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Petrography and structural features of rocks in the Owambe-Otanchi Mukuru area southeastern Nigeria

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Abstract

This study was done at Owambe-Otanchi community in Boki Local Government which lies in the Mukuru Sheet 305 NW, which is part of the larger Bamenda Massif of the Cameroon into southeastern Nigeria. The area lies between latitudes 06^0 25′ and 06^0 32′ N and longitude 009^0 08' and 009^0 13' E. The area is made up of predominantly high grade metamorphic rocks and igneous intrusions. Field megascopic studies was conducted to identify and determine the mineralogy of the rocks of the area, as well as study features small-scale geological structures as they appear in-situ to determine the tectonic event that led to the formation of the large-scale structures observed in the area, and the trending of the rocks. Representative sample were obtained for petrographic thin section studies. The following major minerals were observed from the rocks in the area. Granite gneiss (quartz (30%), biotite (10%), K-feldspar (23%), muscovite (7%) and accessories minerals; Schists (quartz (27%), feldspar (10%), muscovite (7%), biotite (21%), and Dolerite intrusion (plagioclase (50%), pyroxene (20%), olivine (19%)). Structural plots measurements of strike and dip amount shows a major trend in the NW-SE direction for the Owambe-Otanchi community while that of Begiagbah/Abijah community shows a major trend in the NE-SW direction with a minor trend in the E-W direction. The drainage patterns of the area shows high gradients, irregular courses and waterfalls which are structurally guided, the trend is mostly in N-S to NE-SW directions.

Keywords: Rock Types; Migmatites; Gneisses; Dolerites; Granites; Structures; Owambe-Otanchi Area

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1. Introduction

The study area Owanbe is located in the eastern part of Boki Local Government Area, it lies between latitude 06^0 25' and $06^0$32' N and longitude 009^0 08' and $009^0$13'. It's flanked in the NE-SW by an elongated rifted depression, the Benue Trough and on the southeast by the prominent Cameroun Volcanic Line (CVL) (Ekwueme, 1987; Edet et al.,1994). The Precambrian basement complex of Nigeria lies within the Pan–African mobile belt to the east of the West African Craton and Northwest of the Gabon-Congo Craton (Wright, et al., 1985). The Nigerian basement is polycyclic and includes rocks of Archean and Proterozoic Era and bears imprint of three thermotectonic events; Liberian (2700Ma), Eburnean (2000 Ma) and Pan African (600 Ma) orogenic events (Rahaman, 1988). The basement rocks which covers about fifty percent (50%) of the total surface area of Nigeria of about 192,400km and its extends into neighbouring countries like Benin to the west and Cameroon Republic to the east, and it forms the oldest rock series in Nigeria. The occurrence of structural features in a rock is not a random process, rather they are associated with stresses and prevailing environmental conditions. The spatial distribution and styles of structures in rocks are related to the amount and configuration of stresses that produced them. The objectives of the study is to identify the rocks and analyze structural element in rocks, to effectively interpret the tectonics or orogeny that affected the rocks in the area.

2. Geological setting

The two main units that dominate the regional geologic setting of the southeastern Nigeria are the Obudu plateau and Oban Massif and they constitute part of the Bamenda massif. It is N-S to NE-SW trends with a high grade metamorphic terrain that forms part of the Pan-African Trans Saharan belt exposures in the southeastern part of Nigeria. Ajibade and Fitches (1988), recognised that the basement complex rocks were remobilized and refolded during past orogenies in the Precambrian, before the advent of the Pan-African Orogeny (550+100Ma). Thus, accounting for the polycyclic deformations recorded as structural imprints or signet on the basement complex. Obudu plateau represents crystalline rocks exposures within the Pan-African polycyclic Precambrian period, characterized by high temperature and pressure metamorphic rocks which are predominantly migmatite-gneiss-schist complex, forming the country rocks and charnockitic, granitic plutons and pegmatite, aplite, quartz vein and dolerite dyke severally intruded them (Ukaegbu, 2003). Ejimofor et al., (1996) reports that migmatite-gneiss constitute about 75% of the crystalline basement rocks of Northern Obudu area. McCurry, (1989) reported the occurrence of granulite member that consists of meta-arkoses and hornblende schist at Zungeru, and Ukaegbu (2003), mapped gneissic granulites at Bebi area of Obudu plateau. Ukaegbu (2003), working just north of the Owambe-Otanchi area also reports that the complex axial planar folds deform into a series of tight, close to open isoclinals, anticlines and synclines that trend mainly N-S to NE-SW directions. While the fold constitutes the ductile structures, the large augen and rods of boudins, pinch and swell structures are conspicuous brittle deformational structure in the Obudu sheet southeast. The dominant orientation in the basement rocks are the structural imprints trending N-S to NE-SW direction and the relics of NW-SE and E-W structures are preserved. Foliation with steep dip (60^0-90^0) in the Obudu plateau were

