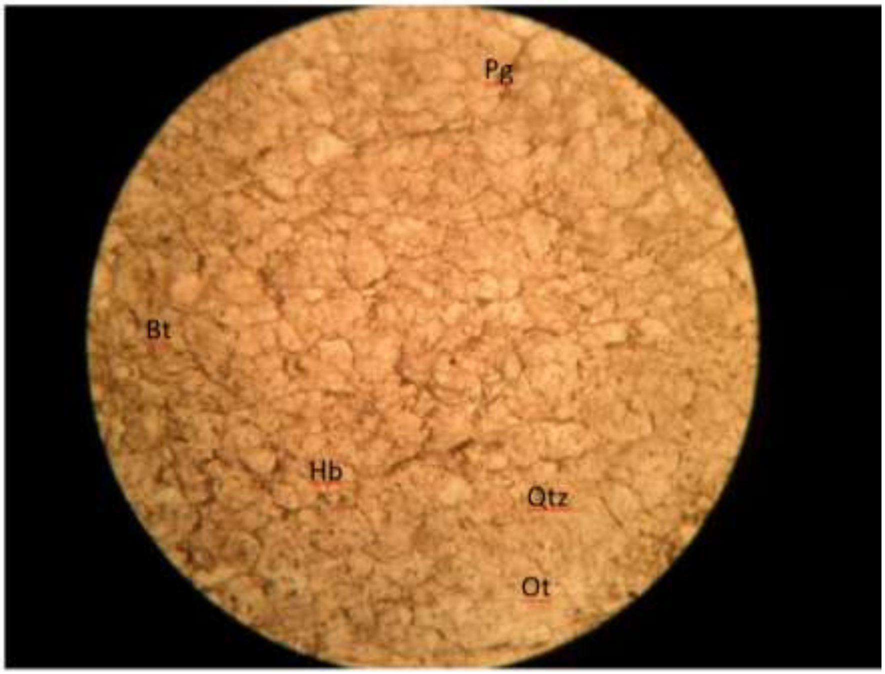

Plate 3.3a: Photomicrograph of foliation in granite gneiss under plane polarized light (Magnification X40)

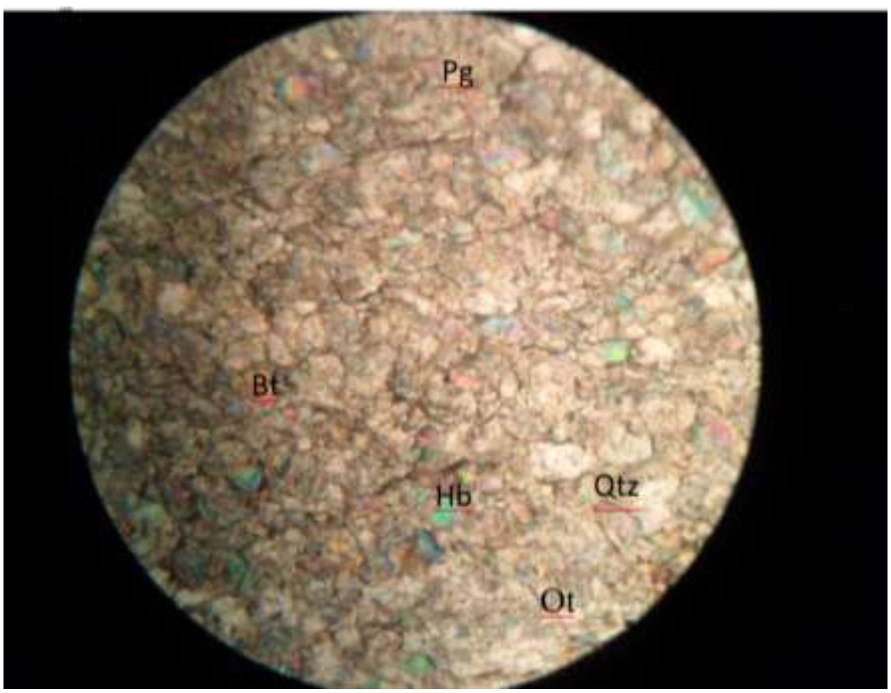

Plate 3.3b: Photomicrograph of foliation in granite-gneiss under cross polarized light (Magnification X40)

Plate 3.4a: Photomicrograph of foliation in granite-gneiss under plane polarized light (Magnification X40)

