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Micropaleontological Analysis of Rocks of Mbakwah and Environs, Gboko, Southeast Nigeria

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Micropaleontological Analysis of Rocks of Mbakwah and Environs, Gboko, Southeast Nigeria

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Abstract- Micropaleontological analyses of rock samples from outcrops and hand-dug wells in Gboko and its environs were carried out to better understand the geology of the area, properly delineate the various lithologies and infer the ages of the rocks. Detailed geologic mapping, micropaleontologic and petrographic methods were applied. Micropaleontological analysis involved washing and viewing of shale samples under microscope for the identification of the microfossils. The area is underlain by black shale inter-bedded with calcareous sandstone and carbonaceous limestone beds. Results of micropaleontological analysis yielded foraminifers and ostracods ranging from Cenomanian to Coniacian. *Ovocytherideasymmetrica* and *Ovocytheridea-reniformis*ranges from *Cenomenian* to Coniacian, while *Ovocytherideaashakaensis and Clithocytheridea-senegali*are indices of Turonian age. Foraminiferal analysis reveals the occurrence of benthic and planktonic index forms including *Ammobaculitesjessensis, Ammobaculitesbenuensis, Whiteinellabaltica* and *Heterohelixreussi.* The dominant arenaceous benthic foraminifers and the smooth ostracods suggests a shallow marginal marine brackish water environment. From the Shanon-Weiner Information functionfor the foraminifer's species, H(s) value of 1.93163 was gotten and the Equitability of the specimen was calculated to be 0.69. This value implies that the species are not evenly distributed. Results of micropaleotological analysis revealed the presence of index species of foraminifers and ostracods, these showed the rocks are of Turonian age, and belong to the Ezeaku Formation.

I. Introduction

The Benue trough is an elongate intracratonic basin of over 1,000 km long and up to 3000 km at its widest parts. Popoff *et al.* (1991), noted that the Benue Trough is a continental scale intra-plate tectonic mega structure initiated from the Late Jurassic to Early Cretaceous Period which is a part of the mid-African rift system, related to the opening of the Central and South Atlantic Oceans. The major geological study covering the Gboko area still remains the work of Shell-BP geologists. The main stratigraphical units in Southern Benue Trough have been established by the Shell D' Arcy geologists. Many other works (Reyment (1965), Petters (1982), Petters and Ekweozor (1982), Adekeye and Akande (2000; 2002) and Adekeye (2003) have published findings from their work in the southern parts of the Benue Trough. Reyment (1965) described the general geology and stratigraphy of Southeastern Nigeria (southern Benue Trough) in which the study area falls. He attempted a biostratigraphic correlation of the formations of the Southeastern Nigeria sedimentary basin, based on index fossils such as ammonites, foraminifera and pelecypods. Fayose and De Klasz (1976), working on the carbonate/shale sequence of the Eze-Aku Shales, exposed at the Nkalagu limestone quarry in Lower Benue Trough, found abundant species of Heterohelix and Hedbergella suborder and some ostracods such as Brachycythere, Ovocytheridea and Paracypris which gave a Lower Turonian age. Petters (1980) also, used Hedbergellaplanispira; Heterohelixmoremani; Guembelitriaharrisi and Praebulimina fang assemblages found in the Nkalagu Formation to assign a Turonian age to the Eze-Aku Shales. This agrees with the Early Turonian ammonite age given by Offodile and Reyment (1976).

a) *Regional Stratigraphic Setting*

Sensustric to, the lithic fill of the Benue Trough spans from the Lower Cretaceous to the Santonian, (Nwajide, 2013). Reyment (1965) undertook the first detailed study of the stratigraphy of the southern Nigerian sedimentary basins, and he proposed many of the lithostratigraphic units in the region. The lithostratigraphic and biostratigraphic divisions of the Abakaliki region proposed by Reyment (1965) have been revised largely as a result of the detailed research carried out in recent times by researchers, institutions and the oil companies. In his work, Ojoh (1992) gave a more detailed division of the Albian to Santonian sediments.

b) *Asu River Group (Albian)*

The Asu River Group was deposited in the earliest stages of the basin's formation. Outcropping sediments are found at Ogoja-Abakaliki-Lokpauku, Uturu and Okigwe and turns to Amuri, Nkalagu forming a closure.

Outcrops of the Asu River Group (Abakaliki Formation) are also found in the Mamfe Embayment and the Calabar Flank. According to Reyment (1965), the Asu River Group is associated with marine transgression. The sediments at Ogoja and Abakaliki are arkosic and non-fossiliferous fanglomerates. Ojoh

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(1992) has divided the Group into three formations (Ekebeligwe, Ngbo, and Ibri and Agila Sandstones) ranging from Middle Albian to the Lower Cenomanian. The Ekebeligwe Formation (mid-Albian) was interpreted as deep marine from the presence of mega slumps and turbidites and from the foraminifera and ammonite assemblages found in the formation (Ojoh, 1992), while the Ngbo Formation (Upper Albian) contains more sands than the former and changes from shelf to nearshore environment (regression?)

