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Lithofacies analysis and Depositional Environment of Eocene – Paleocene Sediments of Ewekoro Quarry SW, Nigeria

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Abstract
The genetic relationship between depositional processes and rock properties (like lithofacies) provide a potentially powerful tool for interpreting ancient depositional environments. The study aims at a more detailed lithologic and Petrographic description of the sediments of this formation in other to acertain the chemical characteristics of the limestone so as to better delineate its uses both industrially, agriculturally and other applications. Seven samples were collected from Ewekoro quarry on the Latitude of $6^0 48^1$N- $6^0 53^1$N and Longitude of $3^0 35^1$E-$3^0 40^1$E south western part of Nigeria. The sediments were subjected to lithologic description and petrographic analysis. The lithologic description was carried out with the aid of binoculars microscope, this shows the following lithologies are present sandy shale, shale, marl, limestone, and sandstone. Petrographic analysis shows that the limestone consists of 90-99% calcite, 0-2% quartz as its constituent minerals, sample NSA2 is mainly Sparitic limestone and sample SSA1 is mainly Micritic limestone. The sandstone composition are 50- 65% quartz, 0-5% feldspar and the calcite serve as the cement and it is about 10-32% of the rock volume. Microfossils account for 10-18%. The sediments were deposited in shallow environment based on the presence of ichnofossils (burrows), micro gastropod shells and other broken shells. From the mineralogy, the calcite crystals are suggests a fresh water vadoze environment while the Sparry calcite shows evidences of diagenesis within the formation. The relative age of foraminifera present indicate a Palaeocene/Eocene boundary to Lower Eocene and a lagoonal to inner neritic environment with little influence of marine transgression. Ewekoro limestone is well suited as a raw material for fertilizer besides its general usage for cement manufacturing.
Keywords: *Ewekoro sediments, sparitic sandstone, micritic limestone, shallow marine, lithofacies*

INTRODUCTION

The Dahomey basin is an extensive sedimentary basin extending almost from south-eastern Ghana in the west through southern Togo and southern Benin Republic (the axis of the basin and precisely, the Benin hinge-line) to the western flank of the Niger-Delta in Nigeria in the east (Jones and Hockey, 1964, Omatsola and Adegoke, 1981). The thickest sediments occur slightly west of the border between Nigeria and Benin Republic. It is bound in the west by fault (Adegoke et al., 1981 and Whiteman, 1982) and other tectonic structures. The eastern limit is marked by the Benin hinge line which is the major fault marking the limit of the western part of the Niger-Delta basin (Omatsola and Adegoke, 1981). Okitipupa ridge is located west of the Benin hinge line. The Tertiary sediments of this basin thins out and are partly cut off from the sediment of the Niger-Delta basin against this ridge of basement rocks i.e. Okitipupa ridge, (Omatsola and Adegoke 1981). The Dahorney basin (Figure 1) is a marginal pull-apart basin (Odebode *et al.*, 1996) or Margin sag basin (Prothero and Scwab, 1996), which was initiated during the Early Cretaceous separation of African and South American Lithospheric plates. From available subsurface stratigrahic information, it is apparent that some of the basement blocks that underlie the Dahomey embayment are displaced towards the NNE-SSW axes of the basin as well as towards the offshore. Enormous bitumen bearing sands of economic potential occur at the base of the sedimentary succession. The correlation of marine shales from shallow bore holes has with Nkporo shale formation which is nearer to the coast and offshore helped to deduce that the marine shales are older. Lower

Tertiary marine units are well exposed to Ewekoro and Shagamu quarry in Ogun State and that of Onigbolo and Tabligbo of neighbouring Benin Republic. (Culled from the internet.com/link/geody, 2005.)

Structural and Tectonic setting

Separation of African -South American continents was responsible for the evolution of Dahomey Basin (like other west African coastal sedimentary basins) and subsequent opening of the Atlantic ocean during the rifting at the margin of the Gulf of Guinea that started during the Late Jurassic, Omatsola and Adegoke, (1980, 1981). Sedimentation was initiated in fault controlled depressions which was as a result of a rift generated subsidence that has affected the crystalline basement complex during the Early Cretaceous (Neocomian), Omatsola and Adegoke, (1981). This gave rise to the deposition of a very thick sequence of continental grit and pebbly sands over the entire basin, Lehner and Ruiter, (1977).

