SEDIMENTARY STRUCTURES AND PETROGRAPHY OF ROCKS WITHIN AKPOHA AREA OF THE AFIKPO BASIN SOUTHEASTERN NIGERIA CONSTRAINTS ON PROVENANCE

ABSTRACT

Sedimentary structures and petrographic studies of Akpoha area in Afikpo/Abakilikibasin wasundertaken in an attempt to understudy and determiningconstraints in depositional processes in the area . The major outcropsin the ereaare alternating succession of sandstones and shales striking in a NE-SW direction primarily as a result of folding due to past orogeny in the area . The sandstone outcrops at Akpoha are highly indurated due to age, compaction and tectonism and occur in ridges within the shale unit. The studied shale outcrops were poorly laminated and low in fossil content.Sedimentary structures identified include:Wavy/ripple lamination,Mud cracks, Parallel laminationandFissility.The results of the petrographic modal analysis from thin sections studies show that the sandstone consists predominantly of quartz (55 - 64%); feldspar (22 - 30%) and rock fragment (1 – 9%). The sandstones were immature, poorly to moderately sorted with angular to sub-angular grain shapes which gives clear indication of high energy of sediment deposition and short transport history from provenance.The abundance of well preserved sedimentary structures is an indication of prolong calmness of tectonic/orogenic activities in the area. The fissility observed in shale outcrops and the high induration of the Akpoha sandstones was as a result of compaction from overburden pressure before uplift and exposure.

KEYWORDS: Afikpo Basin, Sedimentary structures, Akpoha sandstones, petrographic Fissility

1. INTRODUCTION

Field studies of exposedoutcrops and structures in a sedimentary environment give the necessary parameters and clues in determining or interpreting past environment of deposition and deformation history of an area. Sedimentary structures as a matter of description are large physical features generally seen, analyzed or described in three dimensions in exposed sedimentaryrocks. They are seen mainly on exposed outcrops with the eyes or in large hand specimen rather than through a microscope in the laboratory. Sedimentary structures include features like mud cracks, beddings, ripple marks, fossil tracks and trails. Stratigraphy studies on the other hand describe rock successions and their interpretation in terms of general time scale.

"Akpohaarea is characterized by the predominance of sandstones which were visibly exposed. Studies have shown that these sandstones which dotted the length and breadth of the study area belong to the Ezeaku Group which has been identified as a shallow marine sequence" (Simpson, 1954 and Reyment, 1965). "The sandstones consist of NE-SW trending ridges believed to be of sub tidal origin alternating with marine shale" (Banerjee, 1980). Evidence of storm deposition was derived by Amajor (1987) after a detailed study of the AmasiriSandstone ridges. Ojoh, 1990 reported that "the sandstone from Akpoha is of marginal marine origin". This work therefore is focused on the integration of sedimentary structures, stratigraphic analysis and petrographic assessment which has never been done by previous authors in studying and understanding the depositional environment, diagenetic alterations as well as a the influence of tectonism on the initial depositions of rock formations in Akpohaerea.

2. STUDY AREA LOCATION AND GEOLOGICAL SETTING

Akpoha(study area) is within Afikpo North Local Government Area of Ebonyi State, in Southeastern Nigeria. Geologically it is confined within theAfikpo/Abakilikibasin in the southern Benue Trough.The extent of study or mapped area lies between latitudes 5^0 55´N and 6^0 00´N and longitudes 7^0 55´E and 8^0 00´E(Fig. 1).

