

# Metamorphic Textures and Textural Development in Sandstones of Ndagbo Area, Afikpo Basin, Southern Benue Trough, Nigeria

Oloto, I.N.

Senior Lecturer, Department of Geology, University of Port Harcourt, Port Harcourt, Nigeria

**Abstract** Detailed lithostratigraphic and petrographic analyses were carried out on thirteen samples obtained from Ndagbo and its environs in Afikpo Basin. The area is located within latitude  $5^{\circ}45'$  and  $5^{\circ}47'30''N$  and longitude  $7^{\circ}45'$  and  $7^{\circ}47'30''E$  in the Afikpo basin, Southern Benue Trough. The lithologic unit of the succession is basically sandstone with shale intercalations. The Petrographic analysis of rock samples from Ndagbo and its environs in Afikpo Area form part of the Abakaliki anticlinorium, Southern Benue Trough and yielded several results. The field area is in the region of Benue Trough graben with sediments infilling which had suffered deformations (NE-SW trending axis) and extensive magmatic activities, as evidenced by the widespread occurrence of intrusives and extrusives rocks. The Cenomanian episode affected only the Albian sediments while all the pre-Santonian sediments are unaffected. The Petrographic analysis carried out reveals that the study area are mostly meta-sediments .

**Keywords;** Metamorphism, Afikpo Basin, Benue Trough, Sandstone, Nigeria

## I INTRODUCTION

The Benue Trough is a major geological formation underlying a large part of Nigeria and extending about 1000km North East from the Right of Benin to Lake Chad. It is a part of the broader Central African Rift system. The Trough has its Southern limit at the Northern boundary of the Niger Delta where it dips downward and is overlaid with tertiary and more recent sediments. It extends in the north-easterly direction to the Chad basin and is about 150km wide. The Trough is divided into Lower, Middle and Upper regions. The Anambra basin in the west of the lower region is more recent than the rest of the trough. The Benue Trough was formed by rifting of the central West African basement, beginning at the start of the Cretaceous Era. A common explanation of the Troughs formation is that it is an aulacogen, an abandoned arm of the three -armed radial rift system [2,3]. Metamorphic process in this study have been considered largely in terms of mineralogical and chemical changes involving experimental synthesis, determination of the physical conditions under which minerals and mineral assemblages are formed. Metamorphic Textures are considered as a comprehensive evaluation of texture forming processes. Both texture and mineral assemblage is essential to understanding metamorphic rocks. In these study the lithologic and petrography techniques were employed to unravel the metamorphic textures and textural development of the study area.

### *Location of study area*

The studied samples were recovered from Afikpo Basin, south-eastern Nigeria the study area lies within latitude  $5^{\circ}45'$  and  $5^{\circ}47'30''N$  and longitude  $7^{\circ}45'$  and  $7^{\circ}47'30''E$ . (See figure 1 and See Table 1).