c) *Eze-Aku Group (Cenomanian-Turonian)*

Cenomanian sediments within the Abakaliki basin were assigned to the Odukpani Formation consisting of sandstones, shales and limestones of shallow marine shelf environment (Reyment, 1965, Kogbe, 1989). Although some authors think that the Cenomanian is absent in Abakaliki Basin, Nwachukwu (1972) attributes the absence of the Cenomanian to a possibly slight folding phase within this area. Ojoh (1992) established the presence of the Cenomanian in the Abakaliki Basin using pollen and spores. He placed the upper formations (Ibir and Agila Sandstones) in the Lower Cenomanian while the marine shales outcropping at Ezillo originally classified as part of the Eze-Aku Shales was dated upper Cenomanian. The upper members of the Eze-Aku Group are Turonian (Reyment, 1965, Kogbe, 1989). A widespread transgression that occurred during this period deposited black shales with limestone and calcareous sandstones. This was the first transcontinental connection of the Tethys Ocean (present day Mediterranean Sea) with the Atlantic. The Makurdi Sandstones (Nwajide, 1982), Agala Sandstones (Murat, 1972), Konshisha Section, Amaseri Sandstones (Kogbe, 1989) and the Agu-Ojo Sandstones (Ojoh, 1992), are storm deposits laid by a short localised regression that occurred during mid-Turonian period. Renewed transgression laid some limestone deposits on the platforms areas (Nkalagu Limestone). Others include bluish grey shales with limestones and calcareous sandstones. Since there was no break in deposition, some authors classify these later deposits that continued into Coniacian as belonging to the Awgu Group. However, the presence of ammonites in some of these Awgu Group (Coniacian-Santonian)

As mentioned earlier, the Awgu Group is similar to the Ezeaku Group. The shales are believed to be of marine origin considering the limestones contained in some locations. Sediments in the Abakaliki Basin were folded into an anticlinorium during the Santonian deformation thereby causing subsidence in the platforms. Also, there was emplacement of intrusions in some localities, especially in the core of the anticlinorium, by magmatic activity that accompanied this event. Although most authors are of the opinion that there was no deposition during the Santonian, Ojoh (1992) noted that sandstones in Ugep contains fossil assemblages dated Santonian to Lower Campanian. This indicates that, contrary to widely held opinions (Reyment, 1965; Kogbe, 1989), deposition probably occurred during the Santonian in some areas within this basin. The Coniacian stage records the beginning of the regression that culminated in the uplift that ended the first tectonic phase. At the end of the Santonian, deposition in the Abakaliki-Benue Trough ended while deltaic complexes were developed on the Anambra Platform axis units places them in the Turonian Eze-Aku Group.

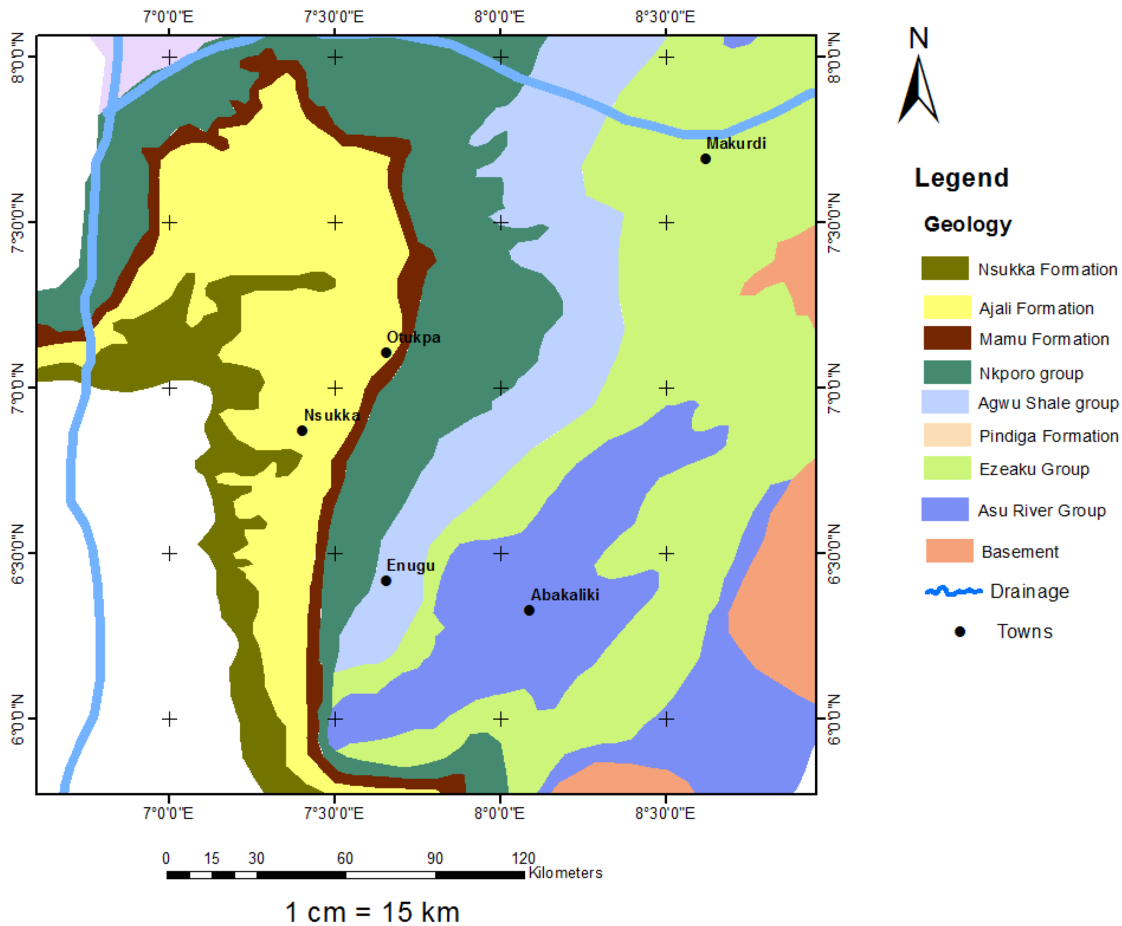

Fig. 1: Regional stratigraphic map of Southeastern Nigeria (after Nwajide, 1990)

