Original Article

Geology

Inventory of the Quaternary Geology and the Evolution of the Oguta Lake, in Southeastern Nigeria

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ABSTRACT [ENGLISH/ANGLAIS]

Individual and/or combined contributions of globally accepted processes of natural lake formation were investigated and used in consonance with field observations to propose a geologic setting for the genesis and evolution of the Oguta Lake. Results suggest that combined structural and fluvio/hydrodynamic forces initiated its formation during the Wurm-Wisconsin (10,000 YBP) eustatic low sea level that affected the Guinea Coast. The resultant base level incision of the Niger and Njaba Rivers and subsequent aggradations of thick sandy alluvium during eustatic Flandrian transgression, would have caused, the Njaba R. to erode its valley into a 'U' shape around the Oguta area. The valley was further aggravated by instability, resulting from subsurface growth faults common within the Niger Delta. Around Oguta, both Rivers could have deposited enough sediments to choke their passage, resulting in meandering, braiding and ox-bow lakes. The depressions formed by natural levees and the outer margins of the floodplains then became filled with water, and then the coalescence of a number of ox-bow lakes from the wailing Niger and Orashi Rivers resulted in the Oguta Lake. Alternatively, the Awbuna and Utu Rivers could have built deposits across the Njaba R. valley to pond it or the latter could have aggravated its valley flow more rapidly than its two tributaries and ended up being ponded. Hydrodynamics between sedimentation and erosion under varying climatic conditions broke the empoundment at the western end into an outflow route, which eventually was captured by a fast flowing Orashi R., giving birth to the Oguta Lake System.

Keywords: Oguta lake, Nigeria, quaternary geology, evolution

RÉSUMÉ [FRANÇAIS/FRENCH]

Les contributions individuelles et / ou combinée des processus de formationmondialement acceptée lac naturel ont été étudiées et utilisées en accord avec les observations de terrain à proposer un cadre géologique de la genèse et l'évolution du lacOguta. Les résultats suggèrent que combinée des forces structurelles et fluvio /hydrodynamiques lancé sa formation durant le Wurm-Wisconsin (10.000 YBP) eustatiquedu niveau des mers à faible qui a touché la côte de Guinée. L'incision de base résultanteniveau des fleuves Niger et Njaba et aggradations ultérieure des alluvions sableusesd'épaisseur pendant la transgression flandrienne eustatique, aurait causé, le R. Njaba à éroder sa vallée en forme de «U» autour de la zone Oguta. La vallée a été encore aggravée par l'instabilité, résultant de défauts de croissance du sous-sol commun dans le delta du Niger. Autour Oguta, les deux fleuves pourrait avoir assez de sédiments déposésà étouffer leur passage, résultant en méandres, de tressage et de bras morts du fleuve.Les dépressions formées par des digues naturelles et les marges extérieures des plaines inondables, puis se remplit avec de l'eau, puis la coalescence d'un certain nombre debras morts du fleuve du Niger et des lamentations Rivers Orashi entraîné dans le lacOguta. Alternativement, les rivières et les Awbuna Utu aurait pu construire des dépôts à travers la vallée d'Njaba R. étang, il ou celui-ci pourrait avoir aggravé son flux vallée plus rapidement que ses deux affluents et a fini par être accumulée. Hydrodynamique entre la sédimentation et l'érosion dans diverses conditions climatiques brisé le empoundment à l'extrémité ouest dans une voie d'écoulement, qui a finalement été capturé par un jeûne R.coule Orashi, donnant naissance au Système Oguta lac.

Mots-clés: Oguta lac, le Nigeria, la géologie du Quaternaire, l'évolution

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INTRODUCTION

Most studies carried out so far on Oguta Lake like all others are principally on two subject matters; agriculture and recreation, and a few on the chemistry and biological importance. Omin [1], for example identified the phytoplankton community; Ita [2] identified the primary productivity of the Oguta Lake, while Nwadiaro [3, 4] identified the taxonomic composition and nutrients of the algal jellies.

