Pectographic Study of Carbonate Sediments around Yewa River, Eastern Dahomey Basin, South Western Nigeria

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Abstract- Limestone is the major component of carbonate sediments, and is usually deposited with the remains of skeletal fragments or marine organisms such as plants and microscopic animals as a result of both organic and inorganic processes. The associated minerals are:calcite, aragonite and dolomite. The major ways of classification of limestone are based on its mineralogies, (allochems, cements, matrix) and texture (grain stone, packstone, mudstone, wackestone and boundstone). The topographic maps of Idogo NE, sheet 273NW of the study area includes adjoining communities around the North East and North West of River Igbin and south east of River Ogun, south of River yewa which drains in a sub dendiritic and dendiritic pattern and flows into the Yewa lagoon were studied and divided into grids of 500m intervals. Pitting exercise was carried out to expose the limestone beds after representative core samples were collected from labeled core boxes. Petrographic slides were prepared from seven limestone samples as a representative sample of borehole 4 borehole 5, borehole 7 borehole 9, borehole 10, borehole 13 and borehole 14 were prepared at the department of geology, Obafemi Awolowo University, Ile-Ife, the prepared slides from the collected samples were closely examined under plane polarized light. The stage of the microscope was rotated continuously to attain different views of the slides. Photomicrographs of each slide were taken under crossed nicols and comparison was made with carbonate photomicrograph catalogue to ascertain the compositional features. The limestone sediments of the study area classified pectrographically as biomicrite and biosparite based on its average fossil content into: brachiopods, echinoids (58%), sparite (21%) micrite (17%) and other cement matrix components such as: quartz, ooids, pellets, pelloids and intraclasts (4%). Texturally the limestone of the study area are medium grained with colour ranging from light to dark grey, with some patches of dark brown stains as an indication of oxidation of the iron content. The limestone is texturally classified as wackestone, skeletal grains 58% and non skeletal grains 42%. The lithological profile of the boreholes of the study area shows correlation along NNW-SSE and E-W directions and also confirms that limestone is thinly distributed. The constituents observed from the slides indicate that the limestone of the study area belongs to the class of biomicrite, biosparite and silicified wackestone hence, could have been deposited in a quiet and low tidal energy sublittoral shelf environment.

Index Terms: carbonate, pectrographic, texturally, depositional environments, allochems, cement matrix, fossilferous, wackestone

I. INTRODUCTION

About 25% of sediments are made up of carbonate rocks such as limestone and dolomite (Chilingar et al. 1972). The Dahomey Basin alongside other West African coastal sedimentary basins was initiated during the Mesozoic as a result of the separation of the Africa – South American continent and subsequent opening of the Atlantic Ocean. According to Omatsola and Adegoke (1981), deposition was initiated in fault – controlled depressions on the crystalline baseline complex (Lehner and Ruiter, 1977). The eastern Dahomey Basin have undergone various studies by previous authors some of which include Jones and Hockey, 1964;Reyment, 1965; Omatsola andAdegoke, 1981, Coker and Ejedawe, 1983; Billman, 1992; Elueze and Nton, 2004 and Akinmosin et al, 2005. Adegoke et al (1970) and Ogbe (1972) provided the basic stratigraphic framework and description of the

different microfacies. Fayose (1970); Jones and Hockey (1964), Reyment (1965) have attempted the reconstruction of the paleoenvironments using sedimentological and microfossil data from the onshore area. Hydrocarbon generation within the Dahomey Basin has been identified in the Abeokuta Group and the deep marine Upper Senonian-Maastrichtian anaerobic Araromi Formation (Avbovbo, 1978). Adegoke et al, (1970) subdivided the Ewekoro formation into three microfacies based on field evidence and petrographic studies. These are the Lower Sandy biomicrosparite, the Middle shaly biomicrite which is the thickest and most fossiliferous and an Upper Algal biosparite. Ogbe, (1972) recognized a discontinuous topmost unit of limestone which he described as a red phosphatic alga biomicrite. Various attempt had been made by Dunham (1962) and Folk (1959, 1962) in the pectographic classification of limestone, Dunham, 1962 classified the limestone on the basis of texture into packstone, wackesotne, boundstone, mudstone, grainstone. Folk 1962 classified the limestone into matrix, cement and allochem.

The work is aim at describing and correlating the lithological units and using the pectrographic studies to deduce the depositional environments.

II. STATIGRAPHY

The area of study lies within the latitude 6°49'N and`6°51' and 2°55'E and 3°00' The cored limestone samples were taken around the North East and North West of River Igbin which drains in a sub dendiritic and dendiritic pattern and flows into the River Yewa (Jones and Hockey, 1964) around Ebute Adewale. River Yewa is a creek to Yewa lagoon which is one of the nine lagoon in the south western Nigeria, (kusemiju, 1998, Nwankwo 2004, Onyema 2008, Onyema and Nwankwo 2009, Onyema & Emmanuel, 2009, Onyema 2009) with adjoining communities: Alagbe, Andrew, Alaran, Erin, Irogun akere,Idogo,Araromi papanla, Igbobe, Oke odan, Owode, Ado-odo, Ipokia, Idi-Iroko, Ibatefin, Ogun State, South Western Nigeria, Eastern dahomey basin.

