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DEPOSITIONAL ENVIRONMENT AND RESERVOIR QUALITY ASSESSMENT OF AFIKPO SANDSTONE, SOUTHEASTERN NIGERIA

Ayonma W. Mode, Ijeoma M. Umeadi and Okwudiri A. Anyiam*

Department of Geology, University of Nigeria, Nsukka, Nigeria

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Abstract

This study discusses some methods for predicting the quality of sandstone reservoir systems in areas around Afikpo, Southern Benue Trough. The relationship between sandstone porosity, permeability, thickness and lateral extent determines the reservoir quality. Although quality prediction is most effective with large amounts of data, useful predictions can still be made from very limited data. The study involved field observations and laboratory analyses. Results from lithofacies analysis show that seven (7) lithofacies deposited in a low to high energy environment were delineated. They are (1) Dark Gray Shale Facies (2) Bioturbated Sandstone Facies, (3) Wave Rippled Sandstone Facies, (4) Cross Stratified Sandstone Facies, (5) Horizontal/Laminated Sandstone Facies (6) Heterolithic Sandstone Facies, and (7) Pebbly/Conglomeritic Sandstone Facies. The Micaceous Dark Gray Shale Facies belongs to the Eze-Aku Group while others are those of the Nkporo Group. Based on the observed sedimentary structures such as tabular and trough cross-bedding, flat bedding plus parting lineation, low-angle crossbeds, channels and scoured surfaces, ripples and cross-lamination, the sediments are fluvial dominated high energy shallow marine system. The sandstones show good (50-250mD) to very good (250-1000md) permeability with few showing moderate (15-50mD) to excellent (>1000mD) permeability values. Similarly, the porosity values indicate that most of the sandstones show poor to fair (7.0 - 15%) reservoir quality.

***Keywords**: Reservoir quality; Facies; Porosity; Permeability.*

1. Introduction

The relationship between sandstone porosity, permeability, thickness and lateral extent determines reservoir quality. Although quality prediction is most effective with large amounts of data, useful predictions can still be made from very limited data. This study focuses on the ways for predicting the quality of sandstone reservoir systems in areas around Afikpo, Southern Benue Trough (Fig. 1). The sandstones within the Afikpo area occur as ridges which consist of sands that are occasionally pebbly with few heterolithic beds and abundant clays/fines. These ridges form northeast-southwest-trending topographic prominences while the shales underlie the swales. The ridges are laterally extensive and show deep weathering, such that exposures of fresh rock are available only along with new road cuts, ditches/gullies, quarries and some stream channels.

The Southern Benue Trough was affected by the Santonian uplift which deformed the trough and inverted the main depocenter of the Abakaliki Trough and subsequently created the Anambra and Afikpo Basins to the north-west and south-east respectively [2-3,10]. These basins were subsequently filled with Campanian-Maastrichtian sediments.

2. Tectono-sedimentologic setting

The formation of Afikpo Syncline is related to the opening of the Benue Trough. The trough itself is a continental-scale intra-plate tectonic megastructure which is part of the Mid-African Rift System, initiated in the late Jurassic-Early Cretaceous, and related to the opening of the Central and South Atlantic oceans [10]. The development/evolution of the Afikpo Syncline is related to the tectonics of the Benue Trough. The south-western portion of the Benue Trough consisted of two longitudinally demarcated sections: to the west, a tectonically stable part - the Anambra Platform, receiving little or no sediment, and to the east a subsiding area called the Abakaliki Basin, receiving large amounts of sediment [6].

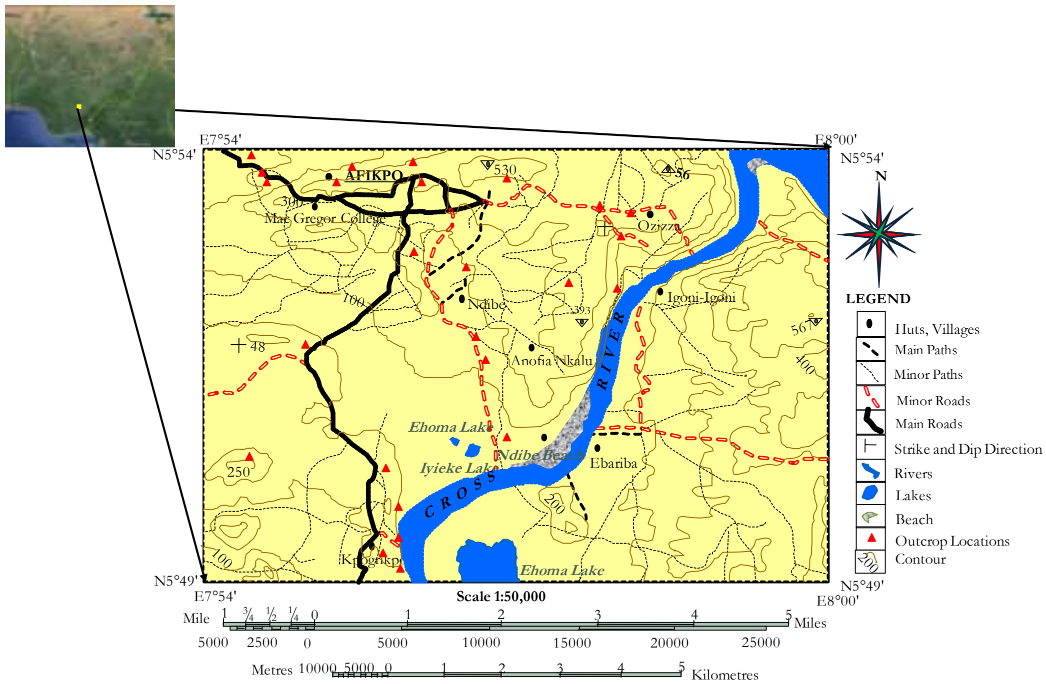
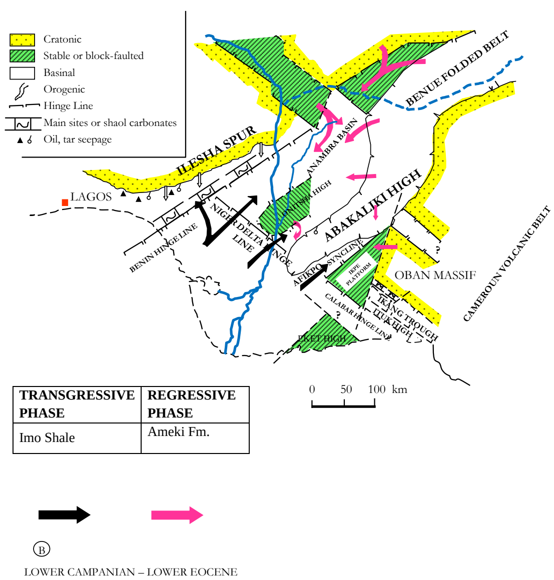


