Original Research Article

Palynological and ~~paleobotanic~~ paleoecological characterization of ~~u~~Upper Eocene-~~l~~Lower Miocene deposits of the southeastern part of the onshore sedimentary basin of Côte d'Ivoire (West Africa)

ABSTRACT

~~Samples~~ Sedimentary rocks cuttings from two boreholes in Bingerville and Assinie (Côte d'Ivoire) were the subject of this study. ~~The main objective of this work is to make an inventory of the plant species that existed at the time of the establishment of these formations on both sides of the lagoon fault.~~ ~~The samples were processed according to the classical procedure of extraction and concentration of palynomorphs.~~ ~~The palynostratigraphic analyzes revealed a palynoflora characterizing the upper Eocene and the lower Miocene.~~ ~~The lithology consists of s~~Sands and clays ~~for the~~were collected from the Bingerville well and sands, green clays and limestones ~~for~~ from the Assinie well. The main objective of this work is to make an inventory of the plant species that existed at the time of the deposition of sediments on both sides of the lagoon fault based on palynomorph fossils. ~~These green clays contain glauconites and remains of marine organisms, evidence of a transgressive sea at this time.~~ Paleovegetation consist~~s~~ed of freshwater species (determined spores~~such as~~ *Verrucatosporites usmensis, Laevigatosporites ovatus, Polypodiaceiosporites regularis, and Deltoidospora* ~~*delicata*~~*delicate*), which ~~develop~~ thrieved in a coastal wetland environment under a tropical climate with alternating warm and humid periods. ~~The p~~Palynostratigraphic analy~~z~~ses ~~revealed a palynoflora characterizing~~point to the age of the ~~u~~Upper Eocene and the ~~l~~Lower Miocene for the studied samples.

Keywords: palynomorphs; paleobotanic; Miocene; Eocene; Bingerville: Assinie.

1. INTRODUCTION

The basin of Côte d'Ivoire in which this study is located, is part of a large set of coastal basins bordering the west Atlantic coast from southern Morocco to beyond Angola [1]. Cenozoic deposits, contain glauconites and remains of marine organisms, evidence of a transgressive sea, along with pollen grains and spores derived from the land.

Palynological studies on the ~~i~~Ivorian sedimentary basin began in 1960 with the work of [2], devoted to the Cretaceous deposits.

~~Also, other contributions from~~Several other authors contributed to the ~~palynological~~ palynolostratigraphical study ~~to the knowledge~~ of the ~~stratigraphy of the i~~Ivorian basin ~~have been made~~, sometimes on Tertiary deposits [3, 4, 5, 6], sometimes Cretaceous [7, 8].

Many unpublished dissertation studies (DEA) dissertations have also provided data on the biostratigraphy of Tertiary age deposits [9, 10, 11] and upper Cretaceous age [12, 13, 14].

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Comment [1]: Tertiary is no more official stratigraphic unit, see : http://www.stratigraphy.org/ICSchart/ChronostratChart2019-05.pdf
Please change the order according to the chronolkogy, older findings first

Comment [2]: Paleogene and Neogene
Older deposits studies first !

The present study was undertaken to date the formations of these two wells made in the I~~i~~vorian onshore basin on both sides of the Lagoons fault in order to contribute to the paleobotanic reconstruction of the region which remains enigmatic.

2. PRESENTATION OF THE STUDY AREA

The study area (Fig. 1) is located south-~~-~~east of the I~~i~~vorian sedimentary basin on both sides of the lagoon fault. Two wells made at Bingerville (P1) and Assinie (P2), the geographical coordinates and depths of which are given in Table 1 below are concerned to this study.
The geological history of the sedimentary basin of Côte d'Ivoire is linked to the opening of the S~~s~~outh Atlantic, the consequence of which is the dislocation of Gondwana, which intimately united south America and Africa. This story recently recalled by [15] indicates that this basin is characterized by two distinct domains.

a) a continental domain or onshore basin area affected by a major "lagoon fault" along the coast from west to east. This accident has a vertical discharge of several thousand meters (4000 - 5000 m).
(b) a marine domain or offshore basin known only through oil drilling. This offshore basin is subdivided into two margins including the margin of Abidjan and that of San~~-~~ ~~p~~Pedro.

