Structural Analysis of Barkin Timanga Area, Northwest Wamba Central Nigeria

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Abstract- ***The structures and mineral resources of Barkin Timanga Area, Northwest of Wamba town were studied. The area is underlain by the basement rocks of Central Nigeria. The study includes rock identification, structural measurements, and laboratory thin section studies. The area is part of the extensive mineralized pegmatite belt of Central Nigeria that lies within the Precambrian Basement Complex. The Polycyclic Basement Complex of the Barkin Timanga area is composed of gneisses, diorites and granite pegmatites which include the older rocks of this area, and emplaced as large mass of dyke. The non-foliated diotrite and granitic pegmatite constitute the late tectonic granite suite of the area. All the rocks of the area are granite in composition which includes mainly K-feldspar, plagioclase feldspers, quartz, biotite and muscovite are main component. Dykes, foliations, joints, veins, faults and folds express the structural features of the study area. The basement rocks show dominant strutural trends in N-S, NE-SW, and NW-SE direction. Those trends reflect the multiple cycles of deformation that may have affected the area. Oriented strike-slip faults are interpreted to represent the last compressional phase related to the Pan-African tecto-genesis. The pegmatites are mineralized with gemstones, cassiterite-columbite and tantalum. In addition, the large rock of granite-gneiss and gneiss are source of aggregate building materials, which could serve many purposes in building and engineering if crushed into desired shapes and sizes.***

I. INTRODUCTION

Background to the Study: The area covers a part of Wamba town, Barkin Timanga area and Wamba Forest Reserve, Northwestern part of Wamba town in Wamba Local Government Area of Nasarawa State. The entire area falls within the Basement Complex of Nigeria which forms part of the upper proterozoic mobile belt extending from Nigeria across the Sahara into Nigeria, Benin and Cameroon. The Basement Complex is dominated by gneisses migmatites, schist, granite and pegmatite (Wright, 1971), most of which have been weathered into boulders. The rock found within this part of Nigeria Basement Complex include gneisses, granite gneisses, diorites and granite pegmatites, which outcropped as massive or relatively small bodies. Emphasis were made on the structures associated with each lithological unit, the deformational mechanism responsible for the formation of these structures and how these structures can be used to reconstruct the paleo-environment and geological history of the area. Attempts were also made to ascertain the economic and mineralogical potential of the area based on the mode of occurrence of the various rock types and the structures.

Objectives of the Study

The objective of the study area is as follows:

1. Identification and measurement of the various geological structures associated with those lithological units and their trends.
2. To carry out a petrographic, mineralogical and structural investigation of the rocks in the study area.
3. To carry out a petrographic examination of the thin sections of the rock samples to further help in studying the general geology and the mode of emplacement of the various rock types in the study area.

Study Area:

Location: The study area is located at Barikin Timanga Northwest of Wamba, which cut across part of Wamba town in Wamba Local Government Area of Nassarawa State, and within the Basement Complex of North Central Nigeria. It lies between longitudes $8^0 39' 20'' E$ and $8^0 41'$ and latitudes $8^0 56' 45'' N$ $8^0 58' 20'' N$ (Figure 1). It is covered by Wamba topographic map (sheet 210). The study area lies within the Basement Complex of Nigeria with an approximate area extent of $9km^2$.

Figure 1: Geological map of the study area

Physiography: In term of relief, the topography of the Northeastern part of the study area is hilly, while the region to the South is exceedingly flat. The hill in the study area, which rise to 1.727 metres above the plain is composed of granite-gneiss with dyke of pegmatite. The area is situated in the Savanah belt of West Africa with wet season from May to September, followed by a long dry season October to April. From November to early March, the Northern trade wind, known as the 'hamathan' keeps the humidity extremely low.

The region is characterized by two seasons the wet and the dry season. The mean monthly temperature of the area ranges from about 21^0C in August to about 25^0C in April, while the monthly rainfall is about 140mm.

The study area falls within the Guinea Savannah belt of Nigeria characterized by sparse vegetation, mainly of shrubs, grasses and short scattered trees, with average height of about 3-5 metres but tall trees covered some parts.

