Petrography and Structural Features of Migmatites, Granites and Granite Gneisses at Osokom and its Environs Bansara area Southeastern Nigeria

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ABSTRACT

The Osokom area is made up dominantly of varieties of high-grade metamorphosed rock successions and large volume of granite intrusive rocks. These metamorphic rock assemblages were intruded at various locations by prominent exposures of granite, aplite and granite pegmatite, while host rocks are granite gneiss and migmatites of granodioritic composition. Field studies were carried out, on the structural features of the rocks, small scale geological structures as they occur in the field. They were investigated aim at unraveling the tectonic events in the area which terminated with the intrusion of the granite.

Representative samples for petrographic studies were obtained. The following minerals were observed for the rocks biotite granite (quartz, biotite, K-feldspar, hornblende and accessories); migmatites (plagioclase, hornblende, biotite, microcline and quartz); charnokites (plagioclase, hornblende, biotite, microcline and quartz) and pegmatite (quartz, plagioclase feldspar, orthoclase feldspar, muscovite, and biotite). Structures found in the area include; fractures, faults, folds, joints, mineral lineations, as well as pinch and swell structures. Structural plots in the area show a major N-S to NE-SW trending and a minor E-W to NW-SE trend ratio 3:1 are also present. The presence of fractures in the area are asset to groundwater search targets, availability and mineral exploration targets.

(Keywords: rock features, petrographic analysis, basement/sedimentary rocks contact, Bansara area, southeast Nigeria)

INTRODUCTION

The Osokom area in Bansara sheet is part of the terminus of Bamenda Massif of Cameroon into southeastern Nigeria (Egesi and Ukaegbu, 2010; Egesi, 2015). It is in the proximity of the basement sedimentary contact boundary. Some of the available reports of the area are regional aeromagnetic survey which identified the area as Basement Complex with preponderance of NE trending anomalies and lineament analysis which shows that high lineament densities are mapped in areas of outcropping bedrock and thin overburden (Iliya and Bassey, 1993; Edet *et al*., 1994). Figure 1 is the satellite terrain map showing the study area.

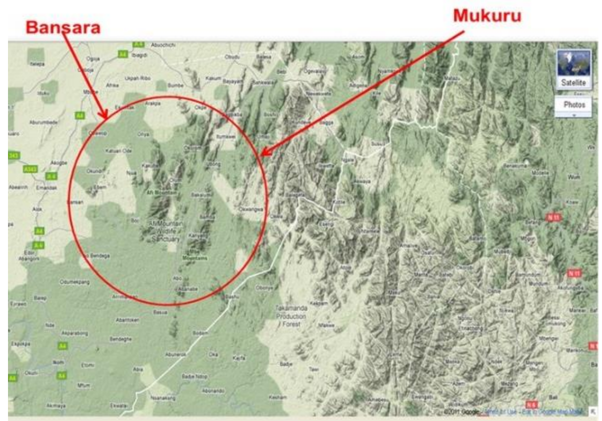

Figure 1. Satellite Terrain Map showing Fractures in Bansara Area. (Google Earth, 2017).

More recently, Egesi and Ukaegbu (2010, 2011), and Egesi (2015) mapped and differentiated the rocks of Bansara and Mukuru (sheets 304 and 305). The Bansara area, in the western part of present day Boki Local Government Area, Cross River State, is part of the terminus of the Bamenda highlands of Cameroon into southeastern Nigeria and it lies between latitude 06º 10' to 06º 30' N and longitudes 008º 43' to 009º 00' E with the famous Obudu Plateau in Obalinku Local Government in the northeastern part of the study area. The Benue Trough is located in the Northwest, Mamfe embayment to the south, and Kanyang in Mukuru sheet to the east.

The Bansara sheet 304 NE and SE consists of Igneous, Metamorphic and Sedimentary rocks**.** The metamorphic rocks which are made up of gneisses, schists, amphiboites, quartzites and phyllites. The gneisses, which are quite extensive, include granite gneiss at Agba Osokom, Augen gneiss at NjuaKaku hills, migmatitic gneiss at Katchuan and pyroxene bearing gneiss (granulites) at Buanchor (Egesi and Ukaegbu, 2010) (Figure 2).