Fig. 1. Map of Nigeria showing the study area (*modified from Google Earth 2013*)



The Abakaliki Basin sediments are the Asu River and Eze Aku Groups (Fig. 2). The east-west oriented compressive forces in the Coniacian-Santonian folded the Abakaliki Anticlinorium, forming depressions on either side of the anticlinorium. The depression on the eastern flank is called the Afikpo Syncline, and that to the west is the Anambra Basin (Fig. 2). This shifted the depositional axis into the two newly formed sub-basins. A major transgression in the Campanian into the Afikpo Syncline deposited mainly prodelta shale (Nkporo Shale) and subordinate coastal plain sands (Afikpo Sandstone). Subsidence, followed by regression in the Maastrichtian, saw the deposition of another deltaic and flood plain facies represented by the Mamu, Ajali and Nsukka Formations (Fig. 2).

Fig. 2. Tectonic map of Southeastern Nigeria during the Campanian to Eocene. (*modified from* [10])

3. Materials and methods

In this study, a total of 25 outcrop sections of Afikpo Sandstone were described in Ndibe, Edobi, Mac Gregor, Amuro Mgbom, Anohia Nkalu, Enohia Itim Ukwu, Ugwu Ati, Amauzu Quarry, Ozizza, Ngodo, Kpoghirikpo and Akpughuru Edda localities of Afikpo, using the descriptive rock characteristics such as lithology, texture, physical and biogenic sedimentary structures and fossil features. The lithologic and sedimentological characteristics of the described outcrops were plotted on a litholog chart which provides insights into the vertical variation in lithologies, textures, physical and biogenic sedimentary structures, fossil contents, bed thicknesses and contact types. Also, the different rock outcrop characteristics (lithologies and sedimentary structures) were used to identify the lithofacies. Then, the vertical lithofacies transition patterns were used to interpret the paleoenvironment of deposition using the methods of Pemberton *et al.* [14] and Miall [9]. Additionally, granulometric analysis was used in the analysis and interpretation of textural data. The model used in this research work for estimating permeability based on grain size is that of Beard and Weyl [1], which was adopted from Krumbein and Monk [8].

$$K = 760 d_g^2 \exp(1.31\sigma_D) \quad (1)$$

where K is permeability given in millidarcies (mD); *dg* is the geometric mean grain diameter (in mm), and σ_D is the standard deviation of grain diameter in phi units.

The porosity was determined using the Coalson *et al.* [7] chart of permeability and porosity plot.

4. Results and discussions

The results of the outcrop studies and rock descriptions in the Afikpo area show that about 7 lithofacies are recognized and each of them has strong implication for depositional environment determination. These lithofacies include: dark gray shale lithofacies (Shd), bioturbated sandstone lithofacies (Sfb), wave rippled sandstone lithofacies (Sfw), cross stratified sandstone lithofacies (Sxm), horizontally laminated sandstone lithofacies (Slh), heterolithic lithofacies (Sfh) and pebbly sandstone lithofacies (Sfp). These lithofacies are discussed as follows:

4.1. Dark Gray Shale Lithofacies (Shd)

The Dark Gray Shale Facies covers a smaller portion of the area and is located in the low lands within the study area. It comprises of dark gray to black fissile and fossiliferous shale (Fig. 3). This facies was studied at the Kpoghirikpo, Enohia Itim Ukwu, Ugwu Ati, Iyioka river channel, Akpuguru Edda, Edobi village and Amuro Mgbom areas. At the Enohia Itim Ukwu section (Fig. 3c), about 5m of the shale is moderately tilted and fractured with the abundance of bivalves.

