https://dx.doi.org/10.4314/ijs.v25i1.4

PALEOBIOGEOGRAPHIC AFFINITIES AND PALEOECOLOGICAL SIGNIFICANCE OF PALEOGENE OSTRACODS FROM EASTERN BENIN BASIN, SOUTHWESTERN NIGERIA

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(Received: 23rd November, 2022; Accepted: 30th March, 2023)

ABSTRACT

Ditch cutting samples from the studied section of the RC-4 Hole, eastern Benin (Dahomey) Basin were studied for their ostracod content. 3671 ostracod fauna belonging to 22 species were recovered and analysed with a view to determining ostracod paleobiogeographic affinities and paleoecological conditions within this part of the basin during the Paleogene. Ostracod assemblages of the studied section bear close affinities to those of some North and West African basins. Species such as *Bairdia ilaroensis, Leguminocythereis* spp., *Bairdia malzi, Paracosta kefensis, Xestoleberis tunisiensis, Buntonia jordanica, Aegyptiana duwiensis* and *Leguminocythereis lokossaensis* identified from the RC-4 hole suggest shallow neritic conditions. *Paracosta kefensis* and *Paracosta parakefensis* occur in high abundance indicating marine upwelling conditions. Many of the species recovered in this study have also been identified from Iullemeden and southern Tethys basins (e.g. Sirte Basin) suggesting ostracod migration from Benin Basin (Gulf of Guinea) to southern Tethys basins through the Paleogene shallow Trans – Saharan Seaway. A distinct ostracod turnover at the top of the limestone unit (Ewekoro Formation) is related to the Paleocene-Eocene Thermal Maximum (PETM) – a climatic phenomenon characterised by 5 – 8 °C global temperature rise at the end of the Paleocene.

Keywords: Ostracod, Paleogene, Paleobiogeography, Paleoecology, Benin Basin, Nigeria.

INTRODUCTION

The pioneering works of Reyment (1960, 1963) on ostracod assemblages of the Upper Cretaceous to Paleogene sections of Nigerian basins and Apostolescu (1961) on ostracod paleontology and stratigraphy of Western Dahomey Basin appear to have set the stage for the investigation of ostracod assemblages in West African sedimentary basins. Following the works of Reyment (1960, 1963) and Apostolescu (1961), several other ostracod studies have been carried out on the region's basins (Diop *et al.*, 1982; Foster *et al.,* 1983; Okosun, 1987; Carbonnel and Oyede, 1991; Digbehi *et al.*, 1994; Sarr, 1998, 2012, 2013).

Ostracod assemblages are proxies to understanding certain ecological / paleoecological conditions such as depth, temperature, turbulence, dissolved oxygen content (Youssef *et al.,* 2017) and are excellent indicators of ancient seaways (Elewa, 2002; Morsi *et al.*, 2011; Youssef *et al.,* 2017). The assemblages of West African basins have been compared to those of North Africa. Barsotti (1963) inferred a link between West African coastal basins, Sirte and Libya basins via the Trans – Saharan Seaway during the Paleogene. Reyment and Reyment (1980) identified diverse ostracod taxa from the Iullemeden and Dahomey basins and noted that some of the species are common to Trans – Saharan and North African basins. Based on this close faunal affinity, the authors posited a Paleogene ostracod migration from the Gulf of Guinea to southern Tethys basins (e.g. Sirte Basin) through the Trans – Saharan Seaway. Ostracod species similar to those of the Sirte and Dahomey basins were identified from Mali and Niger by Carbonnel *et al.* (1990), therefore lending credence to a Trans – Saharan migration route. Studies on ostracod assemblages from the Southeastern Desert of Egypt also supports faunal exchanges between these regions (Speijer and Morsi, 2002; Morsi and Speijer, 2003). A possible migration of few ostracod species along the West African coast to southern Tethys (North Africa) is however not precluded.

In this present study ostracod assemblages similar to those of North African and other West African basins were identified from the RC-4 Hole situated in the Nigerian portion of the Benin Basin, on Km 46, Lagos – Ibadan Expressway (Figure 1). This provides further insight into the paleoecological conditions of deposition, ostracod faunal exchange among, and migration route within African Basins during the Paleogene.

