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Research Article

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Palynomorphs Occurrence in a Shale Bed along River Eleja and its Implication on the K-Pg Boundary in South Western Nigeria

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Abstract The Cretaceous-Tertiary boundary at outcrop is still poorly known in Nigeria. Palynogical analysis of some samples collected along the channel of River Eleja in Ayadi village in southwestern Nigeria was carried out using standard macerating procedures to recover the palynomorphs in search of this boundary. The following recovered palynomorphs, though in rare quantity and very low diversity: *monoporites annulatus*, *zonocostites ramonae* and *psilatricolporites crassus*, suggest Tertiary sediments while the presence of *longapertites sp.* in the assemblage indicates late Maastrichtian. In terms of environment of deposition, the palynomorphs assemblage indicate a high influence of mangrove swamp vegetation, deposition in a marginal marine environment and coastal savannah environment suggesting that the sediments were deposited in Transitional - freshwater environment. Stratigraphically, the shale tends to belong to the Upper Cretaceous Araromi Formation making it difficult to pick the shale as marking the Cretaceous- Tertiary boundary.

Keywords Cretaceous-Tertiary boundary; Araromi Formation; Ayadi shale; *longapertites sp*, *monoporites annulatus*

Introduction

Several detailed works on palynomorphys retrieved from boreholes drilled in the southwestern Nigerian portion of the Dahomey Basin exist [1-7]. However few published information exists on that of outcrops from the basin [8-11]. The well documented palynology of Tertiary sediments of tropical areas by Germeraad et al [1] has to a large extent formed the basis for which age determination, zonation and correlation of sedimentary rocks are made in the basin. The Dahomey Basin is still open to more detailed integrated palynological, foraminifera, sedimentological and seismic studies that could be used to correlate and build up a general sequence stratigraphic model and establishment of geologic boundaries at the surface for the basin.

Up till date the Cretaceous/Tertiary boundary is yet to be well established at outcrop in the Dahomey Basin [11]. A rarely found shale outcrop occurs along River Eleja, in southwestern, Nigeria. This was subjected to study with the aim of establishing the age and environment of deposition of the shale in continuation of the search for the K-Pg boundary in the Dahomey Basin. The shale is buried and does not outcrop as such making it difficult to ascertain its thickness. No detailed palynological study has been performed on this shale. Ayadi town falls within the eastern portion of the Dahomey Basin (Fig. 1) in southwestern Nigeria on this coordinate N060 38′21.4″ E0040 53′02.1″ [12] while the samples were taken along river Eleja very close to the town at longitude 004^0 53.529E and latitude 06^0 38.326N.

2. Geological Background

The Dahomey Basin is believed to have originated during the rifting stage at the margin of the Gulf of Guinea which started during the late Jurassic [13]. This was in response to separation of Africa-South America landmass and subsequent opening up of the Atlantic Ocean. The basin is a marginal pull-apart basin [14] or

margin sag basin [15]. Today the basin consists of very thick sequence of continental grits and pebbly sand of over 1400 m thick preserved in coastal area in Nigeria and offshore part of the Benin Republic.

