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Petrographic and Structural Analysis of Exposed Rocks of Bishini Sheet (Block 2), North Central Nigeria

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Abstract

This study is the second of a series of work to be done on Bishini Sheet 165 SW, which is part of the basement complex of the Kushiriki-Minna area. The area lies between latitudes 9°34′ N and 9°40′ N and longitudes 7°00′ E and 7°08′ E. Due to the continuous play of geologic processes on the earth, there is the need to continuously update the geology of the Nigeria basement complex as this has a very important economic implication in areas like mineral and water exploration. Equally, less attention has been given to this sheet unlike other sheets within the zone. The study of the block has revealed the various rock types and their geological characteristics: field relation, macroscopic and microscopic features and structural elements. Results from the field shows that the block consists of migmatites, gneisses, schists and granites which all show a variety of colours, textures and mineralogy. The displacement of distinctive mineralogy, textures, optical and structural characteristics led to the nomenclature of the rocks. The granitic rocks displayed two petrographic varieties based on their textures. These are the fine-medium grained and coarse porphyritic varieties. The granitic rocks have greatly intruded other rocks and this is thought to be responsible for gold mineralization in the area, The NNE-SSW and the NNW-SSE are the major structural trends determined for the joints and faults while the minor ones are the NE-SW and NW-SE. All these trends are consistent with the general trends of the Nigeria basement rocks. A study of thin sections of the rocks under a petrological microscope reveals characteristic optical properties peculiar to each rock type. The type and nature of the minerals the rocks contain together with their geometry reveal that the rocks have undergone more than one deformational event since the time of their formation. The occurrence of numerous fractures (joints and faults) shows that the area has a great potential for water and mineral exploration.

Keywords: Bishini sheet, basement complex, brittle structures, thin sections, petrographic varieties

1. Introduction

The Basement complex of Nigeria lies within the Pan-African Mobile belt (Caby, 1989) of Late Proterozoic (500-750 Ma) age lying between the Achaean blocks of West African Craton and the Congo Craton. This Basement complex comprises of migmatites and gneisses with supracrustral relics, which have yielded Achaean (c.2700 Ma) and Proterozoic, (2000 Ma) ages (Annor, 1995; Dada et al., 1998). Intrusive to the migmatites, gneisses and supracrustal relics are the granites, termed the Older Granites which have been dated severally at 500-750Ma (Van Breenmen et al., 1977; Fitches et al., 1985; Ajibade et al., 1987; Rahaman et al., 1983; Umeji & Caean, 1984; Ferre et al., 1998; Ekwueme & Kroner, 1998). These granites are products of Late Proterozoic (Pan-African) events that are characterized by high-grade metamorphism; folding, widespread granites plutonism and Late Transcurrent shear zones and faults (Okonkwo & Winchester, 2004). The study area is block 2 of the sheet and consists of rocks similar to those of block 1 mapped by Ako and Abba in 2011.

The study area for this work is located in the south western part of Bishini sheet 165 and is situated between longitudes 9°34′ and 9°40′ N and longitudes 7°00′ and 7°08′ E (Figure 1).

Unlike other sheets within the zone that have been intensively studied (e.g. Zungeru sheet, Ajibade, 1980, 1982) not much work has been done on this sheet. The activities of artisanal miners sourcing for alluvial gold, stimulated great curiosity in the study of the rocks. Also, there is the need to continuously update the geology of the Nigerian Basement complex due to the dynamic nature of geology. This paper examines the geology of the study area with the aim of revealing the various rock types, their petrology, petrography, structures and structural control of gold mineralization by an intensive field work and laboratory study of thin sections of the rocks using a petrological microscope.

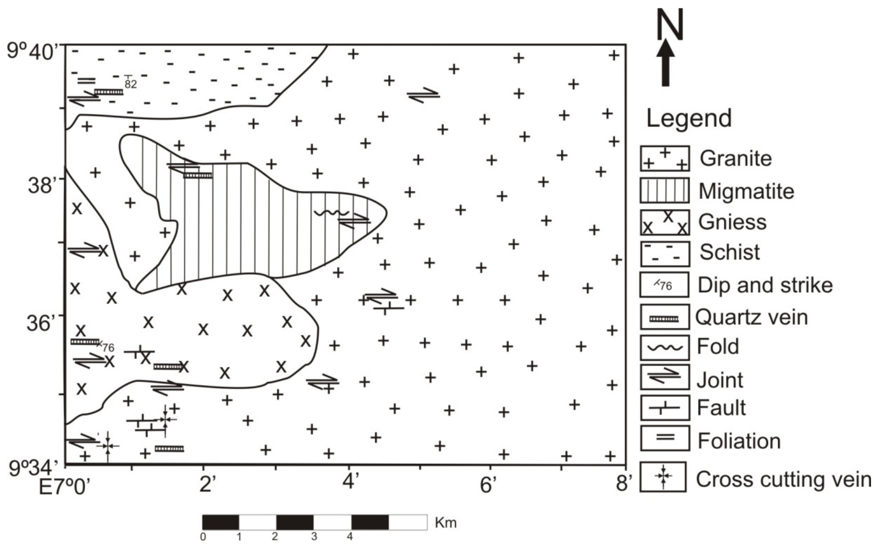

Figure 1. Geological map of the study area

2. Materials and Methods of Study

2.1 Fieldwork

The field work was carried out in March, 2010. Representative rock samples were collected from all available rock exposures in the study area. In the field, each outcrop was observed and described based on it's made of occurrence, macroscopic characteristics, structural elements and field relation with adjacent outcrops. Hand specimens were described based on the following macroscopic features: colour, texture, mineralogy and carefully labelled and points plotted on the base map at the appropriate locations were the samples were collected with the use of a Germin Global positioning system (GPS) and the geographic coordinates of the base map. Careful observation of lithological boundaries was made by observing changes in rock exposures, nature of soil, vegetation and topography. A Silva compass clinometer was used to measure strike and dip values and directions of outcrops using the contact method.

