Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

EVOLUTION OF THE NIGER DELTA, PRESENT DYNAMICS AND THE FUTURE

T. Najime[1], M. O. Eduvie[2] and B. Jolly[1]

[1]*Ahmadu Bello University, Zaria, Nigeria*

[2]*National Water Resources Institute, Kaduna, Nigeria*

Received: 23-05-16
Accepted:12-07-16

ABSTRACT:

Evolution of the Niger Delta is closely linked to the geodynamics related to the separation of the African and South American continents and the tectonics of the formation of the Benue Trough. Tectonic activities, climate and eustasy are the major factors responsible for transgression and regression through the entrant point along the present Niger Delta area and the deposition of marine and non-marine sediments from late Aptian to Eocene. The Santonian and later Campanian to Eocene positive movements of blocks bounded by NE-SW and NW-SE trending faults along the Benue Trough and the present Niger Delta region preceded the subsidence of the Oligocene and younger Niger Delta basin along the NW-SE fault trends. From Paleocene to Eocene, the Anambra basin was filled by the transgressive Imo Shale, the regressive Ameki Formation and from Eocene to Recent the Niger Delta has been filled by Akata, Agbada and Benin Formations. At present rifting and tectonic subsidence are dormant but the basin is under a sag regime with continued deposition of Benin Formation and little changes in climate and eustasy. The present dynamics in the Niger Delta has evolved it to a near mature basin but a climate change with the resultant eustasy could destabilize the ecosystem of the region with corresponding economic consequences.

Key words: Niger Delta; Transgression; Regression; Eustasy; Evolution; Paleogeography.

INTRODUCTION

The Niger Delta occurs at the southern end of Nigeria bordering the Atlantic Ocean on the continental margin of the Gulf of Guinea in the equatorial West Africa. It extends from about latitudes 4° 30″ – 5° 20″ N longitudes 3° – 9^{o} E and (Fig. 1).

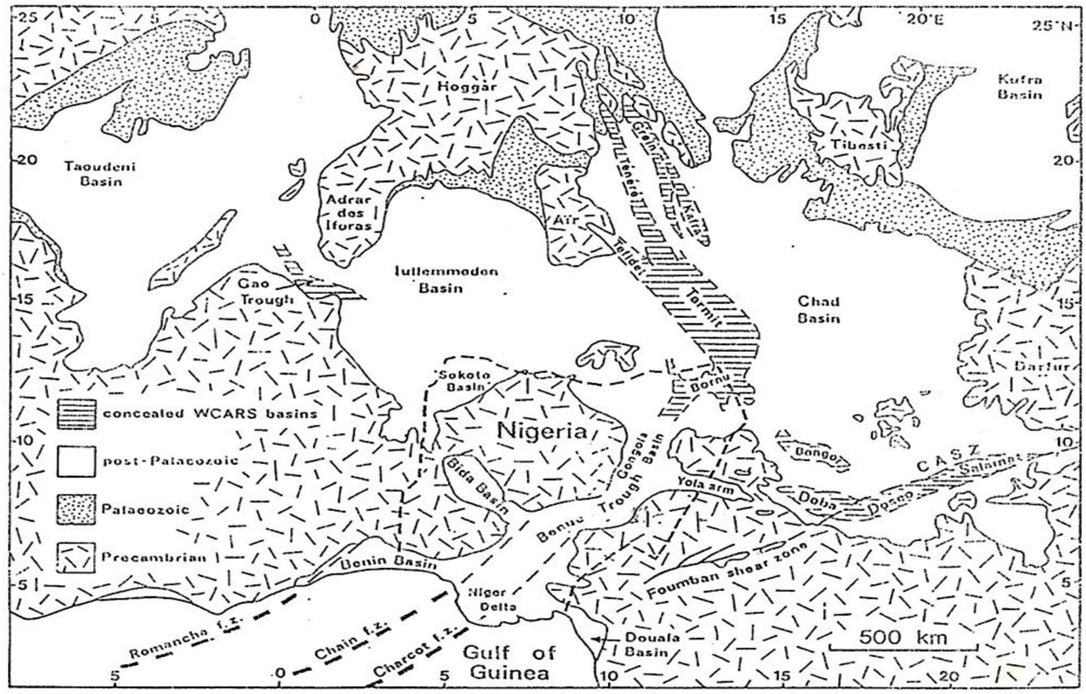

Fig. 1: Simplified geological map showing the sedimentary basins of Nigeria and neighbouring area. (after Zaborski, 1998).

The formation of the Niger Delta is intimately related to the evolution of the Benue Trough, while the formation of the Benue Trough is closely associated with the break-up of the Afro-Brazilian plate in the early Cretaceous. The break-up of the plate and the extension of Chain and Charcot fractures onshore (Sibuet and Mascle, 1978) below the Niger Delta and the formation of a network of anatomizing sinistral strike-slip faults and extensional movements explains the formation of the Benue Trough (Benkhelil, 1986, 1988).

According to Murat (1972) the tectonic evolution of the Lower Benue Trough was controlled by three major tectonic phases. The first tectonic phase from Albian to Early Santonian affected southwest Nigeria in the Albian and was characterized by movements along major NE-SW trending faults resulting in the formation of the rift-like Abakaliki Trough. To the northwest the Benin-Benue fault hinge zone was the limit of the basin (Fig. 2). The second phase took place from Late Santonian to Campanian. It was marked by compression along the established NE-SW trend, which resulted in the formation of the Abakaliki folded belt. Subsequently, the Anambra platform subsided as the axis of the basin was displaced to the northwest of the Abakaliki uplift (Fig. 2). The third tectonic phase took place from late Campanian to Eocene during which positive movements of blocks bounded by NE-SW and NW-SE trending faults preceded the subsidence of the Oligocene and younger Niger Delta basin along the NW-SE faults trends (Fig 3). Murat (1972) documented five sedimentary cycles corresponding to three major transgressions and two minor transgressions in the Lower Benue Trough. Other studies on the transgressive and regressive cycles are the works of Reyment (1965), Reyment and Mörner (1977) Agagu and Adighije

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

(1983), and Agagu *et al.* (1985), Zaborski (2000) and Allix (1987) in the Anambra Basin. Studies on the Niger Delta includes the works of Allen (1964), Hosper (1965), Stonely (1966), NEDECO (1954, 1961), Short and Stauble (1967), Frank and Cordry (1967), Maron (1969), Weber (1971), Burke (1989), Abovbo (1978) Evamy *et al.* (1978), Lambert-Aikhionbare and Ibe (1984), Asseez (1989), Knox and Omotsala (1989), Doust and Omatsola (1990), Reijers *et al*. (1997), Jubril *et al.* (1998), Onuoha (1999), Haak *et al.* (2000), Ako *et al.* (2004). This paper seeks to highlight the tectono-eustatic events and sedimentation related to the evolution of the Niger Delta, present dynamics and consequent changes in eustacy related to climate changes among other factors in relation to changes in the biogeography.

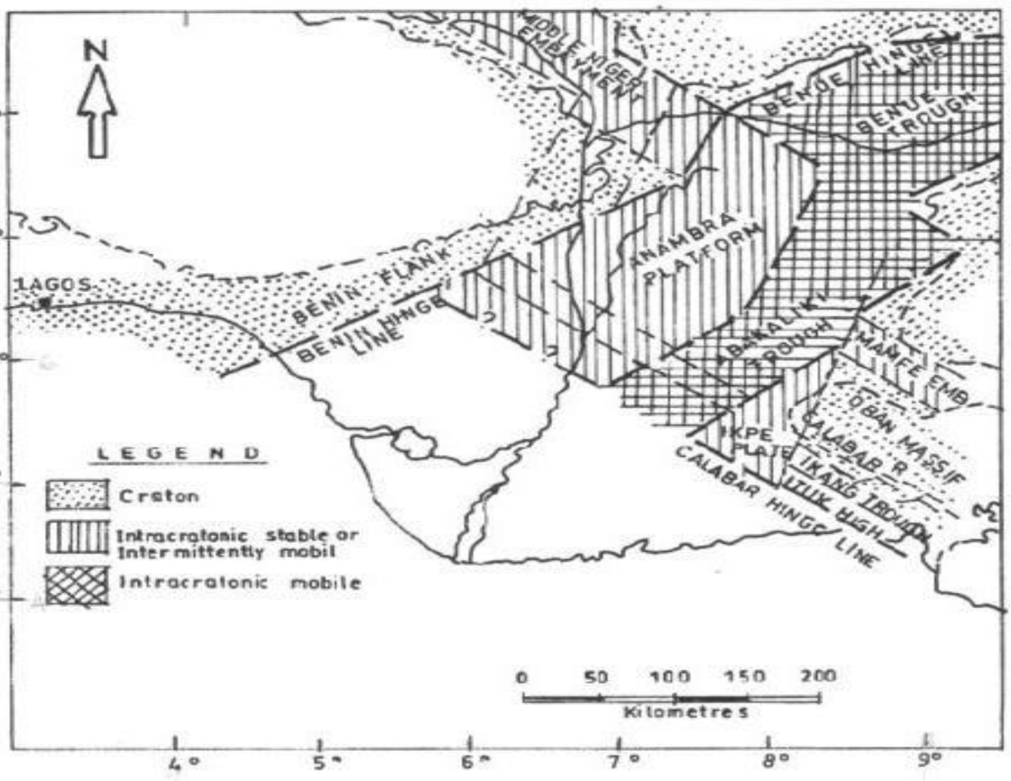

Fig. 2: Megatectonic framework of the Lower Benue Trough region from Middle Albian to Santonian (after Murat, 1972).

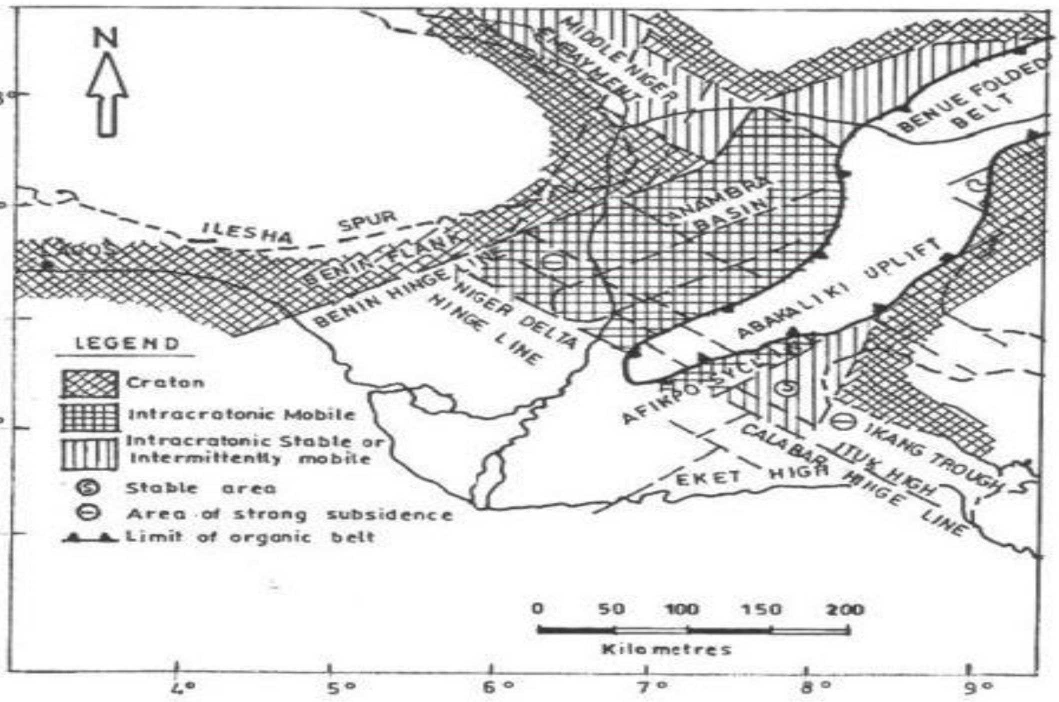

Fig. 3: Megatectonic framework of the Lower Benue Trough region from Campanian to Eocene (after Murat, 1972).

Paleogeography of the Benue Trough/Anambra Basin to Pre-Niger Delta Setting

The transgressive/regressive cycles from mid-Albian to Eocene (Reyment, 1965; Murat, 1972; Reyment and Mörner, 1977; Agagu and Adighije, 1983; Agagu *et al.* 1985; Zaborski, 2000 and Allix, 1987) were responsible for the paleogeography of the Benue Trough/Anambra Basin and the Pre-Niger Delta.

Mid-Albian to early Cenomanian: The first cycle of marine sedimentation started during the Middle Albian. In the Abakaliki region, 3600 m of marine sediments were deposited during the first marine transgression which resulted mainly from subsidence within the trough and sea level rise which coincided with the global rise of sea level in the Albian (Watts and Steckler, 1979; Kominz, 1984). According to Ojoh (1990), the sea rise coincided with rifting and drifting apart of South America and Africa, which also resulted in the interconnection of the South and North Atlantic in the early Late Albian.

The Asu River Group, the "lower limestone" of Murat (1972) on the Calabar Flank and the "Arufu Limestone" and “Gboko Limestone" Reyment (1965) in the "Middle Benue Trough” were deposited at this time as are shelf sediments. The Asu River Group includes deeper water shales and turbidites (Fig. 4), Ojoh, (1990). The transgressive phase ended with extensive deltaic development (Fig. 5).

Late Cenomanian to middle Turonian: The secondary cycle of marine sedimentation in the Benue Trough coincided with the global rise of sea level from Late Cenomanian to Early Turonian. During the transgressive phase the Ezeaku Formation was deposited

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

in the Abakaliki Trough (Fig. 6). A low stand of sea level and a regressive phase in the Middle Turonian (Fig. 7) gave rise to an extensive coastal plain including the the Keana, Makurdi and Agila areas characterized by braided streams (Ojoh, 1990). The Makurdi Sandstone on the Anambra platform and the Agala Sandstone were deposited during this phase. On the eastern edge of the Abakaliki Trough local deltaic systems were deposited, the "Konshisha Group" and "Amaseri Sandstone" of Murat (1972) after Shell BP geologists.

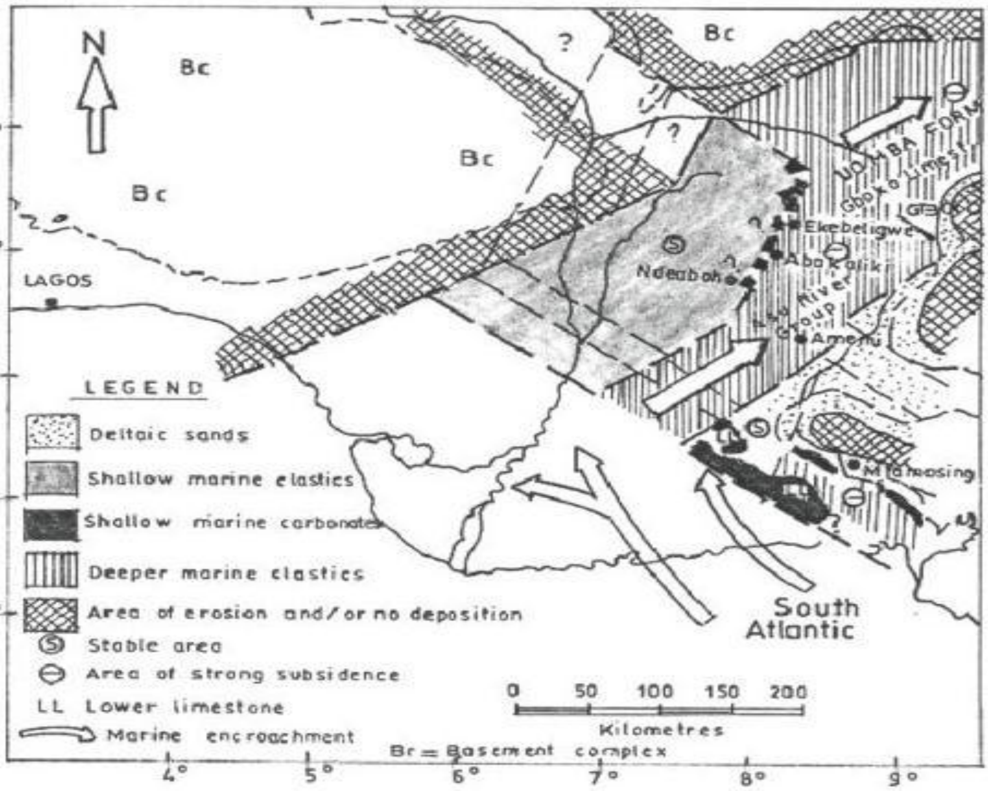

Fig. 4: Paleogeographical sketch map of the Middle Albian transgression in the Lower Benue Trough region. [modified from Murat (1972) and direction of marine encroachment after Ojoh (1990)]

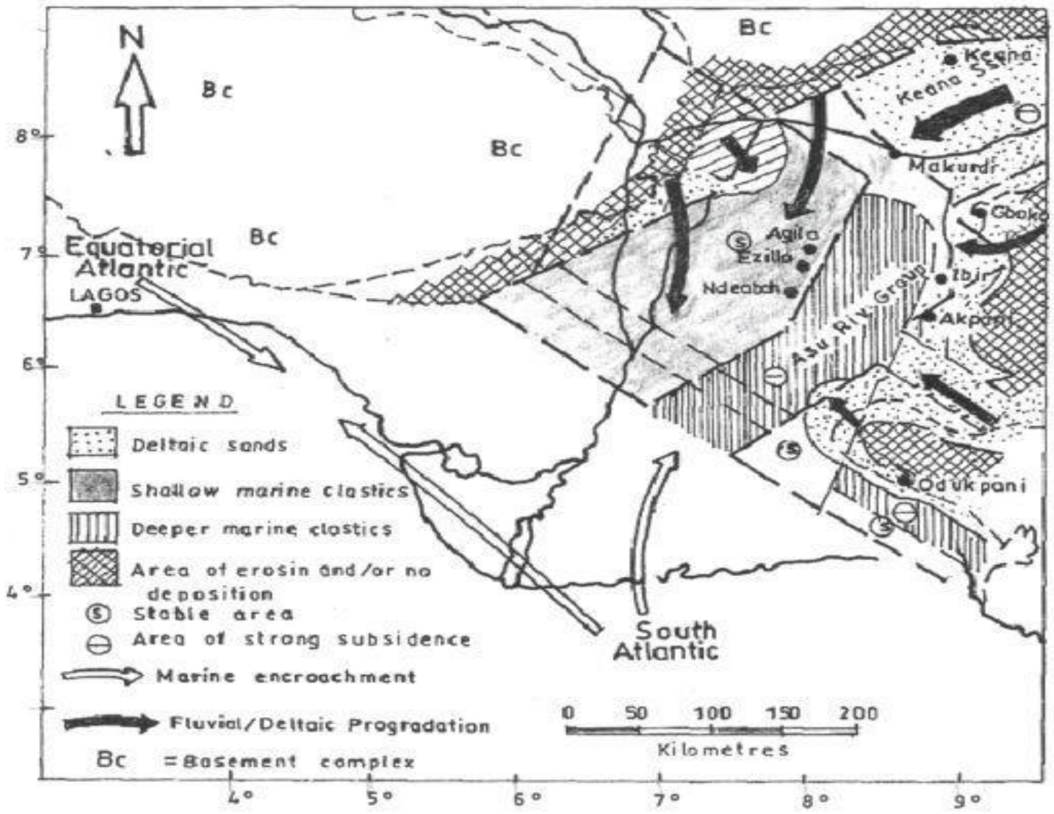

Fig. 5: Paleogeographical sketch map of the Late Albian – Early Cenomanian regression in the Lower Benue Trough region [modified from Murat (1972) with deltaic progradation and marine connection after Ojoh (1990)].

Late Turonian to Santonian: The third cycle of marine sedimentation in the Lower Benue Trough coincided with the Late Turonian to Coniacian rise of sea level (Fig. 8). The transition between the Late Turonian and Early Coniacian in the Anambra platform is characterized by the richly fossiliferous limestone units within the Agala Sandstone and near Makurdi by the Wadatta Limestone with the ammonite *Coilopoceras requienianum.* In the Abakaliki Trough the "Awgu Shale" was deposited. The Coniacian facies consists of limestone and shales in the western part of the Abakaliki Trough while in its eastern part sandstone facies ranging in age from Late Turonian to Santonian dominate (Ojoh, 1990). The Agbani Sandstones, outcropping on the western side of Abakaliki trough east of Enugu (Murat, 1972), are probably part of these units.

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

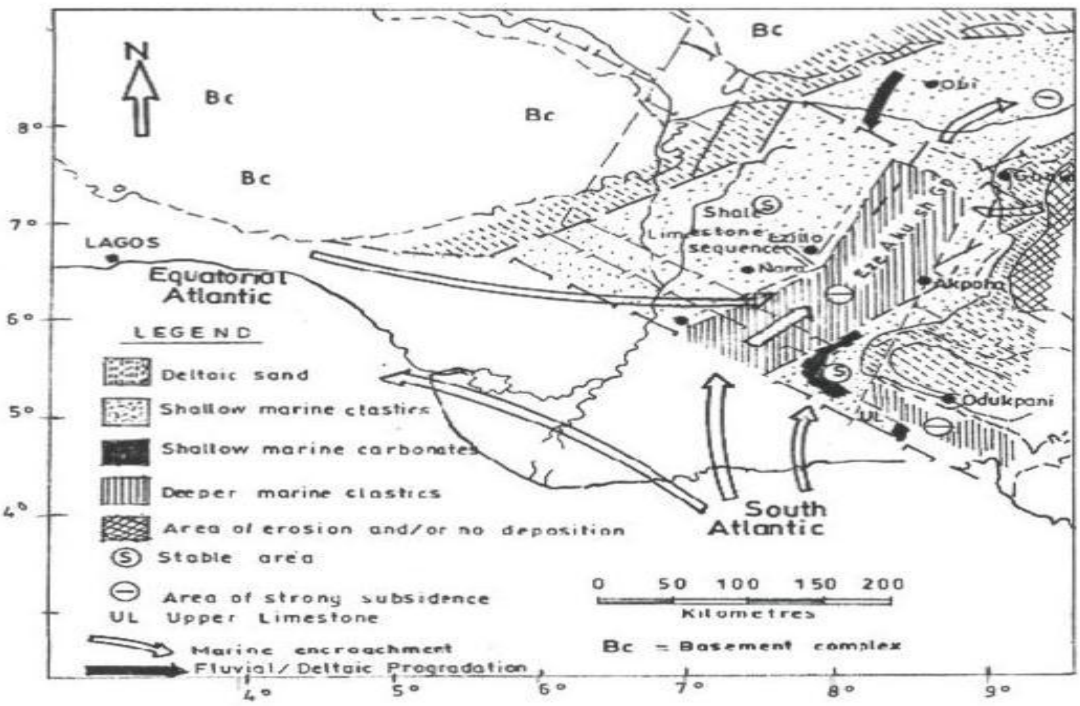

Fig. 6: Paleogeographical sketch map of the Late Cenomanian – Early Turonian transgresssion in the Lower Benue Trough region. [modified from Murat (1972) with deltaic progradation and marine connection direction after Ojoh (1990)

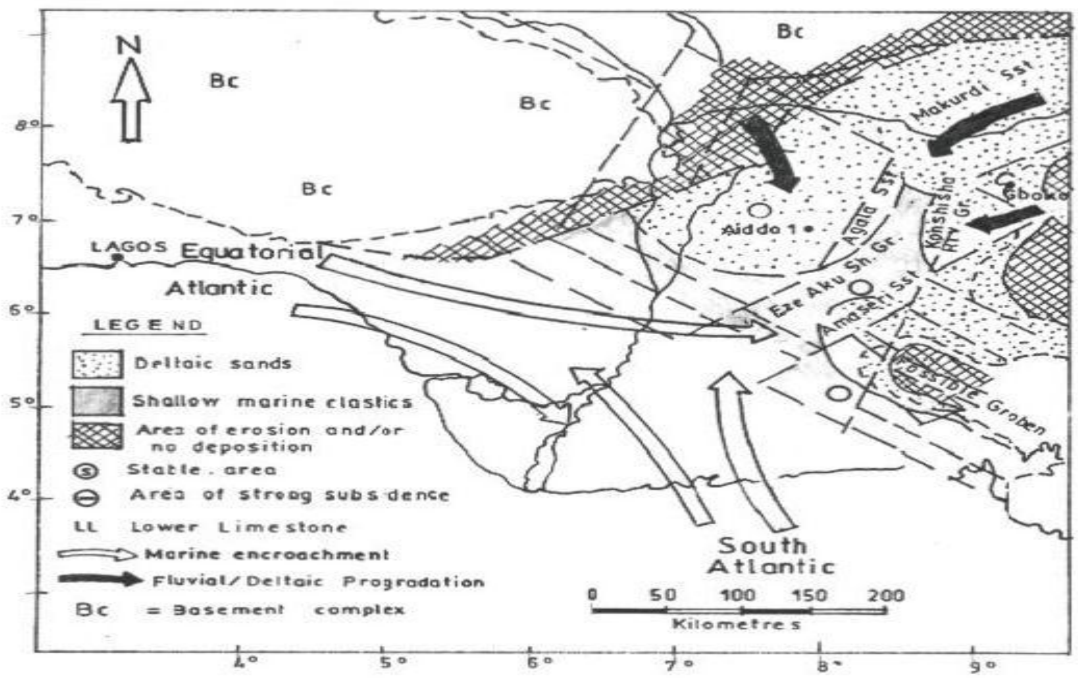

Fig. 7: Paleogeographical sketch map of the Middle Turonian regression in the Lower Benue Trough region [modified from Murat (1972) with with deltaic progradation and marine connection after Ojoh (1990)].

The Santonian was the time of the Abakaliki folding phase (Cratchley and Jones 1965; Burke *et al.*, 1972; Murat, 1972) and the consequent formation of the Anambra Basin to the northwest and the Afikpo Syncline to the southeast. The folding phase was associated with volcanic activity and in some places sediments were deposited during the Santonian and early part of the Campanian (Ojoh, 1990).

Campanian to Maastrichtian: The Campanian – Maastrichtian sedimentation cycle accelerated the sedimentation in the Anambra Basin and Afikpo Syncline. The Early Campanian is characterized by deltaic deposits in the Anambra Basin and constitutes the transition to marine deposits (Allix, 1987). During a Late Campanian transgression, the marine Nkporo Shale and the Enugu Shale were deposited. Another regressive phase in the Maastrichtian resulted in deposition of the Mamu Formation, Ajali Sandstone and Nsukka Formation.

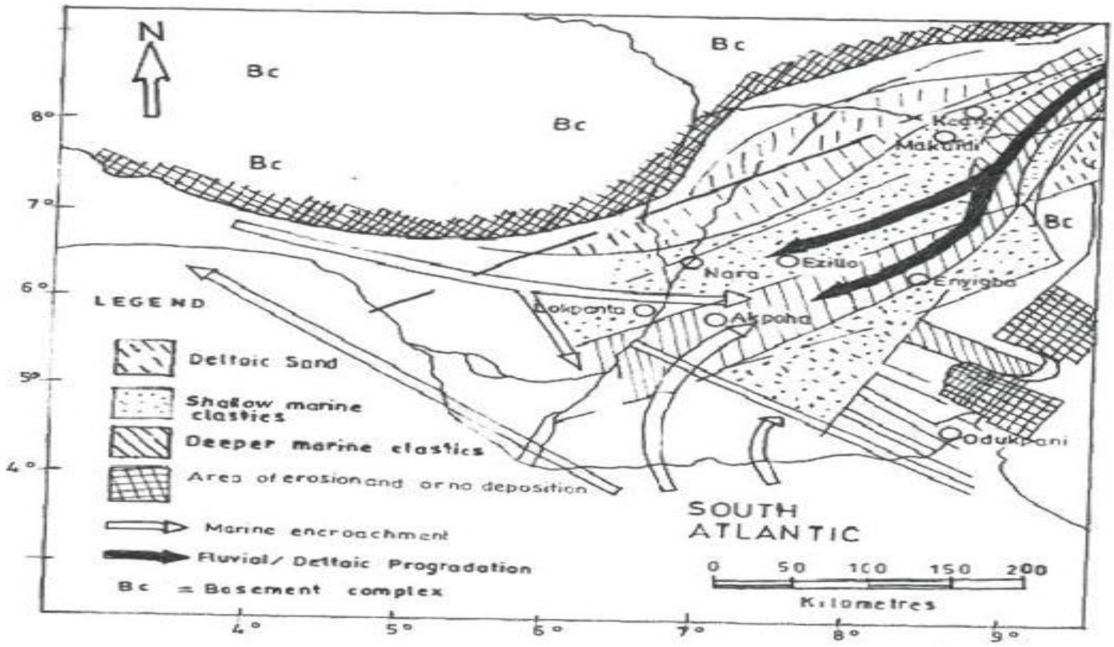

Fig. 8: Paleogeographical sketch map of the Late Turonian - Coniacian transgression in the Lower Benue Trough region (after Ojoh, 1990).

Paleocene to Eocene: An Early Paleocene transgression affected the Anambra Basin and is marked by the Imo Shale. A subsequent prolonged regressive phase is represented by the Ameki Formation and the formation of the Eocene to Recent Niger Delta.

Evolution and Paleobiogeography of the Niger Delta

The Niger Delta has been advancing towards the Benue Trough since the embryo Benue ocean closed about 80 Ma ago (Burke *et. al.*, 1971, 1972). The Proto-delta developed in the northern part of the basin during the Campanian transgression and ended with the Paleocene transgression. The Formation of the modern Delta began during the Eocene as regression set-in. The major depositional environments with the different paleobiogeographies typical of most recent deltaic environments (marine, mixed and continental) are observable in the Niger Delta. These corresponds to the 3 sub-

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

surface stratigraphic units of Benin Formation (continental), Agbada Formation (Mixed) and Akata Formation (marine) recognized by Short and Stauble (1967) in the Modern Niger Delta.

Eocene to Recent
The development of the present Niger Delta is marked by marine deposition of dark grey sandy, silty shale with thin sandstone lenses during the Eocene till date. All these sediments assigned to the Akata Formation occur as deposits of mainly shallow marine with microfauna of mainly foraminifers. The sediments thicknesses range from about 1200 – 3500 m depending on the location on the delta.

Eocene – Oligocene – Recent
The sea level fall and progradation during the Eocene-Oligocene to Recent brought about an increased continental influence in the delta. The mixed environment brought about the deposition of sandstones and shales with shale dominating in the lower parts and sandstones dominating the upper parts. The deposits are assigned to the Agbada Formation; they show an upward coarsening sequence indicating a greater fluviatile influence towards the younger deposits. The microfauna also decrease upward of the sequence. The sediments thicknesses range from about 300 – 4000 m. Major hydrocarbon deposits are associated with this formation.

Oligocene – Miocene to Recent (Benin)
The dominance of continental environment from Miocene to Recent deposits in the Niger delta gave rise to a dominant fluviatile deposition environment with mappable structures such as channel fills, natural levees, point bars etc. These structures show variability due to the influence of fluviatile, tidal and wave influence in shallow water deposits. The sediments consist mainly of sandstones with thin intercalations of shale and are assigned to the Benin Formation. The thickness of these deposits exceeds 2000 m but decreases landward of the delta. The formation has low records of hydrocarbon accumulation.

Present Dynamics and the Future of the Niger Delta
During the Pleistocene lowering of the sea level, the River Niger cut wide valleys through its own delta. It progradated by depositing river sand in distributary channels on the delta and subsequent remobilization to basin floor as turbidites, filling of the channels as the sea level gradually rises in the post Pleistocene and redistribution of the sand by long shore drift to form beach ridges. As the Niger Delta continued to build across the continental margin and deposit thick sand bodies, subsidence by compaction and horizontal squeezing of the underlying mud deposits gave rise to delta rim mud diapirs on the continental slope.

Mud deposited on the continental shelf in front of this sand is of lower bulk density and as the high bulk density sand progrades mud is squeezed horizontally upward towards the delta rim in the subsurface to rise on the continental slope as mud diapirs (Burke, 1989). Basinward of the mud diapirs zone, deep-sea fan sands deposited from submarine canyons occur in the pro-delta mud (Akata Formation). Consequently, the deep-sea fan sands represent low-stand systems tracts and constitute the lowest units of the delta sequence. According to Merki, (1972); Morley and Guerin, (1996) and Corredor *et al*, (2005) the gravitational collapse of the delta gave rise to structural zonation. The zonations consist of an extensional zone with growth faults and rollover anticlines that resulted from deposition of sands (progradation) and compaction; a mud diapir zone located beneath the upper continental slope; an inner fold and thrust belt and an outer fold and thrust belt. At present the Niger Delta fits into a fluvial dominated delta with wave influence with the attendant development of fluvial channels with deposition of continental sand.

The future of the Niger delta can be predicted on the basis of historical and postulated assessment of tectonic uplift or subsidence, compaction subsidence, climatic changes and many other factors. The tectonic influence on the Niger Delta and Benue Trough were related to the transmitted movements along the Chain and Charcot fractures onshore of the African continent which at present are dormant, however movements of the fractures could reactivate the onshore faults as well as create tectonic subsidence or uplft. The trends of prograding and aggrading sand as is still taking place today would continue to induce subsidence by compaction with the creation of related structural features. The present and future climatic condition in the Niger Delta and indeed worldwide favours rise in sea level which may be related to global warming, melting of glacier as well as other climatic controls based on earth orbital cycles of precession, obliquity and eccentricity that also affect the climates of continents, the current systems of the ocean, the elevation of sea level (Einsele, 1982) and many other factors such as weathering, in situ sediment production (Najime *et al.*, 2006) as well as sediment routing in the basin. Consequently, the current trend of delta progradation may be reversed.

DISCUSSION

The formation of the Niger Delta is intimately related to the evolution of the Benue Trough while the formation of the Benue Trough is closely associated with the break-up of the Afro-Brazilian plate in the early Cretaceous. The Niger Delta being the entry point of transgression into the Benue Trough during the Cretaceous was a direct consequence of tectonic subsidence along the trough and the proto-Niger Delta. The Benue Trough was affected by the general rise of sea level from Albian to Early Cenomanian, Late Cenomanian to Early Turonian and Late Turonian to Campanian while the Anambra Basin was affected by the Campanian to Maastrichtian and Paleocene to Eocene regression. Tectonic uplifts along subsident areas along the trough during the Cenomanian, Santonian and Campanian and regression from Eocene to Pleistocene created the setting for the formation of the present Niger Delta. The dynamics between the receding Atlantic Ocean and the River Niger have since Eocene been depositing both marine and continental sediments to build the present Niger Delta. The Chain and Charcot fractures are presently covered with undisturbed sediments indicating no movements but movements along these faults which cannot be ruled out could create earth tremors, reactivate onshore faults with likely subsidence or uplift. Uplift would induce a more fluvial dominant environment with increase in distributary channels with increase in sand deposit while subsidence combined with the compaction subsidence would induce a relative sea level rise with increase in tidal influence. Sea level rise due to climatic influence in the

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

Niger Delta area would also produce increase in tidal influence and when combined with subsidence may lead to landward incursion of the sea (transgression) with consequent flooding of estuarine and island areas.

The Present Niger Delta evolved from complex interaction between tectonism, sedimentation and climatic influence resulting to relative sea levels (transgession/regression) and formation of different environments (paleobiogeography). Some of these factors are dormant while some are presently shaping and maintaining the biogeography of the delta. Future trends indicate that climate change combined with compaction and/or tectonic subsidence would create a relative sea level rise that would move the present fluvial dominated Niger Delta to a tidal dominated delta with all the attendant changes in the biogeography and economic activities.

REFERENCES

Abovbo, A. A. (1978). Tertiary lithostratigraphy of Niger Delta. *American Association of Petroleum Geologists Bulletin*, **62, 1,** pp. 295 – 306.

Allen, J. R. L. (1964). Nigerian continental margin. *Marine Geology.* 1. pp. 289-332

Agagu, O. K. and Adighije, C. I. (1983). Tectonic and sedimentation framework of the Lower Benue Trough, southeastern Nigeria. *Journal of African Earth Sciences* **1,** pp. 267 - 274.

Agagu, O. K., Fayose, E. A. and Petters, S. W. (1985). Stratigraphy and sedimentation in the Senonian Anambra basin of eastern Nigeria. *Nigerian Journal of Mining and Geology* **22**, pp. 377 - 385.

Ako, B. D., Ojo, S. B., Okereke, C. S., Fieberg, F. C., Ajayi, T. R., Adepelumi, A. A. and Ogunnusi, H.O. (2004). Some observations from gravity/magnetic interpretation of the Niger delta. Nigerian Association of Petroleum Explorationist Bulletin. **17**, **1**. Pp. 1-21.

Allix P. (1987). Le bassin d'Anambra: essai du caracterisation de l' évolution tectono-sedimentaire au Crétacé supérieur. *Bulletin des Centres de Recherches Exploration-Production Elf Aquitaine* **11,** pp. 158 - 159.

Asseez, L. O. (1989). Review of the stratigraphy, sedimentation and structure of the Niger Delta. In C. A. Kogbe (ed.) Geology of Nigeria. pp. 311- 324. Rock View (Nigeria) Limited, Jos. 2nd Edition.

Benkhelil, J. (1986). Structure et évolution géodynamique du basin intracontinental de la Bénoué (Nigéria) These de Doctorat Universitie de Nice, 226p.

Benkehlil, J. (1988). Structure et évolution géodynamique du basin intracontinental de la Bénoué (Nigeria). *Bulletin des centres de Recherches Exploration-Production Elf Aquitaine* **12,** pp. 29 - 128.

Burke, K. (1989). Neogene and quaternary tectonics of Nigeria. In C. A. Kogbe (ed.) Geology of Nigeria. pp. 445-

451. Rock View (Nigeria) Limited, Jos. 2nd Edition.

Burke, K. C. Dessauvagie, T.F.J. and Whiteman A. J. (1971). Opening of the Gulf of Guinea and geological history of the Benue depression and Niger Delta. *Nature* **233,** PP. 51 – 55.

Burke, K. C. Dessauvagie, T.F.J. and Whiteman, A. J. (1972). Geological History of the Benue Valley and adjacent areas. In: T.J.F. Dessauvagie and A.J. Whiteman, (eds.) African Geology pp. 187 – 206. University of Ibadan Press, Ibadan.

Corredor, F., Shaw, J. H. and Bibthi, F. (2005). Structural styles in the deepwater fold and thrust belts of the Niger Delta. *American Association of Petroleum Geologist*s *Bulletin*. **89,** pp. 753 – 780.

Cratchley and Jones (1965). An interpretation of the geology and gravity anomalies of the Benue Valley Nigeria. *Overseas Geological Survey's Geophysical Paper* **1,** pp. 1-26

Doust, H. and Omatsola, E. (1990). Niger Delta. In: J. D. Edwards and P. A. Santogrossi. (Eds) Divergent/Passive margin basins. *American Association of Petroleum Geologist*s Memoir. **48,** pp. 239 – 248.

Einsele, G. (1982). General remarks about the nature,occurrence and recognition of cyclic sequences (Periodites). In: G. Einsele and A. Seilacher (eds) Cyclic and event stratification. Pp. 3-7. Spriger-Verlag Berlin Heidelberg New York.

Evamy, B. D., Haremboure, J., Kammerling, P. Knaap. W. A., Molloy, F. A. and Rowlands, P. H. (1978). Hydrocarbon habitat of Tertiary Niger Delta. *American Association of Petroleum Geologist*s *Bulletin*. **62, 1,** pp. 1 – 39.

Frankl. E. J. and Cordry, E. A. (1967). The Niger Delta oil province: Recent developments onshore and offshore. *7TH World Petroleum Congress. Proceeding.* **2**. pp. 195-209.

Haak, R. C., Sundararaman, P.,Diedjomahor, J. O., Hiao, H., Grant N. J. May, E. D. and Kelsh, K. (2000). Niger Delta petroleum systems, Nigeria. In: M. R. Mello and B. J. Katz (eds) Petroleum systems of the South Atlantic margins. *American Association of Petroleum Geologists, Memoir.* **73,** pp. 213-231.

Hosper, J. (1965). Gravity field and structure of the Niger Delta, Nigeria. *Geological Society of America. Bulletin.* **76**, pp. 407-422.

Jubril, M. A., Shaw, H. F. and Fallick, A. E. (1998). Stable isotope and geochemical evidence of formation fluid evolution during diagenesis of Tertiary sandstones and mudstones of the Niger Delta. Journal of African Earth sciences. **27**, **2** and **4**. Pp. 417-435.

Knox, G. J. and Omatsola, E. M. (1989). Development of the Cenozoic Niger Delta in terms of the "Escalator Regression" model and impact on hydrocarbon distribution. In W. J. M. van der Linden et al. (eds) 1987,

Scientia Africana, Vol. 15 (No. 2), December 2016. Pp 42-55
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

Proceeding KNGMG Symposium on coastal lowlands. Geology, Geotechnology. Dordrecht, Kluwer Academic Publishers. pp. 181-202.

Kominz, M. A. (1984). Oceanic ridge volumes and sea level change - An error analysis In: Schlee J. S. (ed.) International unconformities and hydrocarbon accumulation. *Memoir American Association of Petroleum Geologists* **36,** pp. 109 - 127.

Lambert-Akhionabare, D. O. and Ibe, A. C. (1984) Petroleum source-bed evaluation of the Tertiary Niger Delta. *American Association of Petroleum Geologist Bulletin* **68**, pp.387-394.

Maron, P. (1969). Stratigraphical aspects of the Niger Delta. *Nigerian Journal of Mining and Geology*. **2**. Pp. 1-2

Morley, C. K. and Guerin, G. (1996). Comparison of gravity-driven deformation styles and behavior associated with mobile shales and salt. Tectonics, **15** pp. 1154-1170.

Merki, P. (1972). Structural geolgy of the Cenozoic Niger Delta. In: T.F.J. Dessauvagie and A. J. Whiteman, (eds.), *African Geology*, pp. 635 – 646. Ibadan University Press, Ibadan.

Murat, R. C. (1972). Stratigraphy and paleogeography of the Cretaceous and lower Tertiary in Southern Nigeria, In: T.F.J. Dessauvagie and A. J. Whiteman, (eds.), *African Geology*, pp. 251 – 266. Ibadan University Press, Ibadan.

Najime, T., Zaborski, P. M. and Abaa, S. I. (2006). Allocyclic control on the depositional sequence of the Gboko Formation, lower Benue Trough. *Borno Journal of Geology,* **4**, pp. 56-69.

NEDECO (Netherlands Engineering Consultants), (1954). Western Niger Delta. The Hague. 57 p.

NEDECO (Netherlands Engineering Consultants), (1961). The waters of the Niger Delta. The Hague. 317 p.

Ojoh, K. A. (1990). Cretaceous geodynamic evolution of the southern part of the Benue Trough (Nigeria) in the equatorial domain of the South Atlantic. Basin analysis and Paleo-oceonography. *Bulletin des Centres de Recherches Exploration-Production. Elf - Aquitaine* **14,** pp. 419 – 442.

Onuoha, K. M. (1999) Structural features of the Nigeria's coastal margin: an assessement based on age data from wells. *Journal of Earth Sciences.* 29, 3. Pp. 485-499.

Reijers, T. J., Petters, S. W. and Nwajide, C. S. (1997). The Niger Delta Basin. In R. C. Selley (eds) African Basins: Sedimentary basins of the World. 3 Elsevier Science, B. V., Amsterdam. Pp 151-172.

Reyment, R. A. (1965). *Aspects of the geology of Nigeria*, Ibadan University Press, Ibadan. 154 pp.

Reyment, R. A. and Mörner, N. A. (1977). Cretaceous transgressions and regressions examplied by the South Atlantic. *Paleontological Society of Japan, Special Paper* **1**, pp. 247 – 261.

Short, K. C. and Stauble, A. J. (1967). Outline of the geology of Niger Delta.

American Association of Petroleum Geologists. Bulletin. 51. PP. 761-779.

Stoneley, R. (1966). The Niger Delta region in the light of the theory of continental drift. *Geological Magazine* **103,** pp. 385 – 397.

Sibuet, J. C. and Mascle J. (1978). Plate kinematic implication of Atlantic equatorial fracture zone trends. *Journal of Geophysical Research.* **83**, pp. 3401– 3421.

Watts, A. B. and Steckler, M. S. (1979). Subsidence and eustacy at the continental margin of eastern North America. In: Talwari, O N. Hay, S. and Ryan W.B.F (eds.) Deep drilling results in Atlantic Ocean continental margins and paleoenviroment. *American Geophysical Union* **3,** pp. 218 - 234.

Weber, K. J. (1971). Sedimentological aspects of oilfields in the Niger Delta. *Geology en Mijnbouw.* 50, pp. 559-576.

Zaborski, P. M. (1998). A review of the Cretaceous System in Nigeria. *Africa Geoscience Review* **5,** pp. 385-483

Zaborski, P. M. (2000). The Cretaceous and Paleocene transgressions in Nigeria and Niger. *Journal of Mining and Geology* **26,** pp. 153 – 173.