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THE GEOLOGY AND GEOCHEMISTRY OF ANGWAN MALLAM AND ENVIRONS KEFFI

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ABSTRACT

The Geology and geochemical mapping of latitude N 08° 51', N 08° 45' and longitude E 007° 45',E 008° 00' of Nigeria North Central Part of Keffi Sheet 208 NE.
Thin section of the various rock types in the study area were carried out, with migmatite, granodiorite, pophyritic granodiorite, and biotite gneiss intruded by mineral bearing pegmatite dyke were Identified. Structures like fault, vein, joint and foliations were also observed during the field mapping and they trend NE - SW.
Geochemical analysis of the rocks using x-ray fluorescent techniques reveals the concentration of Potassium, Calcium, Titanium, Manganese, Iron, Copper, Nickel, Zinc, Arsenic, Robidium and Strontium.
The structural trend of the rocks conforms with the general pan-African Orogeny deformation and mining activities in some of the villages does not contaminate or pollute its water, soil and wellbeing of the people living in the Agwan mallam. This study reveal some major elemental composition of earth across Agwa mallam village and how they are respectively distributed, the deduced findings will be a benefit to Environmental Impact Assessment and further research is hereby recommended on the Hydrochemistry with special emphasis on water contamination due to leached ion from rock.

INTRODUCTION

The research area falls within the Basement complex of Central Nigeria precisely, the area is characterized by high land towards the north-west part with coordinate N 08° 49' 56.6" E 007° 55' 00.5'' with elevation of 266m while eastern part has elevation of 344m with coordinate; N 08° 47' 42.6" E 007° 52' 54.7''.

Relief of the study area is largely controlled by rock outcrop especially gneisses, granites, migmatites gnesisses and porphyroblactic biotite granite of late Pan-African orogeny (Obaje et al, 2005) the study area is rich in tourmaline therefore it is an area of interest to miners.

Concentration of the elements that posed environmental threats to the people of Agwan mallam and its environs were analysed, The diverse rock types in order of decreasing age was divide into three main groups: Basement Complex, Younger Granites and the Sedimentary Basins (Kogbe, 1989). Both the igneous and metamorphic rocks of the Basement Complex and the Younger Granites together occupy about 50% of Nigeria's surface while the sedimentary Basins occupy the remaining (Ogezi, 2002).

MATERIALS AND METHODS

The methods of study involves desk study, field work and laboratory analysis. The mapping was done with the aid of field equipment such as geological hammer, compass, measuring tape, Global Positioning System (GPS), masking tape and writing materials; Pasing and traversing were used in reaching outcrops through footpaths and reliefs.

During the field work, a total of twelve rock samples were collected. Five were selected for thin section and four for chemical analysis.

GEOLOGY OF THE STUDY AREA

The study area forms part of the Basement Complex of Nigeria (Wright 1970), precisely within the Migmatite-Gneiss Complex. This chapter reveals both the field descriptions and the petrographic studies of rocks via thin sections.

Migmatites: The migmatites outcrop in location with coordinates; N08^{0}45' 37.8"
E007^0 5. It has a fine grain texture characterized by a layered appearance caused by the segregation of mafic minerals from felsic minerals. The migmatites are found in southern parts of the study area occupying 5% of the study area.

Biotite Gneisses: The rock is medium grained in texture with discontinuous parallel light and dark mineral bands. The dark minerals comprise of biotite while the light band contains quartz, feldspars. The Biotite gneisses cover about 25% of the study area.

Granodiorites: Granodiorites occurred as a hilly outcrop especially in the north-eastern part of the study area. In hand specimen the rock is dark in colour, coarse-grained texture. Granodiorites occupied about 20% of the study area.

Porphyritic Granodiorites: These rocks occur as hilly outcrop mostly in northwest of the study area. The rocks show inclusions of hexagonal quartz crystals. The rock is gray in colour and coarse to medium grained texture. They occupy about 47% of the study area.

Pegmatites: Pegmatites in the study area occurred as dykes and veins (Ogezi 2002). The rock is very coarse grained in nature and are granitic in composition. This rock intruded into the biotite gneisses as dikes while in the porphyritic granodiorites as veins. Pegmatites in the study area are light colour with black crystals of tourmaline occurring within the rock. The pegmatites cover about 3% of the study area.