identified (Ukaegbu and Oti, 2005). Crystalline basement rocks that form part of the basement complex of Nigeria underlie the Bamenda massif. The megascopic observation classifies the rocks of the area in to six (6) sub groups namely: amphibolite, migmatitic schist, granite, gneiss, meta-gabbro, intrusives, migmatitic gneiss. Field evidence shows that the Pan-African orogeny has left it structural imprints on the rocks of this area however, relicts of pre-Pan-African are also present. The occurrences of structural imprint on the basement complex of the Nigeria has always led to divided opinion. Grant (1978); Onyeagocha and Ekwueme (1982); Ekwueme (1987); Oluyide (1988); Ukaegbu (2003), Egesi and Ukaegbu (2010) believes that though very pervasive, the Pan-African event left some traces of the earlier structures. However, McCurry (1971) and Rahaman (1976) are of the opinion that the last Pan African event was so pervasive that it erased all earlier structural imprint. Figure 1, is the geological map of parts of Mukuru, Boki area, Egesi and Ukaegbu, (2013).

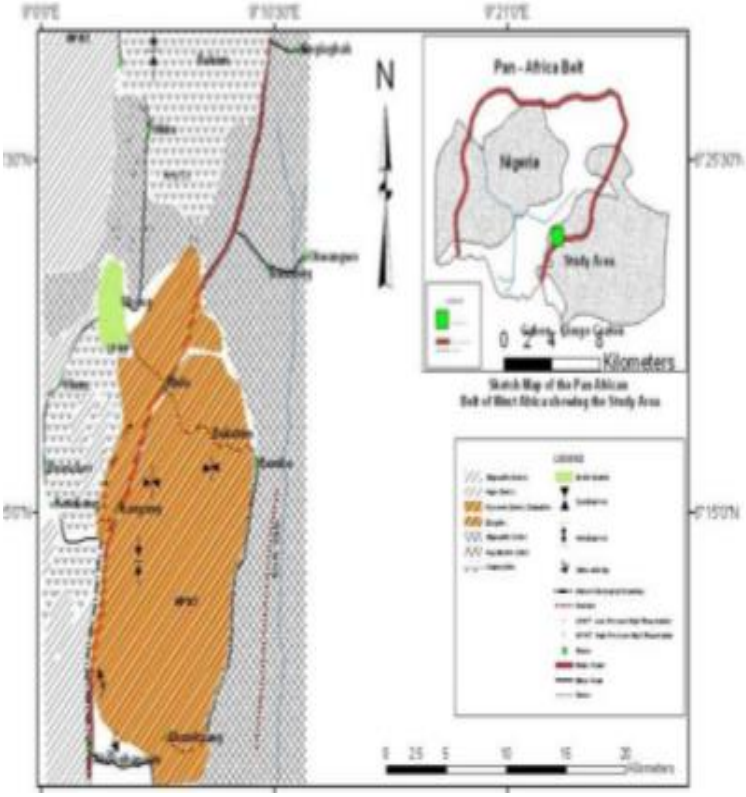

Figure 1. Geological Map of Part of Mukuru, Boki area, Southeastern Nigeria (Egesi and Ukaegbu 2013)

3. Methodology

Field work spanned over a period of three days was carried in the study area Boki Local Government. In the field small scale geological structures were studied as they were emplaced on the field. Sampling were made randomly but representative samples along the study area. Field transverse were made along roads, footpath, drainage channel, road cuts, waterfall surfaces. Field relations between rock units selected were given adequate attention. Fresh and representative samples for petrographic studies were collected. Samples were collected from Owambe-Otanchi, Abijah, Boki-Obanliku boundary and Begiagbah. The hand specimen of rocks

in the field were studied using hand lens which aided in giving tentative name to the sample. Structures present in the rocks were recorded as well as the texture of the rock. Eleven (11) fresh rock samples were collected from carefully selected rocks in the study area during the field mapping exercise for the preparation of thin section or rock slides for petrographic studies. The rock slides were prepared at the thin section laboratory of the Department, University of Port Harcourt, Port Harcourt, Nigeria.

