Structural Characteristics of Parts of the Abakaliki Area South-Eastern Nigeria

N. Egesi, Ph.D.

Department of Geology, Faculty of Science, University of Port Harcourt, Port Harcourt, Nigeria.

E-mail: ndukauba.egesi@uniport.edu.ng
ubaegesi@yahoo.co.uk

ABSTRACT

The Abakaliki anticlinorium is a major structural feature in the study area. There are small scale geological structures which are also present, strike-slip faults system, polished normal fault planes, slickensides, cinder cones, composite cones and shield volcanoes features. They indicate evidence of deformation and magmatism in the area which they are usually associated with, also poorly visible metamorphism or unmappable contact metamorphism are also present.

The rock types are quartzo-feldspathic sandstone, mudstone, shale, slate, phyllite, gabbro, anorthosite and tractolite. There is also Lead-Zinc-Barytes association rocks. The sandstones show variable color, nodules and concretions. The volcano-sedimentary structures observed at the hilltop area can also yield aggregates for construction like Ezza Imagu shielded volcano, but the depth of the sedimentary cover to the top of the igneous rock has to be estimated with Aeromagnetic and Landsat ETM data before the design of any type of quarry operation at the site.

(Keywords: Abakaliki anticlinorium, rock types, structures, deformation, magmatism, SE, Nigeria)

INTRODUCTION

There are three main geologic features which dominate the southern part of Benue Trough, the Abakaliki Anticlinorium to the east, the Anambra Basin to the west and the Niger Delta to the south. The re-constructed stratigraphic column of the Abakaliki region consists seven main outcropping stratigraphic units with a total thickness of about 3600m (Ojoh, 1992). The Cretaceous basin in the Abakaliki-Ogoja region contained about 5000m of sediments according to geophysical results published by (Adighije, 1981) before, the Santonian event in the Benue Trough. This shows that about 1400m thickness of pre-Middle Albian age sediments have been removed or do not outcrop in the area.

Early authors like Murat (1972), has identified the geological history of the southern Nigeria sedimentary terrain in three major tectonic phases. The first tectonic phase in Albian gave rise to the en echelon Benue and Abakaliki Troughs which received sediments during Albian-Santonian time; the second phase resulted in the folding and uplift of Benue-Abakaliki folded belts and the formation of the Anambra Basin and smaller Afikpo syncline as a major depocenter of sediments during the Campanian-Eocene time. The third phase was the formation of proto Niger Delta in Upper Eocene. This paper is an attempt to identify the structural characteristics in the Abakaliki area with reference to surface and sub-surface features for geo-resources and sustainable mining activities in the area.

LOCAL GEOLOGICAL SETTING

The rock types found in the area includes; quartzo-feldspathic sandstones which contains alkaline feldspars with euhedral laths characteristic of pyroclastic rocks has been identified in parts of the Abakaliki area (Uzuakpunwa, 1974; Olade, 1979; Hoque, 1984). They have been interpreted as subareial falls of subaerial-submarine explosions during the Upper Albian. They indicate evidence of the inter-relationship between volcanism and sedimentation, or volcano-sedimentary tendencies in the Cretaceous evolution of the Abakaliki anticline area (Figure 1). In the Southern Benue Trough, Albian volcanism has been identified as transitional to alkaline in affinity (Baudin et al., 1987), was generated during a distensible intra-continental tectonic phase when South America was being separated from Africa (Ojoh, 1992).