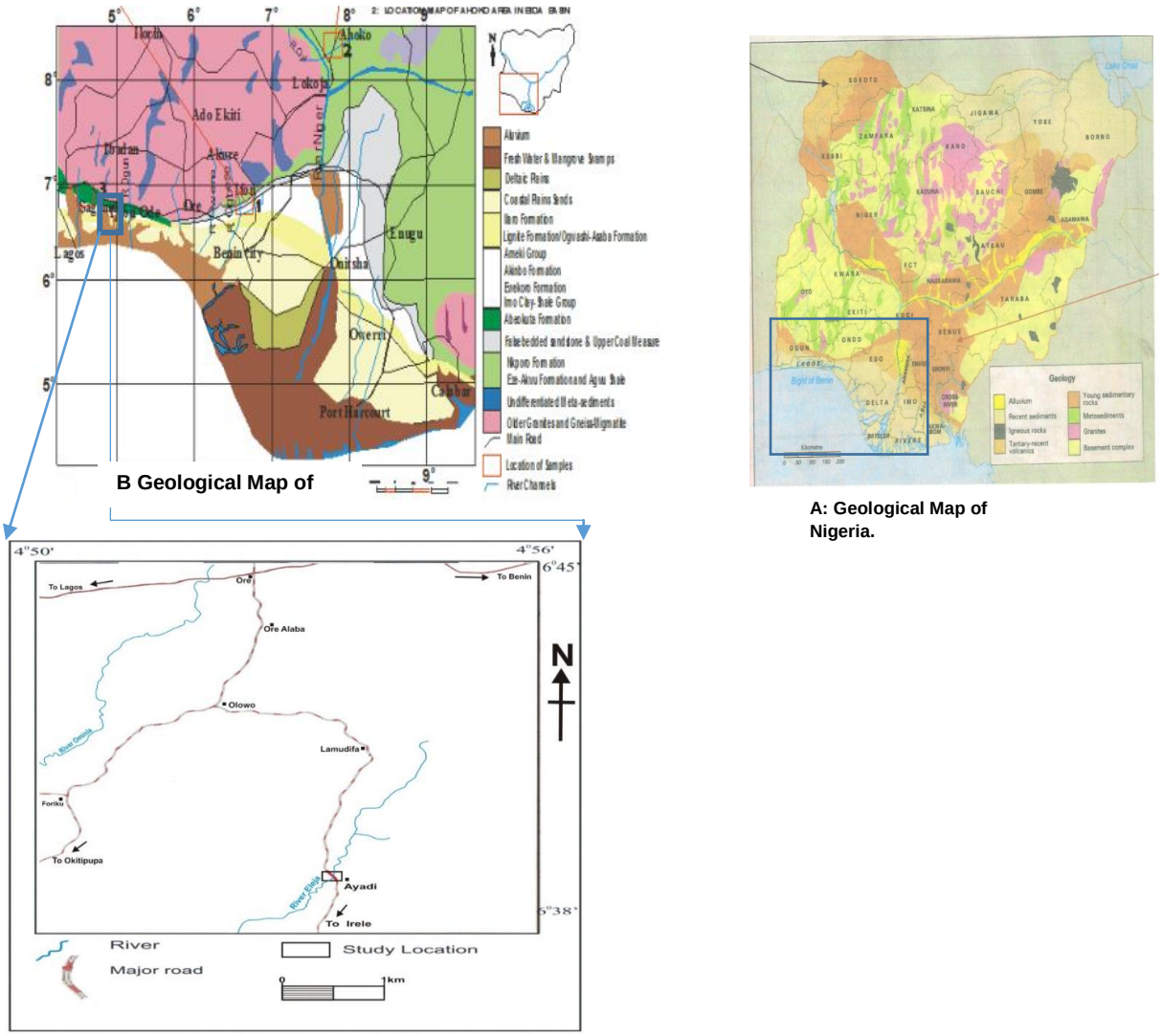

Figure 1: Topographical Map of the Study Area. Source: Federal Survey of Nigeria (1964)

The Dahomey Basin too was affected by the early - late Cretaceous (Santonian) major tectonic activities that lead to the closure and opening of the Benue Trough and Anambra Basins, respectively. During this period, the basement rocks (granites, gneisses and associated pegmatites), as well as the sediments in the basin (Dahomey), were tilted and block-faulted, forming a series of horsts and grabens, some of which are still active today creating canyons along the coast and occasional seismicity within the continent [16-17].

Considerable erosion activities accompanied the uplift, block-faulting and the extensive lower Cretaceous sediments were almost completely eroded from the horst. A Summary of four stages of evolutional model consisting of an intracratonic synrift, transitional and ocean were proposed for Dahomey Basin [13]. Generally the stratigraphy of the basin is still riddled with controversy as summarized in Figure 2.