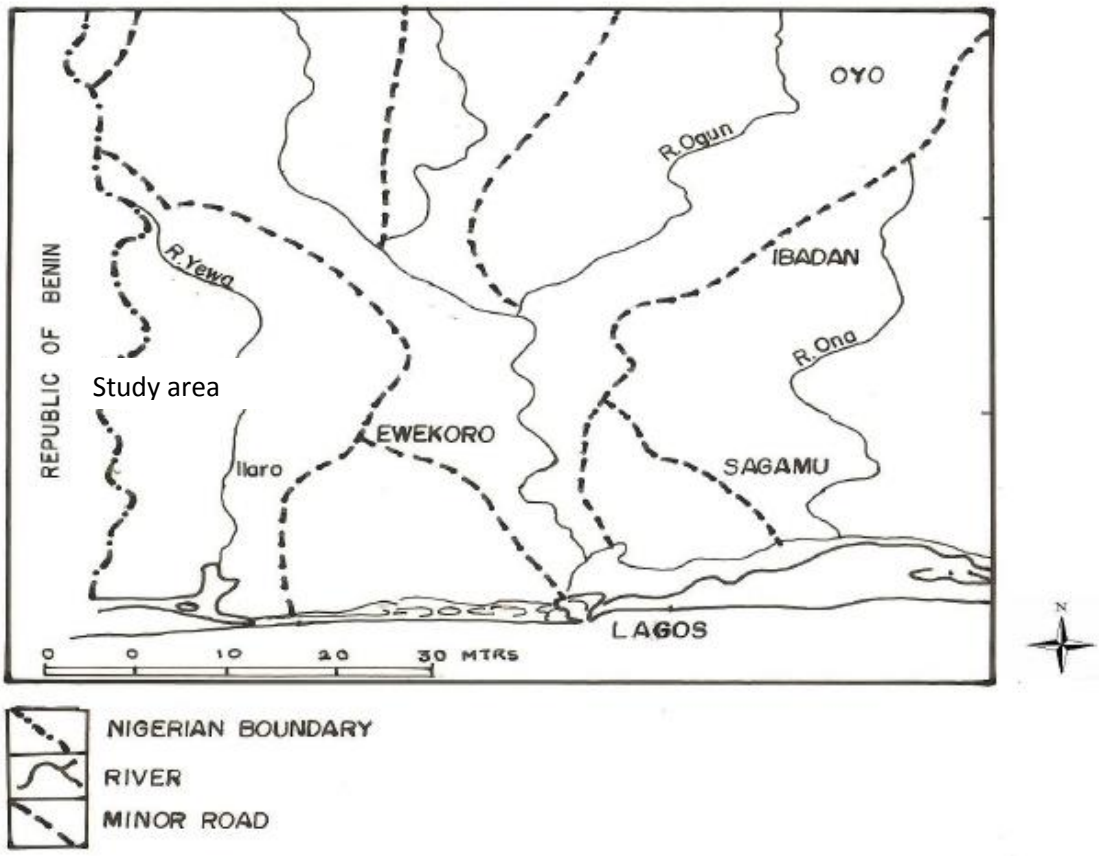


Fig 1*: *The principal rivers and water shed parts of South Western Nigeria (after Jones and Hockey, 1964)

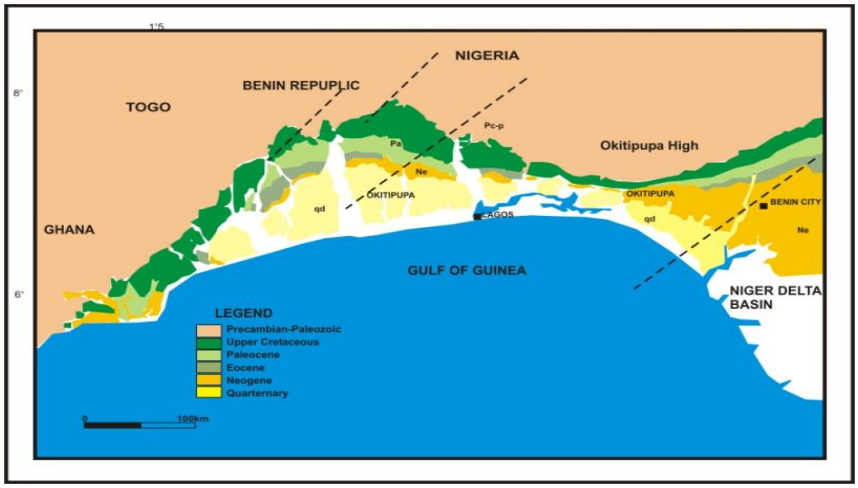


Fig 2: ***Generalized geology of the Dahomey basin Modified by Billman, 1976***

The Abeokuta Formation is the oldest formation in the Dahomey Basin. It is sub-divided into three formations, namely, from the oldest to the youngest; the Ise, Afowo and Araromi Formations (Ako et al, 1980, Omatsola and Adegoke, 1981). The Abeokuta Group unconformably overlies the basement complex. The Ise formation is the oldest unit of the Abeokuta group. It consists of continental sands, grits sediments and sandstone uncomfortably overlying the basement complex. They are in turn overlain by coarse-medium grain loose sands, sandstone and grits with interbedded kaolinitic clays. Based on the Palynological assemblages a Neocomian age has been assigned to this formation (Omatsola and Adegoke, 1981). The Afowo formation overlies the Ise formation. It consists of transitional to marine sands or sandstone with variable but thick interbeded shale, siltstone and clays. The shale components increase progressively from bottom to top. The grains are well sorted to medium size. The transitional zone is marked by the basal arenaceous beds to fairly thick shale intercalation. It is assigned Turonian (Billman, 1976). The Araromi formation is the youngest of the Cretaceous sediments in the eastern Dahomey Basin {Omatsola} and Adegoke, 1981). It is composed of fine-medium grained sandstones at the base, overlain by shales and siltstones with interbedded limestone, marl and lignite. The formation has been dated Maastrichtian to Paleocene on the basis of its fossil content (Adegoke et al, 1980) .The Araromi Formation is essentially composed of fossiliferous limestone, shale and a sandy base as it grades into the Abeokuta group. (Jones and Hockey, 1964; Reyment, 1965, Ogbe, 1972). The Ewekoro Formation is associated with shallow marine environment due to abundant coralline algae, gastropods, pelecyods, echinoid fragments and other skeletal debris (Elueze and Nton, 2004). It consists of well laminated greenish grey and black shale. The base is defined by glauconitic rock band in places (Ogbe, 1972) The environments of deposition range from fluviatile /continental to true marine shelf (Ogbe, 1972).Based on the palynological assemblages a Paleocene –Eocene age has been assigned to the formation. The oshosun formation consist of massive phosphate bearing shale which varies from nodular, granular, disseminated, and vesicular textured bodies to concretionary and oolitic varieties with interbeded sand unit which overlies the Akinbo Formation (Reyment1965, Antolini, 1968; Adegoke, 1969; Okosun, 1990; Odigi and Brown-Awala, 1992). The Ilaro formation overlies the Oshosun Formation this formation is predominantly made up of massive coarse, sandy estuarine deltaic and continental beds displaying rapid changes in facies. It is consists of medium-fine grain sands yellowish in colour with some clay fractions (Jones and Hockey, 1964). The Formation is poor in micro fauna but pollens and spores that are present indicate an Eocene Age (Adegoke, 1969). Jones (1964) described the Ilaro Formation as a lateral equivalent of the Oshosun Formation. The coastal plain sand is the youngest sedimentary unit in the eastern Dahomey basin. It overlies the Ilaro formation. The Formation consists of soft poorly sorted, clayey sands and sandy clays which are red, pinkish to brown due to weathering. It is assigned Oligocene in age (Reyment 1965).