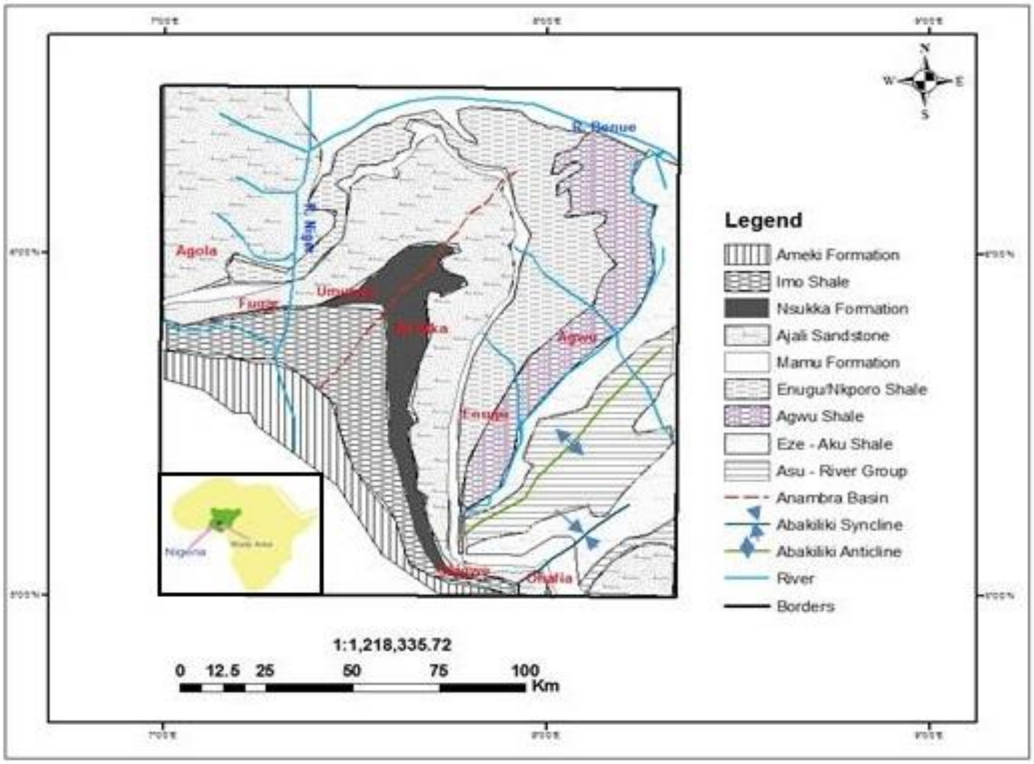

Figure 1: Geological Map of Parts of South-Eastern Nigeria showing the Study Area (Egesi, 2017).

In the nearby Afikpo syncline a two-layer structural model of the depth of the sedimentary cover to top of igneous body has been proposed on the basis of evidences from airborne magnetic and Landsat ETM data by Opara *et al.,* (2014).

The shallower magnetic source has an average depth of 1.195km while the deeper magnetic signatures have average of 2.660km. They observed that the shallower magnetic source anomalies are as a result of igneous rocks, gabbros, and dolerites which intruded into the sedimentary rocks in the Albian volcanoes. These had been identified in the Abakaliki area at Ezza Imagu quarry site, Ishiagu-Enyingba and Ameta Lead-Zinc-Barytes deposits, while the deeper magnetic anomalies they believed are associated with intra-basement discontinuities like tectonics and major fractures.

The Precambrian Basement Complex rocks of Oban massif area south-eastern Nigeria are the oldest rocks. They are overlain by the non-marine to marine deposits Asu River Group (Odigi, 2010). The Asu River Group represents deposits of the first transgressive–regressive marine depositional cycle in the area (Petters, 1982).

The Eze Aku beds overlie the Asu River Group unconformably and consist of shales, limestones and sandstone ridges which strike on the average N040° E with dips ranging from 20° to 68°. The sandstone bodies appear in elongate Okeke and others in press. The Eze Aku beds represent the second transgressive depositional cycle that occurred during the Upper Cretaceous (Murat, 1972, Nwachukwu, 1972). The Lower Cretaceous sediments are in places rather strongly folded. A zone of fairly strong folding occurs south of Abakaliki anticlinal axes traced for over fifty kilometres. The fold axes are oriented in a northeast-southwest direction and dips values of the anticlines range from 5° to 80°, the highest values obtained around Ameka, in the region of Lead-Zinc mineralization (Reyment, 1965).

METHODOLOGY

A close study of the factors conditioning the exposure of the region was made. The correlation of exposures with particular elements of the relief highlands and lowlands was established using topographical maps and aerial photograph. Field mapping of the selected area was carried out to identify rocks and structural features associated with them.

