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Stratigraphic Architecture of the Oweli Sandstone, South-Eastern Nigeria

Chiamaka Janefrances Uduezue
Ph.D. Research Student, Department of Geology,
Chukwuemeka Odumegwu Ojukwu University, Nigeria
Shirley Onyinye Odunze-Akasiugwu
Senior Lecturer, Department of Geology, Chukwuemeka Odumegwu Ojukwu University, Nigeria
Gordian Chuks Obi
Professor, Department of Geology, Chukwuemeka Odumegwu Ojukwu University, Nigeria

Abstract:
Stratigraphic analysis and correlation of thirteen measured outcrop sections confirms that the Nkporo Group includes a major sandstone interval (the Oweli Sandstone) that is encased by two distinct mud rock intervals: a basal fossiliferous shale and limestone that correlates with the shallow shelf Nkporo Formation and a coal-bearing mud rock that correlates with the coastal plain Enugu Shale. Lithofacies and environmental analysis reveals that the Oweli Sandstone contains two depositional facies: a basal, fine-medium grained delta front facies and an overlying medium-coarse-grained, tidally-influenced fluvial channel facies. Down-dip sequence stratigraphic correlation of the stratigraphic units and depositional environments reveals a gradational transition from the underlying shallow shelf facies of the Nkporo Formation to the distal delta front facies of the Oweli Sandstone. The contact is defined by the 76Ma maximum flooding surface that records the onset of the Oweli clastic influx into the Campanian Sea. The Oweli delta front facies is truncated at the top by the 75 Ma unconformity surfaces over which the tidally-influenced fluvial channel facies of the sand body accumulated. The contact between the tidally-influenced fluvial facies and the overlying coal-bearing mud rocks of the Enugu Shale is sharp and represented by a transgressive surface of erosion (TSE). Analysis of trends in thickness and facies changes reveals that the Oweli Sandstone exhibits a general proximal-fluviatile and distal-marine character. These new findings should serve as useful information toward the better understanding of the stratigraphic architecture of the Nkporo Group in south-eastern Nigeria.

Keywords: *Nkporo group, oweli sandstone, paleo-environment, stratigraphic relations, age*

1. Introduction

1.1. Background to Study

The post-Santonian Nkporo Group of south-eastern Nigeria includes the Nkporo Shale, the Oweli/Afikpo Sandstone and the Enugu Shale (Reyment 1965; Obi et al. 2001; Onuigbo and Okoro 2014). The exact stratigraphic position and age of the Oweli Sandstone within the Nkporo Group, has been a matter of controversy. Grove (1951), Simpson (1952), and Reyment and Barber (1956) previously called the sand body “Awgu Sandstone”. Reyment (1965) first described the Oweli sand body as “the sedimentary rock intervening between the deformed Coniacian-Santonian Awgu Formation and the gently-dipping Campanian-Maastrichtian Enugu Shale in the Awgu area of Anambra basin”. Obi (2000) and Obi et al. (2001) recognized the Oweli Sandstone as intervening between the Nkporo Shale and the Enugu Shale. Others (e.g., Akande et. al. 2011; Odumoso et al. 2013; Nwajide 2013; Onuigbo and Okoro 2014) described the sandstone as being laterally equivalent to the Nkporo Shale and Enugu Shale.

Reyment (1965) assigned Campanian-Maastrichtian age to the Oweli Sandstone and this remained widely adopted until recently when mix-ups in the age showed up in the print media. Obi (2000), Obi et al. (2001) and Nwajide (2013) proposed Campanian age for the sand body, while Tavershima (2011) quoted Maastrichtian age. This paper aims at resolving these controversies especially at this time when the Nigerian Stratigraphic Commission is reviewing the stratigraphic framework for Nigeria.

1.2.Study Area and Accessibility

This paper is based on detailed outcrop descriptions carried out along the scarp slope of the Enugu Cuesta in the Ihe-Awgu axis of south-eastern Nigeria (Fig. 1). The study focused on the region for the following reasons: (i) The angular unconformity that separates the deformed pre-Santonian succession from the overlying relatively un-deformed post-Santonian succession (Anambra Basin-fill) outcrops in the region (Nwajide and Reijers 1996; Obi 2000; Obi and Okogbue 2004); (ii) The scarp face of the Enugu Cuesta (Obi et al. 2001) in this region presents readily accessible exposures that contain the complete stratigraphic profile of the Nkporo Group; (iii) In this region also, the Enugu-Port Harcourt expressway closely tracks the scarp-foot of the Cuesta and enhances easy access to the outcrops (Fig. 1).

2. Literature Review

2.1.Regional Stratigraphic Setting

The evolution of the stratigraphic nomenclature for south-eastern Nigeria has been summarized by Obi (2000; Table 1). Tattam (1944) first recognized seven lithostratigraphic units in the region namely, the Cross River and Benue Shale, the Awgu Sandstone and Shale, the Nkporo Shale, Lower Coal Measure, False-bedded Sandstone, the Upper Coal Measure, and the Imo Clay Shale (Table 1). Later modification by Simpson (1954) led to the subdivision of the Cross River and Benue Shale into the Asu River Series, and the Ezeaku Shale; the Awgu Sandstone and Shale became known as the Awgu-Ndeaboh Shale, while the Nkporo Shale was renamed the Asata-Nkporo Shale (Table 1). A major modification in the nomenclature was introduced by Reyment (1965). In this scheme the Asu River Series was changed to Asu River Group, and dated Albian; the Ezeaku Shale was re-named Ezeaku Group and dated Turonian; and the Awgu-Ndeaboh Shale became known as Awgu Group (including the Agbani Sandstone) and dated Coniacian.