During the late Cretaceous (Santonian), there was another episode of tectonic activity which was probably associated with the closure and folding of the Benue Basin. The basement rocks are well as the sediments in the Basins were tilted and block fault forming a series of horst and graben, (Ola *et al.*, 2018). Considerably erosional activity accompanied the uplift and block faulting, and the extensive lower Cretaceous sediments were almost completely eroded from the horst, Omatsola *et al.*, (1981). During the Maastrichtian, the Basin became quiescent and had experienced only gentle subsidence since.

Omatsola and Adegoke 1981, Adekeye *et al.*, 2019, Adediran and Adegoke, 1987 have proposed a four stage evolution model for the Dahomey Basin and these include:

- Intracratonic stage
- Synrift stage
- Transitional stage
- Oceanic stage

Stage One: Intracratonic Stage

This is marked by deposition of continental/lacustrine sediments in fault control depression over the entire basinal surface which follows the thermotectonic event which caused the rifting that led to separation between continental plates.

Stage Two: Synrift Stage

There was another episode of tectonic activity during the late Cretaceous which was probably associated with the closure a folding of the Benue trough, large scale basinal down warping and a subsequent subsidence series of steep sided normal fault. (Omatsola and Adegoke, 1981).

Stage Three: Transitional Stage

This stage followed the synrift stage and it led to the deposition of paralic sediments composed of alternating sands or sandstones and fossiliferous shales.

Stage Four: Oceanic Stage

The stage is repetitive of the marine conditions. It was characterised by the deposition of fine-medium grained low sandstones and organic shales rich in marine fauna and flora. (Elvborg and Dalode, 1985; Adediran and Adegoke 1987).

Stratigrapghy

The stratigraphy of the basin has been described by various workers: Jones and Hockey, 1964; Omatsola and Adegoke, 1980; Omatsola and Adegoke,1981; Akinmosin, 2005; Akinmosin *et al.*, 2012, Ola and Olabode, 2017.

The reviewed work of Omatsola and Adegoke (1981) on the Cretaccous stratigraphy of the Dahomey basin has recognised three formations belonging to the Abeokuta group. These are:

- Benin Formation
- Ogwashi Asaba Formation
- Ameki Formation
- Oshoshin Formation
- Akinbo Formation } Imo group
- Ewekoro Formation } Imo group
  Younging direction
- Araromi Formation } Abeokuta group
- Afowo Formation } Abeokuta group
- Ise Formation } Abeokuta group

↑ Younging direction

Figure 2: Generalised Stratigraphic column showing age, lithology and sequence of fprmation and their tectonic stage of Basin development in the Nigerian sector of the Basin (Ola and Olabode, 2017)

Table 1: Uppermost Cretaceous-Paleocene Stratigraphic Sequence of the Eastern Dahomey Basin and Adjacent Areas (Adapted from Jones and Hockey, 1964)

AGE	EASTERN DAHOMEY BASIN	WESTERN ANAMBRA BASIN
Middle Eocene younger	Western Nigeria Benin Formation	Eastern Nigerian Ameki
Lower	Ilaro Formation Os-hoshun Formation	Nanka sand
Eocene	Akimbo	
Paleocene maastrich-tian middle-upper cretaceous	Ewekoro Formation Araromi Abeokuta Group Afowo Forma-tion	Imo Shale, Nsukka Formation, Ajali Formation
Neocene	Ise Formation	

Biofacies of Dahomey Basin.

The flora and fauna remains found in the sediments of the eastern Dahomey Basin have been used to date the formations.

Ise Formation:

Sporomorphs recovered by Shell-BP geologists indicate a Neocomian probably Valenginian-Barremian age.

They include; Pilosisporites trichopapillosus, Klukisporites pseudoreticulatus, all from Ise-2 borchole (Omatsola and Adegoke, 1981).

Afowo Formation:

The palynological assemblages, which characterise this formation, include representatives of Elytranthe subzone and Multiporopollenites aff. M. maculosus zone. In the upper parts are marine foraminifera and ammonites (Spenodiscus and Pachydiscus) indicating a range into the Maastrichtian, (Sahay *et al.*, 2015)

Araromi Formation:

The formation is richly fossiliferous, being abundant with planktonic foraminifera, ostracods, pollen and spores. The Hedbergella monmonthensis and biliying afra undoubtedly mark the Araromi Formation (Fayose, 1970).

Ewekoro Formation:

It is richly fossiliferous with abundant fauna that characterise the formation. They are Globorotalla pseudobulloides, G. acuta and Glabigerina linaperta (Adegoke, 1969). A Paleocene age was proposed.