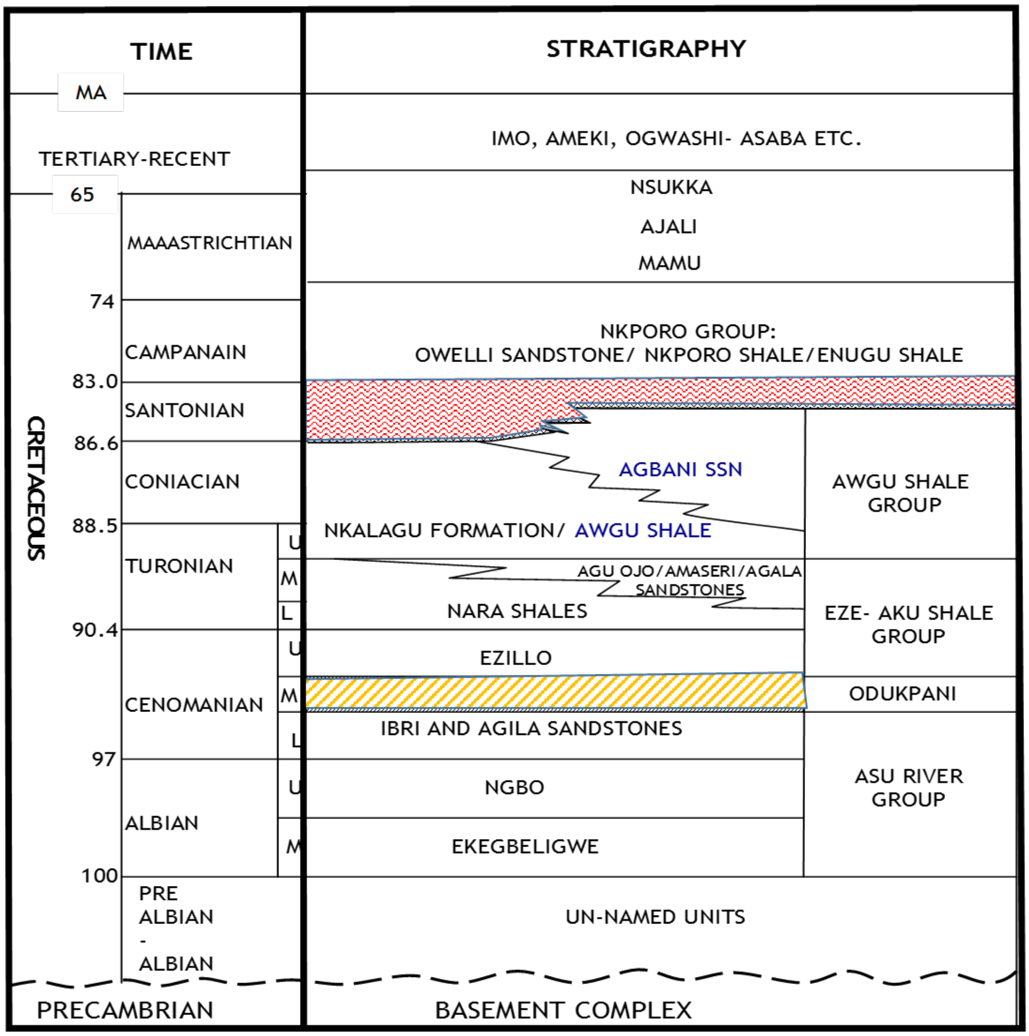

Fig. 2: Summarized stratigraphy of the Benue Trough and Anambra Basin (after Reyment, 1965 and Ojoh, 1992)

II. Materials and Methods

Preliminary reconnaissance studies were carried out in March 2014 and involved visiting the area, getting acquainted with the local traditional rulers and arrangement for accommodation were made. Detailed field work started in November and lasted till December 2014, spanning a total of 21 days. It involved the detailed mapping and description of lithologic units within the area. Instruments used for the field work were the Global Positioning System (GPS), geologic hammer, compass, topographic map, sample bags, hydrochloric acid, digital camera, masking tape, field notebook, and sediment-size description guide. The GPS was used to get the coordinates and elevation of the various locations, and thus locate the outcrop on the map. The compass was used to measure the attitude of the beds and other structures while the sediment-size description guide was used to determine the grain sizes of the sediments.

III. Sampling

Samples were collected with the aid of the geologic hammer, labeled and put into the sample bag. Lithological characteristics of outcrops were described megascopically in the field and recorded in the field notebook. Representative shale samples were collected from hand dug wells and outcrops for micro paleontological analysis. The following procedure and precautions were taken during sample preparation for paleontological analysis. 50grams of each shale sample was measured using a weighing balance, each sample was soaked in beaker containing kerosene and allowed to stand for 24 hours. The dissolved samples was washed in a 63 microns sieve mesh, and shale filtrates were allowed to dry for a day. Dried samples were poured into fossil trays for fossil identification under the paleontological microscope. Fossils were picked using picking brush based on its diagnostic forms and placed in a fossil box for more detailed description. Precautions including rewashing of the sieve mesh after sieving a particular sample, cleaning up the fossil plate and picking brush after each use were taken to avoid contamination of samples.

IV. Measurement of Diversity

This is a statistical attempt to quantify the relationship between the number of individuals and the number of species in an assemblage of fossil or recent organisms. Shannon – Wiener information function H(S) (Shannon *et al*. 1949);this is represented by the formular;

$$H(s) = -\Sigma PilnPi \qquad (1)$$

Where pi is the proportion of individuals found in ith species.

a) Equitability (E)

The equitability 'E' is a parameter related to the information function H (s). It measures the evenness with which species are distributed in a population.

$$\text{Equiitability 'E'} = (e^{H(s)})/\ S \qquad (2)$$

H(s) – information function

S - Number of species.

V. Results and Discussion

a) Field description

From the results of field studies, the area is chiefly underlain by dark grey to light grey shale mapped in two outcropping sections and in over 40 hand dug wells studied within the area.