2.1.1 Mapping of Structures

Fractures (joints and faults), lineations and foliations were the main structural elements present in the rocks. Joints were mapped by observing areas in outcrops where cohesion is lost with no relative movement of the rocks along the fracture plane. The relationship of the joints, whether parallel to the dip, strike or not in alliance with either the strike or dip of the rocks was also observed. The spacing between joints in each set, the rocks each set penetrates and the chronological sequence of sets of joints were noted. All the joint values were measured and plotted on a Rose diagram.

Faults, lineations and foliations were mapped by the method described by Ramsay (1967).

2.2 Laboratory Work

In the laboratory, petrography analysis was done on selected representative rock samples for microscopic study. Five rock samples (each of gneiss, migmatite, schist and granites) were used for thin sections preparation according to the method by Rowland (1953). The thin sections were examined using a petrological microscopic (model NP-107B) under plane polarized Light (PPL) and crossed polarized light (XPL)with the aid of transmitted light and photomicrographs of the thin sections produced. The laboratory analysis was done at the laboratory and workshop of Department of Geology, Federal University of Technology, Minna, Nigeria.

3. Results

3.1 Field Distribution of Rocks

The study area consists of four main lithologies which occur at low topographic levels. These are migmatites, gneisses, schists and granites. The migmatites occur in association with the gneisses and granites and form a well defined (sharp) contact with the granites while that with gneiss is not defined. They occur as massive outcrops in a N-S trending unit and are marked by the development of foliations and lineations.

The gneisses occupy the western portion of the study area and are sandwiched by the migmatites and granites. They show contacts with the granites that are marked by the development of cataclasites. In some places, they occur as isolated bodies without any defined contacts with themselves.

The schists are situated is the north-western portion of the area and are highly weathered and exfoliated, resulting in the peeling of the surface layers which are usually in millimetres to a few meters in thickness. The schists have been intruded by the granites bodies where they form a sharp contact.

Granites occupy almost 80% of the study area and form contacts with the other rock types. Field relations and structural features show that the granites occur in a shear zone which is a very important structural discontinuity surface in the rocks. The sense of shear is dextral which is indicated by foliation into the shear zone. Two petrographic varieties of granites were observed in the field on the basis of their textures. These are the fine-medium grained and coarse, porphyritic varieties.

3.2 Petrography of the Rocks

3.2.1 Migmatites

The migmatites are dark and light in colour and comprised leucocratic (leucosome) and melanocratic (melanosome) fractions. The melanocratic fraction is the metamorphic host rock while the leucocratic fraction is the metasomatic acid injection. The rock displayed a migmatitic texture marked by the development of foliations and lineations. The foliations are defined by the parallel arrangement of dark and light coloured minerals while the lineations are defined by low, sub parallel ribs and furrows on the cleavage surface of the rocks.

The mineral grains have been highly deformed and occur as sub-anhedral to anhedral deformed grains. Hand specimen of the rock shows the presence of hornblende, plagioclase, biotite and quartz.

Under the microscope, the rocks show euhedral and anhedral crystals of dark and light coloured minerals. The dark coloured minerals are hornblende and biotite while plagioclase and quartz are the light coloured minerals. The orientation of the dark and light coloured minerals defines the foliations and lineations in the rock. The rock shows a coarse grained texture due to the development of the mineral gains into well defined crystals though some have been deformed.

The rock shows light coloured bands with a granoblastic texture and this composed of plagioclase and quartz. It also consists of dark coloured bands of short prismatic crystals of hornblende and biotite. Hornblende occurs as xenoblastic crystals, green in colour and shows pleochroism form yellowish green to dark green. It shows a high relief and two directions of cleavage which are lacking in some crystals. Where cleavage is lacking, minor fractures are displayed in their place (Plate 1a). Plagioclase occurs as large crystals, colourless and anhedral in shape. The crystals are well developed with characteristic polysynthetic twining. It shows a moderate relief; poor cleavage traces and is non pleochroic.

Biotite occurs as brownish coloured crystals, poikiloblastic within hornblende. It is anhedral in shape, exhibits pleochrosim characterized by a dark pleochroic haloes, a very high relief and one direction of cleavage. Quartz occurs as a colourless mineral with inclusions of unidentified minerals with a low relief, no cleavage and lacks twining. It is tubular and anhedral in shape. It shows no pleochroism and exhibits a high interference colour of yellow to brown (Plate 1b).

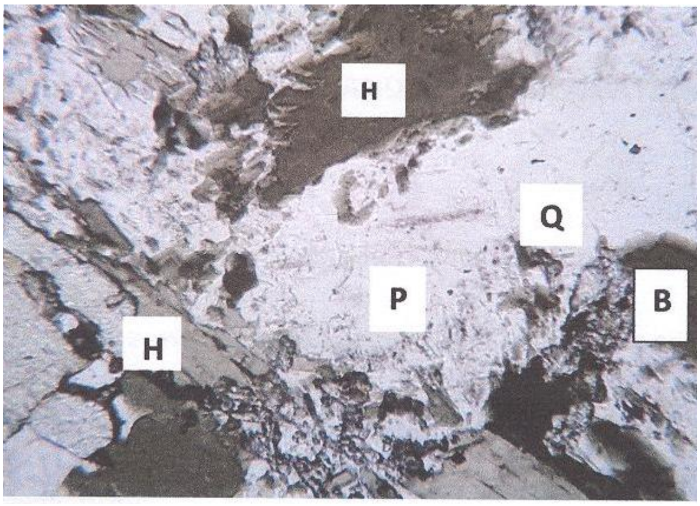

Plate 1a. Photomicrograph migmatite under plane polarized light (PPL) showing plagioclase (P), biotite (B), quartz (Q) and hornblende (H). Note the characteristic prismatic habit of hornblende and its preferred orientation. Plagioclase and quartz show characteristic light colour