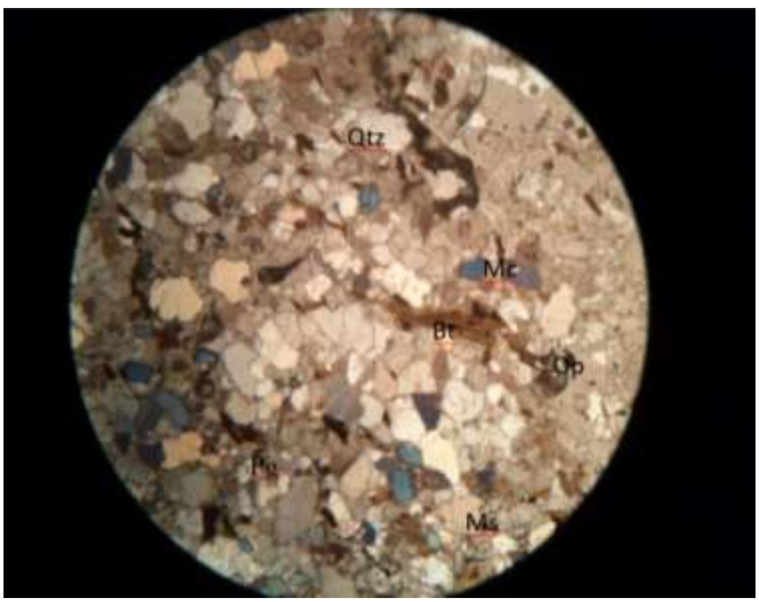

Plate 3.4b: Photomicrograph of foliation in granite-gneiss under cross polarized light
(Magnification X40)

(Mc = microcline, Qtz = quartz, Bt = biotite, Pg fd = plagioclase feldspar, Ms = muscovite, Op = opaque, Ot = orthoclase, Hb = hornblend)

Table3.1: Modal mineral Composition of granite-gneiss

Minerals	Relative % Composition
Quartz	**26**
Plagioclase feldspar	**27**
Microcline	**15**
Biotite	**13**
Orthoclase	**11**
Muscovite	**5**
Hornblende	**3**
Total	**100**

Quartz; It is colorless and shows a low relief under both PPL and XPL (see plates 3.2-3.4).
Biotite; It is brown in color, strongly pleochroic, having cleavages and showing parallel extinction in both PPL and XPL. Under PPL, it shows a high relief. It is subhedral in shape under XPL (see plate 3.2-3.4).
Orthoclase; Under PPL, it shows a low relief, it is colorless, subhedral in shape. It is cloudy with oblique extinction, and exhibit Carlsbad twinning pattern. Anhedral in shape, under XPL (see plate 3.2-3.4)
Muscovite; It is coarse grain under both PPL and XPL. Under PPL, it is colorless with perfect cleavage and has a parallel extinction. It shows a low relief and is subhedral in shape, under XPL (see plate 3.2-3.4).
Plagioclase; It is fine grained under both PPL and XPL. Under PPL, it shows a low relief, it is colorless and has a weak first order grey. Shows a low interference color, and multiple twining under XPL (see plate 3.2-3.4).
Microcline: It shows a low relief and has fine texture in both PPL and XPL.Under PPL, It shows an oblique extinction and crosshatch twinning pattern. Anhedral in shape and second order grey, under XPL (see plate 3.2-3.4).
Opaque: Appears to be dark in both PPL and XPL.
Hornblende: It has a low relief, and is fine grained in both PPL and XPL (see plate 3.2-3.4).

Banded Gneiss Megascopic description

Banded gneiss was mapped in the north-western part of the study area. It outcrops along River Andu and on its banks. The rock is medium to coarse grained, having an alignment of light and dark colored minerals i.e. leucocratic and melanaocratic bands (Plate 3.5). Minerals present include amphibole, biotite, quartz, and feldspar. Structures such as joints, quartz veins, and foliation were observed.

Plate 3.5: Banded gneiss exposure along Mararaban Kokona-Bokoko road (8°49’31”N, 7°59’02”E)

Microscopic description

In thin section minerals present include**:** quartz**,** biotite, plagioclase feldspar, and microcline. The rock shows a coarse grained texture in thin section.