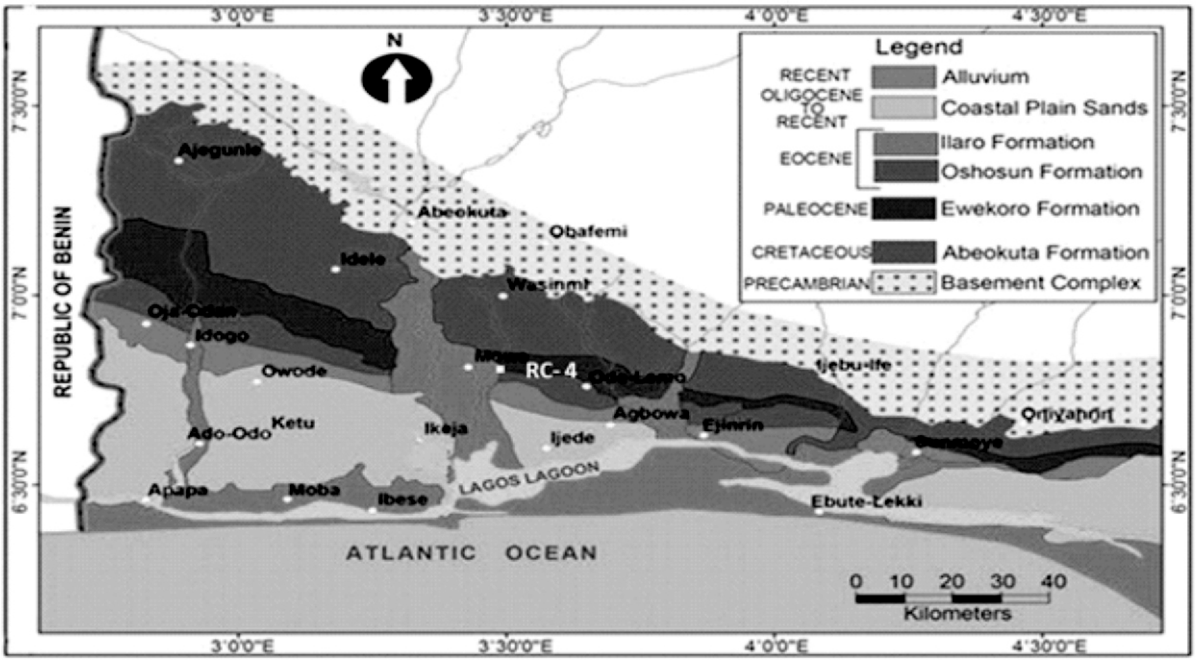

Figure 1. Geological map of eastern Benin Basin indicating the RC-4 Hole (After Billman, 1976).

Geologic framework of the study area

The tectonic framework of the Benin Basin has been the subject of discussion in a number of research papers (Billman, 1976; Omatsola and Adegoke, 1981; Adediran and Adegoke, 1987). The Gulf of Guinea in which the Benin Basin is situated has gone through phases of evolution which can be summarized as follows:

- Intracratonic stage: deposition of mainly angular to subangular sands and fresh water shale (Adediran and Adegoke, 1987).
- Syn-rift stage: characterized by episodes of tectonic activities, erosion, sedimentation and deposition of fluvio-lacustrine sediments.
- Deposition of marine sediments (shale, sands and evaporites). The deposition of fossil rich marine sediments signaled the end of the basins' evolution.

The Benin or Dahomey Basin consist of thick succession of sediments which Omatsola and Adegoke (1981) divided into two groups as follows: The Cretaceous Abeokuta Group and Paleogene – Neogene sequences. The Abeokuta Group consist of the Ise, Afowo and Araromi formations (from the oldest to the youngest). The Paleogene – Neogene (Tertiary) sequences comprise the Ewekoro, Akinbo, Oshosun, Ilaro, Ogwashi - Asaba and Benin formations.

The sedimentary sequence encountered in the RC-4 Hole (Figure 2) consists four formations, from base to the top as follows: The Araromi, Ewekoro, Akinbo and Oshosun formations. The Araromi Formation is represented by over 50 m thick fossiliferous shaly sand unit in the Hole.