Petrographic description of rocks

Migmatite: The microscopic studies under plane polarized and cross polarized light (PPL and XPL) respectively reveal the major minerals which are quartz, orthoclase feldspar, plagioclase feldspar and biotite.

Quartz occur as anhedral, colourless crystals having a low relief in plane polarized light. It is whitish in cross polarized light and shows undulose extinction. Orthoclase feldspar occur as rectangular, colourless crystals having a low relief and cloudy in plane polarized light. It is grayish in cross polarized light and shows Carlsbad twining.

Plagioclase feldspar appear as prismatic colourless crystals having a low relief in plane polarize light. It is grayish in cross polarized light and shows polysynthetic twining.

Biotite occur as elongated and platy crystals having a moderate relief in plane polarize light. It is greenish PPL and pleochroic from pale green to dark green colour. It has a perfect cleavage and exhibits pleochroic hallos. It is greenish in XPL and has a straight extinction see Plate (3A and 3B) below.

A

B

Plate 1: Photomicrograph of migmatite of the study area under A(PPL) and B(XPL).

Table 1: Modal percentage composition of minerals in migmatite

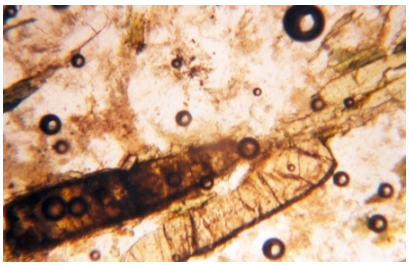
Minerals	Composition (%)
Quartz	30
Orthoclase (Feldspar)	20
Plagioclase (Albite)	40
Biotite	10

Biotite Gneiss: Microscopic observation of the slide under Plane Polarized Light and Cross Polarized Light (PPL and XPL) respectively reveals the major minerals present as quartz, plagioclase feldspar and biotite.

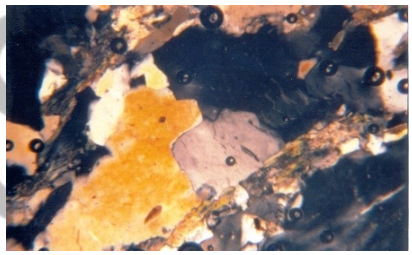
Quartz occur as colourless, anhedral crystals having a low relief in Plane Polarized Light (PPL). It is whitish in Cross Polarized Light (XPL) and shows undulose extinction.

Plagioclase feldspar appear as prismatic, colourless crystals having a low relief in Plane Polarized Light. It is grayish in Cross Polarized Light and shows polysynthetic twinning, with some crystal exhibiting zoning.

Biotite occur as elongated crystals having a moderate relief and perfect cleavage in plain polarized light (PPL). It is greenish in PPL but pleochroic from pale green to dark green. It is greenish in cross polarized light and has a parallel extinction (Plate A and B).



A



B

Plate 2: Photomicrograph of Biotite gneiss of the study Area under A in (PPL) and B (XPL).

Table 2: Modal percentage composition of minerals in Biotite gneiss

Mineral	Composition (%)
Quartz	50
Plagioclase (Albite)	30
Biotite	20

Granodiorite: General features when studied under plane polarized light and cross polarized light (PPL and XPL) respectively revealed minerals like quartz, microcline, plagioclase feldspar,

Biotite and orthoclase feldspar. Quartz occur as anhedral, colourless crystals having a low relief in plane polarized light and whitish in cross polarized light. It exhibits undulose extinction. Microline is present as tabular crystal having a low relief and colourless in PPL. It is grayish in XPL and shows cross – hatch twining.

Plagioclase feldspar was also observed, it occurs as prismatic crystals having a low relief in plane polarized light and colourless in plane polarized light. It is grayish in cross polarized light and shows polysynthetic twining.

Biotite occur as platy crystal having a moderate relief and a perfect cleavage in cross polarized light (XPL), also greenish under XPL and pleochroic from pale to green to dark green. It is dark green in CPL and has a parallel extinction. Orthoclase feldspar appear as tabular, colourless crystal that is cloudy in plane polarized light. It is grayish in cross polarized light and shows perthitic texture (Plate A and B).