At the end of the observations a working scheme of igneous and sedimentary strata was made and indices and of the various intrusive rocks was established. The mapping intersect both marginal and central parts and the intrusive display sharp contact relationships with the host country rocks. The area is associated with volcano-sedimentary features the highlands with gabbro and anorthosite while the lowlands with Lead-Zinc-Barytes mineralization.

Measurements of exposures and outcrop features such as altitude, strike-slip fault systems, normal faults, shear zone, fault planes, slickensides surfaces, cinder cones, composite cones and shielded volcanoes to produce rose diagram and stereonet to interpret the major and minor trends. Petrographic study of the igneous and sedimentary rocks which occurs in the area were also made. The thin section petrography appears to thick making it difficult to identify some minerals.

RESULTS AND DISCUSSION

Petrography

The Abakaliki hilltop area is the highest point with an elevation of about 162m. The rock types exposed are ferroginised sandstones, feldspathic sandstone and quartzo-feldspathic sandstone and clay minerals like kaolinite. The quartz minerals are sub-hedral and visible in hand specimen occurs as swarms. The area near the local rice processing zone are made up of Albian shales which are friable, fissile and the color varies from dark shale, brown shale and reddish-brown clay minerals types which are mostly weathered.

The Igneous rocks gabbro, anorthosite and tractolite were identified at Ezza Imagu, there are also unmappable slate and phyllite around small intrusions quarry site, the local miners stated that the community mine have been operation for over three decades.

The Lead-Zinc- Barytes deposits at Ishiagu-Enyingba and Ameta areas are believed to be of igneous origin, they were formed as a result of the volcano-sedimentary activities in Albian time volcanoes.

Structural Characteristics

The Abakaliki area has been identified as a volcano-sedimentary region. Volcanic action results in the formation of five basic types of volcanoes; but no two are ever quite alike. The kind of materials that erupt from a volcano determine the shape of the cone. Fluid streams of lava travel far and usually produce wide-based mountains; thick lavas usually build up steep cones, the later was prominent in Abakaliki area.

Two types can be identified at the hilltop area cinder cones and composite cones, while shield volcanoes were observed at Ezza Imagu area Figure 2. The composite cones which house the state water board reservoir tank is at an elevation of about 130 m above mean sea level. Fractured and brecciated sandstone nodules and concretions boulders are also present at the sides of the composite cone.

The area has strike-slip and normal fault system, slickensides surfaces, which has been polished and striated from grinding or sliding motion of an adjacent rock mass are also very prominent. The heave and throw of the hanging wall from the footwall is 25m and 2.5m respectively. The upper section of the footwall has several small-scale fault features that can be identified as a fault zone or shear zone. The throw of the normal faults ranges from 46cm at the top of the cinder cone to about 2.5m at the foot of the cinder. The structural characteristics of the Abakaliki area can be clearly understand through deformed structures and volcanic features, that is, the spatial orientation of the components of a rock as imposed by external stress. Figure 2 is showing the types of volcanoes identified in the area, Plates 1 and 2 are field photographs showing strike-slip fault, slickensides and fault planes.

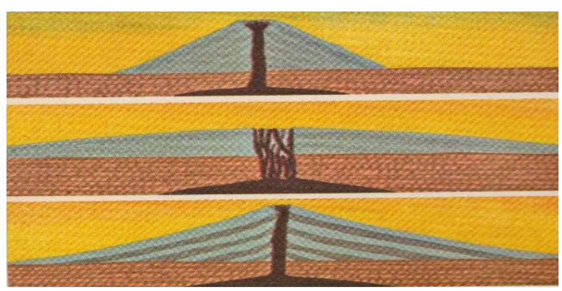

Figure 2: Three Types of Volcanoes Cinder Cones on Top, Shield Volcanoes at the Center, and Composite Cones Below observed in the Abakaliki area (Rhodes *et al*., 1972).

Plate 1: Field Photograph showing Footwall or Left-hand of the Strike-Slip Fault with Slickensides Surface at the Base of the Hilltop Area Abakaliki.