4. Petrology

4.1. Granite gneiss

They are coarse grained igneous rock dominated by light coloured minerals consisting of orthoclase, quartz, mica and plagioclase and ferromagnesian minerals. In the study area they occur as low lying outcrop at the center of Owambe-Otanchi community Plate 1. The outcrop is highly weathered. The rock is light coloured in hand specimen, fractures such as joints are also present on the outcrop. The rock is mainly made up of quartz, feldspars and ferromagnesian minerals, biotite flaks, with a medium – coarse grained texture. The rock is mainly dark and light coloured. Quartz, orthoclase, pyroxene, biotite, hornblende, chlorite and accessory minerals are the minerals that compose the rock

Plate 1A. Field Photograph showing granite gneiss at Owambe-Otanchi community

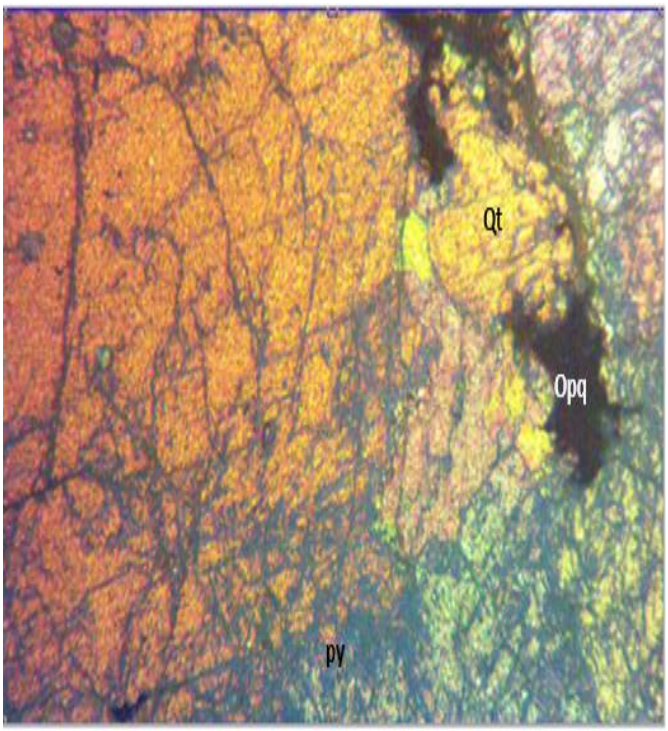

Plate 1B. Photomicrograph showing granite gneiss under XPL (X25) Qt- Quartz, Py- Pyroxene, Opq- Opaque

4.2. Schist

Schist is a strongly foliated metamorphic rock dominated by fibrous or platy minerals, it is formed by regional metamorphism and can be readily split into flakes or slabs due to well-developed parallelism of more than 50% of the minerals present, particularly mica and hornblende with lamellar or prismatic habit.

Schist is the dominant sedimentary rock type found in the area. They are medium grained rocks. They are found to be massive and extensive in the River Owan and also as low lying rocks at the boundary between Begiagba community and Owanbe-Otanchi community Plate 2. They are extensive and massive. They are highly weathered and also highly foliated. The rock is fractured (joints, folds). The rocks are grey to dark in colour in the field.They are mostly composed of more than 50% of elongated and tabular minerals. The most common minerals in schists are mica, quartz. Under microscope schist appears to have a thin alternating bands composed of brown or black band of mica. The mica sheet have their cleavage and their flat sides parallel. The quartz occurs in rounded, ellipitical or irregular grains, with a small mixture of feldspar (plagioclase-oligoclase). Minerals present in schists include the following quartz, plagioclase, K-feldspar, garnet, biotite, muscovite and hornblende.