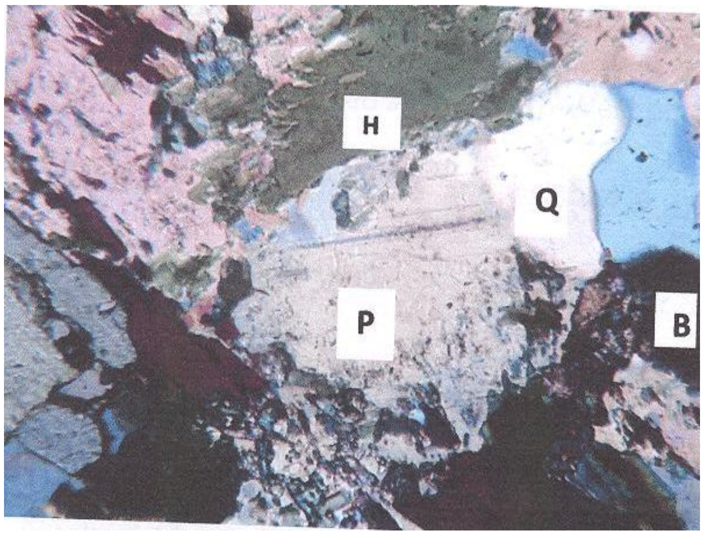

Plate 1b. Photomicrograph of migmatite under Crossed Polarized Light (XPL) showing the various shades of colours of mineral grains. Note the interference colour of quartz from light grey to blue and two directions of cleavage shown by plagioclase.

3.2.2 Gneisses

Gneisses occur as a medium-to coarse-gained foliated rocks with variable colours. It contains porphyroblasts of feldspar in large amounts and up to 2-3 cm in length. It is highly banded with ferromagnesian minerals representing the dark bands. The dark bands contain hornblende and biotite while the light bands are made up of quartz and feldspar. In hand specimen the rock consists of quartz, feldspar and biotite.

Under the microscope, the rock shows variable grains of minerals closely packed showing preferred orientation. It displays an even texture though individual grains are irregularly shaped. The following minerals can be distinguished- feldspar, quartz, biotite, hornblende, garnet and epidote which occur under plane polarized light as colourless grains. The feldspar observed is a plagioclase and occurs as a colourless mineral, which is sub-hedral to euhedral in shape. It shows two directions of cleavage, low relief and has not been altered. The crystals exhibit lamellar twining and oscillatory zoning. Quartz occurs as a colourless mineral, sub-hedral in shape and shows no cleavage traces. Biotite is seen as large plates, brown to black in colour and contains inclusions of some opaque minerals. The crystals are arranged in an elongated pattern parallel to the foliation plane. It shows pleochroism from dark brown to black and a perfect cleavage in one direction. Epidote which occurs as an accessory mineral shows shades of yellow to blue and pleochroic with a high relief. It occurs as small granular aggregates in the rock and the crystals are clustered together while others are dispersed in the matrix of other minerals (Plates 2a and b).

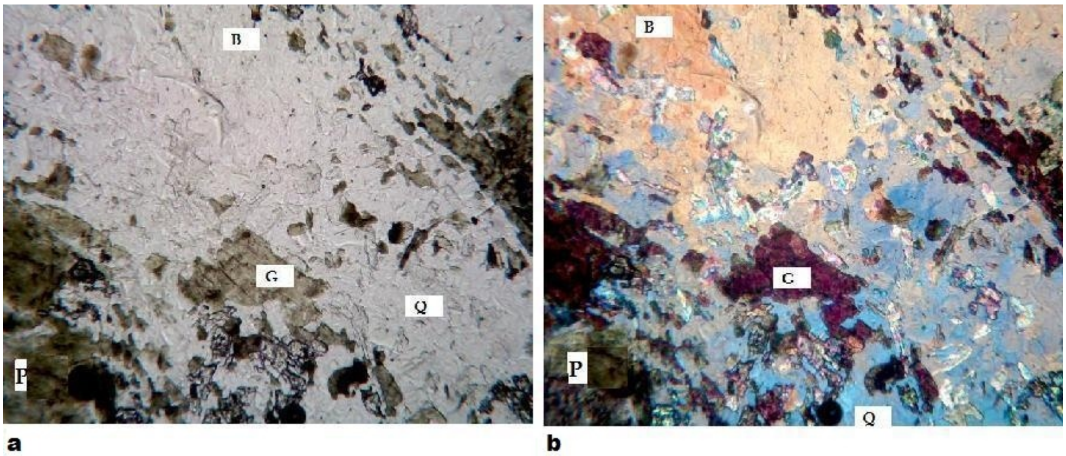

Plate 2. Photomicrographs of gneiss under PPL (a) and XPL (b) showing biotite (B), quartz (Q), garnet (G) and plagioclase (P)

3.2.3 Schists

These rocks form extensive bodies characterized by preponderance of quartz rubbles and disaggregated mica "books" over the area where they occur. They are white to light grey in colour, coarse grained with large crystals of quartz and large intergranular muscovite plates. The schists are largely pelitic and contain very little feldsparthic minerals. The rocks display well-defined schistosity that makes it splits easily and contains mica flakes distributed in wavy lines which alternately meet and separate into sheets.. In hand specimen the rocks are light in colour, fine-to-medium grained and consist of plagioclase, quartz, muscovite, biotite, epidote, chlorite and opaque minerals.