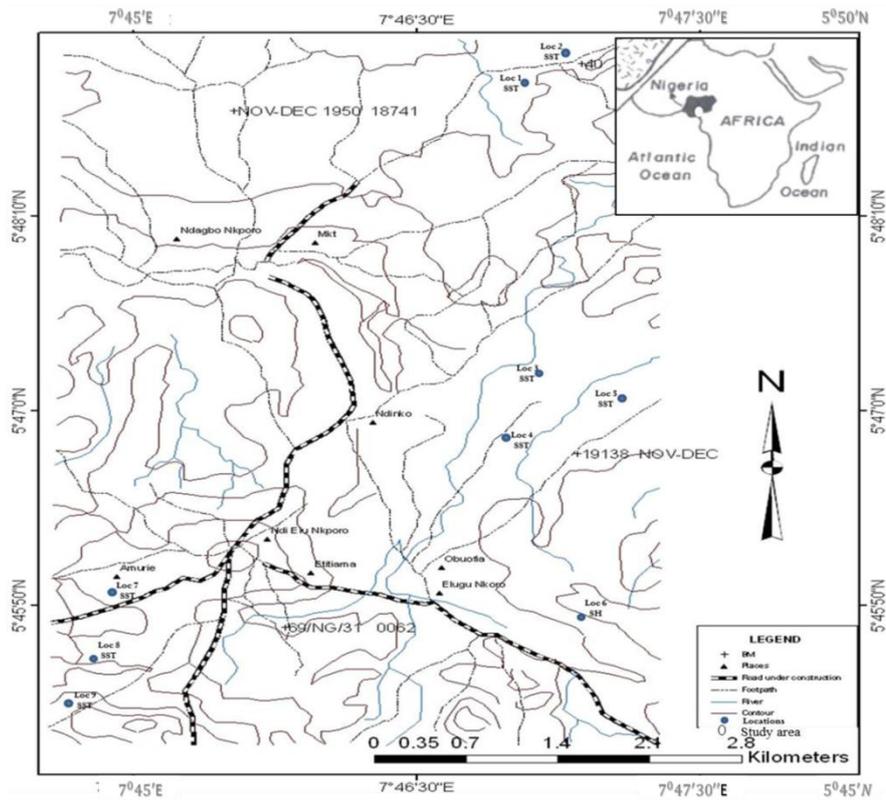


Figure 1: Map showing location of the Study Area

## II. AIM AND OBJECTIVES OF THE STUDY

The aim of this research work is to study metamorphic textures and the fundamental process involved in textural development in the Study area of Afikpo Basin. The understanding of texture is based on the fact that metamorphism is regarded as a series of structural transformations rather than as chemical-reactions.

### A. Stratigraphy of the Afikpo Basin (study area)

The geology of northeast Afikpo consists of two major lithostratigraphic units of sandstone ridges and low-lying shales, each of which forms significant component of the Middle Albian Asu River Group and Turonian Eze-Aku Formation. The major fold in the area has the northeast – southwest trend and comprises both anticlines and synclines. These mega-tectonic structures developed in response to crustal solidification processes linked to the opening of the south Atlantic and the post-Santonian structural frame as a result of these processes. Wright (1985) had stated that ‘no break has yet been discerned between the marine Albian and Turonian strata in the Benue trough. [1] (See figure 2).

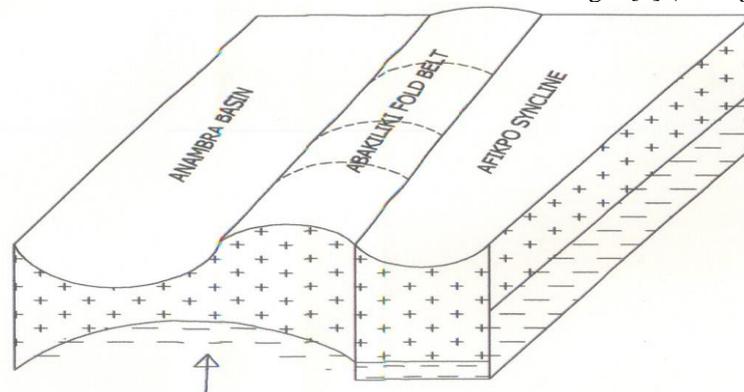


Figure 2: Formation of Afikpo Syncline (Ugwu, 2010)

The uplifted part of the fold became known as the Abakaliki anticlinorium. The Abakaliki fold belt becomes a positive element to shed sediments and detritus into the depressed platforms of Anambra basin and Afikpo syncline. After the Santonian tectonic event and the formation of the Afikpo syncline, marine transgression resumed during the Campanian–Maastrichtian erosion in the lower Benue trough with the deposition of the Nkporo Formation first. The Nkporo shale consists dominantly of shale in most parts of the Benue trough but its lateral equivalent in the Afikpo syncline is a sandstone unit called the Afikpo sandstone composed of quartz Arenite. The Nkporo shale is overlain by the heterolithic Mamu formation comprising of shales, sandstones, siltstones and some coal measures. The Mamu formation is succeeded by the Ajali sandstone [5,8,10].

### III. MATERIALS AND METHODOLOGY

Materials used during the project include the following; compass clinometers, global positioning system (GPS), sample bag, measuring tape, camera, writing materials and geologic hammer. All these materials were used during the field work, While the laboratory work involve the use of Petrographic Microscope.

#### (1) Field work

The field work entails detail mapping involving beds measurement, descriptive and sampling of the outcropping sections. Fresh samples were collected at exposed outcrops along the road sides and other areas during the traverse. The collected samples were placed in sample bags which were properly labelled and numbered against the locations. elevation of outcrops were measured during the field work, and positions of outcrops recorded photographs of important features were taken for better and adequate information of the features encountered in the field. The samples were then taken to the laboratory for further analysis.

#### (2) Laboratory work.

The lithologic analysis involves the systematic description of the samples in hand specimen. Indurated samples were thin sectioned and analysed under petrographic microscope.

