IMPLICATION OF SYN-SEDIMENTARY STRUCTURES DOCUMENTED FROM MAMU FORMATION SOUTH-EASTERN NIGERIA

Adiela, U.P[1], Omontese, S.O[2], Akomolafe, M.T[3],

[1]Department of Petroleum Engineering, Nigerian Agip Oil Company, Port Harcourt

[2] Department of Earth Science, Federal University of Petroleum Resources, Effurun, Nigeria.

[3]Department of Geology, University of Port-Harcourt, Rivers State, Nigeria.

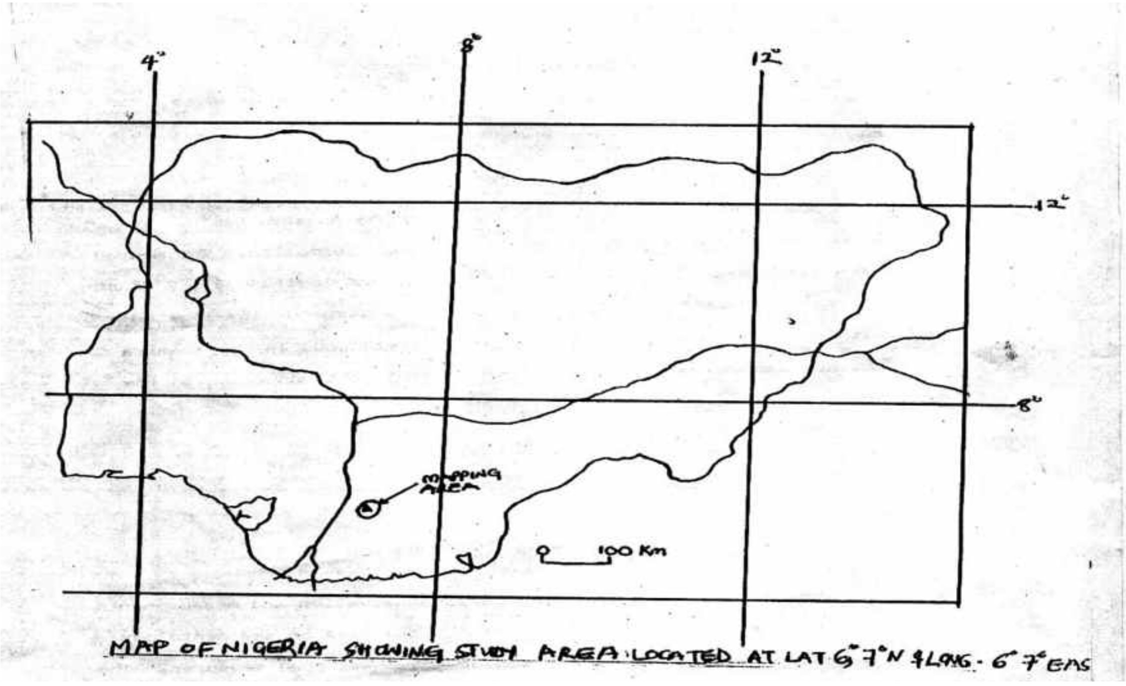
Abstract: The sedimentary structures in Mamu Formation exposed at Enugu-Onitsha express road were studied. The method of study involved field observation and photographs taken from the field. This study looks at the implication of syn-sedimentary structures on Mamu Formation in South-Eastern Nigeria. The Paralic Mamu Formation (Lower Coal Measures) found in the Anambra Basin of Nigeria intercalates with the marine sequence of the Enugu Shale. The Mamu Formation is also overlain by the continental sequence of the Ajali Formation. Sedimentary structures are formed as a result physical, chemical and biological processes during or shortly after deposition. These structures are the best indicators in any deposits of processes operating with depositional environment because they formed where they are presently found. The syn-sedimentary structures are the primary structures that formed during the time the sediments were deposited. The Mamu Formation consists of sandstones carbonaceous shales and sandy shales with coal seams. They include current formed and tool mark structures. Current formed structures are either depositional or erosional. They are Channel & Rills, Flute Marks, Stratification, Ripple Mark &Cross Lamination, Cross bedding, Current Lineation, Graded Bedding while tool mark structures may include grooves, rolls, slide marks, bounce and brush. Sedimentary structures observed in the field were primarily depositional and erosional. These factors were documented based on the syn-sedimentary structures from the Mamu Formation.