There are several hills which form Afi mountain chains and Afi Sanctuary, and Mbe mountain chains. The schists which have been fractured and weathered occur and these schists include migmatite schist and homogenous schist. Also, intrusive rocks are found to occur in this area and they include, granite at Ogep Osokom, charnockite at Buanchor, granite and granite with pegmatite at Iso Bendiga and pegmatite at Uwupriver near Boje the Local Government Area (LGA) headquarters. This research therefore, sets out to characterize the petrographic and structural features of the intrusive and metamorphic rocks which are found at the contact between the basement and the sedimentary rocks of the Bansara area with a view to putting up a petrographic history of the study area.

GEOLOGICAL SETTING

The rock types found in the study area are granite and granite gneiss at Osokom, migmatite at Katchuan Ode and Njua Kaku, pegmatite at Uwup River and granite, granite pegmatite at Iso Bendiga. They are the locations were surface exposure of the basement rocks were observed and mapped, and sedimentary basement contact identified within range of 150m to 257m (Egesi, 2015).

Accessibility of the study area is through Okundi, Okubushyu, and Bansan areas which are within the sedimentary area basement contact. Figure 2 is the structural map showing cross-section A-B displaying the rocks encountered. The major communities in the sedimentary/basement contact areas are Okundi, Ogep Osokom, Agba Osokom, Okubushuyu, Katchuan Ode and Iso Bendiga. Intrusive igneous rocks are formed from magma rising within the Earth's crust. Unlike the extrusive rocks crystallize below the earth's surface, and their presence becomes obvious only after the country rock into which they were intruded has been removed by erosion.

Intrusions show great variation in form. Some cut across bedding planes (discordant), while others run parallel with them. At Ogep Osokom, the rocks are discordant having size of boss with circular steeply inclined features. Metamorphism is the process of change that rocks undergo when exposed to increasing temperatures and pressures. Rocks of any kind may undergo metamorphism. The preservation of relicts of parent rock or bedding as observed at Katchuan and Njua Kaku implies that metamorphic change takes place in a solid, rather than a molten state (Egesi and Ukaegbu, 2011).

The occurrence of structural features in rocks is not a random process; rather they are associated with stresses and prevailing environmental conditions. Consequently, the spatial distribution and styles of structures in rocks are related to the amount and configuration of stresses that produced them. The analysis of these structural elements in rocks is an effective means of determining the tectonics that affected the rocks in a region. Information from such analysis gives an idea about the nature, amount of strain as well as the orientation of the maximum, intermediate and minimum stresses (σ_1, σ_2 and σ_3) which affected the geometry of the rocks and their associated structures occurring within the region.

METHODOLOGY

Field work was carried out in the area to identify the rock types. The selection of samples for analysis was done randomly in such a way that they are statistically representative of the entire rocks under investigation. The main goal is to collect sufficient random samples so that the main petrographical characteristics are adequately represented in which case sampling bias was eliminated. However, strict statistical requirements could not be satisfied because the samples were selected from exposures which are not continuous some areas have lateritic deposits of about 6 to 35m.

Ten (10) fresh surface representative rock samples were collected from outcrops of all the intrusive in the area and carefully selected during field mapping exercises for the preparation of thin sections or rock slices for petrographic studies. The rock slices were prepared at the laboratory of the Department of Geology, University of Calabar, Calabar and University of Port Harcourt, Port Harcourt Nigeria.