At location 3-Mbakwagh, the exposure is about 10m thick and over 150m in lateral extent (fig. 5a). The outcrop is made up of alternation of highly indurated sandstone, limestone and shale. The sandstone in the location is fine, micaceous and highly indurated with wave parallel ripple laminations observed between the contacts of adjacent sandstone beds. The sand beds are calcareous especially close to contacts with the limestone beds. On the other hand, the limestone beds are highly indurated and carbonaceous. The shale is the dominant lithology, it is highly indurated at the base of the exposure but becomes more fissile at the top. The second exposure of the shale unit is along Uerku River at Anhur (fig. 5b). The exposure is about 3m in thickness and about 30m in lateral extent. Here there is about 1m thick shale with a trend of 50NE-230SW.

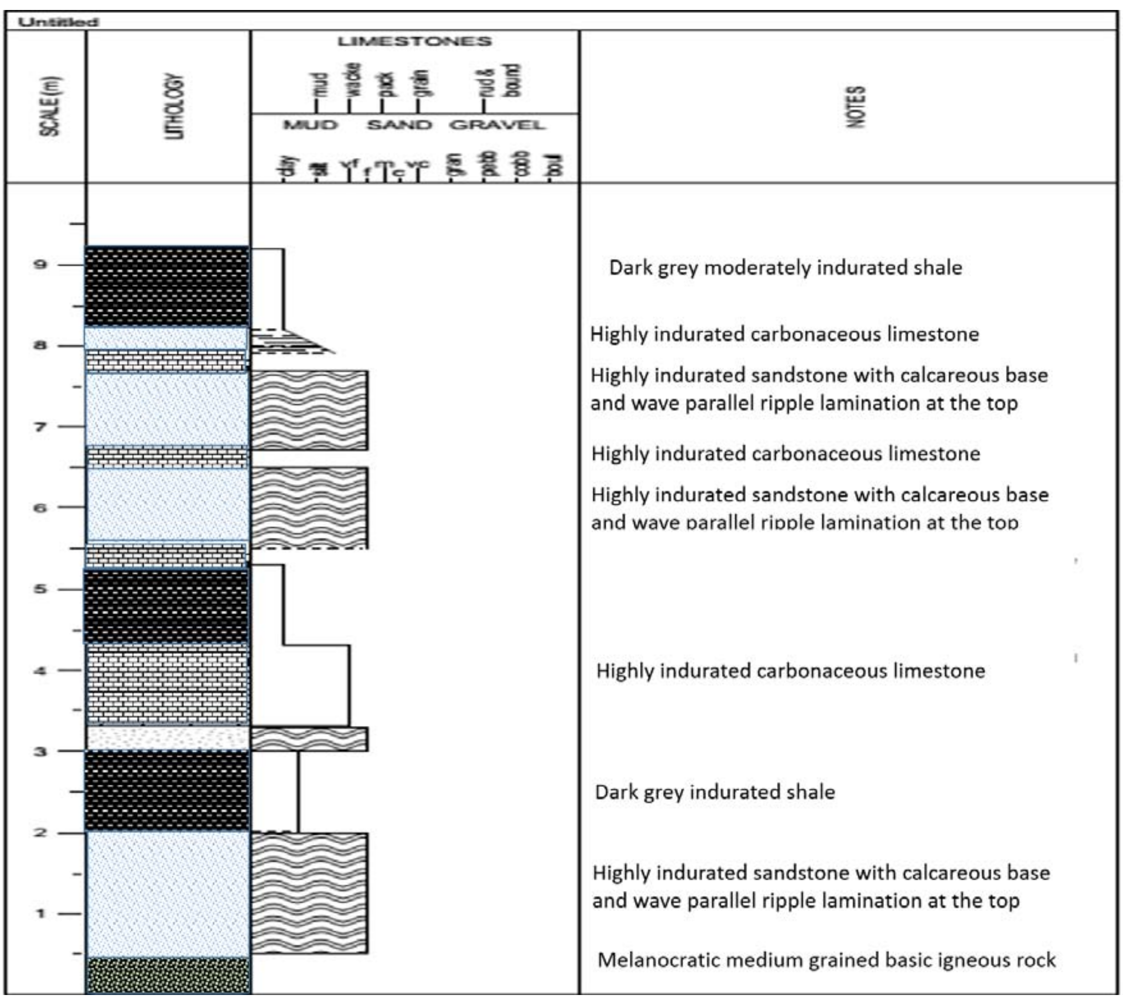

Fig.3: The lithologic log of the outcrop at location 3, (OOH/3/MBAKWAGH)

The grey shale unit was also observed in hand dug wells within the study area (fig 5c & d). Over 40 hand dug wells was studied during this field work, all scattered within the map area. The dominant lithology in these hand dug wells is shale but fine micaceous sandstone, limestone and intrusions where also observed in some of the wells. The wells range from a depth of 3m to over 7m with laterite covering between 2-3m of the total depth of the wells.

VI. Hand Dug Well Correlation

From the hand dug wells mapped, certain correlations can be made. Some of the hand dug wells with similar lithologic units encountered were mapped close to one another and hence could be easily correlated.