### IV. PRESENTATION OF RESULT

#### (A) Lithologic analysis:

This involves description of the lithologic aspect of the samples collected and involve colour, lithology, and some observable features **See Table 1.**

TABLE I  
LITHOLOGIC DESCRIPTIONS OF SAMPLED AREAS

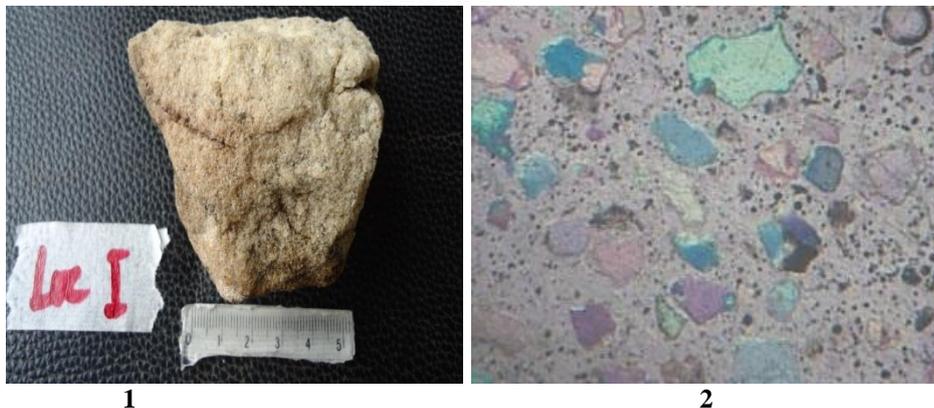
S/N	Sample Site	Sample Location	Lithologic Description
1	2.4km NE of Ndagbo Nkporo	1	Sandstone, greyish, fine grained.
2	3km NE of Ndagbo corner of the map	2	Sandstone, whitish, fine grained
3	1km NE of Ndiriko	3	Sandstone ferruginised, reddish brown, coarse to medium grain, non-indurated
4	South west of Location 3 (few		Sandstone ferruginised, weathered sandstone, reddish brown, fine grained, non-indurated
5	South east of Location 3	5a	Sandstone, weathered top, reddish brown, coarse to pebbly, non-indurated
6	South east of Location 3	5b	Sandstone, fairly weathered middle section, medium to coarse grain, non-indurated
7	South east of Location 3	5c	Sandstone indurated, fresh whitish bioturbated, fine to medium grain
8	Ngworeter east of Elugu Nkoro	6a	Shale, black, carbonaceous with lenticular inclusions.
9	Elugu Nkoro	6b	Claystone, brown, fine grained
10	Amurie	7	Sandstone ferruginised, reddish brown, medium to fine grain
11	500m south of Amurie Location 7	8	Sandstone ferruginised, reddish brown, fine to medium grain
12	1km South of Location 8	9a	Sandstone indurated, fine to medium grain, Brown to pink
13	South of Location 8	9b	Sandstone indurated, medium to coarse grain, whitish

*(B) Petrographic Analysis.*

Location 1, 2, 5, 6, 8, and 9 thinned section samples were analysed. They were dominantly indurated sandstones (See Plates 1 – 6). This was carried out on seven indurated sedimentary rocks to study their various mineral components and their inter-grain relationship. It is an aspect of petrology which considers the description of the mineral content, chemical composition, texture, structure, and classification of rocks. The following steps were applied The locations are indicated on figure 1 and listed on Table 1. The Petrographic analysis of rock samples from Ndagbo and environment in Afikpo Area from part of the Abakaliki anticlinorium, South Benue Trough yielded several results. The field area is in the region of Benue Trough graben with sediments infilling which had suffered deformations( NE-SW trending axis) and extensive magmatic activities, as evidenced by the widespread occurrence of intrusives and extrusives rocks. The Cenomanian episode affected only the Albian sediments while all the pre-Santonian sediments are unaffected [1].