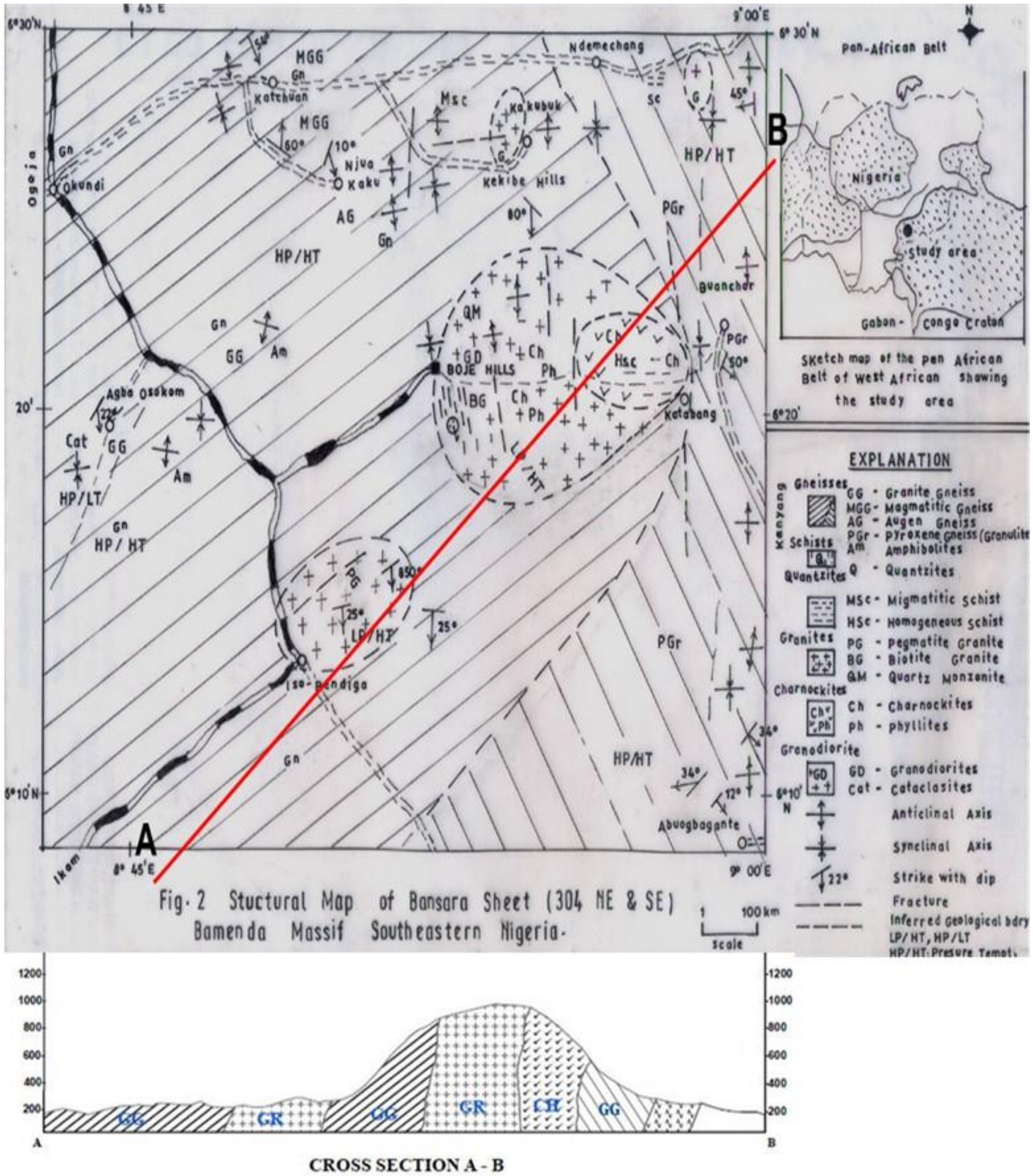

Figure 2: Structural Map of the Study Area with the Western Part of the Map showing Katchuan Ode, Njua Kaku, Agba Osokom, and Iso Bendiga Areas.

RESULTS AND DISCUSSION

Petrographic Analysis

Migmatites and granite gneisses Plate 1, were identified at Katchuan Ode, Njua Kaku and Osokom areas while biotite granite, granite-pegmatite and pegmatite, are present at Ogep Osokom, Iso Bendiga and Uwup River.

The migmatites are massive and form two highlands above 200m in the area Plates 1 and 2. Petrographic and chemical analysis indicates that they of granodioritic composition (Egesi, 2015).

Plate 1a.

Plate 1b.