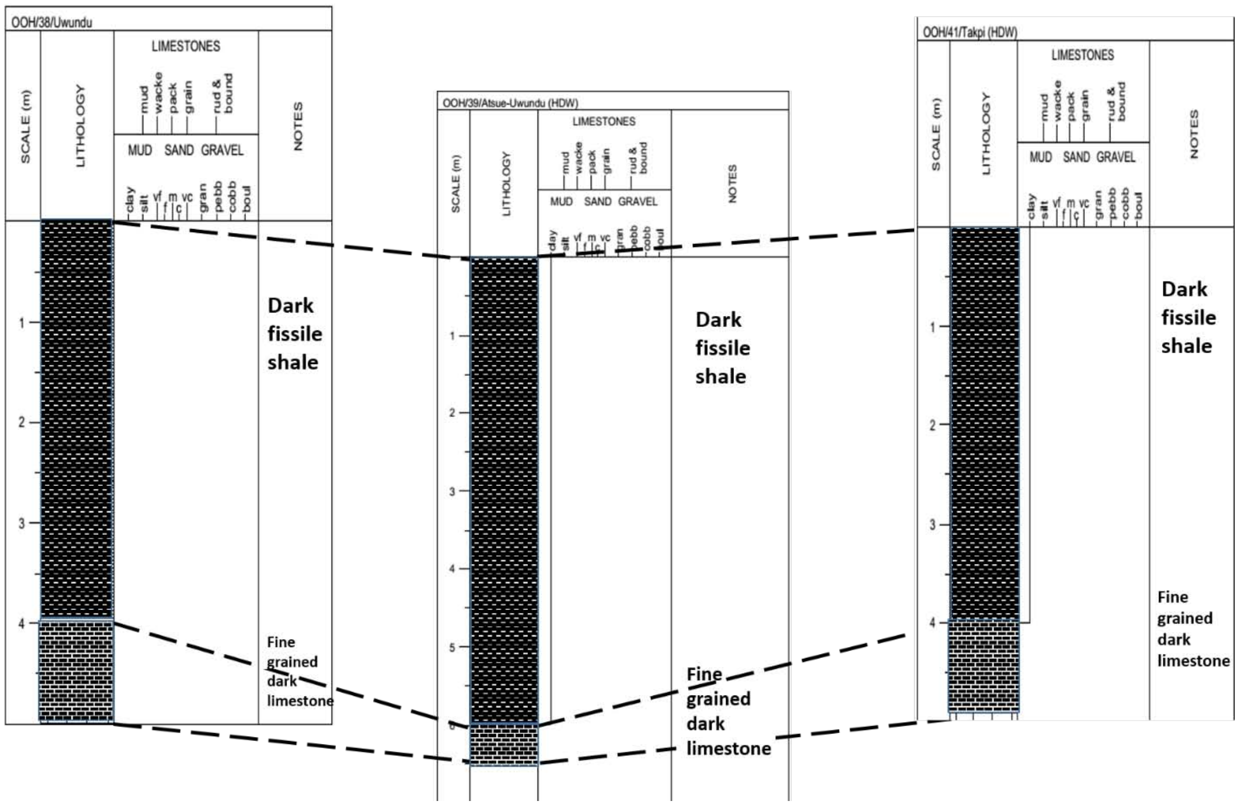

Fig. 4: Correlation of hand-dug wells from location 38-Uwundu, 39-Uwundu and 41-Takpi respectively, showing similarities in their lithologic makeup

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Fig. 5: A &B shows outcrops along dry river banks. C: a shallow hand-dug well. D: Hand-dug well cuttings. (Scale: Geologic hammer).