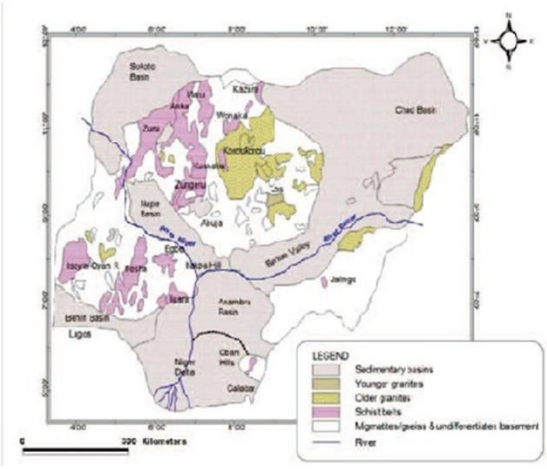


Figure 2: Generalized Geological Map of Nigeria showing the Basement Complex Rocks, Schist Belts, the Younger Granites and the Sedimentary Basins. (Black, 1980)

Geology: The lithology of the area comprises rock of the Basement Complex. The general geology of the area lies on the geology of North Central Nigeria. The North Central Basement Complex form an integral part of the Nigerian Basement Complex which falls within the reactivated part of the pan-African belt between the West African Craton to the West and Congo Craton to the Southwest. The area lies within the part of Basement Complex of Nigeria. Rocks in this belt experienced their last major deformation and metamorphism during the pan-African orogeny (600±150ma) (Wright *et al*., 1985). Apart from the broad belt of the Upper Cretaceous sediments along the Niger Valley, Central Nigeria is underlain by igneous and methamorphic rock consisting largely of gneisses, schists and granites. The pegmatites of Wamba area of Nasarawa State in Central Nigeria form part of a group of late-Pan-African rare-metal bearing pegmatites which occur in abroad belt extending from Southwestern to Central Nigeria (Jacobson *et al*., 1946, Wright, 1970). The area is part of the Wamba Pegmatite field where cassiterite and columbite-tantalite deposits have been mined since the beginning of 20^{th} Century.

The polycyclic Basement complex of the study area is made of gneiss granite, gneiss, diorite and granite pegmatite, which host the primary rare-metal mineralization and believed to have intruded the gneiss in the area. The gneiss and granite gneiss

marked the oldest rock in the area and they are believed to have formed as a result of magmatization and granitization.

II. METHODS

Geological Field Mapping: The field mapping was carried out with the use of base map on a scale of 1:10,000, which was obtained from a topographical map sheet 210 (Wamba sheet) covering the area on a scale of 1:100,000. The field geological mapping involved outecrop identification, mapping and delineation of various rock types as well as documentation of structural features present on the rocks such as foliation, joints, veins, faults, folds and fractures. The field work was done with the aid of compass-clinometers, geological hammer, measuring tape, field notebook, sample bag, protractor, camera etc.

Traversing along footpaths and river channels were used in reaching out to the outcrop. Rock samples were collected from the field and labeled for other laboratory work and thin sections preparation.

Field Relationship and Preparation of Samples: Field relationship enfolds the occurrence and the relationship of the various rock types observed on the basis of their respective outcrop contacts. The lithological units mapped out in the area include the gneiss, granite gneiss, diorite and pegmatite.

The field relationship with respect to actual contacts within the rock types in the area were difficult to determine owing to poor exposures in critical areas and the nature of the terrain covered with thick vegetation.

The megascopic description of the rock samples collected in the field was carried out based on some physical features such as colour, mineralogical composition, texture and structure. Fresh samples of the four rock types were collected from the field. The samples were used for thin section preparation, which aided the microscopic examination of samples to determine their mineralogical composition and optical features under the polarizing microscope.

III. RESULTS

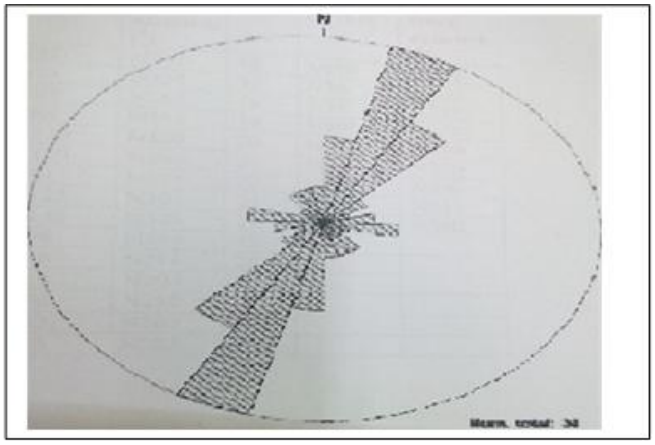
The measurement of structural altitudes (strikes, dips and dip direction) of some structures from the area are presented in Tables 1 to 10. Each table summarizes the field measurement of either foliation, joint or vein in the area.