Plates 1: Photomicrograph Showing Sutured Grain Boundary between Microcline Cross-Hatching, Orthoclase and Quartz Crystals. The rock has microperthite features (X40).

The depth to the basement from boreholes drilled at Okubushuyu and Katchuan range from 35 to 40m and increases as one move to Okundi areas, while Iso Bendiga areas are from 6 to 10m.

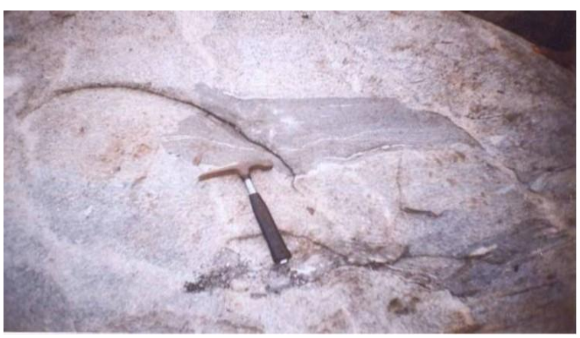

Plate2a: Field Photograph of Granite Gneiss showing a Lens of Amphibolites and Exfoliation Features at Agba Osokom.

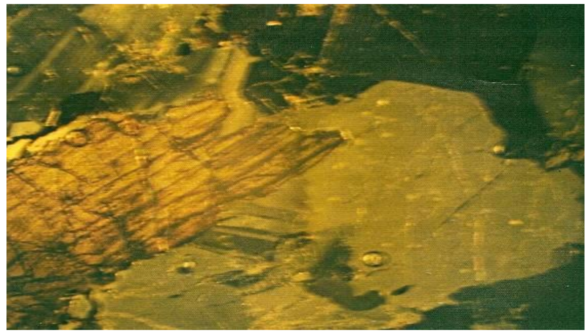

Plate2b: Photomicrograph showing Dominant Minerals Carlsbad Orthoclase and Microcline Twin, Albiteplagioclase Twin, Quartz, Opaque Minerals in Granite Gneiss at Agba Osokom.

Structural Analysis

The structural imprints or features of Katchuan, Njua Kaku, Agba Osokom, and Ogep Osokom Bansara Area, shows that the metamorphic rocks have undergone series of deformation resulting in planar and linear structures. It also shows the similarity between Precambrian basement rocks of the study area and the crystalline basement rocks occurring in other parts of Nigeria like Obudu sheet 291.

The orientation of the structural imprints or features indicates that N-S and NE- SW are products of the pan African orogeny, while the E-W and NW-SE orientations are relicts of pre-pan African orogeny, which were not completely obliterated in the area.

The E-W fracture trends are attributed to brittle deformation which was produced by transcurrent movement. Lenticular leucosome minerals, ptygmatic folds, and undulose extinction in quartzo-feldspathic minerals are also present Figures 3 and 4.

The stereonet in Figure 5 indicates concentration of structures in the NW part of Kekibe Hills and the rose diagram is indicated on Figure 6. Plastic deformation, fault and high degree of migmatisation is indicated by flow structures at Ogep Osokom stream, Plates 3 and 4, and dykes on Plates 5 and 6.

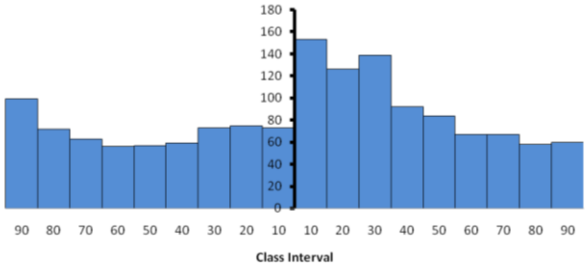

Figure 3. Histogram of Foliation Trends shows Development of Wavey or Contorted Layers under more intense Metamorphism at Katchuan.