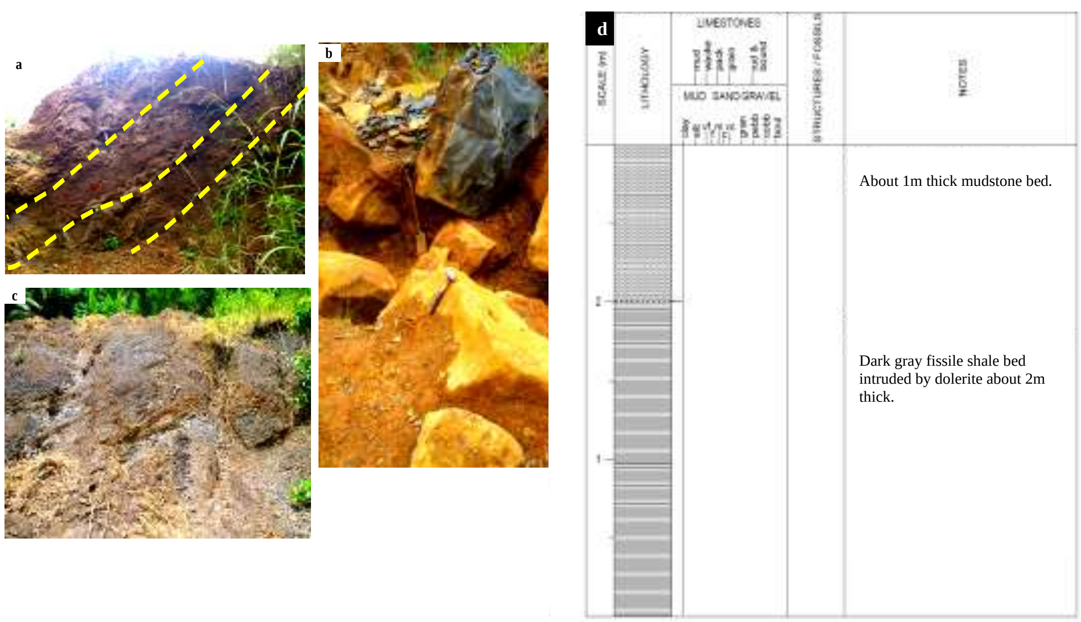


Fig. 3. Dark Gray Shale lithofacies (a) Micaceous dark gray shale showing the orientation of the shales at Edobi village (b) Dolerites which intruded the micaceous dark gray shale at Edobi village (c) Tilted and fractured fossiliferous dark gray shale at Enohia Itim Ukwu (d) Graphic sedimentary log of the outcrop in Edobi village. *Scale: Hammer (0.25m)*

The abundance of bivalves supports a shallow marine environment. This lithofacies is interpreted to be of shallow marine that grades from the lagoon to offshore settings; representing a composite transgressive, shallow marine lag, which forms a type of abandonment deposit on top of the underlying high energy subtidal deposits.

4.2. Bioturbated Sandstone Lithofacies (Sfb)

This lithofacies shows prominent traces of *Ophiomorpha isp* burrows in fine to coarse sandstone beds (Fig. 4). The burrows range from vertical to sub-horizontal; 5cm to 25cm in length and 1.0 - 2.0cm in diameter. Bioturbation of the sandstones varied from moderate to intense. The lithofacies was located at Enohia Itim Ukwu, Kpogrikpo, Ndibe, Ozizza, Ngodo *etc*. (Table 1). The vertical to sub-horizontal traces on the sandstones suggest moderate to high energy environment [12].