III. Study Area

Limestone units were logged at a depth that does not exceed 20 meters in fifteen wells. The average thickness of limestone cored is 2.94meters. The limestone is generally hard with yellowish tints, light, shaly, slightly weathered or fragmented, fossillerous, dark grey and occasionally intercalated with phosphate nodules and marl (Odigi and Brown-Awala (1992).

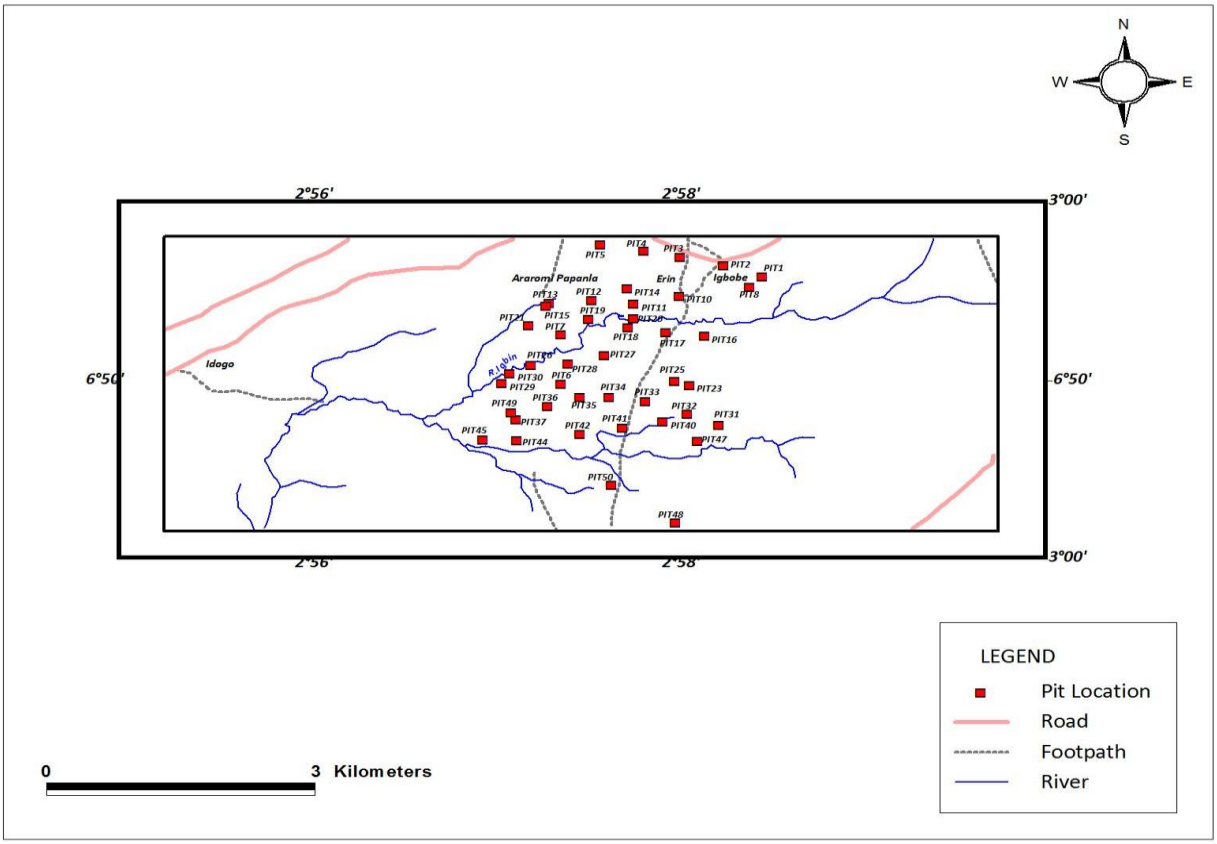


Fig 3: The pitting points to expose the limestone samples

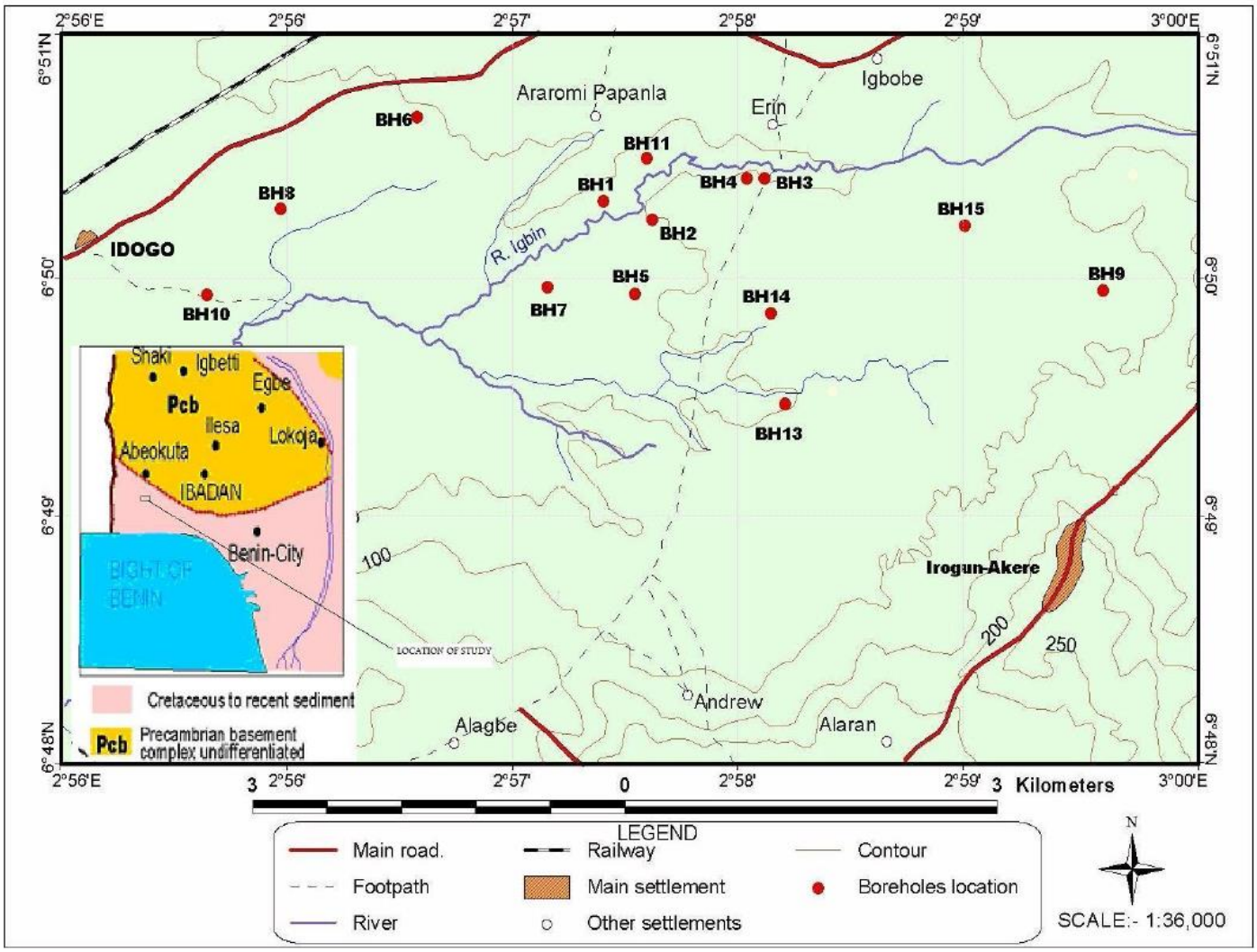


Fig 4: The cored points where representative limestone samples were collected

IV. METHODOLOGY

The topographic maps of Idogo NE, sheet 273NW, were studied and divided into grids of 500m intervals; pitting exercise was carried out to expose the limestone beds after which core drilling was carried out using a rotary drilling method to reveal the underlying lithology. These processes were followed by logging and documentation of exposures with standard form containing information, such as rock type, texture, colour and core recovery. Each sample is taken as soon as there is a change in lithology with depth as drilling progresses. Detailed lithologic description of the core samples were recorded in tabular form with column for depth, rock type, colour and other salient qualities. Samples were then collected into well labeled sample bags for storage and laboratory analysis.

