Geochemical And Mineralogical Composition Of Granitic Rock Deposits Of Michika Area NE Nigeria.

Gabriel Ike Obiefuna, Peter Hassan Sini, Abubakar Maunde

ABSTRACT: The aim of this study is to determine the geochemical and mineralogical composition of granitic rock deposit of Michika area of northeastern Nigeria. Detailed geological mapping of an area of 188.5 Km2 around Michika area has been mapped on a scale of 1: 50,000. The mapping revealed that the area is underlain by granitic rocks of Pan African Age. These are grouped into three types: coarse grained biotite granites, coarse porphyritic granites and medium grained granites which are intruded by the new basaltic rocks of Tertiary Age. A plot of Rose Diagrams indicate they trend in the NE-SW and NW-SE directions and occurs as irregular or massive bodies, veins and sometimes as a cross-cutting discordant dykes. The fracture ranges from about 5 cm to about 2 meters. Seven samples were collected at different locations representing the three types for petrographic analyses. Petrographic studies show that the samples are essentially composed of quartz, feldspar, mica and iron oxide. Twenty samples were analyzed geochemically using XRF method to determine some major oxides which include SiO2, Al2O3, K2O, Fe2O3 and CaO. The SiO2 content are mainly (70.58%), Al2O3 (14.30%), K2O (5.44%), Fe2O3 (2.73%) and CaO (2.62%) were obtained for the samples. The results indicate that granitic bodies of the Older Granites that underlie the study area are strongly peraluminous calcalkaline igneous series that are of both lithospheric origin or are associated with subduction related areas.

Keywords: Granites, geological mapping, Rose diagrams, Michika area, Northeastern Nigeria

1 INTRODUCTION

Granitic rocks are light-colored igneous rocks with grains large enough to be visible with the unaided eyes. They form from the slow crystallization of magma below earth's surface and composed mainly of quartz and feldspar with minor amounts of mica, amphiboles and other minerals. Granites has a felsic composition and is more common in recent geologic time in contrast to earth's ultramafic ancient igneous history. Felsic rocks are less dense than mafic and ultramafic rocks, and thus they tend to escape subduction whereas basaltic or gabbroic rocks tend to sink into the mantle beneath the granitic rocks of the continental cratons. Therefore, granitic rocks form from the basement of all land continents. In Nigeria, granites are associated with the Pan-African Older Granitic rock suite of the Precambrian Basement Complex rocks. The Older Granites are widespread throughout the Basement Complex and occur as large circular masses within the schist and the Older Migmatite-Gneiss Complex. They are of enormous variety and vary extensively in composition. This type of granites found in Michika area has not been clearly established in terms of its mineral assemblages and geochemistry. This study intends to classify the granite deposits as exposed in this area on the basis of its chemical and mineralogical composition.

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The geochemical study includes field observation of the collected samples as well as its mineralogical composition under cross and plane polarized light. From these, granitic rock deposits of the study area will be classified in relation to its mode of origin and occurrence. Previous works in the study area is rather regional in extent [4], [3] and [8]. They did not give information on the chemical, mineralogical composition as well as origin of the underlying granitic rocks. These studies which discussed the geography, geology and groundwater quality of the old northern Nigeria were only speculative of the geology and geochemistry of the study area. A few numbers of literatures are available elsewhere regarding the geology and geochemistry of common igneous [6], [10], [7] and [9] This study is targeted at conducting geological mapping of the study area with a view of identifying and classifying different rock types as well as the field, compositional and textural relationship among the granitic rocks of the study area. It also involves petrographic examination and geochemical analyses of selected rock samples.

2 STUDY AREA

The area falls within the Basement Complex of the Northeastern Nigeria and covers an aerial extent of about 188.5km2. It lies within latitudes 100 32'N to 100 14'N and longitudes 130 19' E to 130 25'E. It is bounded to the east by Republic of Cameroon, to the south by Mubi Local Government Area of Adamawa State. To the West by Askira Uba Local Government Area of Borno State and to the North by Madagali Local Government Area respectively. The area is traversed by one major highway that runs from Yola to Maiduguri. Other minor roads are Michika – Yammu/ Warakanza, Michika- Kopa- kwapale/Villegwa and Michika-Moda/ Mandara roads. These roads link the villages and provide access routes to hilly areas. The study area is hilly to the eastern part and relatively flat to the west. Despite the hilly nature of some parts of the study area, there are still good road networks, foot-paths and tracks that made it accessible (Figure 1). The study area which falls within the semi-arid climatic zone of Nigeria in Sub-Saharan Africa is characterized by two distinct seasons; a hot dry season lasting from October to April and a cool rainy season lasting from April to October. These seasonal climatic conditions are caused by the north-south fluctuations of a zone of discontinuity between the dry continental air mass and the humid maritime Atlantic air mass [5]. At the surface it forms a boundary called a surface of discontinuity which lies further south during dry season. Thus showing a south-ward movement of winds and pressures from the high pressure zones of the Sahara. Then, during the rainy season the zone of discontinuity moves northwards. The Saharan air causes the dry season which is accompanied by low relative humidity and intense aridity that makes the atmosphere very dusty. Temperature goes low during the harmattan sub-season and the rainy season follows the advancing Atlantic Maritime Air which is companied by high humidity and intense rains and high vapour pressure. Peak rainfall occurs during the months of August to September. There is characteristic "August break" lasting about 2 weeks in which the rains more or less cease. This occurs during the months of August but may extend to early September. The area is covered by a mantle of gravels, coarse sands, loamy and clayey soils with the grain-size of the soil decreasing with increasing distance from the hills.