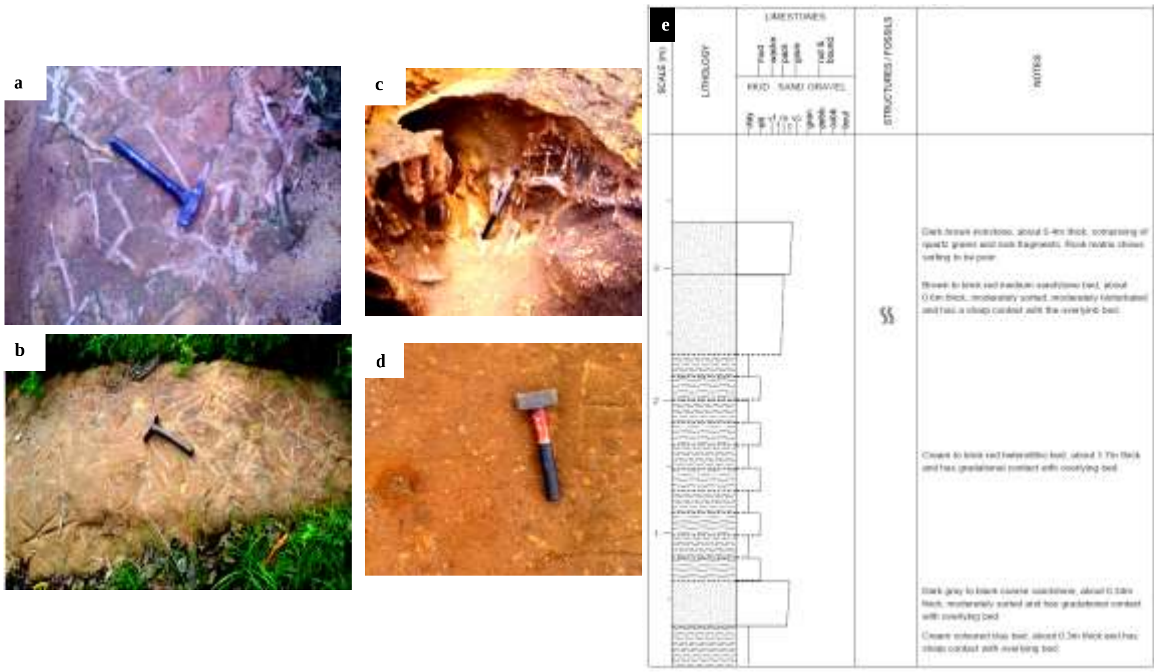


Fig. 4. Bioturbated Sandstone Facies showing trace of Ophiomorpha trace fossil (a and b) Anohia Itim Ukwu (c) Nitel Area Ngodo (d) Anohia Nkalu village (e) Graphic sedimentary log of the outcrop in Enohia Itim Ukwu village. *Scale: Hammer with red and black handle (0.25m), Hammer made of iron all through (0.3m), Pen (0.06m)*

4.3. Wave rippled sandstone lithofacies (Sfw)

The lithofacies occurred as fine to very coarse grained ferrogenized sandstones that exhibit coarsening upward motif and moderately sorted. It was described at location UI/18/Ngodo (Fig. 5). Ripple bedforms exhibiting symmetrical geometry are common. The ripple crests are generally straight with few bifurcations. The lengths of the ripple crest range from 26 to 30cm and heights between 5 and 7 cm (Table 2a). The Ripple index (RI) for this lithofacies varies between 3.71 and 6 (Table 2a) which are interpreted as being formed by wave action as a result of short-lived traction processes due to turbidity current and tidal-current reworking [5, 15].

Table 2a. Ranges of wavelength (L), height (H) and ripple index for wind, wave-formed and current ripples

Wind ripples	L 2.5 – 25cm H 0.5 – 1.0cm	Mostly 10 – 70
Wave ripples	L 0.9 – 200cm H 0.3 – 25cm	4 – 13 Mostly 6 – 7
Current ripples	L< 60cm H < 6cm	>5 Mostly 8 – 15

H = Ripple height ; L = Ripple length; Ripple index (RI) = L/H

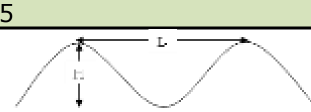


Table 1. Outcrop locations and their details

Location No.	Location name	Longitude (E)	Latitude (N)	Elevation (m)	Lithologic Type	Strike	Dip direction	Dip magnitude
UI/01	Itim Ukwu Village, behind Government Primary School, Kpoghrikpo.	7°55'28.0"	5°49'36.1"	37	Mudrock, heterolith and sandstone	35°N and 215°S, 17°N and 197°S	125°E, 107°E,	10°
UI/02	Kpoghrikpo Beach along the Cross River, Kpoghrikpo.	7°55'48.4", 7°55'51.1", 7°55'46.2"	5°49'16.7", 5°49'13.9", 5°49'13.3"	54, 27 and 50	Mudrock and sandstone	135°E and 315°W, 85°NE and 265°SW	225°SW, 175°SE	12° and 10°
UI/03	Enohia Itim Ukwu Beach along the Cross River	7°55'43.7"E	5°49'41.0"	28	Mudrock and sandstone	20°N and 200°S,	110°E	11°.
UI/04	Ugwu Ati, Amoncha Village, Kpoghrikpo	7°55'45.1"	5°50'12.4"	56	Mudrock and sandstone	17°N and 197°S	107°E	7°
UI/05	Uji Stream, Enohia Itim Ukwu.	7°55'22.3"	5°49'49.5"	29	Sandstone	-	-	-
UI/06	Excavation Site, Akpuguru Edda	7°54'17.6"	5°49'46.9"	66	Mudrock and sandstone	140°SE and 320°NW	230°SW	5°
UI/07	Roadcut exposure along Afikpo Unwana Road	7°55'0.26"	5°51'35.4"	53	Sandstone	84°NE and 264°SW, 83°NE and 263°SW	174°SE, 173°SE	12° and 8°
UI/08	Beside Maria Island Hotel, Ndibe Beach Road	7°56'46.4"	5°50'50"	36	Sandstone	10°N and 190°S	100°E	3°
UI/09	Ground surface exposure in Anohia Nkalu village	7°56'50.3"	5°51'46.7"	71	Sandstone	4°N and 184°S	94°E	10°
UI/10	Excavation Site by Endrock Solid Block, Ndibe Road	7°56'30.3"	5°51'59.5"	44	Silt and sandstone	64°NE and 244°SW	154°SE	12°
UI/11	Behind Amuro-Mgbom Secondary School, Afikpo	7°56'01.5"	5°52'58.0"	47	Mudrock and sandstone	58°NE and 238°SW	148°SE	11°
UI/12	Water Works in Ndibe	7°56'47.1"	5°52'42.3"	35	Mudrock and sandstone	8°N and 188°S	98°E	10°
UI/13	Amauzu Local Quarry	7°57'20.4"	5°52'33.4"	102	Sandstone	42°NE and 222°SW	132°SE	24°
UI/14	Ozizza Beach	7°58'13.5"	5°52'35.8"	25	Sandstone	0°N and 180°S	90°	6°
UI/15	Ozizza roadcut exposure, Ozizza	7°58'0.2"	5°53'24.3"	101	Sandstone	169°SE and 349°NW	259°SW	8°
UI/16	Orra Ozizza Roadcut Near Poultry	7°58'0.4"	5°53'0.5"	91	Mudrock and sandstone	18°N and 198°S	108°	8°