Table 1. Coordinates of the wells

Site	**~~Désignation~~Location**	**Longitude (w)**	**Latitude (N)**	**Depth in meters**
Bingerville	P1	03° 52' 53,8"	05° 20' 06,8"	120
Assinie	P2	03° 24' 02,3"	05° 08' 54,8"	180

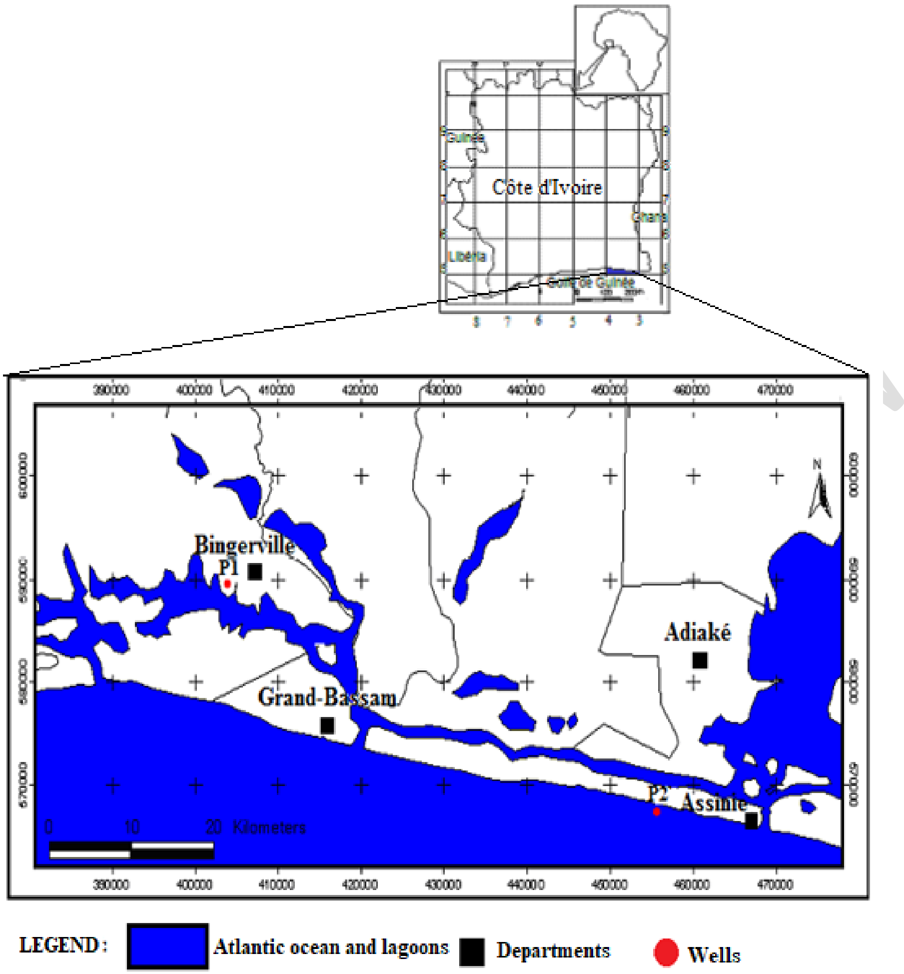

Fig. 1. Location of wells

3. MATERIALS AND METHODS

The studied ~~used~~ material consisted of twenty-five (25) ~~samples of~~ cuttings from two water wells located at Bingerville (10 samples) and Assinie (15 samples). Each ~~cuttings~~ sample was palynologically prepared as practiced in paleobotany laboratories [3].

~~It~~ Procedure consists of destroying all the mineral phases of the sediment with strong acids (30% HCl and 70% HF) and preserving the organic phase generally consisting of sporopollinic materials.

A final attack with nitric acid (HNO3) 68% cold ~~whose~~ in order~~purpose~~ ~~is~~ to clear the palynological material and organic matter content. After this last attack, the residue is sieved on a 10 µm single-use cloth and then the sporopolleni~~e~~en residue obtained is mounted between the blade and the coverslip using a special resin.

