IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

Environmental and Earth Sciences Research Journal
Vol. 5, No. 3, September, 2018, pp. 66-73
Journal homepage: http://iieta.org/Journals/EESRJ

The geology and petrography of the Arikya Tsauni quartzite and pegmatite ridges, central Nigeria

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https://doi.org/10.18280/eesrj.050303

Received: 19 July 2018
Accepted: 29 August 2018

Keywords:
Arikya Tsauni, geology, pegmatite, petrography, quartzite.

ABSTRACT

The Study area is located in Arikya Tsauni, in Lafia East Local Government Area of Nassarawa State. Bounded by latitude $08^{0}46' 44''$ N to $08^{0}48' 44''$ N and longitude $008^{0}38' 34''$ E to $008^{0}41' 14''$ E, it forms part of Wamba sheet 210NW. The study addressed the geology and petrography of the study area. The geological mapping indicated five (5) rock types namely, migmatite, foliated gneiss, granite gneiss, quartzite and pegmatite. The quartzite and pegmatite ridges are striking in NE-SW direction. Petrographic studies showed the presence of the various rock forming minerals which include - plagioclase, quartz, biotite, microcline, hornblende and opaque minerals as observed within the field of view under plane and crossed polarized light. Careful study of the pegmatite in the study area has clearly shown that they are barren. The structural features of the study area were seen as foliation, joints, comb structures, veinlets and faults, where the major structural trends were in the NE-SW, NNE-SSW directions, corresponding to that of the underlying Basement Complex. Economically, the study area portend the ability to host quarries, as the rocks would serve as major source of construction materials.

1. INTRODUCTION

Central Nigeria is part of an Upper Proterozoic mobile belt extending from Algiers across the southern Sahara into Nigeria, Benin, and the Cameroun. This Pan-African belt continues into Northeast Brazil where analogous rare-metal mineralized pegmatites are also known [5, 9-10]. Bordered to the west by the West African Craton (stabilized around 2Ga) the Pan-African belt itself is made up of gneiss-migmatites, metasediments, and metavolcanics that have been subjected to polycyclic metamorphism and emplacement of igneous rocks. These rocks all constitute the Precambarian to Lower Paleozoic Basement Complex rocks.

The Nigerian pegmatites occur in a belt which extends from southwestern (Ijebu area) to northern Nigeria (through Wamba-Jema'a to Zuru-Gusau area) covering a broad, over 400km long zone trending NE–SW and parallel to the linear pattern of the other two metallogenic provinces (Younger Granite and Cretaceous Benue Trough provinces) [4, 6- 8].

The mineralized or rare metal-bearing pegmatites consist mainly of quartz, potash feldspar, albite, muscovite and less commonly, biotite and a range of accessory minerals including tourmaline, beryl, aquamarine, lepidolite and economically important cassiterite, columbite and tantalite [12].

The mineralized pegmatite belt, also known as the Older Tin field of Nigeria, is the only basement metallogenic feature that cross-cuts the schist belt structures although most pegmatites are oriented N-S [6, 11]. The belt is divided into 3 zones: (i) the main central Nigerian pegmatite belt (ii) area of richest stanniferous pegmatites (iii) and area of subordinate mineralization (Figure 1).

The pegmatites of the Nassarawa area were grouped into Simple and complex pegmatites by [2] who described them thus:

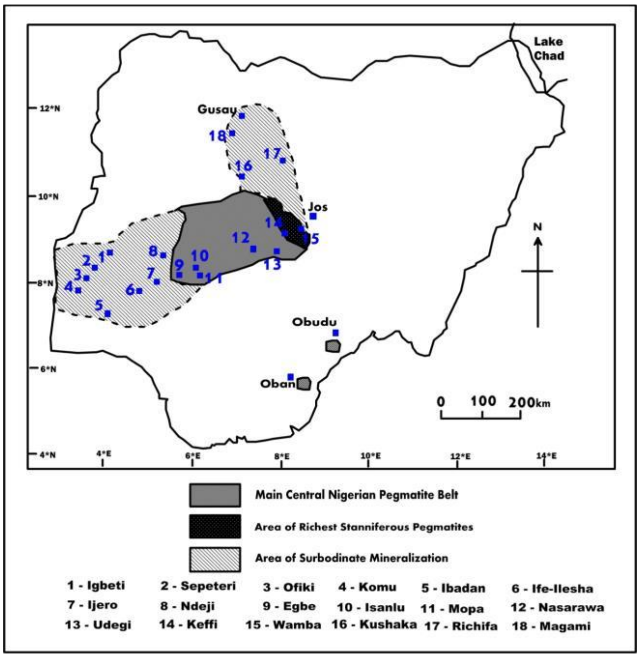


Figure 1. Map showing the locations of notable tin-bearing pegmatites in Nigeria [12]

(1) Simple, usually barren massive quartz microcline pegmatites with minor muscovite and accessory tourmalines and

(2) Complex, albitized muscovite-quartz-microline pegmatites, bearing the rare-metals Ta, Nb, Sn, Li and Be mineralization.

Pegmatites in Nasarawa area of Central Nigeria lie within a fracture controlled east-northeast trending rare metal pegmatite belt closely associated with late Pan African peraluminous granites in Nigeria.

This work deals with the study of the lithological units, detailed description of the rock types both in hand specimen and thin section (petrography) of selected rock samples from the study area with major emphasis on the quartzite and pegmatite. The major rock types found within the study area constitute the Basement Complex rocks (Migmatite, foliated gneiss, granite gneiss, quartzite and pegmatite), typified by such structural features as joints, fractures, veins, foliations, spheroidal weathering etc.

2. STUDY AREA

The Arikya Tsauni area as well as its adjoining environments lies within the Basement Complex of central Nigeria. The area of study which was mapped covers major villages such as Arikya Tsauni, Langi I, and Langi II a total ground coverage of about 18.125 km^2 and is located within Lafia East local Government Area of Nassarawa State. The area lies within the bounds of latitudes 08^0 46′ 44″N and 08^0 48′ 44″ N and longitudes 008^0 38′ 34″ E and 008^0 41′ 14″ E. (Figure.2).

The study area and its adjoining towns is accessible through the secondary road that branches off at Nassarawa Eggon along the Akwanga-Lafia road. The untarred road passes through Bekyano, Arugbadu, Arikya Tsauni, Langi II and Arikya. Other local hamlets can be accessed through foot paths that criss-cross. Rock exposures are accessible with the use of motorcycles, available footpaths and stream channels.

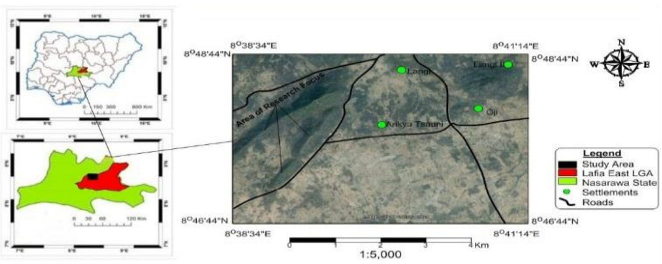


Figure 2. Maps showing location and satellite image of the study area

3. GEOLOGY AND GEOMORPHOLOGY OF THE STUDY AREA

The study area is underlain by the crystalline rocks of the Precambrian basement of central Nigeria. About 55% of the total are is mainly occupied by granite-gneiss, while migmatite, gneiss, quartzite and pegmatite occupies the other 45%.A migmatite hill and gneiss /granite-gneiss outcrops occupies the north-eastern part of the area. (Figure 3 and 4). The most striking topographic feature of the area is the occurrence of massive ridges of mainly quartzite and pegmatite. The ridges and hills are high rise in the range of 330m – 350m above MSL as depicted in the digital elevation model of the area. (Figure 5).