Plate 2A. Field photograph showing schist

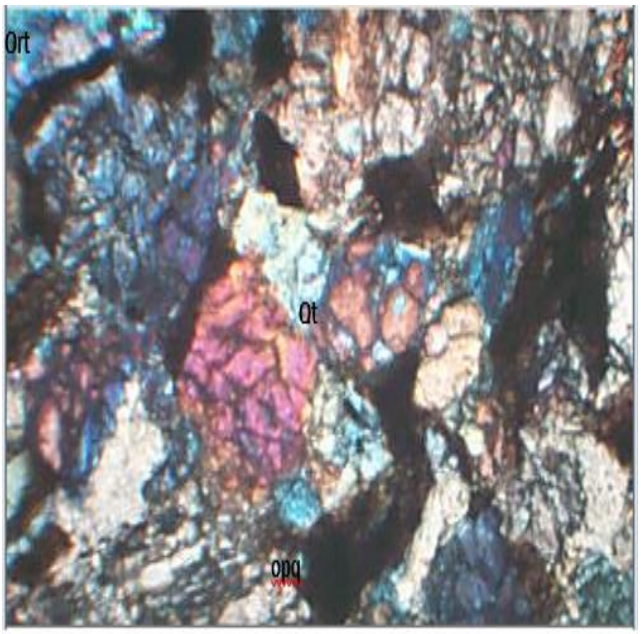

Plate 2B. Photomicrograph showing schist under XPL (25) Ort- orthoclase, Qt- Quartz, Opq- Opaque

4.3. Biotite gneiss

Biotite gneiss are present in the area. They are metamorphosed and displays a sharp contact relationship with the intruded rock. They were found to occur in Begiagbah village. In the field they occur as stock and bosses and are intruded by the Pan African granite and dolerite. Biotite gneiss is mainly made up of Quartz, orthoclase and ferromagnesian minerals with coarse grained texture. They are light to dark (mesocratic) in colour. Minerals compoistion of biotite gneiss includes quartz, biotite, feldspar, pyroxene, and accessories minerals. Biotite has a pale brown colour with high relief and occupies about 20% of the total mineral composition of the rock. Quartz is colourless which appears as groundmass in thin section with low relief, grains are large and

euhedral to subhedral in shape. Feldspar is pale brown to colourless under thin section, the grains are fairly cloudy due to alternation and are also subhedral in shape. The type of feldspar present is andesine due to its close association with the with biotite and hornblende.

Plate 3A. Field photograph showing Biotite gneiss at Owambe-Otanchi community

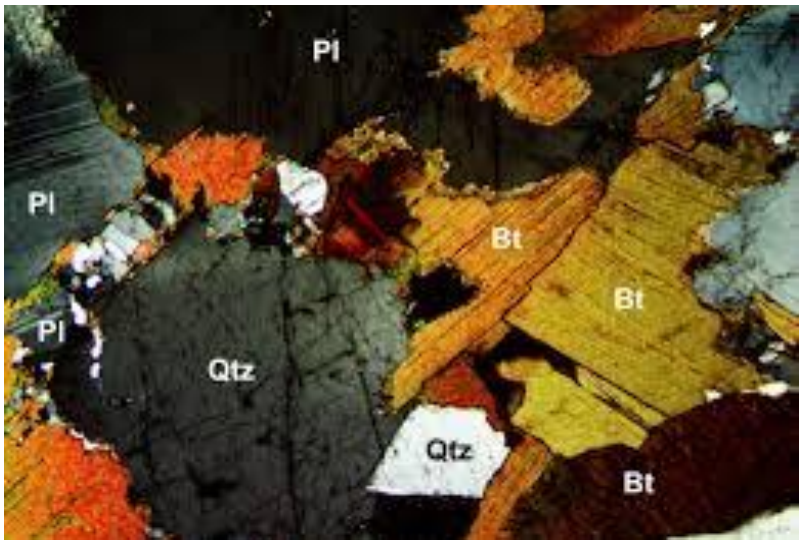

Plate 3B. Photomicrograph of biotite gneiss under XPL (X25)
Pl- plagioclase, Qtz- quartz, Bt- biotite

4.4. Dolerite

Dolerite was found in the study area as shallow intrusive igneous bodies with spheroidal weathering. They were found along Boki – Obanliku LGA boundary. They are medium grained. They are dark in colour. Dolerite

found in the study area has ophitic texture with euhedral shaped plagioclase crystals set in fine matrix of clinopyroxene mostly augite. It also has minor amount of olivine, magnetite and ilmenite and other oxides of iron and accessories minerals.

