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Geology and Petrography of Basement Rocks around Paki, Northwestern Nigeria

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ABSTRACT

The geology and petrography of basement rocks around Paki and environs was studied with the aim of characterizing different rock types present based on their petrographic analysis. The area is part of Ikara Sheet 103NW Federal Survey Topographic Sheet underlain by rocks belonging to northwestern Nigerian basement complex. From the field mapping, three major lithological units belonging to one rock type were observed namely; porphyroblastic gneiss, medium to coarse grain gneiss and fine grain gneiss. These rock types were intruded by pegmatites, quartz veins and aplites belonging to Pan African magmatic suite. Specimen of the rock samples were studied based on their hand specimen mineralogical composition, colour, and texture in the field. The results of the petrographic analysis showed that porphyroblastic gneiss consists of quartz, plagioclase feldspar, orthoclase feldspar and biotite as essential minerals. Visible grains of orthoclase feldspar, biotite, quartz, hornblende and epidote were observed in Medium grain gneiss whereas Fine grain gneiss was also characterized by the same set of mineral assemblage but in varying proportion. The geological structures observed in the field include fracture, foliation, fault and veins which serve as the structural controls to mineralization in the study area.

Key words: *Petrography, Porphyroblastic, Gneiss, Pan African, Geological Structures*

1. INTRODUCTION

Northwestern Nigeria is underlain by gneisses, migmatites and metasediments of Precambrian age which were intruded by a series of granitic rocks of late Cambrian to lower Paleozoic age. The oldest rocks are represented by a series of older metasediments and gneisses believed to be of Birrimian age and older. These rocks have been variably metamorphosed and granitized through two tectono-metamorphic cycles so that they have been largely converted to migmatites and granite-gneiss [1]. The rocks in the study area belong to a suite of metamorphic rocks (gneiss).

The aim of this research is; to study rocks in the study area in terms of their mode of occurrence, texture, mineralogical composition, the structural features associated with them and their petrography.

The study area is located in Ikara Local Government Areas of Kaduna State and forms part of Federal Survey Map of Nigeria Sheet 103 Ikara NW, which falls within the Nigerian Basement Complex. It lies within the coordinates; latitude N11º25'41.66" to N11º30'00"and longitude E08º07'31.66" to E08º10'26.6" covering an area of about 40 km^2. The prominent settlements in the study area are: Gidan Bagobiri, Unguwan Bala and Bakin Kanwa in the north-east, Tudun Soda in the north-west, Gidan Magori and Gidan Isa in the south-west, Masasaka, Unguwan Abdu Razaki and Kariya in the south eastern axis.

The study area is easily accessible through a network of footpath due to lower level ground. The field work was basically done on foot along available footpaths and along dry cultivated farm lands.

2. GEOLOGICAL SETTING

Several works have been done on the Basement Complex of Nigeria (within which the study area falls) by various workers including [2], [3], [4], [5], [6] and [7]. Reference [6] carried out a reconnaissance survey and mapped a part of the Basement Complex of Nigeria on a scale of 1:100,000 based mainly on photo geological interpretation, supported by selected field investigations. She postulated that the rocks in the area belong to the Basement Complex of Nigeria and are Precambrian to early Paleozoic in age.

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She classified the rocks into three groups namely; gneiss considered to have been metamorphosed more than 2,000 million years ago; metasediments, mainly schist and quartzite laid down and then metamorphosed during the Pan-African Orogeny, and which now occupy linear north-south belts; and older granites, intruded from 580 to 650 million years ago. Reference [3], [4] and [5] studied the geology of the Crystalline Basement of the north-western Nigeria and gave a review of the petrography and distribution of the various rock types in the area including the detail geology of part of the Niger and Zaria provinces in northern Nigeria. Reference [7] described the coarse porphyritic granite as the most abundant and typical member of the Older Granite suite.

3. SCOPE AND METHODOLOGY

The geological mapping of the study area involved the study and identification of the different rock types, recognizing structural features associated with the rocks by taking measurements of their trends, and the hand specimen and petrographic description. The mapping exercise was conducted with the use of base map extracted from sheet 103 Ikara NW, and other geological instrument like GPS, Compass clinometer geological hammer and metric tape. The information acquired was portrayed on a geological map of the study area on a scale of 1:25,000. The basic methods and techniques used during mapping exercise were traverse mapping using compass and Global Positioning System (GPS). Compass was used for traversing along footpaths and dry river channels to locate outcrop exposures. Strike of veins, fault, dykes and joints, were taken using compass clinometers and Global Positioning System (GPS) was used to take coordinates of exposures and locate the actual position of the outcrops. Using the hand lens, texture, shapes and proportions of individual mineral grains in the rocks were described. The depth to water level in hand dug wells, the length and width of some structural features were measured using measuring tape. The photographs of some of the distinguishing features were taken with a digital camera. With the aid of a geological hammer, fresh samples of rocks were collected, labeled and kept to produce thin section for petrographic studies using polarized microscope.

4. RESULTS/ DISCUSSION

The study area is dominantly composed of one rock type (gneiss), although, there are occurrences of minor rocks in the area. The rock type is majorly gneiss (porphyroblastic, medium to coarse grained and fine grain gneiss), whereas the pegmatite, and veins constitute the minor rocks. The gneiss is described below based on the grain size distribution within the study area. The description is systematically done in three ways; the first part of the description contains the field relations of the rocks. This shows the in situ characteristics of the rocks. This is followed by the megascopic description; here the samples collected from the field are analyzed in terms of colour, texture and rough estimate of mineral composition (%). The third part of the description contains the petrographic description of the rocks in terms of mineralogical composition and optical properties as observed under the polarizing microscope in both plane polarize (PPL) and cross-polarized (XPL) modes. 4

4.1 THE MAJOR ROCKS DESCRIPTION

4.1.1 Porphyroblastic gneiss

4.1.1.1 Field Description

This occupies roughly 5% of the southern portion of the study area. It appears dome shape and trends in N-S direction. The rock is believed to be metamorphosed porphyritic granite. It is light grey in color due to the dominance of feldspar. The types of structures observed are majorly joints and some minor faults and xenoliths (plate 1).

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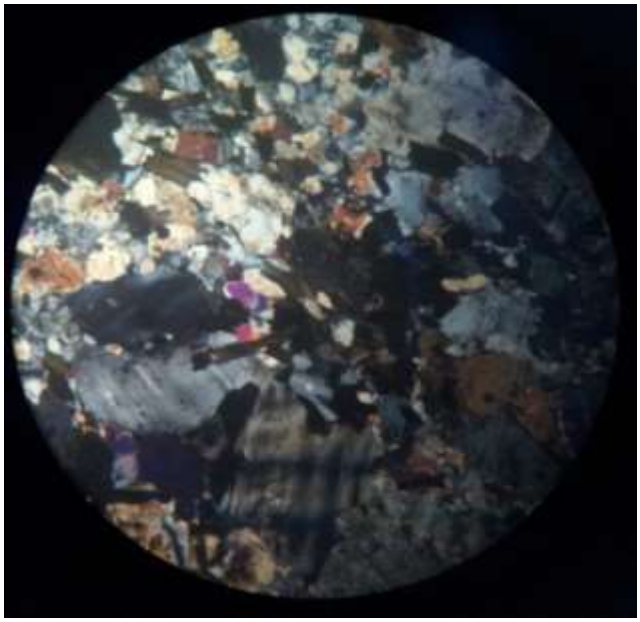
Plate 1: Porphyroblastic gneiss in the study area



4.1.1.2 Megascopic Description of Porphyroblastic Gneiss

The rock is light-colored due to dominance of felsic mineral; consisting roughly of alkali feldspar (35%), biotite (30%), quartz (20%) and plagioclase (15%). The most striking feature of its texture is the large pink angular feldspar roughly to 1.7cm. The large well-formed crystals in a finer matrix are called porphyroblasts. It indicates that there were two stages of cooling history during cooling and crystallization of magma which formed the parent rock.

4.1.1.3 petrographic description of porphyroblastic gneiss

Generally the rock is very coarse grained with individual mineral grain been well developed. The minerals that are present in the rock include orthoclase feldspar (32%), plagioclase feldspar (15%), quartz (20%) and biotite (23%). Accessory minerals account 10% of mineral composition, See (plate 2).

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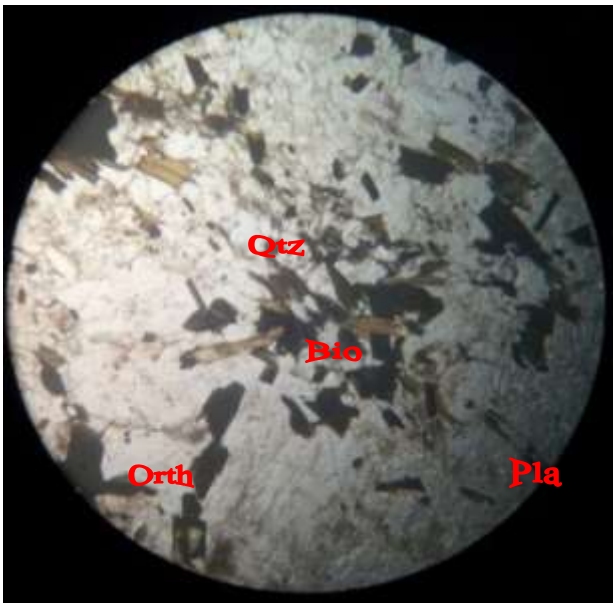

Plate2: Photomicrograph of Porphyroblastic Gneiss showing its mineralogical composition under (XPL) and (PPL) respectively. Orth = Orthoclase, **Pla** = Plagioclase, **Qtz** = Quartz, **Bio** = Biotite. Mag. = X40

Orthoclase: It is as anhedral to subhedral crystal, colorless with low relief in plane polarized light. It occurs as grayish, low birefringence (first order) and a simple Carlsbad twinning in cross polarized light. It constitutes about 32% of the entire mineralogy observed in the slide.

Plagioclase: It occurs as euhedral crystals, colorless and low relief with perfect cleavage in plane polarized light. It occurs as grey (interference colour), display albite twinning and low birefringence (first order) in cross polarized light. It constitutes about 15% of the entire mineralogy observed in the slide.

Quartz: It is monocrystalline in nature. It is clear, anhedral in form, low relief, fractures, display no pleochroism, alteration and cleavage in plane polarized light. It is cloudy to light grey (weak birefringence), and exhibit a characteristics phenomenon known as undulose extinction in cross polarized light. It constitute about 20% of the total mineral present in the slide.

Biotite: This mineral is strongly pleochroic in shades of brown to dark brown, as the stage is turn, it as a perfect cleavage, it is euhedral in form with high relief in plane polarized light, and exhibits a high birefringence in cross polarized light. It occupies about 23% of the entire mineral composition of the rock.

4.1.2 Medium to Coarse-Grained Gneiss:

4.1.2.1 Field Description of Medium to Coarse-Grained Gneiss

This is medium to coarse gneiss in texture. It occupies about 85% of the study area and of gneissic bodies that have different shapes which include whalebacks, low-lying and dome-shaped outcrop, flanked by flat terrain with light-grey soil. Plate 3 shows an exposure of medium-to-coarse-grained gneiss in the field.

The general colour of the rock ranges from light grey to light brown, the later resulting from the abundant of biotite. It is made up of biotite, quartz and feldspar. The structures found on the rock include joints, xenoliths and faults, in which the outcrop trends in north-south direction generally.

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Plate3: An exposure of medium to coarse grained gneiss in the field.

4.1.2.2 Megascopic Description

In hand specimen it appears medium to coarse grained in texture and grayish in color. Mineralogical composition include: plagioclase feldspar, orthoclase feldspar, quartz, and biotite.

4.1.2.3 Petrographic Description

The rock is medium to coarse grained with some of the crystals having well developed boundaries. The minerals in the rock include orthoclase (35%), biotite (30%), quartz (20%) and plagioclase (10%), (plate 4). The accessory minerals account to 5% of the total minerals.

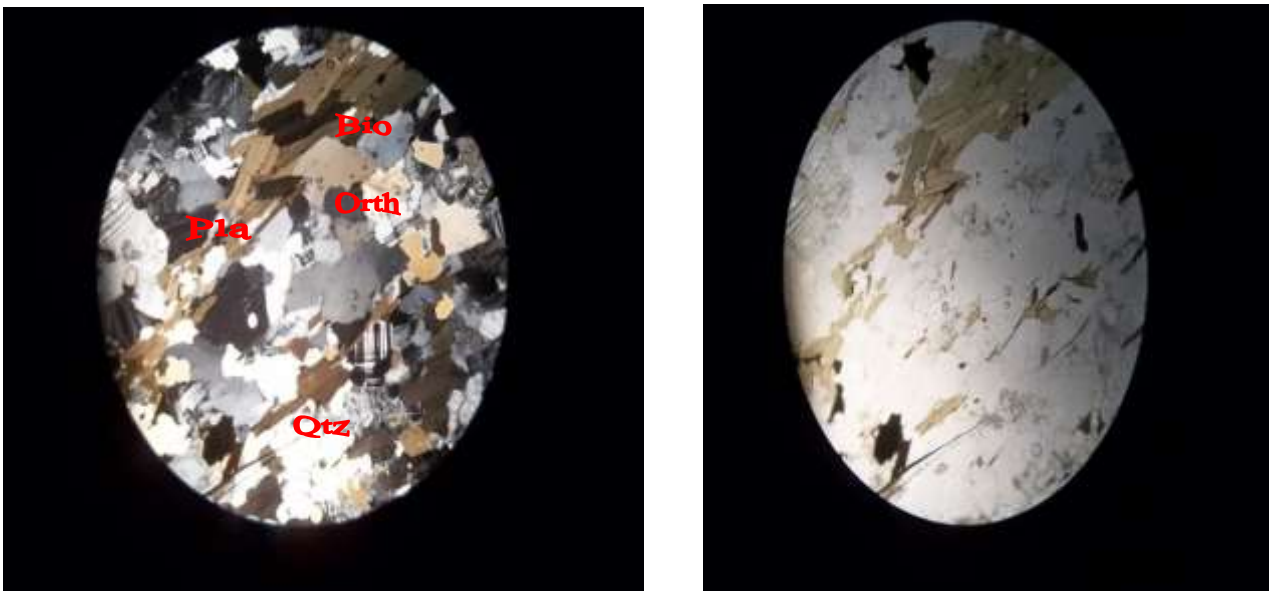

Plate4: Microphotograph of gneiss under cross polarized light and plan polarized light respectivily.MagX40

Orthoclase: It is appears colourless in plane polarized light and grayish in crossed polarized light. It is euhedral and has low relief. It constitutes 35%of the rock volume.

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Biotite: This constitutes 30% of the rock by volume. Biotite has well-developed large crystals that are needle-like in shape. It is euhedral in form. Under plane polarized light, it is brown in colour. It appears reddish-brown in cross polarized light. The mineral is strongly pleochroic in shades of brown, reddish-brown and light green colors. It has a perfect cleavage in one direction with near-parallel extinction.

Quartz: Quartz is present in the rock as anhedral crystals. It is colorless in both plane polarized light (PPL) and cross polarized light (XPL). It has no cleavage. Quartz exhibits undulose extinction, There is no alteration or twinning. It has a moderate relief and low birefringence. It makes up to20% of the rock. General trend of the outcrop is north-south direction.

Plagioclase: It occurs as a colorless mineral in thin-section under plane-polarized light. Under cross-polarized light, it is characterized by albite twinning. It has a low birefringence. It constitutes 10%of the minerals in the rock.

4.1.3 Fine-Grained Gneiss

4.1.3.1 Field Description of Fine-Grained Gneiss

In the study area, the fine-grained gneiss occurs in the northwestern portions of the study area**.** It covers roughly 7% of the study area. They occur as whalebacks outcrop, trending north-south direction. The vegetation cover of the area surrounding it appears to be very thick. The structures found on the outcrop include joints, and faults (plate 5).

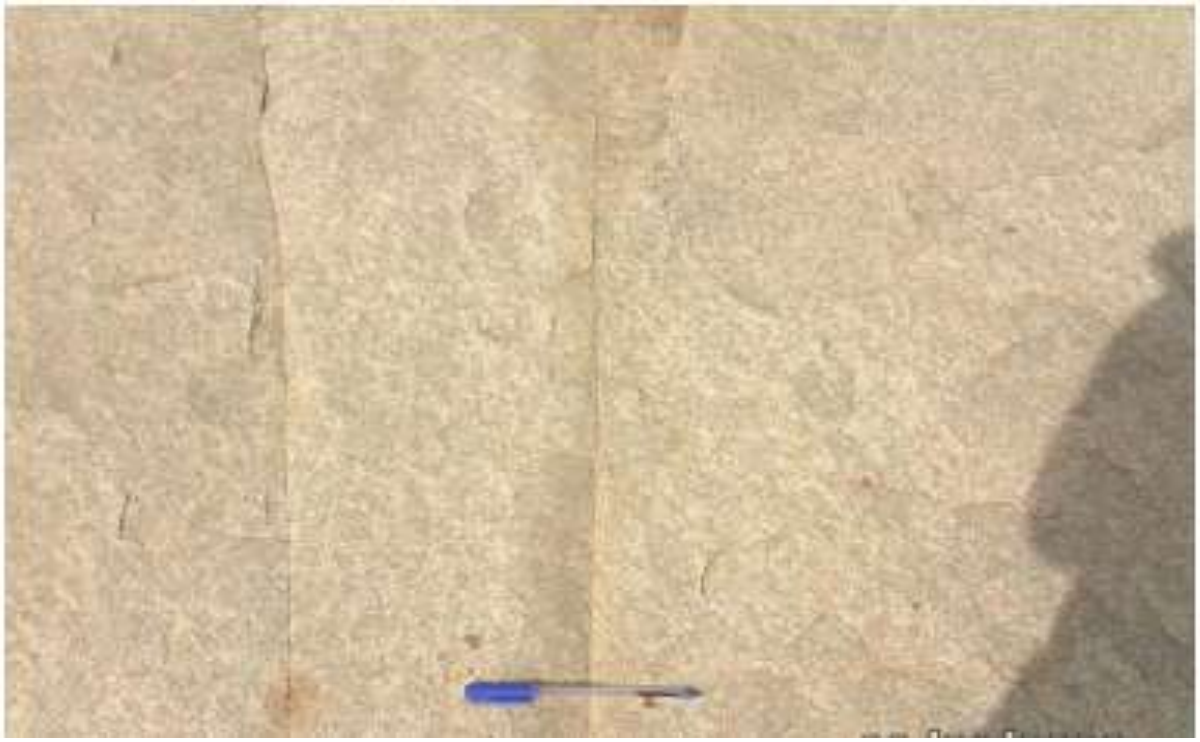

Plate5: photograph of fine-grained gneiss in the study area.

4.1.3.2 Megascopic Description

In hand specimen the fine-grained gneiss is light grey in color and fine grained in texture with average grain size about 3mm. The mineralogical composition of the rock includes plagioclase, orthoclase, biotite, and quartz.

4.1.3.3 Petrographic Description

The rock is fine-grained with most of the crystals not having a well developed crystal forms. The minerals in the rock include biotite (35%), orthoclase (22%), plagioclase (17%) and quartz (13%). Accessory minerals constitute (13%) of the total mineral (plate 6).