Using a biological microscope, observations are made to identify the palynomorphs contained in the slides. These palynomorphs made it possible to date the formations studied and to

Comment [3]: Compound light microscope Biological refers to the purpose and not the type characterize the paleoenvironment of the region. ~~The resulting p~~Paleobotan~~y~~ical analysis is based on the ecological importance and ~~the~~ different botanical affinities of the determined sporomorphs.

4. RESULTS

4.1 Lithological analysis of the wells

4.1.1 Lithology of the Bingerville well

The lithology of cuttings from the well (P1) located in Bingerville shows, ~~in the direction of sedimentation~~from the bottom tot he top ~~(Fig. 2)~~: coarse white sand (120 - 97m); sandy variegated clays (97 - 92m); coarse sands (92 - 86 m); compact variegated clays and dark clays (86-44 m); reddish-brown sands (44 - 39 m) testifying to a strong presence of ferric oxide; very compacted dark clays (39 -25 m) and yellow-orange laterite clays (25-2 m) (Fig. 2).

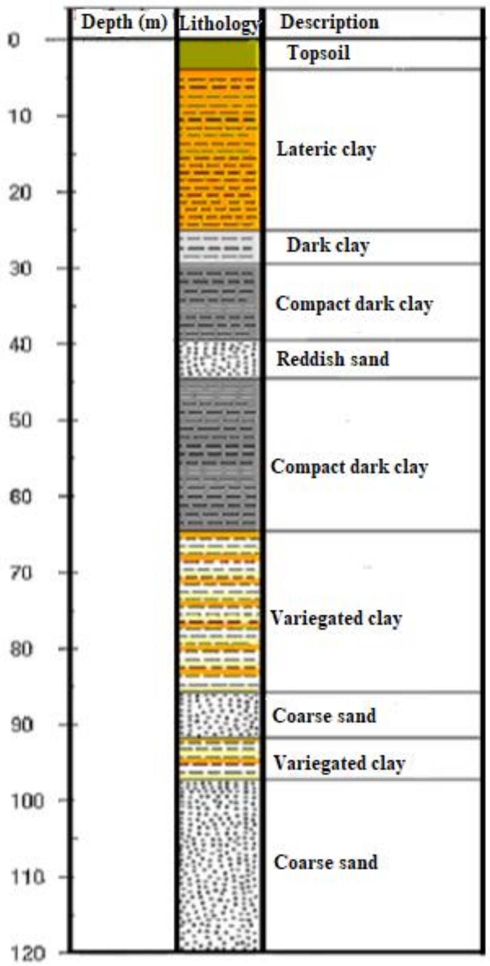

Fig. 2. Schematic ~~L~~lithological ~~synthesis~~ column of the P1 well (after Gbangbot et al., 2012)

4.1.2 Lithology of the Assinie well

The lithological analysis of the cuttings of the Assinie well (P2) shows, ~~in the direction of sedimentation~~from older to younger horizons ~~(Fig. 3)~~: ~~glauconious~~ glauconitic limestones of greenish gray color with shell debris (180-164 m); ~~very~~ intensively green clays, past calcareous plastics, rich in glauconites (164 - 65 m), sandy clays (65-47m); coarse orange-yellow sands, with rare shelly debris (47 - 23 m); medium- to fine-grained shellfish sands~~,~~ of a light yellow color, rich in ~~shellfish~~ bivalve debris ~~of bivalves~~ (23 - 2 m) (Fig. 3).