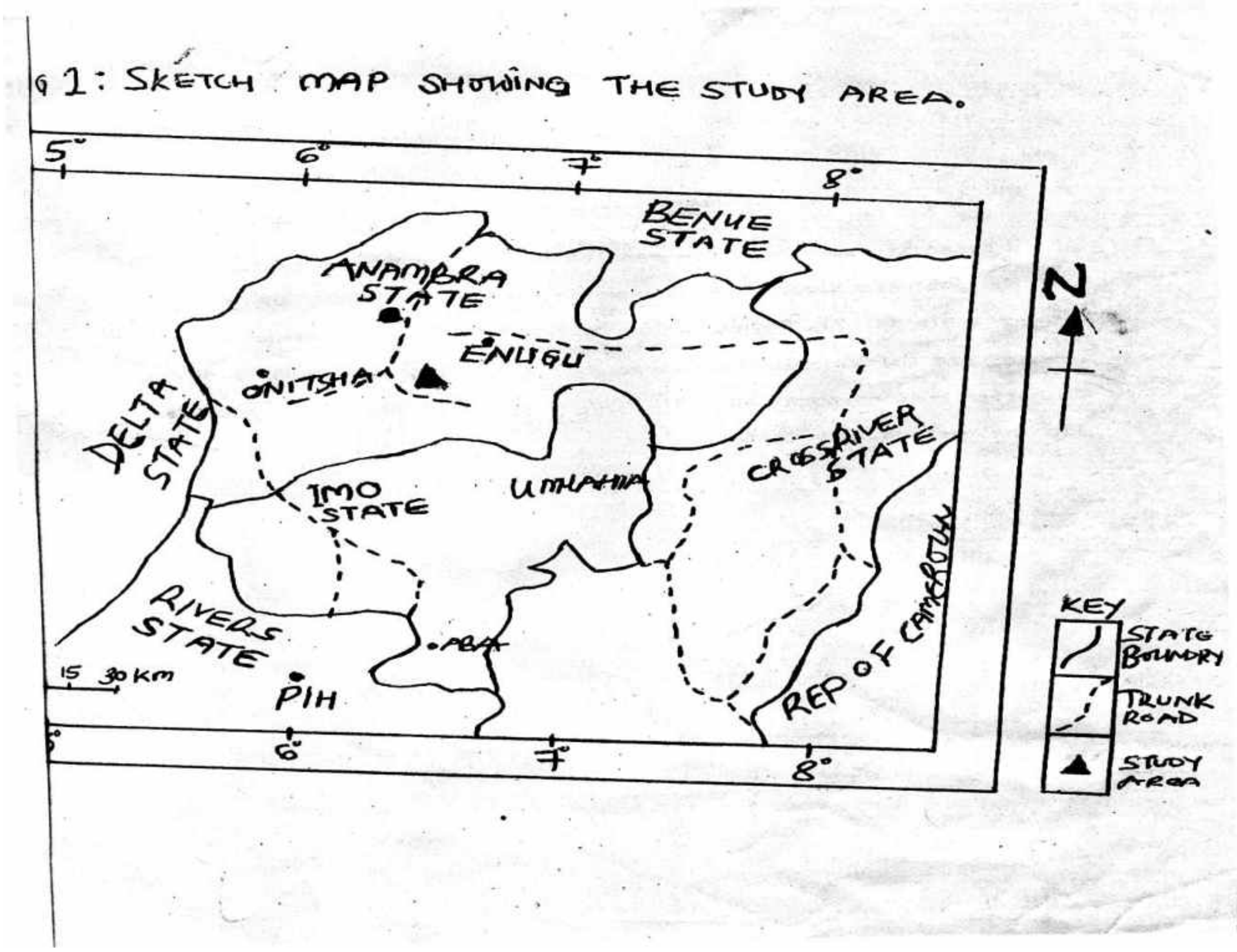
Keywords: Mamu Formation, Structures, South-Eastern Nigeria.