Tables 1, 2, 3 and 4 show the field measurements of foliation trends. Figure 4, 5, 6 and 7 show the rose diagram of the foliation. The dominant trends are in the NE-SW and NW-SE directions. Table 1 shows the foliation readings as observed on gneiss of the area.

Table 1: Foliation readings as observed on gneiss of the study area.

S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth
1	N35	N215	14	N20	N200	27	N115	N295
2	N37	N217	15	N24	N204	28	N92	N272
3	N09	N189	16	N21	N201	29	N50	N230
4	N15	N195	17	N26	N206	30	N56	N236
5	N14	N194	18	N25	N205	31	N40	N220
6	N12	N192	19	N174	N354	32	N28	N208
7	N30	N210	20	N88	N268	33	N78	N258
8	N32	N212	21	N156	N336	34	N153	N333
9	N20	N200	22	N60	N240	35	N140	N320
10	N18	N198	23	N121	N301	36	N136	N316
11	N22	N202	24	N101	N281	37	N30	N210

12	N38	N218	25	N170	N350	38	N12	N1192
13	N19	N199	26	N90	N270	39	N08	N188

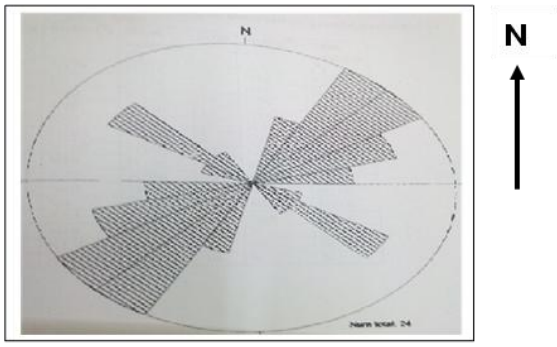


Strike Direction: 30 classes

Figure 3: Rose diagram showing trend of foliation on gneiss SW of the area, Major trend: NNE-SSW.

Table 2: Foliation readings as observed on granite gneiss NE of the area.

S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth
1	N52	N232	9	N146	N326	17	N20	N300
2	N54	N234	10	N96	N276	18	N55	N235
3	N82	N262	11	N36	N216	19	N102	282
4	N68	N248	12	N23	N203	20	N39	N219
5	N120	N300	13	N70	N250	21	N40	N220
6	N100	N280	14	N85	N265	22	N60	N240
7	N94	N274	15	N45	N225	23	N30	N210
8	N122	N302	16	N108	N288	24	N130	N310

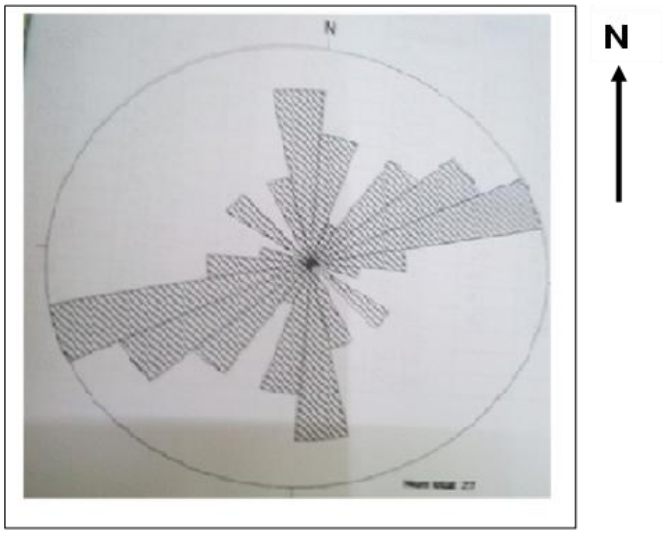


Strike Direction: 30 classes

Figure 4: Rose diagram showing trend of foliation on granite gneiss NE of the area, Major trend: NE-SW.

Table 3: Foliation readings as observed on granite gneiss SW of the area.

S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth
1	N178	N358	10	N40	N220	19	N168	N348
2	N174	N354	11	N04	N184	20	N70	N250
3	N40	N220	12	N50	N230	21	N60	N240
4	N70	N250	13	N48	N228	22	N90	N270
5	N60	N240	14	N170	N350	23	N42	N222
6	N164	N344	15	N60	N240	24	N125	N305
7	N160	340	16	N12	N192	25	N130	N310
8	N10	N190	17	N80	N260	26	N55	N235
9	N20	N200	18	N79	N259	27	N48	N228



Strike Direction: 30 classes

Figure 5: Rose diagram showing trend of foliation on granite gneiss SW of the area, Major trend: E NNW-SSE

Table 4: Foliation readings as observed on granite gneiss central part of the area.