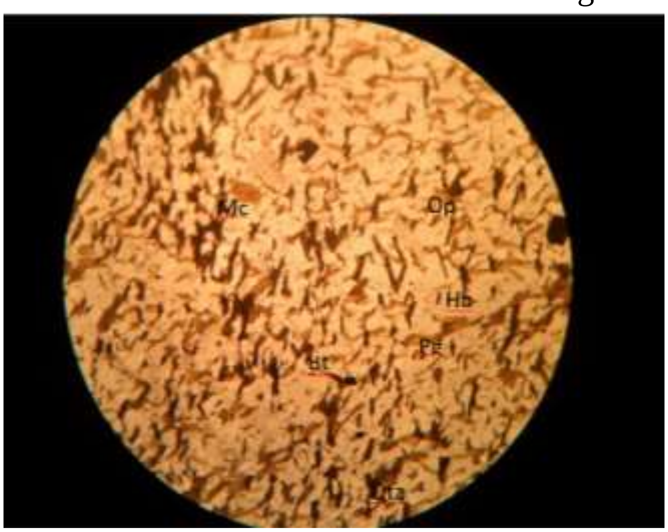

Plate 3.6a: Photomicrograph of banded-gneiss under plane polarized light (Magnification X40)

Plate 3.6b: Photomicrograph of banded-gneiss under cross polarized light (Magnification X40)
(Mc = microcline, Qtz = quartz, Bt = biotite, Pg = plagioclase feldspar, Ms = muscovite, Op = opaque, Hb = hornblend)

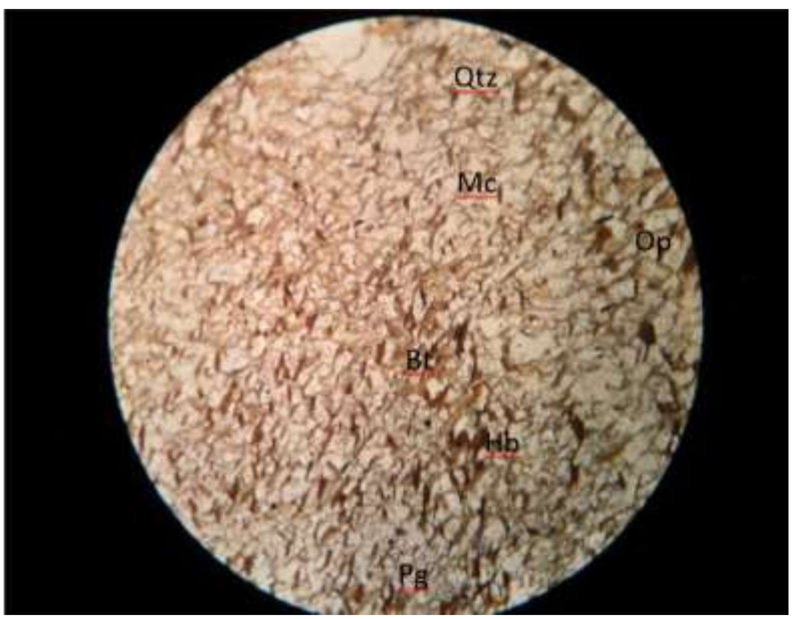

Plate 3.7a: Photomicrograph of banded- gneiss under Plane Polarized Light (Magnification X40)

Plate 3.7b: Photomicrograph of banded-gneiss under Cross Polarized Light (Magnification X40)
(Mc = microcline, Qtz = quartz, Bt = biotite, Pg = plagioclase feldspar, Ms = muscovite, Op = opaque, Hb = hornblend)

Table 3.2: Modal mineral composition of banded-gneiss

Minerals	Relative (%)composition
Quartz	33
Plagioclase feldspar	30
Biotite	21
Hornblende	8
Microcline	5
Opaque minerals	3
Total	100

Hornblende : Has a low relief, and is fine grained in both PPL and XPL. Under PPL, it appear zoned relative to adjacent crystals and displays two cleavages at angle 120^0. Has a high interference colour in XPL (Plate 3.6-3.7).
Biotite: Has a high relief in both PPL and XPL. Under PPL, it is brownish in color. Under XPL, it is light to dark brown, with straight extinction and third order interference colour (birefringence).

Quartz: Low relief, and colorless under both PPL and XPL (see plate 3.6-3.7) respectively.

Plagioclase feldspar: It is anhedral in shape in both PPL and XPL. Show a low relief, colorless in PPL, under XPL, it is grey in color with oblique extinction and Carlsbad twinning pattern.