The interpretations of their observations are considered incomplete without a multidisciplinary approach, including the geology of the Lake. Eutrophication and

trophic studies of lakes on a karst lithology for example, would be erroneous if the interpretations are strictly based on paralimnetic sources. The thrust of this paper thus, is to present an inventory of the geologic setting and evolution of the Oguta Lake.

Quaternary deposits of Nigeria are distributed in three main locations: In the Chad Basin, in the Guinea Coast and on the pediments, including the alluvium on River Valleys such as, the R. Niger, R. Imo and R. Njaba, which hosts the Oguta Lake [5, 6], Figure 1). Oguta Lake is the largest natural lake in Imo State, Southeastern Nigeria. It is bounded by Latitudes $5^{0}41'$ to $5^{0}44'$N and Longitudes $06^{0}41'$ and $06^{0}50'$E, with an elevation of 50m above sea level. It occupies a surface area ranging between 1.8km^2 and 2.5km^2, a shoreline length of 10km, and maximum and mean depths of 8.0m and 5.5m respectively.. The sketch map of the Oguta Lake and overview of the lake are presented in figures 2 and 3 respectively.

The lake is of immense value to the indegenes, because they draw their water from it, get 80% of their protein from it. The lake serves as a septic pool for domestic urban sewage. The local people also dredge the lake for sand, which is used in the construction industry.

GENERAL THEORIES ABOUT THE EVOLUTION OF LAKES

Many scientific theories abound today to explain the genesis of lakes. These include the following; structurally-related basins, marine, solution basins, glacial basins, wind deflation basin, volcanic, landslide-derived basins and basins developed in response to fluvial dynamics [7]). A review of these existing theories was carried out and using elimination process based on field observations, in line with the geology of S.E. Nigeria, the most likely geologic setting for the evolution of the Oguta Lake was arrived at.

Figure 1: This figure shows geologic map of Nigeria showing Quaternary Deposits (Modified from Durotoye [6])

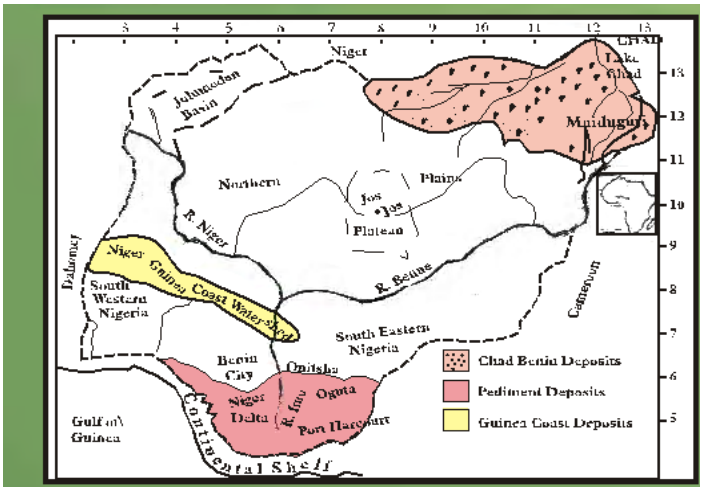


Figure 2: This figure shows, inset, map (Nigeria) showing the location of the Lake (Modified from Nwadiaro [3]