Location No.	Location name	Longitude (E)	Latitude (N)	Elevation (m)	Lithologic Type	Strike	Dip direction	Dip magnitude
UI/17	Ozizza Sandstone Ridges	7°58'30.0" and 7°57'48.6"	5°53'45.2" and 5°53'57.0"	177 and 150	Sandstone	140°SE and 320°NW	230°SW	10°
UI/18	Nitel Area Ngodo	7°56'36.8"	5°53'51.8"	167	Mudrock and sandstone	3°N and 183°S 70°NE and 250°SW 10°N and 190°S	93°E160°SE100°E	0°9°10°
UI/19	Behind Government College, Ngodo	7°55'43.9"	5°53'54.2"	90	Mudrock and sandstone	7°N and 187°S, 8°N and 188°S, 25°N and 205°S, 19°N and 199°S	97°E, 98°E, 115°E, 109°E	12°, 10°, 11° and 11°
UI/20	Roadcut exposure at Mac Gregor roundabout	7°55'18.9"	5°53'38"	108	Sandstone	58°NE and 238°SW, 83°NE and 263°SW	148°SE, 173°SE	7° and 8°
UI/21	Why Worry Spring Water (Water Works Sandstone)	7°55'15.0"	5°53'40.1"	83	Mudrock and sandstone	100°E and 280°W	190°S	11°
UI/22	Mac Gregor roadcut opposite Block Industry 1	7°55'05.7"	5°53'38"	109	Sandstone	68°NE and 248°SW	158°SE	4°
UI/23	Mac Gregor Roadcut Opposite Block Industry 2	7°55'00.1"	5°53'37.6"	97	Sandstone	177°SE and 357°NW	267°SW	4°
UI/24	Roadcut exposure along Afikpo/Amasiri/Abakaliki Road	7°54'52.9"	5°53'45.0"	63	Mudrock and sandstone	134°E and 314°W 132°E and 318W	224°SW, 222°SW	18° and 19°
UI/25	Dolerite Intrusion in Edobi, Afikpo	7°54'41.1"	5°53'58.9"	58	Mudrock	94°E and 274°W, 58°NE and 238°SW, 18°N and 198°S, 90°E and 270°W	184°S, 148°SE, 108°E, 180°S	36°, 62°, 76° and 40°

Table 2b. Ripple height (H), Ripple length (L) and ripple index measurements

S/N	Ripple Height (H) (cm)	Ripple Length (L) (cm)	Ripple Index (RI=L/H)
1	7	26	3.71
2	5	30	6
3	5	30	6
4	6	30	5
5	5	30	6
6	7	30	4.29
7	5	30	6
8	5	30	6
9	6	30	5

