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Research Article

Petrographic evaluation of rocks around Arikya and its environs, North Central Nigeria

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The study area covers Arikiya and parts of Wayopini in Lafia Local Government Area of Nassarawa State, situated in central Nigeria. This falls within the Basement Complex of central Nigeria that forms part of the Upper Proterozoic mobile belt extending from Algeria across the Sahara into Nigeria, Benin and the Cameroon. The area consists of gneisses, granite gneisses, migmatites and Porphyroblastic gneiss. Dolerite dyke and Pegmatite form intrusions into the host rocks. The major rock forming minerals are plagioclase, orthoclase, quartz and biotite, The major structures includes joints, foliations, quartz vein, fold and fault, Predominant structural trends include the NE-SW and NW-SE with minor E-W and N-S structural trends which are in agreement with the general trend of structures in the Basement Complex. Mineral resource potential of the study area include feldspar and mica from the gneiss and pegmatites as well as alluvial garnets, columbites, tantalite, and cassiterite (derived from the pegmatites) as evidenced from mining activities along river channels in the entire area.

Key words: Basement Complex, Gneiss, Minerals, Older granite, Petrography, structures.

INTRODUCTION

The studied area is located North West of Wamba Sheet 210 NW. The area is underlain by basement complex rocks of the Precambrian age. The North Central Nigeria is one of the four major zones where the Basement complex rocks are exposed in Nigeria. The Basement Complex rocks found in this area have undergone series of tectonic deformations, the last of which is the Pan-African orogeny. The study area is comprises of the rocks around River Arikya and its environs (Fig. 1). It is predominantly a basement environment which has been reactivated by multiple phases of tectonic activities and events. The area covers about 20km^2, characterized by hilly massive outcrops made up of predominantly gneiss and granite-gneisses. Micro-granites occur as minor rocks while pegmatite and dolerite are intrusive into the basement. The hills form steep escarpments. The mineral suites identified include feldspars, quartz, biotite, muscovites, hornblende, and opaque minerals probably iron oxides. The feldspars include plagioclase, orthoclase, and microcline. The major structural features in the study area include dykes, veins, joints, folds, faults and foliations. The major structural directions are oriented in the NE-SW, NW-SE, E-W and NNE-SSW which correspond with the structural trend of the Basement Complex of Nigeria.

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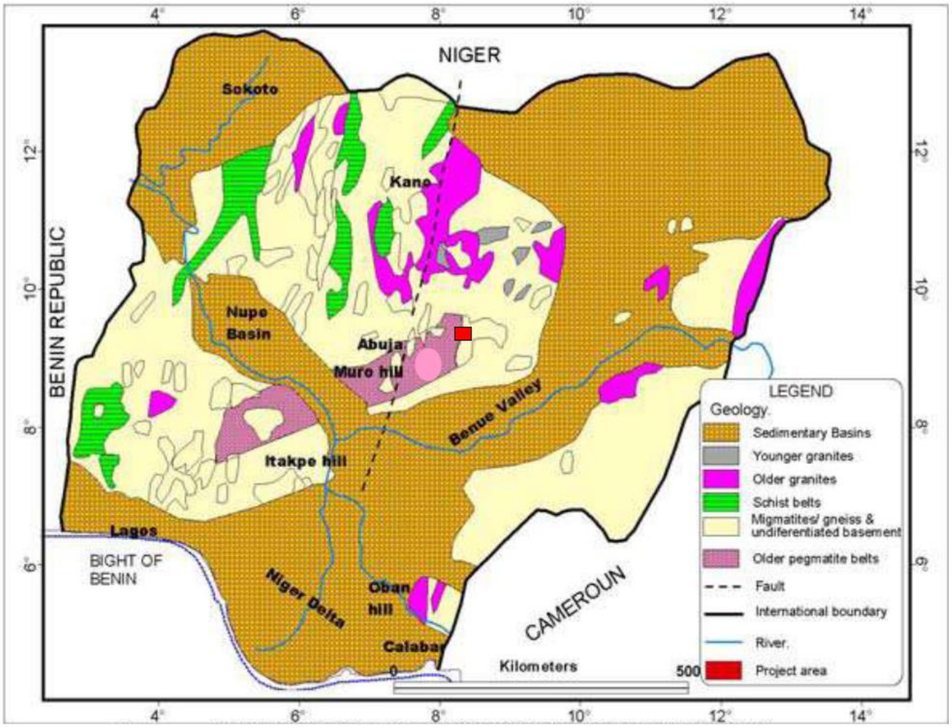