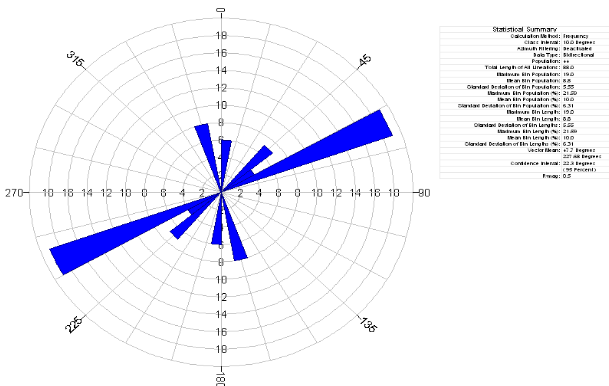

Figure 4. Fold Axis of migmatitesat Njua Kaku hills (n=60).

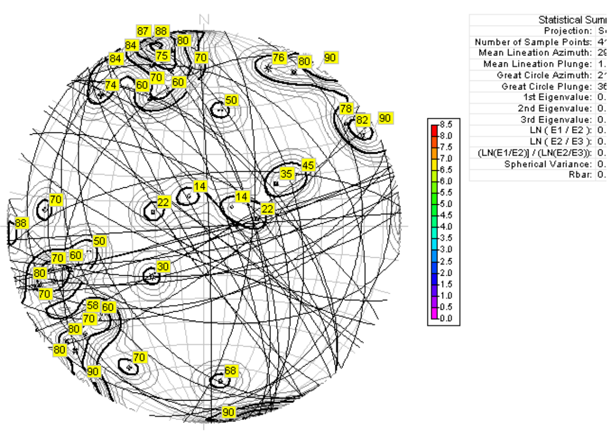

Figure 5: Stereonet with Strike and Dip of Foliations Amounts Plots in SW, NE and NW at Kekibe Hills.

The rose diagrams at Kekibe Hills, Katchuan Ode and Agba Osokom are for mineral lineation are comparable Figures 6, 7, and 8.

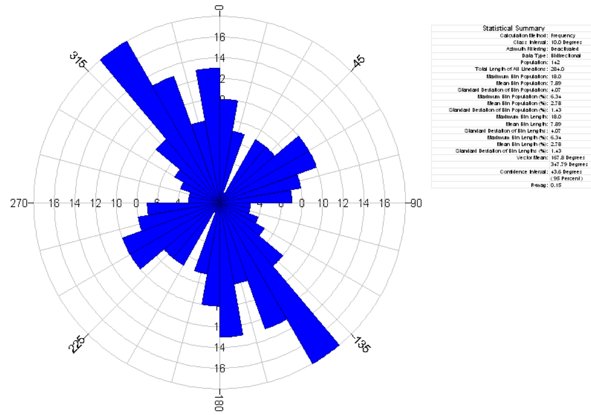

Figure 6: Rose Diagram of Mineral Lineation of Kekibe Hills (n=350).

Plate3: Field Photograph of a Normal Fault on Granite Gneiss at Ogep Osokom.

Plate 4: Field Photograph of Planar Structures, Symmetrical, Asymmetrical and Flow Structures Evidence of Plastic Deformation in Granite Gneiss.

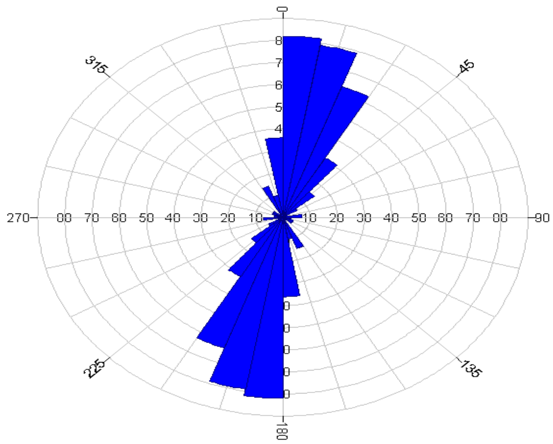

Figure 7: Rose Diagram of Mineral Lineation in Granite Gneiss showing mainly NE-SW at Katchuan (n=500).