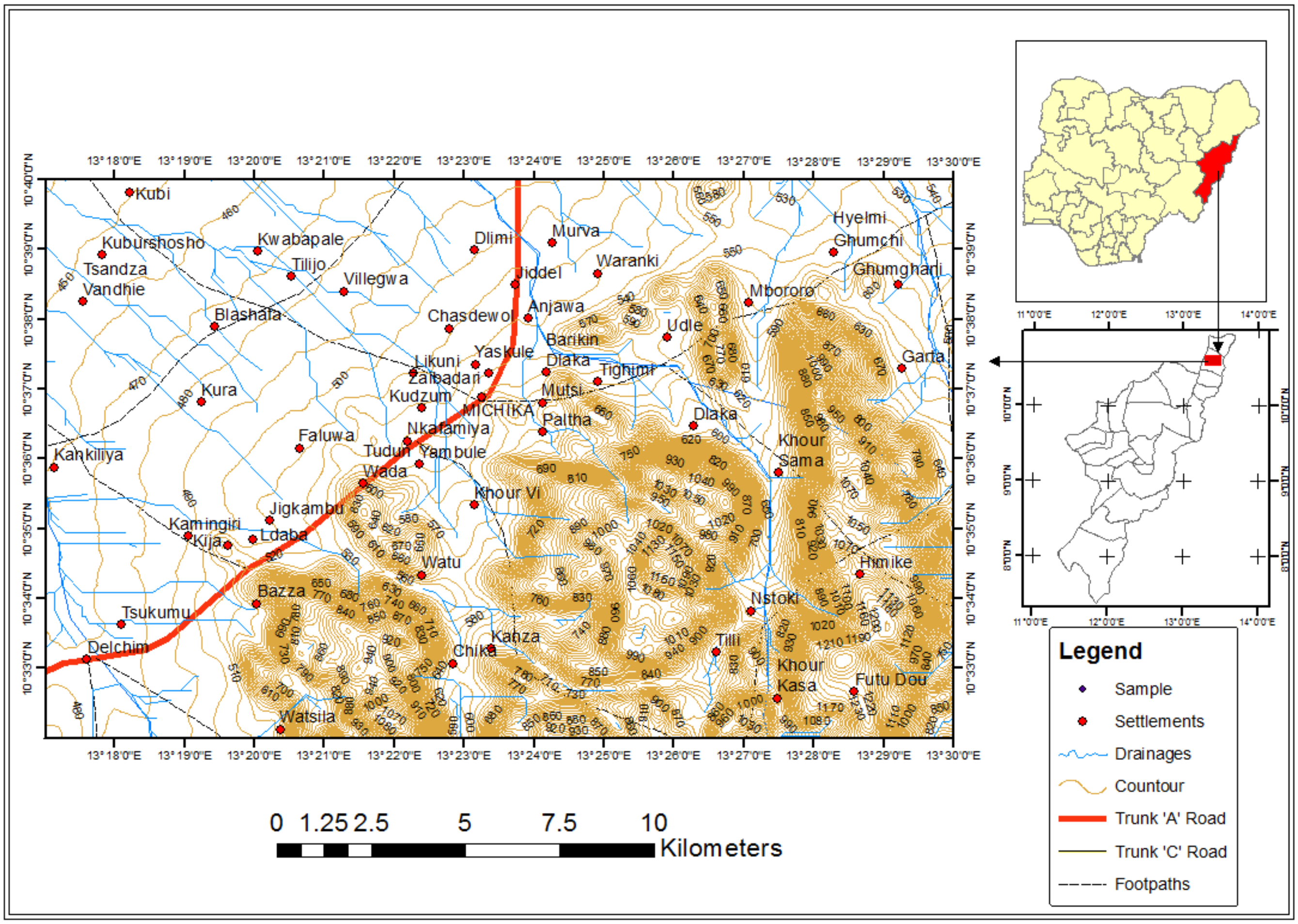


Fig 1: *Topographic map of Michika and its Environs.*

3 GEOLOGY OF THE STUDY AREA.

The study area is part of the Hawal Massif which is one of the three Massifs that occur within the eastern province of the Basement Complex of Northeastern Nigeria. The major rock type in this area includes the New Basalt, Coarse grained Biotite Granites, Coarse Porphyritic Granites and Medium Grained Granites (Fig 2). These rocks which has been subjected to tectonism leading to fracturing such as joints, faults, dykes and veins were intruded by the New Basaltic rocks. The rock body which intrude into the granite mostly trend in the NE/SW and NW/SE directions and occurs as irregular or massive bodies, veins and sometimes as a cross-cutting discordant dykes [7]. The dykes ranges from about 5 cm to about 2 meters. Hand specimen examination of fresh granites reveals interlocking crystals of feldspar, quartz and micas. They have undergone complete weathering, decomposition and lateritization leading to about 6 meters to 20 meters of unconsolidated weathered overburden layer consisting of gravels, clays, laterites and sands.