Microcline: Shows a low relief in both PPL and XPL. Under PPL, it is colourless, and has relatively fine texture**.** Under XPL, it is cloudy, with oblique extinction and anhedral in shape

Opaque: Appears to be dark in both PPL and XPL

Schist Megascopic description

Schist outcrops as low isolated rock unit occupying the north-western part of the mapped area. It is fine to medium-grained in texture, dark coloured with large mica flakes in a preferred orientation. Minerals present include: hornblende, biotite, muscovite and minor quartz. Structures include joints and foliations.

One of the obvious features of the schist is the preferred orientation shown by platy minerals (schistosity) usually developed as a result of deformation, recovery and recrystallization. The plane of weakness in the schistose fabric is dominated by muscovite, and the rocks are easily split along these planes. The preferred orientation of the platy minerals is mainly in the NE-SW direction, parallel to the strike of the exposures. The average dip is 30^0NW.

Plate 3.8 Schist exposure (8°49’28”N, 7°58’42”E)

Microscopic description

In thin section, minerals present are: hornblende, biotite, muscovite, quartz, and Orthoclase. Its texture under the thin section is fine grained

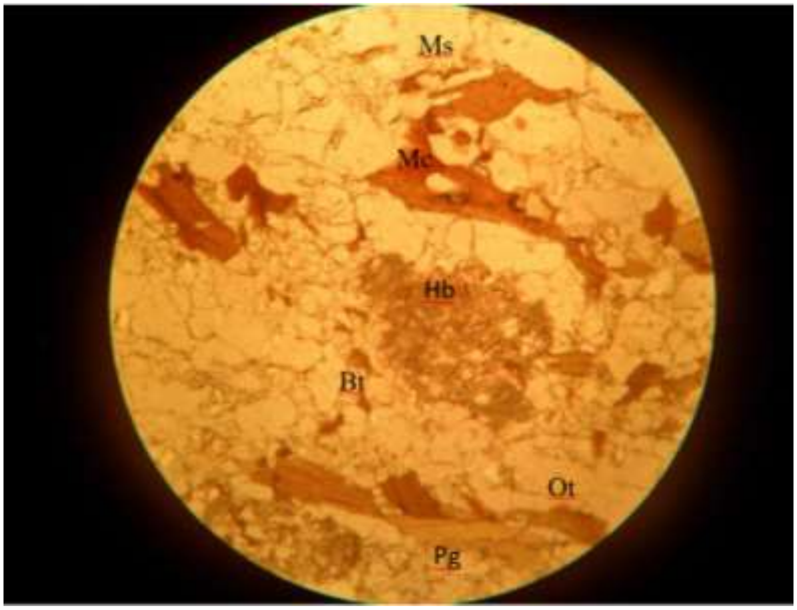

Plate 3.9a: Photomicrograph of schist under plane polarized light (Magnification X40)

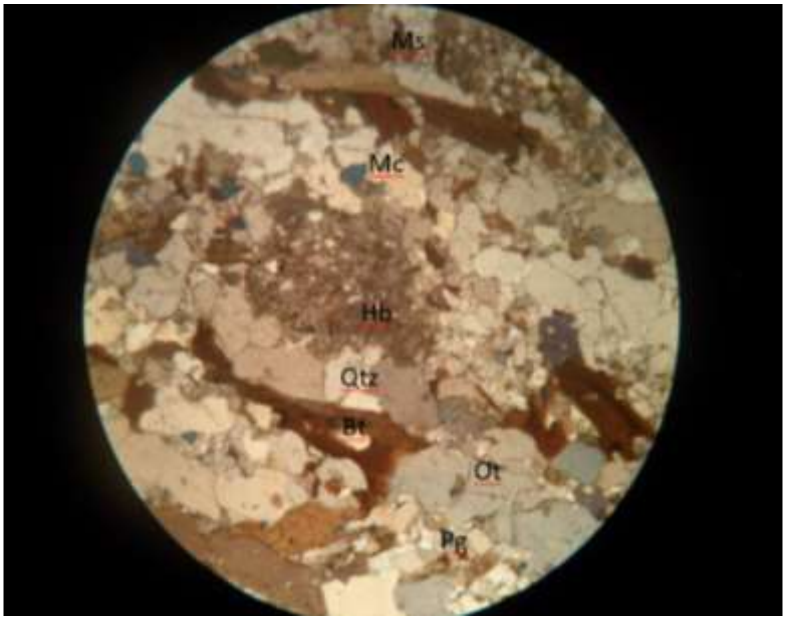

Plate 3.10b: Photomicrograph of schist under cross polarized light (Magnification X40)