Plate 2: Field Photograph of Feldspathic Sandstone Hanging Wall or Right Hand of the Strike-Slip Fault showing Slickensides Surface and Joints Heave 25m and Throw 2.5m from the Footwall at Hilltop Area Abakaliki.

The field photographs on Plates 3 – 6 are top and base of the cinder cone feature which shows quartzo-feldspathic, concretions and nodules, while Plate 7 is a composite cone feature which was formed during Upper Albian. Most of the minerals occur in irregular masses of small crystals because of restricted growth, the quartz have sub-hedral crystals which are visible with the hand specimen. There are also presence of small scale sandstone nodules and concretions on the feldspathic sandstone at the base and top of this cinder cone highland.

Plate 3: Field Photograph of Measurements at the Highest Point of the Study Area about 162m a Cinder Cone Volcanoes Feature.

Plate 4: Field Photograph of Quartzo-Feldspathic Sandstones with Restricted Growth of Quartz Minerals, Sub-hedral Features near the Highest Elevation.

Plate 5: Field Photograph showing a Cinder Cone from the Top of Composite Cone Volcanic Feature.

Plate 6: Field Photograph of Nodules and Concretions in the Feldspathic Sandstones in the area.

Plate 7: Field Photograph of the South-eastern part of the City from the Highest Elevation Point showing a Composite Cone Volcanoe about 500m from the Cinder Cones feature in Abakaliki.

Some other sedimentary rocks identified are shale, mudstone and clay, near the rice processing mill at outskirts of Abakaliki. The rock types identified in a community mining site at Ezza Imagu which has been in operation for over 30 years are igneous rock; gabbro, anorthosite and troctolite while the metamorphic rocks are slate and phyllite.

The rocks are being mined by the villagers indiscriminately without bench design, no reclamation program in view, several overhang rock bodies that pose dangers to life, the mining pits were filled with water and no health, environment and safety concern has been put in place. There is need for appropriate regulations in these quarries to reduce most of the human impacts on mining in the area plates 8 – 10. Figures 2 and 3 are the rose diagram and stereonet plots of the measurements in the area. The photomicrograph of the thin sections is on Plates 11 -13.

Plate 8: Field Photograph of Shale, Mudstone and Clay, near the Rice Processing Mill at Outskirts of Abakaliki.

Plate 9: Field Photograph of Anorthosite Mined out Surface with Three Meters of Overburden at Ezza Imagu Quarry Site.

Plate 10a: Field Photograph of a Suite of Gabbro, Anorthosite, Troctolite and Hornfels being Mined at Ezza Imagu Area, a Shield Volcanoes Feature, the Overburden has been largely Removed leaving Several Overhang Mined Surfaces.

Plate 10b: Field Photograph showing the Contact Metamorphic Feature is the NE part of the Photograph just Next to the Pointed Intrusion Hornfels surrounded with Slate and Phyllite.

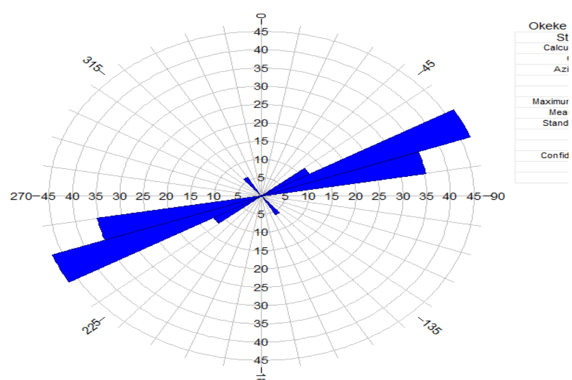

Figure 2: Rose Diagram showing NE – SW Trends in the Area.

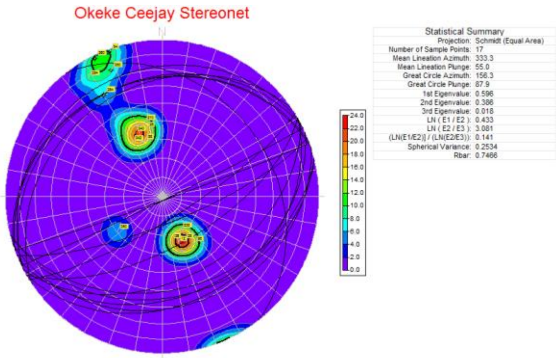

Figure 3: Stereonet of Plots with Red Indicating the Highest Concentration Points.