A

B

Plate 3: Photo micrograph of granodiorite of study Area under A(PPL) and B (XPL)

Table 3: Modal percentage composition of minerals in granodiorite

Mineral	Composition (%)
Quartz	40
Microcline	10
Plagioclase (Albite)	25
Biotite	15
Orthoclase Feldspar	10

Pophyritic Granodiorite: The microscopic studies under plane polarized and cross polarized light (PPL and XPL) respectively reveals the major minerals which are quartz, plagioclase feldspar.

Quartz occur as anhedral colourless crystals having a low relief in plane polarized light (PPL), it is whitish in cross polarized light and shows undulose extinction. Plagioclase feldspar occur as prismatic, colourless crystals having a low relief in PPL. It is grayish in cross polarized light and shows polysynthetic twinning. Biotite appears as elongated crystals having a low relief in PPL and a perfect cleavage. It is greenish in cross polarized light but pleochroic from green to brown. It is greenish in cross polarized light and has a parallel extinction.

Orthoclase feldspar in the slide occur as tabular, colourless crystals having a low relief in PPL. It is grayish in cross polarized light and has an oblique extinction (see Plate A and B) below.

A

B

Plate 4: Photomicrograph of Porphyritic granodiorite of the Area A(PPL) and B(XPL)

Table 4: Modal percentage composition of minerals in porphyritic Granodiorite

Minerals	Composition (%)
Quartz	40
Plagioclase (Albite)	30
Biotite	10
Orthoclase (feldspar)	20

Pegmatite: Microscopic observation under plane polarized and cross polarized light (PPL and XPL) respectively. The major minerals are quartz, orthoclase, feldspar, muscovite and plagioclase feldspar.

Quartz occur as a tabular anhedral colourless crystals having a low relief in plane polarized light. It is whitish in cross polarized light and shows undulose extinction. Orthoclase feldspar is present as a tabular, colourless crystal having a low relief in plane polarized light. It is grayish and in cross polarized light and exhibit perthitic texture.

Muscotive occur as prismatic, elongated, colourless crystals having a moderate relief and a perfect cleavage. It shows a high interference colour in cross polarized light and has a parallel extinction. Plagioclase feldspar was also observed showing a prismatic, colourless crystals having a low relief in PPL. It is grayish in cross polarized light and shows polysynthetic twining (Plate A and B).

A

B

Plate 5: Photomicrograph of pegmatite of the study Area under
A (PPL) and B(XPL).

Table 5: Modal percentage composition of minerals in pegmatite

Minerals	Composition (%)
Quartz	40
Orthoclase (Feldspar)	25
Muscovite	20
Plagioclase (Albite)	15

SAMPLE PREPARATION AND METHOD OF ANALYSIS

The pre analysis involved washing and oven drying of the sample (Malik et al, 2006) breaking down of the rock samples to few centimeter to millimeter. And then splitted to few tens to hundred of grains. This small sample splitted was

then grounded and sieved to 75μm as the unit that is suitable for the method of analysis (CERD 2009) and the method adopted for the rock analysis was X-ray fluorescent method.

RESULTS AND DISCUSSION

Field Code: KLA I
Sample Location: Angwan Mallam
Name of Rock: Pegmatite
Global Position System (GPS) reading: N08^0 45' 52.3" E007^{0}21.6".

Table 6: The geochemical analysis of pegmatite.

Element	Conc. Value	Conc. Error	Unit
K	5.7609	± 0.0706	wt. %
Ca	7449	± 181	ppm
Ti	792	± 41	ppm
Mn	661	± 15	ppm
Fe	2.1280	± 0.0140	wt. %
Cu	708	± 24	ppm
Zn	1788	± 100	ppm
As	12	± 0	ppm
Rb	9	± 0	ppm

Field Code: KLA II
Sample Location: Kokona
Name of Rock: Pophyritic Granodiorite
Global Position System (GPS) reading: N08^0 97' 42.6" E007^0 54.7".

Table 7: The geochemical Analysis of porphyritic -Granodiorite.

Element	Conc. Value	Conc. Error	Unit
K	3.03765	± 0.04747	wt. %
Ca	3.3107	± 0.0332	wt. %
Ti	2552	± 85	ppm
Mn	453	± 9	ppm
Fe	2.9647	± 0.0095	wt. %
Ni	125	± 7	ppm
Cu	106	± 4	ppm
Zn	144	± 9	ppm
As	12	± 0	ppm

Field Code: KLA III
Sample Location: After Angwan Lambu
Name of Rock: Granodiorite
Global Position System (GPS) reading: N08^0 49' 56.6" E007^0 00.5".