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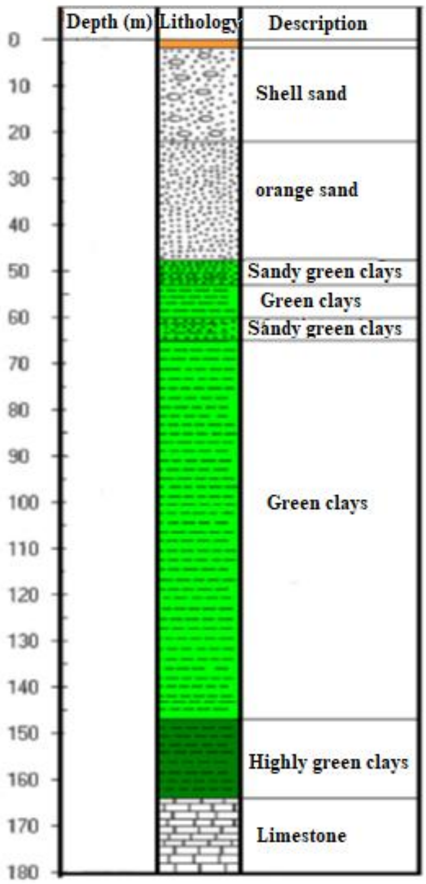

Fig. 3. ~~L~~Schematic lithological ~~synthesis~~ column of the P2 well (after Gbangbot et al., 2012)

4.2 Qualitative and quantitative analysis of palynomorpha from the P1 and P2 wells

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The palynomorphs of the well P1 are composed mainly of spores and pollen grains (85%) and scarce dinocysts (15%). The state of conservation of these palynomorphs is excellent.
The palynological material of the well P2 is composed of spores and pollen grains (73%) as well as dinocysts (27%). This quantitative study has made it possible to observe many fossil palynomorphs, some of which are of stratigraphic interest.

Table 2. Palynomorph Count Sheet ~~in~~ for the well P1

				DINOCYSTS				SPORE AND POLLEN GRAIN														
STAGE	DEPTH IN METER	TOTAL DINOCYSTS	TOTAL SPORE AND POLLEN	*Batiacasphaera sp.*	*Lingulodinium machaerophorum*	*Selenopemphix quanta*	*Operculodinium centrocarpum*	*Cupressacites hiatipites*	*Verrucatosporites usmensis*	*Retitricolporites irregularis*	*Polyadopollenites microreticulatus*	*Striatopollis catatumbus*	*Retitriporites sp.*	*Psilatricolporites crassus*	*Verrustephanocolporites complanatus*	*Psilatricolporites laevigatus*	*Monocolpopollenites sp.*	*Inaperturopollenites sp.*	*Magnaperiporites spinosus*	*Monosulcites sp.*	*Retimonocolpites irregularis*	*Laevigatosporites ovatus*
Lower Miocene	30		15					2	6	1	1		1			2	1					1
	34		12					1	3	2	2		1			1	1					1
	42		23						13	1	2	1	2			1	1					2
	47	1	17			1			5	1	1	3	3			1	2					1
Upper Eocene	53	2	20			2			6	2			2	2	1	3	2	1				1
	59	1	16			1			3	2			1	1	2	1	2	1				3
	64	4	16	2		2			4	3			1	1	1	1	1	1	1			2
	70	6	20	5		1			2	3			3	2	1	1	2	2	2			2
	75	7	18	3	1	3			3	1			1	2	1	2	1	2	1	1	1	2
	94	11	23	6	1	2	2		4	1			4	1	3	2	1	1	2	1	1	2
TOTALS				16	2	12	2	3	49	17	6	4	19	9	9	15	14	8	6	2	2	17

