

Geologic settings and petrographic analysis of Uding granitic hills and environs part of Hawal Massif North Eastern Nigeria

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Abstract

The Uding granites are situated in the Hong area of Adamawa state, where the Hawal massif clearly defined the geologic unit. Hawal massif is the name given to the basement complex rocks of Northeastern Nigeria. The granite is underlain by 300-400m of intensely metamorphosed rocks of the earlier Precambrian – the migmatite-gneiss. Field mapping was carried out on a scale of 1:25,000, traversing the area was challenging due to the natural stationing of smooth surfaced hills of batholithic granite. Field observation shows that the hills are mainly coarse-grained massive granitic batholith, with no observable evidence of metamorphism. Opened cracks and joints have also been observed, with no sealing. Evidence of high-grade metamorphism as schistosity and bandings were conspicuously absent. Elsewhere at the lowermost parts of some hills, particularly the Northwestern part of the study area near Pella, fabrics of metamorphic facie were encountered, signifying onset of metamorphism. There, the porphyritic texture of the granite hills were deformed and obliterated. Mineral assemblages obtained from petrographic studies confirm the rocks to be chiefly biotite-granite with accessory minerals as muscovite, zircon and hornblende. Exclusively metamorphic minerals have not been observed in the thin section studied both under plane polarized and cross-polarized lights. Both field and mineralogical evidences obtained in this study indicated that the Udinggranitic hills have not been transformed, hence remained as differentiated part of the basement complex of northeastern Nigeria, the Hawal massif.

Keywords: Hills, Granite, Hawal Massif, Geologic settings and Petrography.

Introduction

The Uding granite is a subunit of the large and interconnected chains of mountainous range in the Hawal massif, a name given to the basement complex of Northeastern Nigeria. The area is hilly in the eastern part and relatively flat in the west, and despite the hilly nature of the area, there are good road networks, footpaths and tracks. The area is characterized by two climatic seasonal patterns; the wet and dry seasons. The wet season is between the months of May and October, while the dry season is between the months of November and April. The average annual rainfall is about 753.5 mm. Studies from rainfall data in the area has shown that, the months of August and July usually record the heaviest and also the greatest number of raining days.

Temperatures in the study area are extreme; both the diurnal and annual ranges of temperature are wide. Temperatures during this period range from 20 - 24°C, while at night; temperatures could be as low as 16°C at higher altitudes. Months of March to June usually experience increasing temperatures as the rainy season set in the daily maximum temperature may exceed 39°C. The coldest night of the year occur in the months of December and January during which air is often hazy and visibility is poor due to fine dust particles in the air (Harmattan). During the raining season, the relative humidity of the study area is high, but with

the onset of the dry season and tropical continental air mass with dry dust laden north-east trade wind, with the relative humidity falling to about 15% or less are experienced¹.

The study area is rarely flat, massive hills of batholithic outcrops dominate the surface area, where the elevation of the mountains ranges between 2500m to 3500m above sea level. Other rock units in the area are the massive granitic plutons in association with diorite, dacite and gabbro occurring as dykes. The area mapped is located between latitude 10° 6' 57'' and 10° 10' 50'' N and longitudes 12° 50' 54'' and 12° 56' 58''E. It covers areal extent of 50km² within the Hawal massif.

Location and accessibility of the area: The study area is located in an East western village of Uding, about 10km south east-east of Hong and 150km north-north west of Yola, Adamawa state Nigeria. The area falls within the geographic coordinates of 10° 6' 57'' and 10° 10' 50'' North of equator and longitudes 12° 50' 54'' and 12° 56' 58'' East of the Greenwich Meridian. This area is hilly in the southeastern part and relatively flat and lower in the northwestern part. In spite of this rugged and hilly nature of the area, movement is fairly unhindered as movement in the area is eased by fairly good number of road networks and footpaths. Figure 1 shows the map of the study area.

Table-1: Average monthly temperature and rainfall (Adapted from Adamawa state Ministry of Environment).