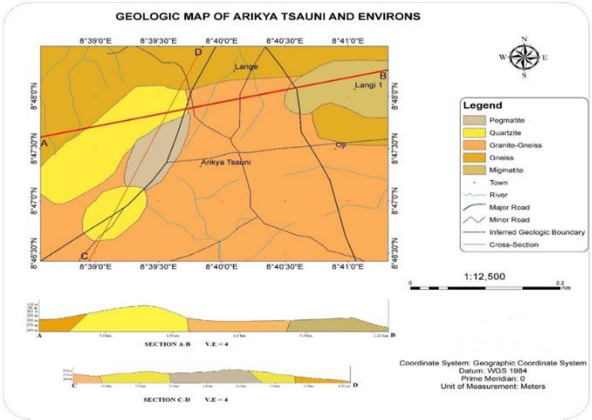


Figure 3. Geologic Map of the study area

(a) Migmatite outcrop showing foliation (8˚48′09″N, 8˚40′46″E)

(b) Gneiss in Langi II (8˚47′58″N, 8˚40′44″E)

(c) Granite gneiss (8˚48′19″N, 8˚40′08″E)

(d) Quartzite (8˚48′20″N, 8˚39′19″E)

Figure 4. Various rock types in the study area

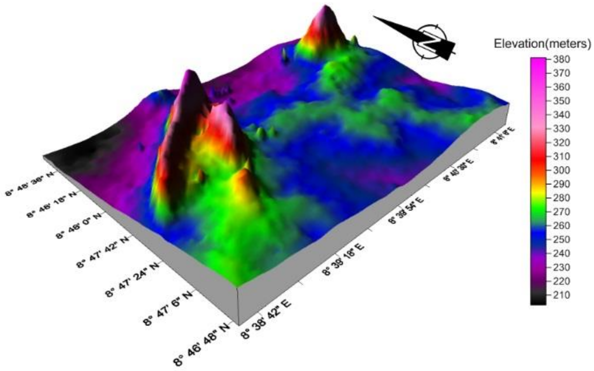


Figure 5. Digital elevation model of the study area

3.1 Quartzite

The normal quartzite is fine grained and has quartz as its main constituent mineral. The cataclastic quartzite is mainly fine to medium grained rock, containing quartz and muscovite. Quartzite is the predominant rock that occur in the form of massive ridges within the study area. (Figure 6a)

The quartzite in the study area are faulted and highly fractured forming very high ridges and exhibiting both horizontal and vertical fractures in some places (Figure 6b). The ridge trends in the Northeast-Southwest direction, with a length of about 2.16 km long. The highest point on the ridge is about 410m with coordinates 08^0 48′ 05.1″ N and 008^0 39′18.7″E. The ridge seem to occur within a strike-slip fault zone striking at 036^0 NE and at different point along the ridge, the rocks were found to be dipping 030^0 W. Another quartzite occurs in the form of a small ridge near the pegmatite ridge. This small ridge trends 122^0 SE and dip at 20^0 E.

(a) Part of the Quartzite ridge

(b) Fractures on Arikya Tsauni Quartzite

Figure 6. Section of the Quartzite ridge and associated structures

3.2 Pegmatite

Pegmatite is a very coarse-grained rock (with grain size larger than 1 to 2 cm), typically found in veins or lenticular or pod-like bodies around the margins of large deep- seated plutons usually extending from the pluton itself into the surrounding country rocks. The pegmatite found within the study area occurred in a form of a massive ridge formed adjacent two quartzite ridges. The main composition of Arikya Tsauni pegmatite is quartz and feldspar (Figure 7a). It is characterised by a lot of comb-structures and net-veining mainly made up of quartz. This structures in most cases indicates the infilling of an open fracture (Figure 7).

(a) Feldspars and Quartz Striations (8˚47′50″N, 8˚39′26″E)

(b) Net veining of quartz crystals (8˚47′50″N, 8˚39′26″E)

(c) Quartz intergrowths on the Pegmatite

Figure 7. Associated structures on the Pegmatite

4. METHODOLOGY

The systematic method of mapping along profiles from one outcrop to another taking note of river channel that revealed sub – surface lithology was used in the field. Climbing of ridges and hills, structural measurements were made while computer softwares were used to generate lineament map and rose plot. Samples of fresh rocks units were taken at each location with coordinates labelled using GPS and pencil. Megascopic description of each rock sample (that is, texture, colour, composition) in hand specimen and field names were given to rocks.