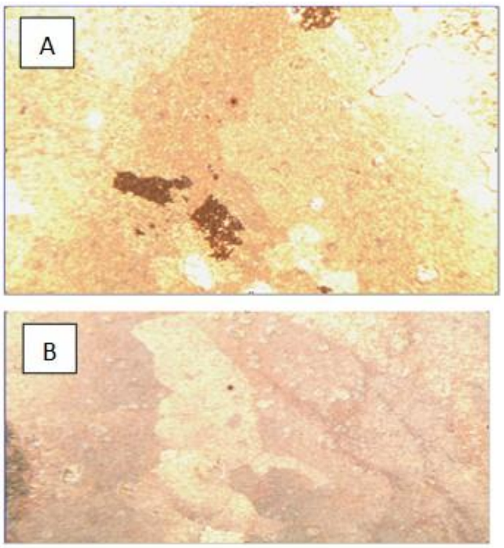

Plate 11 a/b: Photomicrograph of Anorthosite, Minerals are Plagioclase, Olivine, and Fi-Ti Oxides.

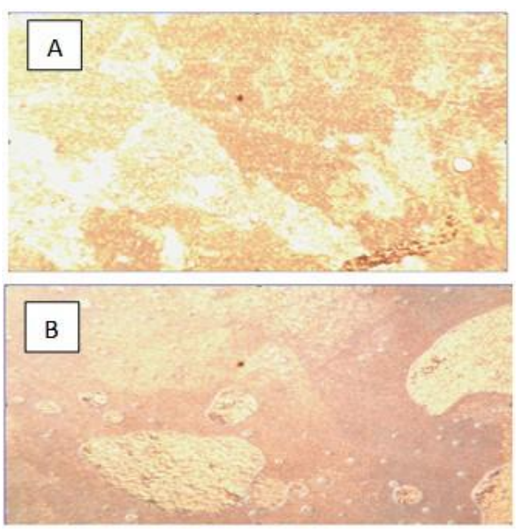

Plate 12 a/b: Photomicrograph of Lead-Zinc-Barytes at Enyingba.

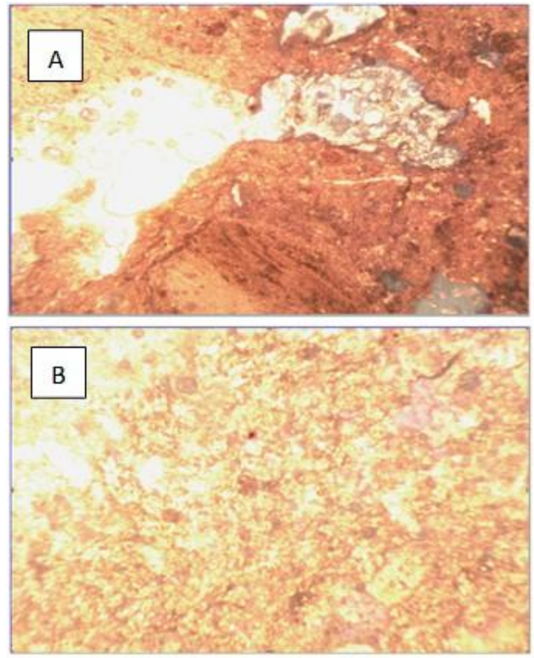

Plate 13a/b: Photomicrograph of Gabbro showing Granitic Texture, Plagioclase and Quartz.

DISCUSSION

The small–scale geological structures observed in the Abakaliki area are probably of tectonic origin like the strike-slip fault, normal fault and slickensides observed near the foot and top of the cinder cones highland. These are visible evidence of rock deformation caused by stresses and movements induced on the rocks by external tectonic forces after the deposition of the sediments, that is post-depositional structures. According to Ojoh (1992), the shale in the area contains abundant microspecies of Heterohelix and Hedbergella within ammonite-rich black shales of Upper Albian age, showing deep marine environments existed in the Middle Albian, while sand-dominated littoral environment progressively passed into shale-dominated shelf in the Upper Albian.