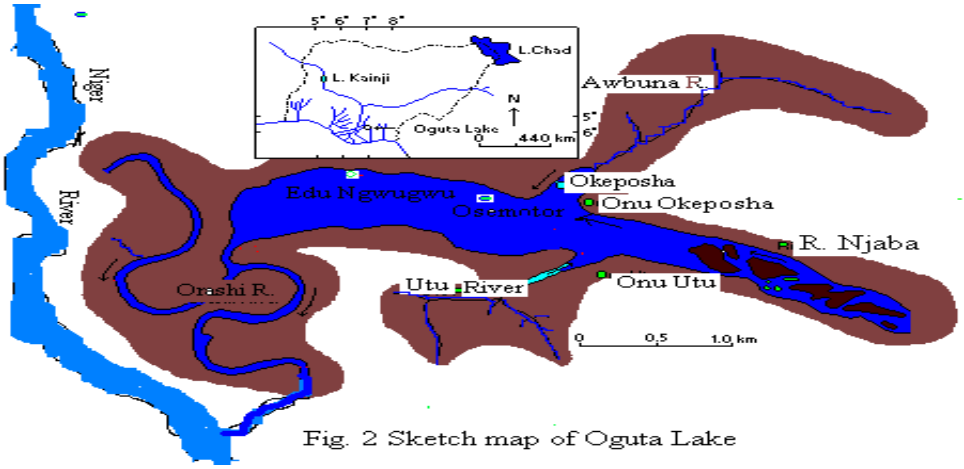


Fig. 2 Sketch map of Oguta Lake

Figure 3: This figure shows an overview of the Oguta Lake (Modified from Nwadiaro [3])

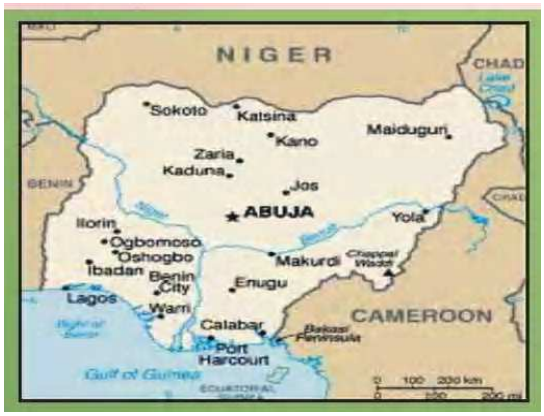
The location of the Lake in the tropical rainforest far from the desert influence alienates the possibility of wind deflation to have been at the origin of the lake. Also, the absence of carbonate and igneous rocks in and within the immediate vicinity of the lake means it is neither a solution basin lake, nor is it directly/remotely connected to any known volcanic activity. The distance of the lake from the Atlantic Ocean, makes any connection with marine origin (via a lagoon) less unlikely, because it is a fresh water lake.. Even if there were some evidence of marine fauna/flora, marine transgression and avian contributions cannot be excluded, thus making ponding of the basin a post formation event and not a contemporaneous activity as would a lagoon. The elevation of the Oguta Lake above sea level is about 50m, and an absence of elevated landmasses in form of hills and mountains in that vicinity, makes the landslide model unlikely to have contributed to the creation of the lake. The glacial model for lake formation on the other hand requires depressions and valleys as products of erosion, which are, later on filled with glacial water. Irregular glacial deposits in front of the glacial waters and surrounding the depressions act as barriers to further water flow, and hence give birth to glacial lakes, a common feature with the Great Lakes of North America. The size and depth of the lake could have been aggravated by broad warping of the crust during glacial periods. Evidence of a glacial connection with Oguta Lake remains remote, except proved by data (varves and from ^{18}O and ^{16}O ratios).

GEOLOGIC MODELS FOR THE FORMATION OF OGUTA LAKE

By the Upper Eocene, the Niger Delta front passed from Aboh through Oguta to Orlu and resulted in the creation of the Ihuo embayment [6] . Furthermore, the Oguta area was seriously affected by the Cenozoic faults whose trends exhibit a general E-W orientation [6]. These observations lend credence to faulting (structural model) as an initiator/contributor to the evolution of the Oguta Lake.

The Wurm-Wisconsinian eustatic low sea levels that affected Guinea Coast, caused rivers and streams like Rivers Niger and Imo and their tributaries to respond to it by a fall in the height of their base levels of erosion as they incised deeply into their valleys [5, 8].