For the petrographic studies, the rock samples were cut into chips with a micro-cutting machine and subsequently polished on glass ground plate using carborundum to obtain required thickness and a perfectly smooth surface, the cut rock samples were thereafter mounted on a clean glass slide with adhesive [1]. The prepared slides were examined under the petrological microscope to identify mineralogical features of the rock samples on a microscopic scale.

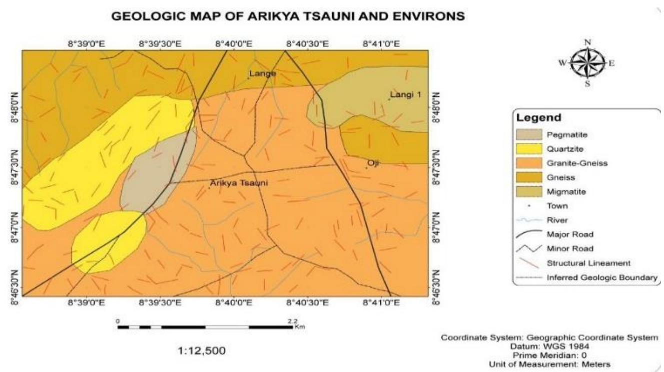
5. RESULTS AND DISCUSSION

5.1 Structural geology

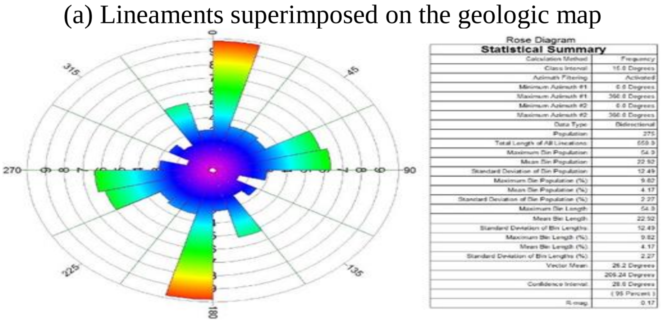
Geologic structures are usually as a result of the powerful tectonic forces that occur within the earth. These forces fold or break rocks, form deep faults, and build mountains depending on whether the rocks are brittle or ductile. As observed in the field, the structural features are mainly secondary resulting from tectonic events.

The field tectonic studies and analyses of the structures within the study area were descriptive**,** through recognizing and describing the structures. The systemic evaluation of their attitudes is essentially defined by strike and dip respectively. The structures found to have occurred and identified within the area under study includes; joints, restites, foliation, fault, comb structures, veinlets etc. (Figures 6 and 7)

The off-field descriptive analyses of these structures entail the generation of structural lineaments superimposed on the geologic map of the area, and the plotting of rose diagram which reveals the dominant structural trend of the area as NNE-SSW, NE-SW. (Figure 8). This has to a large extent enable the reconstruction of the tectonic history of the area under study.



(a) Lineaments superimposed on the geologic map



(b) Rose diagram showing the General Structural Trend

Figure 8. Structural disposition of the study area

5.2 Petrography

Representative samples were carefully selected and taken for thin section preparation. Hence this section deals with the detailed description of the representative samples of the rocks in thin section, such that with the use of a microscope the mineralogical features exhibited by the minerals upon contact with a polarized light (light in one direction) either plane or crossed polarized light can be observed within the field of view. Each of these sections essentially reveals minerals of varying crystallographic features.

5.3 Modal analysis

Based on the hand specimen and petrographic observation, the modal composition of constituent minerals in the three (3) representative samples of quartzite is quartz. The other three (3) samples of pegmatite contains mainly quartz and feldspar in varying modal composition as shown in (Table 1). Table 2 shows the modal composition of various minerals in migmatite, gneiss and granite-gneiss while Figure 9 shows a 3-D representation of the modal compositions of the pegmatites.