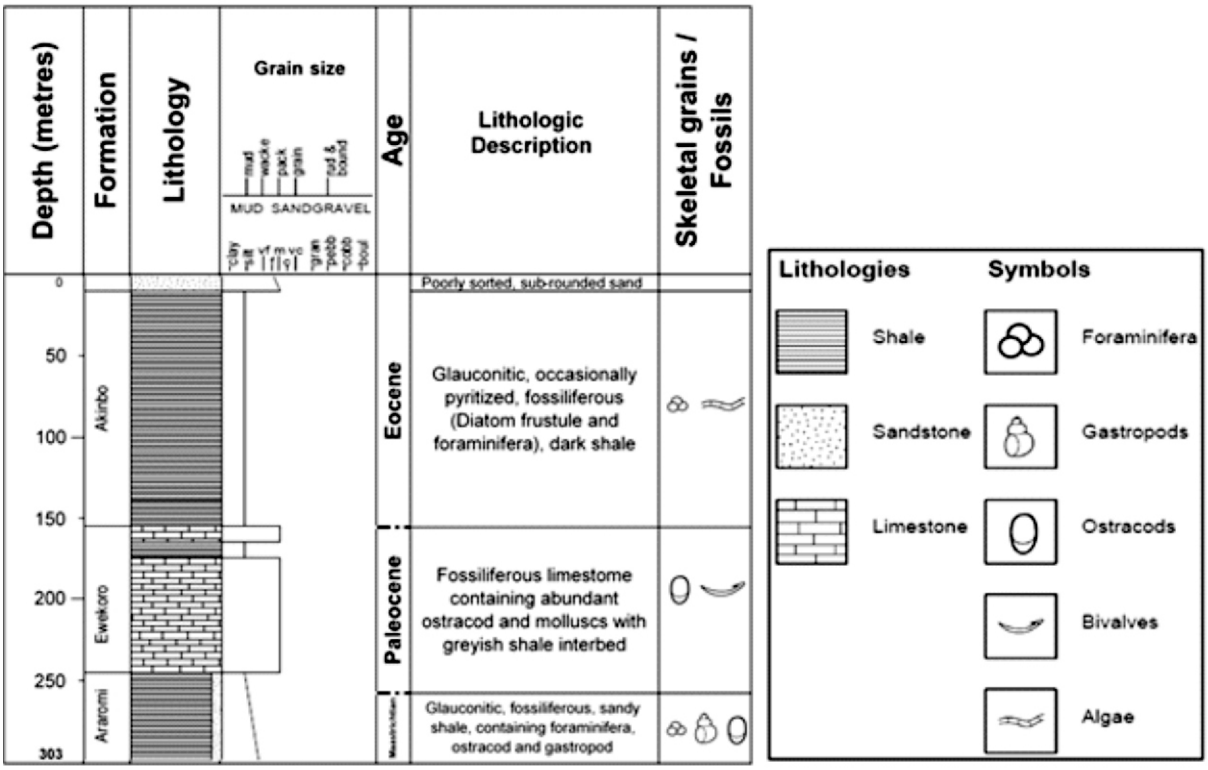

Figure 2. Lithostratigraphic units encountered in the RC-4 Hole, eastern Benin Basin

The Ewekoro Formation comprises about 85 m of limestone containing glauconitic sands and abundant fossils. The unit contains rich Paleocene foraminifera, ostracod and gastropod assemblages with grey shale interbed. Overlying the limestone unit is a 135 m sequence of greyish shale which contains foraminifera and moderately abundant diatom frustules. The shale is overlain by about 10 m of reddish, poorly sorted, subrounded sands referred to as the Oshosun Formation.

MATERIALS AND METHODS

Twenty-seven subsurface samples collected at an average intervals of 10 m over a depth of 303 m were processed following the ostracod / foraminiferal sample processing procedures of Nagy *et al.* (1988). A 35 g quantity of each sample was soaked in soapy water having been treated with kerosene to aid disaggregation.

The samples were thereafter washed through a 63 μm sieve and resultant residues were dried in a temperature controlled blast air oven. Ostracods were recovered from the residues under binocular reflected light microscope. Species were identified using published photomicrographs in Morsi and Speijer (2003) and Youssef *et al.* (2017).

RESULTS

Ostracod Distribution

Analysed samples from the RC-4 yielded rich assemblages of ostracod. Three thousand, six hundred and seventy one (3671) ostracod individuals belonging to 22 species were recovered (Table 1). Ostracod were recovered mainly from interval 168 – 267 m (Figure 3). The limestone and basal shaly sand (Ewekoro and Araromi Formations) of the borehole section yielded more counts of ostracod than the shale unit up hole. The upper shale unit is impoverished of ostracods with only single occurrences of *Ordoniya bulaqensis* and *Nigeroloxoconcha aegyptiaca* at sample depths 41 and 96 m, respectively.