Table 8: The geochemical Analysis of Granodiorite

Element	Conc. Value	Conc. Error	Unit
K	2.9432	± 0.0464	wt. %
Ca	3.5399	± 0.0342	wt. %
Ti	8418	± 106	ppm
Mn	3.81	± 8	ppm
Fe	3.6525	± 0.0105	wt. %
Ni	25	± 3	ppm
Cu	110	± 4	ppm
Zn	185	± 11	ppm

Field Code: KLA IV

Sample Location: Angwan Toni
Name of Rock: Biotite Gneiss
Global Position System (GPS) reading: N08^0 97' 42.6" E007^0 54.7".

Table 9: The geochemical Analysis of Biotite Gneiss

Element	Conc. Value	Conc. Error	Unit
K	2.4722	± 0.0426	wt. %
Ca	1.8123	± 0.0245	wt. %
Ti	4299	± 75	ppm
Mn	569	± 10	ppm
Fe	4.2973	± 0.0123	wt. %
Ni	143	± 9	ppm
Cu	112	± 5	ppm
Zn	230	± 15	ppm
Rb	42	± 0	ppm
Sr	1445	± 69	ppm

Discussion

Potassium is a highly reactive electropositive metal and it is difficult to obtain from its minerals, it is highly concentrated in pegmatite of the study area probably due to plagioclase feldspar found in it. Potassium is found in all the rock samples ranging from $2.47x10^{-4}$ ppm to $5.76x10^{-4}$ ppm and have an average of $3.55x10^{-4}$ ppm in the study area (Fig 1). Calcium is mostly present in plagioclase (Dufer et al, 1964) and it is also found in high proportion in pegmatite (KLA1) of the study area, also it occurs largely in pophyritic granodiorite (KLA2) and biotite gneiss (KLA4) but are below detectable limit in granodiorite of the area (Fig 2).

Titanium is a transition metal that occurs within a number of mineral deposits principally in granodiorite (KLA3) and biotite gneiss (KLA4) of the area study, less concentrated in pegmatite (KLA1) and pophyritic granodiorite (KLA2) and generally has an average of 4015.25ppm in the study area (Fig 3).

Manganese occurs as a trace element and can oxidize easily. They are mostly found in pegmatite (KLA1), manganese are found above average (421.70ppm) in porphyritic granodiorite and biotite gneiss but are below detectable limit in granodiorite (Fig 4).

Concentration of iron is highly found in Biotite Gneiss (KLA4) and granodiorite (KLA3) of the study area while they are found below average in pegmatite (KLA1) and porphyritic granodiorite (KLA2), iron has a strong affinity for oxygen and have an average of $3.26x10^{-4}$ ppm in the study area see (Fig 5).

Copper is one of the transition elements largely found in pegmatite (KLA1). It is highly found in pegmatite of the study area, it has an average of 259.5ppm, porphyritic granodiorite (KLA2), granodiorite (KLA3) and biotite gneiss (KLA4) are found below average in the study area (see Fig 6), the mobility of manganese and copper are largely controlled by pH of the underground water (Offodile et al 2002).

Zinc are generally associated with fissure veins and large larva flow highly concentrated pegmatite (KLA1) of the study area with an average of 586.75ppm Zinc can produce a barren area as result of toxicity to vegetation (Levinson 1980). While others are far below average (Fig 7).

Arsenic in the study area is mostly found in pophyritic granodiorit (KLA2) and pegmatite (KLA1), having an average of 6ppm, arsenic is below a detectable limit in granodiorite and gneiss of the study area (Fig 8) Arsenic can cause cyclotoxic effects on human and animal cells (EHP 1994).

Robidium occurs as a trace element and it is highly concentrated in biotitegneiss (KLA4) and pegmatite (KLA1), others are below detectable limit of the study area, concentration of rubidium ranges from 42ppm to 99ppm with an average of 12.75ppm (Fig 9).

Nickel make up about 0.08% of the earth crust, it is magnetic at room temperature and often occur in combination with Sulfur, high concentration of Nickel are found in pegmatite(KLA1) and biotite gneiss(KLA4), little in granodiorite (KLA3) and below detectable limit in porphyritic, it has an average of 73.25ppm in the study area (Fig 10).