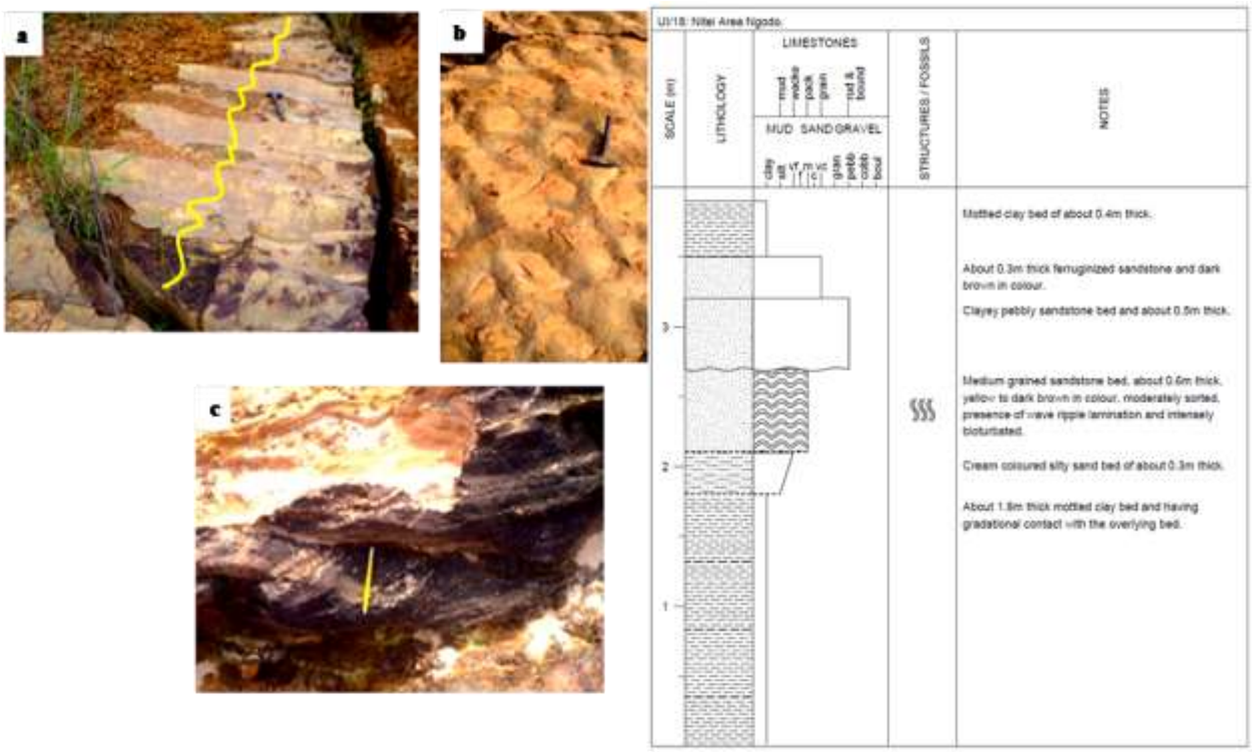


Fig. 5 (a, b and c).Wave Rippled Sandstone Facies showing ripple patterns noted on fine to very coarse grained sandstone at Nitel Area Ngodo (d) Graphic sedimentary log of the outcrop in Nitel Area Ngodo. *Scale: Hammer (0.3m), Pencil (0.047m)*

4.4. Cross Stratified Sandstone Lithofacies (Sxm)

This consists of fine to very coarse, but dominantly medium to coarse grained sandstones with thick cross–stratified bedsets. It exhibits coarsening upward motifs with graded foreset laminae and scattered quartz pebbles. Sharp and scoured erosive basal contacts, most often lined with vein quartz pebbles are common. Occasionally, this facies shows clay draped foresets, reactivation structures and micro folds. The degree of sorting ranges from moderately to very well. Some of the exposures are slightly indurated, friable, lots of fractures with ferrogenized fillings with iron concretions.

The units that showed trough cross stratifications were studied at locations UI/04/ Kpoghrikpo, UI/06/Akpuguru Edda, UI/10/Ndibe and UI/22/Mac-Gregor and they show inter-set boundaries that are scoop shaped or have the curved appearance and tangential bases (Fig. 6a). Herringbone cross beddings were also observed at locations UI/04/Kpoghrikpo, UI/06/Akpuguru Edda and UI/14/Ozizza (Fig. 6b). Planar cross beds with angular to tangential contact and the basal surface (Fig. 6c and d) were also observed at locations UI/09/Nkalu, UI/13/Amauzu, UI/18/Ngodo, UI/19/Ngodo and UI/22/Mac-Gregor.

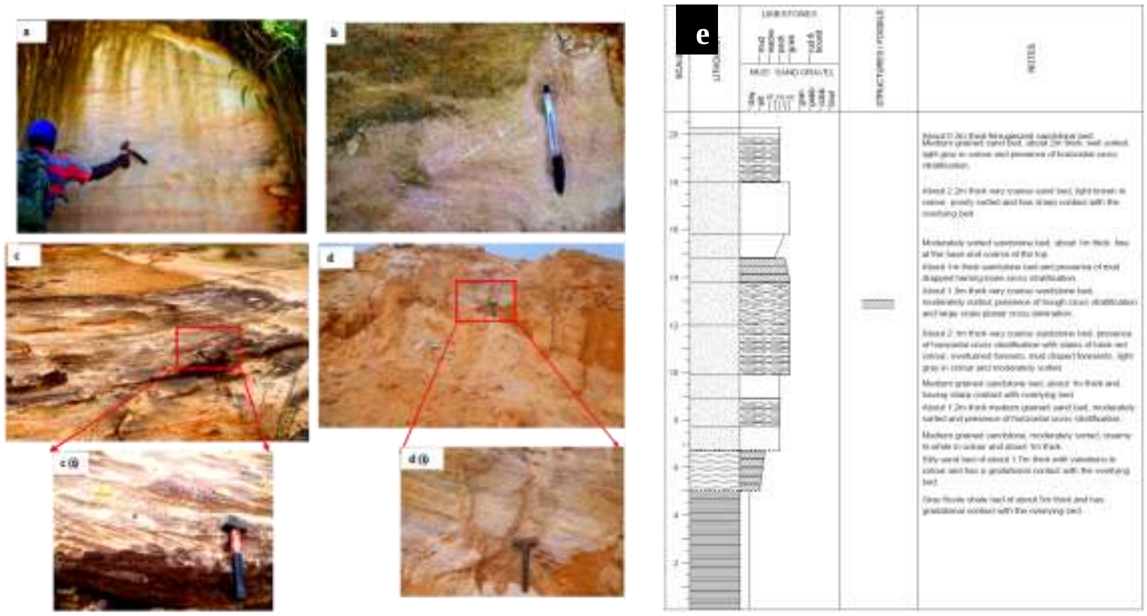


Fig. 6. Cross Stratified Sandstone lithofacies. (a) Trough structures at Kpoghrikpo (b) Mud draped herringbone cross bedding, (c) horizontal bedding at Ngodo (d) parallel lamination (e) Graphic sedimentary log of the outcrop in Akpuguru Edda. *Scale: Hammer with red and black hand (0.25m), Hammer made of iron all through (0.3m), Pen (0.06m).*

The presence of coarsening upward succession of the sandstone units and cross-bedding indicate active unidirectional currents which are typical in fluvial environments. The observed reactivation surfaces show tidal sand deposits through tidal-current reversals or the effects of storms in fluvial sediments through changes in river stage. These reactivation surfaces represent short-term changes in the flow conditions which caused modification to the shape of the bed-form. The mud drapes on cross bed surfaces reflect deposition from slack water during tidal current reversals.