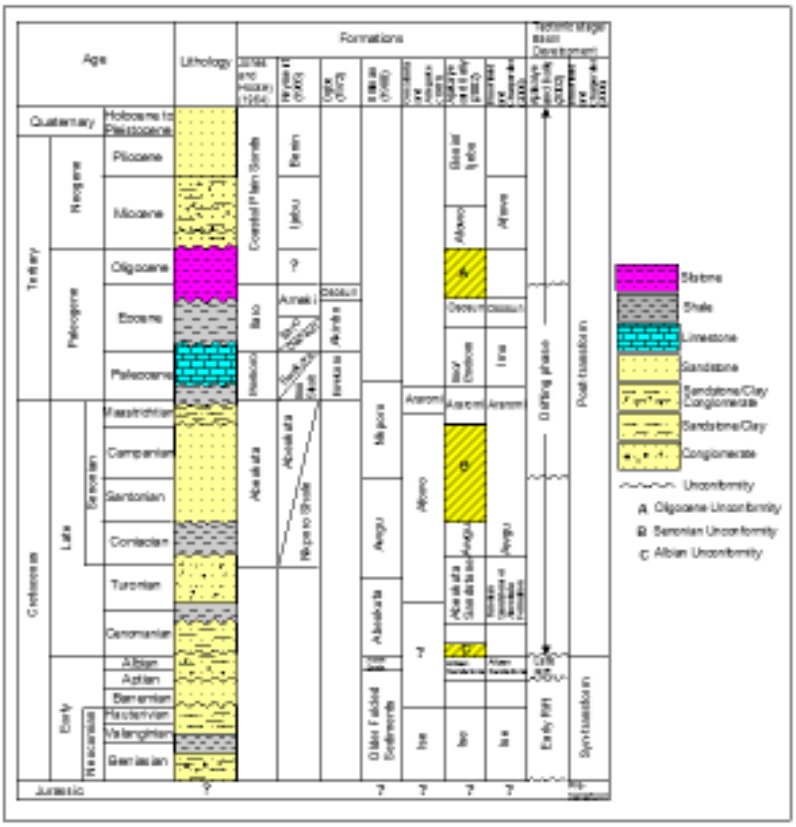

Fig. 2. Generalised stratigraphic column showing age, lithology, and sequence of the formations and tectonic stage of soft basin development in the Nigerian sector of the Benin Basin (Ola and Olabode, 2017).

Figure 2: Generalised stratigraphic column showing age, lithology, and sequence of the formations and tectonic stage of soft basin development in the Nigerian sector of the Benin Basin

3. Materials and Methods

Hand-collected shale samples retrieved from three locations within relatively less than 20 m distance along the channel of River Eleja at the outskirt of Ayadi town were used for this study. The standard laboratory techniques for the extraction of palynomorphs were followed, which involved treatment with hydrofluoric acid (HF) to dissolve and eliminate silicate bonds, centrifuging and further treatment with hot concentrated hydrochloric acid to dissolve and eliminate carbonates. Hot concentrated nitric acid was used to oxidize the residue and concentrate the palynomorphs. Hot potassium hydroxide treatment was carried out to dissolve and neutralize the effect of the acid from the residue before treating it with 0.5% hydrochloric acid. Organic materials (which floats) from the inorganic materials separation was done in Zinc bromide with S. G. of 2.2. The floating organic material was separated into another labeled 10 cc centrifuged tube while the inorganic material was disposed. Again 0.5% hydrochloric acid was then added to the organic residue, stirred properly, centrifuged and decanted before treatment with alcohol. The remains were then mounted on slides. The identification of the palynomorphs was carried out using a light-transmitted microscope. Identification of the palynomorphs were facilitated using the works of Germeraad at al. [1]; Schrank [18]; and Sowunmi [19]. The palynomorphs whose identification could not be completed were given generic names. Photographs of these were taken using a Leitz laborlux s binocular microscope with camera attachment.

4. Results

4.1. Palynomorph Constituents of the Shale

The studied shale bed along river Eleja in Ayadi shows palynomorphs which indicate mainly marine origin. The palynomorphs distribution in the three samples studied is very poor and relatively low in abundance and

diversity. The following particulate palynological constituents were found to occur in the shale: *Laevigatosporites sp., Fungal spore, psilatricolporites crassus, Zonocostites ramonae, Longapertites sp., Monoporites annulatus, Psilamonocolpites sp., Charred graminae cuticle* and pollen indeterminate (Plate 1). Each recognized species was counted and recorded (Table 1).

Table 1: Palynomorphs retrieved from a shale outcrop in Ayadi village, eastern Dahomey Basin A. Identified Palynomorphs in each of the three samples B. Distribution of Palynomorphs in the sales.

Slide C	Slide B	Slide A	
*		*	Laevigatosporites sp.
*		*	Fungal spore
		*	Psilatricolporites crassus
		*	Zonocostites ramonae
*			Longapertites sp.
*			Monoporites annulatus
*			Psilamonocolpites sp.
*			Charred graminae cuticle
*			Pollen indeterminate

B

Slide	Names of Sporomorphs	No of Counts
A	*Laevigatosporites sp.*	2
	Fungal spore	1
	Psilatricolporites crassus	1
	Zonocostites ramonae	1
B	No Sporomorph recovered	
C	*Fungal spore*	3
	Longapertites sp.	2
	Laevigatosporites sp.	1
	Monoporites annulatus	2
	Psilamonocolpites sp.	1
	Charred graminae cuticle	1
	Pollen indeterminate	1
		Total: 16