The Middle Albian period had instability, which also engendered submarine explosions, these led to formation of pyroclastics at Uturu area and the emplacement of the Pb-Zn-Barytes mineralization at Ameta and Enyingba areas.

Presently, barytes and copper have been found to associated with Pb-Zn mineralization at Ameta and Enyingba Fatoye *et al.,* (2014), Ogundipe and Obasi (2016). Three volcanoes features has been identified, cinder cones and composite cones at the Hilltop area and shielded volcanoes at Ezza Imagu which are associated with and also indicates volcano-sedimentary characteristics in the Abakaliki area which was identified by Ojoh (1992).

However, metamorphism of the rocks observed in the area are dynamic or cataclastic at Hilltop area which is due to faulting and contact or thermal at the Ezza Imagu quarry site due to igneous intrusions. These features of dynamic metamorphism and unmappable contact metamorphism are also present in the Afikpo Syncline about 60km from the study area. They have been identified to be due to faulting with lineaments mostly in the N-S and NE-SW directions and intrusions of dolerites and gabbros at a distance of about 500m from MacGregor College and at Mgobm area along Uwana - Afikpo road, can also be observed.

Slickensides features have also been identified in Afikpo area at Akanu Ibiam Girls' Secondary School Uwana road Afikpo Egesi (2016). Odigi and Amajor (2009), observed that slickensides features at the Afikpo area are probably associated with proto-Niger Delta in the Upper Eocene.

The highest surface elevation in the nearby Afikpo syncline is about 173m near the Nitel mast at Ngodo area with an estimated thickness of about 2, 660m Opara *et al*., (2014), which indicates sediment deposits in the area was high from the erosion of the Abakaliki fold belt during Campanian sedimentation into the Anambra and Afikpo basins which was initially estimated at 5, 000m Adighije (1981), and at about 3,600m Ojoh (1992), total thickness of the surface feature elevation of about 162m at the hilltop area Abakaliki was measured showing a difference of about 11m.

Hoque 1977, stated that some of the clastic sedimentation in the Abakaliki area are from the Bamenda highlands Basement Complex of Cameroon which terminates into southeastern Nigeria around Okundi- Boje axis Bansara sheet 304, Boki area.

CONCLUSION

The Abakaliki area have structural features which are probably of tectonic in origin which occurred after the Santonian structural inversion phase. There is presence of deformation, magmatism and un-mapable metamorphism observed in the area. These small-scale geological structures slickensides surfaces, strike-slip fault, normal fault systems and volcanoes features are post-depositional structural features.

The sandstone bodies are completely free of visible biogenic sedimentary structures except concretions and nodules. The volcano-sedimentary structures cinder cone and composite cone observed at the hilltop area can also yield aggregates for construction like Ezza Imagu shielded volcanoe, but the depth to the top of the igneous rock body can be obtain with airborne magnetic and Landsat ETM data before design of any quarry operation for geo-resources exploitation in the area.

REFERENCES

1. Adighije, C.I. 1981. "A Gravity Interpretation of the Benue Trough, Nigeria". *Tectonophysics*. 79: 109 – 128.

2. Baudin, P., C. Coulon, and M. Popoff. 1987. "Etude du Magmatisme Mesozoique – Fosse de la Benoue Nigeria". *Trav. Lab. Sci. Terre*. St-Jerome, Marseilles, x93:1 – 47.

3. Egesi, N. 2016. *Geological Field Trip to Parts of Southern Nigeria Sedimentary Basins*. 1 -29.

4. Egesi, N. 2017. "Structural Features of Ajali Sandstone in the Western and Eastern parts of River". *Journal of Geography, Environment and Earth Science International*. 11(2): 1-12.

5. Fatoye, F.B., M.A. Ibitomi, and J.I. Omada. 2014. "Lead-Zinc-Barytes Mineralization in the Benue Trough, Nigeria: Their Geology, Occurrences and Economic Prospective". *Advances in Applied Research*. 5(2): 86 – 92.