INTRODUCTION:

The Mamu Formation is among the formation that makes up the Anambra Basin (Nwajide and Reijers, 1996). The Anambra basin is a major sedimentary basin in the south-eastern region of Nigeria (Nwajide and Reijers, 1996). The Anambra sedimentary covers about 40,000sq.km and extends northwest beyond the lower Benue river (Nwajide and Reijers, 1996). The Anambra basin formed after the Santomian tectonic episode, dating back to 84 million years (Short and Stauble, 1967). During the Albian-Santomian time, the Benue trough with the Abakaliki and Benue basins was essential an intracratonic mobile sedimentary basin (Nwanjide and Reijers, 1996). Some geological formations make up the Anambra basin. They include Mamu Formation, Nsukka Formation, Imo Formation, Nanka Formation, Ajali Sandstone, Enugu Shales, the Awgu Shales and Nkporo Formation. The Anambra basin is located in the south-eastern region of the Benue trough. The main focus of this project work is the Mamu Formation exposed along Enugu- Onitsha express road. The aim of this work is to ascertain the implications of syn-sedimentary structures documented from Mamu formation in southeastern Nigeria. The Mamu Formation of Nigeria formerly called the Lower Coal Measures is found within the Anambra Basin. It occurs as a strip trending North-South from the Calabar Flank, swinging West round the Ankpa Plateau and terminating at Idah near the River Niger (Nwajide and Reijers, 1996).The location of the study area is the escarpment of the Mamu Formation along Enugu-Onitsha expressway. Its compass beaming is between latitude $6^0$83N and $6^0$89N and longitude $7^0$25E and $7^0$27E. The study area is easily accessible because the road makes it accessible to the outcrop location.

FIG 1: MAP OF NIGERIA SHIOWING STUDYAREA





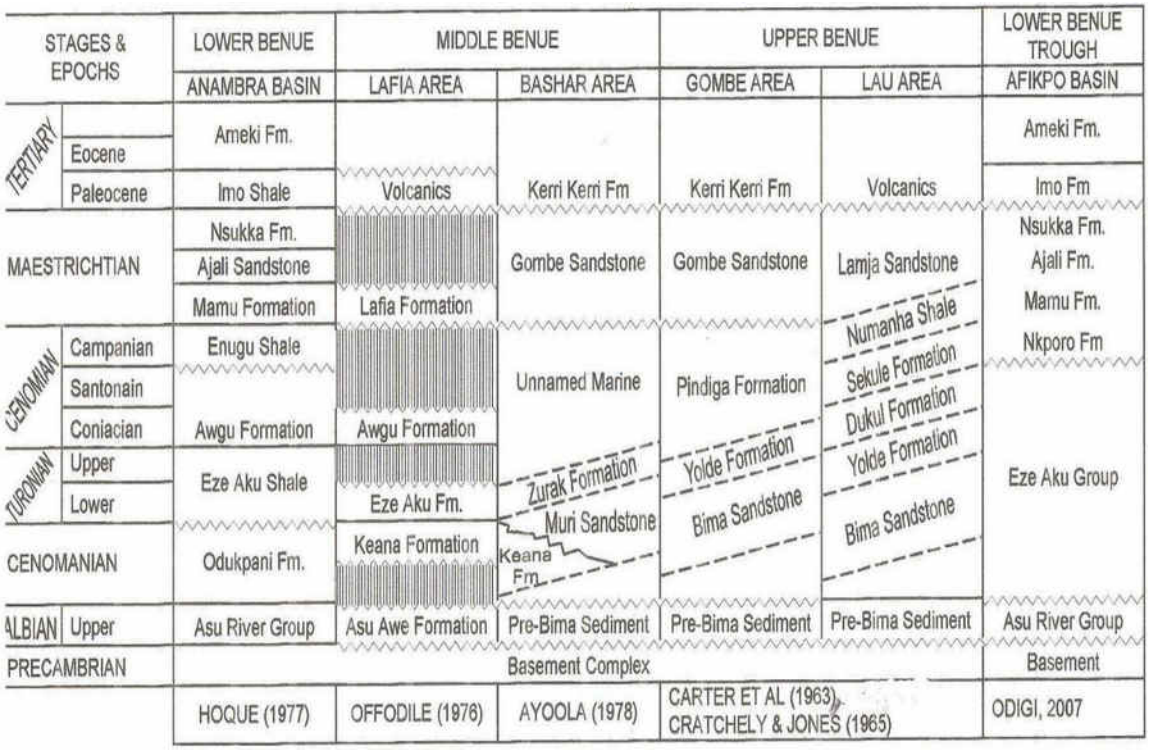


Fig.3 Stratigraphic succession in the lower Benue Trough, (Odigi 2007).

