Petrographic And Structural Characters Of The Basement Units In Kura Area, Northeastern Nigeria.

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Abstract: Field mapping, structural studies and petrography of the basement complex around Kura area in Bauchi State exposes variations in rock types and structural features. Deformation and migmatization of the rocks, produced orientations in different directions, with abundance of geologic structures such as foliation, ptygmatic folds, veins, fractures and dykes. Most of these structures found on the rocks tend to trend towards the NE – SW and E-W directions, these trends are consistent with the general trends of Pan-African structures and of schist belt respectively. This study provides some dynamic information on the rocks exposed around the area and reveals the various rock types and their geological characteristics: field relation, macroscopic and microscopic features as well as structural elements. The main aim of this work is to study the geologic conditions of the study area in order to infer the level of deformation on the rocks with the intent of recognizing and further suggesting the variations in paleo-environmental regimes of pressure, temperature, and fluid activity. Results from the field shows that the area consists of migmatites, granitic gneisses and biotite hornblende granites which all show a variety of colors, textures and mineralogy. The displacement of distinctive mineralogy, textures, optical and structural characteristics led to the nomenclature of the rocks. Exposure of rocks in the area were mostly high and medium level outcrops with elevations ranging from 574m to 597m. Petrography reveals pelitic mineral assemblages suggesting high grade metamorphism. Characteristic structures such as gneissosity, and typical metamorphic textures such as granoblastic textures are present in the migmatites and granitic–gneisses respectively, while granitic textures characterize the granites.

Keywords: basement complex, deformation, metamorphism, migmatization.

1. Introduction

The study area covers approximately 13km^2 and occupies part of sheet 149 NE of Bauchi State. It lies between latitudes N10˚21’41.1’’ and N10˚23’45.8’’ and longitudes E09˚48’23.7’’ and E09˚50’28.4’’. It represents part of northern Nigeria Neoproterozoic basement complex. Early research and geological mapping of the basement rocks in the northeastern part of Nigeria was mainly motivated by the potential of discovery of mineral deposits such as tin ores and columbite in Jos plateau [18], [21]. Formerly, in Kura area, remoteness was a barrier to detailed geological studies. This paper seeks to examine and address questions on the nature of the rocks in the Kura area, with emphasis on their structure and petrography: with attempts to establish the geotectonic history of the study area.

2. Background Geology

The geology of the study area is mainly characterised by metamorphic and plutonic rocks which are represented by migmatites, granitic gneisses and pre, syn and post-tectonic rocks granites emplaced on the gneisses and schists [16]. The study area happens to be part of the Eastern Nigeria’s terrain which according to [7] stretches from the Cameroon line to the area between Kaduna and Jos. This Jos-Bauchi transect situated to the east of the main terrain boundary includes mostly gneisses and anatexites of metasedimentary origin [5] [6]. The depositional age of the sediments is poorly constrained and no basement-cover relationships have been identified. The use of U-Pb Zircon isotopes to determine the ages of the syn-kinematic and late kinematic plutons suggests that most of the outcrop found in the study area irrespective of the composition are 638 + 3ma and 585 + 7 Ma [1], [4]. Other minor rock units are monzodiorites, charnockites, amphibolites, quartzites and pegmatites, [5]. Some of the foliations and other structural features found on metasedimentary assemblages within the area often displays a mean N-S to NE-SW low angles away from the plutons [4] but becomes upright towards the plutons and locally parallel to their igneous foliations [8]. The area has in place biotite-hornblende granites which have more rounded shapes molded by country rock structures in conformity envelopes, suggesting a late tectonic emplacement [5].