6. Hoque, M. 1977. "Petrographic Differentiation of Tectonically Controlled Cretaceous Sedimentary Cycles, Southeastern Nigeria". *Sed. Geol*. 17: 235-245.

7. Hoque, M., 1984. "Pyroclastics from the Lower Benue Trough of Nigeria and their Tectonic Implications". *Jour. Afr. Earth Sci*. 1: 39 – 47.

8. Murat, R.C. 1972. “Stratigraphy and Paleogeography of the Cretaceous and Lower Tertiary in Southern Nigeria”. In: Dessauvagie, T. F.J. and Whiteman, A.J. (eds). *African Geology*. Univ. Ibadan Press: Ibadan, Nigeria. 251 – 266.

9. Nwachukwu, S.O. 1972. “The Tectonic Evolution of the Southern Portion of the Benue Trough”. *Geological Magazine*. 109: 411 -419.

10. Odigi, M.I. and L.C. Amajor. 2009. “Brittle Deformation of the Afikpo Basin, SE Nigeria: Evidence for a Terminal Cretaceous Extensional Regime in the Lower Benue Trough”. *China J. Geochem.* 28(4): 369 – 376.

11. Odigi, M.I. 2010. “Organic Geochemical Evaluation of Oil/Gas Generative Potential of Organic Matter in Cretaceous Strata from the Lower Benue Trough Nigeria”. *Chinese J. of Geochemistry*. 29(3): 240-256.

12. Ogundikpe, I.E. and R.A. Obasi. 2016. “Geology and Mineralisation in the Albian Sediments of the Benue Trough, Nigeria”. *British J. of Earth Sciences Research*. 4(3): 1 – 15.

13. Ojoh, K.A. 1992. “The Southern Part of the Benue Trough (Nigeria) Cretaceous Stratigraphy, Basin Analysis, Paleo-Oceanography and Geodynamic Evolution in the Equatorial Domain of the South Atlantic”. *NAPE Bulletin*. 7(2): 131 – 152.

14. Olade, M.A. 1979. The “Abakaliki Pyroclastics” of Southern Benue Trough, Nigeria. Their Petrology and Tectonic Significance”. *J. Min. Geol. Nigeria*. 16: 17 – 25.

15. Opara, A.I., R.A. Onyewuchi, S.O. Onyekuru, A.C. Okonkwo, I.E. Nwosu, T.T. Emberga, and O.P. Nosiri. 2014. “Structural Interpretation of the Afikpo Sub-Basin: Evidences from Air-borne Magnetic and Landsat ETM”. *Elixir Earth Sci*. 71: 24546 – 24552.

16. Petters, S.W. 1982. “Central West African Cretaceous-Tertiary Benthic Foraminifera and Stratigraphy”. *Palaeontolographica, Abst. A*. 179: 1 – 104.

17. Reyment, R.A. 1965. *Aspects of the Geology of Nigeria*. University Press: Ibadan, Nigeria. 145.

18. Rhodes, F.H.T., R. Perlman, and V.R. Webster. 1972. *Geology – A Golden Science Guide.* Western Pub. Co. Inc. 84-93.

19. Uzuakpunwa, A.B. 1974. “The Abakaliki Pyroclastics Eastern Nigeria: New Age and Tectonic Implications”. *Geol. Mag*. 111:67 – 70.

ABOUT THE AUTHOR

Ndukauba Egesi, obtained M.Sc. in Mineral Exploration with interest in Structural Geology and Geophysics and Ph.D. in Petrology, Geochemistry and Structural Geology. He is a Senior Lecturer/Graduate Coordinator and Faculty Advisor of NAPE/AAPG/EAGE Department of Geology, Faculty of Science, University of Port Harcourt, Port Harcourt, Nigeria. He has interest in structures of the basement and sedimentary terrains.

SUGGESTED CITATION

Egesi, N. 2019. “Structural Characteristics of Parts of the Abakaliki Area South-Eastern Nigeria”. *Pacific Journal of Science and Technology*. 20(1):382-389.

Pacific Journal of Science and Technology