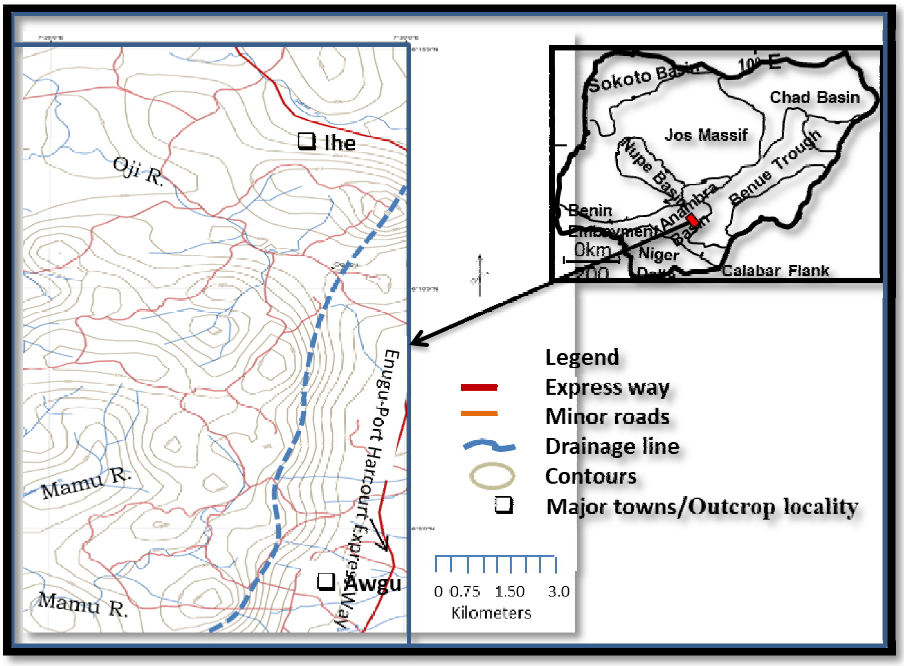

Figure1: Topographic Map of the Ihe-Awgu Area of South-Eastern Nigeria, The Crest Line of the Enugu Cuesta Is Approximated by the Dotted Line (Modified after the NGSA 2017)

Age	Tattam (1944)	Simpson (1954)	Reyment (1965)
Paleocene	Imo Clay Shale	Imo Formation	Imo Formation
Maastrichtian	Upper Coal Measure	Upper Coal Measure	Nsukka Formation
	False-Bedded Sandstone	False Bedded Sandstone	Ajali Sandstone
	Lower Coal Measure	Lower Coal Measure	Mamu Formation
Campanian	Nkporo Shales	Asata-Nkporo Shales	Nkporo Group (Nkporo Shale/Oweli Sandstone/Enugu Sale
Coniacian	Awgu Sandstone and Shale	Awgu-Ndiaboh Shales	Awgu Group (Awgu Formation/Agbani Sandstone
Turonian	Cross River and Benue Shales	Ezeaku Shale	Ezeaku Group (Ezeaku Formation/Amaseri Sandstone
Cenomanian			
Albian		Asu River Series	Asu River Group

Table 1: Summary of the Evolution of Stratigraphic Nomenclature in SE Nigeria (Obi, 2000)

Similarly, the Asata-Nkporo Shale was renamed Nkporo Group and dated Campanian-Maastrichtian**,** with the Nkporo Shale, Oweli/Afikpo Sandstone and Enugu Shale as members (Table 1).

In the Tattam's (1944) and Simpson's (1954) nomenclatures (Table 1), the Maastrichtian was represented by the Lower Coal Measures, False-bedded Sandstone and the Upper Coal Measures, until Reyment's (1965) modifications introduced the names Mamu Formation, Ajali Sandstone and Nsukka Formation (Maastrichtian-Danian), for the Lower Coal Measures, False-bedded Sandstone and the Upper Coal Measures respectively.

The Campanian-Maastrichtian sedimentation in southeastern Nigeria was terminated by the global Danian Extinction event that gave way to the accumulation of marine shale and sandstones of the Imo Formation (Paleocene) and the Eocene Ameki Formation (Reyment 1965).

3. Data and Method

Field description of outcrops was performed along three traverse routes (Fig. 2). A total of thirteen exposures were described and backed-up with logs of four Geological Survey of Nigeria boreholes located at Ihe, Ogugu and Awgu (Fig. 2). Detailed attention was paid to lateral and vertical distribution of lithofacies types, contact relations, textural characteristics, spatial distribution of sedimentary structure, as well as structural relationships of the various lithologic units.