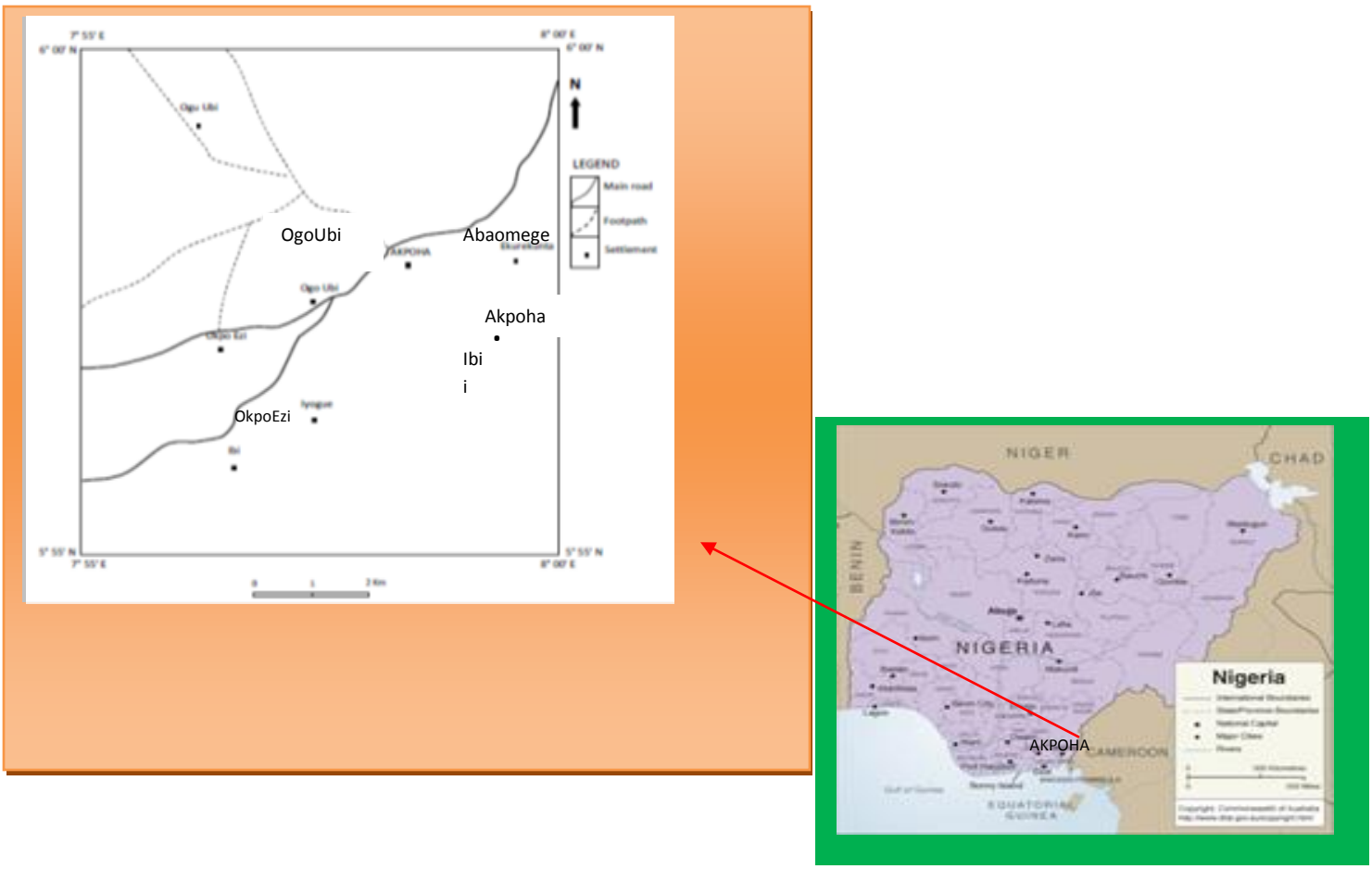

Fig.1 An enlarged map of the study (Nwimo et al 2021) area showing accessibility and adjoining towns .

The study area consists of nearly parallel ridges of sandstone units striking NE-SW with intervening lowland units formed by the shale. Akpoha and itsenvirons lies within the EasternFlank of the Abakaliki Anticlinorium. The sandstone ridges in the area are about 350ft thick above mean sea level while the shale lies at an average elevation of 150m above sea level. The ridges and hills in the areas run from NE – SW along the Abakaliki Anticlinorium

“Sedimentation in the southern Benue Trough, Nigeria began in the early Cretaceous” (Murat, 1972; Burke et al., 1972; Olade, 1975; Hoque, 1977; Petters, 1978). “The stratigraphy of the southern Benue Trough is summarized in Table 1. The Ogoja Sandstone (Aptian-early Albian) which is the basal Cretaceous sedimentary unit in the southern Benue Trough unconformably ovecsrlies the Precambrian Basement Complex” (Reyment, 1965; Nwachukwu, 1972; Uzuakpunwa, 1986). “It is the basal unit of the AlbianAsu River Group and consists of Arkosic sandstone and conglomerates restricted to Ogoja and Ikom areas” (Uzuakpunwa, 1986). “The group also comprises the Awi Formation, Abakaliki Formation and the Mamfe Formation” (Murat, 1972; Whiteman, 1982). “The Abakaliki Formation consists dominantly of dark-grey shales (which are baked in some places within the Abakaliki Anticlinorium), lenses of sandstones and sandy limestones, volcanoclastics with surbordinate mudstones” (Reyment, 1965; Benkheil, 1987). “The deposition of Asu River Group sediments was followed with the deposition of Odukpani Formation, Ezeaku Group and its lateral equivalents and the Awgu Formation all within late Albian - Coniacian. The Odukpani Formation is restricted to the Calabar Flank and consist of dark grey to black calcareous shales which has been assigned late Albian – Cenomanian” (Reyment, 1965; Petters, 1982). However, Murat (1972) and Amajor (1985) attributed “Cenomanian stage in the southern Benue Trough to either unconformity or a minor folding phase”. Meanwhile, Ojoh (1990) has dated “Cenomanian based on the palynological studies of black shales outcropping in Nara, Ezillo and Akaeze”.

“The Ezeaku Group shale facies overlies the Odukpani Formation in the Calabar Flank and unconformably overlies the Asu River Group at both flanks of Abakaliki Anticlinorium. The group consists of thinly laminated, dark grey flaggy shales with sandstones and subordinate limestones rich in pelagic faunas, pelecypods and gastropods” (Reyment, 1965; Petters, 1980). “The Eze-Aku Group is conformably overlain by the Awgu Formation in the western flank of Abakaliki Anticlinorium and unconformably underlies the Nkporo Group in the AfikpoSynclinorium with AwguFormationabruptly missing. This is represented by Santonian angular unconformity in the

basin. The AwguShale consists of dark and bluish-grey well bedded shales with abundant thin limestone and marl inter-beds" (Ofoegbu, 1984, Reyment, 1965).

Table 1: Correlation Chart for Early Cretaceous Tertiary strata in the Southeastern Nigeria (After Nwajide, 1990)

AGE		ABAKILIKI-ANAMBARA BASIN	AFIKPO BASIN
30(m.y)	Oligocene	Ogwashi/Asaba formation	Ogwashi/Asaba formation
54.9	Eocene	Ameki/Nanka Formation / NsugbeSst(Ameki Group)	Ameki Formation
65	Paleocene	Imo Formation Nsukka Formation	Imo Formation Nsukka Formation
73	Maastrichtian	Ajali formation Mamu formation	Ajali Formation Mamu Formati
83 87.5	Campanian	NkporoC Formal	Nkporo shale/AfikpoSst
	Santonian	AgbaniSst/Agwu shale	Non-deposition /erosion
88.5	Coniacian		Ezeaku group
	Turonian	Ezeaku group	(**inc.AmasiriSst**)
93 100	Cenomanian Albian	Odukpani Formation Asu River group	Odukpani Formation Asu River group

The tectonic episode occurring in the mid-Santonian time deformed the Benue trough which led to folding accompanied by structural inversion (Hoque, 1976) and widespread erosion in the sediment fill of the Benue Trough. The Santonian Orogeny resulted in the uplifting of the AbakalikiAnticlinorium(Fig. 2) and the subsidence and formation of the Anambra Basin on its western flank and the AfikpoSynclinorium on its south eastern flank (Hoque, 1976).