Table 1. Modal compositions of quartzite and pegmatite

Sample Identity	% Quartz	% Feldspar	Total%	Rock Type
BIU ST 13	100	-	100	Quartzite
BIU ST 15	100	-	100	Quartzite
BIU ST 21	100	-	100	Quartzite
BIU ST 1	85	15	100	Pegmatite
BIU ST 6	70	30	100	Pegmatite
BIU ST 7	65	35	100	Pegmatite

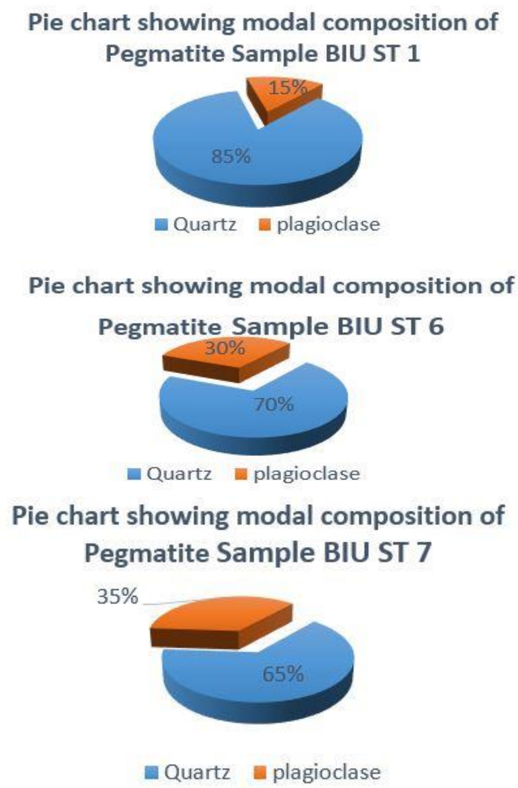


Figure 9. Pictorial representation of the constituent minerals in pegmatite

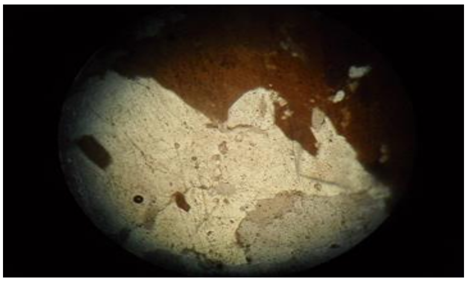
Table 2. Modal compositions of migmatite, gneiss and granite-gneiss

Mineral	BIU. 29	BIU 30	BIU.28	BIU.24	BIU .26
Quartz	35	40	40	40	45
Plagioclase feldspar	30	25	30	20	30
Microcline	20	20	20	35	
Hornblende	10	10			
Biotite	3	4	5	5	24
Opaque mineral	2	1	3		
Accessory			2		1(Zircon)
Total	100	100	100	100	100
Rock Type	Gneiss	Gneiss	Granite-gneiss	Migmatite	Migmatite

5.3.1 Quartzite

As observed under the microscope both in Plane Polarized Light (PPL) and Crossed Polarized Light (XPL), the major mineral revealed by the three representative samples (BIU ST 13, 15, 21) was quartz. Quartz present in the three samples under plane polarised light were colourless, without any pleochroism, fracture, cleavage nor any alteration. Some grains are fine and some are coarse textured, occupying more than field of view as in (Figure 10).

The mineralogical features shown by quartz when observed upon crossing the nicols essentially revealed the following; the interference colour is grey to white while the birefringence is first (1st) order, with no twinning. Some grains exhibit even and undulose extinction (Figure 10).



(a) Photomicrograph of Quartzite (BIU 13) (Mag. = x10)
Mineralogy: Quartz

(b) Photomicrograph of Quartzite (BIU 15) (Mag. = x10)
Mineralogy: Quartz

(c) Photomicrograph of Quartzite (BIU 21) (Mag. = x10)
Mineralogy: Quartz

Figure 10. Photomicrographs of the Quartzite in the study area

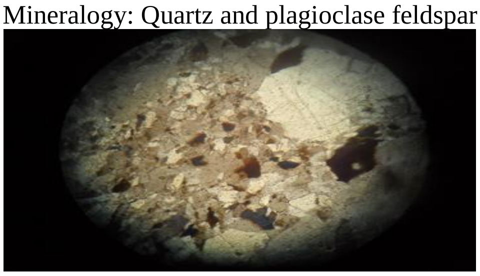
5.3.2 Pegmatite

As observed under the microscope both in Plane Polarized Light (PPL) and Crossed Polarized Light (XPL), the major minerals revealed by the three representative samples from the pegmatite ridge (Samples BIU 1, 6 and 7) were mainly quartz and plagioclase feldspar. Quartz present in the samples under plane polarized light are colourless, with low relief, no pleochroism, no fracture nor cleavage but some portions are weathered as shown in (Figure 11)

The plagioclase feldspar assumes an anhedral crystal shape under plane polarized light. It is colourless to cloudy, possesses a low to moderate relief and characterized with a poor cleavage.