Some of the fractures are filled with iron oxide cement. The presence of concretions is an indication of precipitation of minerals from solutions that permeate the sediments. These concretions form layers within the bed and can act as permeability barriers to fluid flow.

4.5. Horizontal laminated sandstone lithofacies (Slh)

This lithofacies comprises friable, moderate to well sorted, very fine to medium grained sandstone units which are white to light yellow in colour (Fig. 6c & d). In some locations, there are mud beds of about 0.1m thick separating sandstone units. This lithofacies was studied at sections UI/02/Kpoghirikpo, UI/03/ Enohia Itim Ukwu, UI/04/Kpoghirikpo, UI/06/ Akpuguru Edda, UI/12Ndibe, UI/14/Ozizza, UI/16/Orra Ozizza and UI/20/Mac-Gregor. Horizontal laminated sandstone lithofacies were formed largely by deposition from suspension or low density turbidity currents [4-5]. Such lithofacies occurs in a wide range of fine-grained lithologies and depicts distal shelf and lower fan settings [4-5].

4.6. Heterolithic lithofacies (Sfh)

The heterolithic lithofacies comprises of alternation of thin beds of different lithologies, i.e. interbedded thinner beds of dirty yellow and pinkish sand-dominant and mudrocks which is light pink in colour. Each unit thickness varies from 0.10 to 0.50 m. In location UI/01/Kpoghirikpo, the heterolithic beds are interbedded with thin bands of ironstone with a thickness of about 1.7m. They are deposited as a result of tidal influence in tide-dominated deltas and estuaries.

4.7. Pebbly/conglomeritic sandstone lithofacies (Sfp)

The Pebbly Sandstone Lithofacies was noted at the upper parts of the Lower sandstone Member as whitish in colour and poorly cemented (Fig. 7).

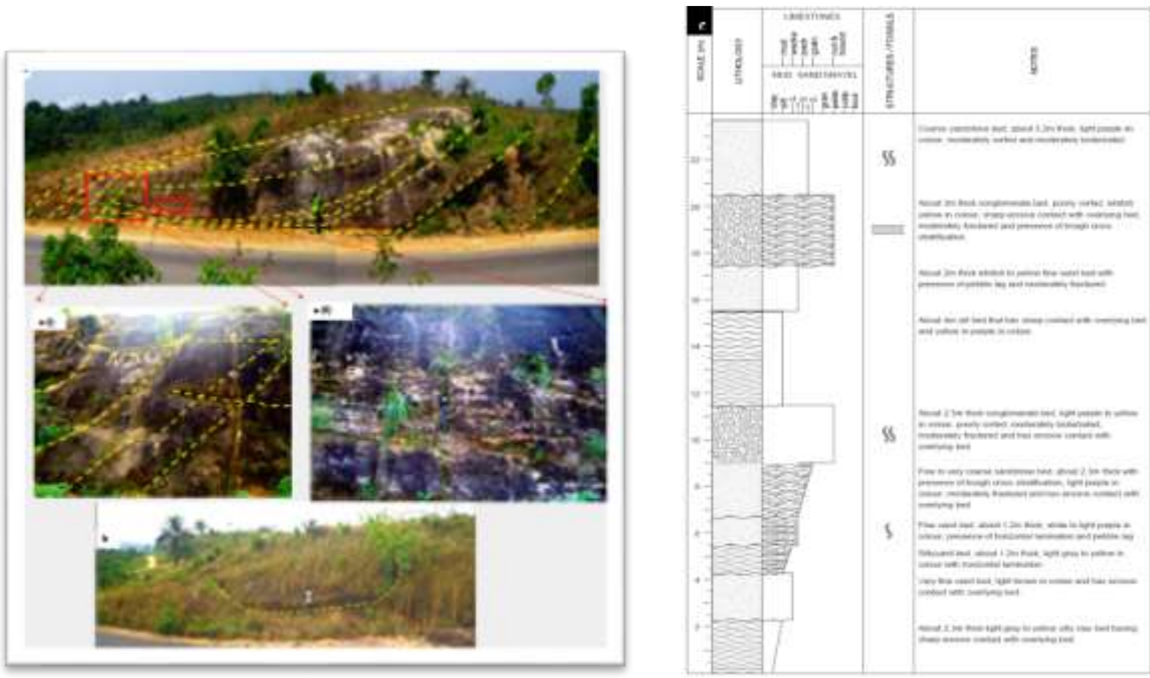


Fig. 7. Channels (a) Fluvial channel filled with coarse/pebbly sand, cutting down into finer sandstones and mudrocks. The cliff is cut perpendicular to the long axis of the channel along the Abakaliki-Afikpo-Amasiri expressway. (a(i)) Close up of a section of the outcrop. (a(ii)) Horizontal bed. (b) Channel noted in roadcut exposure at location UI/15 Ozizza roadcut exposure, Ozizza (c) Graphic sedimentary log of the outcrop in Ozizza roadcut exposure. *Scale: Man (1.68m), Hammer (0.3m)*