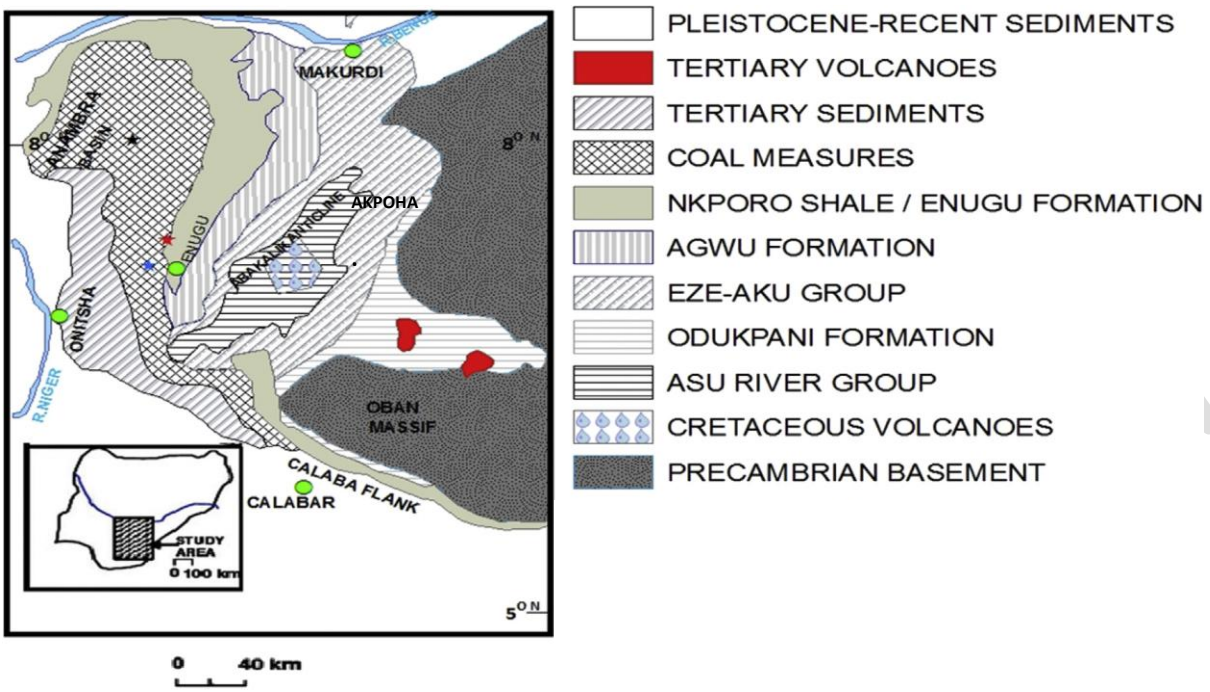

Fig. 2 Geological Map of Southern Benue Trough (Modified from Ojo et al., 2009).

Campanian - Maastrichtian transgression resulted in deposition of marine sediments. Over 2000 metres of sediments deposited in the Afikpo Sub-Basin and Anambra Basin were eroded from uplifted Abakaliki Anticlinorium (Hoque, 1976). Thus the Anambra Basin and Afikpo Syncline (Fig.3) became the major depocentres for the Campanian - Maastrichtian sediments (Murat, 1972). The Nkporo Group, Mamu Formation, Ajali Sandstone and Nsukka Formation were deposited in these basins.

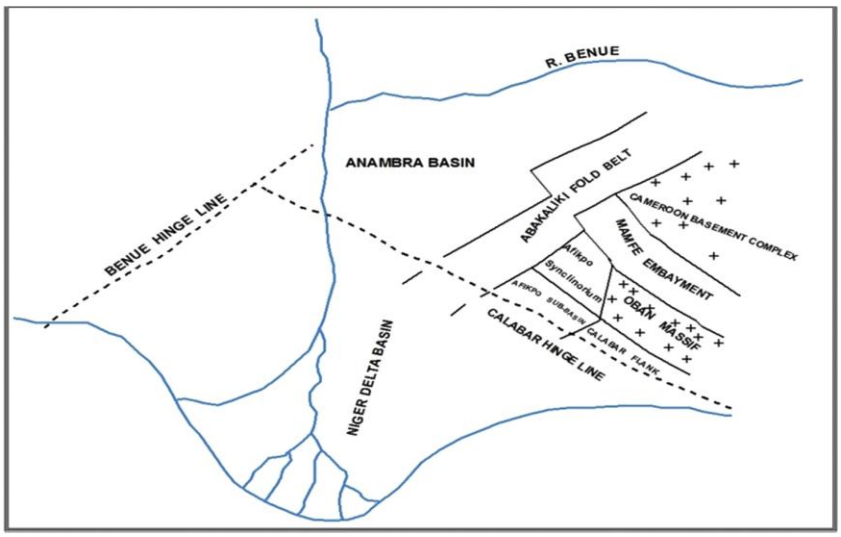

Fig.3Tectonic Elements map of the Southern Benue Trough (Modified after Murat, 1972).

The Ezeaku Group is believed to represent typical shallow water deposit, consisting mainly of hard grey to black shales and siltstones. Facies changes to sandstones and sandy shales are common. The thickness of this Formation varies and locally may be up to 100 m thick and passes laterally into sandstone ridges at Amasiri sandstone, limestone, calcareous sandstone, and sandy limestone. Murat (1972) was of the view that “the Ezeaku Shale shows deposits of marine condition in a tectonically controlled basin (the Abakaliki Trough). He believed that sandstone deposits mark a period of regression, while the shale deposits indicate a period of transgression”. On the basis of the predominance of shale from Aba-Omege towards Abakiliki, Nwachukwu (1975) concluded that “deep-sea conditions terminated at Aba-Omege from where a shallow marine condition commenced. He also believed that a distant metamorphic basement had contributed to the sediments in the Ezeaku Shale because he found metamorphic minerals in the sandstone units, in addition to conclusions he drew from heavy mineral analysis”.