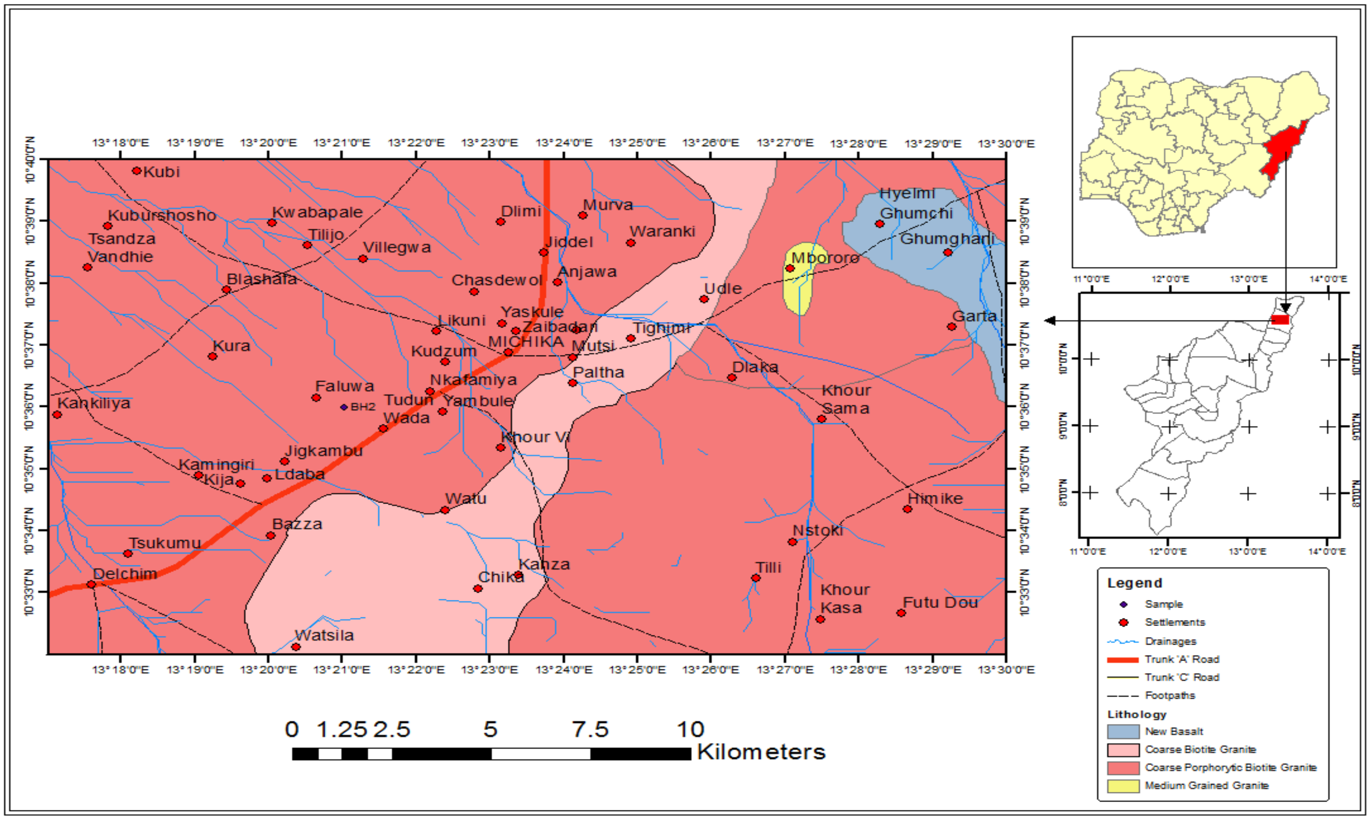


Fig 2: *Geological Map of Michika and Its Environs.*

4 MATERIALS AND METHODS

Reconnaissance field trips were made during which topographic and geologic maps were employed in the identification of the rock formations as well as their structural and stratigraphic relationships. Geological field mapping was undertaken in order to collect, identify and study the field occurrences and structural relationship of all the rock types present in the study area. Fresh and unweathered rock samples were broken for hand specimen examination. Preliminary observation and identification of each constituent mineral were carried out using magnifying lens. Other structural imprints like joints trends, dimensions of xenoliths, veins dykes were also recorded, Sources and causes of groundwater pollution were located and plotted on a map. This was followed by detailed surface and subsurface geologic studies during which geological boundaries were demarcated and hydraulic parameters measured. An inventory of wells in the area were performed which included location with Global Positioning System (GPS) and documentation of each well site, including land-use, soil type, geology, For the petrographic studies, seven 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 [7]. The prepared slides were examined under the petrological microscope to identify mineralogical features that were not heatherto seen with unaided eyes in the rock samples. Geochemical tests of 20 granitic rock samples were carried out at Ashaka Cement Ashaka Gombe State, Nigeria to determine relevant elemental oxide composition. X-Ray Florescence equipment was used to analyze ionic oxides in the granitic rock samples at the Ashaka Cement, Ashaka, Gombe State.