Under the microscope, quartz occurs as a colourless mineral usually cloudy and anhedral in shape with a low relief. It shows no cleavage, alteration and pleochroism. Muscovite occurs as coarse elongated plates, colourless and often found within the intergranular spaces of interlocking quartz crystals. Biotite occurs as sub-hedral grains in between crystals of other minerals. It exhibits pleochroism, moderate relief and one direction of cleavage. Plagioclase occurs as a colourless mineral with a prismatic anhedral form. Chlorite and epidote are other minerals seen under the microscope (Plates 3a and b).

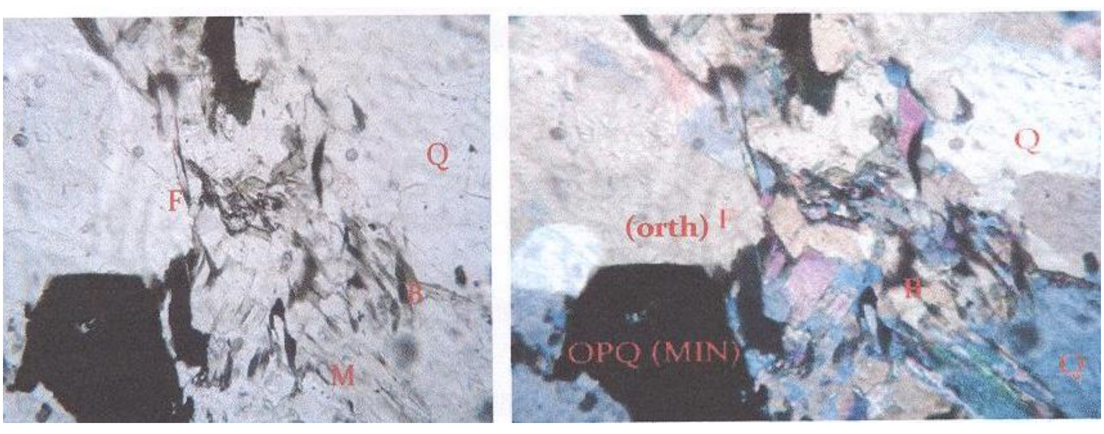

Plate 3. Photomicrographs of schist under PPL (a) and XPL (b) showing anhedral crystals of quartz, feldspar, biotite, muscovite and some opaque minerals (black). The quartz exhibits interference colours from grey to blue

3.2.4 Granites

3.2.4.1 Fine-to-medium Granites

These rocks contain quartz, microcline, plagioclase together with small amounts of hornblende and biotite. In some places, a little muscovite occurs at the grain boundaries of other minerals. Accessory minerals include zircon, chlorite and magnetite. The plagioclase shows a dusty appearance while quartz is clear. Hornblende and biotite are the main dark coloured minerals in the rocks. Due to sharing most of the crystals have preferred orientation resulting in ribbon shape fabrics (Plates 4a and b).

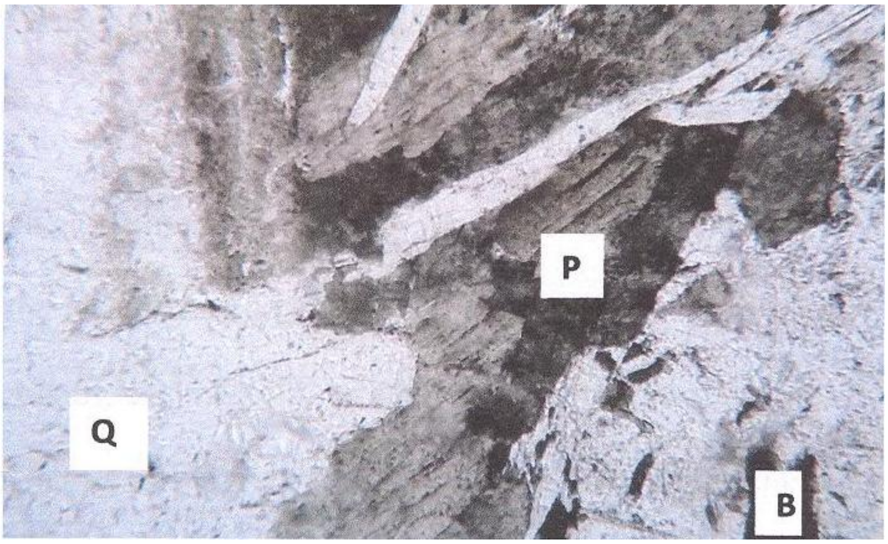

Plate 4a. Photomicrograph of fine-medium-grained granite under PPL. Note the preferred orientation of minerals due to strain giving the minerals a ribbon shape