Figure 4: This figure shows position of the gulf of guinea where eustatic sea level drops in the coast were initiated Longwell et al. [9])

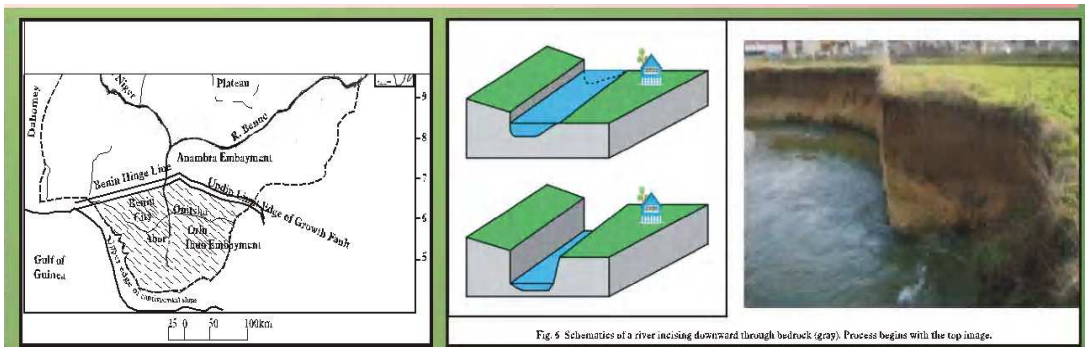


The subsequent rise in eustatic sea level during the Flandrian transgression also helped to increase the height of the base level of erosion. The rivers responded by aggrading their stream beds, burying their entrenched valleys by the accumulation of thick sandy alluvium. By this postulation, the earliest age of the depression that now hosts the Oguta Lake and its sediments is Wurm-Wisconsinian (about 10,000 YBP).

The stream/fluvial model, thus, seems to be the best model/contributor, that accounts for the formation of the Oguta Lake, more that any other else. Invoking this

model, it is conceptualized that the Niger, Njaba, Utu, Awbuna and the Orashi Rivers played very crucial roles in the formation of the lake. Field relationships further show that the immediate vicinity of the Lake is characterized by numerous networks of river meandering, ox-bow lakes, natural levees at low gradients.

Figure 5: This figure shows structural depressions and embayment at Ihou and Oguta; Niger Delta Cenozoic Fault Trends passing through the study area (5a), proggrssive development of river incision (5b and 5c). (Modified from Longwell et al. [9])



(a) (b) (c)

Figure 6: This figure shows hypothetical schematic for R. Njaba incision

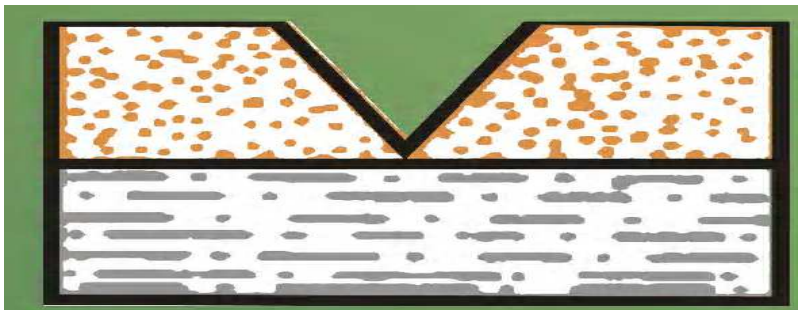
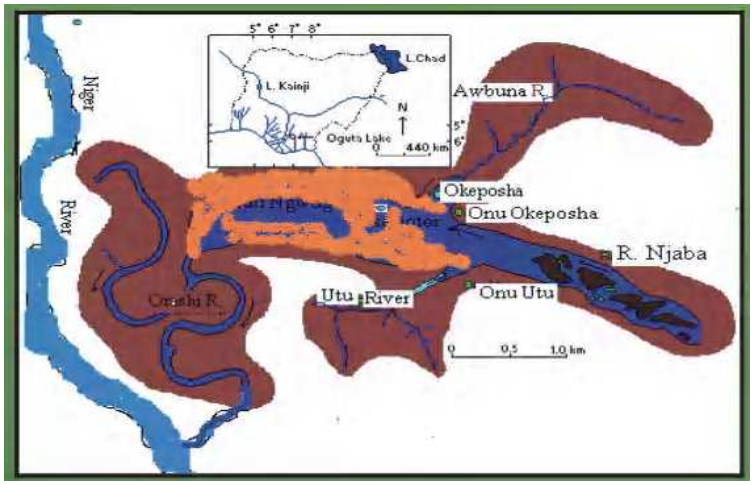