Plate 4A. Field photograph showing dolerite with ex-foliation weathering at Boki-Obanliku boundary

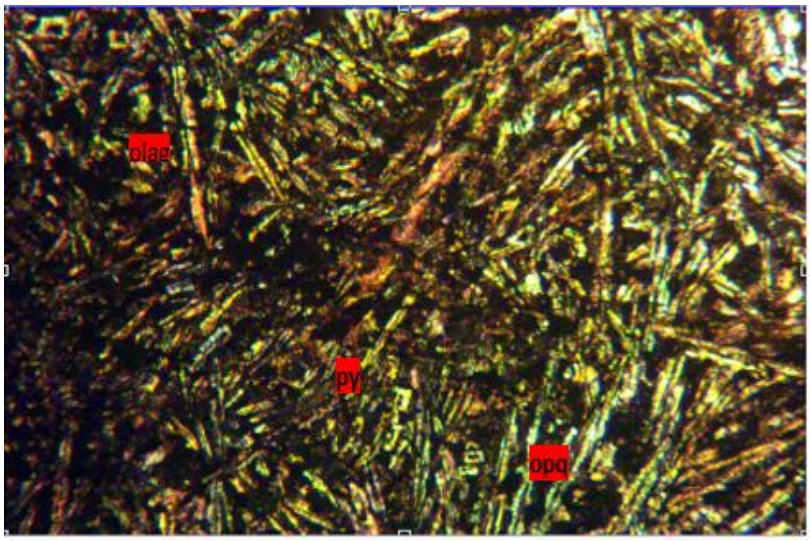

Plate 4B. Photomicrograph showing dolerite under XPL (X25). Plag- plagioclase, Py- pyroxene, Opq- Opaque minerals

Table 1. Showing the average modal composition rocks in Owambe-Otanchi community

Minerals	Granite gneiss	Schist	Dolerite	Biotite gneiss	Migmatite
Quartz	27	27		25	30
K-feldspar	23	10		20	13
Plagioclase	18	20	45	12	22
Biotite	10	21	15	17	18
Muscovite	7	7		9	9
Hornblende	4	7		10	5
Pyroxene			18		
Mymerrkite					
Garnet		4			
Kyanite		3			
Olivine			19		
Epidote				5	
Opaque Minerals	3		3	2	3

5. Structural geology

Three deformational episodes have affected the parts of the Bamenda Massifs and this has resulted in the alternation of the rocks of the area. Since the close of the pan African orogeny, the rocks have probably responded to stresses within and resulted in the formation of structures such as folds and fractures.

5.1. Fractures

Fractures are surfaces of discontinuity in rocks which are formed due to the sudden release of pressure which been previously been confined in a rock. Fractures may be filled with and may not be filled with mineral fluids.

5.2. Joints

Joints are fractures on any shear displacement in which no appreciable movement has occurred or taken place. It can be healed or open joints that are very closely spaced such that the interval between them is measured in

inches or fraction of an inch. They very common in rocks of this area and they are present in different directions, either in lines with the strike of some of the rocks, cutting across, or perpendicular or cross-cutting the surface of the rocks. These are much more prominent within the schist Plate 5**.**

5.3. Faults

A fault is linear fracture or discontinuity in a volume of rock, across which there has been significant displacement as a result of rock-mass movement. It is a surface of rock rupture along which movement has taken place. Fault was observed in rocks at Owambe community Plate 6.

Plate 5. Field photograph showing joints on an outcrop of pegmatite and migmatite near a waterfall at river Owan

Plate 6. Field Photograph showing measurement of fault heave at Owambe community

5.4. Folds

Smal-scale folds were identified drag, chevron, box. Some having antiform or synform features Plate 7.