S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth
1	N60	N240	15	N106	N286	29	N138	N318
2	N84	N262	16	N52	N232	30	N66	N246
3	N140	N320	17	N134	N314	31	N122	N302
4	N44	N320	18	N42	N222	32	N123	N303
5	N71	N251	19	N106	N286	33	N65	N245
6	N72	N252	20	N136	N316	34	N68	N248
7	N104	N284	21	N134	N314	35	N88	N268
8	N54	N234	22	N142	N322	36	N90	N270
9	N120	N300	23	N142	N322	37	N118	N298
10	N65	N245	24	N148	N328	38	N60	N240
11	N58	N238	25	N122	N302	39	N120	N300
12	N136	N316	26	N148	N328	40	N136	N316

13	N98	N278	27	N145	N325	41	N30	N210
14	N70	N286	28	N150	N330	42	N22	N202

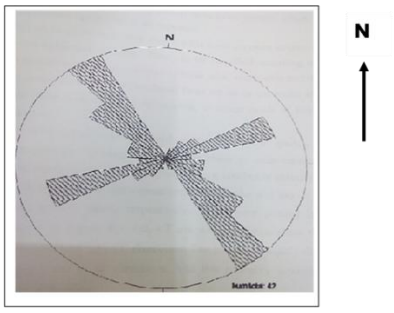


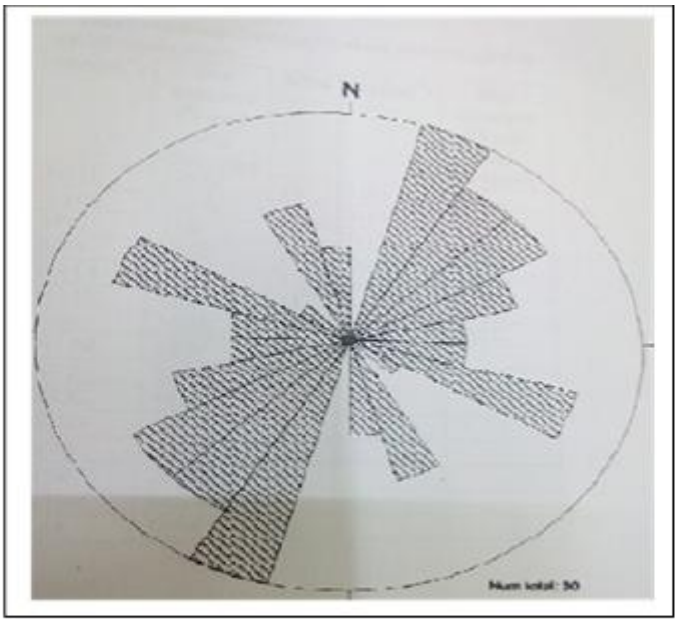
Figure 6: Rose diagram showing trend of foliation on granite gneiss from Central part of the area, Major trend: NW-SE and ENE-SSW

Joints: These are fractures along which there has been no observable movement of one side of the block relative to the other.

In the area, joints were observed on the outcrops of gneiss, granite gneisss and pegmatite. Gneiss show shear or cross-cutting joints (Figure 8) while granite gneiss and pegmatite show cooling or shrink joints (Figure 9 and 10). Tables 5, 6, 7 and 8 show measurement of strike and dip of joint on gneisss and the granite gneiss respectively. These were plotted into rose diagram as shown figures 8, 9, 10 and 11. The joints show the dominant trends in the NE-SW and NW-SE directions. The joints are widely distributed in the rocks and trends in all directions and this probably account for the dendritic pattern in the area.

Table 5: Joint readings as observed on gneiss SW of the area.