The ostracod assemblages are dominated by *Nigeroloxoconcha aegyptiaca, Paracosta kefensis, Cytherura* spp.*, Ordoniya bulaqensis, Bythocypris* spp.*, Paracypris* spp. and *Cytherella cf. farafraensis*. Each of these species show highest abundance counts in excess of 200 specimens and occur almost exclusively within the lower 150 meters of the Hole. Conversely, *Ovocytheridea* spp., *Mauritsina coronata*, *Buntonia jordanica*, *Xestoleberis* spp. and

Oertliella posterotriangulata show sparse occurrences within the borehole section. Sample 303 m, which is the deepest sample studied in the hole is devoid of ostracod. Peak abundances occur at sample depths 222 and 267 m with well over 1000 specimen counts. Sample depth 213 m show highest diversity of assemblage with 10 ostracod species occurring at this depth (Table 1 and Figure 3).

Table 1: Ostracod abundance / diversity counts in RC-4 Hole, eastern Benin Basin.

Depth (m)	3	15	45	54	75	87	96	111	125	138	147	159	168	177	186	195	204	213	222	231	240	249	258	267	303	Total abundance / diversity count
Ostracod abundance count	0	0	1	0	0	0	1	0	0	0	0	0	40	327	42	81	2	133	1060	377	149	150	40	1267	0	3671
Ostracod diversity count	0	0	1	0	0	0	1	0	0	0	0	0	7	7	8	6	3	10	6	8	7	7	7	8	0	22

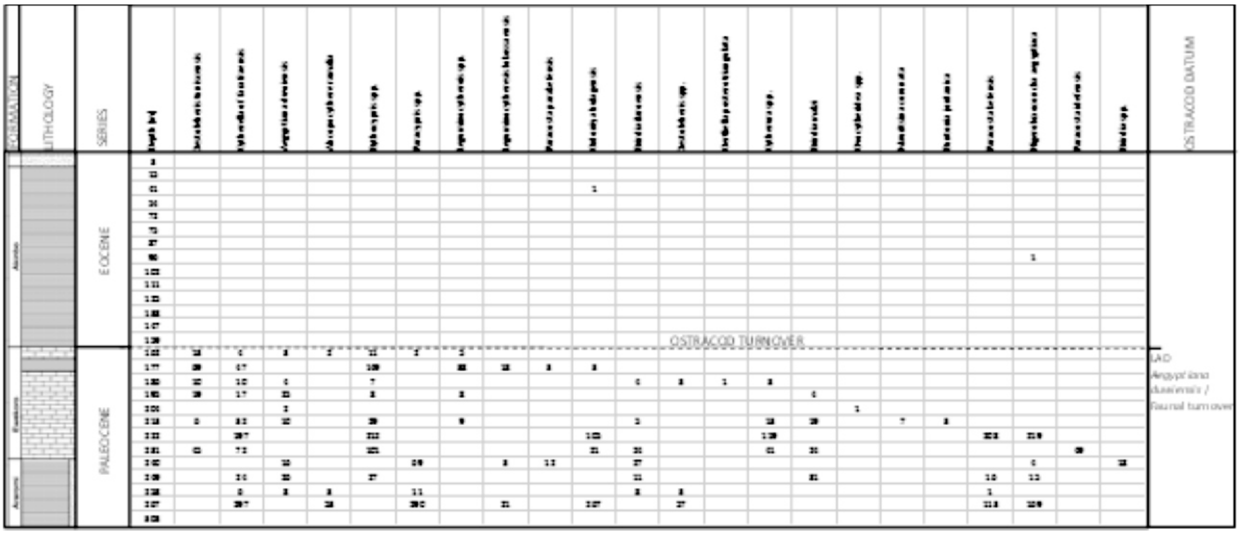

Figure 3. Stratigraphic distribution of ostracods in the RC-4 Hole, eastern Benin Basin.