Lithologic contacts were inferred based on abrupt change in lithology and soil color, change in slope and change in vegetation. The lateral extent of the key stratigraphic surfaces that bound genetically related strata were

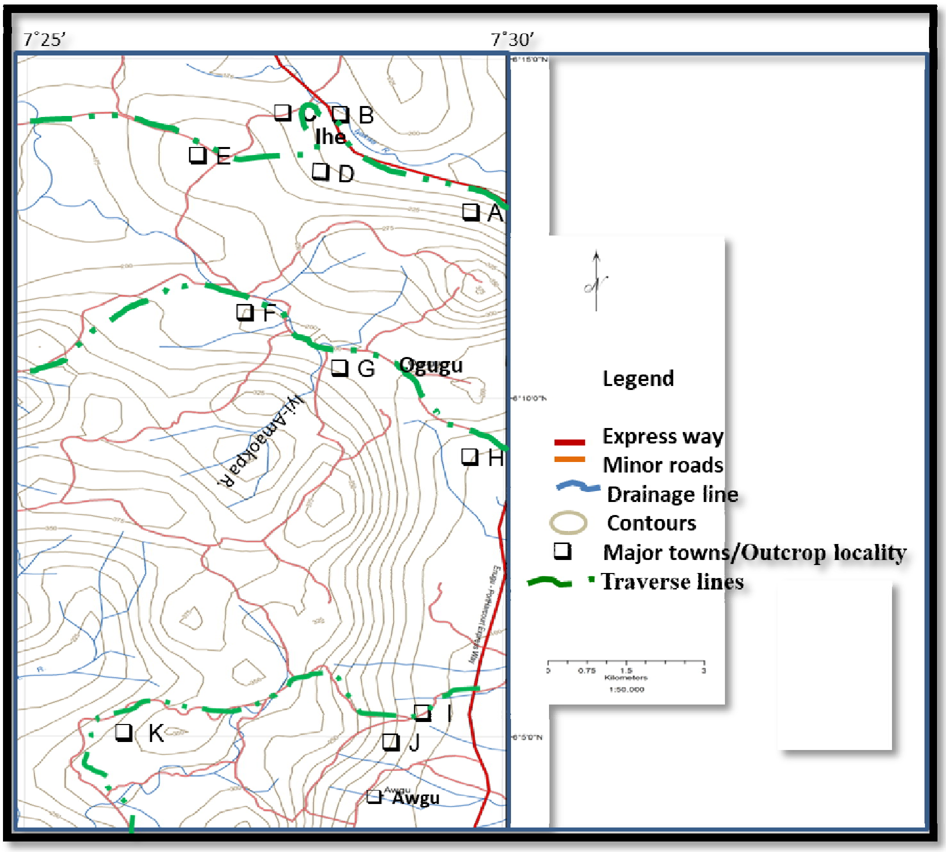

Figure 2: The Study Area Showing Down-Dip Traverse Routes (Lines A-E, H-F, & I-K), Key Outcrop Localities are Numbered (A=Ogbaku, B=Agbaogugu Junction, C=Ihe Road, D= Umuogba, E=Ihe, F=Amoli, G-H=Ogugu, I=Awgu Road, J=Awgu, K=Awgu-Nmaku Road)

Delineated across the study area. The method of facies analysis as described by Anderton (1985) was followed to provide basis for environmental interpretation. Down-dip sequence stratigraphic correlation of stratigraphic units was adopted to determine the lateral extent/distribution of the facies and to establish the position of the Oweli Sandstone within the regional chronostratigraphic framework.

4. Results

4.1.Lithologic Units and Facies Associations

Figure 3 shows the correlation of key outcrops described in the study area. Four major lithologic units are identified. In stratigraphic order these include (i) bioturbated conglomerates (ii) fossiliferous mud rock (iii) cross-bedded sandstone and (iv) coaly heteroliths.