*Location 1 (Plate 1)* The vertical section of location 1 consist of Buchite of sandstone (arenite) with web texture, quartz grains sparingly distributed, loosely packed, sub-angular to sub-rounded grains. Feldspar (highly stippled with cleavages) about grains of quartz 90% while Feldspar 10%, slightly more of matrix and less of grains. The horizontal section of location 1 consists of Burchite of sandstone with loosely packed sub-angular to sub-rounded grains present. The percentage minerals present are chiefly 85-90% quartz and 10-15% fragments of feldspar. It also contains Oolitic grains of Perthite. It has small fragment of Exsolution texture sparingly distributed or scattered throughout. It also has Globular inclusions. Its texture is Porphyroblastic.[7] ( See Plate 1)

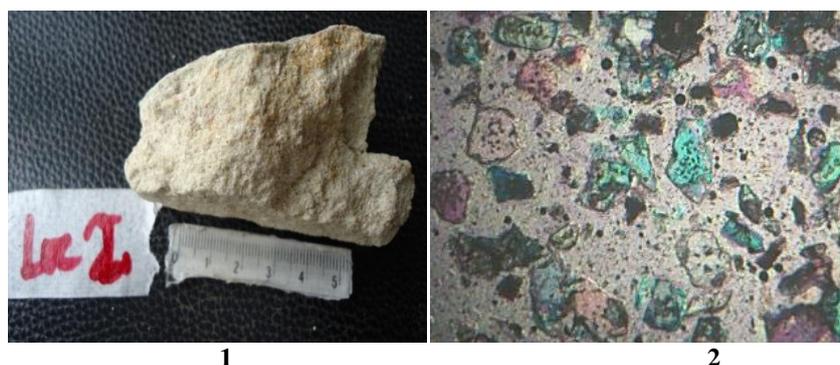
**PLATE 1**



- 1: Hand specimen from metasediment from location 2.4km NE of Ndagbo Nkporo.
- 2 Vertical section: web texture in Buchite loosely packed grains, quartz grains sparingly distributed

*Location 2 (Plate 2)* The vertical section consists of Buchite of sandstone (arkose) with Relic grains of Plagioclase 90-95% of quartz, 5-10% of Orthoclase and microcline. Grains sub-rounded but not well sorted, porosity is negligible, although the detrital grains are loosely packed while the horizontal section consist of Buchite of sandstone (arenite) with slightly more of grains and less of matrix, the grains are tightly packed (plate 2) and are sub-angular to sub-rounded in nature. It has web texture (plate 1) and the percentage minerals present are 85-90\$ quartz and 10-15% fragments of feldspar with cleavages. It has Exsolution textures and Globular inclusions. The Exsolved phase has become completely separated and forms an intergranular phase [5,9].

**Plate 2**



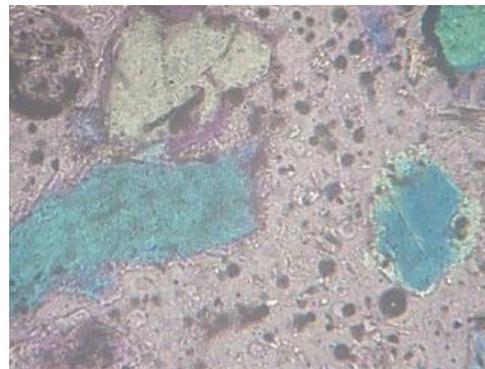
- 1: Hand specimen (7 inches) of fine grained, arkosic sandstone from location 2.3 km of Ndagbo Nkporo NE corner of the map.
- 2: Horizontal section; buchite of sandstone, grains are tightly packed and sub angular to sub rounded in nature.

*Location 5 (plate 3)* The vertical section consist of tightly packed sub-angular to angular grains, Burchite of sandstone (graywacke), contains Oolitic Pyrite which is usually formed in marine reducing environment (plate 4), 30-40% Pyrite, an unsorted angular grains of sand and coarse silt set in an abundant argillaceous matrix while the horizontal section consist of Buchite of sandstone (arenite) with loosely packed grains which are sub-angular to sub-rounded in nature. Oolitic Pelletes which represents marine reducing environment is also present [3,15]. It has exsolution texture and globular inclusions. The percentage minerals present are 85-90% quartz and fragments of feldspar. It also has unevenly sorted grains of quartz.

**Plate 3**



1



2

1. Hand specimen of indurated sandstone from Ngworeter east of Elugu Nkoro.
2. Horizontal section; buchite of sandstone (arenite) with tightly packed grains which are sub-angular to sub rounded in nature, globular inclusions and exsolution textures.