AIM AND OBJECTIVES:

The aim of this study is to determine the implication of sync sedimentary structures on Mamu Formation. The objectives are;

- To document syn-depositional sedimentary structures from Mamu Formation in south-eastern Nigeria through observations verified from the field.
- Interprete the sedimentology of the Mamu Formation exposed at Enugu-Onitsha express road.

METHODOLOGY:

The research work involves site data gathering through observation. The sedimentary logging and facies were carried out with a map of the location.

- Hammer
- A measuring tape
- Camera
- Field notes, pen, marker.
- Compass clinometers

The outcrop sections along Enugu-Onitsha expressway have allowed the shale silt store sandstones and the coal bed to undergo sedimentary changes. In the field, fresh samples of various rock types were collected from various horizons with the aid if a hammer. The compass clinometer was also used to record strike and dip values. The tape was used to estimate the thicknesses of beds.

Lithologic Description

The lithology expressed here is mainly on field observations. Hence mapping units were present at the outcrop to delineate the various rock types encountered. Lithologically, they consist of dark grey shales, siltstone, sandstones, heteroliths and coal beds which were subjected to sedimentological studies.

Texture Characteristics

The sandstone facies are fine, moderately well sorted, very fine skewed leptokurtic. Scattered grains among the textural parameters indicate the sandstone to be of fluvial origin. Major element geochemistry illustrates an enrichment of quartz and depletion of chemically unstable grains.

RESULT:

Mode of Formation

The sync sedimentary structures documented from the sites shows that integrated information as provenance indicator suggests that the sample sets were derived from the adjacent Pre-Santonian Abakaliki Trough and the basement complex Oban massive (Boore et al, 2004). Framework work composition and major element data indicates a highly recycled nature and/or extreme chemical weathering under humid and warm climate sedimentary attributes of the sedimentary products suggests deposition in shallow marine environment with operational cross bedding.

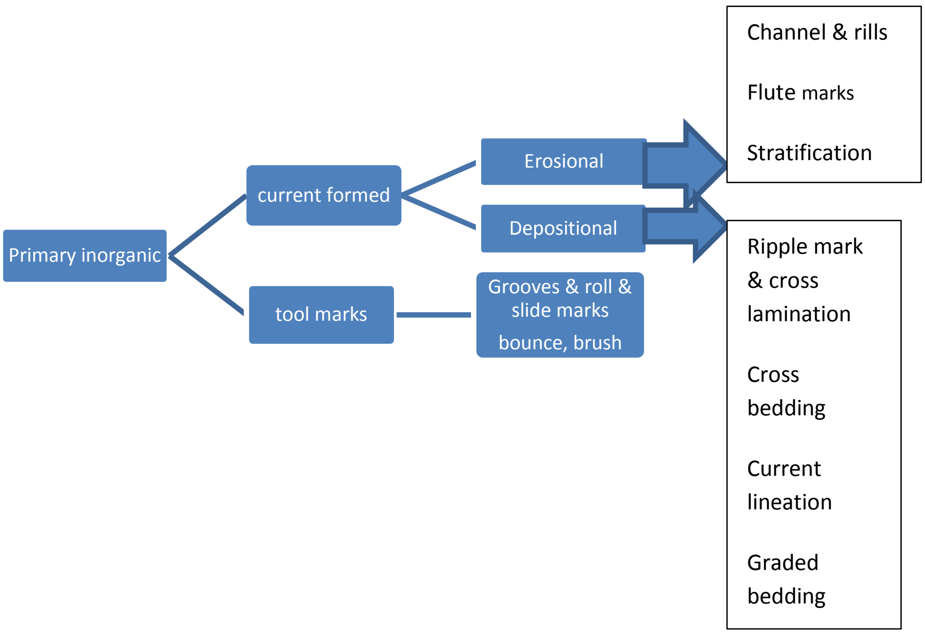
Lithification

Lithification is the general term for the processes that convert loose sediment into sedimentary rock. Most sedimentary rocks are lithified by a combination of compaction which packs loose sediment grains tightly together and concentration in which the precipitation of cement around sediment grains binds them into a firm coherent rock.