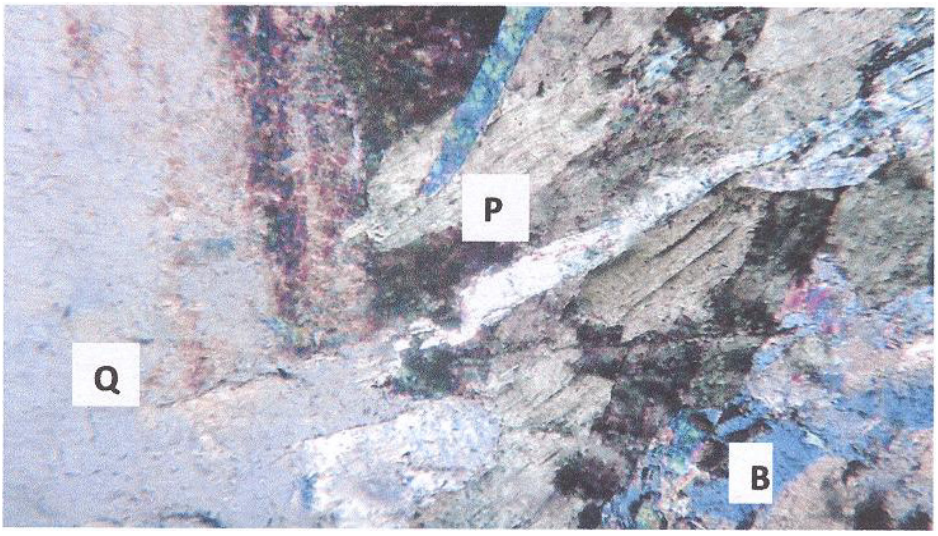

Plate 4b. Photomicrograph of fine-medium-grained granite under XPL showing variably coloured grains of quartz, Plagioclase and accessory minerals

3.2.4.2 Coarse, Porphyritic Granites

These consist of interlocking prismatic feldspars and irregular quartz crystals, all in shades of dark grey through grey to white. Muscovite occurs in shades of yellow. The rocks have very large feldspar crystals (phenocrysts) set within smaller ones (ground mass) giving the rock a porphyritic texture. In some places, the quartz and feldspar form pairs of crystals growing through each other in a complex pattern resulting in an intergrowth. The hornblende, biotite and plagioclase have been altered to chlorite and epidote respectively.

Under the microscope, quartz is the most abundant mineral and is easily distinguishable from other minerals due to the unaltered nature and lack of twining and cleavage. Under PPL it occurs as a colourless mineral with a low relief. It has no cleavage but shows traces of fractures that are interconnected. It is euhedral to anhedral in shape with interlocking grain boundaries with one another and shows no pleochroism. Under XPL, it shows varieties of colours ranging from purple to blue and brown with no zoning. Plagioclase appears dark grey in colour with a poor cleavage and subhedral in shape. Under PPL it shows moderate relief and does not exhibit pleochroism.

Under XPL multiple twining was observed in most of the crystals, characterized by polysynthetic twining of plagioclase.

Biotite is relatively characterized by its anhedral shape, pleochroic in nature and a high relief. It shows a good cleavage and shows interference colour from blue, yellow and brown (Plates 5a and b).

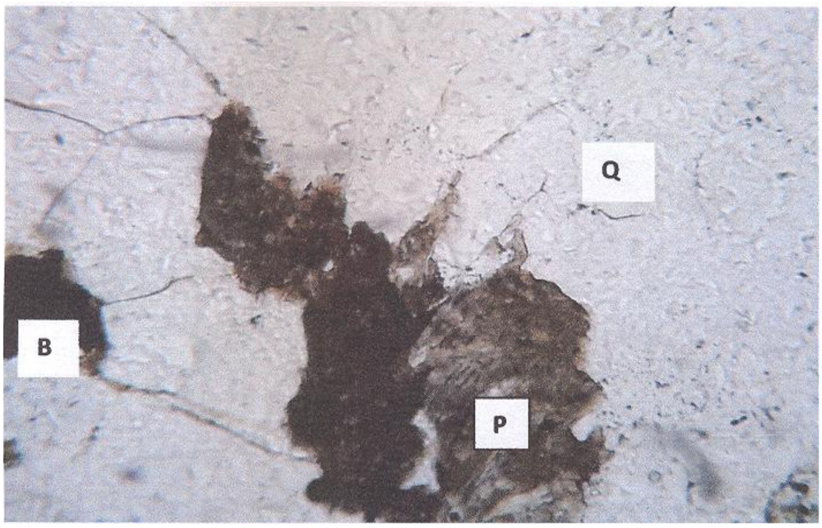

Plate 5a. Photomicrograph of coarse, porphyritic granite under PPL exhibiting a porphyritic texture where feldspar (Plagioclase) and quartz are set in fine matrix. Note the fractures within the quartz crystals

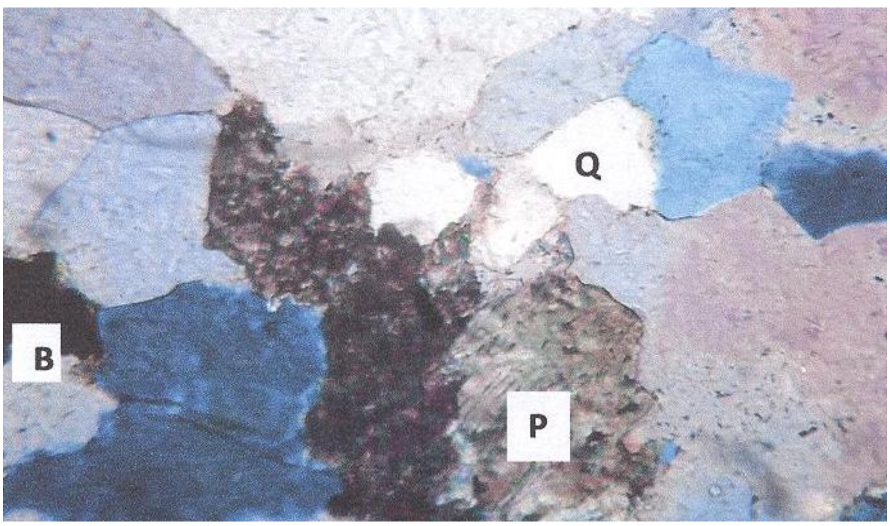

Plate 5b. Photomicrograph of coarse, porphyritic granite under XPL showing and anhedral quartz crystals with variable interference colours sandwiching plagioclase and other minerals

3.3 Structural Elements

The structural elements observed in the field include those formed due to brittle deformation (brittle structures) and ductile deformation (ductile structures).