*Location 8 (Plate 4)* The vertical section consists of loosely packed sub-angular to sub-rounded grains, more matrix and slightly less grains of feldspar, Burchite of sandstone (arenite), web texture in Buchite, 90-95% of quartz, 5-10% feldspar and unsorted grains of quartz 90-95% of quartz and 5-10% of feldspar while the horizontal section consist of Buchite of sandstone (arenite) with tightly packed grains which are sub-angular to sub-rounded in nature and has web texture. It has more of grains and less of matrix. The percentage minerals are 85-90% quartz and 10-15% feldspar with cleavages. It also has well sorted grains of quartz.

**Plate 4**



1



2

- 1: Hand specimen; sandstone ferruginised 500m south of Amurie.
- 2: Vertical section; buchite of sandstone with web textures, 90 – 95% of quartz.

*Location 9a (plate 5)* The vertical section consists of Burchite of sandstone with web texture with quartz grain sparingly distributed. Unsorted aggregate of angular to sub-rounded grains of quartz and feldspar lightly stippled with cleavage. Poikiloblastic texture, exsolution texture, globular inclusions and exsolved phase has become completely separated and forms an intergranular phase. It contains 85-90% of quartz and 10-15% of feldspar while the horizontal section consists of Burchite of sandstone (arenite) containing slightly more of grains and less of matrix, the grains are sparingly distributed which are sub-angular to sub-round in nature. The percentage minerals present are 85-80% quartz and 10-15% feldspar. It has Exsolution texture and Globular inclusions. The grains are Poikiloblastic in nature.

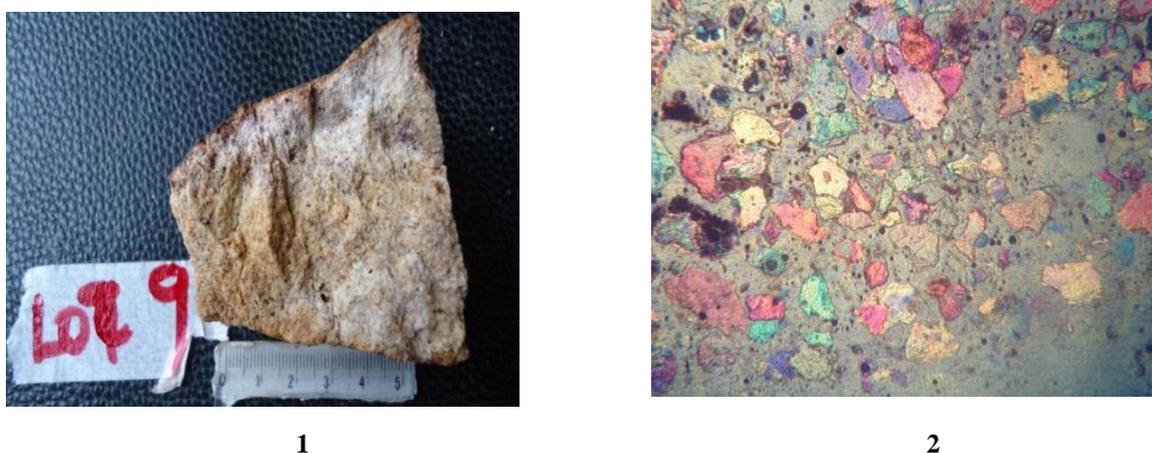
**Plate 5**



- 1: Hand specimen from 1km south of location 8, sandstone fine to medium grain.
2. Horizontal section; buchite of sandstone (arenite) the grains are sparingly distributed which are sub-angular sub rounded in nature; there are also presence of exsolution textures and globular inclusions.

*Location 9b (Plate 6)* The vertical section consists of Burchite of sandstone, grains loosely packed which are sub-rounded matrix and sub-rounded fragments. It contains Oolitic grains of Perthite, 85-90% of quartz grains, 10-15% of Feldspar with cleavages. The grains are loosely packed; it has exsolution texture and globular inclusions. Quartz grains are very abundant and Feldspar is common. This is known as greywacke [13,14,15]. It has been classified as Graywacke deposits that have scarcity of rock fragment because it has the proper texture while the horizontal section consists of Burchite of sandstone (arenite) with rounded grains and irregular texture. Perthitic texture of quartz and feldspar present, the quartz is 85-90%, Feldspar is 10-15% present. The grains are unevenly sorted. It has Exsolution texture; Globular inclusion and the grains are Poikiloblastic.

**Plate 6**



- 1: Hand specimen sandstone indurated medium to coarse grain from south of location.
- 2 Vertical section; buchite of sandstone, grains loosely packed which are sub rounded matrix and sub rounded fragments, presence of oolitic grains of perthite. 85 – 90% of quartz.