Sedimentary Structures

Sedimentary structures are formed as a result physical, chemical and biological processes during or shortly after deposition. These structures are the best indicators in any deposits of processes operating with depositional environment because they formed where they are presently found. Most sedimentary structures are best studied in the field where it is essential to describe them fully with sketches or photographs so that a latter return to the exposure for details. Sedimentary structures may be of inorganic or biogenic origin. Inorganic structure may be primary or secondary inorganic structure.

Fig 4: Examples of Primary Inorganic Structures



Secondary Structures

These structures indicate physical or chemical conditions in the digenetic environment. A variety of structures are formed on the sediment after deposition by mechanical processes.

Biogenic Structures

These are structures that are formed as a result of the activities of organisms. They are evidence of activity by an organism fossils or recent, other than the production of the body parts.

Fig 5: Photograph showing planar bedding and current lineation in sandstone body of the Mamu Formation.

Sandstone is formed by the cementation of sand grains. Any deposits of sand can lithify the sandstone. As you might imagine, sandstones show a great deal of variation in mineral composition, degree of sorting and degree of rounding. Shale is a fine-grained sedimentary rock notable for its ability to split into layers (called fissility). Splitting takes place along the surface of very than layers (called laminations) within the shale.

Fig 6: Photograph showing current lineation in sandy-shale unit of the Mamu Formation.

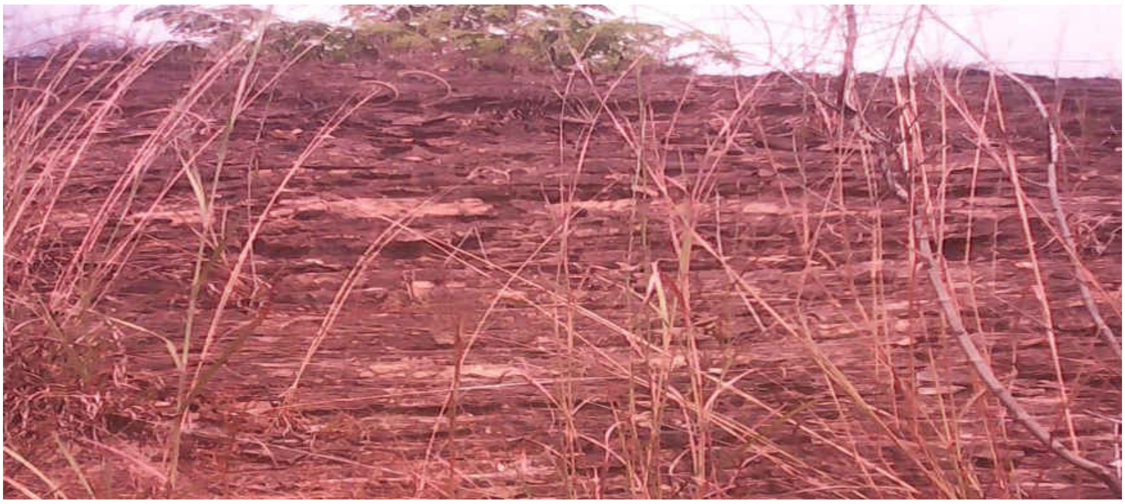


Fig 7: Photograph showing stratification in sandy-shale unit of the Mamu Formation

Fig 8: Photograph showing stratification in coal unit of the Mamu Formation

Fig 9: Photograph showing stratification in shale unit of the Mamu Formation.

Fig 10: Photograph showing grooves, rolls and slide marks in shale unit of the Mamu Formation

Factors controlling the characteristics of Syn- Sedimentary Structures

A sedimentary rock owes its characteristics texture and particular mineral content to several factors, the most important being;

- The composition of the parent rock before changes
- Temperature and pressure during changes
- The effects of tectonic forces
- The effects of fluids such as water

These factors were studied and their implications with reference to the Mamu Formation in South-Eastern Nigeria.