The mineralogical features shown by the minerals when observed upon crossing the nicols essentially revealed that quartz exhibits grey to colourless interference colours on rotation of the stage while the birefringence is first (1st) order, with no twinning and exhibits even extinction.

(a) Photomicrograph of Pegmatite (BIU 1) (Mag. = x10)
Mineralogy: Quartz and plagioclase feldspar



(b) Photomicrograph of Pegmatite (BIU 6) (Mag. = x10)
Mineralogy: Quartz and feldspar

(c) Photomicrograph of Pegmatite (BIU 7) (Mag. = x10)
Mineralogy: Quartz and feldspar

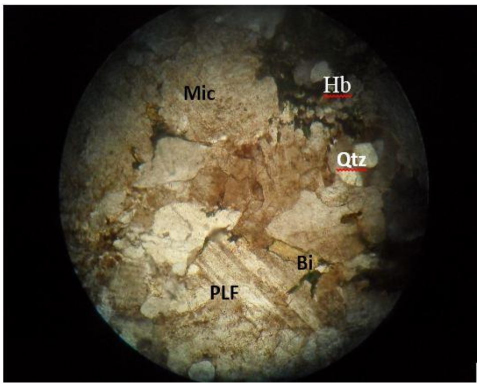
Figure 11. Photomicrographs of the Pegmatites in the study area

5.3.3 Gneiss

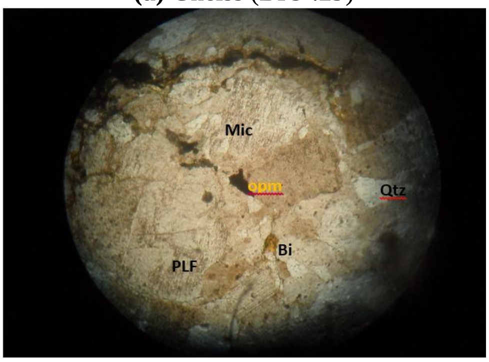
Gneiss shows subhedral and anhedral crystals of mafic and felsic minerals. The dark coloured minerals are hornblende, biotite and some opaque minerals. The minerals show different properties when viewed under the microscope as shown in (Table 3 , Figure 12).The rock shows a coarse grained texture due to development of mineral grains into well define crystals though some have been deformed.

Table 3. Microscopic studies of Gneiss (BIU 29, 30)

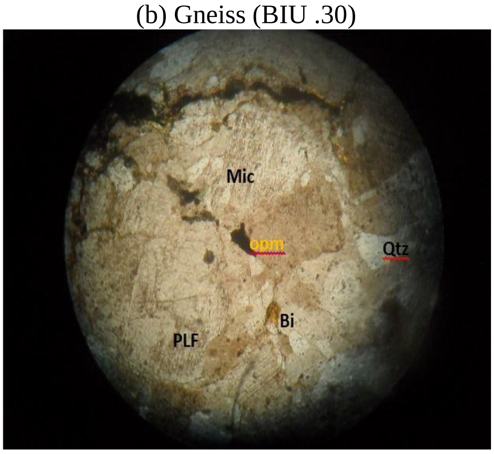
	Quartz	**Plagioclase**	**Biotite**	**Microcline**	**Hornblende**
colour	colourless	colourless	Green	colourless to cloudy	green
relief	low	low	high	low	High
Habit	Anhedral	subhedral to anhedral	Subhedral to euhedral	Anhedral	Anhedral
Cleavage	none	Perfect	Perfect	Few Slight	
Pleochroism	none	none	green to pale yellow		none
Fracture	none	none		none	
Birefringence	1st order	1st order	2nd order	1st order	2nd order
Interference colour	grey to white	grey to white	brownish green to light green	grey	green
Extinction	Undulose	41^0 and 40^0	Straight	Oblique	Straight
Twinning	none	polysynthetic	none	Cross hatched	none