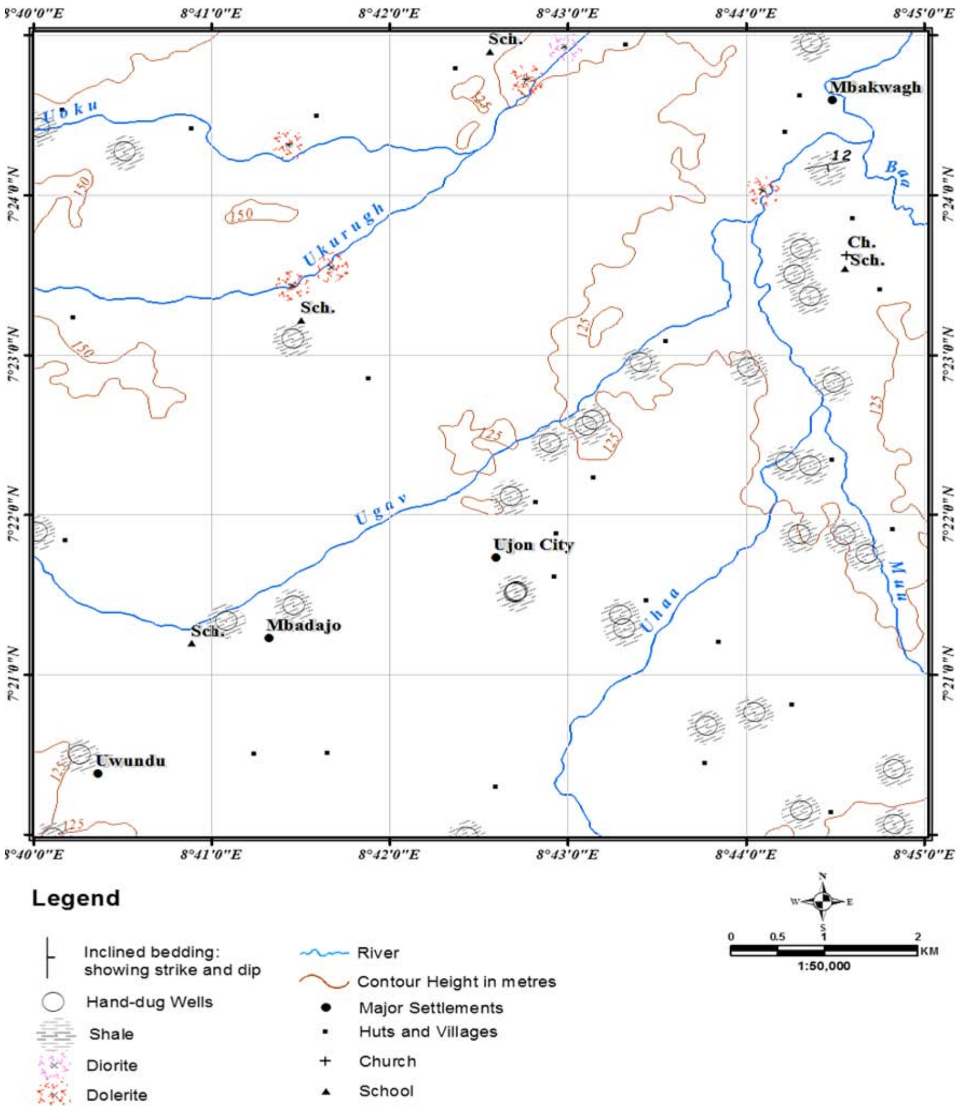

Fig. 6: Outcrop map of the study area

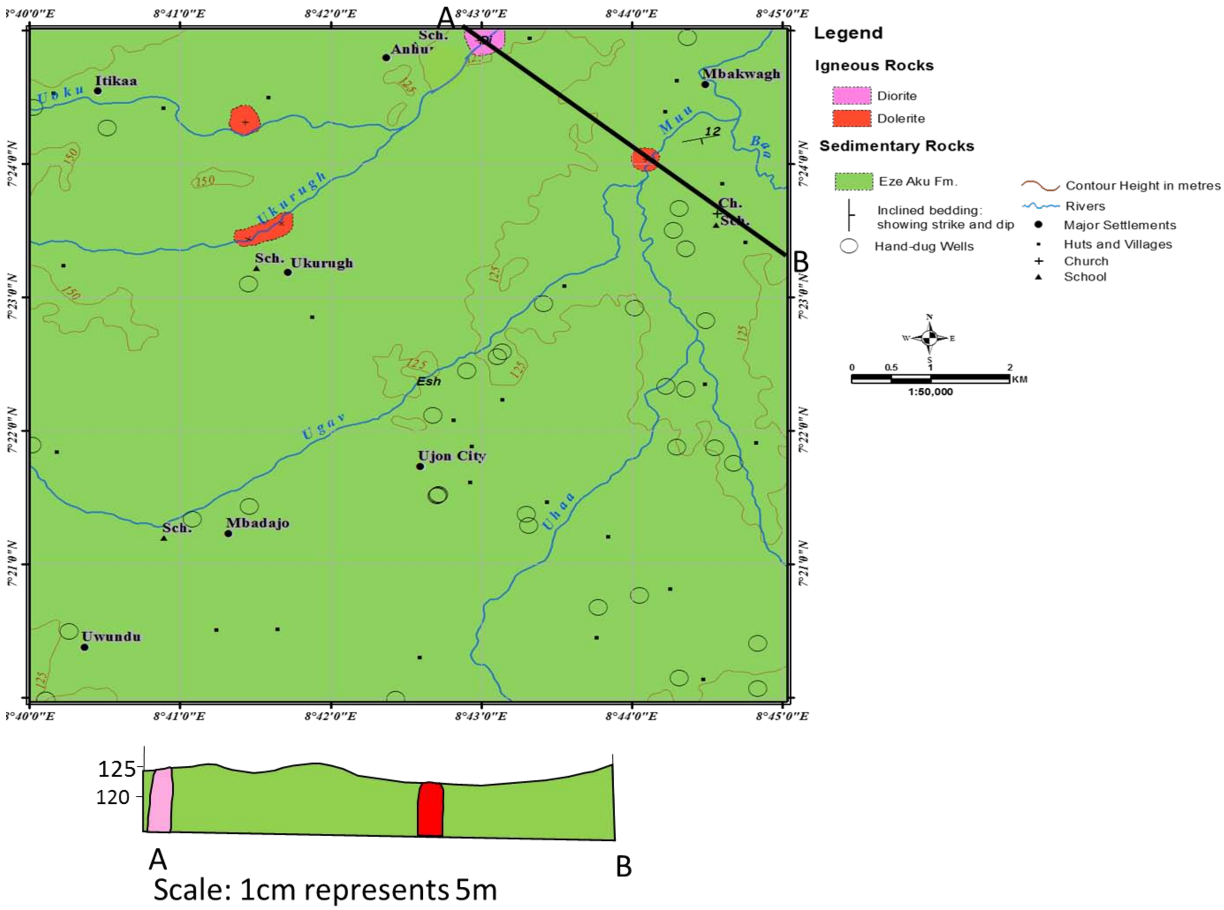

Fig. 7: Geologic map and cross section.

VII. Micropaleontology

A total of ten shale samples were analyzed, out of which four of the samples were fossiliferous. Samples from OH/14 and OH/35 were rich in planktonic foraminifers', OH/18 yielded dominantly benthic species while the fourth (OH/12) yielded exclusively ostracods. Four ostracod species recovered (Table 1) include; *Ovocytherideasymmetrica* (Reyment 1960), *Ovocytherideareniformis*(Bold 1964), *Clithrocytherideasenegali Apostolescu*and *Ovocytheridea Ashakaensis* (Okosun 1992). Benthic species (Table 2) include; *Ammobaculitesbenuensis* (Peters 1982), *Ammobiculitesbauchensis* (Peters 1982), *Ammotium Bornum* (Peters 1982). The planktonic species (Table 3) include; *Whiteinellabaltica* (Douglas and Rankin, 1969), *Heterohelixreussi* (Cushman, 1938), *Heterohelixmoremani* (Cushman1938), *Hedbergella cf. delrioensis* (Carsey, 1926). 1982), *Ammobiculitescoprolithiformis* (Schwager 1868), Ammobaculitesamabensis (Peters 1982).