3.3.1 Brittle Structures

3.3.1.1 Joints

These structures occur in all the rock types although very pronounced in the granites. The joint spacing was within the range of a few millimetres to 10cm in areas where they occur as a joint set. In some places, they cross-cut the rocks horizontally while in others vertically. Field evidence shows that the rocks have more than one generation of joints (Plate 6a). The orientation of the joints in the field does not follow any particular trends (directions), as they trend in all directions. The joint values recorded in the field range from 10^{o}-35^{o}. In some places, the joints have been filled with silica material probably quartz resulting in the crosscutting relationship which enables one to determine their order of formation (Plate 6b).

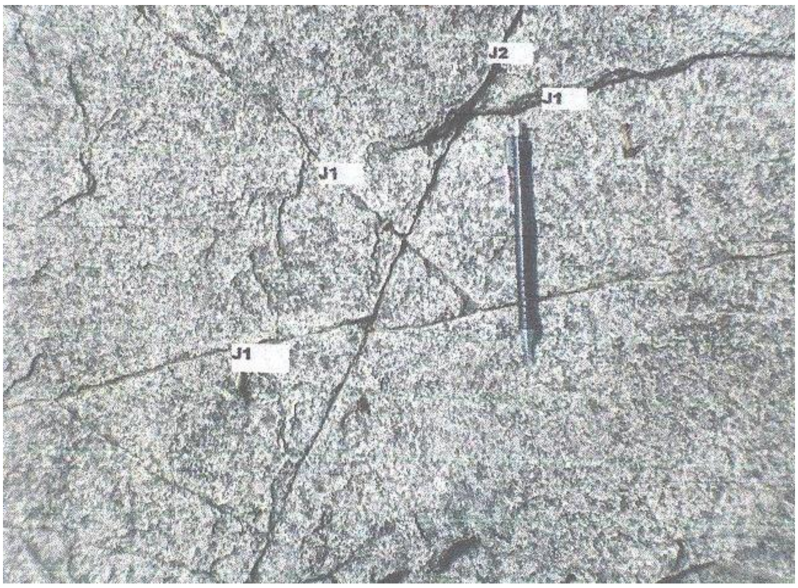

Plate 6a. Photograph of joints in granites displaying crosscutting relationship that provided a guide to the recognition of the two generation of joints on the outcrop

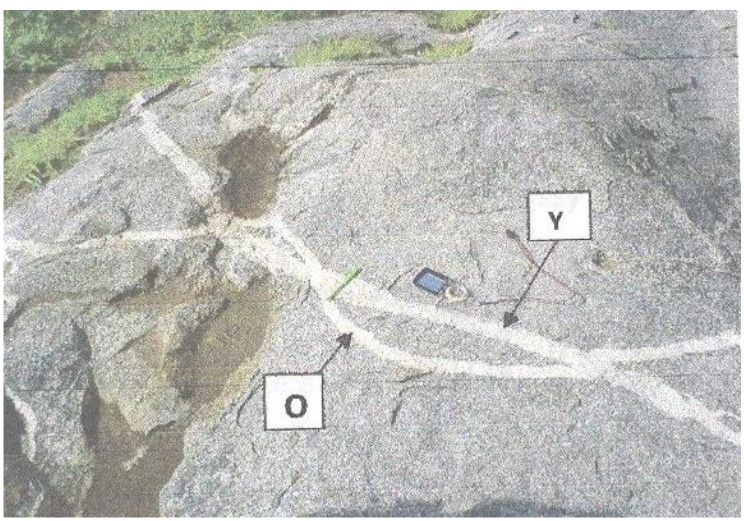

Plate 6b. Photograph of joints in granites that have been filled by silica materials particular quartz resulting information of quartz veins. Note the order of formation of the veins. O= older and Y= younger

Joint values plotted on a Rose diagram show that the principal joints values in the area are in the NNW-SSE and NE-SW direction (Figure 2).

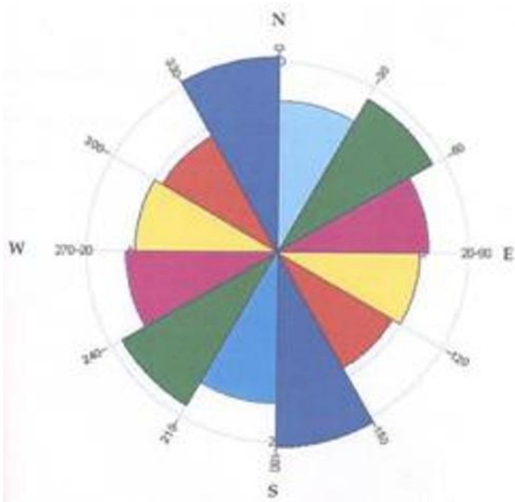

Figure 2. Rose diagram of joints and foliations in rocks of the study area

3.3.1.2 Faults

The faults in the field were mainly minor faults with small displacements of the order of 5-25 cm. Two types of faults occur in the area. There are the normal and reserve faults. In the normal faults, the hanging wall has moved down relative to the footwall, distorting the schistosity on the schists. Based on the sense of movement, it is a dip-slip fault as the movement or displacement is in the dip direction. Due to decrease in length of rock material along the fault plane, it is a constructional fault because distance is lost (Plate 7a).

The reverse fault has a hanging wall moved up relative to the footwall. It is also a dip-slip fault based on the sense of movement but extensional fault because there is increment due to increase (gain) in distant (Plate 7b).