5. Discussion

5.1. Age Determination

The age determination was facilitated by comparison of the palynomorph assemblages recovered from the shale in Ayadi with the published works of Germeraad et al [1]; Lucas and Ishiekwene [20]; Umeji [21]; Evamy et al [7] and Legoux [4], among others who have carried out similar work on early Maastrichtian - Tertiary sediments. The important pollen grains and spores recovered include: *fungal spore, laevigatosporites sp, psilatricolporites crassus, psilamonocolpites sp., monoporites annulatus and zonocostites ramonae* which have been interpreted to be Tertiary except *longapertites sp.* that is known to be late Maastrichtian. The composition of this assemblage is also similar to the miospore (pollen and spore) assemblage for late Cretaceous - Tertiary succession of Gbekebo-1 well, Benin flank, Anambra basin by Lucas and Ishiekwene [20]. It is also similar to the palynological data obtained from the road section at the Ogbunike Tollgate, Onitsha, southeastern Nigeria that is dated Tertiary by Umeji [21].

The following recovered palynomorphs; *monoporites annulatus, zonocostites ramonae* and *psilatricolporites crassus* are also present in the palynological assemblage of Tertiary sediments of tropical areas obtained by Germeraad et al [1]. The presence of *longapertites sp.* in the assemblage indicates late Maastrichtian [6, 10]. Longapertites was reported by Van Hoeken-Klinkenberg [22] in the Nigerian coal deposits from southeastern Nigeria. It was described to indicate a transition from Cretaceous into Tertiary period. The sporomorphs *laevigatosporites sp.* and *longapertites sp.* were reported by Atta-Peters and Salami [23] in the late Cretaceous - early Tertiary sediments form Tano basin, Ghana. The presence of *Psilamonocolpites sp.* and *fungal spore* in the palynomorph assemblage indicates a Tertiary age [19, 22-23]. The age of the studied shale in Ayadi is therefore recognized to be late Cretaceous - Tertiary.

5.2. Paleoenvironment

The presence of *longapertites sp., psilatricolporites crassus, zonocostites ramonae* and *psilamonocolpites sp.,* indicate a high influence of mangrove swamp vegetation in the environment at the time of deposition [1, 21, 25-26]. The presence of *longapertites sp.* may suggest deposition in a marginal marine environment [27-28]. The recovery of *monoporites annulatus* points to coastal savannah environment [1, 24-25]. The presence of *laevigatosporites sp.* indicates a swampy freshwater or brackish water environment [1, 29]. According to Hoorn [30] *laevigatosporites sp* is common in freshwater and swamps. The paleoenvironment of the shale deposit in Ayadi is therefore suggested to be Transitional - freshwater environment. However, shale is generally known to be deposited under a quiet condition.

5.3. Stratigraphic Unit

Based on the geologic map of Nigeria and the geographic position of Ayadi, the shale sample belongs to a Formation that has been named variously as Ameki Formation, Akinbo Formation, Ewekoro Formation, Imo clay-shale Group. The shale is found to underlain a limestone deposit which suggest that it could not be Akinbo Formation. Akinbo Formation lies directly above Ewekoro Formation. Ameki Formation is probably restricted to Anambra basin likewise the Imo Shale. This therefore suggests that the shale could be part of the Ewekoro Formation. However, it is important to note that the geological map does not portray it to be Ewekoro Formation. Paleozoological results of previous work [13] on the Dahomey Basin also suggest a Maastrichtian - Paleocene age for Araromi Formation in which the studied Ayadi shale lies. Therefore, it can be inferred that the studied Ayadi shale is occurring at the flank of Araromi Formation in Dahomey basin.

6. Conclusions

A total number of 3 samples were collected from the exposed section of Ayadi shale of the Dahomey Basin. Ayadi shale which is the study location is situated on longitude 004^0 53.529E and latitude 06^0 38.326N. Palynogical analysis of the samples was carried out with the use of standard macerating procedures to recover the palynomorphs and also biological microscope to identify the palynomorphs from the shale samples. This was done in order to reveal the constituent palynomorphs and then determine the age and also the environment of deposition of the shale deposit.

Among the palynomorphs recovered from the samples analyzed are: 3 *laevigatosporites sp.,* 4 *fungal spore,* 2 *longapertites* sp., 2 *monoporites annulatus,* 1 *psilatricolporites crassus,* 1 *zonocostites ramonae,* 1 *psilamonocolpites sp.,* 1 *charred graminae cuticle.* These sporomorphs were compared with similar ones obtained by Germeraad *et al,* [1]; Lucas and Ishiekwene, [20]; Umeji, [21]; Lawal and Moullade, [6]; among others who carried out similar work. Through this, the age of the shale was determined to be Late Maastrichtian to Tertiary while the paleoenvironment is Transitional - Freshwater environment of deposition.

Declaration

This is a self-sponsored project.

There is no conflict of interest to declare.

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