S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction
1	N22	8SE	11	N45	32SE	21	N27	60SE
2	N40	20SE	12	N60	35SE	22	N56	11SE
3	N164	72SW	13	N118	80SW	23	N116	70SW
4	N110	50SW	14	N60	12SW	24	N170	35SW
5	N120	40SW	15	N30	21SE	25	N105	64SW
6	N178	90	16	N38	20SE	26	N90	58SE
7	N50	90	17	N160	13SE	27	N78	20SE
8	N19	40SW	18	N42	53SE	28	N100	20SW
9	N48	70SW	19	N25	10SE	29	N80	80SE
10	N60	45SE	20	N18	63SE	30	N156	72SE

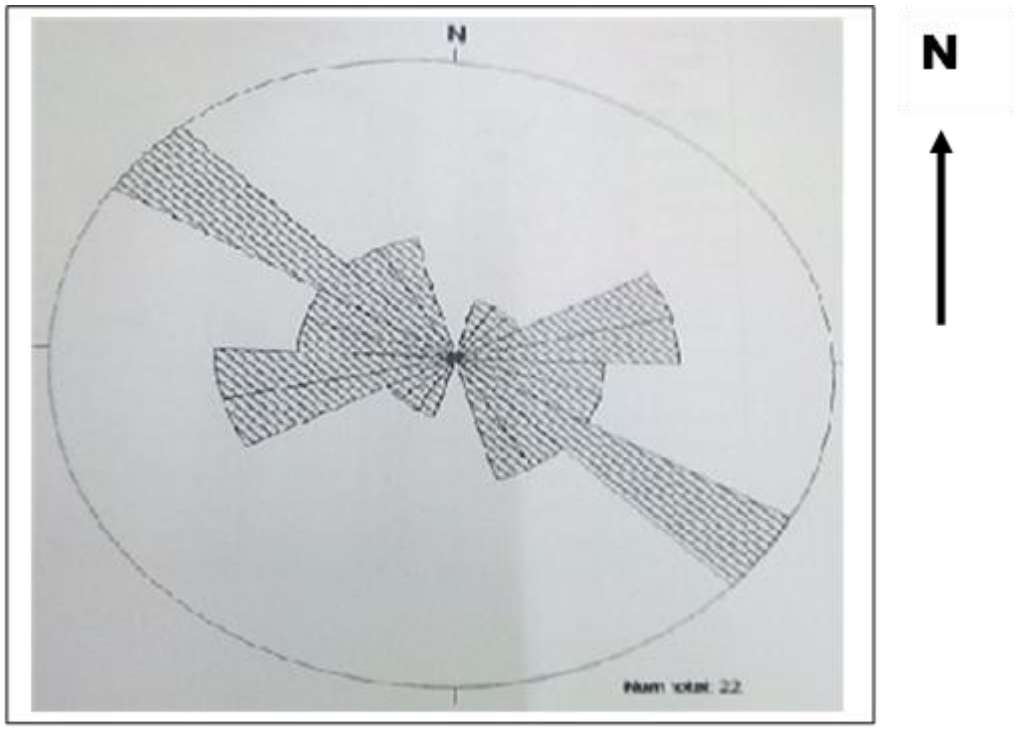


Strike Direction: 30^0 Classes

Figure 7: Rose diagram showing trend of joints on gneiss SW of the area. Major trend: NE-SW.

Table 6: Joint readings as observed on granite gneiss NE of the area.

S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction
1	N120	22SW	9	N75	25SE	17	N150	17SW
2	N108	18SW	10	N132	48SW	18	N150	16SW
3	N90	15S	11	N134	10SW	19	N148	80SW
4	N84	27SE	12	N70	19SE	20	N126	12SW
5	N114	40SW	13	N58	28SE	21	N30	56SE
6	N140	52SW	14	N100	34SW	22	N24	48SE
7	N60	30SE	15	N66	40SE	23		
8	N130	4SW	16	N80	9SE	24		