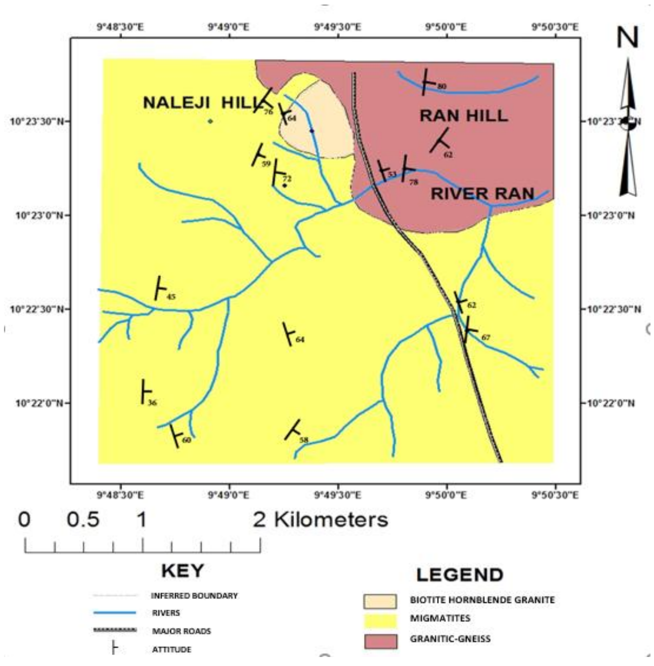

Figure 1: *Geological Map of Kura area*

3. Field Studies

The geological map of the Kura area is given in figure 1 showing the three major rocks types encountered in the area: migmatites, Granitic Gneisses and Biotite Horneblende Granites. The migmatites, are which are more wxtensive around Naleji, form several hills which have been fractured and weathered upon which the granites were emplaced, having characteristic gradational contacts. The migmatites are meso to melanocratic due to the unequal proportion felsic and mafic minerals. Other salient structures on the migmatites are the abundance of Ptygmatic folds, quartzo-feldspartic veins, lit-per-lit injections, contorted gneissose foliation (figure 2C). The granitic gneisses are encountered in the Ran area forming the Ran hills. They are coarse grained, leucocratic and show weak mineral foliation (figure 2B). Abundant felsic and mafic veins and bands have been injected into these granitic gneisses. The granites are biotite hornblende granite, which occurs as a road side section and minor hill, and seems to be cross-cutting the Naleji hill migmatite. They are also coarse grained granites with minerals as large as 3mm. macroscopically, quartz, feldspars and biotite are observable. The granites which seem to have intruded the country rocks shows gradational contact, probably suggesting a non-magmatic origin [13]. Minor basic intrusions were also encountered cutting the granitic gneiss (figure 3A). They occur as tabular dykes which have sharp contact and are also discordant to the basement complex.

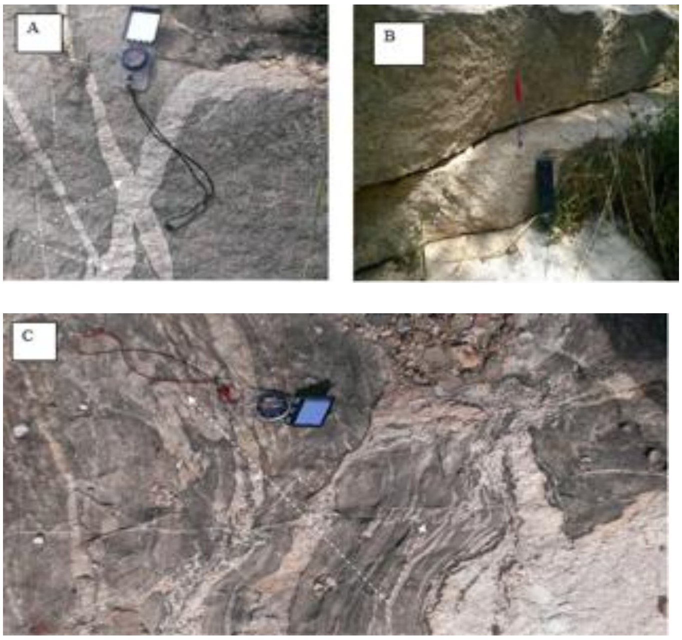

Figure 2: *A: Cross cutting veins. B: Gneissic foliation and boudinage. C: Ptygmatic folding and contorted gneissose foliation.*