Plate 7a. Photograph of a normal fault that occurred in the schists. Note the down movement of the hanging wall relative to the footwall and distortion of the schistosity in the rock. Also note the displacement in the dip direction and constrictional nature of the fault

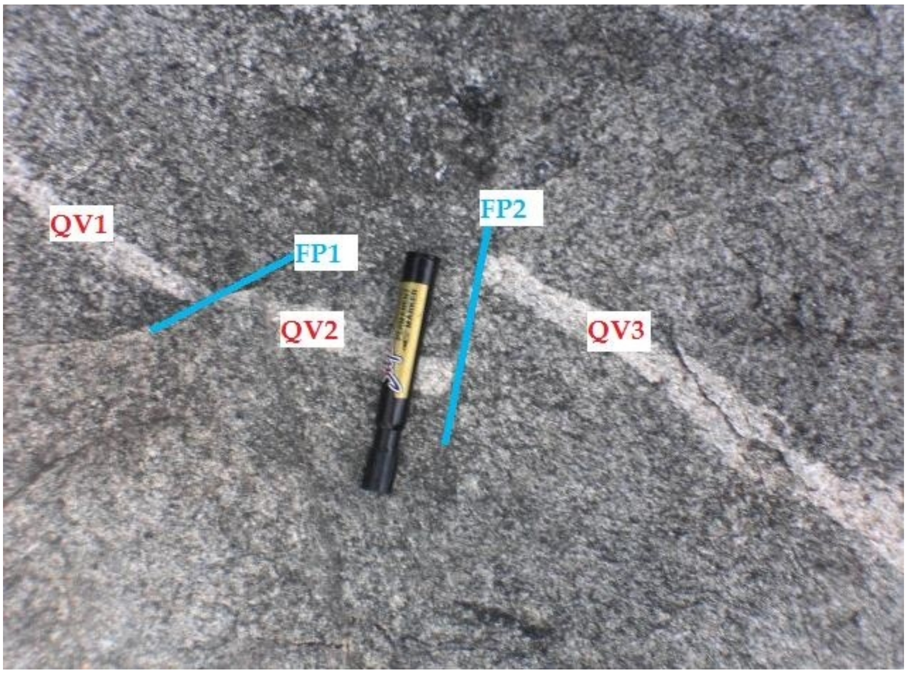

Plate 7b. Photograph of a reverse fault in granite where the hanging wall has moved up relative to the footwall. It is a dip-slip fault but extensional in nature

3.3.2 Ductile Structures

3.3.2.1 Foliations and Lineations

Foliations which are common in the migmatites, gneisses and schists occur as simple mineralogical banding. There are two generations of foliations S_1 and S_2. The development of the S_2 foliations has destroyed some of S_1 foliations. The S_1 foliations are less repetitive and penetrative than the S_2 foliations. Both types of foliations have altitude and orientation in the range of N150^o-N165^o and 20^{o}S-35^{o}S respectively (Plate 8a).

Lineations in the rocks are displayed by the parallel alignment or preferred orientation of dark and light coloured minerals. The dark coloured minerals are the ferromagnesian minerals (hornblende and biotite) while the light coloured minerals are the quartzo-feldsparthic minerals (quartz and feldspar). Like the foliations, there are two generations of lineations, the first being more or less horizontal while the second is inclining (Plate 8b). A special type of lineation (crenulations) defined by formation of low, sub-parallel ribs and furrows occur in the cleavage surfaces of schists.

Plate 8a. Photograph of foliations in migmatite showing mineralogical banding and S_1 and S_2 foliations

Plate 8b. Photograph of lineations in migmatite displaying parallel alignment of dark and light coloured minerals. There are two generations of lineations, the first being more or less horizontal while the second is inclining

4. Discussion of Results

Geological studies of rocks of Bishini block 2 reveal lithologies with distinctive mineralogical, textural, petrographical and structural characteristics which have implication on their overall geology. Despite these distinctions, field and laboratory evidence show that the area is part of the basement complex of Nigeria and consists of migmatites, gneisses, schists and granites. Like a typical Nigerian basement, the three main lithological units are represented and exposed.

This area is part of the Kusheriki-Minna area systematically mapped by Truswel and Cope (1963) and Ajibade (1976) that reclassified the rocks and differentiated the Zungeru formation. Chukwu (1988) revealed that the area composed originally of the low grade schists belt of the Kusheriki Formation. The schists were later intruded by granitic rocks of Pan-African age. His work is in agreement with that of Akinpelumi (2008) who equally identified schists and granites in the whole area. Their work is however not in agreement with this work.

Field evidence shows that the migmatites/gneiss was formed as a result of magmatic injection into the low grade schists. This implies that some of the migmatites/gneiss is younger than the schists. The magmatic injection is equally thought to have resulted in the emplacement of the granites in the migmatites, gneisses and schists accompanied by gold mineralization in the area. Most of the minerals in the rocks have been highly deformed. This coupled with the abundance of foliations and lineations suggest that the rocks have been subject to many deformational histories. The displacement of distinctive mineralogy, textures, optical and structural characteristics is the basis of the nomenclature of the rocks.

The area is a typical metamorphic terrain with rocks of diverse nature, complexly deformed with the presence of both planar and linear structures. The occurrence of chlorite, epidote, garnet and biotite in many of the rock samples further ascertained a metamorphic terrain that was intruded by an acidic magma. The textural variation in the rocks is due to varying size and amount of feldspar crystals they contained. This in turn is a function of the petrogeneiss of the individual rock type.

Because the rocks occur at very low topographic level, complex structures were not encountered in the field though such may occur at the subsurface. However, the presence of minor joints and faults at the surface may be an indication of major ones at the subsurface.