The Ezeaku Group was deposited in the Turoniantransgressive phase but in a shallow marine environment. The lithologies include shale, sandstones, and calcareous sandstones. The fossils in this Formation include vascocerastids, pelecypods, gastropods, echinoids, fish teeth, decapod, and plant fragments (Reyment, 1965).The predominantly Albian-Cenomanian marine depositional cycle was terminated by a phase of folding (Nwachukwu, 1975; Olade, 1978), which affected the Asu River Group in the area. The second transgressive-regressive phase of deposition in Turonian to Santonian was terminated again by a phase of folding and faulting in the early Santonian times, which affected all the sediments deposited before the tectonism and this produced the Afikpo syncline.

3. MATERIALS AND METHODS

Field investigations involved geological mapping. The aim was to delineate and correlate various rock units and structural elements in the study area, measure their geographic positions and elevations as well as establish sample locations. Field mapping was carried out with the aid of Afikpo Northeast topographic map (Sheet No. 313 of the Nigerian Geological Survey Agency, with scale of 1:100,000), Brunton compass, measuring tape, geological hammer and Global positioning system device (GPS-Garmin Model). Strike and dip directions of studied rock units as well as flow directions of ripple laminations were taken with aid of the Brunton compass. Focus was, however, placed on the geological and geographic distribution of the Amasiri Sandstone in Akpoha town. The sampled rocks used for petrographic analyses were fresh and unweathered.A total of six (6) representative samples were randomly collected from different sandstone bodies within the Akpoha area for petrographic studies . The samples were collected with the aid of a sledge-hammer.The petrographic modal analysis involves identification and quantification of mineral and particulate constituents of rocks in thin sections under a petrographic microscope. In this study, modal analysis was carried out under a polarizing microscope following the 'point-counting' method, given by Chayes (1956). This analytical procedure identifies a mineral on the basis of its optical properties and quantifies it on the basis of percentage area it would occupy, if it were to be fixed together. Details of the optical behaviours of common rock forming minerals that aid their identification under the petrographic microscope have been presented by numerous researchers such as Chayes (1956) and Blyth and de Freitas (1984).

. RESULTS AND INTERPRETATIONS

4.1 Findings from Field Mapping

The geology of Akpoha and environs (Fig.4) consists of alternating succession of sandstone and shales striking in a NE-SW direction(see Fig.5). The northern part of the study area is generally lowland, rising to some 30m above sea level. The high ridges are underlain by the Amasiri Sandstones in Okpo-Ezi (about 120m high), Ibii and Akpoha areas (about 75m high). The sandstone ridges have been subjected to prolonged and intense weathering producing huge craggy blocks of boulders and rock falls. The sedimentary rocks exposed are Cenomanian - Turonian in age and belong to the Amasiri Sandstone of the Ezeaku Group.