Petrographic slides were prepared from seven limestone samples as a representative sample of borehole 4 borehole 5,borehole 7 borehole 9, borehole 10, borehole 13 and borehole 14(see fig 4) were prepared at the department of geology, Obafemi Awolowo University, Ile-Ife, prepared slides from the collected samples were closely examined under plane polarized light. The stage of the microscope was rotated continuously to attain different views of the slides. Photomicrographs of each slide were taken under crossed nicols and comparison was made with carbonate photomicrograph catalogue to ascertain the compositional features.

V. RESULTS AND DISCUSSIONS

LITHOLOGIC DESCRIPTIONS

The limestone samples from the communities around River Yewa are medium grained with colour ranging from light to dark grey. Dark brown stains were also observed on some of the exposed samples which is an indication of oxidation of the iron content. The samples were observed to be highly fossiliferous.

Plate 1-4: Lithology of representative limestone selected for pectrographic analysis

The lithological profile of the boreholes and general description of the core are shown in the appendices. Correlation of wells 13, 14, 4 along NNW-SSE and 10, 7, 5, 14, 9 along E-W were done to show a better insight to the lithology of the area (see figure 5&6).

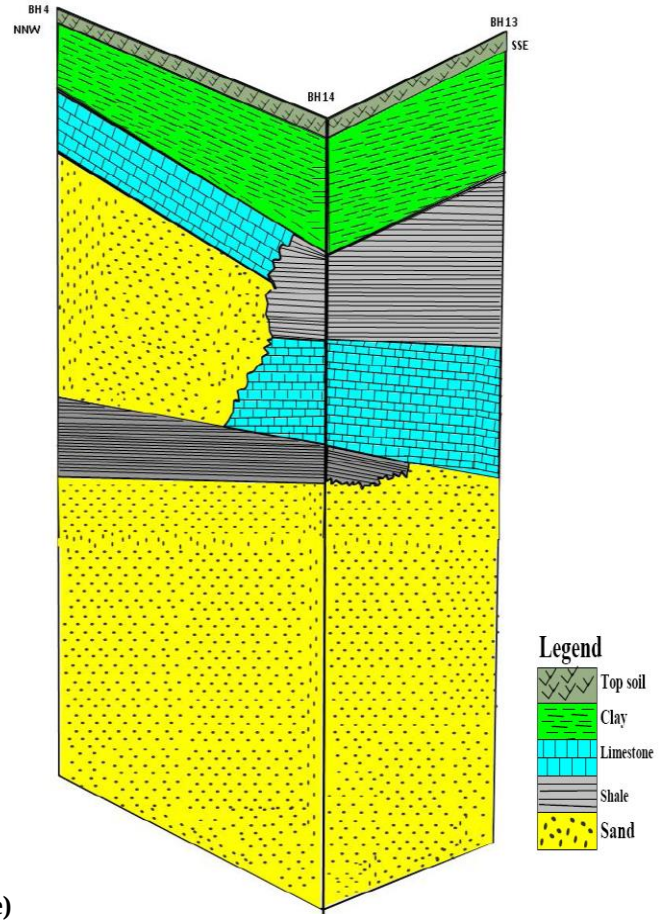


Fig 5: Correlation of borehole 4,14 & 13(not to scale)