Figure 7: This figure shows R. Awbuna and Utu aggrading across the R. Njaba to form the Oguta lake (a hypothetical diagram, modified from Nwadiaro [3])



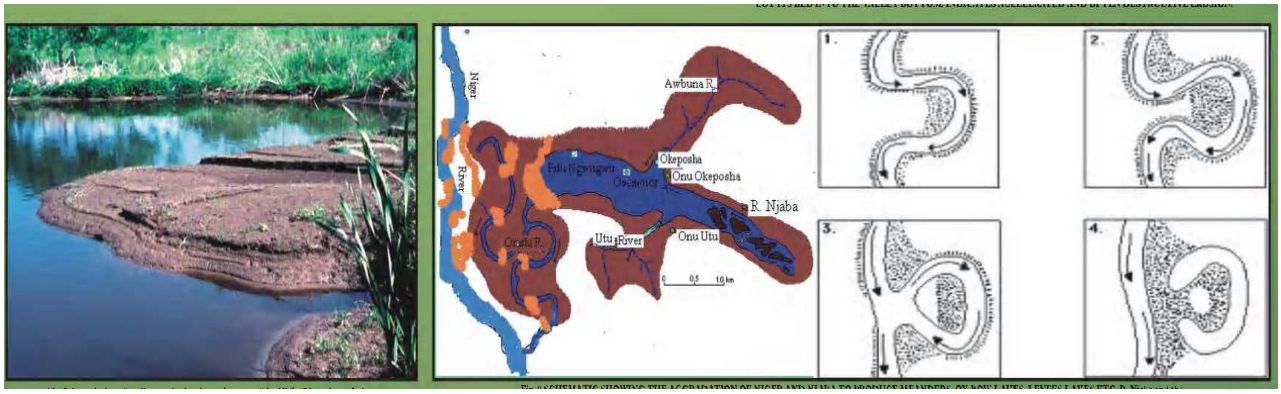
Applying this model, R. Njaba during the Flandrian transgression, could have aggraded at its mature stage, thus choking its passage and leading to the development of meanders. Later on, the river could have established normal flow by eroding its valley into a U-shape around these low gradient plains of the Oguta area. The valley could have been further aggravated by instability resulting from faulting in the subsurface, associated with the Niger Delta growth faults.

As a consequence of meandering, ox-bow lakes were left in the meanders abandoned by the cut-off process and in abandoned temporary channels excavated during flood (slough lakes formation). Additionally, in such a floodplain, depressions formed between natural levees and the outer margins of the floodplains were later filled by large pools of water.

The hydrodynamics in the area could have progressed in a way that, the tributaries of R. Njaba, (i.e. R. Awbuna and R. Utu) could have built deposits across the valley of R. Njaba to pond it into the present Oguta Lake.