(a) Gneiss (BIU .29)



(b) Gneiss (BIU .30)

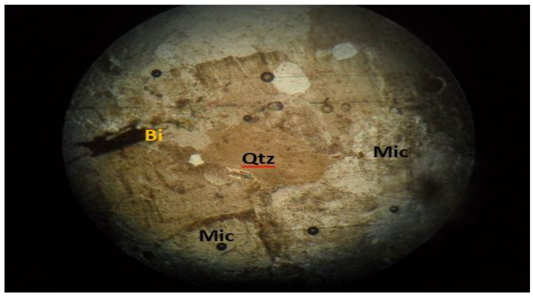


(c) Gneiss (BIU .30)

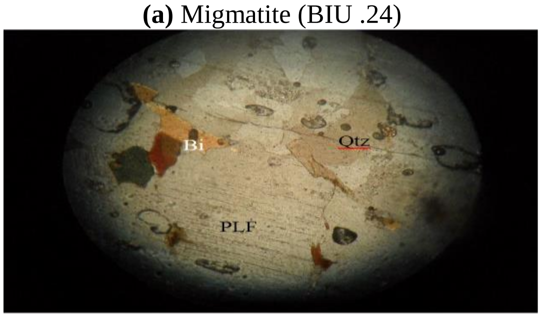
Figure 12. Gneiss under cross polarized light. (Mag. = x10). Mineralogy: Biotite, Plagioclase, Microcline, and Quartz

5.3.4 Migmatite

The microcline shows its cross hatched twin property with low relief and interwoven into the other minerals. Colourlss quartz with anhedral form exhibits even to wavy extinction. The biotite seen exhibits reddish-brown to brown colour and brown to green (BIU 24). The biotite also contains inclusions of zircon (BIU 26) Figure 13. Other properties exhibited by the minerals are as shown in Table 4



(a) Migmatite (BIU .24)



(a) Migmatite (BIU .26)

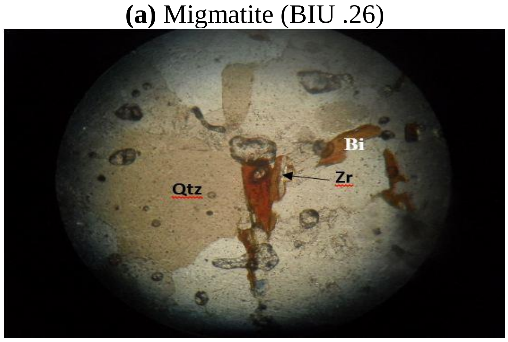


Figure 13. Migmatite under cross polarized light. (Mag. = x10). Mineralogy: Biotite, Plagioclase, Microcline, and Quartz

Table 4. Microscopic studies of migmatite (BIU 24, 26)

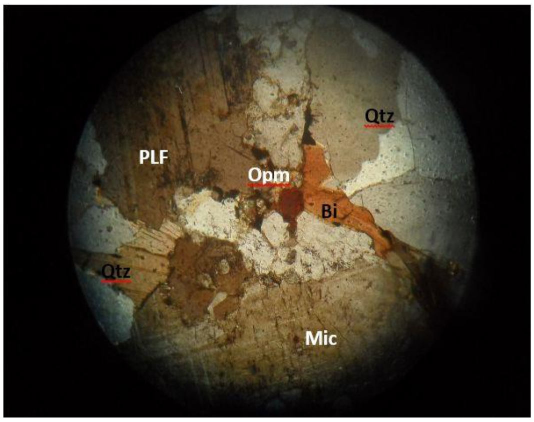
	Quartz	Plagioclase	Biotite	Microcline
colour	colourless	colourless to cloudy	Reddish brown	colourless to cloudy
relief	low	Low to moderate	high	low
Habit	Anhedral	subhedral to anhedral	subhedral to anhedral	Anhedral
Cleavage	none	Poor	Perfect	Slight
Pleochroism	none	none	Reddish brown to brown	
Fracture				Fractured
Birefringence	1st order	1st order	1st order	1st order
Interference colour	grey to white	grey to white	dark brown to reddish brown	grey
Extinction	even to wavy extinction	47^0	straight	Oblique
Twinning	none	polysynthetic	none	Cross hatched