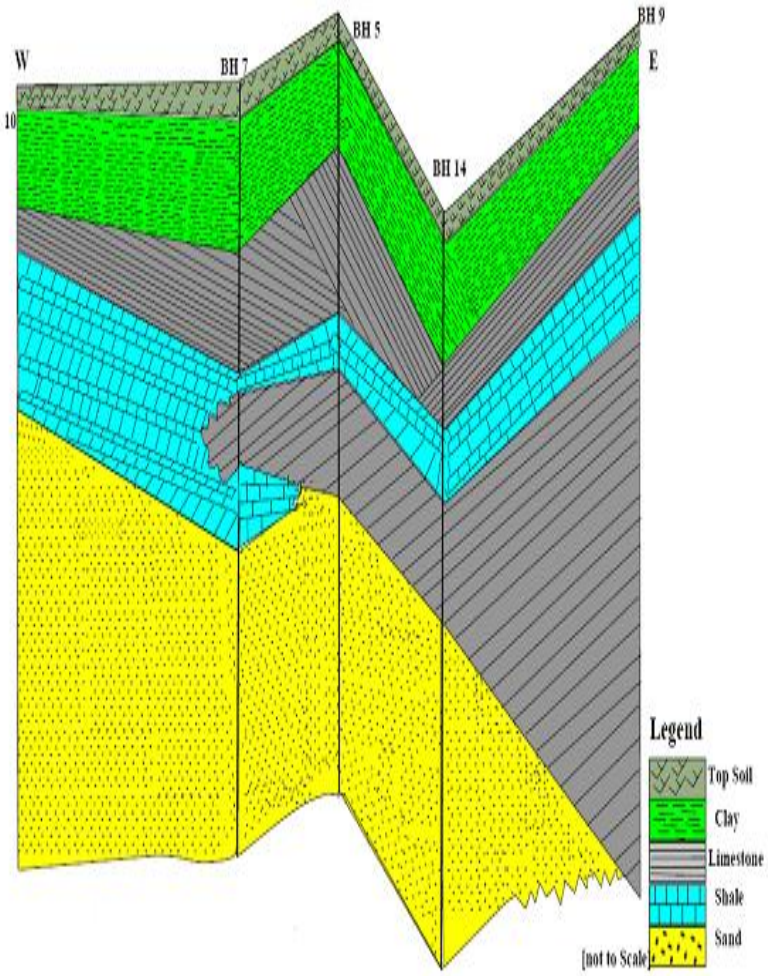
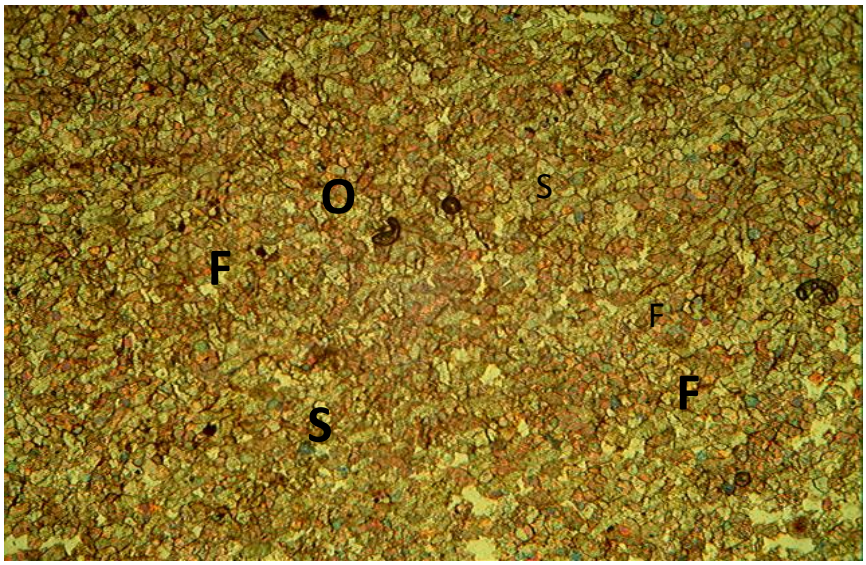


Fig 6: correlation of borehole 10, 7, 5,14 & 9 (not scale)

PECTROGRAPHIC DESCRIPTION



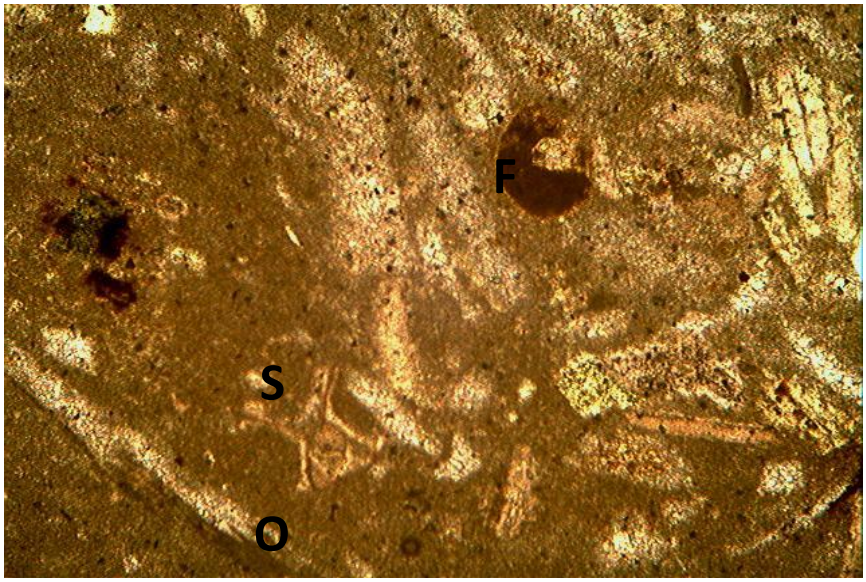
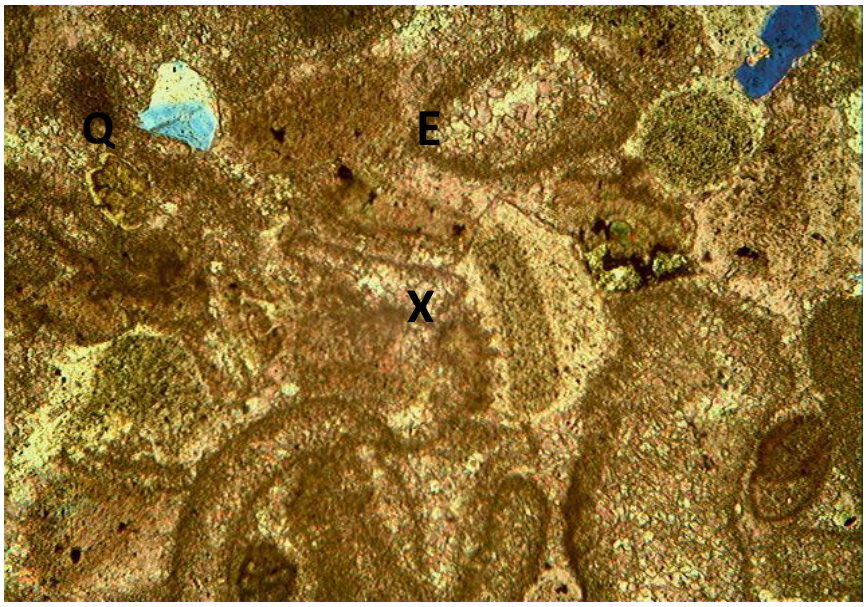