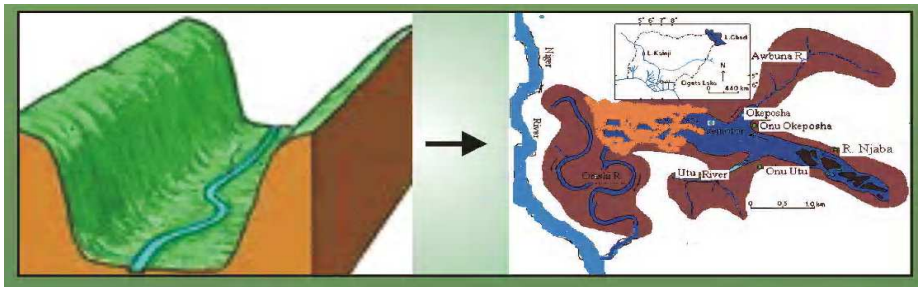
If however, for some reasons, this situation was reversed and R. Njaba aggraded its valley flow more rapidly than both R. Utu and R. Awbuna, these tributaries could have ended up being eroded and then ponded to form the Oguta Lake. The lake thus became a large receptacle for sediments, from the Njaba and its tributaries; but as the dynamics between sedimentation and erosion continued and under varying climatic conditions, the empoundment was broken at the western-end to form an outflow route, which eventually was captured by a fast flowing Orashi River.

Figure 8: This figure shows Aggradation of sediments in the channel centre of the R. Njaba (a). Schematic conceptualization for the aggradation by R. Niger and R. Njaba to produce meanders, ox-bow lakes, levees, lakes etc. (b, c). R Njaba and R. Niger during the Flandrian transgression, could have aggraded at their mature stages, thus choking their passages (the light brown colour) and leading to the development of meanders. Aggradation, the process by which a stream gradient steepens due to increased deposition of sediments (a).



(a) (b) (c)

Figure 9: This figure shows incision of the r. Njaba (a) and subsequent self-ponding (b) (a hypothetical diagram)

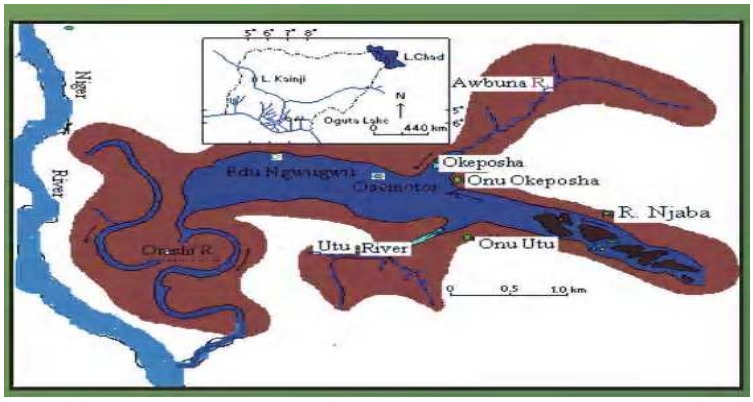


(a) (b)

This makes Oguta Lake a hydrodynamically open lake system in which inflow and precipitation are balanced by outflows. The contributions of sediments deposited by the wailing R. Niger and the Orashi, which exhibit

numerous sand bars and abandoned channels cannot be overlooked. A coalescence of a number of resultant ox-bow lakes and slough lakes could have resulted in the empoundment now known as the Oguta Lake.

Figure 10: This figure shows breaking of impoundment by the Njaba R. to meet the Orashi R. and its capture; hence its present state, with eroded sediments constituting its banks - accumulated from built up levees (a hypothetical diagram, modified from Nwadiaro [3]



CONCLUSION

Of all the existing models that explain the formation of lakes worldwide, field relationships, local and regional geology suggest that the fluvial and structural (faulting) models offer the most acceptable explanations for the formation of the Oguta Lake. A Wurm-Wisconsinian to Flandrian age (10,000YBP) is suggested for the Lake. It is believed that the results of this study will act as a catalyst, to reawaken the interest of geologists in lacustrine studies, as well as offer a much more robust scientifically comprehensive knowledge of the Quaternary geology of the Lake.

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CONFLICT OF INTEREST

No conflict of interests was declared by authors