5.3.5 Granite gneiss

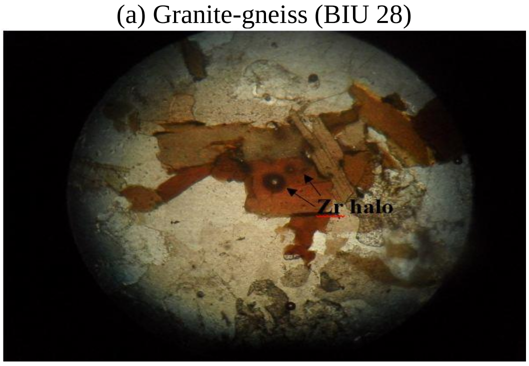
The plagioclase shows its polysynthetic twin property with low relief and interwoven into the other minerals. Colourless quartz with anhedral form which sometimes looks tabular were seen in the section. The quartz shows even extinction. The biotite seen exhibited its distinctive brown colour and 1-directional perfect cleavage. Zircon inclusions were also visible (Figure 14). The properties exhibited by the minerals are as shown in Table 5.

Table 5. Microscopic studies of Granite-gneiss (BIU 28)

	Quartz	Plagioclase	Biotite	Microcline
colour	colourless	colourless	brown	colourless to cloudy
relief	low	low	high	low
Habit	Anhedral	subhedral to anhedral	Euhedral	Anhedral
Cleavage	none	one directional	1-perfect	Slight
Pleochroism	none	none	brown to dark brown	
Birefringence	1st order	1st order	2nd order	1st order
Interference colour	grey to white	grey to white	brown to green	grey
Extinction	even	130	straight	Oblique
Twinning	none	polysynthetic	none	Cross hatched



(a) Granite-gneiss (BIU 28)



(b) Zircon inclusion in Granite-gneiss (BIU 28)

Figure 14. Granite-gneiss under Cross Polarized Light. (Mag. = x10). Mineralogy: Biotite, Plagioclase, Microcline, and Quartz

5.4 Economic geology of the quartzite and pegmatite

The Quartzite and pegmatite of the study area contains mainly quartz and feldspar. Quartz serves as a raw material in the production of abrasives, refractories, and in the making of glass. Feldspars are used in ceramics and in making of glass. They also serve as a source of alumina and as a partial replacement of soda ash. They are indispensable raw material used for the production of porcelain enamels, flux and filter in latex paints (when finely ground). They are employed in the manufacture of abrasive, cleaners, and polishes.

Ground feldspars are extensively used in scouring and cleaning, and as dusting agent for oil and slippery floors. Weathered or altered feldspar leads to formation of clay minerals like Kaolinite. Kaolinite is used widely in paint industry, pharmaceutical industry, textile industry for various industrial mineral applications. Silica sand and gravels are used for various building and construction purposes.

6. CONCLUSION

The systematic geologic mapping and petrographic studies of the Arikya Tsauni quartzite and pegmatite ridges has been carried out and the overall results have shown that the quartzite is composed exclusively of quartz; while the pegmatite contains only quartz and plagioclase feldspar. The composition of the pegmatite happens to be simple and non-mineralised; an indication that the pegmatites are barren. Nevertheless, detailed geochemical studies should also be carried out in order to get a broader understanding of the geologic and geochemical histories as well as mineralogical potentials of the area especially of the pegmatite.

Economically, various rocks in the area have very good potentials for engineering purposes. Although there are no mining records available, the occurrence of mineral deposits in the area cannot be ruled out completely. However, some economic resources have been identified in the study area, such as clay, alluvial sands, gravels, as well as the rocks that can serve as good construction materials.

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NOMENCLATURE

XPL	Cross polarised light
PPL	Plane polarised light
Qtz	quartz
PLF	Plagioclase feldspar
Mic	microcline
Bi	biotite
Hb	hornblende
Zr	zircon
Opm	Opaque mineral
BIU	Coded sample identity