Plate 5&6: Photomicrograph of borehole 4 and borehole 5
F= Fossils, O=oolite,S=sparite



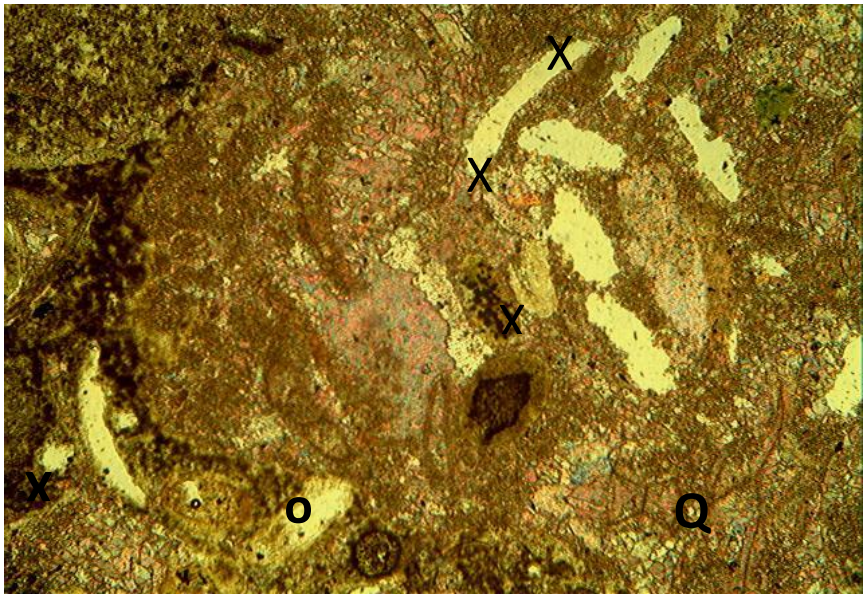
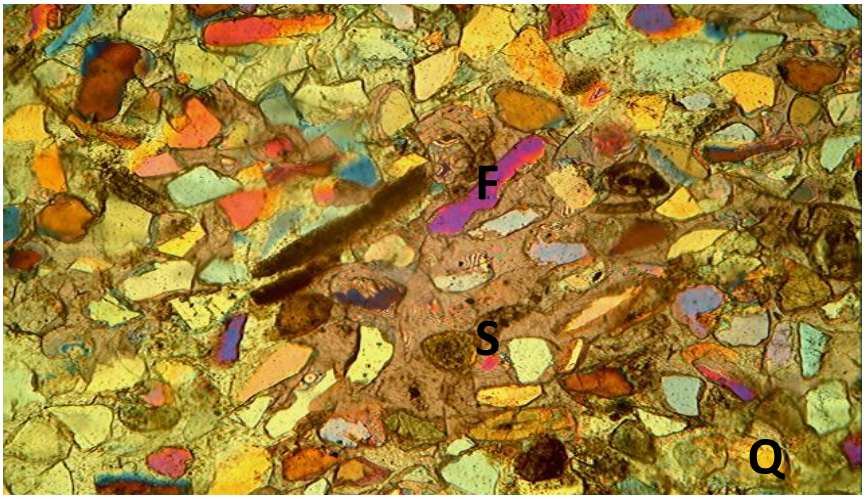
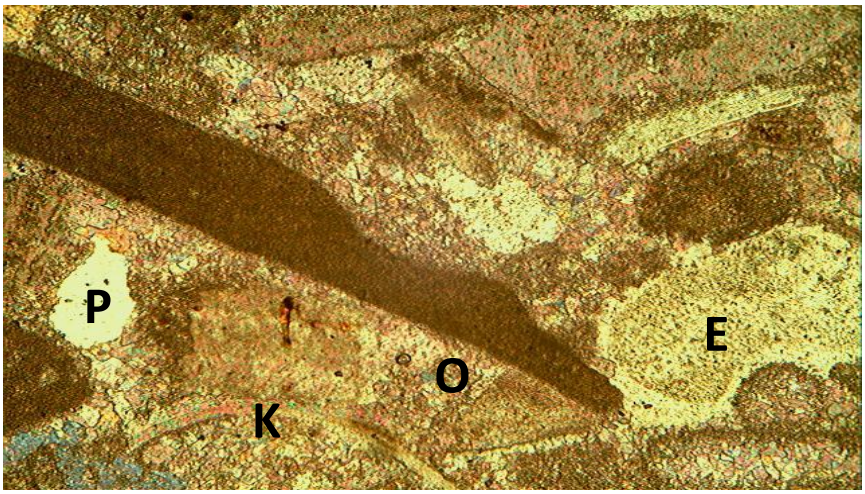