DISCUSSION:

The Paralic Mamu Formation (Lower Coal Measures) intercalates with the marine sequence of the Enugu Shale. The Mamu Formation overlain by the continental sequence of the Ajali Formation and they both form part of a large delta complex laid down during a regressive phase. The study area lies within the Anambra Basin.. The granulometric study of Mamu Formation shows coarse grain to poorly sorted grain for Mamu Formation. The standard derivation indicates poorly sorted, the kurtosis shows leptokurtic, while the skewness values indications positive and symmetrical. These structures observed are syn-depositional, i.e were formed as the rocks were emplaced.

Composition

Usually no new elements or chemical compounds are added to the rock during changes except perhaps water. Therefore, the mineral content of the sedimentary structures is controlled by the chemical composition of the parent rock.

Temperature

The particular temperature for a rock at a given depth depends on the local geothermal gradient. A mineral is said to be stable if given enough time, it does not react with another substance or convert to a new mineral or substance. Any mineral is stable only within a given temperature range. The stability temperature range of a mineral varies with factors such as pressure or the absence or presence of other substances. Some minerals are stable over a wide temperature range. By knowing the particular temperature range in which a mineral is stable, a geologist may deduce the temperature of metamorphism for a rock that include that mineral. Minerals that are stable at higher temperature tend to be less dense (or have a lower specific gravity than chemically identical minerals (polymorphs) stable at lower temperature.

Pressure

Any new mineral that has crystallized under high-pressure conditions tends to occupy less space than did the mineral or minerals from which it formed. The new mineral is denser than its low- pressure counterparts because the pressure forces atoms close together into a more closely packed crystal structure.

Differential Stress

Most syn-sedimentary structures show the effect of tectonic forces. This was observed in the Mamu Formation in the field. When forces are applied to an object, the object is under stress, force per unit area. If the forces on a body are stronger or weaker in different directions, a body is subjected to differential stress. Differential stress tends to deform objects into oblong or flattened forms. Differential stress is caused by shearing which causes a part of the body to move or slide relative to one another across a plane.

Foliation

Differential stress has a very important influence on the texture of sedimentary rock because it forces the constituents of the rock to become parallel to one another. When a rock has a planar texture, it is said to be foliated. Foliation is manifested in various ways. If a platy mineral (such as mica)is crystallizing within a rock that is undergoing differential stress , the minerals grows in such a way that it remains parallel to the direction of shearing or perpendicular to the direction of compressive stress. Any platy mineral attempting to grow against shearing is either ground up or forced into alignment. Minerals that crystallize in needle like shapes (such as hornblende) behave similarly growing with their long axes parallel to the plane of foliation. The three very different textures described next (from lowest to highest degree of metamorphism) are all variations of foliation and are important in classifying sedimentary rocks:

- If the rocks easily along nearly flat and parallel planes, indicating that preexisting microscopic, platy minerals were realigned during metamorphism, the rock is said to be slaty or that it possesses slaty cleavage.
- If visible minerals that are platy or needle-like shaped have grown essentially parallel to a plane due to differential stress, the rock is schistose.
- If the rock became very ductile and the new minerals separated into distinct (light and dark) layers or lenses, the rock has a layered texture.

CONCLUSION:

Stratigraphic principles also help in creating syn-depositional structures in rocks. A very good example is the Mamu Formation as exposed in the study area. Most of the individual parts of the larger problems are solved by applying several simple principles while studying the exposed rock. In this way, the sequence of events or the relative time involved can be determined. Contacts are particularly useful in deciphering the geologic history of an area. Contacts are described as the surfaces separating two different rock types or rocks of different ages. The stratigraphic principles of *original horizontality*, *superposition*, *lateral continuity* and *cross- cutting relationships* determine the geologic history of a locality or a region. These principles are major players in the creation of primary structures that are found in the Mamu Formation and other Formations present in the Anambra Basin of Nigeria.