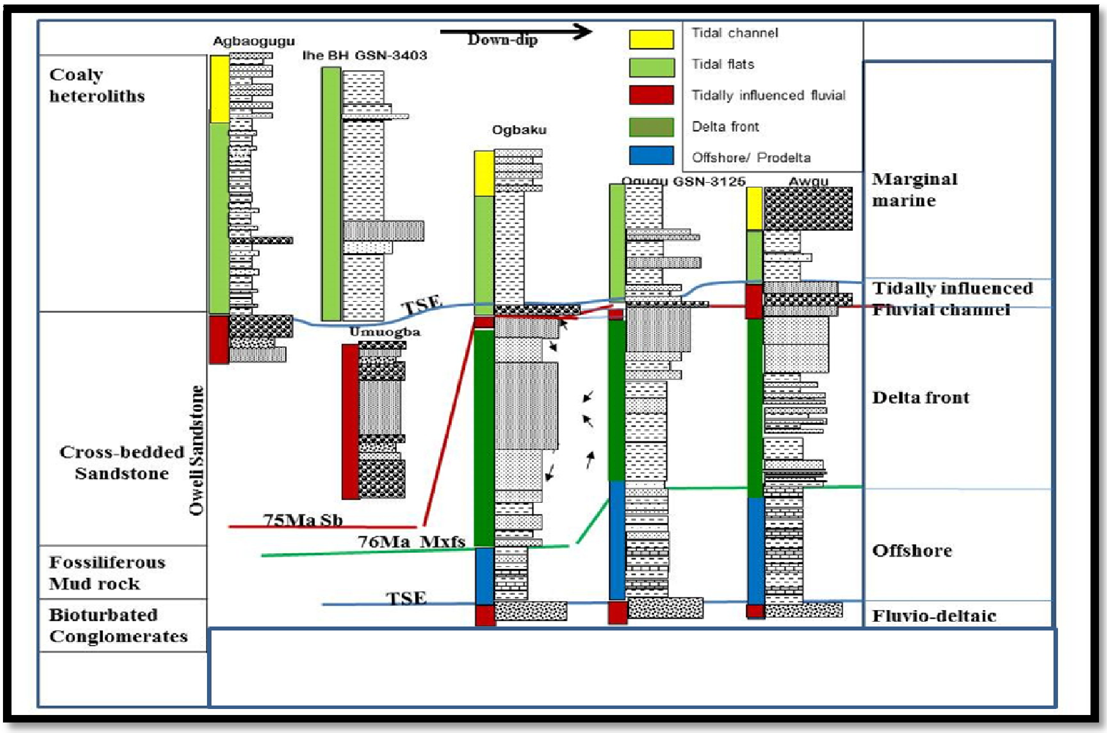

Figure 3:' Down-Dip Correlation of Key Outcrops in the Ihe-Awgu Area, Note the Wedge-Shaped Geometry of the Owelli Sandstone, the Fluviatile Facies is Better Developed up-Dip, While down-Dip Shows Apparent Improvement in the Marine Facies Development

4.1.1. Unit I-Bioturbated Conglomerates

This unit is represented by strongly ferruginized, pebbly-coarse grained, bioturbated sandstone characterized by the Skolithos and Ophiomorpha (Fig. 4).

The unit was encountered only at Ogbaku and Awgu (Fig. 2), where attitude measurements reveal strata dip values in excess of 20° to the southwest, thus indicating structural deformation. The presence of Skolithos and Ophiomorpha (the Glossifungites ichnofacies association) in this coarse-grained sandstone facies aids in its identification as a coastal plain deposit (Pemberton et al. 1992). Obi (2000) had earlier interpreted the rocks to be of fluvio-deltaic origin based on the gross sedimentary characteristics.

4.1.2. Unit II-Fossiliferous Mud Rock

The outcrop belt of Unit II extends from south of Awgu, to Ogugu and Ogbaku (Fig. 2), where the unit unconformably overlies Unit I. Northwards the unit hardly outcrops on the surface. This dominantly muddy unit is divisible into two facies associations (i) a basal shale-limestone facies association composed of black carbonaceous shale inter-bedded with grey to milky-white, sharp-based micritic

limestone (Fig. 5) containing abundant marine bivalve shells (Obi 2000); and (ii) an overlying mud-rich heterolithic facies association composed of inter-laminated thin lenses of fossiliferous, fine grained sandstone,
siltstone and mudstone. The association of limestone, black shale and mud-rich heteroliths containing marine fossils, strongly indicates shallow shelf origin for Unit II (Friedman et al. 1992).

Figure 4 Sections of the Bioturbated Conglomerates at Ogbaku Showing (A-) Skolithos and (B) Ophiomorpha

Figure 5: Fossiliferous Shale (Sh) and Limestone (Ls) at Iyi-Amaokpa River, Ogugu

4.1.3. Unit III-Cross-Bedded Sandstone

This unit maintains a transitional contact with the underlying shallow marine heteroliths and consists of three facies associations: (i) a basal, sand-rich heterolith association characterized by thickening and coarsening upward motif, wave ripple-lamination and containing Teichichnus (ii), a sharp-based, fine-medium grained, micaceous and fossiliferous hummocky-cross stratified sandstone facies association (Fig. 6), and (iii) medium-coarse grained sandstone facies association containing bi-directional (NE-SW), planar tabular cross-beds, reactivation surfaces, gutter casts, and mud drapes. Ophiomorpha, and Paleophycus (Fig. 7) are commonly associated with facies associations (ii) and (iii).

Based on the stratigraphic position (Unit III overlies shallow shelf mudstone of Unit II), the overall thickening/coarsening upward motif and the presence of the Skolithos ichnofacies, unit III is recognized as a fluvio-deltaic deposit. Facies associations (i) & (ii)) containing wave-generated sedimentary structures, bivalves and Teichichnus, represent the delta front, while facies association (iii) containing tide-generated structures associated with the Ophiomorpha, Paleophycus and the Skolithos, is interpreted as delta plain deposit, based on the deltaic model as described by Coleman and Prior (1982), Bhattacharya and Walker (1992) and Friedman et al. 1992; Fig. 8). The parallel-laminated sand-rich heterolith and the hummocky cross-stratified, very-fine grained sandstone which succeeded the muddy shelf facies probably record the onset of terrigenous influx into the quiet shelf environment (Walker and Plint 1992). The change from parallel laminated/hummocky cross-stratified facies, to a succession of wave-ripple laminated, fine-medium grained , micaceous and fossiliferous

Figure 6: Details of Unit Iii at Awgu the Researcher Points at the Sharp Contact Between the Basal Part of Unit Iii (Facies Association I) and the Overlying Hummocky-Cross Stratified Sandstone (Facies Association Ii)