5 DISCUSSION OF RESULTS

Granitic dykes are observed at Michika, Tudun Wada, Garta, and Kamale areas respectively. The dykes in the outcrop are not affected by weathering of the country rock in which they occur. They can be pronounced in the field because they weather differently from the rock they penetrate. The dykes are found mainly in the northeastern part of the study area and trends mainly in the NE-SW direction. They range from 1 m to 1.6 m in thickness. The quartzofeldspatic veins observed are found in the southern part of the study around Watsila, Kaoza and Chika and are more felsic than the host rock. These are due to the presence of quartz and feldspar which makes them lighter coloured. They trend mostly in NE-SW and NW-SE direction (Table 1 and Figures 3 to 6). The dykes and veins run through some of the major rocks found around the study area and mark the last phase of intrusive activities.They run through some of the major rocks found around the study area [1]. Some parts of the study area are observed to be highly faulted and while some faults are inherited from offloading by erosion causing some minor fractures, others resulted from stresses acting on the study area. They trend mostly in NE-SW and NW-SE direction (Table 1 and Figure 3 to 6). Joints were observed and recorded in most parts of the study area. The Joints are small-scaled parting in a bulk surface of a material which are irregular in shape. They are formed when water has been deposited in the rock, evaporated leaving the rock to dry. When the rock dries, there is a contraction at the middle, which results from the cohesive forces acting on the grains and crack occurs. They trend mostly in NE-SW and NW-SE direction with minor E-W direction (Table 1 and Figures 3 to 6).

***TABLE 1:** ORIENTATION OF LINEAMENTS IN THE STUDY AREA*

Location	*Strike (General Trend)*
Michika	*40,74,64,25,160,90,197,210,80,225 237,45,70,82,20155,220,230,74,50*
Tudun Wada	*50,78,70,30,170,98,190,230,85,220 240,47,76,87,205,60,210,228,76,48*
Garta	*60,64,74,42,190,70,210,86,30,36 94,187,152,60,220,240,70,47,54,88*
Kamale	*123,50,42,66,180,90,234,90,33,38 90,192,154,60,210,232,80,40,30,52*

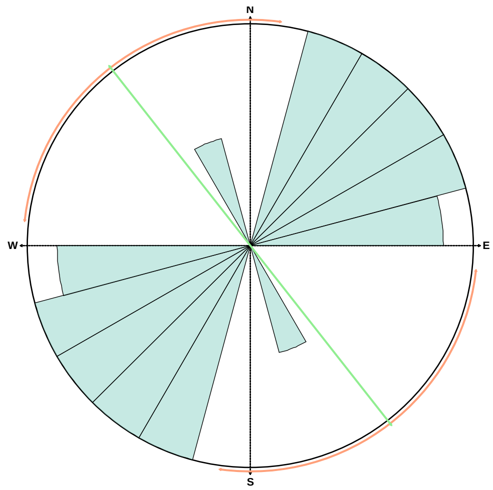
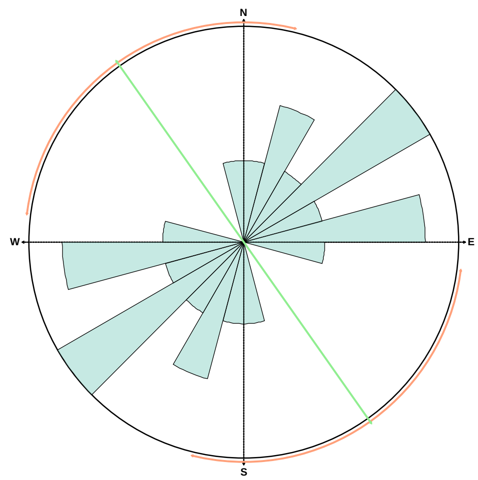


***Fig 3:** Rose Diagram of Lineaments in Granitic Rocks of Michika Area. Total Number of Points = 20*

***Fig 4:** Rose Diagram of Lineaments in Granitic Rocks of Tudun Wada. Area Total Number of Points = 20*



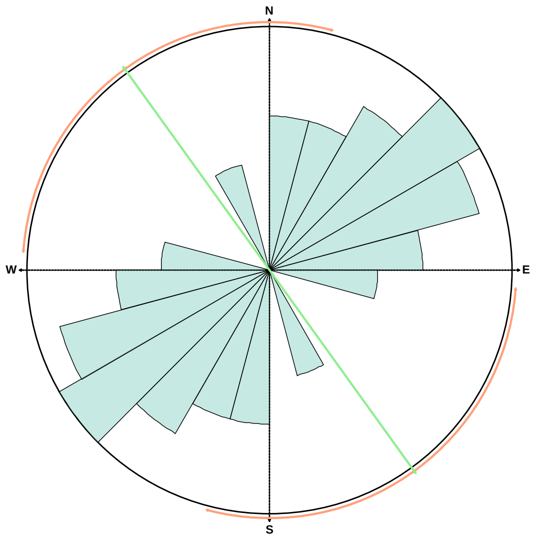


Fig 5: *Rose Diagram of Lineaments in Granitic Rocks of Garta Area. Total Number of Points = 20*

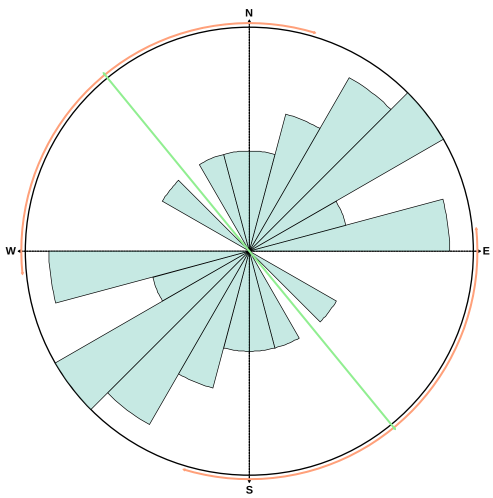


Fig 6: *Rose Diagram of Lineaments in Granitic Rocks of Kamale Area. Total Number of Points of Points = 20*