REFERENCES:

1. Adeleye, O. R., : Nigerian Late Cretaceous Stratigraphy and Paleogeography. *American Association of Petroleum Geologist. Vol. 59, pp 2302-2312.* (1975).
2. Agagu G.O., : Introduction to structural geology pp.295-311, (1985).
3. Akande, S. O., and Erdtmann, B. D., : Burial Metamorphism (Thermal Maturation) in Cretaceous Sediments of the Southern Benue Trough and Anambra Basin, Nigeria. *American Association of Petroleum Geologist Bulletin Vol. 82, No. 6. pp 1191-1206.* (1998).
4. Amajor, L.C., : Comparative geochemistry of the cretaceous from Abakaliki and Uturu south Benue trough. (1984).
5. Banerjee, U.G., : Applied sedimentology. vol.22 pp.155-158, (1979).
6. Benkhelil, J. M., : Structural Frame and Deformation in the Benue Trough of Nigeria. *Bulletin Centre Research in Exploration-Production. Elf – Aquitaine, Vol. 11, pp 160-162.* (1987).
7. Burke, E. K. C., Dessauvagie, T. F. J. and Whiteman, A. J., : Geological history of the Benue Valley and Adjacent Areas. In: Dessauvagie, T. F. J. and Whiteman, A. J. (editors), *African Geology. University of Ibadan Press, Nigeria. pp 187-218.* (1972).
8. Charles C. P., : Physical geology vol. 4 pp. 137-167, (2002).
9. Diane, H. C., : Physical Geology vol4. Pp.383-404. *Earth science journal 2004.* (2003).
10. Grant, N. K., : The South-Atlantic, Benue Trough and Gulf of Guinea Cretaceous Triple Junction. *Geology Society. American Bulletin, Vol. 82. pp. 2295-2298.* (1971).
11. Hogue, D.J., and Ezepue R.U., : Structural geology of Nigeria, (1977).
12. Hogue, D.J., and Nwajide : Introduction to structural geology pp.51-67, (1984)
13. Ikogbo, J., : Principles of sedimentology and stratigraphy vol.2 pp. 210-301. (1976).
14. Jones, B., : The origin of the Benue Trough. *Geological Survey Bulletin, Nigeria, no. 18, pp. 79.* (1965).
15. Kogbe, C.A., : Geology of Nigeria. *University of Ife, Earth Sciences Library. QE327. N5 E49 1976(Branner). 2nd Edition. Elizabethan Publishing Company, Lagos.* (1989).
16. Lisa H., : Physical geology vol.15 pp.519-542, (2004).
17. Muatetall, H., : Principles of sedimentology and stratigraphy vol 22 pp.107-115. (1970).

18. Murat, R. C., : Stratigraphy and Palaeogeography of the Cretaceous and Lower Tertiary in Southern Nigeria. *In: Dessauvagie, T. F. J. and Whiteman, A. (editors), African Geology, University of Ibadan, pp 257- 266.* (1972).
19. Nwajide and Reijers, : Essential of physical geology Vol.2, pp 51-67, (1996).
20. Nwajide, C. S., and Reijers T. J. A., : Sequence Architecture of the Campanian Nkporo and Eocene Nanka formation of the Anambra Basin, Nigeria. *NAPE Bulletin, Vol. 12(1), pp. 75-87.* (1997).
21. Ofoegbu, C.O., : A Review of the Geology of the Benue Trough. *Journal of African Earth Sciences, Volume 3, Issue 3, Pages 283-291.* (1982).
22. Petters, S. W. and Ekweozor, C. M., (1982). Origin of Mid-Cretaceous Black Shales in the Benue Trough, Nigeria. Palaeogeography, Palaeoclimatology and Palaeoecology. *American Association of Petroleum Geologists. Bulletin, Vol. 40, pp. 311-319.*
23. Petters, S.W., : Stratigraphic Evolution of the Benue Trough and its implications for the Upper Cretaceous Paleogeography of West Africa. *The Journal of Geology 86 (3): 311-322.* (1978).
24. Reyment, R.A., : Structural geology. pp.5-35, (1964).
25. Reyment, R.A., : Aspect of the Geology of Nigeria. *Ibadan University Press. 1-333.* (1965).
26. Sampson, M., : Introduction to classic sedimentology. (1955).
27. Short and Stauble : sedimentology and stratigraphy vol 3.pp. 102-131, (1967).