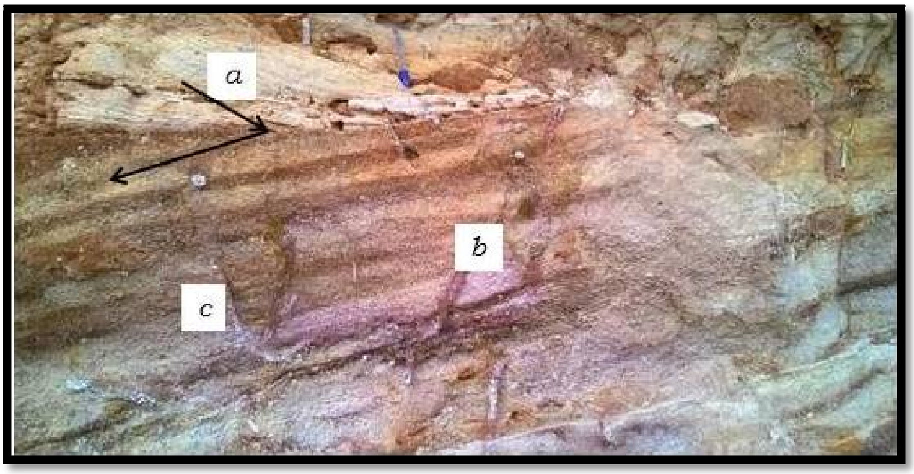

Figure 7: A Section of the Cross-Bedded Sandstone Facies Association at Ogbaku Showing Bi-Directional Cross Bed (A), Ophiomorpha Verticalis (B) and Paleophycus

Sandstone and siltstone, containing Teichichnus, Skolithos and Ophiomorpha is consistent with the distal-proximal delta front transition (McCubbin 1982). Facies association (iii) represents flood-generated sediment influx probably from a river-distributary mouth. Ophiomorpha burrows are known to occur mainly in open ocean beaches of barrier island/spit complex, and tidal channel bars (Coleman and Prior 1982; DeWindt 1974; Howard et al. 1973). The Ophiomorpha observed in this facies, therefore, reinforces its identification as a tidal channel deposit. The superposition of tidal channel deposit on delta front facies reflects a regressive depositional system**.**

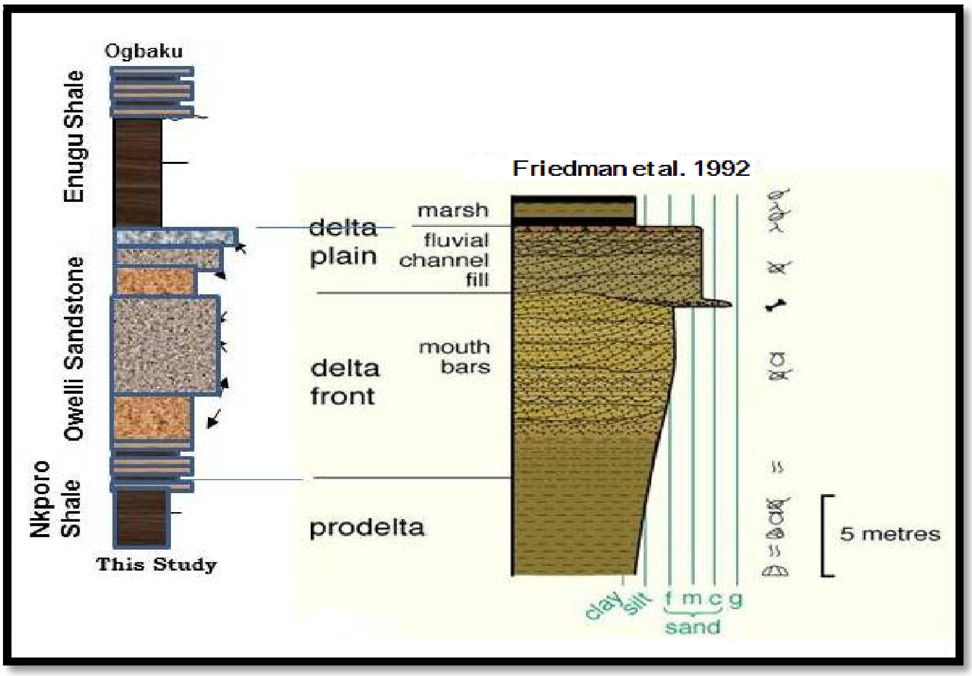

Figure 8: The Owelli Sandstone Interpreted on the Deltaic Model of Flint and Sanders (1992). Note the Close Match among the Sub-Environments

4.1.4. Unit IV-Coaly Heteroliths

This unit is separated from the tidal channel deposit at the top of unit III, by a thin lateritic crust. Two facies associations, Mud-rich heteroliths and Sand-rich heteroliths are identified in the unit.

Mud-rich heteroliths are composed of gray-black carbonaceous, sideritic/gypsiferous shale and thin units of sharp-based, wave-ripple, laminated/lenticular bedded siltstone. This interval locally contains thin coal seams.

Sand-rich heteroliths are characterized by wave-ripple lamination and lenticular bedding, as well as planar-tabular cross bed and tide-generated sedimentary structures including herringbone structures, mud drapes, flaser bedding, and reactivation surfaces. Leaf imprints occur in places. The contact with the underlying mud-rich heteroliths is strongly bioturbated and dominated by Arenicolites, Thalassinoides and Planolites.