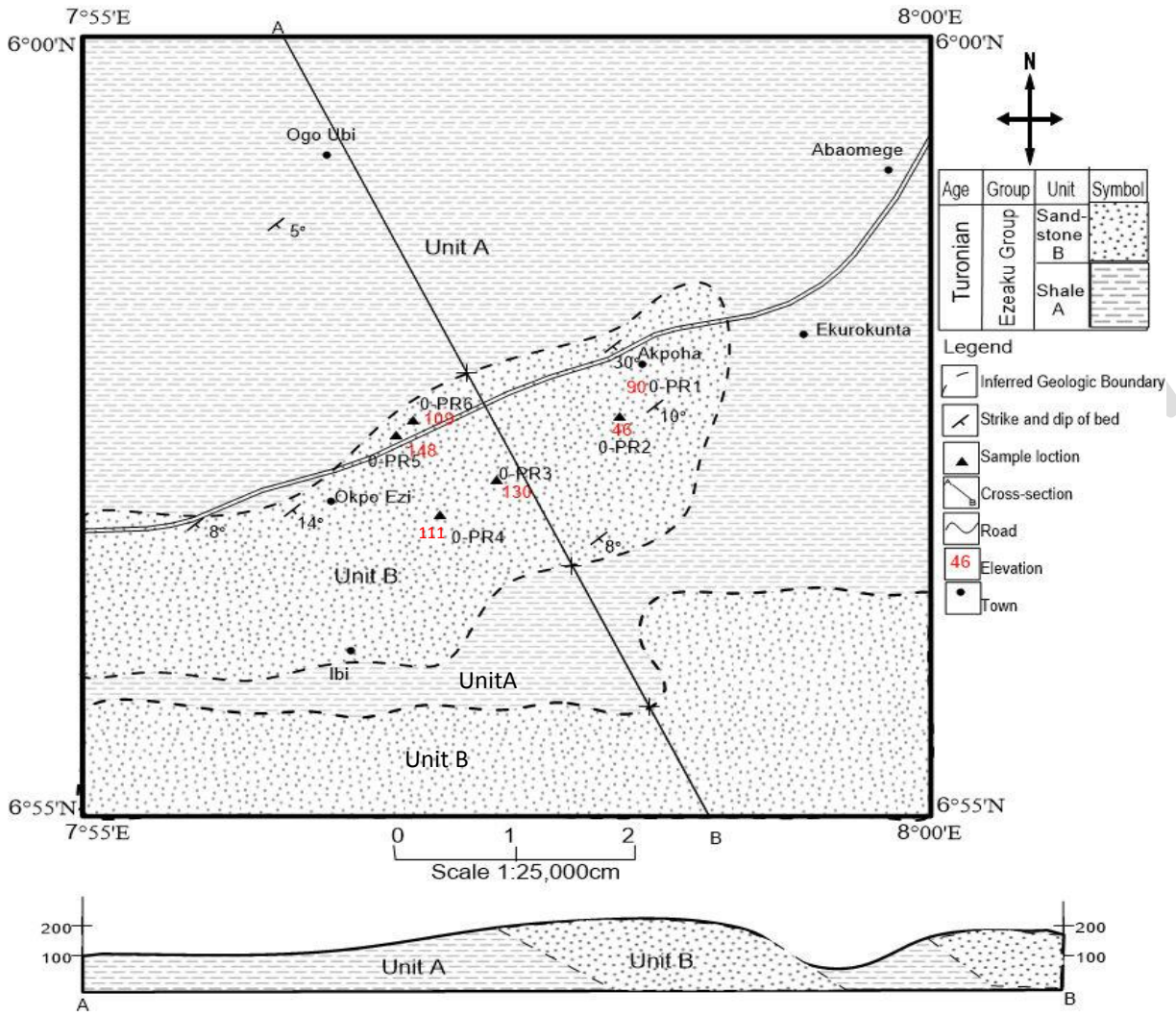

Fig. 4 Geological map of Akpoha area.

There is rapid successions of sandstone and shales in the Ezeaku Group which could be attributed to sufficient sediment supply and deposition . The units were delineated based on their structure, Sedimentological characteristics and stratigraphic position. The lithofacies that constitute the local geology of the study area include sandstones, dark to grey shale and brown –flaggy shale (see Fig.5).

Fig.5 Sandstone ridge trending NE-SW&Shale outcrop at Amata village

4.2 Stratigraphy

4.2.1 Unit A– Shale (Ogo-Ubi)

This unit comprises mainly shales in the study area (Fig.4). It consists predominantly of grey shale which covers large extent of the northern part of the mapped area. They are poorly laminated and low in fossil content. The shale formed the low-lying part of the Ezeaku Group. The shale around Amata-Elu is black, fissile, laminated and underlies the sandstone. Weathered part of the shale show high fissility and are brownish/yellowish-red in. Along the Ebonyi River, the dark grey and fissile shales of unit A are weathered with reddish brown while the shale found around Amata-Enu are fissile and yellow to reddish in colour. The dip of the shale varies from 5^0 to 15^0, while the general strike is NE-SW direction.

4.2.2 Unit B-Sandstone (Akpoha)

The sandstone outcrops at Akpoha, Okpo-Ezi and Ibii are highly indurated and occur in ridges within the shale unit. The maximum height of the beds is 75m with thickness that rangefrom 90cm to 200cm. The sandstone consists of abundant quartz and feldspar. The dip of the sandstone ranges between 8° and 30° in the southeast direction and strike in the northeast – southwest direction. The sandstones vary in grain size from medium to coarse and are moderately sorted. The outcrops are mostly boulders. The sedimentary structures in the sandstones include cross beds/cross laminations, parallel lamination/bedding, ripple/wavy beds, ripple cross laminations and burrows.

4.3Petrographic Modal Analysis

The results of the modal analysis from thin section petrography are summarized in Table 2. Photomicrograph of the studied thin sections is presented in Plate 1, 2, 3, 4 and 5. The sandstone consists predominantly of quartz (55 - 64%); feldspar (22 - 30%) and rock fragment (1 – 9%).

Table 2. Results of petrographic modal analyses on the samples of the Akpoha Sandstone.

Sample code	**Major Constituents**				
	Quartz (%)	**Feldspar (%)**	**Calcite (%)**	**RF (%)**	**Total (%)**
O-PR 1	63	23	5	9	100
O-PR 2	60	25	10	5	100
O-PR 3	55	28	10	7	100
O-PR 4	60	30	9	1	100
O-PR 5	64	22	8	6	100
O-PR 6	60	25	11	4	100
Minimum	55	22	5	1	
Maximum	64	30	11	9	
Mean	60.33	25.5	8.83	5.33	

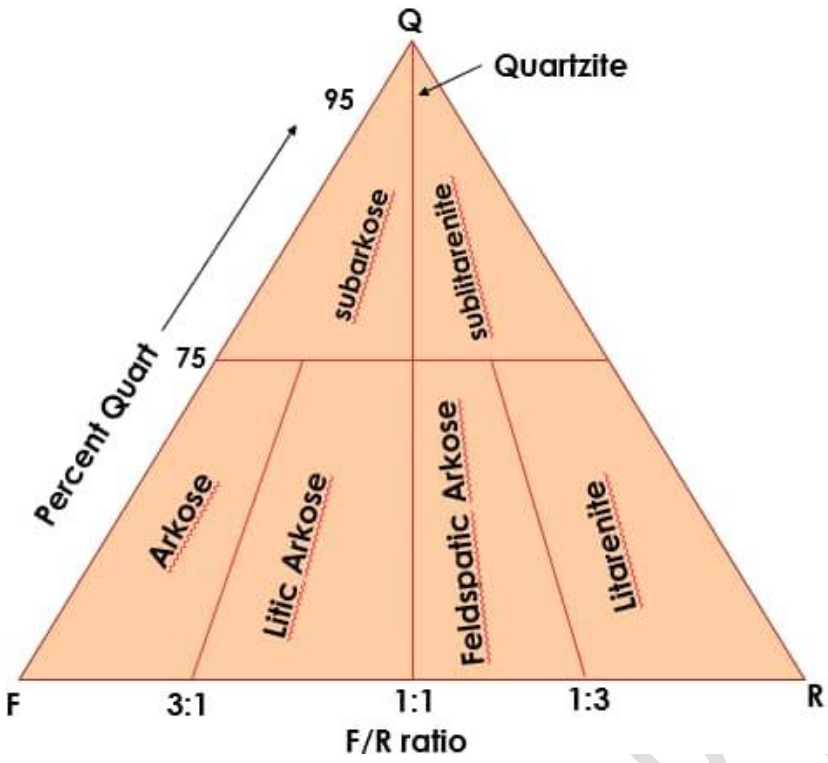

Fig.6 Folk classification of Sandstone

Classification of the sandstones on the mean values of quartz (60.33%), Feldspar(25.5%) and Rock fragments (8.83%) base on Folks classification shows that the studied rocks are majorly lithic arkose and Feldspathic lithareinite(fig.6).Feldspar and quartz minerals show concave/convex contact with, angular to subangular and subrounded grain shapes. Sorting was poor to moderate with fairly distributed matrices .