Akinbo Formation:

It is very richly fossiliferous containing molluses, ostracods and foraminifera but the fossils are poorly preserved. It is assigned an Eocene age.

Oshoshun Formation:

Adegoke (1969) noted that the fauna of this formation includes mollusc's corals, crinoids, crustaceans, pelagic and planktonic foraminifera and fishes. They also indicate an Eocene age.

Haro Formation:

Fossils are very rare but some benthonic foraminifera have been described here. The formation has been assigned a Lutetian age (Slansky, 1962).

Location of Study Area

The samples used for this study were obtained from Ewekoro quarry in Ewekoro, Ogun State where sediments of Ewekoro Formation are exposed in LAFARGE (formerly known as West African Portland Cement (WAPCO)) industry at the site. The Ewekoro quarry lies within Ijebu-ode sheets, 280^0NW of the Geological Survey Map, and it is situated along Lagos-Abeokuta road, about 64km NW along Abeokuta Lagos express way on the Latitude of $6^0 48^1$N and longitude of $3^0 35^1$E-$3^0 40^1$E south western part of Nigeria.

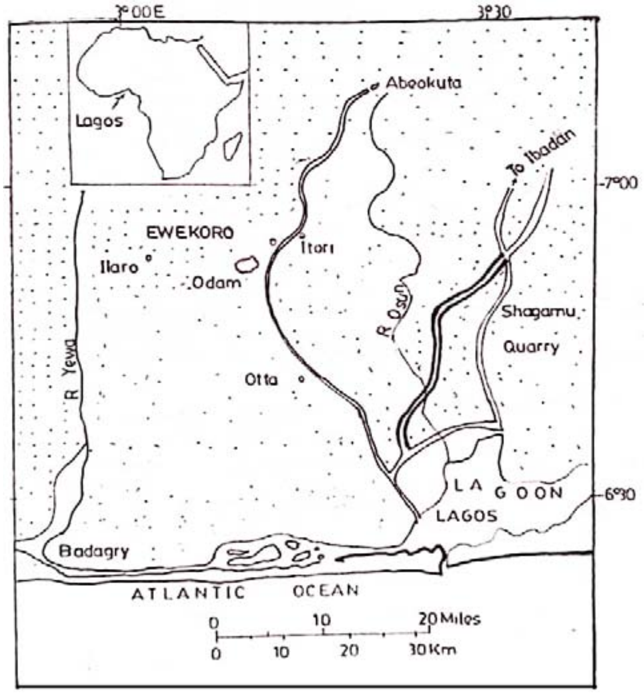

Figure 1: Map showing Study Area

Methods

Thin Section Sample Preparation

Seven samples were analysed for thin section analysis. Fresh loose samples were air dried for 24 hours, the samples were then impregnated with epoxy A and B and left to core for at least 24hours, the cored sample is the trimmed to fit on a glass slide, the trimmed surface is lapped on the glass plate using water and silicon carbide 600grits, this is done so as to have a very smooth surface for bonding with the glass slide. One surface of the glass slide is also lapped and made smooth for bonding with the sample. The sample is then bonded to the glass slide using epoxy on the hot plate, this is allowed to bond for 24hours, the sample is then trimmed to 50µm on the glass slide using the cut-off saw machine and later transferred to the lapping plate and lapped to 30µm using silicon carbide and water, at 30micron the slide is ready for study under petrographic microscope (Mohammed *et al.*, 2018). Ingersoil *et al.*, (1984) counting method, which was also adopted by Tijani, *et al.*, (2010) was employed for the mineral grains compositional analysis, and the modal analysis, the Dickinson, (1970) method of counting over 300 points per thin section was used.

Results

Lithologic Description of Ewekoro Sediments

Table 2: Lithologic description of Ewekoro sediment

Sample Serial No.	Thickness(m)	Lithology	Description
Southern Part			
SSA4	3	sandy	Light grey, fine grained sandy shale
SSA3	12	Shale	Light grey, fine grained fissile shale with dark stain probably carbonaceous (of carbon fumes)
SSA2	1	Sandstone	Light grey, fine grained with whitish particles
SSA1	13	Limestone	Light grey, fine grained whitish particles
Northern Part			
NSA3	3	Marl	Light grey, medium-coarse grained sub angular, poorly sorted marl with whitish particles probably calcitic
NSA2	6	Limestone	Light dark grey, medium-coarse limestone with whitish speck, poorly sorted and sub-angular
NSA1	2	Sandstone	Reddish brown colour, fine medium grained with clasts of quartz (medium grained) poorly sorted and sub-angular

Ewekoro quarry is situated in Dahomey Basin which consists of mainly limestone, and interbeds of sandstone, shale, sandy shale and marl. The degree of sorting ranges from poorly sorted to well sorted and the texture ranges from fine grained-medium grained which are sub-angular.