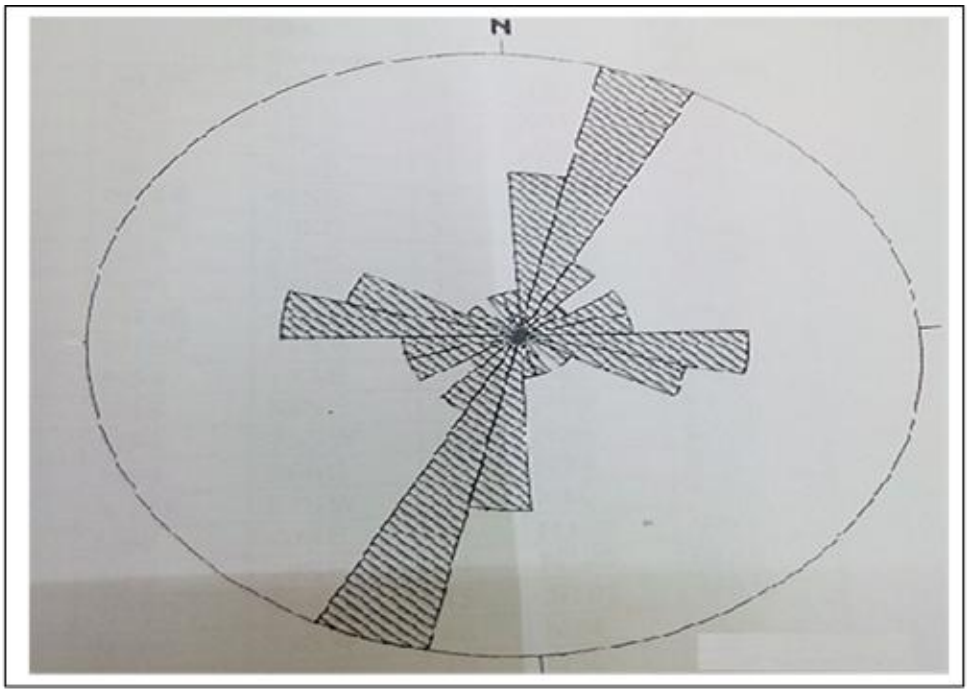


Strike Direction: 30^0 Classes

Figure 8: Rose diagram showing trend of joint on granite gneiss NE of the area. Major trend: NW-SE.

Table 6: Joint readings as observed on granite gneiss SW of the area.

S/NO	Strike(^{0})	Dip amount(^{0})	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction
1	N102	18	9	N100	68	17	N35	25
2	N115	12	10	N23	87	18	N29	56
3	N120	66	11	N15	45	19	N12	83
4	N96	42	12	N30	9	20	N10	22
5	N20	58	13	N60	22	21	N97	27
6	N27	62	14	N20	74	22	N16	44
7	N88	70	15	N50	31	23	N110	14
8	N70	38	16	N86	10	24	N12	23



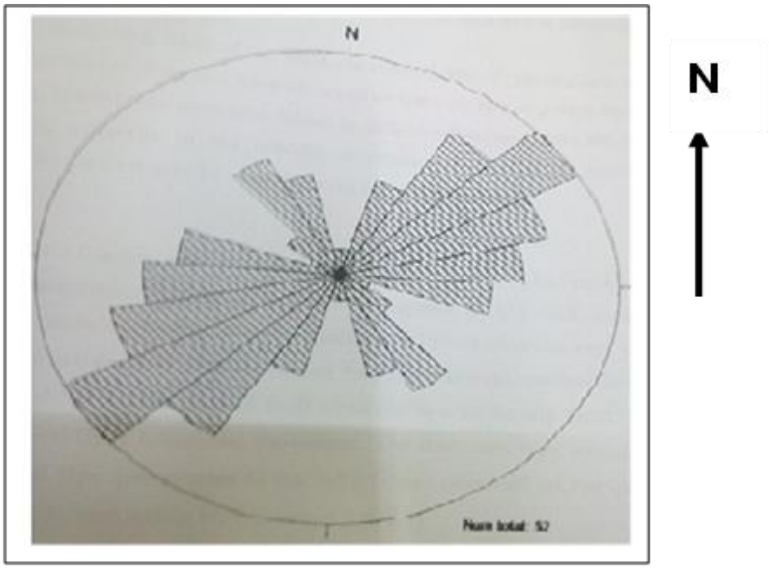
Strike Direction: 30^0 Classes

Figure 9: Rose diagram showing trend of joints on granite gneiss SW of the area. Major trend: NE-SW.

Table 8: Joints readings as observed on granite gneiss central part of the area.

S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction	S/NO	Strike(^{0})	Dip amount(^{0}) and dip direction
1	N126	60SW	19	N100	35SW	37	N48	33SE
2	N66	38SE	20	N76	20SE	38	N45	48SE
3	N45	90SE	21	N142	62SW	39	N10	30SE
4	N84	90SE	22	N60	15SE	40	N26	20SE
5	N148	40SE	23	N55	54SE	41	N34	30SE
6	N146	70SE	24	N50	80SE	42	N60	50SE
7	N68	22SE	25	N160	64SW	43	N150	60SW
8	N94	78SE	26	N85	90S	44	N140	68SE
9	N148	42SW	27	N70	90S	45	N102	60SW
10	N164	82SW	28	N20	22SE	46	N24	58SE
11	N34	18SE	29	N43	10SE	47	N50	66SE
12	N48	84SE	30	N52	45SE	48	N40	56SE
13	N94	75SW	31	N34	30SE	49	N84	60SE
14	N80	36SE	32	N40	62SE	50	N54	50SE
15	N178	88SW	33	N98	63SW	51	N60	30SE
16	N68	40SE	34	N120	38SW	52	N32	9SE
17	N89	20SE	35	N112	39SW			