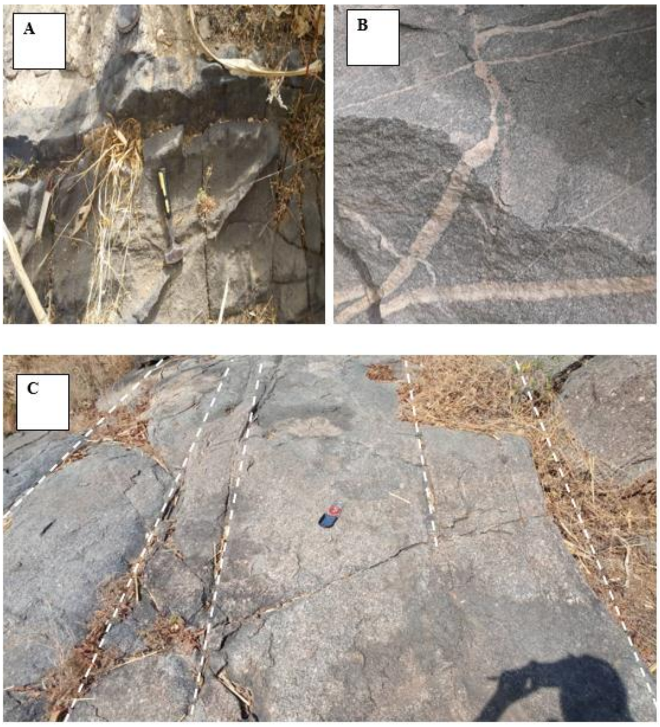

Figure 3: *A: Basic dyke intruding the granitic gneiss. B: poorly developed linear structures and network of intersecting quartzo-feldspartic veins. C: NE-SW trending fractures.*

4. Petrography

Characteristic samples from the field were selected and studied in the laboratory under thin section in order to identify individual minerals present using their distinctive properties under both plane and cross polarized light which goes on to further describe the rocks and the structures found on them. These results are given and interpreted below.

4.1 Biotite Hornblende Granite

Biotite hornblende granite (figure 4) is generally leucocratic, coarse grained and has an interlocking texture which is characteristic of granites. The quartz grains occur as subhedral colourless crystals having no relief under plane polarized light and showing undulose extinction under cross polarized light. The plagioclase occurs as lath shaped subhedral crystals which have no relief. They are twinned according to the Albite law with slim laminae and exhibit an oblique extinction with a maximum extinction angle of 23° which corresponds to oligoclase on the Michel-levy curve. Biotite occurs as light brown stout crystals which are strongly pleochroic to dark brown while the hornblende occurs as thinner greenish crystals. Biotite crystals show one directional cleavages in longitudinal sections while basal sections of the hornblende reveal two directional cleavages intersecting at roughly 124° and 56°. Under cross polarized light, they show a perfect parallel extinction. Hence, the essential minerals observed in the rock are quartz, plagioclase, alkali feldspar, biotite and hornblende
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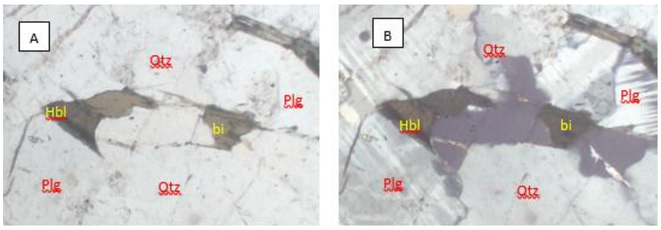

Figure 4: *Photomicrograph of Biotite hornblende granite (magnification = ×20) under A: plane polarized light. B: cross polarized light*

4.2 Granitic Gneiss

The photomicrograph in figure 5 suggests the rock as granitic gneiss. The grains show possible seritization. Hornblende is identified as having a greenish brown coloration, very pleochroic with a high relief under plane polarized light and showing a second order orange interference color under cross polarized light. Biotite is seen as having a dark brown color, appearing as separate grains and as aggregates with hornblende. Pyroxene also occur sparsely. Microcline with a characteristic polysynthetic cross hatched twinning is common.