Based on the fact that Unit IV succeeds tidal channel facies, the dominance of mudstone and sand-rich heteroliths and association with the sedimentary characteristics outlined above, these rocks are recognized as low-energy marginal

marine deposits. The basal mud-rich heteroliths is interpreted on the model of Dalrymple (1992) to represent the tidal flat facies, while the overlying sand-rich heteroliths represents the tidal channel facies. The overall coarsening-upward trend of Unit IV is consistent with a regressive shelf setting (Dalrymple (1992).
The gross sedimentary characteristics of the four lithologic units are summarized in Table 2.

Unit	Characteristics
IV	Thick interval of rhythmically inter-bedded with siltstones/very fine-grained sandstones and mudstone; includes coal seams at the upper horizons.
III	Fine-medium grained sandstones that is prominently cross-bedded, exhibits wave-generated structures at the base, and tide/current-generated sedimentary structures toward the top
II	Micaceous black shale, sharp-based shelly limestone and fossiliferous heteroliths, rests unconformably upon Unit I.
I	Bioturbated pebbly-coarse grained sandstone, strata dip> 20 degrees

Table 2: Summary of the Sedimentary Characteristics of the Lithologic Units in the Ihe-Awgu Area

4.2. Stratigraphic Correlation

To establish the stratigraphic position of the Oweli Sandstone in time and space, the succession established in this study was correlated to the existing stratigraphic framework for the Anambra basins as provided by Nwajide (2005) and Odunze and Obi (2013; Figure 9). At the base of the succession is the tilted unit I over which the shallow shelf facies of Unit II rests unconformably. The later maintains a gradational contact with the overlying fluvio-deltaic sandstone of Unit III which in turn is sharply overlain by the coaly Unit IV.

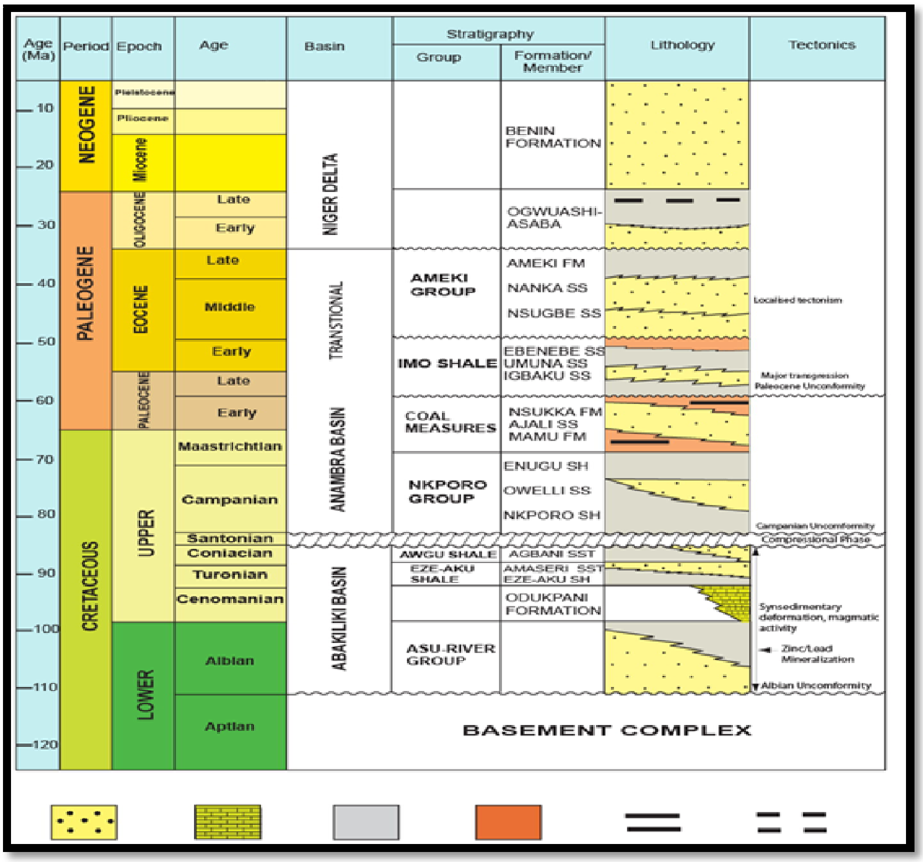

Figure 9: Stratigraphic Succession in South-Eastern Nigeria (Nwajide 2005)

The Campanian-Maastrichtian Nkporo Group in the Anambra basin is known to overlie the Coniacian-Santonian Awgu Sandstone in the study area, with an angular unconformity (Petters 1978; Obi 2000; Nwajide 2013). In addition to the Oweli Sandstone, Nkporo Group is generally accepted to include two muddy members: (i) the marinel Nkporo Shale composed of dark grey, shale and heteroliths and (ii) the coal-bearing Enugu Shale (Agagu et al.; Obi 2000; Odunze and Obi 2013).

The high average dip value of Unit I facilitates its identification as part of the deformed pre-Campanian succession in this region. The stratigraphy and gross sedimentary characteristics of Units II, III and IV aid their easy identification as components of the Nkporo Group. The dominantly sandy Unit III which is encased by the muddy units II and IV correlates with the Oweli Sandstone, while Units II and IV represent the Nkporo Shale, and the Enugu Shale respectively.