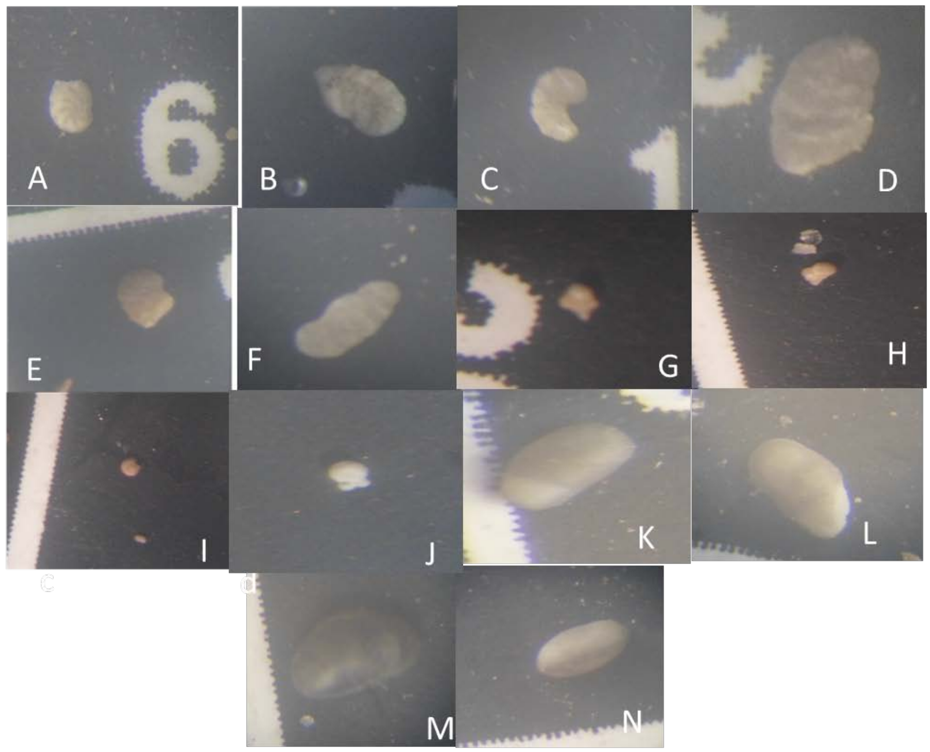

Fig. 8: A: Ammobacullites. Jensiensis, B: Ammobaculitesbenuensis C: Ammotiumcfnwalium D: Ammotium Nkalagum E: Ammobiculitesbauchensis:F: Ammobiculitescoprolithiformis G: Heterohelixmoremani I: Whiteinellabaltica H: HeterohelixreussiI: J: Hedbergella cf. delrioensis K: Clithrocytherideasenegali Apostolescu L: Ovocytheridea. Ashankaensis M: Ovocytheriddeareniformis N: Ovocytherideasymmetrica

Table 1: Result of micropaleontological analysis of ostracods

S/N	Location	Species Count	Scientific Name
1	OH/12 from black shale sample at location 12.	4	Ovocytherideasymmetrica (Reyment 1960)
2	OH/12 from black shale sample at location 12	7	*Ovocytherideareniformis* (Bold 1964)
3	OH/12 from black shale sample at location 12	3	*ClithrocytherideasenegaliApostolescu*
4	OH/12 from black shale sample at location 12	1	*OvocytherideaAshakaensis* (Okosun 1992)

Table 2: Result of micropaleontological analysis of benthic foraminifera

S/N	Location	Species Count	Scientific Name
1	OOH/18 from black shale sample at location 18	18	*Ammobaculitesbenuensis*(Peters 1982)
2	OOH/18 from black shale sample at location 18	12	*Ammobiculitesbauchensis* (Peters 1982)
3	OOH/18 from black shale sample at location 18	7	AmmotiumBornum(Peters 1982)
4	OOH/18 from black shale sample at location 18	15	*Ammobiculitescoprolithiformis* (Schwager 1868)
5	OOH/18 from black shale sample at location 18	8	Ammobaculitesamabensis(Peters 1982)

Table 3: Result of micropaleontological analysis of planktonic foraminifera

S/N	Location	Species Count	Scientific Name
1	OH/14 from dark grey shale sample at location 14	2	Whiteinellabaltica (Douglas and Rankin 1969)
2	OH/14 from dark grey shale sample at location 14	3	Heterohelixreussi (Cushman 1938)
3	OH/14 from dark grey shale sample at location 14	1	*Heterohelixmoremani (Cushman1938)*
4	OH/35 from dark grey shale sample at location 35	3	*Hedbergella cf. delrioensis (Carcey)*

VIII. Depositional Environment

The study area is predominantly underlain by shale. The shale is dark grey, fissile and calcareous at contacts with limestone. The shale is interbeded with carbonaceous limestone and fine, micaceous sandstone beds as exposed along Baa River.

The depositional environment of the sedimentary rock in the study area is inferred based on the rock type (dark grey shale) and presence of ostracods and foraminifera recovered from the shale samples. The alternation of shale and limestone and sandstone beds can be associated with sea level fluctuation due to intermittent sea level fluctuation (Opeloye, 2009). The predominance of sandstone units, calcareous sandstone, massive beddings and cross-stratification suggest deposition in a shallow marine environment during transgressive/regressive phases in Turonian times (Ukaegbu et al., 2009).

The presence of dark grey shale indicates deposition under low energy in a reducing environment (absence of oxygen) condition which prevents complete decomposition of fossils (Oertli, 1971).

The dominant arenaceous benthic foraminifers and the smooth ostracods suggest a mainly shallow marginal marine brackish water environment with an increase in water depth represented by horizons with planktonic foraminifers (Saka, 2012). The abundance of the different forms of Ammobaculites are related to their successful exploitation of the environment as detritivores. Species of Ammotium are also typical of brackish habitats below 10m depth (Murray, 1991).

The dark colour of some of the ostracod carapace is indicative of some degree of pyratization. Pyrite is an early diagenetic mineral that forms when the overlying sediments is being deposited. The pyritization of the ostracods probably took place shortly after death when individuals were buried a few millimeters of centimeters below the surface, where reducing conditions prevented the complete decomposition of the organic matter (Oertli, 1971). Due to the high amount of pyrite formed, it probably replaced the calcite that originally formed the test, which gave some of the tests their black coloration.