Figure 1: Outline Geological Map of Nigeria (after Olugbenga, et al., 2009)

The main lithologic unit in the study area includes migmatites, gneisses, granite-gneisses, porphyroblastic gneisses, and dolerites with well delineated geologic boundaries. These include fractures (faults and fold), foliation, dyke etc Some of them are not deformational but are secondary structures developed during metamorphism of the rocks (Rahaman, 1988) Representative rock type were sampled on the field which were taken for thin section for further petrographic analysis. Cassiterite and subordinate columbite-tantalite have been mined in the Lafia area on a small scale mainly from alluvial placers .in the study area There are not much record of detailed work carried out on the various areas of the Basement Complex. The study area is bordered by Farin Ruwa in the East, Konva in the West, River Arikya in the South and Angwan Mission in the North. This paper deals with detailed and comprehensive petrographic studies of the rock types both on hand specimen and under the microscope.

REGIONAL GEOLOGIC SETTING

The Precambrian Basement Complex of Nigeria lies within the Pan-African mobile belt, east of the West African craton and Northwest of the Congo-Gabon craton. Evidence from the Eastern and Northern margins of the West African craton indicates that the Pan-African belt evolved by plate tectonic processes which involved the collision of the passive continental margin of the West-African craton and the active margin of the Pharusian belt (Tuareg shield), about 600Ma (Burke and Dewey, 1972; Leblanc, 1981; Black et al., 1979). This includes the presence of mafic to ultramafic rocks believed to be either remnants of mantle diapirs or a paleo-oceanic crust. These rocks are characteristic of an ophiolitic complex. Also a high positive gravity anomaly which occurs in a narrow zone within the Dahomeyide orogeny located at the margin of the West African Craton in Togo and Benin Republic (Schuler and Trauth, 2006). The collision at this plate margin is believed to have led to the reactivation of the internal region of the Pan-African belt which formed part of the Nigerian Basement Complex (Rahaman, 1976). Radiometric ages indicate that the Nigerian Basement Complex is polycyclic and includes rocks of Liberian (2700 ± 200 Ma), Eburnean (2000 ± 200 Ma), Kibaran (1100 ± 200 Ma), and Pan-African (600 ± 150 Ma) (Black et al.,1979; Caby et al.,1981). Recently, the use of International Geological Time Scale (2002) in Gunter and Mensing (2005) has further easing the application of geochronology. These ages can be referred to as “Precambrian to Mesoproterozoic (3600 to1600 Ma)” for Liberian and Eburnean, “Mesoproterozoic to Neoproterozoic (1600 to 1000 Ma)” for Kibaran, “Neoproterozoic to Early Paleozoic (1000 to 545 Ma)” for Pan-African (Obiora, 2008). Two distinct provinces can be recognized in the Nigerian Basement Complex (Fig. 1), namely; the western province characterized by narrow sediment trending N-S with low-grade schist predominantly migmatite-gneiss and the Mesozoic ring complexes (Younger Granites) of North Central Nigeria (Ajibade et al., 1987; Kogbe, 1989). The evolution of the Nigerian Basement Complex during the Pan-African can be best discussed in the regional context of the Pan-African orogenic belt of West Africa. Geological and geophysical evidence from the western province of the belt has been used to erect geophysical evidence for the evolution of the belt (Grant, 1970; Burke and Dewey, 1972; Black et al., 1979; Caby et al., 1981). Essentially, the evolution of the belt is seen as a collision type orogeny with an eastward dipping subduction zone. Initial crustal extension and continental rifting at the West African cratonic margin, about 1000 Ma, led to the formation of graben-like structures in the Western Nigeria and the subsequent deposition of the rocks of the Schist belts. Closure of the oceanic margin, about 600 Ma and crustal thickening in the Dahomeyan led to the deformation of the sediments, reactivation of the pre-existing rocks and the emplacement of the rocks of the Pan-African granites (McCurry, 1976). The granitoids have been emplaced within both the migmatites-gneiss complex and the Schist belts, and they occur in all parts of the Nigerian Basement Complex, though the extent of the Pan-African plutonism had not been fully understood (Rahaman, 1976). Fitches et al. (1985) have shown that the Older Granites are high level intrusions emplaced by diapiric processes in different parts of the country. The migmatite-gneiss complex is considered to contain rocks of the Archean age which have been deformed and modified several times prior to the Pan-African orogeny (Rahaman, 1976).

The Basement complex are mostly related to the Pan-African (900-450 Ma) thermotectonic event, with few imprints of the older events such as the Liberian, Eburnean, and the Kibaran (Obiora, 2005). Evidence from the Ibadan area indicates that Archean rocks includes meta-sedimentary and meta-volcanic rocks which were deformed prior to the emplacement of the Eburnean granite-gneiss (Burke and Dewy, 1972). The early Proterozoic (Eburnean) event was probably accompanied by sedimentation, deformation, metamorphism and syn-tectonic igneous activity (Burke and Dewy, 1972). Since the recognition of the suture along the eastern margin of the West African craton, attempts have been made to relate the Schist belts to the subduction processes at the cratonic margin (McCurry, 1976). Vaniman (1976), Holt (1982) and Turner (1983) consider that the Schist belts have been deposited in a back-arc basin developed after the onset of subduction at the cratonic margin.

MATERIALS AND METHODS

The field activities involved taking traverses and mapping the study area. Structures of various rock types were noted in the field. Rock samples from various outcrops were taken using geological sledge hammer and chisel. Field photographs of the following rock types were observed; gneiss, granitic gneiss, microgranite, migmatite and dolerite.

These were done at University of Ibadan laboratory, Ibadan. Petrographic studies of the representative samples were made with the aid of a polarizing microscope and resultant production of photomicrographs were obtained.

The photomicrographs of five rock types at ×10 magnifications are shown in figs. 8 to 12. Some of the major minerals observed under the microscope were; biotite, muscovite, plagioclase, pyroxenes, and quartz. The essential features of these minerals in the thin section as shown by the microscope were described.

RESULTS AND DISCUSSION

Megascopic study is the description of the different rock types of the study area in hand specimen which was facilitated with the photographs of the outcrops. The lithologic units, mineralogy, texture, structures, mode of occurrence and field relationships, were all considered in the field mapping to enhance megascopic studies (Fig. 1).

Gneiss

Gneiss is a high grade metamorphic rock characterized by banding caused by segregation of felsic and mafic minerals. The gneisses in the studied area are mostly medium to coarse grained with gneissic textures. They comprise of mainly quartz and feldspar minerals (Table 1 and Fig. 3). They are foliated, showing gneissocity type of foliation and are mostly occurring in-situ. There are evidence of dynamic recrystallization structures and microtextures.

The gneiss is found mostly in the eastern part of the studied area. In hand specimen, the bands differ in colour and composition with some bands richer in feldspar and quartz (light coloured bands), and others richer in olivine or mica (the dark coloured bands).

As observed under the microscope both in Plane Polarized Light (PPL) and Crossed Polarized Light (XPL), The major minerals observed occurring in the rock type include quartz, plagioclase feldspar, biotite and microcline.

Table 1 shows the modal composition of the representative sample of the gneiss in terms of the volumetric proportions of the minerals in it. Under PPL Plagioclase is with anhedral crystal form characterized by a one-directional cleavage with no pleochroism. Under XPL it shows a first order birefringence with an interference colour of gray to white, inclined extinction.

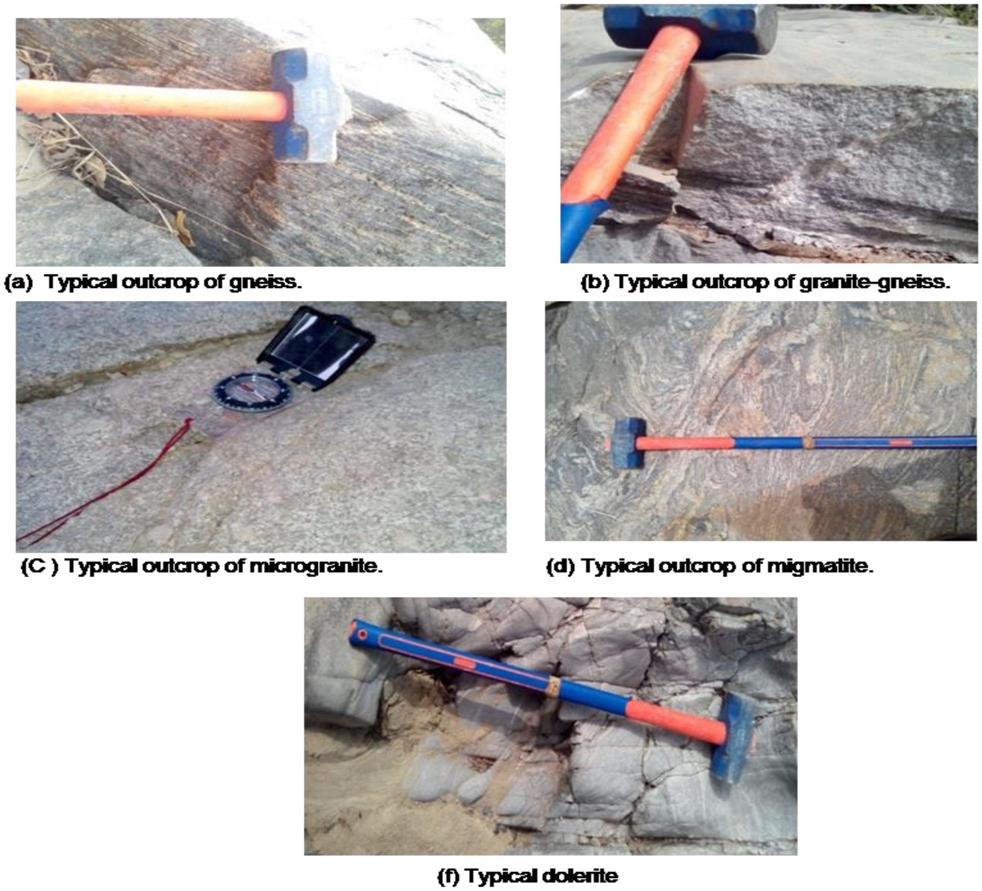

Figure 2: Photomicrographs of different rocks obtained in the studied area.

Table 1: Average modal composition of the gneiss

MINERALS	AVERAGE COMPOSITION (%)
Plagioclase	40
Quartz	30
Biotite	10
Muscovite	5
Microcline	5
Opaque	10
Total	100

Quartz on the other hand, under PPL is colourless, low relief, anhedral crystal form and has no pleochroism but the crystals are fractured. There is no cleavage observed. While under XPL it shows first order birefringence with first order interference colour.

Biotite under PPL is brown with high relief and euhedral crystal form. It is characterized with a perfect basal cleavage in one direction and pleochroism of light brown to dark brown. Biotite under XPL shows second order birefringence with interference colour of brown to purple brown.
Microcline under PPL is colourless shows low relief with an anhedral to subhedral crystal form. It is characterized with a perfect cleavage and does not exhibit pleochroism. Under XPL it shows first order birefringence (gray and white), Pale yellow interference colour with an inclined extinction of cross-hatched.

Granite-Gneiss

The granite-gneiss is associated with the gneisses in the study area. It is a heterogenous group of rock predominantly granodioritic in composition and fine to medium grained in texture. It is composed of quartz, biotite, feldspars and muscovite (Table 2 and Fig. 3). It shows a low degree of weathering and deformation which is particularly evident around the contacts with the

Table 2: Average modal composition of granite-gneiss

MINERALS	AVERAGE COMPOSITION (%)
Plagioclase	40
Quartz	30
Biotite	10
Microcline	10
Opaque	10
Total	100

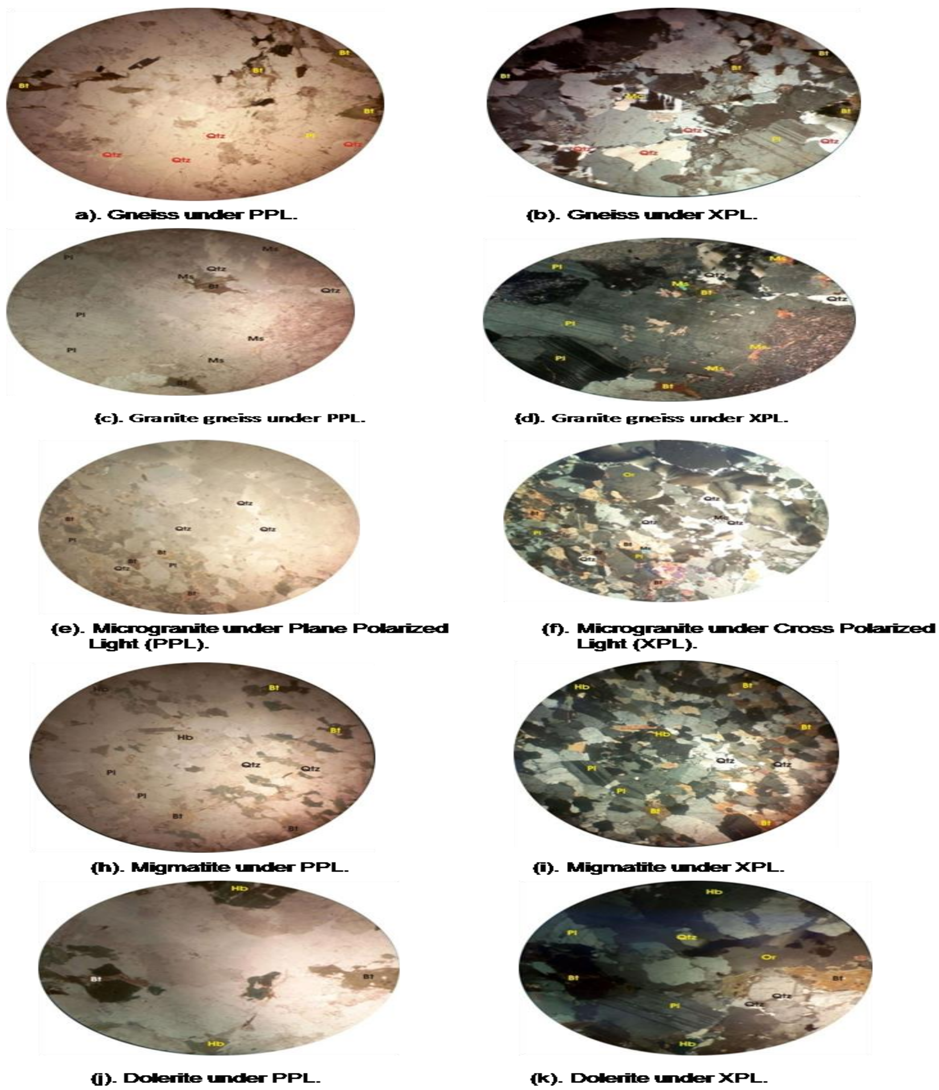

Figure 3: Photomicrograms of selective rock samples. Mineral includes: Bt= Biotite, Pl= Plagioclase, Qtz= Quartz, Mc= Microcline, Ms= Muscovite, Or=Orthoclase, Hb= Hornblende.

gneisses. They occur as moderate to low-lying hills and are exposed from the North-central to the South-western part of the study area.

Micro-Granite

This is a medium-grained intrusive rock which has regular composition as regular granite, but contains small crystals which are interlocking and randomly oriented because it cooled more quickly. It is pinkish in colour. It contains mostly feldspars and quartz, and also small specs of mafic (dark coloured) minerals (Table 3 and Fig. 3).

Migmatite

The migmatites in the study area are leucocratic to melanocratic fine grained to medium grained rock

Table 3: Average modal composition of micro-granite

MINERALS	AVERAGE COMPOSITION (%)
Plagioclase	45
Quartz	30
Biotite	10
Muscovite	5
Opaque	10
Total	100

Table 4: Average modal composition of migmatite

MINERALS	AVERAGE COMPOSITION (%)
Plagioclase	40
Quartz	30
Biotite	15
Muscovite	5
Hornblende	5
Opaque	5
Total	100

Table 5: Average modal composition of dolerite.

MINERALS	AVERAGE COMPOSITION (%)
Plagioclase	40
Quartz	20
Biotite	20
Hornblende	15
Opaque	5
Total	100

comprising of biotite, quartz, feldspars and some other mafic minerals as seen in hand specimen. They are found in the north-western part of the study area.

Dolerites

Dolerites may occur as dykes, sills, lopolith and laccoliths. The dolerites in the study area occur as dykes and are fine to medium grained, containing mainly mafic minerals and feldspars (Table 5 and Fig. 3). They occur in the rock types of the study area. The dolerites are the product of magma that cools quickly when it rises into weak areas and cracks to form crystals and dykes.

Hornblende under PPL is brownish with moderate to high relief and show a subhedral crystal form with characterized two-directional cleavage. The pleochroism is green to brown. Under XPL birefringence is 0.02 with interference colour of second to third order.

CONCLUSION

Based on the field and microscopic observations, the petrographic evaluation depict that the studied area is a metamorphic terrain (Basement Complex). Three major cycles of deformation, metamorphism and remobilization including the Liberian, Eburnean and Pan-African orogeny may have affected the rocks as recorded in the literature. This is evident from the nature of structures and their trends (NE-SW, NNE-SSW, NW-SE, E-W) in the studied area. The intrusions which include dolerite and pegmatites are relatively the youngest rock units in the area since they are found to be intruding the basement rocks. The dolerite and pegmatite dykes are structurally controlled and assumed a common NE-SW, NNE-SSW trending direction. Fractures were first formed before the dykes. Therefore, it is worthy of note that mineralization in the area is structurally controlled.

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