Plate 7&8: Photomicrograph of borehole 7 and borehole 9
X- Brachiopoda foraminiferal grains, E-echinoderm foramniferal grain, Q-quartz, O-ooids,





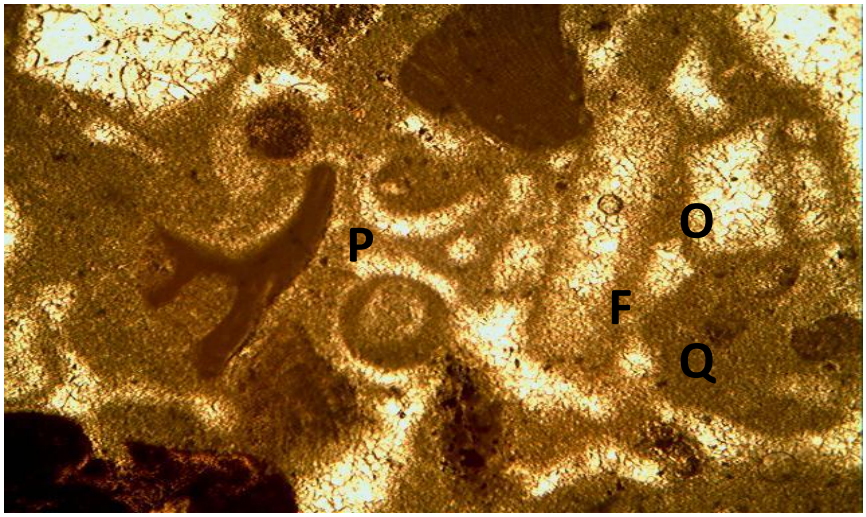


Plate 9, 10 & 11: Photomicirograph of borehole 10, 13 and borehole 14

F-fossil, S-sparite, Q-quartz, P-peloids, O ooids,K- Brachiopoda skeletal grains, E-ecinoderm skeletal grain

PECTROGRAPHIC DESCRIPTIONS

Micrite (carbonate mud/matrix), allochemical constituents and sparry(calcite cement) are the major components of carbonate rocks, Folk (1959, 1962). The petrographic description of limestone around in the study area was based on these the term "allochem" is applied to carbonate grains greater than 0.062mm Rich, 1964.

Skeletal grains (fossil content)

For the identification of the fossil content of the limestone in the communities around River Yewa, the following criteria were used: shape, internal micro-structure and presence of spines or pores. The two major fossils identified were with depth: shelly biosparite and shelly biomicrite, Brachiopodal foraminiferal skeletal grain, echinoderms foraminiferal skeletal grains *Globorotalia cerroazulensis* (bivalves, pelecypods, coralline algae foraminifera).Skeletal fragment (calcite cement) was identified since there is continuous plane of Echinoderm fragment rounded to elongated in borehole 4, depth 1.6-4.0m, borehole 9, depth 10.0-12.8m, borehole 10, depth 9.8-11.5m and borehole 14, depth 12.2m-16.1m. The limestone of the study area is highly fossilferous, its percentage compositions are: Fossil 55% and 60. See plate 5 to 11.

Echinoderms

It was observed that sparite cement crystal had grown syntaxially around the echinoderm fragment and there occurs a continuous plane of Echinoderm fragment rounded to elongated in section of borehole 4, depth 1.6-4.0m and borehole 7, depth 6.0-.6.2m,see plate 7 and plate 8.

Bivalves

Bivalve shells identified in the deposit consisted of several layers of specific internal microstructure composed of micron-sized crystallites .This was encountered in borehole 9, depth 9.8-11.5m, the shelly calcitized bi-valve, originally composed of aragonite but replaced by calcite with some retention of original shell structure, the elongate grain is made up of drusy sparite and its original aragonite dissolves leaving a void borehole 10, depth 4.0-7.0 m see plate 10.

Intraclasts

These are fragments that have been reworked within the area of deposition thereby forming new sediment. Sizes of identified intraclasts ranged from sand size to pebble or boulder size. Sub-angular or sub rounded types were rare and some of them were identified to possess irregular protuberances. Some have complex internal structure and contain fossils, pellets, quartz as seen in Plates 5, 7, 9 and 11.

Pellets

These are rounded, spherical to elliptical or ovoid aggregates of microcrystalline calcite ooze which are devoid of any internal structure. They show a uniformity of shape and size (See Plate 11).

Ooids

These are particles that show either radical or concentric internal structure (Plates 2 and 5). Ooid typically form in agitated water form as a product of dissolution of aragonite as a void, see plate 5, 6,8,10 and 11.

Carbonate Mud Matrix (Micrite)

It is considered as forming very largely by rather rapid chemical or biochemical precipitation in sea water settling to the bottom and at times undergoing some later drifting by weak currents. Micrite are mostly peloidal and was identifed from borehole 5,depth 8.0-10, borehole 7, depth 6.0-6.2m and borehole 13, depth 4.0-7.0m ,see plate 6,7 and 10.

Sparry Calcite Cement

This type of calcite generally forms grains or crystals10 microns or more in diameter and is distinguished from macro crystalline calcite by its clarity as well as coarser crystal size. Large coarse grains of sparry calcite which were white and grey in colour some sparite are drusy and elongated, see plate 5,8,9 and 11.

Pelloid

These are ellipsoidal aggregates of microcrystalline calcite, mostly micritic forms as a result of faecal pellets from worm or fishes (see plate 10).

Non carbonate minerals

These are terrigeneous detritus (see plate 7, 8, 9&11).

Environmental Interpretation

This is based on the fossil content and the dominant support of the communities around River Yewa. The fossil contents include: echinoids, bivalves, coralline algae, pelecypod which are typical of a sublithoral or open shelf environment and are chracterised by low-medium energy environments. The presence of echinoid indicates deeper waters. The allochemical micrite (lime mud),a dense, dull-looking sediment, made of clay sized crystals, formed from the breakdown of calcareous algae skeleton. The limestone formation in the study area is highly fossiferous (55-60%) hence called biomicrite (Folk 1959, 1962) analogous silliclastic wacke, sand imbedded in a lot of matrix (Dunham 1962).