18	N150	76SW	36	N20	62SE			



Strike Direction: 30^0 Classes

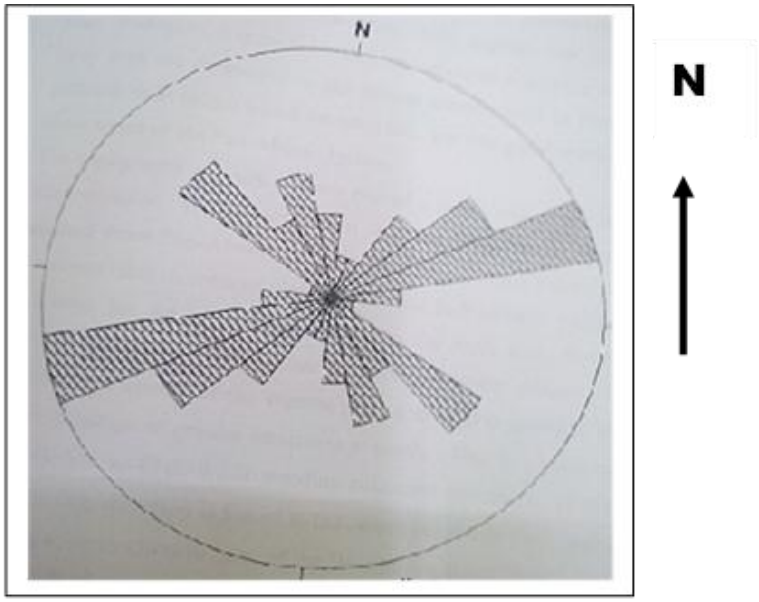
Figure 10: Rose diagram showing the trend of joints on granite gneiss central part of the area. Major trend: NE-SW.

In Barkin Timanga area, there are quartz veins and quartzofeldspathic veins. The quartzofeldspathic veins were scantly distributed while the quartz veins occur more frequently in different directions on the outcrop of the granite gneiss and gneiss. Rose diagram of the quartz veins on the rock units (gneiss and granite gneiss) show dominant trends in the NE-SW direction (Table 9, and Figures 13). These trending directions represent the oldest fractures, which have been annealed by mineral filling (Oluyide, 1988).

Table 8: Quartz vein readings as observed on granite gneiss of Barkin Timanga.

S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth	S/No	Strike (^{0})	Back azimuth
1	N60	N240	20	N50	N230	39	N165	N345
2	N70	N250	21	N130	N310	40	N128	N308
3	N40	N220	22	N170	N350	41	N128	N308
4	N37	N217	23	N121	N301	42	N60	N240
5	N120	N300	24	N65	N245	43	N45	N225
6	N140	N320	25	N40	N220	44	N50	N230
7	N50	N230	26	N80	N260	45	N143	N323
8	N150	N240	27	N33	N213	46	N60	N240
9	N60	N240	28	N31	N211	47	N150	N330
10	N60	N240	29	N150	N330	48	N140	N320
11	N105	N285	30	N70	N250	49	N170	N350
12	N134	N314	31	N15	N195	50	N60	N240
13	N60	N240	32	N48	N228	51	N74	N254
14	N12	N192	33	N55	N235	52	N165	N345
15	N85	N262	34	N70	N250	53	N58	N238

16	N11	N191	35	N20	N200	54	N150	N330
17	N75	N255	36	N130	N310	55	N136	N316
18	N160	N340	37	N95	N275	56	N125	N305
19	N50	N230	38	N130	N310			



Strike Direction: 30^0 Classes

Figure 13: Rose diagram showing trend of quartz vein on granite gneiss of Barkin area. Major trend: ENE-WSW.

IV. STRUCTURAL INTERPRETATION

The dominat strike direction of major structures (foliation, joint, strike-slip, fault and shear zone) in all parts of Barkin Timanga area are NE-SW and N-S but NW-SE direction also occur. The pegmatites were emplaced along these structural directions.

