

# GEOLOGY AND PETROGRAPHY OF PRECAMBRIAN ROCKS OF KATSINA URBAN AREA, NORTHWESTERN NIGERIA

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**ABSTRACT:** *This present study, the mapped area is located between latitude E07°35'00" to E07°39'00"11" and longitude N13°00'00" to N12°57'00" of sheet 34NW, Katsina State, Northern Nigeria. The area is underlain by Basement Complex rocks and syeno-granitic rocks which dominate in the area. The two sets of granitic rocks were observed and distinguished by texture. The northwest of the mapped area consists of very coarse to coarse grained syeno-granitic rocks, while in the southeast, the rocks are medium to coarse grained. These outcrops exhibit various systems of joints. The mineralogical compositions determine by thin section results displays: quartz, biotite, muscovite, plagioclase feldspar, apatite, sericite, hornblende, augite and microcline. There are two generalizations of joints with primary WSW to ENW direction and NE-SW, MMW-SSE and WWW-ESE secondary direction of NE-SW, MME-SSE and WWW-ESE.*

**Keywords:** *Petrography, Geology, Precambrian rocks, Katsina-Urban, NW Nigeria.*

## INTRODUCTION

The rocks of the Basement Complex are divided into three (3) main groups. The ancient migmatite with subordinate gneiss and quartzite complex, the schist rocks and granites that are older than 650 million years commonly called the Pan-African granite suites (Bowden, 1982; Kankara, 2014) The most famous and notable tectonic igneous reactivation of this suite are attributable to the Pan African episode (Trompette, 1979).

Validity of the Eburnean event was highlighted. These Pre-Cambrian crystalline complex rocks cover nearly more than half of the surface of Nigerian territory and extend to neighbouring countries (Ajibade et al., 1987). Igneous rocks of the older gran-

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ite suite which include basic, intermediate. Both the basement complex and the younger metasediments during the episode that brought the formation of older granites. In Nigeria, Pan African older granites were first named by Falconer in the year 1911, to differentiate them from the Jurassic younger granites complex. The older granites are the youngest of the three main types of rocks forming the Precambrian geology of Nigeria through which they intruded (McCurry, 1974; Kogbe, 1976).

Precambrian rocks are crystalline igneous and metamorphic rocks older than the Cambrian age (650 + 150 My). The name refers to the great shield shaped arc as of ancient rocks. The emplacement of these earth materials occurred in many parts of the world. Everywhere on the earth's surface is covered with loose sediments, the alluvial deposit and plants. The underground beneath the earth's surface is basically supported by crystalline rocks which serve as bed rock that shield the mobile belt of the earth. This geological approach is referred to as petrography of Precambrian rocks could effectively be done with deep field mapping and laboratory analysis; for the purpose of this research several attempts, have been made by considering lithological settings, outcrop patterns, structural frequency, availability of data and textual variation. All crystalline rocks in this area formed display coarse grain texture signifying their formation beneath the crust (Kankara, 2014).

Lithology, distribution and field relationship have shown that part of the study area is underlain by grey to pink colored granitoids, which occur as small pockets of low-lying granites. The granitoids occur as massive fractured plutons irregular shapes, roughly occupying two belts in the NW-SW parts of the map area. There is a gradual contact between the granites and the gneiss.

Granites in the study area are scattered and occur as sporadic, low-lying (Figures 2 and 6) Spatial relations (e.g., sharp contacts) show clearly that the granites in the study area were emplaced as liquid melts, and that the fine-medium grained varieties are older than the porphyritic varieties. In addition to that, structural grain that dips into north-south direction in the eastern neighboring sheets has influenced the surfacing of porphyritic granites and inselberg, like in areas around Muduru. Dada (2006) and Kankara (2014) observed that due to their limited exposure scattered around urban Katsina, most of them do not represent mappable units (mostly in a locality around Dutsen-Amare). Biotite granites outcrop the EW parts. Scattered outcrops are observed in Modoji and New Government House areas (Black et al, 1979) They are bounded by migmatite-gneisses in neighboring sheets. They extend to the upper western and eastern part.