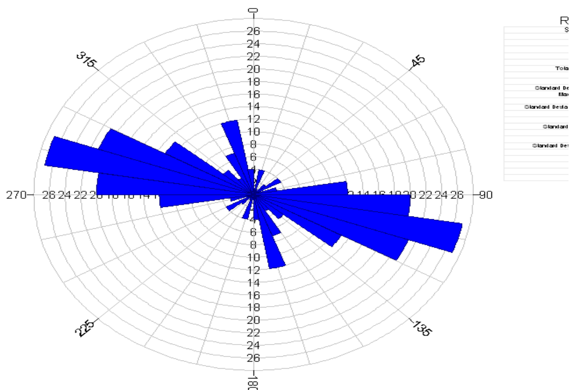

Figure 8: Rose Diagram of Mineral Lineation in Granite Gneiss showing mainly NW-SE at Agba Osokom (n=550).

Plate 5: Field Photograph showing Measurements on Pegmatite at Uwup River.

Plate 6a: Field Photograph showing Granite Pegmatite at Iso Bendiga

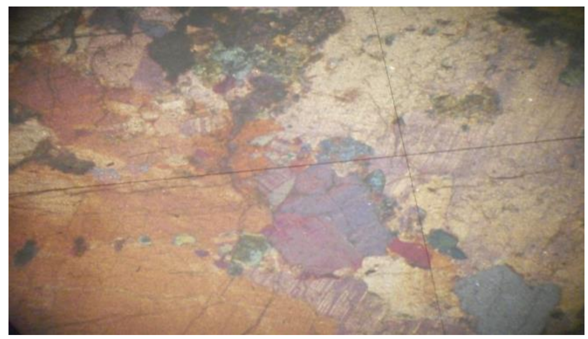

Plate 6b: Photomicrograph of Orthoclase, Quartz, Biotite and Opaque Minerals.

The migmatites of the study area may have resulted from mineral reaction, which generated leucosome bands under close system in anatectic situation (Dougan, 1981). Ekwueme and Kroner (1997) were of the view that the migmatites of Obudu area are anatectic in origin. The migmatites are frequently in association with granitic intrusions and are absent where no intrusion exists. Similar relationship exists in the basement of SW Nigeria (Rahaman, 1989). Therefore, the migmatites in Bansara area probably have genetic link with the intrusions.

The granites mapped in the area are granite with pegmatite and biotite granite. The pegmatites are simple and complex types at Iso Bendiga and Uwup River. The simple pegmatites occur in granite, the width varies from 0.5 – 3 cm and length 15 cm to 5.0 m. The latter is target for rare earth elements in mineral exploration of the area.

Table 1 shows the average modal composition of minerals in migmatite, granite gneiss, granite and pegmatite at the basement/sedimentary contact from the Bansara area.

Plate 7: Field Photograph showing Biotite Granite with Exfoliation features at Ogep Osokom hills.

Table 1: Average Modal Composition of Rocks from Bansara Basement/Sedimentary Contact.

Mineral	Migmatite n = 14	Granite Gneiss n=16	Granite n=16	Pegmatite n=8
Quartz	25	27	30	36
K-feldspar	20	30	29	30
Plagioclase	22	20	15	14
Biotite	10	7	8	2
Muscovite	5	5	7	3
Chlorite	-	-	-	-
Hornblende	6	6	-	-
Orthopyroxene	-	-	-	-
Clinopyroxene	-	-	-	-
Garnet	8	-	-	-
Olivine	-	-	-	-
Kyanite	-	-	-	-
Sillimanite	-	<1	-	-
Myrmekite	2	-	7	2
Perthite	-	3	<1	10
Opaque minerals	2	2	3	2

DISCUSSION

Fractures with normal faults show throws of (30 cm - 70 cm) from different points on garnet-mica-schist. Major and small scale faults also occur in igneous rocks at Ogep Osokom, Iso Bendiga, Enyi Boje, Ebok, and in metamorphic rocks at Agba Osokom, Kekibe Hills, Katchuan, Njua Kaku, Buanchor, and Katabang areas (Figure 2) with lineaments mostly in the N-S and NE-SW trends. In the shear zones at Ogep Osokom, Agba Osokom, Enyi Boje, Buanchor, and Kanyang areas, slickenside striae are widespread. They can be recognized by their sharp, fractured and brecciated features on rocks on top of the downthrown block in this fault zone.