Petrographic Analysis

The outcome of the petrographic analysis of the different samples showed the following are present.

Table 3: Petrographic characteristic of the Ewekoro sediments

Sample Serial No.	Quartz	Calcite	Feldspar	Fossils	Others	Total
Southern Part						
SSA4	65	-	33	-	2	100
SSA3	20	30	-	47	3	100
SSA2	65	10	5	20	-	100
SSA1	-	99	-	-	1	100
Northern Part						
NSA3	12	85	-	3	-	100
NSA2	2	90	-	8	-	100
NSA1	70	22	-	8	-	100

Calcite: This is present in samples (NSA2 and SSA1) as 90% and 99% respectively.
Quartz: This is present in samples SSA4, SSA2 and NSA1 65%, 65% and 70% respectively.
Feldspar: This is present in sample SSA4 as 33%
Organic material: These are organic present in the sediments. They represent the fossils and they are the reflections of the carbonate secreting invertebrates through time and space. They include bivalve, foraminifer's echinoids and micro gastropods. It is 47% of the rock volume.
Others: These are opaque minerals that are present in small quantities compared to other minerals in the sediments; they range between 0-3percent of the sediments.
Other components shown by the petrographic analysis are:

a. Non-skeletal grains: Two types of non-skeletal grains were observed in the sediments, they are zooids which are spherical-sub-spherical grains with diameters less than 2mm and pelloids which are spherical or angular grains with diameter range 0.1-05mm.
b. Skeletal components: These represent the fossils and have been described under organic minerals above.
c. Cement: Cement present in the sediment includes calcite and quartz
d. Micrite: These are fine grained usually dark matrix composed of fine grained carbonate.

Plate 1: NSA 1- Microphotogram of Limestone showing bisuccates, algae, filamentous plant plaktonic materials, bentonic materials with so many chambers present.

Plate 2: NSA 2 – Microphotogram of Sparitic limestone, with plant fossils, bentonic materials and algae present.

Plate 3: NSA 3 – Microphotogram of Micritic limestone, with filamentous plants present and poorly fossilized.

Plate 4: SSA 1 – Microphotogram of non – fossilized, micritic limestone.

Plate 5: SSA 2 – Microphotogram of Sparitic limestone with evidences of plant remains, lignitic materials, palynomorphs present.

Plate 6: SSA 3 – Microphotogram of limestone with worm burrows (ichno fossils) and filamentous plants.

Plate 7: SSA 4 – Microphotogram of non-fossilized Sandy-Shale.

Discussion

It was observed that the texture is mostly fine to medium grained with poorly sorted to well sorted grains, sub-angular to angular roundeness index with fine to medium sand, which depict that the samples were deposited in a low energy environment, with favourable condition for sediments of similar sizes to accumulate, while sub-angularity of some of the grains indicate that they have not travel far from the source. The principal diagenetic process taking place is cementation. The cement, which occupies the majority of the cement, is micrite (plate 3-4) which is a clear equant calcite that occupies the majority of the pure space with minor quartz and other minerals that are cemented together by calcite crystals. In much limestone a cement generation was precipited before the sparite. The sparite limestone (plate 2), refers to an interstitial component consisting of relatively coarse-grained calcite or aragonite that either accumulates during deposition or was introduced later as a cement. This early cement is typically a thin fringe of fibrous calcite around grains. (Maurice, 1981).

Another type of early cement in the grains is micrite (plate 5). Micritic envelope indicates a period of alteration concurrent with deposition. The micritised surfaces of grains commonly survive dissolution and provide a surface for latter precipitation of the cement. A syn-depositional cementation by filamentous calcite was also observed in Ewekoro sediment, (plate 6). The distribution of the micrite lining cavity walls together with a vague pelleted texture indicates a cement origin. Cementation of micritic limestone points to a poikilotopic cementation of carbonate muds which consisted of varying portions of aragonite, calcite and terrigeneous matter. The petrographic study of sediments reveals that the Ewekoro sediments were deposited in shallow environment evidently the neritic zone based on the presence of ichnofossils (burrows), micro gastropod shells and other broken shells. The mineralogy authenticates this inference made from the fossil assemblages and further confirms that the calcite crystals are from fresh water vadoze zone. The sparry calcite, indicates that the aragonite present is unstable and has been replaced to calcite, sequel to a replaceplacement and diagenetic process.