Additionally, in these neighboring areas, the outcrops form low ridges in some places, and probably have gradual boundaries with the strongly lineated, pink-grey coarser gneisses. Here too, it consists principally of quartz, biotite and feldspar minerals with minor accessories.

## MATERIALS AND METHODS

### Data Collection and Analysis

The accessibility to these locations was achieved by traversing the urban area with motor cycle where necessary (see Figure 1) There was ground trekking by the researchers. Katsina emirate has been chosen as the center of the 5km radius across the cardinal points. Moving northward from the emirate council is not shown on the map probably due to diplomatically unveiled reasons. However only 1.5 km is shown, but the geology and the relief is the same. The west, east and southern parts of the study area appear on the map which was accessed through vehicle and traverse by trekking. Ten (10) samples of rocks were collected for laboratory analysis.

### Location and Extend

Urban Katsina is the capital of Katsina State. Located between latitudes N13°00' to N12°7'00" to longitudes E07°39'0" and E07°33'45' (Figure 1), the location is the extreme part of Northern Nigeria, some 45 kilometers from the Nigeria-Niger border. The mapped area covers a total of 32 square kilometers of its total 23,938 square kilometers land area.

## RESULTS

### Geological Field Mapping

Mapping was conducted within six days in January, 2012 (see Figure 1) where five locations were observed. Traverse technique was used to access the outcrop throughout the mapped area. Field mapping equipments that were used include map base, global positioning system, compass clinometers, hammer, hard rope book, writing materials, sampling bag and vehicle. In the map displayed (Fig. 1).

### Laboratory Work

For the investigation of rock samples under the microscope, their slices or sections are required. The procedure involves cutting of a chip of rock samples using a diamond saw and the grind perfectly flat on one side of the stage to a finer provider.

A glass slide of 3 inches was made and a small amount of balsam was compressed to become firmly cemented after cooling. This operation has continuously been repeated on the other side of the thick chip to a thickness of 30 mm and finally covered carefully and perfectly with slides to avoid air bubbles. After cooling, the remaining balsam around the slide has been removed by mentholated spirit and labeled. This has been repeated for the remaining rock samples and their slides here were obtained. Using the

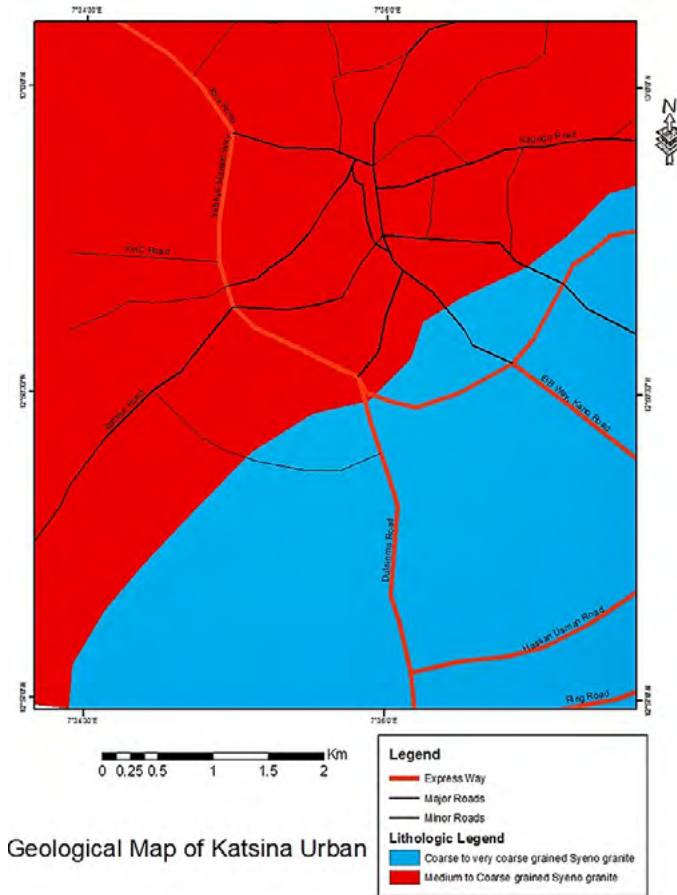


Figure 1. Geological map of the study area

above procedure the labeled thin sections were obtained from slices respect to the outcrop location as; L1-L10.