Figure 3 is the histogram of plots of small-scale structures in the area showing development wavey or contorted layers at Katchuan.
These trends when compared with others are in agreement with those reported in other parts of the Nigerian basement. The E-W fold axis direction on migmatitic gneiss at Bamba appears to be the most prominent metamorphic rock structures in the area.

McCurry (1976) and Chukwu-Ike (1978) recognized only E-W and N-S trending folds in the western half of the Nigerian basement. However, Oluyide (1988) recognized four trends N-S, E-W, NE-SW and NW-SE. Ene and Mbonu (1988), Egesi and Ukaegbu (2010, 2013) recognized also four structural trends; E-W (Pre-Palaeozoic), N-S (middle Precambrian-Palaeozoic), NE-SW (Mesozoic?), and NW-SE (Santonian?).

The N-S and NE-SW directions were plotted at several locations like Katchuan, NjuaKaku, Katabang and Buanchor (Figures 4 and 7), while the NW-SE direction was plotted at Kekibe hills, Ogep Osokom and Agba Osokom (Figures 5, 6, and 8). The augen gneiss contains large porhyroblasts of feldspar, or aggregates of feldspar and quartz, often a centimeter or more across, which are eye-shaped at Njua Kaku.

The augengneiss at Buanchor is at the boundary area between the two sheets Bansara and Mukuru (Figure 1). They tend to be banded on a large scale with layers and streaks of darker and lighter colored gneiss. Boudins are common features in the schists at Kekibe hills and consist of leucocratic feldspar and quartz minerals, Njua Kaku rocks also displayed augen characteristics. Complex, disharmonic, drag, ptygmatic folds and pinch-and-swell structures are common features at Buanchor and Kanyang granulites.

Folds are more abundant in gneisses than in schists and amphibolites. Fold types are best displayed by structures that were formerly approximately planar prior to metamorphism. In NjuaKaku hills, migmatitic gneiss and augen gneiss occur. They are well formed open folds in augen-gneiss at elevation of 226.4m (Egesi and Ukaegbu, 2010). Metamorphic rocks of the area have been folded into antiforms and synforms. There are also similar folds which thicken towards their hinge. Asymmetrical type of fold is common at Kekibe Hills, Ogep Osokom, Agba Osokom and Katchuan in Bansara and Kanyang, Wula, Bakalum and Bamba in Mukuru areas. Plunge of 44º - 10º were identified with parasitic folds of Z-type and S-types (Egesi and Ukaegbu, 2010).

Mineral lineations, slickensides, boudins and fold axes are common in schists, migmatites and gneisses. They shows elongated parallel arrangement of schistose minerals along Ashuben-Katabang boundary areas while Ogep Osokom indicates slickensides on granite and in granite gneiss at Agba Osokom on the downthrown block with the strike 012º and dip of 22ºSE. At Katchuan mircotectonic station, the rose diagram indicate (000º-012º) fold axis of direction, mineral lineations and fractures (000º-030º) trend in north-south to northeast-southwest directions. Ekwueme (2003), pointed out that fine ridging of phyllosilicates, stretched quartz and feldspar aggregates define a prominent lineation in the migmatitic schist in the Kwa River Falls in the Oban Massif area.

CONCLUSION

The depth to top of Igneous and metamorphic rocks which occurs at the contact or boundary area between sedimentary and basement rocks ranges from 6 m to 35 m. The granite which are massive at Ogep Osokom area indicates exfoliation weathering while the granite gneiss and migmatites shows fractures, faulting, folding and dismembered boulders at the stream channel section which points to structural control flow direction. The size of the rocks is suitable for the production of aggregates and dimension stone construction while rare earth elements could be target for exploration in the complex pegmatite at Uwup river area.

REFERENCES

1. Chukwu-Ike, I.M., 1978. “The Regional Tectonic setting of the North-Western Nigeria Low-Grade Meta-Sedimentary Belt”. *Nigerian J. Min. Geol*. 15: 19 – 22.