(Mc = microcline, Qtz = quartz, Bt = biotite, Pg fd = plagioclase feldspar, Ms = muscovite, Op = opaque, Ot = orthoclase, Hb = hornblend)

Table 3.3: Modal mineral composition of Schist

Minerals	Relative % composition
Hornblende	**50**
Biotie	**20**
Muscovite	**15**
Orthoclase	**10**
Quartz	**5**
Total	**100**

Hornblende: It shows a low relief and is fine grained in both PPL and XPL. Under PPL, it has a high interference colour. Under XPL, it is zoned relative to adjacent crystals and displays two cleavages at angle 120^0.

Biotite: It shows a high relief and is brown in color under both PPL and XPL. Under PPL (See plate 3.9a), It has a perfect cleavage. Under XPL (See plate 3.9b), boundary with other minerals clearly is shown.

Orthoclase: It is anhedral in shape and fine grained in both PPL and XPL. Under PPL (See plate 3.9a), It shows a low relief and is Colourless. Under XPL (See plate 3.9b), It is cloudy to grey in color with oblique extinction.

Muscovite: It shows a high relief, and has cleavage in both PPL and XPL. Under PPL (See plate 3.9a), it shows weak pleochroism, and parallel extinction. Under XPL (See plate 3.9b) it has twining according to the mica law.

Quartz; It is colorless in both PPL and XPL. Under PPL (see plate 3.9a), it shows a high relief. Under XPL (See plate 3.9b), it shows a low interference color.

Structural Geology

Structural elements such as foliation, joints, and quartz vein are among the prominent structural features observed within the mapped area. The structures occur mainly in the granite gneiss, schist and banded gneiss.

These structures result from the deformational stresses and filling of fractures and cavities by late magmatic fluids. Strike readings were taken for quartz veins, joints, and pegmatite veins, and used to plot rose diagrams in order to determine the general structural trend in the study area. Also to determine the dominant structural trend which will help in reconstructing the geological history of the area.

Foliations

This is defined by parallel alignment and planer feature in a rock caused by metamorphism of the rocks. Foliations in the rocks of the area are dominantly in the NE-SW direction and prominent in the banded gneiss, and schist but weak in the granite gneiss. In the banded gneiss the foliation is defined by parallel layers of alternating dark and light bands

Plate. 3.10: Foliation on granite-gneiss at Marke (8°50’08”N, 7°59’50”E). The compass is oriented in the regional trend of the area (NNW-SSE).