The many structures and the different structural trends in the area indicate that at different geological times, different geological events affected the rocks of the mapped area. The fracture in the rock where either filled with quartz or materials of aplitic and pegmatite composition. The rose diagram of the quartz veins in the gneiss show trends in the NE-SW and NW-SE directions. This suggests that the fractures in which the vein bodies were emplaced were oriented along these directions. The dykes show NW-SE trends. This also suggests the directions of the earlier fractures formed in the host rocks. The micro-faults are indication of shearing in the rocks of the mapped area. The mineral have been rearranged so that most of the felsic ones is in one layer while the mafic part is in another layer. The alternating granite gneiss indicates that the rocks are products of recrystallization under directed stress at a relatively high temperature. The micro-fold defined by these band suggest that the rock were deformed plastically. This is another indication of high temperature condition during the formation of the oldests rocks of the area. The flow banding associated with the rocks may have developed as a response to the external pressure exerted on the rocks.

V. DISCUSSION

The field distribution of the Pan-African (Older) Granite (e.g. diorite) and their relation with the pegmatites show that the emplacement of the pegmatite was controlled by the late Pan-African shear system considering the more precisely studied area of

granite-related rare metal deposits (Kuster, 1990, Andrew-Jones, 1999). The topography of the area appears to have played a major role in the location of mineralized area. The mineralization is concentrated in the shear zones that resulted from Pan-African Orogeny and followed the pre-existing zones of weakness (that is foliated planes, joints and fault planes), which provided the pathways for the mineralizing fluids. In Barkin Timanga, Sn-Nb-Ta bearing sheeted structures were observed along fracture plane. The regional geochemical zoning of the Wamba pegmatite field is probably intrusions at depth, which is controlled by NW-SE and NE-SW to ENE-WSW trending structural lineaments of the mega shear system. This direction is linked to the Jemaa pegmatite field, and a NNW-SSE prolongation to Gwantu (part of the Wamba pegmatite field) where one of the most evolved pegmatites in central Nigeria has been mapped (Kuster, 1990).

It thus appears that pegmatite intrusion and subsequent mineralization in both Wamba and Jama fields are related and controlled by the same late tectonics of the Pan-African shear movement. The pegmatites are typically products of crystal recycling and related to major tectonic lineaments. The repeating pattern of crystal reactivation are typical for the whole of West Africa and have probably been a fundamental factor in determing the occurrence and distribution of economic mineral deposits (Matheis, 1983, Wright *et al*., 1985)

CONCLUSION

Barkin Timanga area is underlain by rocks of the Basement Complex (gneiss, granite gneiss, diorite and granite pegmatite). The gneiss and granite are foliated while diorite and granite pegmatite are not foliated. The development of the pan-African rare-metal pegmatites of Central Nigeria is genetically related to the post-kinemagnetic late orogenic shear tectonic. The late orogenic shear tectonic and other associated process such as granitization, uplift, fracturing are believed to have probably tapped the consolidating granites and enhanced the capture residual pegmatitic melts and fluids to escape and intrude into the shear opened joints and other tension gnashes of the gneissic country rock where they finally crystallized.

The structures which characterized the rocks in the Barkin Timanga area represent emplacement and tectonic structures. They include foliation, joints, folds, faults, veins and dyke, which have various trends in NE-SW, NW-SE, N-S and ENE-WSW. These structural directions are almost conformable with the major structural trends of the Nigeria Basement Complex.

The differential erosion, which occurred after the associated uplift of the Pan-African Orogeny led to the formation of eluvial and alluvial deposits that resulted from the transportation and deposition of valuable economic minerals along river and stream chained in the studied area.

REFERENCES

[1] Jacobson, R. and Web, J.S. (1946). The pegmatite sod Central Nigeria. *Geological Survey of Nigerian Bulletin*. No. 17.

[2] Kuster, D. (1990). Rare-metal pegmalites of Wemba, Central Nigeria: Their formation in relation to late Pan-African granites. *Mineral Deposits*. 25: 25-33.

[3] Matteis, G. and Caen-Vachette, M. (1983). Rb-Sr isotopic study rare-metal bearing and barrer pegmatites in the Pan-African reactivation zones of Nigeria. *Journal of African Earth Science*. 1: 35-40.

[4] Oluyide, P.O. (1988). Structural trends in the Nigeria basement Complex. In: Precambrian geology of Nigeria. *Geological Survey of Nigeria.* Pp. 93-98.

[5] Whitten, D.G.A. and Brooks, J.R. (1972). The penguin dictionary of geology. Hazel Watson and Vinny Publication Limited Aulesbury Buck.

[6] Wright, J.B. and McCury, P. (1971). On place and time in orogenic granite plutonism. *Geological Society of American Bulletin*. 82: 147-1713.

[7] Wright, J.B. (1970). Controls of mineralization in older and younger tin fields of Nigeria. *Economic Geology*. 65: 945-951.