Strontium highly concentrated in Biotite gneiss (KLA4) while other rock samples are below a detectable limit having a general average of 361.25ppm in the study area (Fig 11).

CHARTS FOR THE ROCK ANALYSIS

Potassium (wt.%)

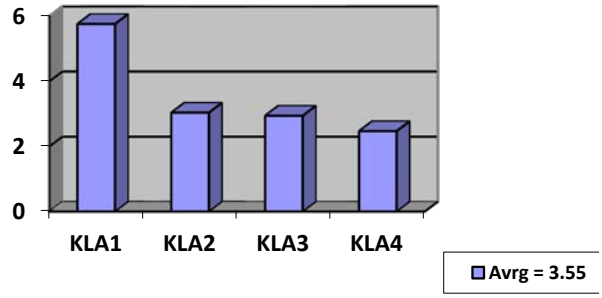


Fig 1: A graph showing concentration of Potassium on rocks sample of the Area

Calcium (wt.%)

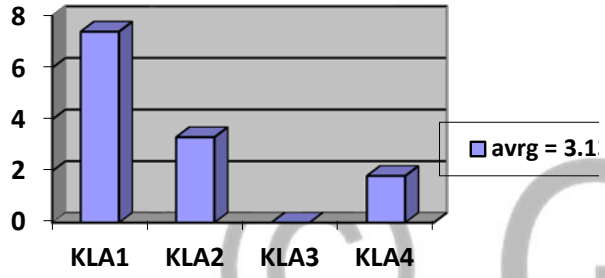


Fig 2: A graph showing concentration of Calcium on rocks of the Study Area

Titanium (ppm)

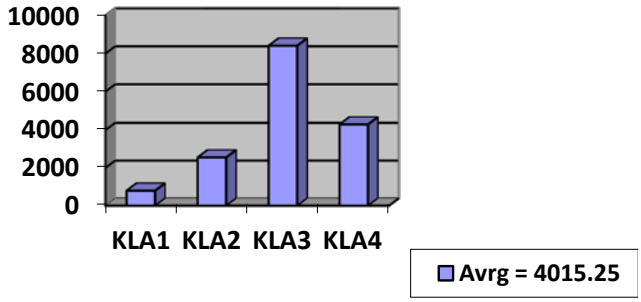


Fig 3: A graph showing a concentration of Titanium on rocks of the study Area.

Manganese (ppm)

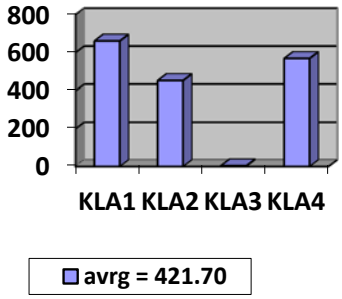


Fig 4: A graph showing concentration of Manganese in rocks of the study showing Area

Iron (wt.%)

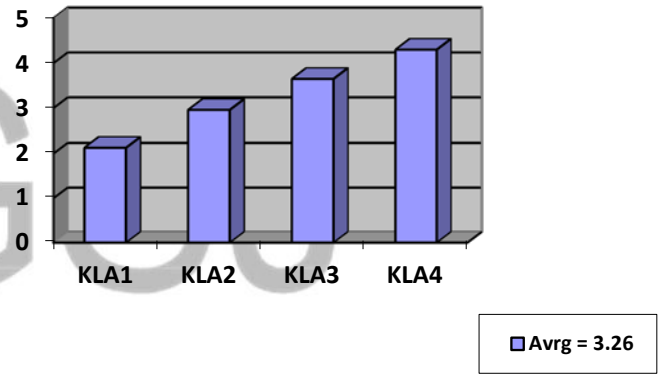


Fig 5: A graph showing concentration of iron in rocks of the study Area

Copper (ppm)

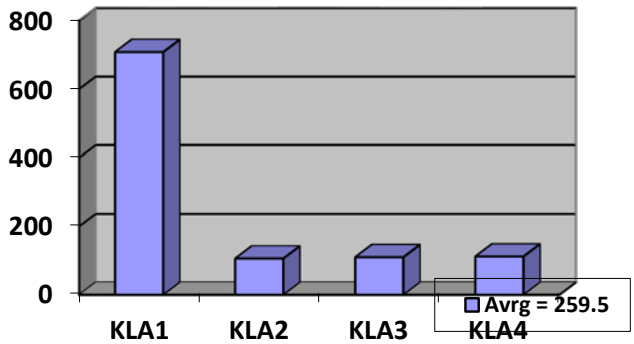


Fig 6: A graph showing concentration of copper in rocks of the study Area

Zinc (ppm)