### Occurrence and Petrography of Rocks

The mapped area comprises of a single lithological unit; a syeno-granite which dominated the area (see Figures 3 and 4) It outcrops as a ridge, hill, and flat body. The rocks exhibit very coarse to coarse grained and medium to coarse grained texture in hand specimen. Rock samples were cut for petrographic analysis of which a leucocratic to slightly melanocratic colour index has been assigned. The degree of weathering is lack to partial in hand specimen. A petrological microscope has been used to study slices of the selected rocks samples (Bohlen et al, 1983; Bertin, 2000). Each slice displays a unique mineralogical composition and texture relationship.

## Petrographical Study

Petrographical study involves description of the individual minerals in a thin section of each representative rock samples. Thin section is truly speaking a starting point for further researches such as the geochemical and isotopic analyses. The petrologic microscopic studies are based on the optical properties of the minerals both in plane polarized light (PPL) and cross polarized light (XPL). The properties determined in cross polarized light were interference colors pleochroism form and habit, cleaving, isotropism, birefringence, interference, extinction, training and zoning.

The modal analysis of coarse to very coarse grained syeno-granite are in table 1.

The rock is composed of varying proportions of microcline (10-20%), hornblende (10-15%), muscovite (5-10%), quartz (15-20%), opaque mineral (8-10%), biotite (18-20%), augite (5-20%), sericite (1-2.5%) and plagioclase feldspar (4-5%) respectively. The amount of plagioclase feldspar and sericite are 5 and 2% respectively (see Table 1).

Quartz grains are whitish in color (Fig 1 and 2). Some plagioclase feldspar grains are present with albite twins.

The modal analysis of thin section of medium to coarse grain syeno-granite in transmitted light is contained in Table 2. The mineralogy is dominantly composed of microcline (about 16.8-20%), quartz (20-35%), hornblende (5-10%), opaque mineral (5-10%), muscovite (10-15%), plagioclase feldspar (5-10%), biotite (about 8-10%), augite (about 0-10%).and chlorite (about 0-5%). augite and chlorite are present in some of the rocks as can be seen in Table 2.

The majority of the rocks contain quartz, biotite and feldspar minerals (Fig 8 and 9) The plagioclase feldspars have subhedral forms (Fig 3). In some occasional localities, the feldspars have been weathered into clay materials, with a lot of air bubbles developed in them (see Fig 10)

Biotite is dark brown in color under cross polarized light. It displays dark brown to green pleochroism. Some of the crystals are platy lath-like and display characteristic basal cleavage. Some have been altered to chlorite (see Fig 5 and 6).

Part of the plagioclase feldspar crystals have been altered into sericite. Muscovite flakes are bluish pink in color under crossed polars (Fig 6) Some opaque minerals are present (see Fig 7). Again, euhedral apatite is the accessory (Fig 10 and 17) Anhedral microcline grains are present (Plate 5.) as well as cloudy augite with numerous cracks.

Anhedral hornblende with diagnostic 600 – 1200 intersection cleavage was observed (Fig 7). Microcline with indicative cross hatch or tartan twinning is present (Fig 5). Pinkish blue anhedral muscovite grains were observed (Fig 12)

Anhedral brown biotite grains are contained in the rocks and some have been altered to chlorite (see Fig 11 and 12)

Hypidiomorphic texture with euhedral apatites are sometimes developed on the rocks (see Fig 10)



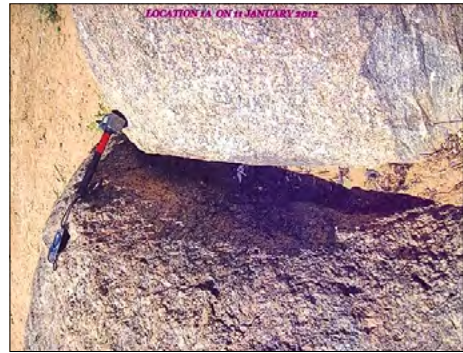
**Figure 2.** A general appearance of granite around Dutsen Amare