From the study of seven rock samples under both plane polarized and cross polarized lights the following minerals were observed: quartz, feldspar, mica and accessory minerals. Quartz is generally anhedral in crystal form, has weak birefringence and shows grey to white first order interference colours. It has low relief, shows parallel as well as undulose extinction and is colourless under plane polarized light. Feldspar is colourless under plane polarized light, sub-hederal in crystal form and shows low relief and weak birefringence. It is also non-pleochroic and shows grey to white first order interference, parallel extinction and Carlsbad twinning. Mica is pale yellowish brown to colourless under plane polarized light, anhedral in crystal form and show moderate relief and moderate birefringence. It is very weakly pleochroic, shows purple to red interference colours and cleaves in one direction. Iron oxide is opaque under plane polarized light, anhederal in crystal form, of high relief and non-pleochroic. Tables 2a, b is a summary of the mineralogical composition and percentages. Petrographic studies show that silica in the form of quartz and iron oxides are the predominant cementing materials for the igneous rocks. Though the occurrence of clays in some samples could have originated from the weathering of the feldspars. The grain-sizes of granitic igneous rocks range from 2.2mm to 0.43mm indicating fine to coarse grained igneous rocks whereas the mineralogical composition consist essentially of 53% to 69 % quartz, 22% to 33 % feldspar and 0.3% to 3.0 % iron oxide (Plates 1 to 3). The grain-sizes of basaltic igneous rocks range from 1,12 mm to 1.15 mm indicating fine grained rocks whereas the mineralogical composition consist essentially of 20.9 % to 29.5% plagioclase, 27.5% to 31% Olivine, 31% to 35.1% pyroxene and 11.5% to 16.5% iron oxide. Microscopic examination of the granitic rock samples in cross polarized light revealed the presence of varying composition of constituent minerals such as feldspar, quartz, muscovite and opaque minerals (iron oxide). Plagioclase feldspar is the most abundant mineral in granitic igneous rocks, its cleavages are noticeable, and its thin, bright and parallel lamella of polysynthetic twinning conform to the albite law [7]. Plagioclase feldspar possess randomly oriented euhedral crystals whereas quartz shows an irregular, subhedral body, greyish to whitish colouration and occupies the interstitial space of plagioclase feldspar. Muscovite displays a brownish green to pinkish blue colouration whereas plagioclase feldspar appear cloudy probably due to the alteration processes in them. Microscopic examination of basaltic igneous rocks collected from Hyelimi, Ghumghar and Ghumchi area reveal fine grained massive basalt with phenocrysts of olivine set in a groundmass of pyroxene, plagioclase and iron oxide (Table 2). Plagioclase is colourless under plane polarized light and non pleochroic and cleave in two directions with very low relief and weak birefringence. Interference colour is grey to white of first order and extinction is oblique and exhibit albite twinning. Pyroxene is light under polarized light and non pleochroic with perfect cleavage in two directions. It exhibit prismatic structure with very high relief and strong birefringence. Interference colour is greenish to dark green under cross polarized light and displays symmetric extinction with polysynthetic twinning. Olivine is colourless under plane polarized light, non pleochroic with no cleavage. It is anhederal to subhedral and has low to moderate relief and birefringence with first order interference colour. It has parallel extinction with no twinning. Iron oxide is opaque, non pleochroic with no cleavage. It is anhederal with high relief and no birefringence and non-twinning.

5.1 Geochemistry

The average weight percentage for major oxides such as SiO2, Al2O3, TiO2 Fe2O3, MnO, MgO, CaO, Na2O, K2O were obtained using the X-ray Fluorescence Spectrometry technique. The results of the geochemical analyses are presented in Tables 3 and 4. The geochemical data show minor variation as far as individual oxides are concerned with SiO2 ranging from 61.5 to 78.26%; TiO2 ranging from 0.13 to 1.12%; Al2O3 ranging from 11.47 to 18.96%; Fe2O3 ranging from 1.05 to 7.07%; Mn2O ranging from 0.04 to 0.10%; MgO ranging from 0.07 to 2.59%; CaO ranging from 0.70 to 3.31%; Na2O ranging from 0.85 to 1.55%; K2O ranging from 3.83 to 7.22%; P2O5 ranging from 0.00 to 0.28% and Loi ranging from 0.05 to 2.49% respectively.