Plate 7. Field photograph showing small-scale folds at Owambe-Otanchi

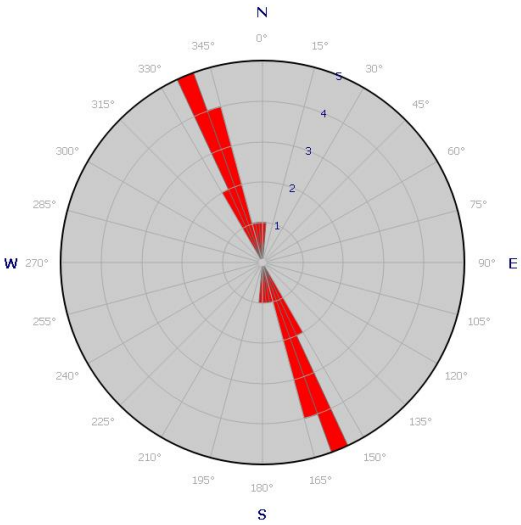

Figure 2. Rose Diagram showing the Trends of Joints and fractures in NW-SE direction in Owambe community

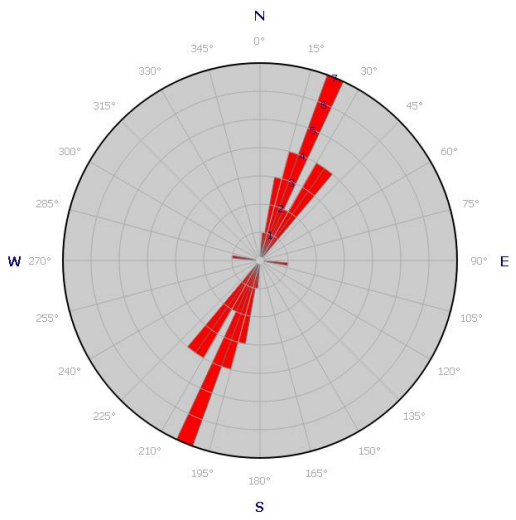

Figure 3. Rose Diagram showing the Trends of Joints and fractures in NE-SW and E-W direction in Begiagba community

6. Discussion

The Mukuru area lies within the Pan African Remobilized Basement Complex of southeastern Nigeria. The study area Owambe majorly consist of high grade metamorphic rock; schist, gneiss and migmatite which appear to be similar to that of nearby Obudu highlands as observed by (Ekwueme, 1994,). The late to post Pan-African intrusive present in Owambe area is mainly dolerite intrusion. The geology of the study area appears to be similar to the southern Obudu (sheet 291) which also lacks abundant granite (Ukaegbu 2003). The intrusives of the area are magmatic in nature. The structural characteristic of the rocks includes fractures, planar and structural features which occurs as a result of the polycyclic deformational episodes of the Libernian, Eburnean and Pan-African event which affected the rocks of the basement complex (Rahaman, 1988). Dolerites intrusion of the area shows spheroidal weathering.The alternation between light and dark coloured minerals present in the gneiss is the reveals lineation. the ferromagnesian minerals (hornblende and biotite) are the dark coloured minerals while the light coloured minerals are the quartzo-feldsparthic minerals (quartz and feldspar). The lineation trends show a NW-SE on the rocks of the Owambe-Otanchi community while the Begiagba community shows a NE-SW major trends and a minor E-S.

7. Conclusion

Owambe-Otanchi is part of the Mukuru sheet (305 NW) forms the Bamenda Massif extension into the South-eastern Nigeria. It is located in Boki Local Government Area, Cross River State, Nigeria. The rocks identified in the area include schist, granite gneiss, biotite gneiss, migmatite, schist and garnet mica schist and dolerite intrusions. Samples were collected from outcrops in Owambe, Begiagbah, Boki-Obanliku boundary and Abijah communities. Results of petrographic analysis carried out on the rock samples shows the following mineralogy

for the rocks; Granite gneiss (Quartz + feldspar + biotite + hornblende and accessory minerals). Fractures such as faults and joints, folds and pinch and swell are the structural features found on the rocks of the study area. In conclusion, it can be said that the study area is made up of metamorphic rock migmatites and minor igneous intrusions. The major events that occurred in the area are deformation, metamorphism and minor magmatism. Small-scale geological structures measured and plotted which are in agreement with the major trends are in the NW-SE and NE-SW direction with a minor trend in the E-W direction.

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