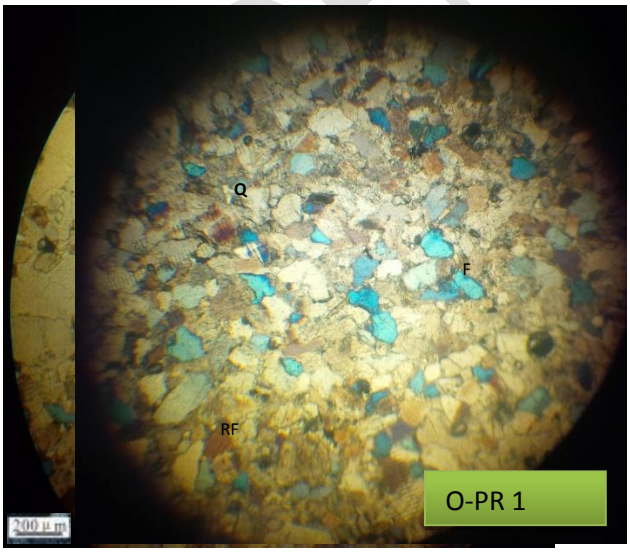

Plate 1. Concave -Convex contact with few line contacts. Monocrystalline quartz, angular to subangular in form, moderately sorted.

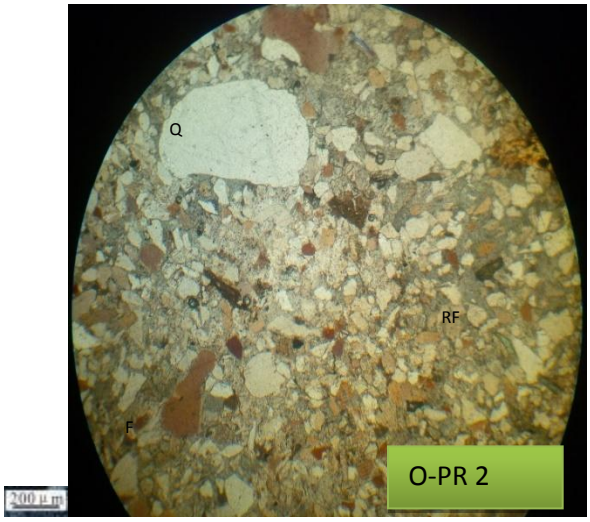

Plate 2. Convex to line contact, monocrystalline quartz, angular to subangular grain, moderately sorted

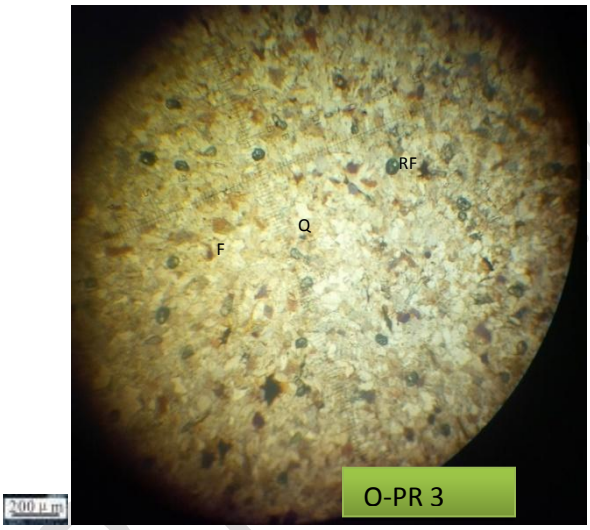

Plate 3. Line contact, monocrystalline quartz, fine grained rounded to subangular, well sorted.

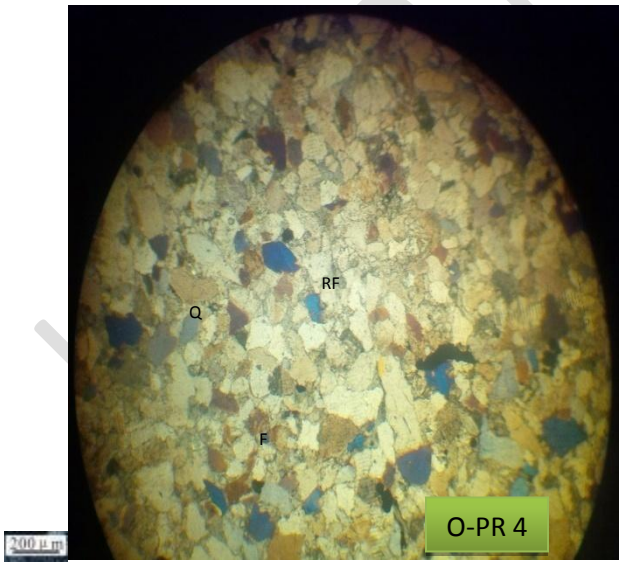

Plate4. Concave-convex contact, monocrystalline quartz, angular to subangular, coarse grained, moderately sorted

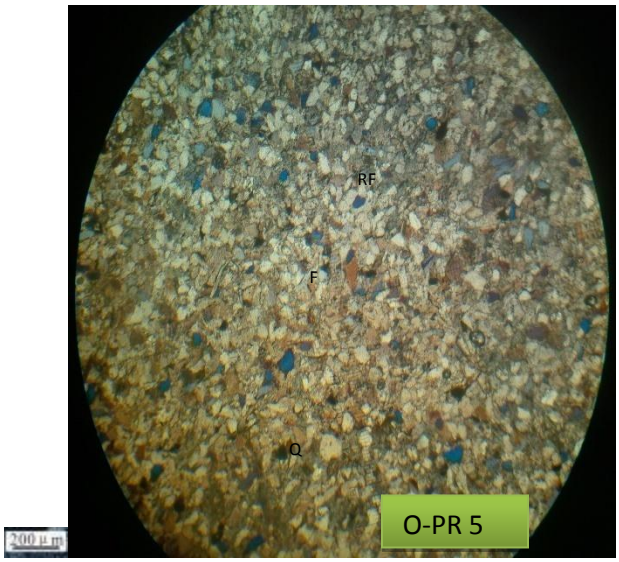

Plate5. Line contact, monocrystalline quartz, rounded to subangular, fine grained, well sorted