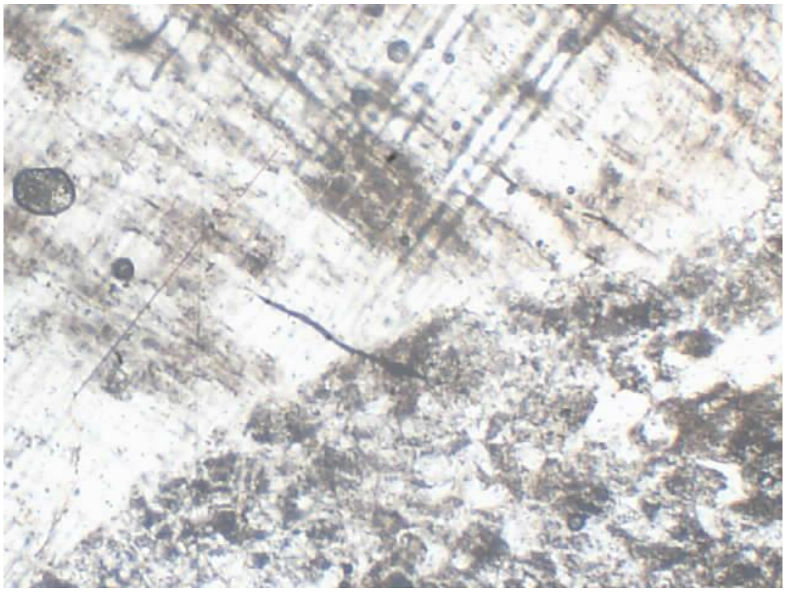


Plate 1: *Photomicrograph Showing Medium Grained Granite Under Plain Polarized Light (Magnification x 100)*

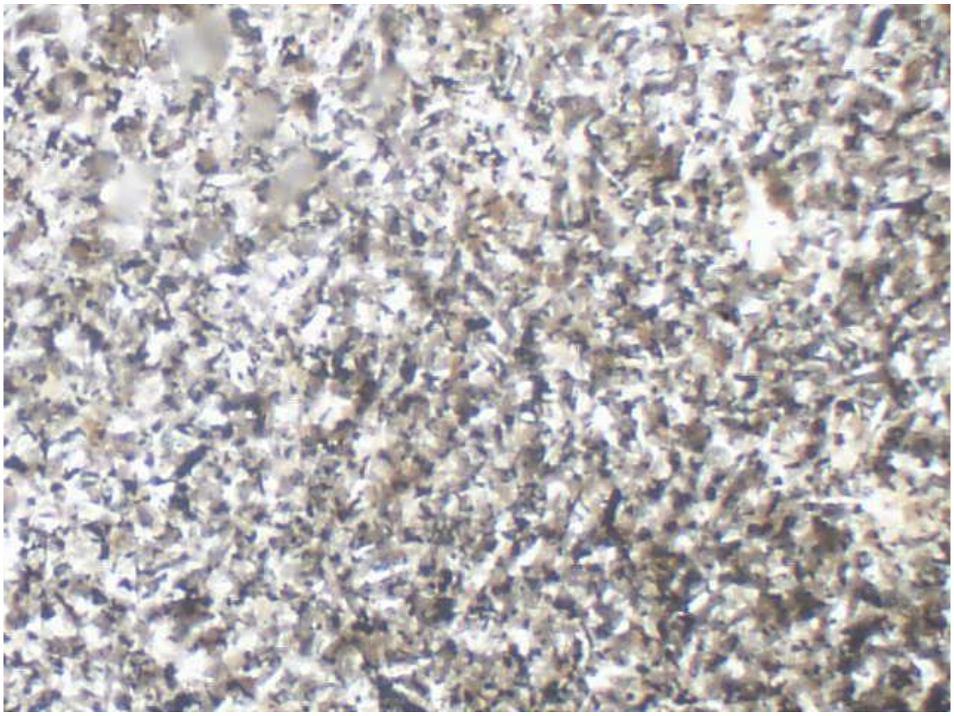


Plate 2: *Photomicrograph Showing Coarse Grained Biotite Granite Under Cross Polarized Light (Magnification x100)*

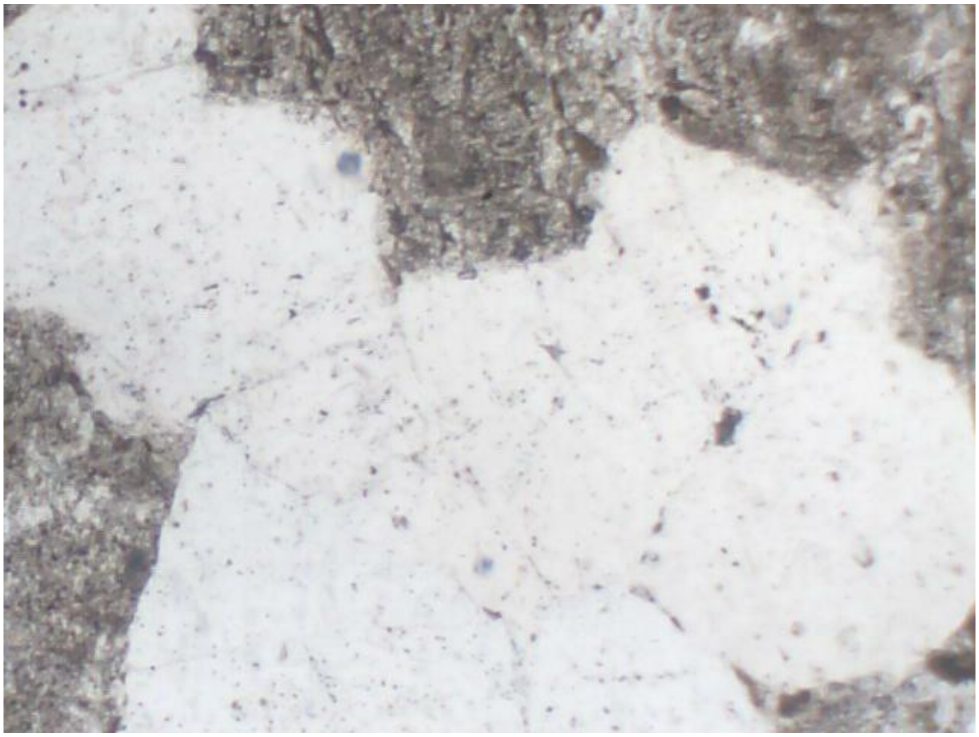


Plate 3: *Photomicrograph Showing Coarse Porphyritic Granite Under Plain Polarized Light (Magnification x 100)*