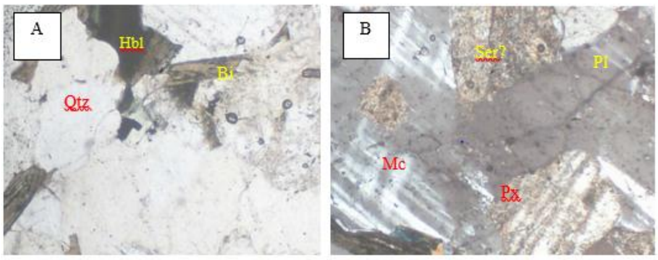

Figure 5: *Photomicrograph of granitic gneiss (magnification = ×20) under A: Plane polarized light B: Cross polarized light*

4.2.1 Basaltic Dyke (basic intrusion)

The basic intrusion (figure 6) is coarse grained and has high proportion of mafic minerals, hence, melanocratic. The essential minerals are clinopyroxenes and ca-plagioclase. It exhibits an ophitic texture as the plagioclase crystals occupy interstitial positions and are enclosed by pyroxenes. The pyroxenes present are recognized by their pale brown color and non pleochroic under plane polarized light. Longitudinal sections show 1 directional cleavage. The plagioclase present are colorless, prismatic crystals which twinned according to the albite law (showing thick bands typical of calcium rich plagioclase) and exhibits oblique extinction under cross polarized light with a maximum extinction angle of 48°. This agrees to labradorite on the Michel-levy curve. The textural and mineralogical properties of this rock confirms it as a basic intrusive, hence, a basaltic dyke.

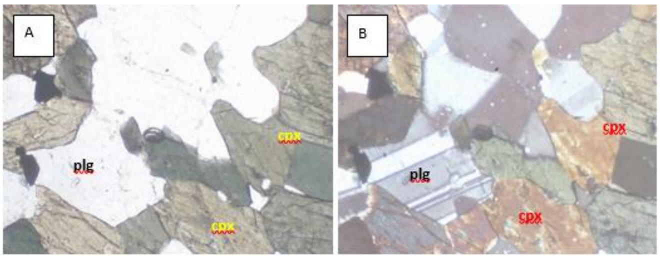

Figure 6: *Photomicrograph of basic intrusion on the granitic-gneisses showing sub-ophitic texture (magnification = ×20) under A: Plane polarized light. B: Cross polarized light*

4.3 Migmatites

The migmatites (figure 7) are generally coarse grained and mesocratic. Idioblastic crystals predominate and are aligned into distinct gneissose foliation which is constituted by the segregation of clear bands of felsic and mafic minerals. The essential minerals observed in the rock are Quartz, K-feldspars (microcline), sillimanite and plagioclase of andesine composition, which make up the felsic bands; while the mafic bands are made up of essentially biotite and occasional horneblende which are arranged mostly in a parallel to sub-parrallel manner. Some of the quartz grains are stretched giving evidence of stress during metamorphism. Some of the plagioclase in the rock have been altered to form chlorite within the felsic part of the rock. Myrmerkitic textures are also observable as a result of the vermicular intergrowth of quartz and microcline.

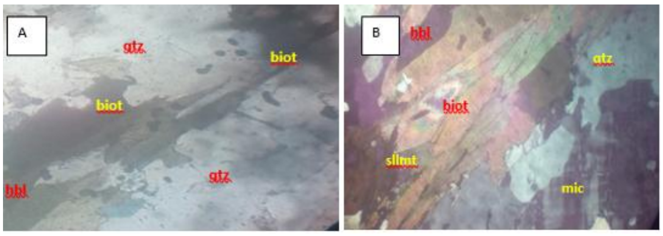

Figure 7: *Photomicrograph of migmatite gneiss subplanar alignment of prismatic minerals and stretched quartz grains (magnification = ×20) under A: Plane polarized light. B: Cross polarized light.*