DISCUSSION

Ostracod biostratigraphy

The samples from the RC-4 Hole yielded rich assemblages of Paleocene - Eocene diagnostic ostracod species such as *Bairdia ilaroensis, Leguminocythereis* spp.*, Bairdia malzi, Paracosta kefensis, Xestoleberis tunisiensis, Buntonia jordanica, Aegyptiana duwiensis* and *Leguminocythereis lokossaensis*. Morsi and Speijer (2003) identified similar assemblages in the Southeastern Desert of Egypt and dated the section Paleogene (Paleocene – Eocene). The Paleocene - Eocene index species identified in the studied hole were abundantly recovered from the limestone unit believed to be the Ewekoro Formation. The Ewekoro Formation have been previously dated Paleocene – Eocene by Okosun and Alkali (2012) based on ostracod assemblages.

The Paleocene – Eocene boundary in the studied section is marked by the last appearance datum (LAD) of *Aegyptiana duwiensis* and a marked ostracod turnover at 162 m (Figure 3). In a foraminiferal study by Adebambo *et al*., (2022) on RCCG BH-4, a borehole in the neighborhood of RC - 4, the authors noted similar turnover in foraminiferal assemblages. The turnover event also coincide with the Last Appearance Datum of *Morozovella acuta*. This datum marks the Paleocene – Eocene boundary (Toumarkine and Luterbacher, 1985). Morsi and Speijer (2003) on ostracod biostratigraphy of Paleocene Southeastern Desert of Egypt observed that the Paleocene – Eocene boundary is characterized by a marked faunal turnover.

Paleoecological interpretation of ostracod assemblages

The distribution of ostracod assemblages are controlled by water mass conditions which include depth, temperature, turbulence and dissolved oxygen content (Youssef *et al*., 2017). The ostracod assemblages of the RC-4 are characteristic of Paleogene warm water inner to middle shelf meiobenthic communities (Morsi *et al*., 2011; Youssef *et al*., 2017). Some taxa such as *Bairdia ilaroensis, Leguminocythereis lokossaensis, Paracosta parakefensis, Oertliella posterotriangulata* and *Ordoniya bulaqensis* are restricted to inner – outer shelf settings (Morsi *et al*., 2011). *Paracosta kefensis* and *Paracosta parakefensis* occur in high abundance. These species are believed to flourish in upwelling conditions in the late Paleocene middle neritic settings of El Kef, Tunisia. They probably indicate enhance food availability in the form of labile organic matter and reduced oxygen levels (Peypouquet *et al*., 1986, 1988).

The ostracod turnover observed in the RC-4 Hole could be ascribed to the environmental perturbations characteristic of the Paleocene – Eocene transition (Morsi and Speijer, 2003; Adebambo *et al*., 2022) and a switch in water mass conditions triggered by a brief but drastic global temperature rise at about 55 Ma (end of the Paleocene). This warming have been attributed to massive outpouring of methane gas from the sediments of the continental margins (Dickens *et al*., 1995; Katz *et al*., 1999). These oceanic and climate perturbations resulted in significant biotic catastrophic events. Marked ostracod turnover have also been reported from Paleogene shelf settings in Egypt (Speijer and Morsi, 2002). Similar observation was made on foraminiferal taxa distribution in the RCCG BH-4 borehole in which marked foraminiferal turnover occurred at 168 m (Adebambo *et al*., 2022).

Paleobiogeographic affinities

The paleobiogeographic distribution of ostracods gives important information about their marine connection, probable migration routes, and facies relationships. There are two main Paleogene biogeographic provinces for ostracods: the Southern Tethys province and West African province. These two provinces were linked during the Paleogene (Paleocene – Eocene) through the Trans-Saharan Seaway (Figure 4) (Keen *et al*., 1994; Elewa, 2002, Speijer and Morsi, 2003). Some of the ostracod species (e.g. *Bairdia ilaroensis, Leguminocythereis lokossaensis* and *Paracosta kefensis*) from the RC-4 Hole have wide paleogeographic distribution along the West African coast through Mali to Egypt and the Southern Tethys region suggesting faunal exchange between the two regions (Reyment and Reyment, 1980; Elewa, 2002, Morsi and Speijer, 2003; Youssef *et al*., 2017). Foraminiferal data from Speijer *et al*., (1996) and Adebambo *et al*., (2022) also indicated foraminiferal faunal similarity between the two provinces thereby lending credence to the presence of a link between the provinces during the Paleocene – Eocene epoch.

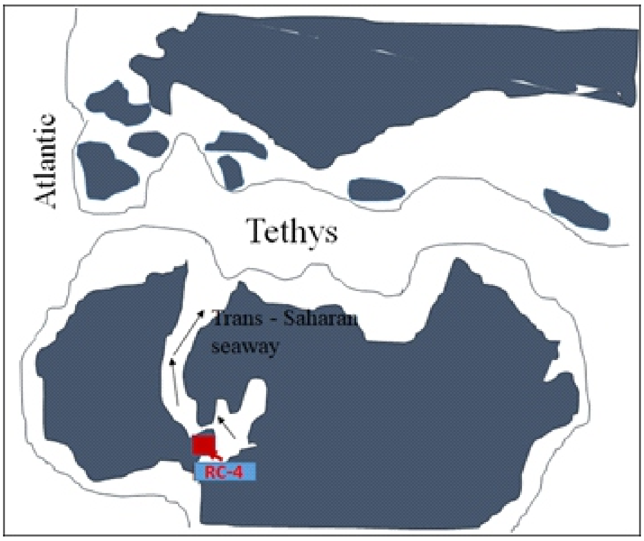

Figure 4. Trans – Saharan migration route of Paleogene faunas from Central West African basins to North African basins (Adapted from Morsi and Speijer, 2003).

Thirteen ostracod species recorded in this study have been identified by Morsi and Speijer (2003) in the Southeastern Desert of Egypt. The species are: *Cytherella cf. farafraensis, Bairdia ilaroensis, Bairdia malzi, Bairdia* spp.*, Alocopocythere ramalia, Leguminocythereis lokossaensis, Nigeroloxoconcha aegyptiaca, Mauritsina coronata, Aegyptiana duwiensis, Oertliella posterotriangulata, Paracosta kefensis, Paracosta parakefensis* and *Xestoleberis tunisiensis*. Thus there is a strong resemblance between the ostracod assemblages of West African coast and those of North Africa indicating marine connection and faunal migration between the two areas. This migration occurred through the shallow marine Trans-Saharan Seaway (Reyment and Reyment, 1980; Bassiouni and Luger, 1990; Youssef *et al*., 2017).

Some of the ostracod taxa of the West African coast as recorded from the RC-4, e.g. *Bairdia ilaroensis, Leguminocythereis lokossaensis, Paracosta parakefensis*, *Mauritsina coronata*, *Oertliella posterotriangulata* and *Paracosta kefensis* are shallow marine inner – middle neritic) hence were able to migrate along the shallow Trans-Saharan Seaway. Deep water form (outer neritic – upper bathyal), *Nigeroloxoconcha aegyptiaca* appear to have migrated through the South Atlantic along the West African coast as the shallow marine Trans-Saharan Seaway may have acted as a barrier to its migration during the Paleogene (Paleocene – Eocene) (Sarr, 2015; Youssef *et al*., 2017). The occurrence of these deep water species in the Senegal – Mauritanian Basin support this possible migration route (Sarr, 2015). The ostracod migration is related to the climatic and water mass changes associated with the Paleocene – Eocene Thermal Maximum (Morsi *et al*., 2011).

CONCLUSION

The analysis of the rich Paleogene ostracod assemblages of the RC-4 Hole, eastern Benin Basin allows for the following conclusions:

1. The assemblages are characteristic of the inner to outer neritic meiobenthic communities as indicated by occurrences of species such as *Nigeroloxoconcha aegyptiaca, Paracosta kefensis, Cytherura* spp.*, Ordoniya bulaqensis, Bythocypris* spp.*, Paracypris* spp. and *Cytherella cf. farafraensis.*
2. The marked ostracod turnover observed at the Paleocene – Eocene contact in the studied Hole is ascribed to the environmental disturbances characteristic of the Paleocene – Eocene transition and a switch in water mass conditions consequent upon the brief but drastic global temperature rise at about 55 Ma (end of the Paleocene).
3. There is a strong resemblance between the ostracod assemblages of the study area and those of North African basins (Southern Tethys) indicating marine connection and faunal migration between the two areas during the Paleogene. This migration supposedly occurred via the shallow marine Trans-Saharan Seaway.

ACKNOWLEDGEMENT

We wish to thank Dr. O. Oteri of Akute Geo Resources, Lagos, Nigeria and the Water Department of the Redemption Camp, Km 46 Lagos – Ibadan Expressway for providing borehole samples used in this study.

FUNDING

Authors received no funding for this research.

CONFLICT OF INTEREST

Authors are not under any obligation to any organisation in respect of this research.

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