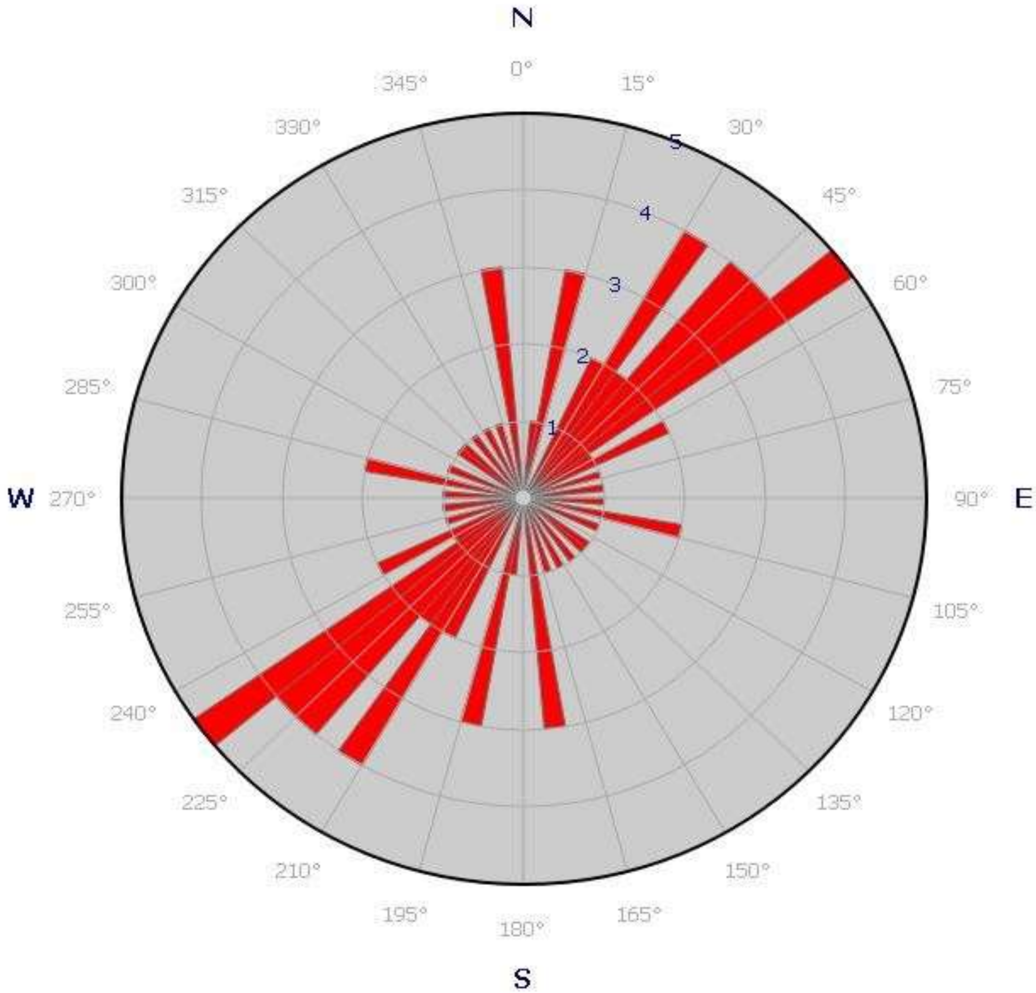

Figure 3.2: Rose diagram of foliation in the study area. (Number of data point =42) Dominant trend = NE-SW

Joints

Joints are structures resulting from brittle deformation of rocks. Joints are formed by fracturing, by the development of cracks along point of weakness in a rock mass where the original cohesion is lost with no relative displacement. On the field, joints were observed on all the rock types (graniti-gneiss, schists, and banded gneisses) and is widely distributed in the studied area.

Plate 3.11: Joint on granite gneiss ($8^0 50' 10''$N, $7^0 54' 57''$E)

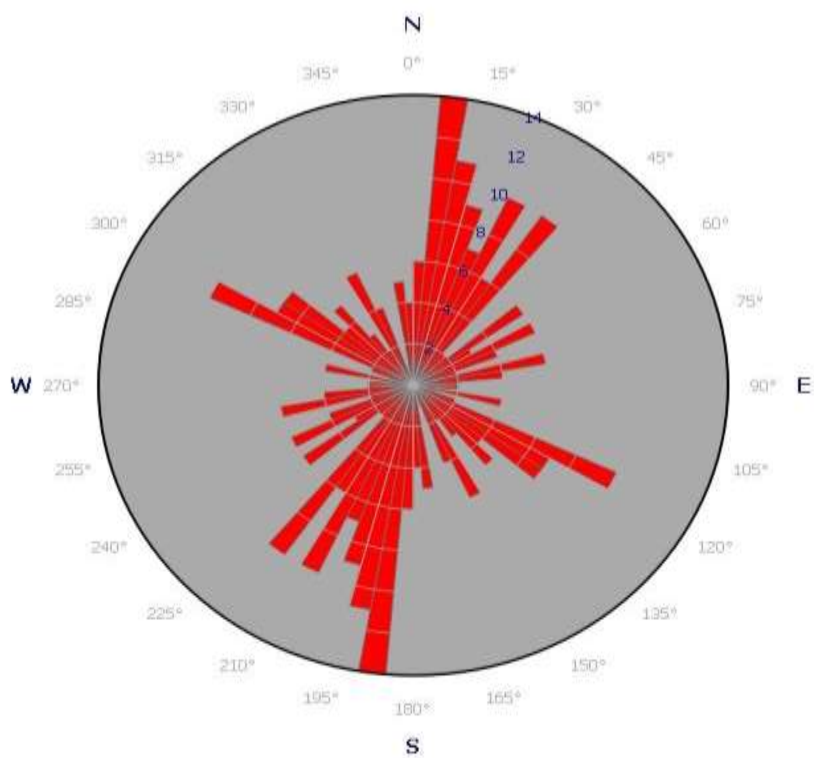

Figure 3.3: Rose diagram of joints in the study area. (Number of data point = 180)