5. Structural Geology

Rocks of the study area pinpoint signatures of migmatization and high level of metamorphism. Macroscopic and microscopic structures were mapped in the area. Some of the structural observations from the field are joint sets, ptygmatic folds, pegmatite dykes, quartzo-felspartic veins/bands, gneissic foliations and crenulation folding (see figure 8). The structural relationships of the Kura area have been interpreted to be superimposed on the geology of the area. The ptygmatic fold is seen in figure 8A as comprising five similar trends of fold axis (S260W, S264W, S260W, S270W and S260W) which collectively define one-fold face trending in NE-SW direction in the Daleji hills area. This indicates one of the direction of shear stress within a shear zone. Field measurements of trends of 70 veins and fractures, and the attitudes of 54 foliation planes (refer to table 1 and 2) are obtained and analyzed using rosette plot as shown in figure 9. Ptygmatitic folding occurs in abundance, these structures are explained as disharmonically folded veins in the competent layers of rocks [2]. Contorted and refolded quartzo-feldspathic veins/bands in the migmatites commonly occur abundantly in the western terrain of the study area and the Daleji hills. Weak foliation on the granitic gneisses occur along with abundance of joint sets and fracturing in the Ran hills (Fig. 8D). Structurally controlled drainage channels are present at River Ran and its essentially N-S to NE-SW trending channels (Figure 1). Boudinage and faulting are however rare occurring structures in the metamorphic rocks.

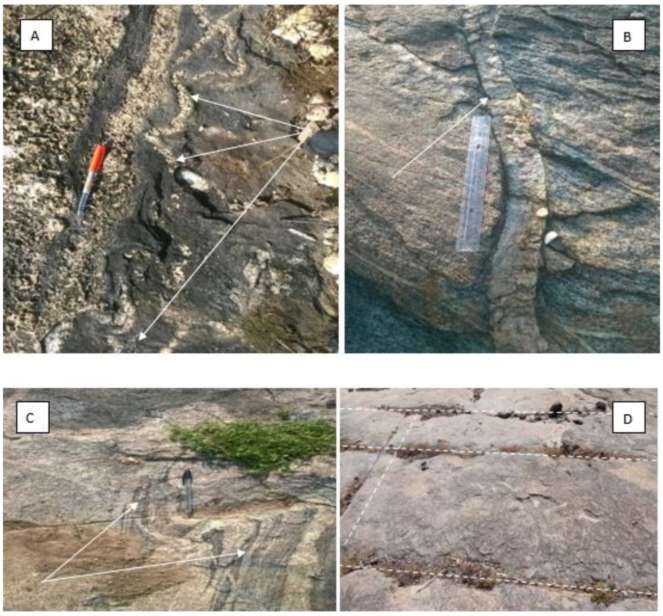

Figure 8: *A: Ptygmatic fold on the mafic part of the outcrop. B: Pegmatite dyke C: Crenulation folding and banded gneissic foliations at Daleji hills D: Joint sets*