Spar/sparite (thickly and cross bedded clear to translucent calcite crystals with rhombohedra cleavage acting as a cement) is precipitated it is highly fossilized and called biosparite, it is precipitated from shallow marine percolation into the sediments after deposition.

VI. CONCLUSION

The limestone deposits of the communities around the River Yewa can be texturally classified as silliclastic wackestone, with sand imbedded in a lot of matrix (Dunham 1962). Pectrographically classified as fossilferous limestone, biomicrite and biosparite (Folk 1962). The limestone deposit was equally observed to be principally mud supported which is indicative of rocks deposited in low tidal water current and a low energy open shelf environment, indicative of the presence of shell fragments.

The limestone are medium grained with colour ranging from light to dark grey with dark brown stains and it correlated along NNW-SSE and E-W . Sand is the dominant lithology in the study area.

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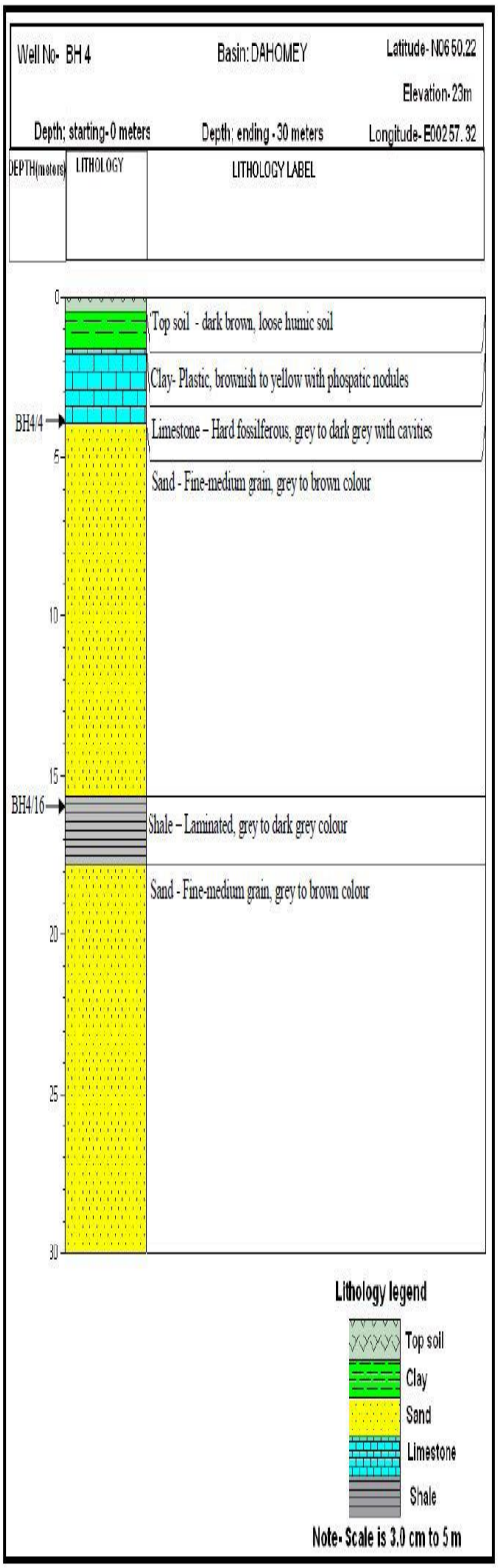
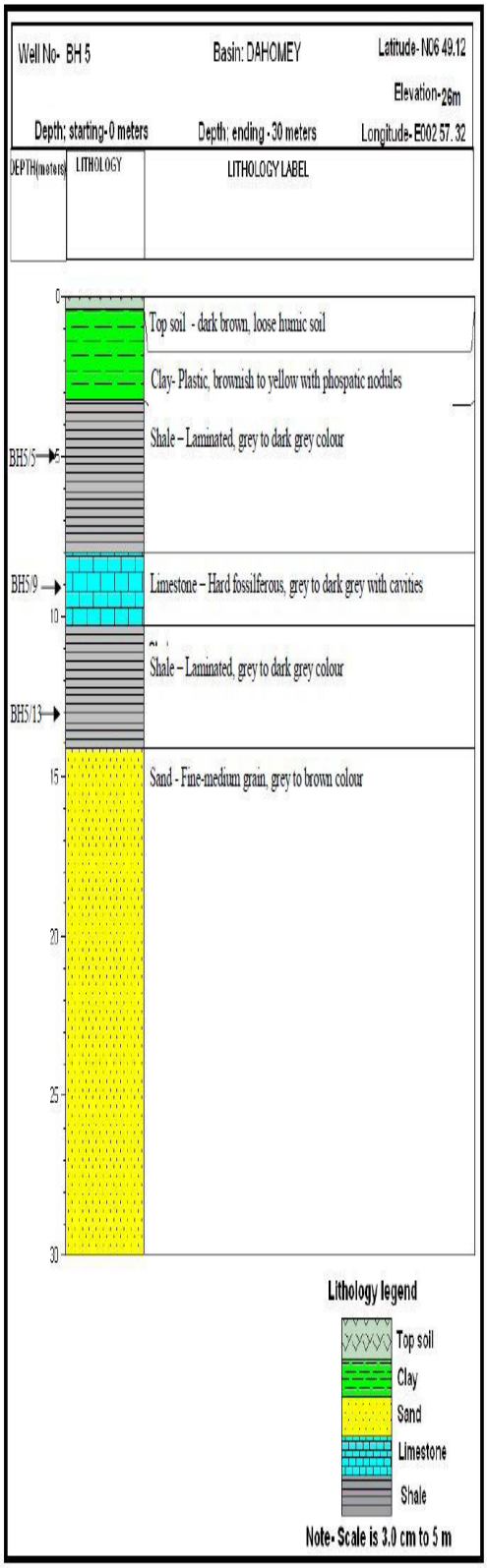
APPENDICES





APPENDIX 2: