THE AMEKE ABAM-EBENEBE SAND RIDGE, SOUTHEASTERN NIGERIA: A FLUVIO-DELTAIC DEPOSIT

[1]Odunze-Akasiugwu, Onyinye Shirley and [2]Obi, Gordian Chuks
[1 2] Department of Geology, Chukwuemeka Odumegwu Ojukwu University- Nigeria.
[1] shirleynique@yahoo.com [2] gc.obi@coou.edu.ng

ABSTRACT

The Ameke Abam-Ebenebe sand ridge is the most prominent linear sand body within the present landscape of southeastern Nigeria. The ridge extends laterally for over 150km between the alluvial plains of the Cross River and the Niger River in southeastern Nigeria. It protrudes up to 600 meters above sea level in the vicinity of Umunze. Topographic analysis reveals that the morphology of the sand ridge is consistent with the definition of a cuesta. The sand body is sub-parallel to the Enugu Cuesta and to the present Nigerian Coastline. These geomorphological parameters provide the first indication of the influence of strong tidal currents in the formation of the sand ridge. Lithofacies and textural analyses reveal that the ridge is composed of fine to very coarse-grained/pebbly, moderately well-sorted sand associated with various types of current- and tide-generated sedimentary structures. Analysis of the grain-size distribution plots indicates that the sands accumulated in a fluvio-deltaic environment (a zone lying between the marine and sub aerial portion of the delta). Pebble form indices indicate that the sand ridge was constructed in a coastal environment, in a zone of interaction between wave and fluvial processes.

Key words: Sand ridge, cuesta, lithofacies, grain-size, fluvio-deltaic

1. INTRODUCTION

A close study of the present landscape of southeastern Nigeria (Fig.1) reveals a NW-SE trending sand ridge that rises from the alluvial plains of the Cross River at Etiti Ulo, and passes through Ameke Abam, Umuezike, Umunze and Ebenebe, to flatten out in the alluvial plains of the Niger River. The sand body has been variously named the Igbakwu/Ebenebe/Ugwuoba Sandstone (Simpson, 1954; Reyment, 1965; Ofomata, 1975, 1978) respectively (Fig. 1.). The topographic prominence is aligned sub-parallel to the adjacent Bende-Orlu-Awka highland, the Enugu Cuesta and to the present Nigerian coastline (Obi *et al.*, 2001).

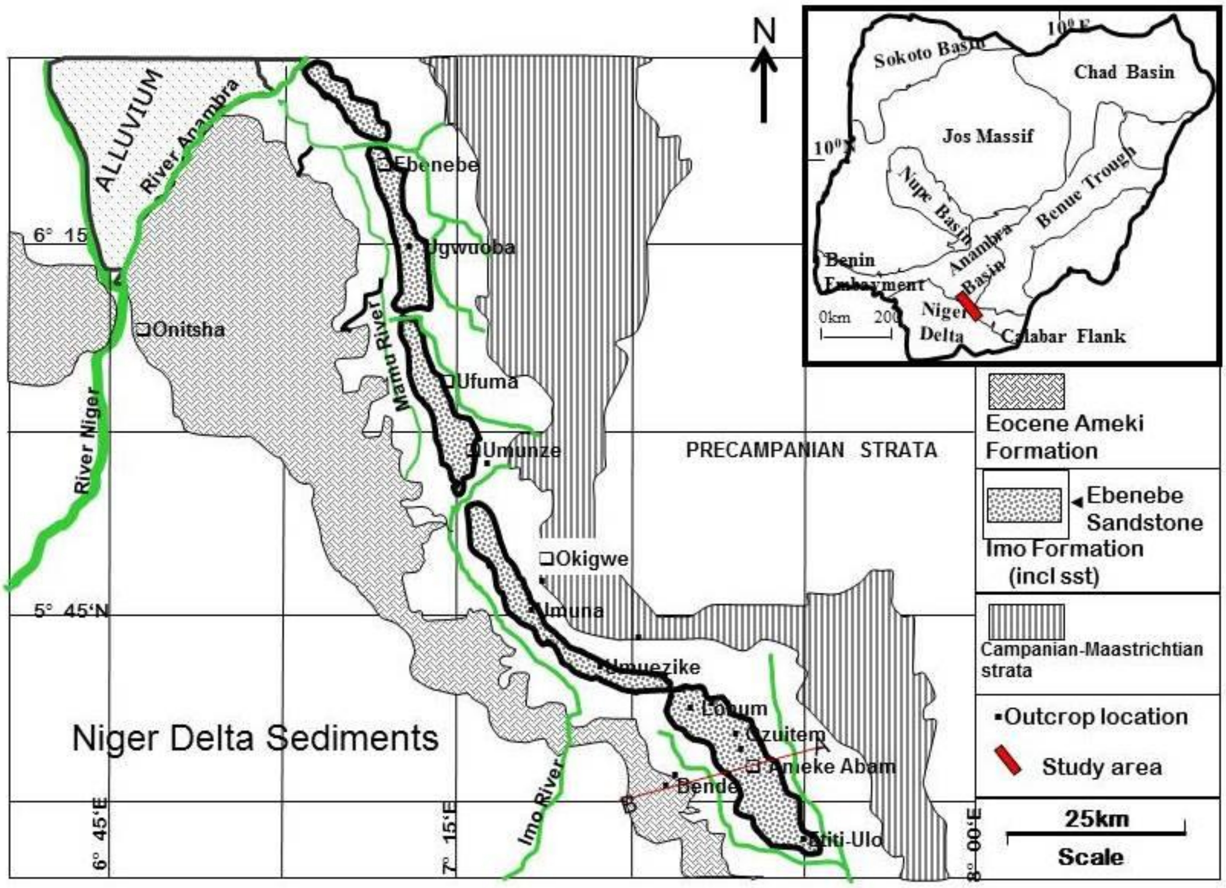

Fig. 1. Present landscape of southeastern Nigeria showing the outcrop belt, key outcrop locations and stratigraphic relations of the Ebenebe Sand ridge. B---------A is the line of geologic profile (Modified after Odunze and Obi, 2011)

The sand ridge which is currently being harvested for civil construction works, accounts for the gulley erosion that is devastating the region. Studies of similar sand deposits found in stratigraphic record of ancient seas show that, aside from being the main source of construction aggregates, many of these sand bodies are important hydrocarbon and groundwater reservoirs (Liu, *et al*., 1989). Previous efforts to explain the origin of sand ridges in southeastern Nigeria include the works of Simpson (1954), Ofomata (1975), Iloeje (1980), Obi *et al*., (2001). These researchers agree that uplift and subaerial erosion played a dominant role in the genesis of the ridge landscape in southeastern Nigeria (Obi *et al*., 2001). The present study integrated evidence from log-probability plot of grain-size distribution (as described by Visher, 1969), pebble form indices and facies characteristics, to infer the depositional processes responsible for the accumulation of the Ameke-Abam-Ebenebe Sand ridge. The result of this study is thus expected to throw more light into the sedimentary evolution of southeastern Nigeria sedimentary basin complex.

2. GEOLOGICAL SETTING

The study area is located within the southeastern Nigeria sedimentary basin, immediately to the north of the Niger Delta. The stratigraphic evolution of the region during the Campanian-Eocene period was controlled by episodic asymmetrical subsidence along the landward extension of the Atlantic Chain fracture associated with the initial opening of the Benue Trough (Ojoh, 1988; 1992; Obi, *et al*., 2001 and Obi and Okogbue, 2005). The stratigraphic succession includes seven depositional cycles of over 4000 m in composite thickness, comprising shallow marine to marginal marine Nkporo Group (Campanian-Maastrichtian), Mamu Formation and Ajali Sandstone (Maastrichtian), Nsukka Formation (Maastrichtian-Paleocene), Imo Formation (Paleocene), Ameki Formation (Eocene) and the Oligocene Ogwashi-Asaba Formation (Obi, 2000; Oboh-Ikuenobe *et al*., 2005; Table 1), These lithostratigraphic components are arranged in a manner in which younger members successively occur southward, thus reflecting a progressive southward migration of the Campanian-Eocene depo-centre (Murat, 1972; Odunze and Obi, 2007). The Imo Formation comprises blue-grey clays and black shale with bands of calcareous sandstones, marl and limestone, that encase a very fine grained-pebble sandy member (the focus of this study) and maintains a conformable relationship with the underlying Nsukka Formation (Oboh-Ikuenobe, et al., 2005). The sandstone member which is variously called Igbaku, Ebenebe, Ugwuoba and Umuna Sandstones in various localities (Reyment, 1965), is widely believed to mark the limit of the Paleocene shoreline.

Table 1. Correlation of Early Cretaceous-Tertiary strata in southeastern Nigeria (Modified after after Nwajide, 2013)

AGE		ABAKALIKI-ANAMBRA BASIN	AFIKPO BASIN	BASIN
30 my	Oligocene	Ogwashi-Asaba Formation	Ogwashi-Asaba Formation	NIGER DELTA
54.9 my	Eocene	Ameki/Nanka Formation/Nsugbe Sandstone	Ameki Formation	
65 my	Paleocene	Imo Formation	Imo Formation	
73 my	Maastrichtian	Nsukka Formation Ajali Sandstone Mamu Formation	Nsukka Formation Ajali Sandstone Mamu Formation	ANAMBRA
83 my	Campanian	Nkporo/Oweli Formation/Enugu Shale	Nkporo Shale/ Afikpo Sandstone	
87.5 my	Santonian	Non-deposition		BENUE TROUGH
88.5my	Coniacian	Awgu Group (Agbani Sandstone/Awgu Shale)		
93 my	Turonian	Ezeaku Group)	Ezeaku Group (incl Amaseri Sandstone)	
100 my	Cenomanian-Albian	Asu River Group	Asu River Group	
119 my	Aptian Baremian Hauterivian	Unamed Units		
Precambrian		Basement Complex		

3. MATERIALS AND METHODS

This study focused on the sandy member of the Imo Formation (herein referred to as the Ameke Abam-Ebenebe sand ridge) in the Ameke Abam-Ugwuoba axis of the outcrop belt (Fig. 1). The study adopted three-stage strategy: (1) Analysis of aerial and topographic maps of the region, and down-dip topographic profiling to provided information on the nature, spatial distribution and dimensions of the sand ridges. (2) Detailed field descriptions, sampling and analysis of outcrop sections at Ameke-Abam, Lohum, Umuezike, Umuna and Ufuma, backed up with available literature on the stratigraphy and sedimentary characteristics of the Imo

Formation in southeastern Nigeria (3) Granulometric analysis involving sand-size particles and pebbles to extract information pertaining to depositional processes.

A total of 28 sand samples were collected (Table 2), sieved and analyzed. The grain-size distribution was presented as segmented log-probability plots to permit interpretation of depositional processes following the methods of Visher (1969) and Obi (1998).

A total of 2,400 pebbles were also collected from the cross-bedded sandstone facies association at Ameke-Abam, Lohum, Umuna and Ufuma (Fig. 1; Table 2) and analyzed for paleoenvironmentally sensitive parameters (maximum projection sphericity, oblate-prolate index and flatness index) following the methods of Sames (1966), Dobkins and Folk (1970) and Obi (1998).

Table 2. Distribution of pebbles and sand samples used in this study

Locality	Pebbles	Sand samples
Ameke Abam	1100	3
Lohum	500	==
Umuezike	==	12
Umuna	400	5
Ufuma	400	8

Table.3. Spot heights (in feet above sea level) of the Ameke Abam –Ebenebe Sand Ridge

Locality	Height (ft) above sea level
Ebenebe	300
Ugwuoba	380
Umunze	600
Ameke Abam	400
Etiti-Ulo	350

4. RESULTS

4.1. Nature of the Ridge: Down-dip geologic profile across the landscape of southern Nigeria shows that the Ebenebe-Ameke Abam sand ridge (Fig.3) is very similar to the adjacent Bende-Orlu-Awka highland and the Enugu Cuesta in being sub-parallel to the present southwestern Nigerian coastline (Obi *et al*., 2001) and in having a steep scarp slope that faces in the general northeast direction, and a gentler dip slope that faces toward the southwest.

The ridge extends laterally for over 150 km and ranges between 2 km-20 km in width and 90-600 m in height above sea level. It attains a maximum height of about 600 ft in the vicinity of Umunze (Table 3). The ridge topography flattens out at both ends into the alluvial plains of the Niger River and the Cross River.

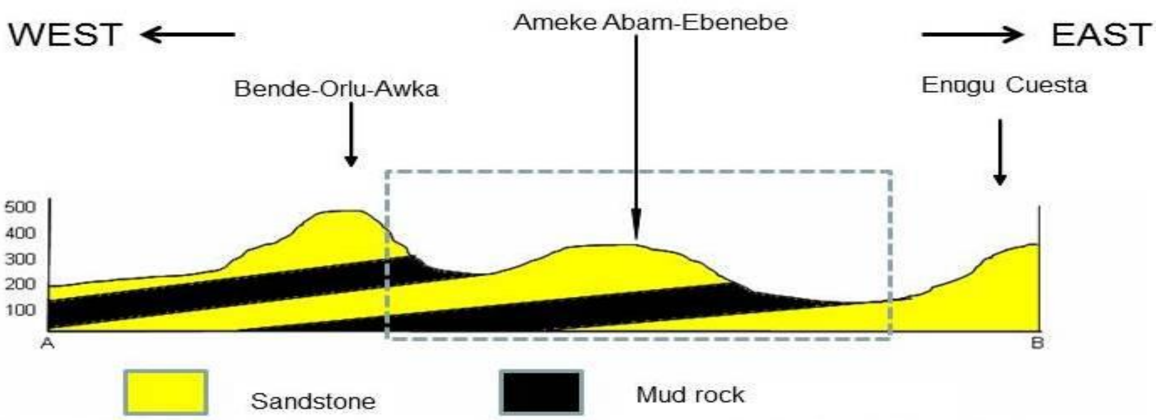

Fig 3.: A down-dip geologic section across the present landscape in the Ameke Abam-Bende axis, exposing the cuestiform morphology of the Ameke Abam-Ebenebe sand ridge and the adjacent Bende-Orlu-Awka ridge to the west. Components of the Imo Formation are boxed.

4.2. Vertical Profile:

Evidence from facies characteristics: Figures 3 and 4 show that the Ameke Abam-Ebenebe sandstone is encased by mud rock components of the Imo Formation. Lithofacies analysis of typical profiles of the sand body in the study area (Fig. 4) reveals that the sand body is consistently composed of three main facies associations: (i) a basal heterolithic facies association, (FA-1) (ii) wave ripple laminated sandstone facies association (FA-2) and (iii) cross-bedded sandstone facies association (FA-3) at the top.

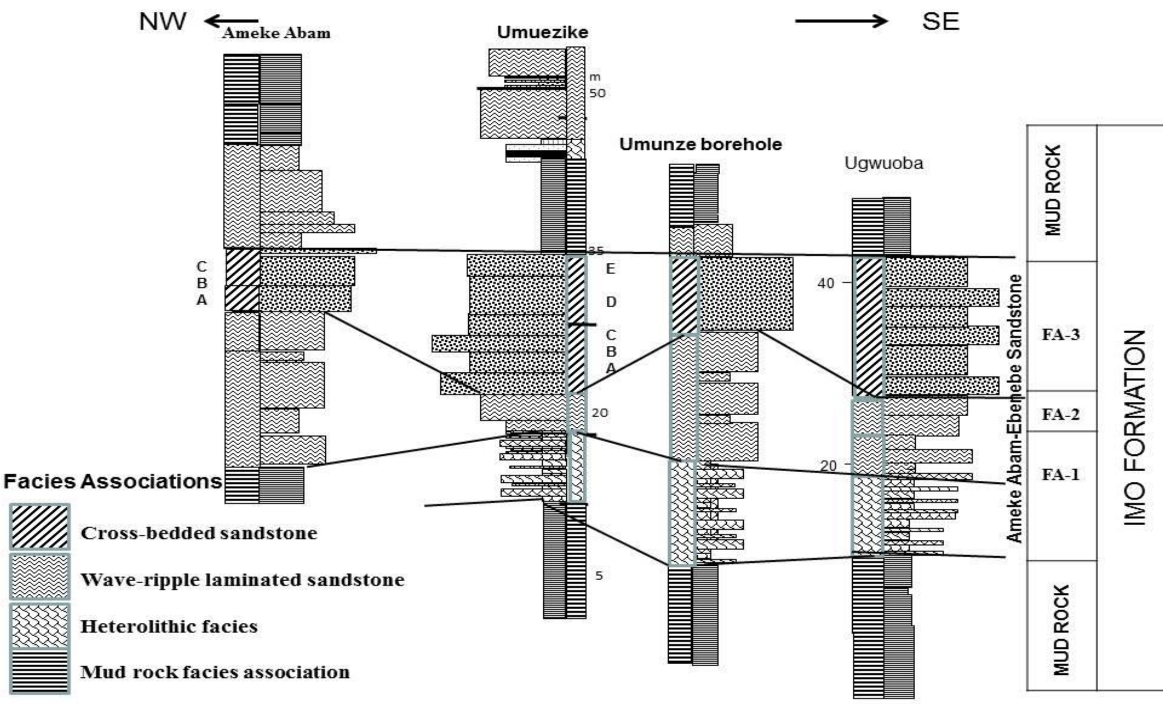

Fig. 4. Typical profile of the Ameke-Abam-Ebenebe Sandstone in the study area . Sampled intervals are numbered A,B, C,D,E

The heterolithic facies association is up to 25 m in thickness (Table 4) and consists of mm-cm scale, sharp-based very fine-grained sandstone laminae, siltstone and shale that show internal coarsening-upward motif. The facies association makes a gradational contact with the underlying marine limestone and black shale facies of the Imo Formation (Odunze and Obi, 2011). The heteroliths are strongly bioturbated, locally calcareous and characterized by flat to gently inclined lamination, swaley/lenticular bedding, fossil shells of bivalves and gastropods, siderite nodules (Fig. 5), as well as a trace suite including *Teichichnus, Ophiomorpha, Planolites, Arenicolites, Rhizocorallium*, and *Diplocraterion* ichnogenera.

The ***wave-ripple laminated sandstone facies association*** maintains a gradual transition with the underlying heterolithic facies association. The interval averages 20 meters in thickness and consists of a rhythmic alternation of sharp-based, hummocky/lenticular-bedded and low angle cross laminated siltstone, very fine-medium grained sandstone and shelly limestone arranged in a coarsening and thickening upward motif. The sandstone is yellow-light green in color, well-sorted, strongly bioturbated and contains the *Teichichnus, Rhizocorallium, Ophiomorpha, Planolites, Arenicolites* (Fig.6) *and Diplocraterion* structures. The facies association is apparently more calcareous in the more basinal areas of Ameke Abam and Akoli in Bende district (Odunze and Obi, 2011).

Table 4. Sedimentary characteristics of the Ameke Abam-Ebenebe Sandstone, SE Nigeria

Facies	Sedimentary characteristics	Estimated thickness (m) at selected localities				
		Ameke Abam	Umuezike	Umuna	Umunze	Ugwuoba
Cross-bedded Sandstone	Alternation of fining-upward, poorly-sorted pebble beds, and coarse-fine grained sandstone containing planar cross stratification, herringbone structures, reactivation surfaces, clay drapes, extra-formational clasts and abundant *Ophiomorpha*	60m	40	> 50	40	40
Wave-ripple laminated sandstone	Friable, well-sorted, micaceous sandstone containing wave ripple lamination, low angle cross bed, small-scale trough cross-bed, HCS, *Teichichnus, Planolites, Diplocraterion, Thalassinoides, Ophiomorpha* and *Skoliths*	30	25	25	20	20
Heterolithic facies	Rapid alternation of clay, clay-shale and siltstone,/very fine grained sandstone, strongly bioturbated and containing *Teichichnus, Thalassinoides and Planolites,*	20	20	20	25	15

The cross-bedded sandstone facies association consists of single- and multi-storey, medium grained to conglomeratic sandstone erosively overlying the wave-ripple laminated facies. Estimated average thickness is in excess of 40 m. It is characterized by fining-upward grain size motif, planar- and tabular cross-beds, moderate sorting and contains herringbone structures (Fig. 7a), reactivation surfaces, mud draped foresets and scattered extra-formational pebbles (Fig. 7b).

Fig. 5.Heterolithic facies at Umuezike showing calcareous nodules (ls)

Fig. 6. Strongly bioturbated unit of the wave-ripple facies at Akoli, showing *Arenicolites* structrs

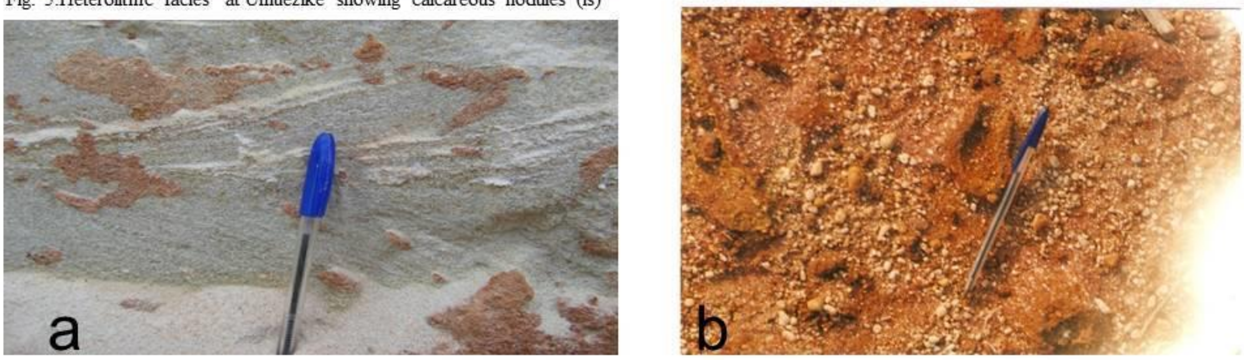

Fig.7. Cross bedded sandstone at Ameke Abam showing herringbone structure (a), *Ophiomorpha* and scattered extra-formational pebbles (b).

Grain-size distribution plots for the sand samples from the facies association at Ameke-Abam, Umuezike, Umuna and Ufuma, fall into the Visher's (1969) 2- and 3-segment varieties (Fig. 8).

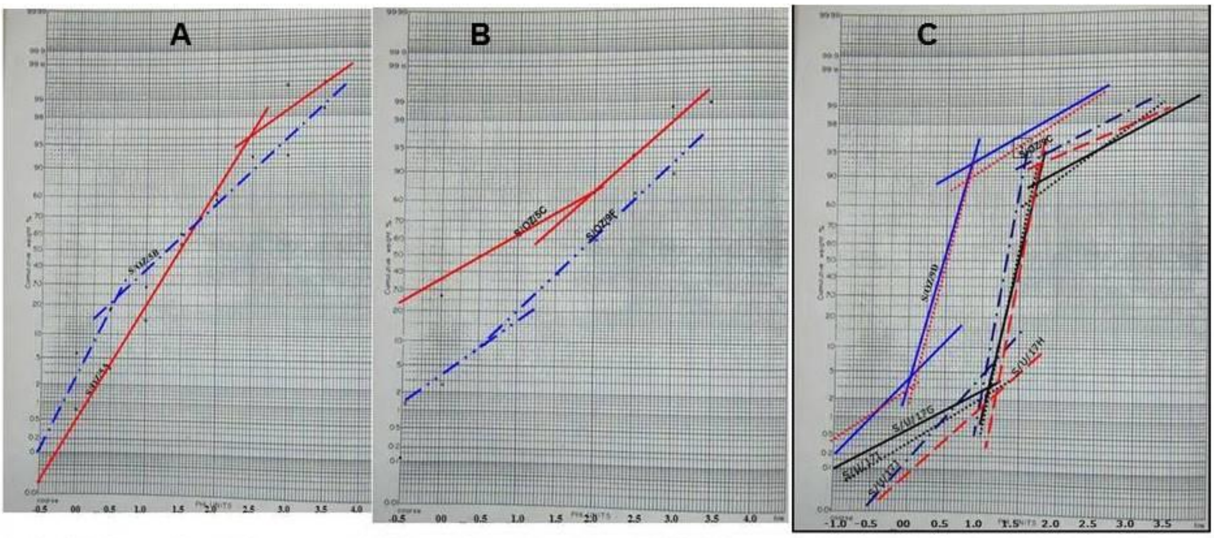

Fig. 8. Examples of 2-segment plots, categories A and (B), interpreted to be of fluvio-deltaic origin. 8C shows 3-Segment plots reflecting delta front sedimentation (After Visher, 1969)

The 2-segment plots are of two categories: (a) Category A, characterized by (i) a well-sorted saltation subpopulation that makes up 18%-98% of the distribution, with the saltation-suspension junction occurring at between 1.0 phi and 1.80 phi and (ii) a poorly sorted suspension subpopulation that is 22%-70% of the population. (b) Category B plots characterized by (i) fairly to moderately sorted bed load subpopulation that forms about 12% of the distribution, and joins the saltation population at 1.0 phi;and (ii) a moderately sorted saltation subpopulation that forms 88% of the distribution.

The 3-segment varieties are characterized by a poorly-sorted traction subpopulation and a very well sorted saltation subpopulation with size ranging from about 2.0 to 3.5phi.

Mean form indices for pebble samples from the cross-bedded sandstone facies association at Ufuma, Umuna, Lohum and Ameke Abam (Fig.4), are summarized in Table 5. The mean maximum projection sphericity (MPS) ranges between 0.53 and 0.61, while the mean oblate-prolate index (OPI) ranges between 0.01 -2.79. Flatness index on the other hand, varies between 35.6% and 45.08%.

Table 5. Range of mean form indices for pebbles from the Imo Formation

Location	No of pebbles	Sphericity (MPS) >0.65= fluvial; < 0.65 = wave	Oblate-Prolate Index (OPI) >-1.5 = fluvial < -1.5 =wave	Flatness Index (FI) >45% = fluvial < 45% =wave
Ameke-Abam	1100	0.60	-2.79	41.23
Lohum (Unit B-3)	500	0.53	-0.33	35.60
Umuna	400	0.60	0.01	40.43
Ufuma	400	0.61	-0.211	45.08

Plots on the sphericity-form diagram using the function established by Sneed and Folk (1958; Fig. 9) show that most of the pebbles plotted within the ***bladed*** field and outside zones that are environmentally diagnostic.

5. DISCUSSION

Depositional Processes

The sedimentary characteristics of the three facies associations that make up the Ameke Abam-Ebenebe sand ridge and their overall vertical arrangement provide a sound basis for the reconstruction of the depositional processes that generated the sand ridge. The gross sedimentary characteristics of the heterolithic facies association and the wave ripple laminated sandstone facies association reflect shoreface sedimentation. The presence of wave generated sedimentary structures within the sharp-based and thin-bedded heteroliths along with shallow marine mollusks and a trace suite belonging to the *Skolithos* and *Glossifungites* ichnofacies associations suggests that the heteroliths accumulated in lower to middle shoreface zone of the shallow marine realm (Swift and Niedoroda, 1985; Walker and Plint, 1992). The presence of rhythmic alternation of sharp-based, hummocky/lenticular-bedded and low angle cross laminated siltstone, very fine-medium grained sandstone and shelly limestone arranged in a coarsening and thickening upward motif suggests that the sediments accumulated above the fair weather wave-base under the influence of storm-generated waves (Cheel and Leckie, 1993; Myrow and Southard, 1996; Mitdgaard, 1996; Odunze and Obi, 2011). The observed progradational facies arrangement is consistent with shoreface/delta front sedimentation (Walker and Plint, 1992).

Based on the stratigraphic position and the overall sedimentary characteristics, the cross-***bedded sandstone facies association*** is interpreted to have accumulated in a delta plain or fluvial channel under strong tidal influence. The presence of fining- upward grain size motif, the planar- and trough cross-beds and extra-formational clasts is consistent with fluvial sedimentation. The presence of herringbone cross-stratification, flaser bedding, mud drapes and reactivation surfaces in these units is evidence for the influence of tidal currents (Archer and Kvale, 1989; Leckie and Singh, 1991; Shanley *et al*., 1992; Hettinger, 1995; Odunze and Obi, 2011).

The results of the grain-size analysis are consistent with the above interpretation. Characteristics of the category A plots are very similar to the characteristics of curves which Visher (1969) identified as fluvio-deltaic sands. These curves are thought to be produced by strong tidal currents in an area where the surface creep population has been removed, possibly in shallow water or on bars in the tidal channel. Similar curves were obtained for sandstone samples from the Almond and Lance Formation (Visher, 1969) which Weimer (1965) interpreted as being of deltaic origin. The observed characteristics of category B plots suggest sedimentation in the shoal areas where breaking waves keep the depositional interface agitated, and suspension material is winnowed out and transported seaward by currents (Visher 1969). Characteristics of the 3-segment plots are similar to those which Visher's (1969) identified as belonging to the delta front.

Further evidence for the combined influence of waves, tide and fluvial current in the accumulation of the cross-bedded facies association, is provided by the form indices of pebbles sampled from the cross-bedded facies association. Table 5 shows that whereas values of *maximum projection sphericity* (MPS) and *flatness index* (FI) of all the pebbles indicate wave influence (i.e. < 0.65 and < 45% respectively), values of the *oblate-prolate index* (OPI) suggest fluvial influence (i.e. > -1.5). Similarly, plots on the sphericity-form diagram as described by Sneed and Folk (1958; Fig. 9) show that most of the pebbles plotted within the ***bladed*** field thus confirming that the pebbles were shaped in a coastal environment/zone of interaction between wave and fluvial processes (Obi, 2000).

6. CONCLUSIONS

The Ameke Abam-Ebenebe Sand ridge of southeastern Nigeria is cuesta with the scarp-slope and dip slope facing northeastward and southwestward respectively, sub-parallel to the present Nigerian coastline. The topographic prominence which dominates the Imo Formation landscape extends for over 150 km, attaining a maximum height of about 600 ft above sea level in the vicinity of Umunze. Lithofacies analysis reveals that the sand body shows a transition from a basal heterolithic facies association, through an interval of wave ripple laminated sandstone facies that reflect the influence of waves, to cross-bedded sandstone

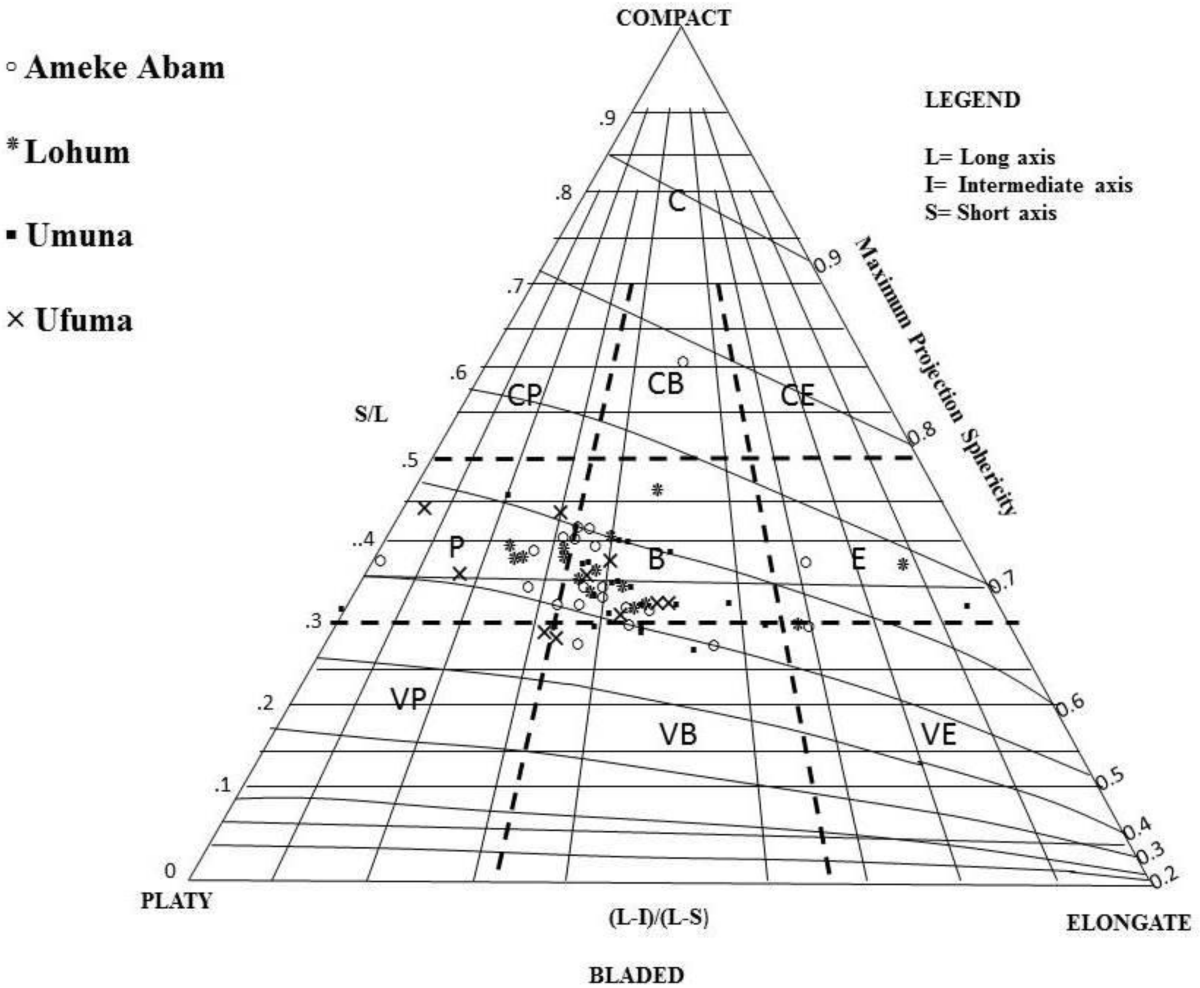

Fig. 9. Sphericity-form plots for pebbles from the Ameke Abam-Ebenebe sand ridge

facies in which gross sedimentary characteristics strongly suggest fluvial and tidal influence. The linear geometry/trend direction, sedimentary characteristics and the overall arrangement of the lithofacies suggest that the sand body originated as wave-influenced fluvio-deltaic sand ridge. Similar sand bodies abound in geologic record and these are known to be important hydrocarbon reservoirs.

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8. REFERENCES

Archer, A.W. and Kvale E.P. (1989). Seasonal and yearly cycles within tidally laminated sediments; an example from the Pennsylvanian in Kentucky, Indiana, and Illinois: Indiana Geological Survey, Illinois Basin Consortium, no. 1, p. 45-46.

Benkhelil, J. (1982). Benue Trough and Benue Chain. Geol. Mag. 119, 155-168.

Cheel, R. J. and Leckie, D. A. (1993). Hummocky cross-stratification In: Sedimentology Review volume 1 (V. P. Wright (Ed)) Blackwell Science Publication London, pp. 103-122.

Dobkins, J. E., and Folk, R. L. (1970). Shape developments on Tahiti-Nui. J. Sediment. Petrol., v. 40, p. 1167-1203.

Hettinger, R. D. (1995). Sedimentological Descriptions and Depositional Interpretation in sequence Stratigraphic context, of two 300-meter Cores from Upper Cretaceous Straight Cliffs Formation Kaiparowits Plateau, Kane County, Utah. US Geol. Survey. Bull. 2115-A. 32p.

Iloeje, N. P., 1980. A new Geography of Nigeria. 201p. Longman.

Iloeje N.P. (1980). A New Geography of Nigeria (2nd Eedition), Longman Nigeria Limited, 200p.