Foraminiferal analysis reveals the occurrence of benthic and planktonic index forms. These forms are Ammobaculitesjessensis, Ammobaculitesbenuensis, Whiteinellabaltica and Heterohelixreussi. The above fossil assemblage points to a Turonian age for the study area. Similar assemblage was also used to assign a Turonian-coniacian age to the New Netim Formation, Calabar Flank, Nigeria (Bassey et al, 2012). This is also in line with the assertions of both Petters (1982) and Gebhardt (1997) on the ages of other marine formations in the Northern Benue Trough. The age range of the ostracods is Cenomanian to Coniacian (Fig.9) *Ovocytherideasymmetrica and Ovocytherideareni-formis ranges from Cenomanian to Coniacian. Ovocytherideaashakaensis and Clithocytherideasenegali are indices of Turonian age.* (Saka, 2012).

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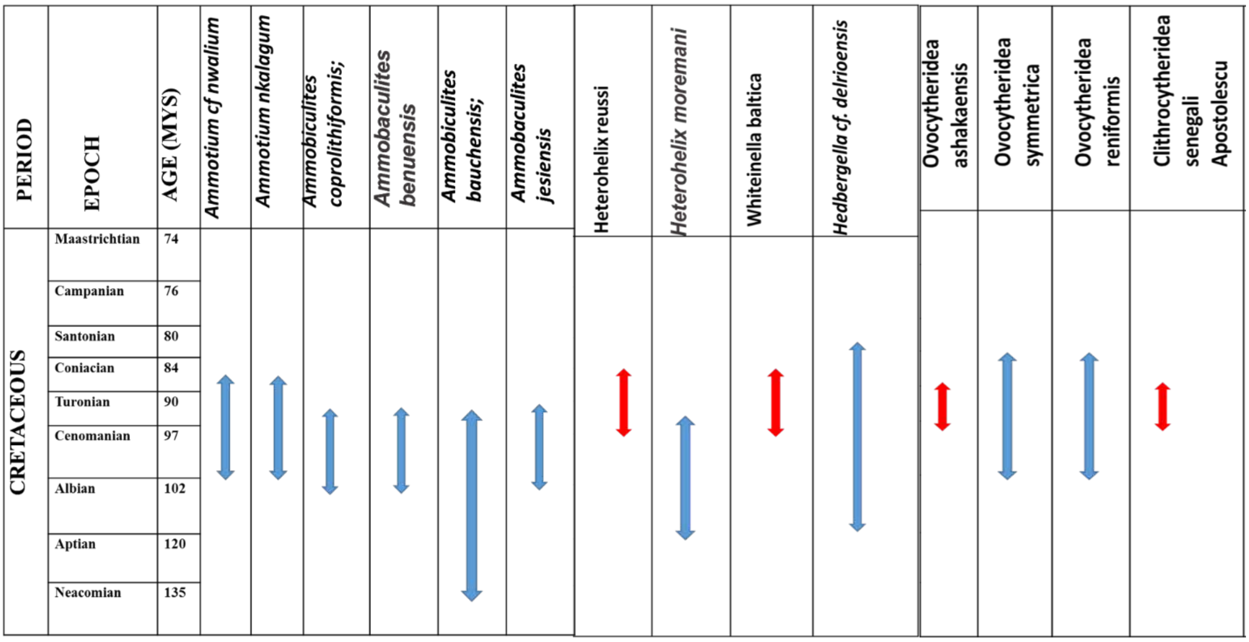

Fig. 9: Biostratigraphic range chart of the study area

IX. Measurement of Diversity

This is a statistical attempt to quantify the relationship between the number of individuals and the number of species in an assemblage of fossil or recent organisms. The results of Shannon-Wienner information function H(S) is presented in table 4.Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increases. From the Shanon-Weiner Information function for the foraminifer's species, H(s) value of 1.93163 was gotten and the Equitability of the specimen was calculated to be 0.69. This value implies that the species are not evenly distributed (Magurran, 2004). This is evident in the greater abundance of benthics than the planktonics. This also agrees with the earlier assertion that the environment of deposition of the shale is typical shallow marine environment.

Table 4: Calculated H(S) for foraminifera assemblage from location 18-Mbakwagh

s/n	Species	frequency	Pi	Inpi	Pi InPi
1	*Ammotiumcfnwalium*	12	0.139535	-1.96944	-0.27481
2	*Ammotiumnkalagum*	14	0.162791	-1.81529	-0.29551
3	*Ammobaculitescoprolithiformis*	8	0.093023	-2.37491	-0.22092
4	*Ammabaculitesbenuensis*	22	0.255814	-1.3633	-0.34875
5	*Ammobaculitesbauchiensis*	18	0.209302	-1.56398	-0.32734
6	*Ammobaculitesjesiensis*	6	0.069767	-2.66259	-0.18576
7	*Heterohelixreussi*	2	0.023256	-3.7612	-0.08747
8	*Heterohelixmoremani*	1	0.011628	-4.45435	-0.05179
9	*Whiteinellabaltica*	2	0.023256	-3.7612	-0.08747
10	*Hedbergelacfdelrioensis*	1	0.011628	-4.45435	-0.05179
	Total	86		Σ	-1.93163

X. Conclusion

The area is underlain by predominantly shale with sandstone and limestone interbeds, The shale unit is generally black to dark grey, fissile and moderately indurated. Based on field and laboratory analysis, the rock belongs to the Turonian Ezeaku Formation. The foraminifera and ostracod species recovered from the shale were used to decipher the environment of deposition and age of the formation. Ostracod specmies including *Ovocytherideasymmetrica* and *Ovocytheri-deareniformis*ranges from *Cenomenian* to Coniacian. *Ovocytherideaashakaensis* and *Clithocy-therideasenegali*are of Turonian age. Foraminiferal species includes benthic and planktonic index forms. These forms are *Ammobaculitesjessensis, Ammoba-culitesbenuensis, Whiteinellabaltica* and *Hetero-helixreussi*. The above fossil assemblage indicates a Turonian age for the study area. The abundance of are naceousbenthics as well as smooth ostracods in the shale indicates a dominantly brackish shoreline environment.

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