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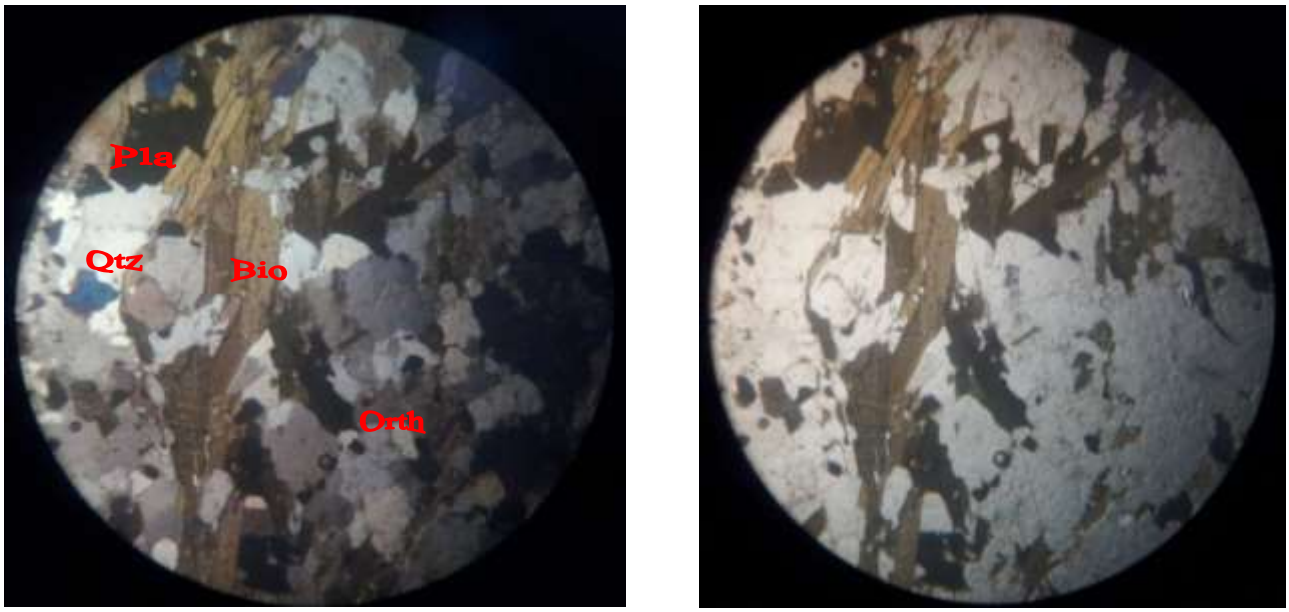

Plate6: Photomicrograph of Fine Grained Gneiss showing its mineralogical composition under (XPL) and (PPL) respectively. **Orth** = Orthoclase, **Pla** = Plagioclase, **Qtz** = Quartz, **Bio** = Biotite. Mag.X40

Biotite: constitutes 35% of the rock by volume. Biotite has well-developed large crystals (euhedral) that are needle-like in shape. It is euhedral in form. Under plane polarized light, it is brown in colour. It appears reddish-brown in cross polarized light. The mineral is strongly pleochroic in shades of brown, reddish-brown and light green colors. It has a perfect cleavage in one direction with near-parallel extinction.

Orthoclase: It is appears colorless in plane polarized light and grayish in crossed polarized light. It is euhedral and has low relief. It constitutes 22%of the rock volume.

Plagioclase: It occurs as a colorless mineral in thin-section under plane-polarized light. Under cross-polarized light, it is characterized by albite twinning. It has a low birefringence. It constitutes 17% of the minerals in the rock.

Quartz: Quartz is present in the rock as anhedral crystals. It is colorless in both plane polarized light (PPL) and cross polarized light (XPL). It has no cleavage. Quartz exhibits undulose extinction, There is no alteration or twinning. It has a moderate relief and low birefringence. It makes up to13% of the rock. General trend of the outcrop is north-south direction.

5. CONCLUSION

Evidences from field mapping and petrographic studies show that the mapped area is underlain by rocks of the undifferentiated basement complex as well as gneiss suites. The evolution of the rocks has been linked to at least three past tectonic events ranging from Archaean to Pan African The area been mapped on a scale of 1:25,000 and is a metamorphic terrain typical of the Nigeria Basement Complex of North-western Nigeria. This area constitutes mainly gneisses with some minor rocks such as pegmatite and veins. The rocks and structures in the area are products of tectonic events. Structural features like faults, joints and xenoliths were observed dominantly trending N-S are evidence that confirms the E-W dominant stress direction of the Pan-African Orogeny. Weathering and erosion has led to the formation of superficial deposits of the area. The topography of the area is low, drained with few river and stream channels. The source of water within this area is predominantly groundwater which is obtained from hand dug wells and boreholes.

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