Conclusion

Petrographically, the Limestone studied were confirmed to be Micritic and Sparitic limestones, with the later revealing that evidences of paleodiagentic processes during sedimentation and cementation.

The microfaunal studies depict a shallow marine environment, characteristically of photic/neritic zones. The sediments been highly fossilised is an indication high index of ecological interplay between the living forms and their environment (the sediments, which in this case is their host).

Furthermore, the findings from this research, places the Ewekoro limestone as a vadose diagenetic environment and been highly fossilised, makes it a raw material for fertilizer besides its already established use as a raw material for cement manufacturing.

Declaration of Interest

We declare that there is no conflict whatsoever as regard this Paper.

REFERENCES

Dickson, W. R. (1970): Interpreting detrital modes of Greywacke and Arkose. Sedimentary Petrology Journal, 40: 695-707.

Dikinson W. R and Shutler R. (1979): Petrography of sand tempers in pacific island potsherds: summary. Geological society of Nigeria Bulletin. 90 (1): 993-95.

Fayose E.A and Assez L. O (1972): Micro paleontological investigation of Ewekoro area, southern Nigeria, micropoleontol. 18(3): 367-378.

Ingersoil, R. V., Bullard, T.F., Ford, R. L., Grim, J. P., Pickle, J.D., and Sares, S. W. (1984): The effects of grain size on data modes : a test of the Gazzi – Dickson point – counting method. Sedimentary Petrology Journal, 46: 620-632.

Jones H. A and Hockey R.D. (1964): The geology of part of southwestern Nigeria. Geological survey of Nigeria Bulletin. 1(31):1-16.

Lehner P, De Ruiter PAC (1977): Structural History of the Atlantic margin of Africa,

American Association of Petroleum Geologists Bulletin, 61: 961-981

Maurice E.T. (1981): Sedimentary petrology; An introduction. Limestones. Blackwell scientific publications. Pp. 96-157.

Mohammad, A.S., Zahra, M.S., Hamid, R.P., Franz, T.F. and Christopher, H. (2018): Provenance and Palaogeography of uppermost Triassic and Lower Cretaceous Terrigeneous rock of Central Iran: Reflection of the Cimmerian events. N. Jb. Geol. Palaont. Abh. 288(1): 49-77.

Odebode, M.O., Ogunjobi, O. and Olowu, A.A. 1996. Paleogene Marine Condensed Sections in the Onshore Eastern Dahomey basin, Southwest Nigeria. NAPE Bull. Book of Abstracts, 1996, 34.

Ola P. S. and Olabode S. O. (2017): Tar sand occurrence: Implications on hydrocarbon exploration in the offshore Benin Basin, Petroleum Science and Technology, 335(6): 23-534, DOI: 10.1080/10916466.2016.1265560

Ola P. S. and Olabode, S. O., (2018): Implications of Horsts and Grabens on the Development of Canyons and Seismicity on the West Africa Coast. Journal of African Earth Sciences. 18(2):130-137.

Omatsola M.E. and Adegoke O.S. (1981): Tectonic Evolution and Cretaceous stratigraphy of the Dahomy Basin. Journal of mining and Geology. Vol 18 (2) pp. 130-137.

Prothero, D.R. and Schwab, F., 1996. An introduction to sedimentary rocks and stratigraphy, Sedimentary Geology. W.H. Freeman and Company New York. 575.

Sahay VK, Mude SN, Samant B (2015): Lithofacies and depositional environment of the ferruginous claystone member sediments of Naredi, Kutch, Gujarat. India India J. Appl Res 5(2):268–270

Slansky M. (1962): Constitbution a letude geologic du basin sedminetaire cortier du dahomey et du Togo. Bureau du Recheerches. Geoogiques et miniere memoir (ii) pp. 270.

Tijani, M.N., Nton, M.E. and Kitagawa, R (2010). Textual and geochemical characteristics of Ajali sandstone, Anambra Basin, SE Nigeria: implication for its Provenance. Comptes Rendus Geo Science, 342: 136-150.

Whiteman, A. J. (1982): Nigeria: Its petroleum geology, resources and potentials. Graham and Trotman, London, 1, pp. 166.

Www.onlinenigeria.com/links/geoadv/(2005): Dahomey basin,