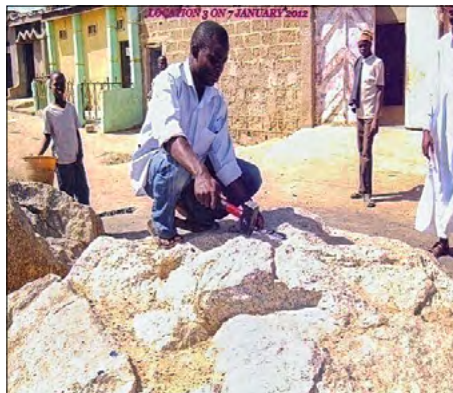
**Figure 3.** A vein in a microgranite at the Goruba quarters



**Figure 4.** A medium-grained granite at Kofar Durbi



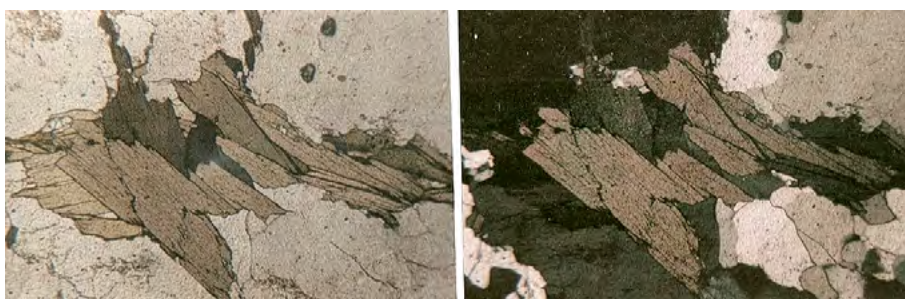
**Figure 5.** Weathered microgranite at the Goruba quarters



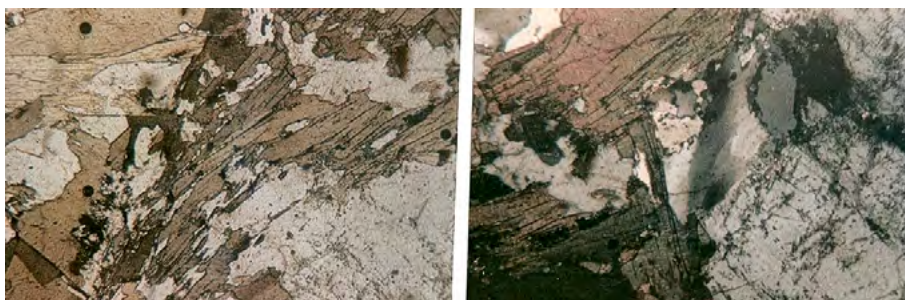
**Figure 6:** Low-lying granite, GRA road

**Table 1:** Modal mineralogical analysis of coarse to very coarse grained syeno-granite

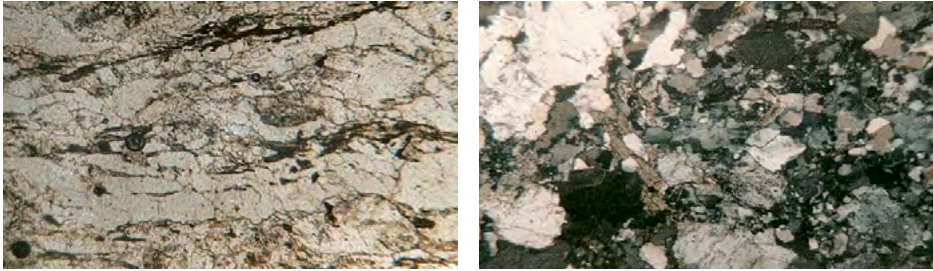
S/Nº	Sample No. Mineral	L1	L2	L3	L4	L5	Range	Mean
1	Microcline	10	20	11	17	14	10-20	14.4
2	Hornblende	10	15	10.5	13	13.8	10-15	12.46
3	Muscovite	10	5	10	8.8	7.9	5-10	8.34
4	Quartz	15	20	18	17.5	16	15-20	17.3
5	Opaque mineral	8	10	9.5	8.5	8.2	8-10	8.84
6	Plagioclase feldspar	5	5	4.5	4.2	8	4-5	5.34
7	Sericite	1.5	2	2.5	1.5	1	1-2.5	1.7
8	Biotite	20	18	19	18.5	19.1	18-20	18.92
9	Augite	20	5	15	11	12	5-20	12.6
	Total	100	100	100	100	100		100