5. Discussion

5.1. Contact Relations of the Oweli Sandstone

The present study has shown that the Nkporo Shale grades upward from the mainly black micaceous and fossiliferous marine shale and limestone into micaceous and fossiliferous mud-rich heteroliths. The contact between the mud-rich heteroliths and the overlying sand-rich distal delta front facies is here regarded as the base of the Oweli Sandstone in this region. The top of the Oweli Sandstone is marked by a sharp transition from channelized, medium-coarse grained, tidally-influenced fluvial channel sandstone, to mud-rich gypsiferous and coaly heterolithic facies. The coaly heterolithic unit which directly rests on a transgressive surface of erosion (TSE) is here interpreted to represent the basal beds of the Enugu Shale.

5.2. Sand Body Geometry

Table 3 summarizes the basin-ward trend in the thicknesses of the Oweli Sandstone in the study area. The Cumulative thickness of the sand body varies from over 40m in the up-dip area of Umuogba where it is dominated by medium-coarse grained tidally-influenced fluvial channel sandstone, to about 30m in the down-dip area of Awgu. South of Awgu the Oweli Sandstone is dominated by fine grained distal delta front sandstone and heteroliths that inter-finger with shallow shelf mudstone (Obi, 2000; Figure 3). Figure 3 illustrates the
apparent wedge-shaped geometry.

Locality	Umuogba	Ogbaku	Ogugu	Awgu
Delta plain	40	32.5	12	10
Delta front	-	10	17	20
Total	›40	42.5	39	30

Table 3: Proximal-Distal Facies Distribution within the Oweli Sand Body in the Umuogba Leru Axis. Note the Proximal Fluviatile -Distal Marine Character of the Facies, the Wedge-Shaped Geometry is indicated by the Basinward Trend in the Total Thickness of the Sand (Figure 3)

5.3. Stratigraphic Position and Age

Results of ammonite biostratigraphic analysis (Zaborski 1983) and sequence stratigraphic analysis (Obi 2000; Obi and Okogbue 2004; Odunze and Obi 2013) provide useful insights into the stratigraphic position and age of the Oweli Sandstone. Zaborski (1983) established that the base of the Group is not older than 78Ma (Mid-Campanian). Obi (2000) established 77.5Ma (Mid-Campanian) age for the type-one unconformity separating the Nkporo Group from the Obi and Okogbue, (2004) and Odunze and Obi (2013) located the 75Ma sequence boundary toward the top of the Oweli sand body. In the present study, the 75Ma surface is identified where the coarse-grained tidally-influenced fluvial channel deposit overlies coarsening-upward fine-medium grained delta front sandstone (Figure 3). The fluvial channel deposit is truncated above by a transgressive surface of erosion (TSE) that defines the base of the Enugu Shale. This implies that the Oweli Sandstone ranges in age from 76Ma to slightly less than 75Ma (Upper Campanian; Table 4).

Formation	Base	Top	Age
Enugu Shale	< 75 Ma	73.5Ma	Upper Campanian
Oweli Sandstone	76Ma	< 75Ma	
Nkporo Shale	77.5Ma	76Ma	

Table 4: Chronostratigraphic Relations of the Oweli Sandstone

6. Summary and Conclusion

This study has shown that the Oweli Sandstone is essentially a coarsening-upward, very-fine to coarse grained, fluvio-deltaic sandstone that accumulated in environments ranging from delta front to tidally-influenced fluvial channels. The sand body exhibits a wedge-shaped geometry and a proximal fluviatile-distal marine character. The stratigraphic correlation presented in this study clearly shows that the components of the Nkporo Group are not lateral equivalents as is often erroneously held by some previous workers. The Oweli Sandstone is younger than the Nkporo Shale and older than the Enugu Shale. The contact between the Oweli Sandstone and the underlying Nkporo Shale is marked by a transition from the mainly black micaceous and fossiliferous marine shale and limestone, to micaceous and fossiliferous sand-rich, distal delta front heteroliths. This contact defines the 76.0Ma (upper Campanian) maximum flooding surface which, most probably, documented the onset of clastic influx into the Nkporo sea during the upper Campanian. The contact with the overlying Enugu Shale is sharp and defined by the transgressive surface of erosion immediately following the 75Ma (upper Campanian) sequence boundary. The study has also confirmed that the Oweli Sandstone is an upper Campanian deposit.

7. References

i. Agagu, O.K., Fayose, E.A., and Petters, S.W., 1985. Stratigraphy and sedimentation in the Senonian Anambra Basin of Eastern Nigeria. Journal of Mining and Geology Volume 22, pp. 25-36.
ii. Akande, S. O., Ojo, O.J., Adekeye, O.A., Egenhoff, S.O., Obaje, N.U. and Erdtmann,

iii. B.D., 2011. Stratigraphic Evolution and Petroleum Potential of Middle Cretaceous Sediments in the Lower and Middle Benue Trough, Nigeria: Insights from New Source Rock Facies Evaluation. Petroleum Technology Development Journal (ISSN 1595-9104), Volume. 1, 1-34.

iv. Anderton, R. 1985. Clastic facies models and facies analysis in: sedimentology, Recent Development and Applied Aspects (eds. P.J. Brenchley and B.P.J Williams) Blackwell Scientific Publication, Oxford, pp. 31-47

v. Bhattacharya, J.P. and Walker, R.G., 1992. Deltas. In Walker, R.G. and James, N.P., (Eds) Facies Models: Response to sea level changes. Geol. Assoc Canada, Ontario. 157-177.