2. Dougan, T.W. 1981. “Melting Reactions and Trace Element Relationships in Selected Specimens of Migmatiticpelite from New Hampshire and Maine”. *Contib. Mineral Petrology*. 339-344.

3. Edet, A.E., S.S. Teme, C.S. Okereke, and E.O. Esu. 1994. “Lineament Analysis for Groundwater Exploration in Precambrian Oban Massifand Obudu Plateau, SE Nigeria”. *Journal of Mining Geology*. 30(1):87 – 95.

4. Egesi, N. and U.V. Ukaegbu. 2010a. “Trace and Rare Earth Element Geochemical Fingerprints on the Petrogenesis and Geotectonics of the Enderbite-Adamellite-Granite Complex in parts of Bansara (sheet 304 NE/SE) SE, Nigeria”. *The IUP J. of Earth Sciences*. 4(2): 7–25. www.iupindia.org

5. Egesi, N. and V.U. Ukaegbu. 2010b. “Petrologic and Structural Characteristics of the Basement Units of Bansara Area, South-Eastern Nigeria”. *Pacific Jour. of Sci. and Tech*. 11(1): 510 – 525. http://www.akamaiuniversity.us/PJST_11_1_510.pdf

6. Egesi, N. and V.U. Ukaegbu. 2011. “Petrology and Major Element Geochemistry of Late to Post-Neoproterozoic Peraluminous Granitoids in parts of Bansara South-Eastern Nigeria”. *The IUP J. of Earth Sciences*. 5(3): 7-19.

7. Egesi, N. and V.U. Ukaegbu. 2013. “Petrologic and Structural of Basement Rocks of Parts of of Mukuru Area, Southeastern Nigeria”. *Earth Science*. 2(4):96 –103.

8. Egesi, N. 2015. “Petrology, Structural Geology and Geochemistry of parts of Bansara (sheet 304) and Mukuru (sheet 305), Southeastern Nigeria”. Unpubd Ph.D. Thesis Univ. of Port Harcourt pp 256.

9. Ekwueme, B.N. 2003. *The Precambrian Geology and Evolution of the Southeastern Nigerian Basement Complex*. University of Calabar Press, Calabar. 1-57.

10. Ekwueme, B.N. and A. Kroner. 1997. “Zircon Evaporation Ages and Chemical Composition of Migmatitic Schist in the Obudu Plateau: Evidence for Palaeoproterozoic (ca. 1789) Component in the Basement Complex of Southeastern Nigeria”. *J. Min. Geol.* 33(2):81–88.

11. Ene, K.E. and W.C. Mbonu. 1988. “The Metasedimentary Belts of the Nigerian Basement Complex – Facts, Fallacies and New Frontiers”. In: P.O. Oluyide (Cordinator). *Precambrian Geology of Nigeria.* Geol. Surv. Nigeria Publ. 53 – 67.

12. Goggle Earth. 2017. *Satellite Terrain Map Showing Factures in Bansara*.

13. Iliya, A.G. and N.E. Bassey. 1993. “A Regional Magnetic Study of Obanand Obudu Plateau Precambrian Massifs SE, Nigeria”. *J. Min. Geol*. 29(2):101–110.

14. McCurry, P. 1976. The Geology of the Precambrian to Lower Palaeozoic Rocks of Northern Nigeria – A Review". In: C.A. Kogbe (Ed.). *Geology of Nigeria*. Elizabethan Press: Lagos, Nigeria. 15 – 39.

15. Oluyide, P.O. 1988. *Structural Trends in the Nigerian Basement Complex.* In: P.O. Oluyide (Co-ordinator). *Precambrian Geology of Nigeria*. Geol. Surv. Nigeria Publ., pp 93 – 98.

16. Rahaman, M.A., 1989. "Review of the Basement Geology of Southwestern Nigeria". In: C.A. Kogbe (Editor). *Geology of Nigeria*. Elizabethan Publ. Co.: Lagos, Nigeria. 41 – 58.

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