Quartz Veins

Quartz vein is a long, thin section of mineral, embedded in a host rock (Plate 3.12). It is usually caused by the infilling of fractures during the late stage of magmatic fluid segregation. It is a tabular or sheet like body of one or more mineral deposited in openings or fissures, or faults sometimes with associated replacement of the host rock. Strike readings were taken and used to plot rose diagram (Figure 3.4)

Plate 3.12: Quartz vein on granite-gneiss at Marke ($8^0 50' 10''$N, $7^0 59' 57''$E)

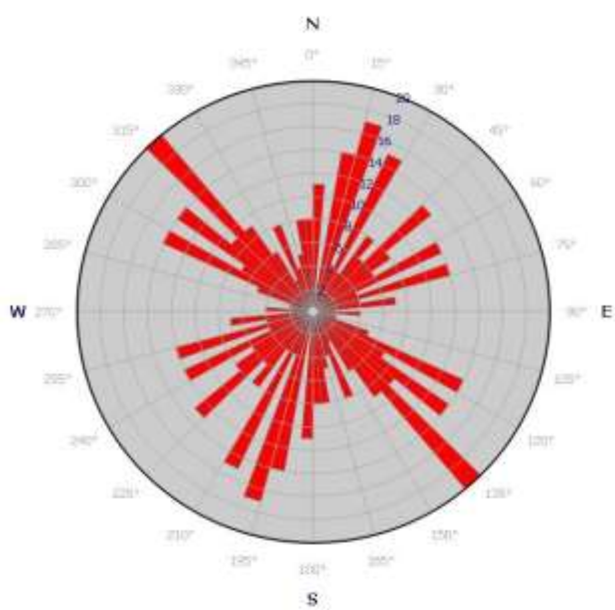

Figure 3.4: Rose diagram of quartz veins in the study area. (Number of data point = 285)

Geological Setting

The study area is underlain by basement rocks of Precambrian age. The rocks are gneiss, which is the oldest rock, schist (older metasediments) formed during the Late Proterozoic age, and granite-gneisses which are part of the migmatite-gneiss complex intruded by quarzo-feldspathic veins. The schist have been variably metamorphosed and granitised through at least two tectono-metamorphic cycles so that they have been largely converted into granite-gneiss.

Pan-African

Granite-gneiss in the study area are part of the migmatite-gneiss complex emplaced during the Pan-African.

Late Precambrian to Lower Paleozoic

During the Late Precambrian to Lower Paleozoic time, the amphibolite- schist in the study area was formed. After the formation, it undergoes metarmorphism and granitisation through at least two tectono- metamorphic cycles (Kibaran and Pan-African), which has extensively modified the amphibolites-schist into migmatite and granite-gneiss. The amphibolite-schist formed the basement upon which all other rock types within the study area invaded.

Economic Potentials of the Study Area

The solid geology of the study area consists of granite gneiss, banded gneiss and schist. These rocks are host to many economic mineral resources and when quarried serve as construction materials. The granite gneiss can be quarried for the production of both dimension stones and aggregate to be used for construction works. The banded gneiss found within the study area can be a good source of construction materials that can be used for both civil engineering works and building. Soils produced from the weathering of this rock are usually rich in ash which in turn makes it very fertile for agricultural activities. The pegmatite intrusion extending from the northwestern-southern part of the study area is linked to the Late Pan-African.

The numerous sets of joints and other structural features found around Bokoko area, if properly studied could be a very good indication of economic viability to mineral explorationist thus, aiding them to find locations or points where economic mineralization is intense and of commercial quantity.

Mica

Despite great variations in their chemical composition, mica minerals are easily grouped together because of their similar atomic structure. Most prominent mica types in the study areas are muscovite (potash white mica) and biotite (ferromagnesian black mica). Books or flakes of micas were observed to be part of the granite gneiss intrusion north-eastern part of the area. Mica is used in electrical insulators and lamp shades therefore, if properly mined can be a raw material to emerging electronic industries if quality and quantity are abundant.

Quartz

Quartz is one of the most useful natural materials. Its usefulness can be linked to its physical and chemical properties. It has a hardness of seven on the Mohr's Scale which makes it very durable. It has electrical and heat resistance that make it valuable in electronic products. Its luster, color and diaphaneity make it useful as a gemstone and also in the making of glass. Quartzofeldsphatic veins and pegmatite intrusions within Bokoko and environs could host large amount of quartz which if properly exploited can be used for glass producing.