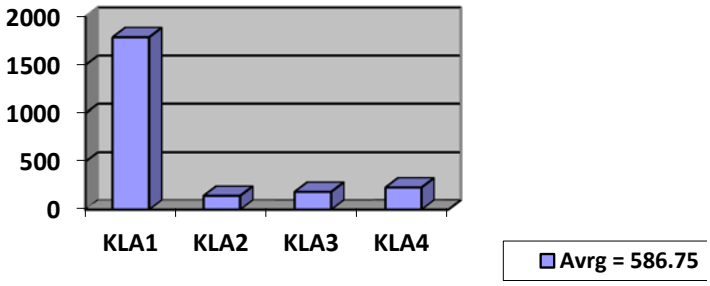


Fig 7: A graph showing concentration of zinc in rock of the study Area

Arsenic (ppm)

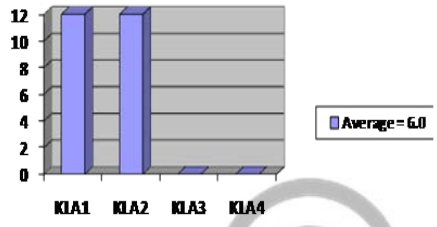


Fig 8: A graph showing a concentration of arsenic in rock of the study area

Robidium (ppm)

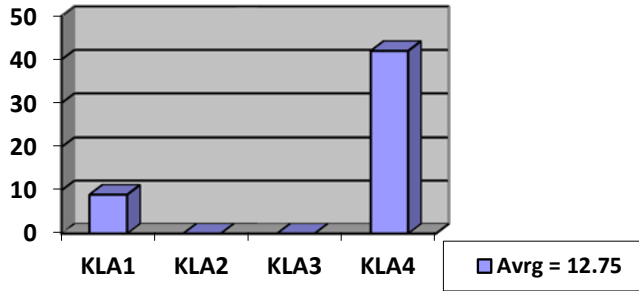


Fig 9: A graph showing concentration of robidium in rock of the study area

Nickel (ppm)

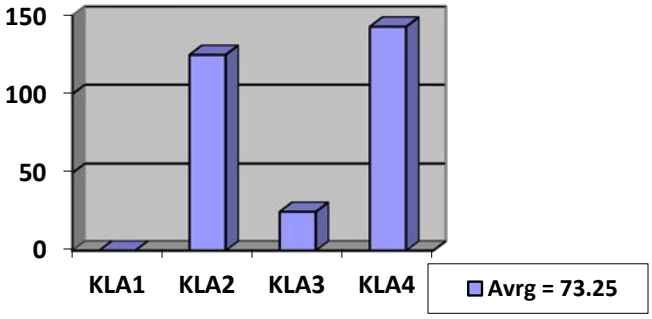


Fig10: A graph showing concentration of nickel in rock of the study area

Strontium (ppm)

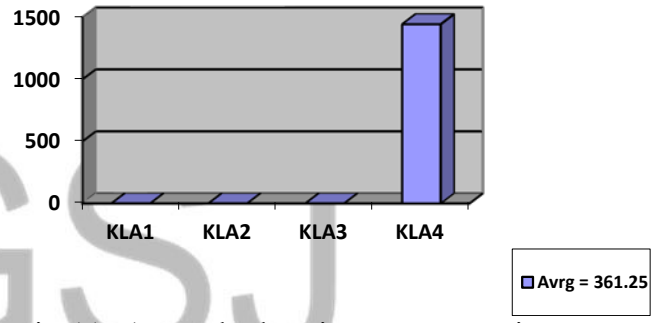


Fig 11: A graph showing concentration of strontium in rock of the study area

CONCLUSIONS

The major rock units of the area is porphyritic granodiorite, petrographic studies show that the rocks are made up of quartz, plagioclase feldspar, biotite and orthoclase feldspar with a structural trend of NE-SW which is in conformity with the general structural deformation of Pan-African Orogeny. Geochemical analysis on those rocks reveals various elemental constituents that are valuable and those that are toxic to human health.

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