vi. Coleman, J.M., and Prior, D.B.K., 1982. Deltaic environments of deposition: In: P.A. Scholle and Spearing, D. (Eds) Sandstone depositional environment. AAPG Publication, Tulsa, 139-178.

vii. Dalyrimple, R.W., 1992. Tidal depositional systems, In Walker, R.G., and James, N.P. (eds.). Facies

viii. Models: Response to sea level changes: Geological Association of Canada, pp. 195-218.

ix. DeWindt, J.T., 1974. Callianassid Burrows as Indicators of Subsurface Beach Trend, Mississippi River Delta Plain. Journal Sedimentary Petrology, Volume 44, pp.1136-1139.

x. Friedman, G.M., Sanders, J.E., and Kopaska-Merkel, D.C., 1992. Principles of sedimentary deposits: Stratigraphy and sedimentology. Macmillan, New York, 686pp.

xi. Grovee, A.T., 1951. Land use and soil conservation. Geological Survey of Nigeria, Bulletin 21.

xii. Howard, J.D., and Frey, L.W., and Cooper, W.A., 1973. Characteristic physical and biogenic Sedimentary structures in Georgia Estuaries. AAPG Bulletin, Volume 57, pp. 1169-1184.

xiii. Klein, D.G., 1970. Depositional and dispersal dynamics of intertidal sand bars. Journal of Sedimentary Petrology, Volume 40, pp. 095-1127.

xiv. Kumar, N., 1973. Modern and ancient barrier sediments: New interpretation based on strata sequence inlet filling sands and on recognition of near shore storm deposits. New York academy of science annals, Volume 220, pp. 245-340

xv. McCubbin, D.G., 1982. Barrier-Island and Strand-Plain Facies, In: P.A. Scholle and D. Spearing (Eds) Sandstone Depositional Environments. AAPG Publication, Tulsa. pp. 247-279.

xvi. Nwajide, C.S., and Reijers, T. J. A., 1996. Geology of the Southern Anambra Basin. In: T. J. A. Reijers (ed.), 133-148. Selected chapters on Geology. SPDC Warri. 197p.

xvii. Nwajide, C.S., 2013. Geology of Nigeria's Sedimentary Basins. Css Press. 565p.

xviii. Obi, G.C., 2000. Depositional model for the Campanian-Maastrichtian Anambra Basin, Southern Nigeria. PhD Thesis, University of Nigeria, Nsukka, 286p.

xix. Obi, G.C., and Okogbue, C.O., 2004. Sedimentary response to tectonism in the Campanian-Maastrichtian Succession, Anambra Basin, Southeastern Nigerian. Journal of African Earth Sciences, Volume 38, pp. 99-108

xx. Odunze, O.S., and Obi, G.C., 2013. New Data on the Sedimentology and Sequence Stratigraphy of the Nkporo Group (Campano-Maastrichtian), Anambra Basin, Nigeria. Journal of Paleogeography, Volume 2, pp. 192- 213.

xxi. Odumoso, S.E., Oloto, I.N., Omoboriowo, A.O., 2013. Sedimentological and Depositional Environment of the Mid Maastrichtian Ajali Sandstone, Anambra Basin, Southern Nigeria. International Journal of Sciences and Technology, Volume 3, No. 1, 26-33.

xxii. Onuigbo, E.N., and Okoro, A.U., 2014. Ichnology of the Enugu Formation: Implications for Campanian sea movements in South-eastern Nigeria. Asian Journal of Earth Sciences, Volume 7, pp. 40-50

xxiii. Pemberton, S. G. and Wightman D. M., (1992). Ichnological signature of a Brackish water deposit: An example from the lower Cretaceous Grand Rapids Formation, Cold Lake oil sands area, Alberta, in S. G. Pemberton, ed., Application of ichnology to petroleum exploration: SEPM Core Workshop No. 17, p. 199-223.

xxiv. Reyment, R.A. and Barber, W.M., 1956. Nigeria and Cameroons, In: Lexique Stratigraphique International, Volume 4, Afrique, pp. 35-59.

xxv. Reyment, R.A., 1965. Aspects of the Geology of Nigeria. Ibadan University Press, 145p.

xxvi. Simpson, A., 1954. The Nigerian Coalfield: The Geology of Parts of Onitsha, Owerri and Benue Provinces. Geological Survey. Nigeria Bulletin. No. 24.

xxvii. Simpson, A., 1955. Geology of the escarpment north of Enugu. Annual Report of the Geological Survey of Nigeria. pp. 9-14.

xxviii. Tattam, C.M., 1944. A review of Nigerian Stratigraphy. Report of the Geological Survey of Nigeria pp. 27-46.

xxix. Tavershima, N., 2011. Depositional framework and Cretaceous stratigraphy of the Gboko Area, Lower Benue Trough, of Nigeria. Journal of Mining and Geology, Volume 47, No. 2, pp. 147-167

xxx. Walker, R.G. and Plint, A.G. (1992). Wave- and storm-dominated shallow marine systems. In: Facies models: Response to Sea Level Change (eds. R.G. Walker & N.P. James), pp. 219-238. Geological Association of Canada. St. Johns, Newfoundland.

xxxi. Zaborski, P.M.,1983. Campano-Maastrichtian Ammonites, Correlation and Paleogeography in Nigeria. Journal of Africa Earth Sciences, Volume 1, pp. 59-63.