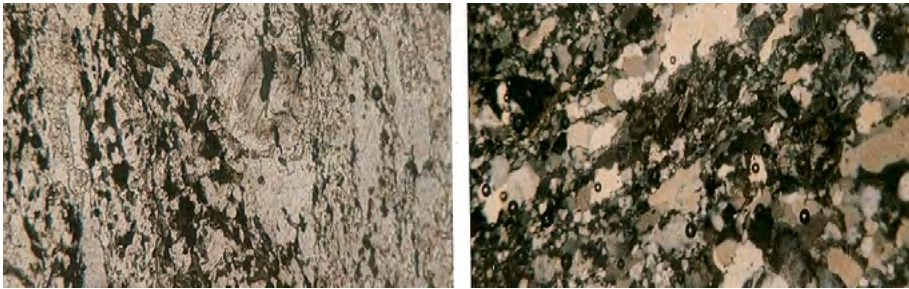
**Fig 7:** Photomicrograph of very coarse to coarse grained granite in transmitted PPL (l) and of XPL (r) displaying platy biotite and anhedral quartz. Latitude 13° 00' 11.9" N; Longitude 7° 37' 23.4" E and Elevation 509 m) L1 in the sample



**Fig 8:** Photomicrograph of very coarse to coarse grained granite in transmitted PPL (l) and cross polarized light (r) displaying platy biotite (B), anhedral hornblende (H) and quartz (Q) (L3)



**Fig 9:** Photomicrograph of very coarse to coarse grained granite in transmitted plane polarized light (l) and cross polarized light (r) displaying sub-hedral plagioclase feldspar (PF), anhedral muscovite (Mu) and quartz (Q). (Latitude 12° 59' 26" N; Longitude 7° 36' 48" E and Elevation 500 m) L3



**Fig 10:** Photomicrograph of very coarse to coarse grained granite in transmitted plane polarized light (l) and cross polarized light (r) displaying hypidiomorphic texture comprising of euhehedral apatite (A), sub-hedral plagioclase feldspar (PF), anhedral muscovite (MU), biotite (B) and quartz (Q) (L3) (Latitude 12° 59' 26" N; Longitude 7° 36' 48" E and Elevation 500 m) L3



**Fig 11:** Photomicrograph of very coarse to coarse grained granite in transmitted plane polarized light (l) and cross polarized light (r) displaying Anhedral Biotite (B), Microcline and quartz (Q) (L) (Latitude 12° 59' 26" N; Longitude 7° 36' 48" E and Elevation 500 m) L3



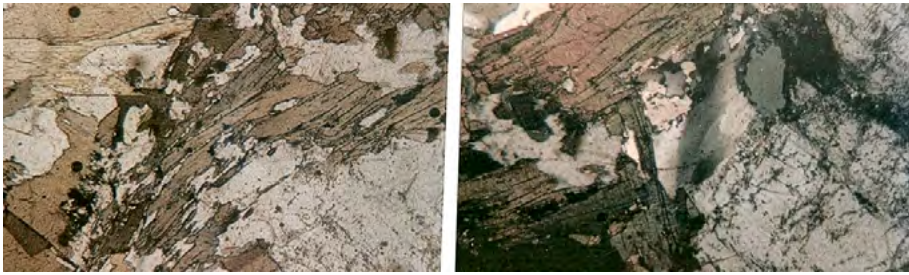


Fig 12: Photomicrograph of very coarse to coarse grained granite in transmitted PPL (l) and XPL (r) displaying anhedral biotite (B), muscovite and quartz (Q) (L) (Latitude 12° 59' 26" N; Longitude 7° 36' 48" E and Elevation 500 m) L3