The bedding contacts are usually marked with sharp erosive or scoured surfaces. The road cut exposure opposite Mac-Gregor Afikpo (UI/23) exhibits alternation of medium grained sandstone and pebbly bed of about five cycles and having a total thickness of about 2.7m. This lithofacies was also observed as channels (Fig. 7a) with sharp erosive bases. They are concave-up in cross-section with upward changes in grain size that is usually fining-up. These channels were seen in road cut exposures near Mac-Gregor slope and Ozizza road (UI/15 and UI/24). This lithofacies was also seen at sections UI/16/Orra Ozizza, UI/17/Ozizza, UI/18/Ngodo, UI/19/Ngodo, UI/20/Mac-Gregor, UI/21/Why worry spring and UI/23/Mac-Gregor in the Afikpo area. The units with interbedded pebbly and less well-sorted components suggest grain flow surges and high density turbidity currents [11]. At location UI/18 (Ngodo), the pebbles which form clasts that float as sandy matrix and show imbrications suggests hyper concentrated sheet floods, especially where the units are tabular and interbedded with finer sediments. The coarser grained sand layers are interpreted as lags resulting from reworking and winnowing of the sands.

Permeability (K) results show that the majority of the samples are of good (50-250mD) to very good (250-1000mD) permeability. Also, two samples each show moderate (15-50mD) to excellent (>1000mD) permeability respectively (Table 3a and b). Similarly, the graphically estimated porosity values indicate that most of the sandstones show poor to fair (7.0 - 15%) reservoir quality while only one location shows good porosity value of 15.7% (Table 4a and b). This poor to fair porosity may be associated with the angularity and heterogeneity of the sand grains.

Table 3a. Estimating permeability based on grain size

Locations	Sample point	Median (50th)	Sorting (Σø)	Granular parameter (mm^2)	Permeability (Md)
UI/03	Base	0.31	0.56	0.15	35.07
	Middle	0.74	0.24	0.54	303.90
UI/06	Base	0.66	0.37	0.41	203.89
	Middle	0.84	0.28	0.58	371.60
UI/07	Top	0.42	0.58	0.20	62.71
UI/08	Base	1.47	0.49	0.77	864.32
	Top	0.42	0.53	0.21	66.95
UI/13	Base	1.37	0.17	1.10	1141.66
	Middle	0.92	0.31	0.61	428.57
UI/16	Middle	0.85	0.14	0.71	457.09
UI/17	Base	0.64	0.33	0.42	202.04
UI/18	Base	0.38	0.66	0.16	46.23
	Middle	2.50	0.11	2.16	4112.56
UI/19	Middle	0.72	0.34	0.46	252.37
	Top	1.15	0.10	1.01	881.69
UI/20	Base	0.68	0.30	0.46	237.22
	Middle	0.69	0.32	0.45	237.93

Table 3b. Terms applied to permeability values

Evaluation	K-value (md)	Number of locations
Poor to fair	<1.0 – 15	-
Moderate	15 – 50	2
Good	50 – 250	6
Very good	250 – 1000	7
Excellent	>1000	2

Table 4a. Estimating porosity using mean and permeability values

Locations	Sample point	Mean (Mz)	Permeability (Md)	Porosity (%)
UI/03	Base	Medium sand	35.07	7.00
	Middle	Coarse sand	303.90	9.00
UI/06	Base	Coarse sand	203.89	8.10
	Middle	Coarse sand	371.60	9.30
UI/07	Top	Medium sand	62.71	9.00
UI/08	Base	Coarse sand	864.32	11.60
	Top	Medium sand	66.95	9.10
UI/13	Base	Coarse sand	1141.66	14.10
	Middle	Coarse sand	428.57	9.50
UI/16	Middle	Coarse sand	457.09	9.60
UI/17	Base	Coarse sand	202.04	8.00
UI/18	Base	Medium sand	46.23	8.00
	Middle	Coarse sand	4112.56	15.70
UI/19	Middle	Coarse sand	252.37	8.30
	Top	Coarse sand	881.69	11.50
UI/20	Base	Coarse sand	237.22	8.20
	Middle	Coarse sand	237.93	8.20

Table 4b. Terms applied to porosity values

Φ/Percent	Qualitative evaluation	Number of locations
0 – 5	Negligible	-
5 – 10	Poor	13
10 – 15	Fair	3
15 – 20	Good	1
20+	Very good	-

5. Conclusions

The examination and description of outcrop sections in the Afikpo area resulted in the delineation of seven distinct lithofacies. Based on the observed sedimentary structures (Physical: tabular and trough cross-bedding, flat bedding plus parting lineation, low-angle cross-beds (lateral accretion surfaces), channels and scoured surfaces, ripples and cross-lamination; Chemical: ferruginization, laterization, etc,; Biogenic: burrows), the sediments are fluvial dominated high energy shallow marine system. The sandstones show good (50-250mD) to very good (250-1000mD) permeability with few showing moderate (15-50mD) to excellent (>1000mD) permeability values. Similarly, the porosity values indicate that most of the sandstones show poor to fair (7.0 - 15%) reservoir quality. Combining results derived from the various analyses, sandstones within the study area belongs to the pre-Santonian Eze-Aku Formation, which is part of the Campanian-Maastrichtian Nkporo Formation and possess the potential to house gas hydrocarbon.

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To whom correspondence should be addressed: Miss Ijeoma M. Umeadi, Department of Geology, University of Nigeria, Nsukka, Nigeria, E-mail umeadi.ijeoma@gmail.com