Table 1: *Data for Rosette plot of fractures and veins*

S/N	Strike	Azimuth (°)	S/N	Strike	Azimuth (°)	S/N	Strike	Azimuth (°)	S/N	Strike	Azimuth (°)	S/N	Strike	Azimuth (°)
1	N34°E	214	15	N284°W	104	29	N284°W	104	43	N350°W	170	57	S266°W	86
2	N46°W	226	16	N272°W	92	30	N280°W	100	44	N312°W	132	58	S262°W	82
3	N30°E	210	17	N310°W	130	31	N268°W	88	45	N300°W	120	59	N312°W	132
4	N64°E	244	18	N324°W	144	32	N292°W	112	46	N272°W	92	60	N287°W	107
5	N62°E	242	19	N270°W	90	33	N260°W	80	47	N280°W	100	61	N332°W	152
6	N290°W	110	20	N274°W	94	34	N300°W	120	48	N280°W	100	62	N320°W	140
7	S268°W	88	21	N280°W	100	35	S234°W	54	49	N274°W	94	63	N340°W	160
8	N24°E	204	22	N22°E	202	36	N24°E	204	50	N22°E	202	64	N20°E	200
9	N22°E	202	23	N20°E	200	37	N22°E	202	51	N20°E	200	65	N20°E	200
10	N25°E	205	24	N22°E	202	38	N30°E	210	52	N18°E	198	66	N24°E	204
11	N30°E	210	25	N310°W	130	39	N24°E	204	53	N12°E	192	67	N300°W	120
12	N24°E	204	26	N26°E	206	40	N28°E	208	54	N14°E	194	68	N300°W	120
13	N22°E	202	27	N300°W	120	41	N26°E	206	55	N22°E	202	69	N286°W	106
14	N22°E	202	28	N324°W	144	42	N24°E	204	56	N20°E	200	70	N282°W	102

Table 2: *Measured attitudes of foliation planes*

S/N	Strike	Dip	S/N	Strike	Dip	S/N	Strike	Dip
1	S266°W	18°SE	19	N40°E	17°E	37	N43°E	42°SE
2	N70°E	10°SE	20	N13°E	14°E	38	S260°W	44°SE
3	S258°W	25°NW	21	N38°E	16°E	39	S106°E	20°S
4	S98°E	10°NE	22	N27°E	15°E	40	N292°W	20°S
5	N290°W	10°SW	23	N78°E	8°SE	41	S194°W	54°SE
6	N89°E	2°S	24	S240°W	14°SE	42	S241°E	10°S
7	N278°W	3°E	25	N290°W	10°SW	43	S140°E	20°NE
8	N287°W	3°W	26	S112°E	2°NE	44	S158°E	60°SW
9	N20°E	9°E	27	N60°E	6°NW	45	N274°W	38°S
10	N33°E	4°E	28	S135°E	45°NE	46	S241°W	14°S
11	N43°E	12°S	29	S234°W	4°NW	47	N316°W	66°SW
12	N40°E	21°E	30	N76°E	12°NW	48	N46°E	32°SE
13	N57°E	8°S	31	N84°E	2°NW	49	S124°E	36°SW
14	N23°E	15°E	32	S146°E	8°NE	50	S122°E	42°SW
15	N89°E	9°S	33	S212°W	8°NW	51	S216°W	54°SE
16	N62°E	20°S	34	S218°W	12°NW	52	S148°E	64°W
17	N79°E	11°S	35	N290°W	36°S	53	S146°E	60°W
18	N348°W	9°S	36	S112°E	16°E	54	S153°E	62°SW

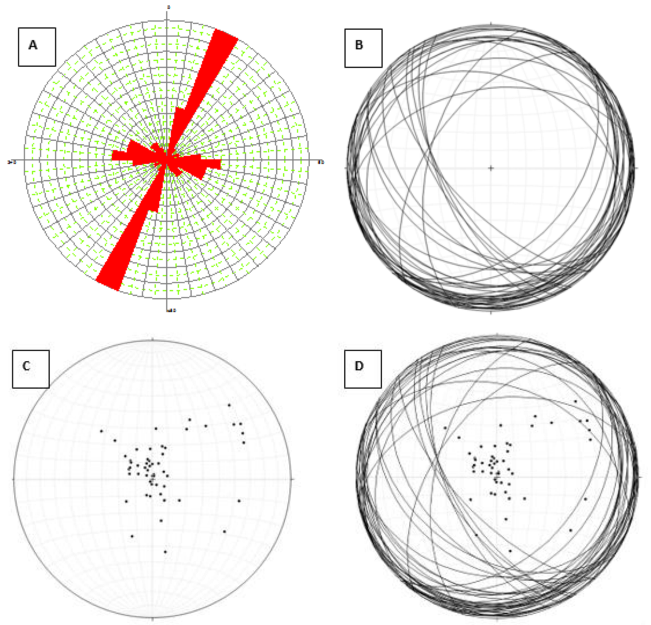

Figure 9: *A: Rosette plot for dykes and veins. B: Beta diagram for attitudes of foliation planes. C: S-pole for attitude of foliation planes. D: Combined Beta and S-pole diagrams for attitude of foliation planes.*