These structures have a great implication for water and mineral exploration in the area. Fractured rocks offer great prospect for groundwater, as they are very important for engineers searching for groundwater due to the development of good aquifers in fractured zones of the basement.

In mineral exploration, they serve as structural control for mineralization as mineral solutions (hydrothermal solution) tend to percolate and crystallize in them as they ascend from the interior of the earth.

5. Conclusions

The study area consists of migmatites, gneisses and schists that have been intruded by the Pan-African granites. These rocks display distinctive mineralogical, textural and structural characteristics that lead to the basis of their nomenclatures. This area had earlier been reported to compose of low grade schists that were later intruded by granitic rocks of Pan-African age. The intrusion of these rocks is believed to be accompanied and responsible for gold mineralization in the area.

The type and nature of minerals the rocks contain together with the geometry reveal that the rocks have undergone more than one deformational event since the time of their formation. The NNW-SSE and NE-SW joints directions show that the area has a great potential for water and mineral exploration.

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References

Ajibade, A. C. (1976). Provisional classification of the Schists Belts of North Western Nigeria: In Geology of Nigeria, C. A. Kogbe Ed. Elizabethan Pub. Co. Lagos, pp. 85-90.

Ajibade, A. C. (1980). Geotectonic evolution of the Zungeru Region. Unpubl. PhD. thesis, Univ. of Wales.

Ajibade, A. C. (1982). The Origin of the Older Granites of Nigeria: Some evidence from the Zungeru region. *Nigeria Jour. Min. and Geol., 19*, 223-230.

Ajibade, A. C., Rahaman, M. A., & Woakes, M. (1987). Proterozoic Crustal development in the Pan-African Regime of Nigeria. ILP working Group 3 Mid-term Report.

Akinpelumi, O. S. (2008). Geology of part of sheet 165, Bishini S.W., Nigeria on a scale 1:25,000 and the Evaluation of Gold in the Rocks of the area. Unpubl. B. Tech. thesis, Federal University of Technology, Minna, Nigeria.

Ako, T. A., & Abba, F. M. (2011). Petrology and Petrography of rocks of part of Bishini (sheet165 SW) north central Nigeria. Nigerian Mining and Geosciences Society Annual International Conference.

Annor, A. E. (1995). U-Pb zircon age for Kabba-Okenegranodiorite gneiss: implication for Nigeria's basement Chronology. *African Geoscience Review, 2*, 101-105.

Caby, R. (1989). Precambrian terrains of Benin-Nigeria and Northeast Brazil and Late Proterozoic South Atlantic rift. *Geol. Soc. American Spec. Paper, 230*, 145-158.

Chukwu, D. U. (1988). Distribution of Gold Mineralization in the Nigeria Basement Complex in Relation toOrogenic Cycle and Structural Setting. Precambrian Geology of Nigeria, GSN. Esho Printers Ltd, Kaduna, Nigeria, pp. 177-182.

Dada, S. S., Briqueu, I., & Bireck, J. L. (1998). Primordial Crustal Growth in northern Nigeria: Preliminary Rb-Sr and Sm-Nd constraints from Kaduna migmatite-gneiss complex. *J. Min. Geol., 34*, 1-6.

Ekwueme, B. N., & Kroner, A. (1998). Single Zircon evaporation ages from the Oban Massif, Southeastern Nigeria. *J. Afri. Earth Sci., 26*, 195-205. http://dx.doi.org/10.1016/S0899-5362(98)00005-0

Ferre, E., Caby, R., Peucatt, J. J., Capdevila, R., & Monie, P. (1998). Pan-African postcollisional ferro-potassic granite and quartz-monzonite plutons of Eastern Nigeria. *Lithos, 45*, 255-278. http://dx.doi.org/10.1016/S0024-4937 (98)00035-8

Fitches, W. R., Ajibade, A. C., Egbuniwe, I. G., Holt, R., & Wright, J. B. (1985). Late Proterozoic schist belts and plutonism in NWNigeria. *J. Geol. Soc. London, 142*, 319-337. http://dx.doi.org/10.1144/gsjgs.142.2.0319

Okonkwo, C. T., & Winchester, J. A. (2004). Geochemistry of granitic rocks in Jebba area, southwestern in Nigeria. *J. Min. Geol., 4*(2), 95-100.

Rahaman, M. A., Emofurieta, W. O., & Vachette, M. G. (1983). The potassic granites of Igbeti area: further evidence of the polycyclic evolution of the Pan-American belt in southwestern Nigeria. *Precambrian Res., 22*, 75-92. http://dx.doi.org/10.1016/0301-9268(83)90059-1

Rormsoy, J. G. (s1967). *Folding and fracturing of rocks*. New York: Me-Graw-Hill, 568 pp.

Rowland, E. O. (1953). Rapid method for preparation of Thin Rock Sections Mineral. *Mag., 30*, 254-258. http://dx.doi.org/10.1180/minmag.1953.030.223.05

Truswel, F., & Cope, R. N. (1963). The Geology of Parts of Niger and Zaria Provinces, Northern Nigeria. *GSN Bulletin, 29*, 41.

Umeji, A. C., & Caen-Vachette, M. (1984). Geochronology of Pan-African NassarawaEggon and Mkar-Gboko granites, southeast Nigeria. *Precambrian Res., 32*, 317-324. http://dx.doi.org/10.1016/0301-9268(84)90048-2

Van-Breemen, O., Pidgen, R. T., & Bowden, P. (1977). Age and Isotope studies of some Pan-African granitesfrom north-central Nigeria. *Precambrian Res., 4*, 307-319. http://dx.doi.org/10.1016/0301-9268(77)90001-8