TABLE 2: *SUMMARY OF MINERALOGICAL COMPOSITION OF IGNEOUS ROCKS*

S/No	Location	Sample Number	Mineral under plane polars	Mineral under cross polars	Mineral percentage
1	Michika Central	A	-	Quartz Feldspar Mica Iron oxide	52.5 21.5 25.6 0.4
2	Kwatabe	B		Quartz Feldspar Mica Iron oxide	54.5 32.5 9.0 3.0
3	Hyelimi	C	Olivine Pyroxene Iron oxide	Plagioclase Olivine Pyroxene Iron oxide	20.9 27.5 35.1 16.5
4	Garta	D	Muscovite	Quartz Feldspar Mica Iron oxide	62.0 25.7 12 0.3
5	Ghumghar	E	Olivine Pyroxene Iron oxide	Plagioclase Olivine Pyroxene Iron oxide	29.5 28 31 11.5
6	Ghumchi	F	Olivine Pyroxene Iron oxide	Plagioclase Olivine Pyroxene Iron oxide	21.5 31 31.5 16
7	Dlaka	G		Quartz Feldspar Mica Iron oxide	64.0 23.4 12.0 0.6

Igneous rocks are classified into four based on their silica (SiO_2) content. The alkalis Na_2O and K_2O have an average values of 1.14% and 5.44% respectively whereas CaO has an average value of 2.62%. Furthermore Na_2O, K_2O and CaO have a total value of 9.20% which is less than the average alumina content of the rocks (14.30%). This indicate that the granitic rocks of the study area is peraluminous and acidic (see Tables 3, 4 and 5). In addition, the iron and magnesium oxides (Fe_2O_3 and MgO) are very low in all the analyzed samples. The average values of Fe_2O_3 (2.73%) and MgO (0.81%) as well as low values of MnO (0.06%) clearly indicate acidic granites (Table 6). Furthermore the relatively high concentration of silica (70.58%) and alumina (14.30%) suggest that the granites of the study area are of lithospheric origin. The Ritman Serial Index $б = (Na_2O+K_2O)^2 /(SiO_2-43)$ units in weight percent according to [11] is used as a convenient petrochemical parameter to discriminate igneous rock series on the basis of alkalinity: calcic ($б < 1.2$), calcalkaline (б between 1.2-3.5), alkaline (б between 3.5 and 8.8) and peralkaline series ($б > 8.8$). Thus based on the Ritman serial index б the granitic rocks of the study area falls within the calcalkaline igneous series which is associated with the subduction related areas. [2] Introduced a classification scheme after extensive work in the Lachlan fold belt of Eastern Australia. They identified two granitoid groups namely the I-type which is metallaminous to weakly peraluminous, relatively sodic with a wide range of silica content (56-77 wt% SiO_2) and the S-type which is strongly peraluminous relatively potassic and restricted to higher silica content (64-77 wt% SiO_2). The granites of the study area with silica values ranging from 61.05 to 78.26% and potassium values ranging from 3.83 to 7.22% falls within the S-type of igneous rock series suggesting metasediment and metaigneous source.