Leckie, D.A. and Singh, C. (1991). Estuarine deposits of the Albian Paddy Member (Peace River Formation) and Lowermost Shaftesbury Formation, Alberta, Canada: Journal of Sedimentary Petrology, v. 61, p. 825-849.

Liu Z, Yichang, H. and Qinian, Z., 1989. Tidal current ridges in the southwestern Yellow Sea. Journal of Sedimentary Petrology, v. 59, No.3, p. 432-437

Midtgaard, H.H. (1996). Inner-shelf to lower-shoreface hummocky sandstone bodies with evidence for geostrophic influenced combined flow, Lower Cretaceous, West Greenland. Journal of Sedimentary Research, v. 66, p. 343-353.

Murat, R. C. (1972). Stratigraphy and paleogeography of the Cretaceous and Lower Tertiary in southern Nigeria. *In*: Dessauvagie, *T. F. J.* and Whiteman, A. J. (Eds.), *African Geology*, Univ. of Ibadan Press, Nigeria. pp. 251-266.

Myrow, P.M. and Southard, J.B. (1996). Template deposition. Journal of Sedimentary Research, v. 66, p. 875-877.

Nwajide, C. S. (1979). A lithostratigraphic analysis of the Nanka Sands, Southeastern Nigeria: Journal of Mining and Geology, vol. 16, p. 100-110.

Obi, G.C. (1998). Upper Cretaceous Gongila Formation in the Hawal Basin, North Eastern Benue Trough: a storm and wave dominated regressive shoreline complex. Journal of African Earth Science. 26 (4), 61-63.

Obi, G.C. (2000). Depositional Model for the Campanian-Maastrichtian Anambra Basin, Southern Nigeria. Unpublished Ph.D. Thesis, University of Nigeria, Nsukka, 291 p.

Obi G. C., and Okogbue, C. O. (2004). Sedimentary response to tectonism in the Campanian Maastrichtian succession, Anambra Basin, Southeastern Nigeria. Journal African Earth Sciences, 38, 99- 108.

Obi G. C., Okogbue, C.O. and Nwajide, C.S. (2001). Evolution of the Enugu Cuesta: A tectonically driven erosional process. Global Journal Pure Applied Sciences, 7/2, pp. 321-330.

Oboh-Ikuenobe, F.E., Obi, G.C. and Jaramillo, C.A. (2005). Lithofacies, palynofacies and sequence stratigraphy of Paleogene strata in southeastern Nigeria. Journal of African Earth Sciences, 41: 79-102.

Odunze, O.S, and Obi, G.C, 2007. New perspectives on the Lithostratigraphy and Depositional Environments of the Imo Formation in Southern Benue Trough. *Presented in 2007 NAPE International Conference and Exhibition, Abuja, Nigeria.*

Odunze S.O. and Obi, G.C. (2011). Sequence stratigraphic framework of the Imo Formation in the Southern Benue Trough. Journal of Mining and Geology, v. 47, p. 135–146.

Ofomata, G. E. K., 1975. Nsukka-Okigwe Cuesta In: Ofomata, G. E. K. (ed.), Nigeria in Maps: Eastern States. Ethiope Publ., Benin. 35-37.

Ofomata, G. E. K., 1978. The Nsukka Environment. Fourth Dimension Publ., 253p.

Ojoh, K. A., 1988. Evolution des bassins albo-santoniens du sud- Ouest du fossé de labénoué (Nigeria). Apports à la connaissance du domaine. Equatorial de l' Atlantique Sud. Thése Doctorat Université Aix-Marseille III.

Ojoh, K. A., 1992. The southern part of the Benue Trough, (Nigeria); Cretaceous stratigraphy, basin analysis, palaeoceanography and geodynamic evolution in theequatorial domain of the south Atlantic. NAPE Bull. 7 / 2, 131-152.

Reyment, R.A. (1965). Aspects of the Geology of Nigeria: the stratigraphy of the Cretaceous and CAENOZOIC DEPOSITS. University of Ibadan, Nigeria, 145p.

Sames, C. W. (1966). Morphometric data of some recent pebble associations and their application to ancient deposits. J. Sediment, Petrol., V. 36, P. 126-142.

Shanley, K.W. McCabe, P.J.and Hettinger, R.D. (1992). Tidal influence in Cretaceous fluvial strata from Utah, U.S.A.—a key to sequence stratigraphic interpretation: Sedimentology. v. 39, p. 905-930.

Simpson, A., (1954). Geology of the escarpment north of Enugu. Ann. Rep. Geol. Survey. Nigeria, p. 9-14.

Sneed, E. D. and Folk, R. L. (1958). Pebbles in the Lower Colorado River, Texas– a study in particle morphogenesis. J. Geol., v. 66, p. 114-150.

Swift, D.J.P. and Niedoroda, A.W. (1985). Fluid and sediment dynamics on continental shelves, in: Tillman, R.W., Swift, D.J.P. and Walker, R.G., eds. Shelf sands and sandstone reservoirs. SEPM Short Course 13, Notes, p. 47-133.

Visher, G. S. 1969. Grain size distribution and depositional processes. J. Sediment. Petrol. 39, 1074-1106.

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

WEIMER,K R. J., 1965. Late Cretaceous deltas. Rocky Mountain region. (Abstract) AAPG Bull. 40, 363