Months	Temperature		Precipitation
	Warmest	Coldest	Average
January	34.2°C	16.6°C	0
February	36.9°C	19.6°C	0
March	39.4°C	24.1°C	0
April	39.0°C	26.0°C	4
May	36.1°C	24.8°C	8
June	33.4°C	23.4°C	9
July	31.5°C	22.8°C	10
August	30.5°C	22.4°C	13
September	31.0°C	22.3°C	11
October	33.6°C	21.9°C	4
November	35.5°C	18.1°C	0
December	34.6°C	16.0°C	0

Regional Geologic Settings

The area forms part of the Pan-African mobile belt -the basement complex, which lies to the east of the West African Craton. The belt which is sandwiched between Benin to the west and Cameroon in the east² and includes the Beninian Gneisses of the internal zone of the Pan-African mobile Belt as well as a vast expanse of reactivated high-grade gneisses believed to be Archaean in age and a supra-crustal succession thought to be Paleoproterozoic³.

Two generations of granites can be identified and these are prominent within the basement rocks. The older granites as termed by Falconer⁴ range widely in composition and age from 750 Ma to 450 Ma⁵. The younger granites (Jurassic in age) are prominently distributed in the North Central Nigerian Basement and occur as ring complexes that form part of a wider province

of alkaline anorogenic magmatism⁵. Figure-2 shows a simplified geologic map of Nigeria showing the different lithologic units.

The study area lies within the northern Adamawa state northeastern Nigeria, located within the Hawal Mountain – one of the regional groups of basement complex rocks. The work of Obaje⁵ have broadly divided the geology of Nigeria into three major geological components and these are: the Basement, Granites and Sedimentary Basins. Obiora et al⁶ further subdivided the basement (Precambrian in age) into five regions on the basis of the occurrence of sedimentary basins. These are the Western Nigerian Basement, North Central Nigerian Basement, Adamawa Highland, Eastern Nigerian Basement and the Oban Massif. Except the older granites, the basement rocks are chiefly “migmatitic gneisses, including banded varieties. These rocks assemblages according to the works of Rahaman⁷ and Dada⁸ are considered as the largest component of the Nigerian basement complex.

The basement complex also consists of rocks like mica-schist, tremolite-schist, graphite-schist, with occasional marbles and dolomites, calc-silicate rocks, meta-conglomerates and banded iron formation (BIF) and Precambrian granites including porphyritic/porphyroblastic muscovite granites, biotite granites, hornblende-biotite granites, non-porphyritic/non-porphyroblastic granites, aplites, granodiorites, diorites, quartz diorites, syenites, quartz-enstatite granites and enstatite granites (charnockites).

The Uding granites falls within the Hawal massif, a subdivision of the Nigerian Basement complex which is found between the Archaean blocks of West African Craton and the Congo Craton. Only little has been done on the account of the geology, stratigraphy, and the tectonic events of the Hawal massif. This basement rocks are emplaced within the Pan-African Mobile belt of Late Proterozoic (500-750 Ma) age Caby⁹. The rock units composed dominantly of the massive granitic plutons in association with diorite and gabbro collectively termed ‘the Older Granites’ which have been dated severally elsewhere at 500-750Ma¹⁰⁻¹⁴.

Other rock units in the area are migmatites and gneisses, which were dated as Archaean (c.2700 Ma) and Proterozoic, (2000 Ma) Annor¹⁵. The granites are products of Late Proterozoic (Pan-African) events, and are characterized by high-grade metamorphism¹⁶.

It is important to note that, being part of the Pan African Mobile Belt¹⁷, the Nigerian Basement Complex has also been intruded by the Ring complexes of Mesozoic age, around Jos area in central Nigeria.

These complexes are overlain uncomfortably by Cretaceous to Quaternary sediments and these have given rise to the present sedimentary basins. Several Coarser granitic occurrences have been investigated and reported in Nigeria.

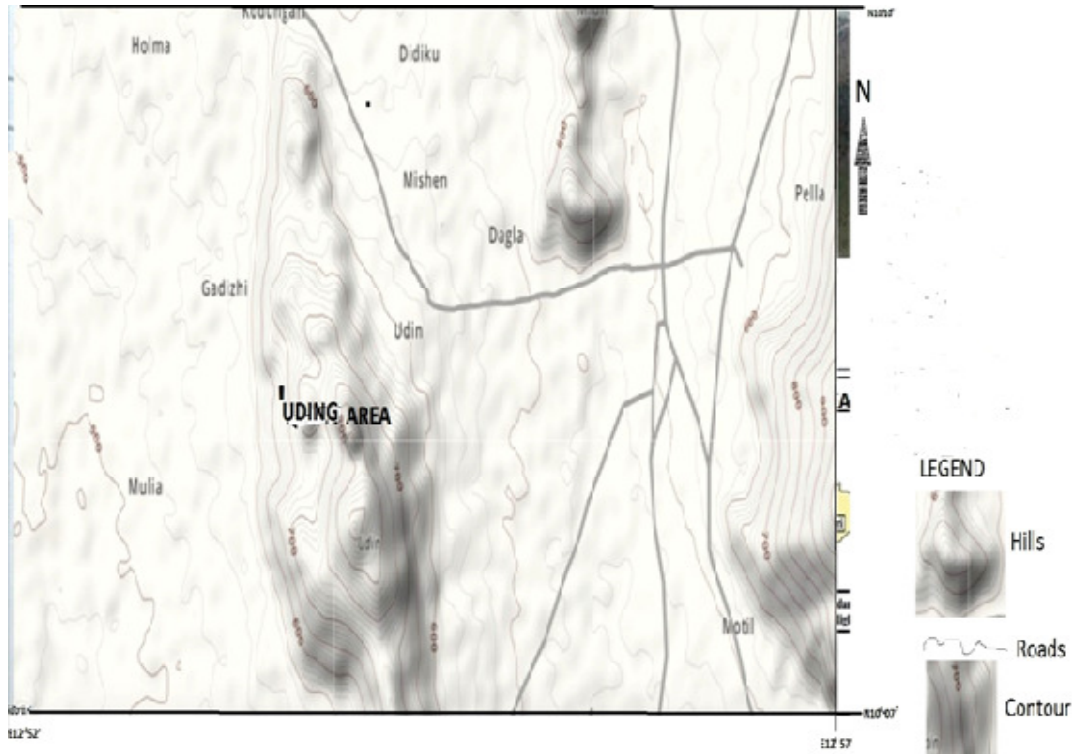


Figure-1: Map of the study area.

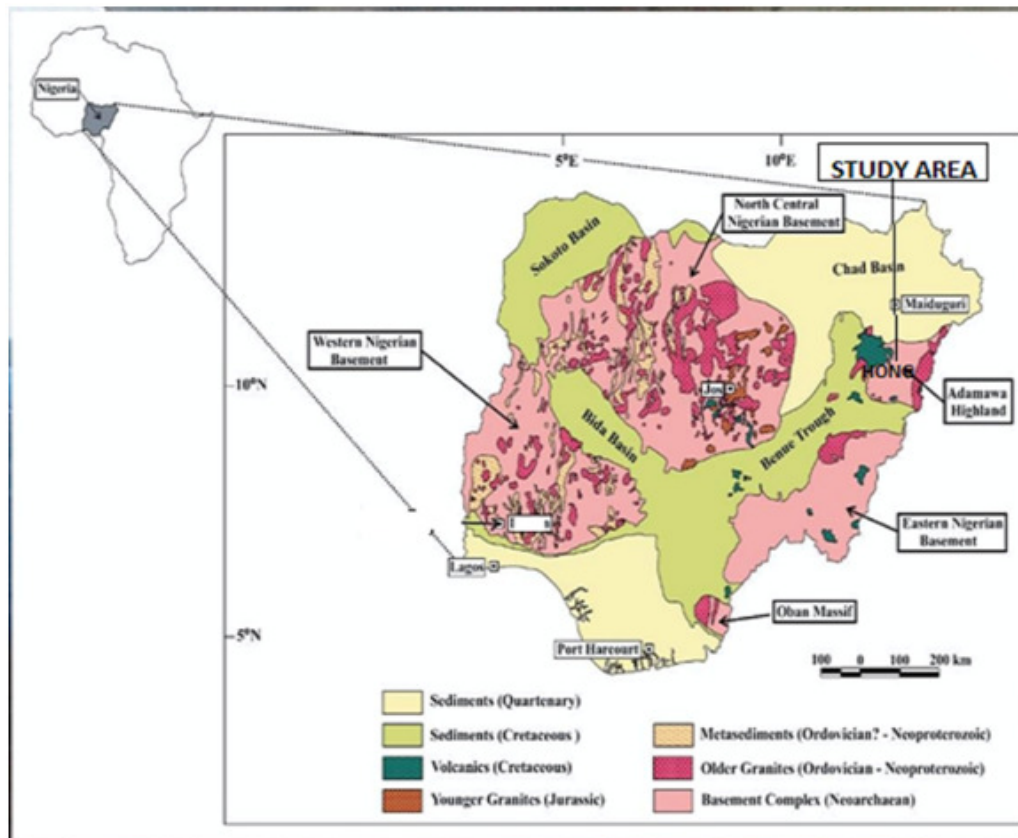


Figure-2: Simplified geological map of Nigeria showing the distributions of the three major geological components as well as the location of the present study (Modified after Obaje⁵ and Schluter³).

Field Data Acquisition

The Udin granite were geologically mapped in detail, rock outcrops in the area were observed in terms of field relationship, colour, texture, mineralogy, structure, and mode of occurrence. Strikes of features as veins, joints were measured at several points. Crystal grains were often very large, as they occur as phenocrysts permitting measurement with ruler.

Field observation in the area revealed numerous massive granitic plutons, originally emplaced at the subsurface. Their present exposure was due to combined effect of weathering and displacement of the overburden through geologic time.

After the field mapping, 40 samples were collected, and 10 were selected for laboratory analysis. Petrographic microscope was employed in the petrographic study of the rock samples, whereas modal analysis was conducted via visual counting mode.

Grains were traced and unraveled from the photomicrographs using an application called the Image J version 1.40c (2008) in Sun Microsystems.

Results and discussion

Petrographic analysis: The thin sections prepared from rock samples collected were described based on their mineral content, observed via polarizing microscope. These minerals were easily identified from the mineral's optical properties under a polarizing microscope. Hand specimen samples were also described mineralogically base on its texture, and mineral composition.

This important aspect of petrographic studies has been found useful in precisely naming and classifying the rocks. The instruments used in these studies is the polarizing microscope/petrographic microscope.

The rock samples analysed indicate the presence of quartz and feldspars, with quartz dominating the mineral assemblage as shown in the sample's photomicrograph in Figure 3-8.

In the photomicrographs, the minerals observed and represented include, Q-Quartz, I-Inclusion, M-Micas (Muscovite) F-Feldspars, and B-Biotite.

Individual crystals are easily distinguished in granitic rock samples when observed via both plane and crossed polarized lights. In the granite rock sample, a larger crystals of feldspars (orthoclase) are clearly visible in hand specimen, the crystal well developed.

Also in Figure-5, the dominant mineral is quartz with a very low relief and feldspars with no twinning. Biotite and hornblende are also visible with inclusions as accessory xenolith.

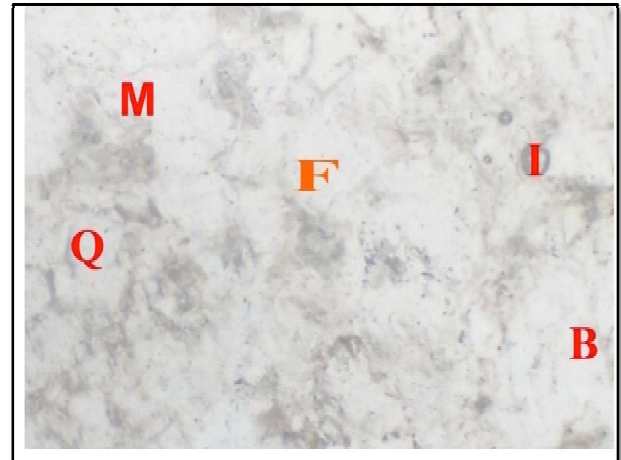


Figure-3: Photomicrograph of medium grained granite under plane-polarized light.

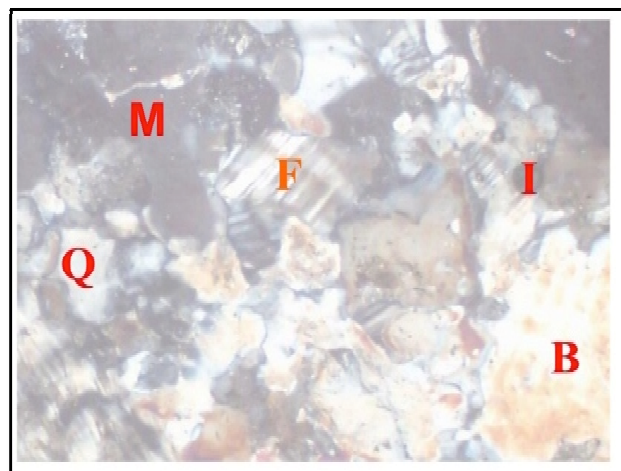


Figure-4: Photomicrograph of medium grained granite under crossed polarized light.

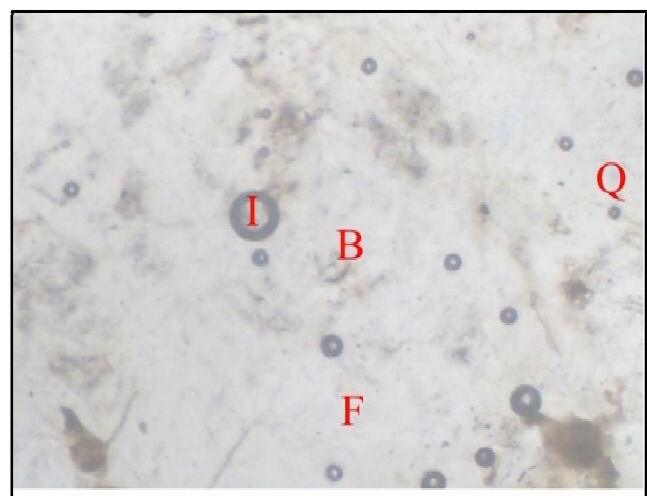


Figure-5: Photomicrograph of fine-grained granite under plane polarized light.

The plagioclase is cloudy while twinning is commonly the Carlsberg type. Other minerals observed include quartz, which are chiefly white in colour as seen in the slide shown in Figure-6 viewed under crossed polarized light. Small traces of biotite and some inclusions of accessory minerals mainly zircon and sphene are also present.

The rock is made up of interlocking rectangular feldspars and irregular clear quartz, chiefly white in colour.

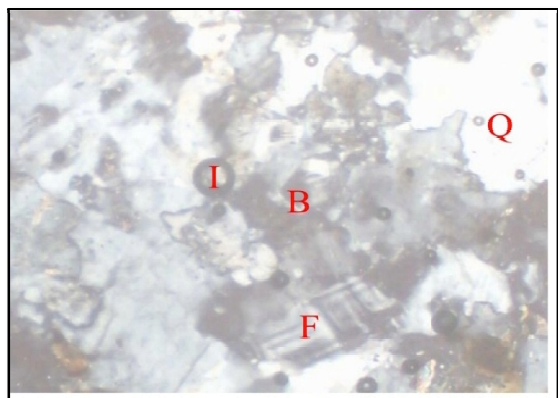


Figure-6: Photomicrograph of fine-grained granite under crossed-polarized light.

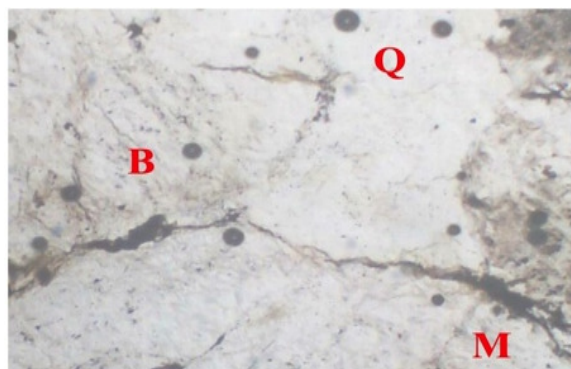


Figure-7: Photomicrograph of medium grained granite under plane-polarized light.

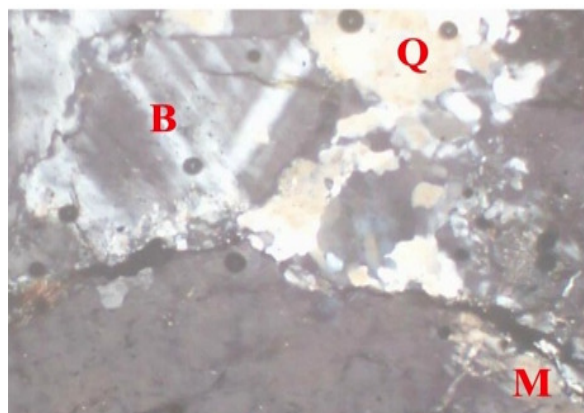


Figure-8: Photomicrograph of medium grained granite under crossed polarized light.

In the thin section above shown in Figure-8, minerals identified are quartz and biotite with accessory minerals as inclusions. Unlike in the previous slides, the quartz here are chiefly grey in colour as seen in the slide shown in Figure-8 above viewed under crossed polarized light. Small traces of biotite and some inclusions of accessory minerals mainly zircon and sphene are also present.

Feldspars include both microcline and plagioclase with the former being dominant. Porphyroclasts are often cracked and rod-shaped or elongated normal to the stress direction.

Compositionally, biotite with fractures, quartz with cleavages, and muscovite where the dominant minerals observed under plane polarized light. Under crossed polarized light, biotite appeared black in color, muscovite grey and the quartz whitish forming the groundmass. Observed also are inclusions of accessory minerals mainly zircon and sphene.

From the petrographic studies presented above, the Uding granitic hills reveals biotite, orthoclase, quartz, muscovite and other opaque mineral assemblages, these are the dominant minerals as observed microscopically. Zircon was identified as accessory in some of the thin sections. The zircon present also occurs as inclusion within the muscovite and other opaque minerals suggesting some replacement of biotite by muscovite accompanied by the release of the ore mineral. Albite twinning and micro cracks were also absent in the feldspars.

Joints: Field observation of the studied rocks revealed massively unmetamorphosed coarse-grained granite, with unaligned grains throughout the plutons. The rocks are clearly different from the low-lying gneisses in the area.

Joints occur mostly in the granites, much more than any other rock in the area. However, some of the migmatites around Muduvu area show some minor folding, such as crenulations and ptygmatic folds. Ptygmatic folds were concentrated at the lowermost base of the granite-gneisses in the northwestern part of the study area.

Other structures in the area include faults and dykes. The joints commonly occur as joint sets in the NE-SW directions.

Veins and Dykes: The granitic rocks in Uding area are associated with series of dykes, mainly as pegmatite dykes.

Intrusions as quartzo-feldspathic veins are associated with the granites. The veins run in different directions but dominantly in the NE-SW and NW-SE directions. The quartzo-feldspathic veins observed in the area contain minerals with high radioactive elements evidenced by observable scintilometer response hovered over it. The dykes occur in all directions but mainly in the NE-SW directions, and this is in concordance with the regional trend highlighted by previous works in the area such as that of Baba¹⁸ and Bassey¹⁹.

The trends of the joints are generally consistent with the trend of many tectonic structures in the Hawal basement. The strike values representing the trend of joints, veins and dykes in the area are plotted on Rose diagram and presented in Figure-9.

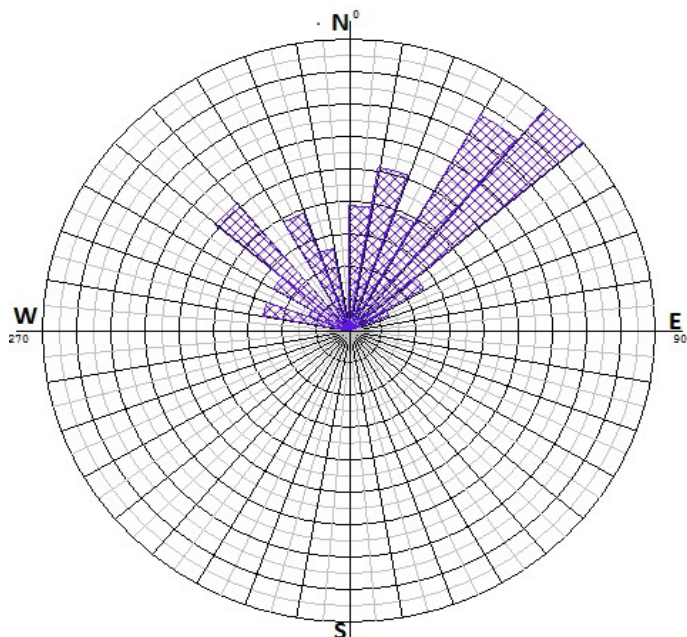


Figure-9: Rose plots for Dykes and Joints in Udin granitic hills.

It can be seen that the dominant trend of structures in the area is the NE-SW trend, typical of the Panafrican orogeny in which the rock was emplaced.

Mode of occurrence and field characteristics: Granites occurred in the study area as massive intrusions within the migmatite-gneiss. The term Batholith, a dome shaped structure best described how the Udin granites occur. The granite also occur as elongated outcrops within the complex. The rocks generally exhibit very coarse-grained texture lacking any intense metamorphic structures. Few medium-fine grained batholiths are found, constituting insignificant portion of the rock units in the area.

Conclusion

Geologically, Udin area mainly comprises of crystalline basement rocks, geomorphologically represented by both low and high lands. The low lands are mostly covered by the gneisses, while the high land are exclusively granitic. Metamorphism is restricted to the lowland areas and it extends gradationally to the relatively higher lands. Migmatites - oldest part of the basement is conspicuously absent, probably hidden underneath the exposed rocks. The granites in the areas are exclusively large grain sized, characterized by sets of phenocrysts of various sizes engulfed by ground mass.

The granites covering the northern part of the maps were explored in detailed, such that field evidence indicates that the granites have actually occur mostly as massively emplaced deep seated batholiths. Evidenced by the large grain quartz and biotite crystals that suggest enough time for full crystal development. A very localized crustal deformation affected the area; this has given rise to limited cracks and fractures with different orientations clearly unrelated to the latest orogeny that affected the Hawal massif. The granitic plutons are massive, largely elongated and characterized by clearly defined contacts with the older country rocks – gneisses.

Petrographic studies of samples collected have shown that the rock's mineral assemblages are mainly quartz, Orthoclase feldspars and biotite, therefore the term granitoids cannot be used to describe these granitic batholiths in Udin area. Although granitoids are also called older granites but they are known to contain feldspars as dominant minerals, little of quartz, biotites, and occasionally microcline. Other rock units in the area are the massive granitic plutons in association with diorite, dacite and gabbro occurring as dykes. Migmatites - oldest part of the basement have not been encountered the survey area, probably hidden underneath the low-lying exposed rocks which are chiefly granite-gneiss and gneisses.

The high land are exclusively granitic, hence metamorphism is restricted to the lowland areas. The gneisses are aptly distinguished by the imminent alternation of leucocratic and melanocratic bands of minerals assemblages containing mostly quartz, feldspars and amphibolitic xenolith. These settings could suggest the existence of gneiss before the granite emplacement, and this can be corroborated by the gneisses' lateral extent within the basement rocks.

The Udin granitic rocks are therefore considered as part of the youngest known differentiated part of the basement complex of Nigeria and least affected by the regional metamorphism.

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