4.4 Structural Geology

4.4.1 Sedimentary Structures

“Sedimentary structures broadly include all the structural features which are formed in sedimentary rocks as a result of the various processes leading to their depositions and subsequent consolidation” (PettiJohn, 1975). “An understanding of these structures is important to the geologist in the field because they can be used to determine the processes involved in the deposition of sedimentary rocks, the environment and conditions of deposition, as well asthe directions of the paleocurrents under which the sediment was deposited” (PettiJohn, 1975).The most common sedimentary structures observed in the mapped rocks are the primaryorsyngeneticstructures. The structures include stratifications, ripple marks, laminations, cross beddings, fissility and mudcracks. The biogenic structures observed in the study area include bioturbations and burrows(Fig.7). Some of the structures are described as thus;

Fig. 7Burrows observed behind G.T.C Akpoha

4.4.1.1 Mud cracks

Mud cracks also known as desiccation cracks. They are sedimentary structures formed as muddy sediment dries and contracts. The cracks develop on the mud surface due to the effect of intermediate exposure and covering by water like flood plain. They are common in shallow water environment which proves Ezeaku Group as a shallow marine sequence (Simpson, 1954 and Reyment, 1965). The structures result from shrinkage due to loss of water during dry season and may be in-filled with sand, silt or organic matter. This structure was observed along the river bank of the Ebonyi River.

4.4.1.2 Laminations

Lamination is a fine layer of rock with thickness of less than 1.00cm (Fig.8). Laminations are normally smaller and less pronounced than bedding layering. It consists of small differences in the type of sediment that occur through the rock. They are caused by cyclic changes in the supply of sediment. These changes can occur in grain size, clay percentage, microfossil content, organic matter content or mineral content. Laminations can occur as parallel lamination or as cross lamination.

Parallel lamination; Theoutcrops behind G.T.C Akpoha are characterized by parallel laminations (see Fig. 8). This may be defined by distinct planar and continuous laminae as evident in the outcrop. The parallel laminations suggest that these lithofacies were deposited in moderate energy deep marine environment (Stow, 1985). The environment was dominated by bottomcurrent reworking with transition from lower flow to upper flow regime.The texture and the planar cross stratifications suggest deposition in shallow shorefaceenvironment dominated by storm events.

Fig.8 Parallel lamination at G.T.C Akpoha

Wavy/ripple lamination;these features was eminent in the outcrop behind G.T.CAkpoha. They are irregular/wavy and ripple laminations (Fig.9). “These ripples are very low amplitude ripples. There is a vertical distribution grading from plane parallel lamination which occur in parallel bedded sandstone litho facies to wavy to ripple drift laminations. The wavy/ripple lamination is interpreted to have been deposited in a low energy deep marine environment” (Walker, 1984 and Stow, 1985). “The depositional process is dominated by traction and bottom current reworking in the lower flow regime. The ripple-laminated/bedded sandstone represents traction deposits, and thin rippled divisions are interpreted to be products of short-lived traction processes” (Bouma, 1962 and Bouma, et al. 2000).

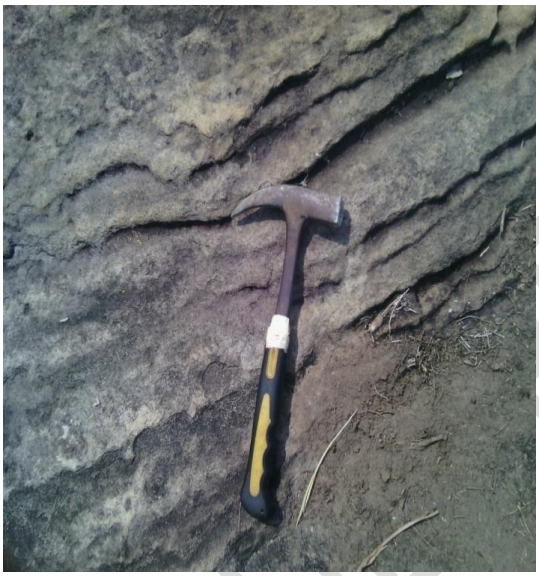

Fig.9 Wavy/ ripple lamination at G.T.C Akpoha

5. DISCUSSION

5.1 Deductions from structural and petrographic analysis

The highpercentage(>25%) of feldspars from the results obtained from petrographic modal analysis suggest they are immature arkose/feldsparthic sandstones which did not move far away as result of weathering and erosion but are relatively close to the provenance (place of origin) possibly the Oban Massif of the southeastern Nigeria basement complexwhich conforms to the views of Odigi and Amajor (2008). Results showthat rock samples selected from different locations in the course of the

field work are medium to coarse grained, consists of angular to sub-angular, anhedral grain with calcite as the cementing materials (5 - 11%).The poor to moderate sorting as well as the angular to sub-angular shapes of the mineral grains give clear indication of high energy deposit and short transport history from provenance. The quartzo-feldspathic sandstones are poor in lithic fragments which corroborates the work of Dickson and Suczek, 1979.