6. Discussion

The Kura area lies within the Pan-African Basement Complex of Northeastern Nigeria. The basement units as represented are the migmatites, granitic gneisses and the biotite hornblende which represent late to post Pan-African Orogeny The granites may have been emplaced into the metamorphic Basement Complex of Nigeria during the Pan African event (600 ± 150 Ma) [10]; [11], hence representing the last stage of its evolution and probably the terminal end of the Pan African orogeny. The continent-continent collision between the Congo Craton and West Africa plate can be proposed as a prototype to explain the geodynamic evolution and geotectonic setting of the Pan-African belt in West Africa which the study area lies within. Tectonism resulting in intense faulting and magmatism in the area may have led to the emplacement of granites. The evolution of the study area ends with the emplacement of these granites. [5]; [8]. On the basis of petrography and structural observations, metamorphic rocks in the study area are unmistakably metasedimentary in progeny. Furthermore, they have attained high grade barrovian sequence metamorphism on the basis of their index mineral assemblages and plagioclase of andesine (An25-44) composition. Occurrence of sillimanite and andesine in the migmatites suggests attainment of granulite facies of metamorphism in most parts of the study area. Most of the structures found on the rocks of the study area generally trend towards the NE – SW directions, which is the general trend of Pan-African [14] structures as evidenced by the dominant trend shown by the results of the Rosette plots. The structural plots of the study area, shows a high level deformation as seen on the results gotten the stereographic plots of the area, while the NE-SW to N-S pattern of fracturing and jointing is more often than not attributed to intense brittle or cataclastic deformation [14]. The trend of the fractures and joints is variable depending on the deformational episodes that produced them. In the area, predominant fracture trends are in the N-S to NE-SW (0-30°), and hence, are attributed to Pan African thermotectonic event. Field observation of structures also provide evidence of high grade metamorphism and migmatization/anatexis in the migmatites. This is seen in outcrops showing ptygmatic folding, contortion of gneissic foliation and crenulation folding. Photomicrographs, in addition to macroscopic field descriptions, of the migmatites and granite gneisses also reveal conspicuous planar arrangement of oriented minerals as indicated by banding and weak foliation formed by segregation and alignment of minerals respectively, under conditions of elevated temperature, pressure and shearing stress. The study area, is observed to have undergone tectonic and metamorphic events. This is consistent with the works of [3] in the Oban massif and [20] in the Bamenda massif, who have postulated high grade barrovian sequence metamorphism (up to the granulite facies) and migmatization. In the study area, intense and multidirectional orientations of planar and linear structures such as fracturing confirm that cataclastic or brittle deformation affected the basement rocks.

7. Conclusion

The widespread orogenic event that occurred in the Pan-African produced a major regional deformational episode, with its associated migmatization, magmatism and metamorphism showing foliations trending N-S to NE-SW. Migmatization and metamorphism resulted in the migmatites and granitic gneisses respectively, while magmatism induced by tectonism and deep crustal faulting represents the last stage of evolution of the basement, and led to the formation of these Pan-African granites. From field observation, these late to post Pan-African granites appear to intrude the metamorphic rocks discordantly and lack clearly defined boundaries/contacts with the metamorphic rocks. Also, macroscopic and petrographic observation indicates granitic composition. The drainage system of the area appears to be structurally controlled probably by the abundant gneissic foliations as the Ran river and its N-S to NE-SW trending tributaries prominently flow in the South to SW direction. The Kura area has lithologic and structural relationships which are consistent with other works on the Northeastern basement complex as the metamorphic units (highly deformed migmatites, and granitic gneisses). Furthermore, additional geophysical, geological and geochemical research in the area might reveal a possible mineralization particularly at the gradational contacts between granites and the country rocks.

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