Feldspar

Feldspars are used in making ceramics, glasses fillers, poultry feeds, construction works etc. It is used as enamel for household utensils and tiles. Feldspars are concentrated in pegmatite veins of the study area. Among the various types of feldspar, potasic feldspar (either orthoclase and/or microcline) are the most useful and important types. These varieties of feldspars have been observed to be the major constituent of the granitic gneiss and banded gneiss dominating Bokoko and environs.

Biotite

Biotite is one of the common rock-forming minerals. It is found in many types of igneous and metamorphic rocks, it is easily recognized because of its perfect cleavage that allows it to separate into thin black, flexible sheet. Biotite has limited commercial uses. Biotite particles are sometimes used as surface treatment in decorative concrete, plaster and other construction materials; it is also used in the potassium-argon method of dating igneous rocks. The gneiss and the granite gneisses of Bokoko area is made up of sufficient amount of biotite mineral which when exploited and sold would be a plus to the country's economy consequently, creating jobs and bringing in new technologies needed in its beneficiation.

Hornblende

Hornblende is a complex inosilicate series of minerals (ferrohornblende-magnesiohornblende). It is not a recognized mineral in its own right, but the name is used as a general term for dark amphibole. It is an isomorphous mixture of three molecules; calcium-iron-magnesium silicate, aluminum-iron magnesium silicate and iron-magnesium silicate. It is also used in steel making, soap, and oil. Hornblene was observed under the microscope to be one the major constituents of the amphibole and the granite-gneiss of the Bokoko area which if exploited and concentrated can be of economic importance.

Building and Construction Materials

Granite gneiss

Granite gneisses as dimension stones are used in bridges, tunnels, pavement, towers, monuments and many other exterior projects to give impressions of elegance and quality. They are also used as ornamental stones when properly polished.

Plate 4.1: Quarried granite gneiss for building purposes ($8^0 47' 21''$N,$7^0 59' 58''$E)

Sand

Sand is loose or fragmented naturally occurring material consisting of very small particle of decomposed rocks. Sand is used to provide bulk strength and other properties of construction material like concrete plaster asphalt. Specific types of sand are used in the manufacture of glass and as molding materials for metal casting. River Andu in the area has an extensive and considerably thick Alluvian in its bank and bed, the sand is coarse grained and whitish-gray, very suitable for construction work.

Plate 4.2: Sand at the bank of river Andu ($8^{0}50^{'}6^{''}$N,$7^{0}58^{'}30^{''}$E)

Water resources

The water resources in the study area include both surface water sources (streams and rivers) and ground water resources (aquiferous zones).

Surface Water resources

Within Bokoko area, surface water resources are river channels and streams. Volume of water in these streams and rivers reduce in the dry season due to evaporation and seepage and returns to its full size during the wet season as a result of the relatively high rainfall experienced within the area between July-

October. The rivers and streams have their sources from the northern plateau such as the Mambila Plateau through the work of smaller water bodies and the contribution from rainfall. Streams empty into the main River Andu from various directions. The water from this source are use for various purposes ranging from construction to domestic use by the community.

Conclusion

Bokoko and its surroundings, is part of the Basement Complex of the North Central Nigeria which is underlain by basement rocks of Precambrian age. These consist of three rock types; granite-gneiss, banded-gneiss and schist intruded by quartz veins trending NE-SW. Structures such as joints, quartz vein and foliation are associated with the rocks. Economic mineral resources within the study area include industrial minerals (quartz, mica, feldspar, and hornblende), construction materials such as granite and sand can also be found in the area. There are limited boreholes and wells in the area, making the people in the area to depend heavily on the surface water from the streams which signifies that the are has good aquifers. Cattle rearing are common in the area, which in turns pollute the waters.

Recommendations

Based on the observations made in the course of this research, I wish to recommend that;

- A detailed geological mapping, geochemical studies, and geophysical studies of Keffi Sheet 208NE, or any particular Sheet should be carried out by all the project students of a particular year. This will enable the department gather important geologic data of the various Sheet, improve understanding of the regional geology, or even market such data to investors.
- An intensive study should be carried out on the structures within the study area, aimed at understanding the importance and economic value of these structures.

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