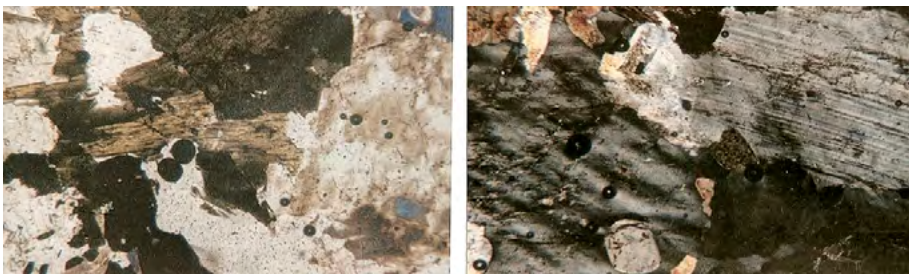


Fig 13: Photomicrograph of very coarse to coarse grained granite in transmitted PPL (l) and XPL (r) displaying anhedral muscovite (Mu), opaque mineral (Om), quartz (Q), biotite (B) and hornblende (H) (L). (Latitude 12°59' 25" N; Longitude 7° 36' 48" E and Elevation 503 m) L4

**Table 2: Modal mineralogical analysis of medium to coarse grained syeno-granite.**

S/Nº	Sample Nº. Mineral	L6	L7	L8	L9	L10	Range (in %)	Mean Value
1	Microcline	20	20	18	19	16.8	16.8-20	18.76
2	Quartz	35	20	32	29	31	20-35	29.4
3	Augite	-	10	3	7.6	3.6	0-10	4.84
4	Hornblende	10	5	7	6.9	7.1	5-10	7.2
5	Opaque mineral	5	10	6	7.6	5.4	5-10	6.8
6	Biotite	10	10	8.1	8.2	9	8-10	9.06
7	Muscovite	15	10	12.5	11	14	10-15	12.5
8	Plagioclase feldspar	5	10	9.7	6.7	9	5-10	8.08
9	Chlorite	-	5	3.7	4	4.1	0-5	3.36
	Total	100	100	100	100	100		100

Source: Field work



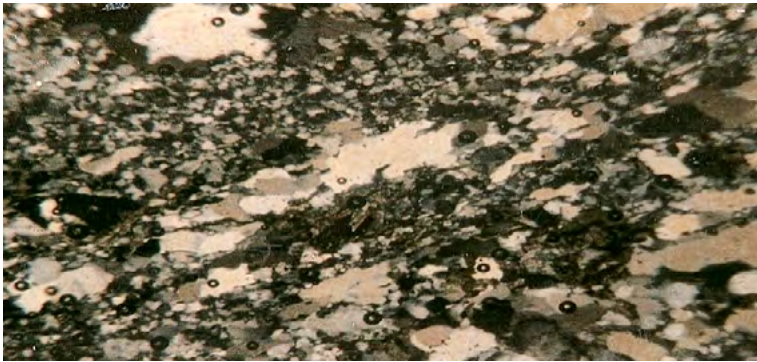
**Fig 14:** Microphotograph of medium to coarse grained syeno-granite showing the whitish area as the quartz (Q), the Biotite in the dark brown portion and a minor portion of Alkali feldspar (AF) under plane polars. The dark portion represent an area where there is no cleavage, the thin section did not cut along or across. Magnification = 30x



**Fig 15:** Microphotograph of medium to coarse grained syeno-granite under plane polars showing biotite exhibiting different pleochroic orientations. The feldspar here has clay alterations and cleavages. Quartz is absent, although in most of the cases cannot be distinguished from feldspar. Quartz is therefore not polycrystalline. Zircon which is radioactive act as pleochroic haloe that also destroys the crystalline structure of the biotite. Magnification =30x