In general, the Ezeaku Group was deposited in shallow marine environment as reported by Simpson, 1954 and Reyment, 1965.This view is strongly supported by the predominance of sandstone, copious presence of bioturbations,burrows and calcite cement(fig.6) which can only take place in a shallow marine oxygenated environment. The rapid alternation of sandstone and shale units support the view on depositions in transgressive and regressive conditions.The abundance and well preserved sedimentary structures in Akpoha and environs is an indication of prolong calmness of tectonic/orogenic activities in the area. The fissility observed in shale outcrops and the high induration of the Akpoha sandstones was as a result of compaction from overburden pressure before uplift and exposure. The Mud cracks were due to the effect of intermediate exposure and covering by flood plain. They are common in shallow water environment which corroborates deposition in a shallow marine environment during transgressive/regression episodes.

The occurrences of laminations in some of the studied rocks suggestthe lithofacies were deposited in moderate energy and most likely deep marine environment away from turbulence sea surface which corroborates the work of Stow, 1985.The occurrence of irregular/wavy and ripple laminations (Fig.9) withvery low amplitude in a northwest-southeast flow direction as recorded during the field work also suggest some of the lithofacies were deposited in a low energy deep marine environment which gives credence to the work of Walker, 1984 and Stow, 1985. If that's the case, it suggests the sandstones were products of different regressive and transgressive episodes.

6. CONCLUSION

The study area falls within the Lower Benue Trough, Southeast Nigeria. The area of study covers an area of about 86 square kilometres. This study revealed the followings:

1. Akpoha and its environs are underlain by one major lithological unit, the Amasiri Sandstone of the Ezeaku Group, comprising shale and sandstones.
2. The sediments were deposited under fluctuating energy conditions which aided in the preservation of the studied geologic structures .

3. The sandstones are calcareous, bioturbated and burrowed with a wide distribution of medium to coarse grain sizes.
4. The sediments were deposited during transgressive and regressive of different episodes.
5. The rocks strike northeast-southwest with a southeastern dip direction.
6. The petrographic studies from maturity view point gives evidence that the sedimentary materials were derived from proximal basement rocks , most probably the Oban Massif, hence a nearby provenance.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Amajor, L.C., 1987. The Ezeaku Sandstone ridge (Turonian) of southeasternNigeria: a re-interpretation of their depositional origin. J. Min. Geol. 23, 17–26.

Banerjee, I., 1980. A subtidal bar model for the Eze-Aku Sandstones, Nigeria. J. Sediment. Geol. 30, 133–147.

Benkheil, J., 1987. Structural frame and deformations in the Benue Trough of Nigeria.

Bouma, A. H., 1962 Sedimentology of Some Flysch Deposits: Agraphic approach to facies interpretation. Amsterdam: Elsevier, p. 168.

Bouma, A. H. and Stone, G., 2000 Fine-grained turbidite systems.AAPG Memoir 72 and SEPM Special Publication, 68, p.342.

Burke, K., Dessauvagie, T.F.J. and Whiteman, A.J. 1971. Opening of the gulf of Guinea and geological history of the Benue Depression and Niger Delta. Nature (Physical Science). Vol. 233, No. 38, pp. 51-55.

Hoque,M., 1977. Petrographic differentiation of tectonically controlled Cretaceoussedimentary cycles southeastern Nigeria. Sediment. Geol. 17, 235–245.

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, University of Ibadan Press, Nigeria, pp. 251- 266.

Nwajide, C.S., 2013. Geology of Nigeria's Sedimentary Basins. CSS Bookshops, Lagos,p. 565.

Nyong, E.E., Ramanathan, R.M., 1985. A record of oxygen-deficient paleoenvironmentsin the Cretaceous of the Calabar Flank, SE Nigeria. J. Afr. Earth Sci. 3 (4),455-460.

Odigi, M.I. and Amajor, L.C. (2008) “Petrology and Geochemistry of sandstones in theSouthern Benue Trough of Nigeria: Implications to provenance and tectonic setting”. 27(4):384-394.

Ofoegbu, C.O., 1984. Interpretation of aeromagnetic anomalies over lower andmiddle Benue Trough of Nigeria. Geophys. J. R. Astron. Soc. 79, 813-823.

Ojo, O.J., Ajibola, U.K., Akande, S.O., 2009. Depositional environments, organicrichness petroleum generating potential of the campanian to MaastrichtianEnugu formation, Anambra Basin, Nigeria. Pac. J. Sci. Technol. 10, 614-628.

Olade, M.A., 1975. Evolution of Nigeria's Benue Trough (Aulacogen): a tectonicmodel. Geol. Mag. 112, 575-583.

Olade, M.A. 1978. Early Cretaceous basalt, volcanism and initial continental rifting in the Benue Trough, Nigeria. Nature (Physical Sciences), Vol. 273, pp. 451-459.

Ojoh, K.A., 1990. Cretaceous geodynamic evolution of the southern part of theBenue Trough (Nigeria) in the equitorial domain of the south Atlantic.Stratigraphy, basin analysis and paleo-oceanography. Bull. Exp. Prod. Elf-Aquitaine 14, 419–442.

Petters, S.W., 1978. Stratigraphic evolution of the Benue Trough and its implicationsfor the upper Cretaceous paleogeography of West Africa. Journal of Geol. 86,311–322.

Simpson, A.,1954 The Nigerian Coal Field: The Geology of parts of Onitsha, Owerri and Benue Provinces. Geological Survey NigerianBlletin, 24,1-67.

Stow, D. A. V. AndCremer, I., 1985 Sedimentary structures of finegrained sediments From the Mississipi Fan: Thin section analysis,pp 519- 532.

Reyment, R.A. 1965. Aspects of the Geology of Nigeria. Ibadan University Press, Ibadan. 145 pp. Simpson, A., 1954. The Nigerian coalfield. The geology of parts of Onitsha, Owerri

and Benue provinces. Bull. Geol. Survey Nigeria 24, 85.

Uzuakpunwa, A.B.,1986.A pre-Albi succession in parts of southeastern Nigeria.Cah. Geol(No.96),358-362.

Walker., 1984 General introduction: facies, facies sequencesand facies models In: Walker, R.G. (Ed.), Facies Models, 2nd Edition, Geoscience Canada, Reprint Series 1,pp 1–9.