TABLE 3: *RESULTS OF OXIDE ANALYSIS OF ROCK SAMPLES FROM THE STUDY AREA*

S/no	location	Sample Number	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	K2O	Na2O	P2O5	MnO	TiO2	Cr2O3	SrO	LOI
1	Michika Central	St1	69.006	16.395	2.200	3.294	0.816	0.015	5.477	1.282	0.119	0.049	0.384	0.001	0.079	0.61
2	Dlaka	St2	61.053	16.745	7.065	2.192	2.592	0.016	6.905	1.000	0.283	0.102	1.122	0.009	0.031	0.48
3	Futu	St3	74.036	13.534	1.047	3.584	0.401	0.038	5.835	1.037	0.040	0.074	0.152	0.002	0.018	2.51
4	Warakanza	St4	68.507	14.179	3.495	1.724	1.469	-0.005	6.151	1.049	0.051	0.066	0.521	0.003	0.024	0.42
5	Whate	St5	75.190	11.467	2.052	0.698	0.240	-0.008	5.285	1.195	0.004	0.045	0.155	-0.006	-0.002	0.87
6	Kamale	St6	72.813	14.187	1.782	1.880	0.725	-0.008	4.392	1.151	0.055	0.050	0.265	0.001	0.045	0.49
7	Garta	St7	72.855	13.990	1.871	1.904	0.708	0.004	4.659	1.120	0.062	0.043	0.221	-0.003	0.049	0.60
8	Himikai	St8	70.489	13.226	2.747	2.400	0.670	0.009	5.519	1.013	0.115	0.050	0.384	0.001	0.019	0.92
9	Zah	St9	69.110	14.981	2.477	2.149	0.807	0.001	5.394	1.179	0.102	0.050	0.370	0.002	0.059	0.31
10	Greate	St10	69.393	13.726	3.084	1.819	0.487	-0.002	7.224	0.882	0.066	0.051	0.356	0.002	0.012	0.78
11	Biza	St11	72.189	14.260	1.668	2.237	0.617	0.019	5.624	1.138	0.066	0.036	0.226	-0.003	0.034	0.71
12	Betso	St12	69.564	14.771	2.152	2.371	0.957	0.000	3.869	1.295	0.079	0.051	0.253	0.006	0.072	0.32
13	Vi	St13	63.061	18.961	4.095	3.810	1.435	0.069	4.550	1.533	0.227	0.096	0.570	-0.002	0.054	0.68
14	Bokka	St14	68.559	14.314	3.561	1.524	1.471	0.006	6.078	1.077	0.051	0.064	0.526	-0.003	0.026	0.61
15	Yamue	St15	69.722	15.023	4.264	2.285	0.594	0.037	7.207	0.845	0.182	0.081	0.545	0.001	0.001	0.74
16	Moda	St16	70.749	13.600	2.755	2.586	0.073	0.037	5.503	1.027	0.119	0.054	0.394	-0.004	0.017	0.05
17	Mikisi	St17	75.107	11.554	2.052	0.730	0.275	0.003	5.246	1.230	0.003	0.043	0.146	-0.005	0.000	0.86
18	Barazuwe	St18	78.264	12.105	2.103	0.695	0.231	0.000	5.311	1.203	0.003	0.044	0.131	-0.005	-0.001	2.49
19	Zah	St19	72.647	14.148	1.895	2.058	0.725	0.008	4.744	1.153	0.069	0.046	0.215	0.000	0.048	0.53
20	Tanghi	St20	69.277	14.909	2.161	2.396	0.950	0.006	3.828	1.315	0.077	0.053	0.253	-0.001	0.071	0.75

TABLE 4: *GEOMETRIC MEANS OF THE MAJOR ELEMENTAL OXIDES IN THE STUDY AREA.*

Major Elemental Oxides	Range (Wt. %)	Average (wt %)
SiO2	61.05 -78.26	70.58
TiO2	0.13 – 1.12	0.36
Al2O3	11.47 -18.96	14.30
Fe2O3	1.05 -7.07	2.73
MnO	0.04 -0.10	0.06
MgO	0.07 -2.59	0.81
CaO	0.70 -3.81	2.62
Na2O	0.85-1.53	1.14
K2O	3.83 -7.22	5.44
P2O5	0.003 -0.28	0.09
LiO	0.05- 2.49	0.79

TABLE 5: *ROCK DESIGNATION ON THE BASIS OF SIO2 CONTENT*

Chemistry	Designation	Rock Type
32-45% SiO2	Ultra-basic	Komalite
45-52% SiO2	Basic	Basalt, Gabbro
52-66% SiO2	Intermediate	Tonolite Andesite Dacite Phonolite
66-75% SiO2	Acidic	Rhyolite, Granite

TABLE 6: *ROCK DESIGNATION ON THE BASIS OF ALUMINA CONTENT*

Chemistry	Designation	Rock Type
AL2O3>Na2O+K2O+CaO	Peraluminous	Muscovite, Biotite, Topaz Corundum, Garnet Tourmaline
Al2O3>Na2O+K2O<Na2O+K2O+CaO	Metaluminous	Hornblende, Epidote Melilite Biotite Pyroxene
Al2O3=Na2O+K2O	Subaluminous	Olivine, Orthopyroxene Cinopyroxene
Al2O3>Na2O+K2O	Perakaline	Sodic Pyroxene, Sodic Amphiboles, Astrophylite Columbite, Pyrochlore

6. CONCLUSION

This study intends to classify the granitic rock deposits of the study area on the basis of its chemical and mineralogical composition. The study area is part of the Hawal Massif which is one of the three Massifs that occur within the eastern province of the Basement Complex of Northeastern Nigeria. The major rock types in the area include the Newer Basalt, coarse grained biotite granites, coarse porphyritic granites and the medium grained granites. These rocks which has been subjected to tectonism ading to fracturing such as joints, faults, dykes and veins were intruded by the New Basaltic rocks. A total of seven and twenty rock samples were randomly collected from the study area were subjected to both geochemical and petrographic studies respectively. The grain-sizes of granitic igneous rocks range from 2.2mm to 0.43mm indicating fine to coarse grained igneous rocks whereas the mineralogical composition consist essentially of 53% to 69 % quartz, 22% to 33 % feldspar and 0.3% to 3.0 % iron oxide. The grain-sizes of basaltic igneous rocks range from 1.12 mm to 1.15 mm indicating fine grained rocks whereas the mineralogical composition consist essentially of 20.9 % to 29.5% plagioclase, 27.5% to 31% Olivine, 31% to 35.1% pyroxene and 11.5% to 16.5% iron oxide. Geochemical investigation suggests that granites of the study area contain silica ranging from 61.05% to 78.26% and potassium ranging from 3.83% to 7.22% with high alumina content (14.30%) and falls within the S-type igneous rock series. They are strongly peraluminous calcalkaline igneous series that are of both lithospheric origin and also associated with subduction related areas.

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