**Fig 16:** Microphotograph of medium to coarse grained syeno-granite showing highly weathered feldspar almost turning into clay. There are a lot of air bubbles and the greener portion of the feldspar suggests that it is thicker than the usual 0.03mm or 30 microns and this makes it to appear with interference colors. As can be identified, albite and potassium feldspar are independent. Magnification=30x



**Fig 17:** Microphotograph of medium to coarse grained syeno-granite showing feldspar that has been weathered into clay. There are also apatite, microcline or Alkali feldspar and a lot of air bubbles under cross polars. Magnification =30x

## DISCUSSION

Petrological data earlier described on the syeno-granite of the study area strongly indicates the greywacke sediments may have been derivatives of moderately to fairly intensively weathered granitic rocks of the study area (Figure 5). Quartz sandstones are generally regarded as formed from recycled sediments or from materials derived from weathering under low relief conditions and under low rates of sedimentation. Such conditions are obtained in stable cratonic environment like the passive margin (Strecherin, 1976; Gilleppe and Styles, 1999) It has been shown that first cycle quartz-rich granites with subordinate schist can be formed under a unique combination of tectonic and climatic conditions.

These include prolonged transport involving slow rate of sedimentation or prolonged alluvial storage with low relief and severe tropical weathering conditions.

The mapping has allowed for the extension of the areal extent of the study area as far east as areas beyond Katsina urban. The presence of basement between the adjacent sheets and beyond is also quite significant. As already observed, there are significant similarities between rock-types, structural and metamorphic events in the granitic and migmatite-gneiss rocks and the area at the western part.

### Aspect of Economic Geology

Economically, the rocks meet the standard for use as constructional and building materials. The availability of Ca, Na and K minerals can aid manufacture in agriculture implements as acid soil ameliorants and nutrients status enhancer. Because of their economic potential the granites can be put into one or more uses, and abundant evidences show that they are being quarried for other domestic and industrial purposes.

## CONCLUSION

Petrographic analysis of syeno-granites from this research has similarity to other granites of the Borborema Province, the African provinces, and Congo craton, and it was re-affirmed that these tectonic units may have been part of a larger continental land-mass, the Pangea. Likewise, similarities in post-Transamazonian (or post Eburnean) metamorphic and magmatic events in the Borborema and African provinces suggest that they shared a common origin and remained in close proximity until when Atlantic Ocean was opened.

The age of earlier and later deformations and metamorphisms in the study area has been shown to be Pan-African on comparative grounds, while the granite plutonism during the same late Proterozoic times, are a result of basement reactivation due to plate tectonics subduction processes.

In summary, the early stage of the Pan-African is the probable time of initiation and first metamorphism under medium temperature amphibolite facies, and the middle-late Pan-African orogeny as the time for subsequent folding, low grade (greenschist facies) metamorphism and stabilisation of the metasediments.

In the area, there are deformation which were polyphase with primary deformed and ductile structures which were in contact with expansion and contraction of rocks affected by orogenic cycle were followed by secondary brittle structures. Also, there has been primary ductile deformation produced the regional tectonic folds and faults, and tight to isoclinal unpronounced folds. There is strain localization that also generated shears of extensional ductile. This was followed by faulting associated with contractions that lead to recumbent folds. These primary post-structures were folded by the major secondary folding.

There are post or secondary open-foldings that crenulated primary folds and faults and deformed early pegmatitic dykes.

## Recommendations

The present result of petrographical analysis carried out for the area require an additional information or data of geochemical and an isotopic analysis of age of rocks. The laterite analysis can then drag the researcher to know the true source of the rock, either from the upper or lower mantle or from the crust.

But the samples to be used in the isotopic analyses are less in number than the samples that were used in the geochemical analyses. Trace elements are least mobile, they therefore remain to tell a lot about a rock. They do not become mobile unless under serious alteration, hence they are very sensitive in geochemical and any further analysis.

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## CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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