### V. DISCUSSION AND CONCLUSION

Petrographic analysis has shown evidences of metamorphic textures and progressive textural metamorphic development in the sandstone and shales of the pre-santonian rocks South Benue Trough Nigeria [[4,6,9]. The rocks were obtained from various localities such as Ndagbo Nkporo, Ndiriko, Elugu Nkoro and Amurie. The rocks ranged from highly indurated arenite, greywacke, pebbly, coarse to fine grained sandstone and dominantly arkosic sandstone include shale. Petrographic analysis indicated the prolific presence of globular, oolitic exsolved texture in arkosic sandstone to nucleation the arkose and buchite arenite. The texture variously indicated progressive metamorphism from the arkosic sandstone to nucleation of globular oolitic exsolved texture to polygonal granoblastic clusters of mineral in clay matrix and finally wholly granoblastic texture [8,12]. The texture is partially relict which indicates retention of the original pre-metamorphic sedimentary feature which have not been obliterated by the metamorphism and typomorphism [12]. The characteristic texture produced by metamorphism is granoblastic. The overall texture indicates that the mineral assemblage which includes quartz, feldspar, clay minerals and prolific exsolves solvent and shifting mineral boundaries are in a state of equilibrium, and the rocks are at the lower limit of metamorphism and can be classified as Buchite arenite and hornfel. The lithostratigraphic and petrographic analysis result from the Study Area reveals that rocks samples obtained from Ndagbo and its environs in Afikpo basin are mostly meta-sediments. (Plate 1-6).

### REFERENCES

- [1] L.C. Amajor., (1987). Paleocurrent, petrography and provenance analyses of the Ajali Sandstone (Upper Cretaceous), Southeastern Benue Trough, Nigeria. *Sedimentary Geology* Vol.54, Pp. 47–60.1987
- [2]. N.P.C Anyanwu., I. Arua.,. Ichnofossils from the Imo Formation and their palaeoenvironmental significance. *Journal of Mining and Geology* Vol.26, Pp. 1–4. 1990
- [3] I. Arua.,. Palaeocene Macrofossils from the Imo Shale in Anambra State, Nigeria. *Journal of Mining and Geology* Vol. 17, Pp. 81– 84., 1980
- [4] M. ,Hoque, C.S, Nwajide.,. Tectono-sedimentological evolution of an elongate intracratonic basin (aulacogen): The case of the Benue Trough of Nigeria. *Journal of Mining and Geology* Vol. 21, Pp.19–26, 1985.
- [5] C.A Kogbe.,. Paleogeographic history of Nigeria from Albian times. In: Kogbe, C.A. (Ed.), *Geology of Nigeria*. Elizabethan Publishers, Lagos, Pp. 237–252,1976.
- [6] K.O Ladipo.,. *Journal of African earth SCIS*, Pp.177-185,1987.
- [7] R.C Murat, . *Structural Geology of the Cenozoic Niger Delta*. African Geology. University of Ibadan press. Vol. 4. Pp635 – 646,1970
- [8] R.C., Murat.,. Stratigraphy and paleogeography of the Cretaceous and Lower Tertiary in southern Nigeria. In: Dessauvagie, T.F.J., Whiteman, A.J. (Eds.), *African Geology*. University of Ibadan Press, Nigeria, Pp. 251–266.
- [9] C.S, Nwajide, . A lithostratigraphic analysis of the Nanka Sands, southeastern Nigeria. *Journal of Mining and Geology* 16, 103–109,1979.
- [10] S.O., Nwanchukwu, The Tectonic Evolution of the Southern Portion of Benue Trough Nigeria. *Geol. Mag.* 109, Pp. 411–419,1972.
- [11] F.E, Oboh.,. Lithofacies, palynofacies, and sequence stratigraphy of Palaeogene strata in Southeastern Nigeria. *Journal of African Earth Sciences* Vol.49, Pp.71 – 101, 2005.
- [12] M.I, Odigi.,. A geological field mapping manual. Lecture note. University of Portharcourt, Nigeria, 2010.
- [13] C.O., Ofoegbu, . A Review of the Geology of the Benue Trough Nigeria. *Journal of African Earth Science*. Vol. 3. Pp. 283 – 291,1982.
- [15] K.C Short, A.J., Stauble.,. Outline of geology of Niger delta. *American Association of Petroleum Geologists Bulletin* 51, 761–779,1967