Table 3. Palynomorph Count Sheet ~~in~~ for the well P2

				DINOCYSTS					SPORE AND POLLEN GRAIN																		
STAGE	DEPTH IN METER	TOTAL DINOCYSTS	TOTAL SPORE AND POLLEN	*Batiacasphaera sp.*	*Spiniferites ramosus*	*Cordosphaeridium inodes*	*Cometodinium obscurum*	*Operculodilium centrocarpum*	*Isbelidium sp.*	*Lingulodinium machaerophorum*	*Brevicolporites molinae*	*Laevigatosporites ovatus*	*Margotricolporites rauvolfii*	*Deltoidospora delicata*	*Cingulatisporites sp.*	*Tricolpites sp.*	*Leiotriletes adriennis*	*Baculatisporites sp.*	*Retitriporites sp.*	*Verrucatosporites usmensis*	*Pachydermites diederixii*	*Retitricolporites irregularis*	*Spinizonocolpites echinatus*	*Cicatricosisporites dorogensis*	*Polypodiaceoisporites regularis*	*Momipites sp.*	*Retitricolporites sp.*
Lower Miocene	52		13								1		1		2		1	1	1	5					1		
	60		12								1		2		1		1	1	2	1					3		
	64		20								2	2	3		1		2	3	2	4					1		
	71	2	22	2							2	3	2		1		1	3	1	8					1		
	76	1	14	1							1	1	1		1		1	2	3	3					1		
	82	1	13	1							1	2	1		1		1	2	1	2					2		
Upper Eocene	94	8	12	1	1	2	1	1	1	1		1	1			1		2		1	2	1	1	1	1		
	103	9	17	2	1	1	1	2	1	1		1	2			1		1		4	1	2	2	1	2		
	112	8	17	1	2	1	1	1	1	1		3	3			1		1		2	1	1	1	2	2		
	121	10	20	1	1	2	2	1	2	1		1	2	2		3		1		3	1	2	2	1	1		1
	130	12	25	2	3	1	2	2	1	1		2	1	1		1		1		11	1	1	2	1	1	1	1
	139	11	18	1	1	1	3	3	1	1		1	1	1		1		2		5	1	1		1	2	1	1
	144	11	16	1	1	1	2	2	2	2		2	3	2		1		1		1	1	1		1	1	1	1
	152	12	17	2	3	2	2	1	1	1			1	2		2		2		2	1	1		1	2		3
	165	7	15		2	1	1	1	1	1			4	1		2		1		2	1	2		1			1
TOTALS				15	15	12	15	14	11	10	8	19	26	9	7	13	10	24	10	54	10	12	8	10	21	3	8

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4.3 Palynostratigraphy

➢ **Well P1**

Palynological analysis of the Bingerville well (P1) revealed two stages ~~(Fig. 4)~~, defined by associations composed mainly of spores and pollen grains and rare dinocysts (Fig. 4).

- **The ~~lower Miocene~~upper horizon** ranges from 25 m to 51 m and is characterized by the following spores and pollen grains: *Hiatipites* ~~*Cupressacites*~~*cupressacites*, *Laevigatosporites ovatus*, *Polyadopollenites microreticulatus*, *Psilatricolporites laevigatus*, *Striatopollis catatumbus*, *Retitricolporites irregularis*, *Verrucatosporites usmensis*, *Retitriporites sp*. and *Monocolpopollenites sp.*

- **The ~~upper Eocene~~lower horizon** ranges from 51 m to 120 m is marked by species of spores and pollen grains such as: *Psilatricolporites crassus*, *Verrustephanocolporites complanatus*, *Retitricolporites irregularis*, *Verrucatosporites usmensis*, *Retimonocolpites irregularis*. These spores and pollen grains are associated with the following dinocysts: *Selenopemphix quanta*, *Batiacasphaera sp.*, *Spiniferites ramosus* and *Cleistosphaeridium flexuosum.*

➢ **Well P2**

Palynological analysis of the P2 well also highlighted two stages as well (Fig. 5).

- **The ~~lower Miocene~~upper horizon** range from 47 to 85 m is revealed by the palynological association composed of spores and pollen grains such as *Laevigatosporites* *ovatus, Leiotriletes adriennis, Polypodiaceoisporites regularis, Polypodiisporites speciosus, Cingulatisporites sp.*

- **The ~~upper Eocene~~lower horizon** extends from 85 to 180 m and is marked by spores and pollen grains ~~characteristic of the upper Eocene~~ such as *Pachydermites diederixii, Retitricolporites irregularis, Spinizonocolpites echinatus, Cicatricosporites dorogensis, Margotricolporites rauvolfii, Verrucatosporites usmensis.* To these spores and grains of pollen are associated dinocysts such as *Cometodinium obscurum, Spiniferites ramosus,* ~~*Operculodilium*~~ *Operculodinium centrocarpum, Batiacasphaera sp., Cordosphaeridium inodes, Isabelidium sp.* and *Lingulodinium machaerophorum.*

Comment [7]: This is the chapter : Results. Here you can divide the two horizons, and later, in the chapter Discussion refer to their age

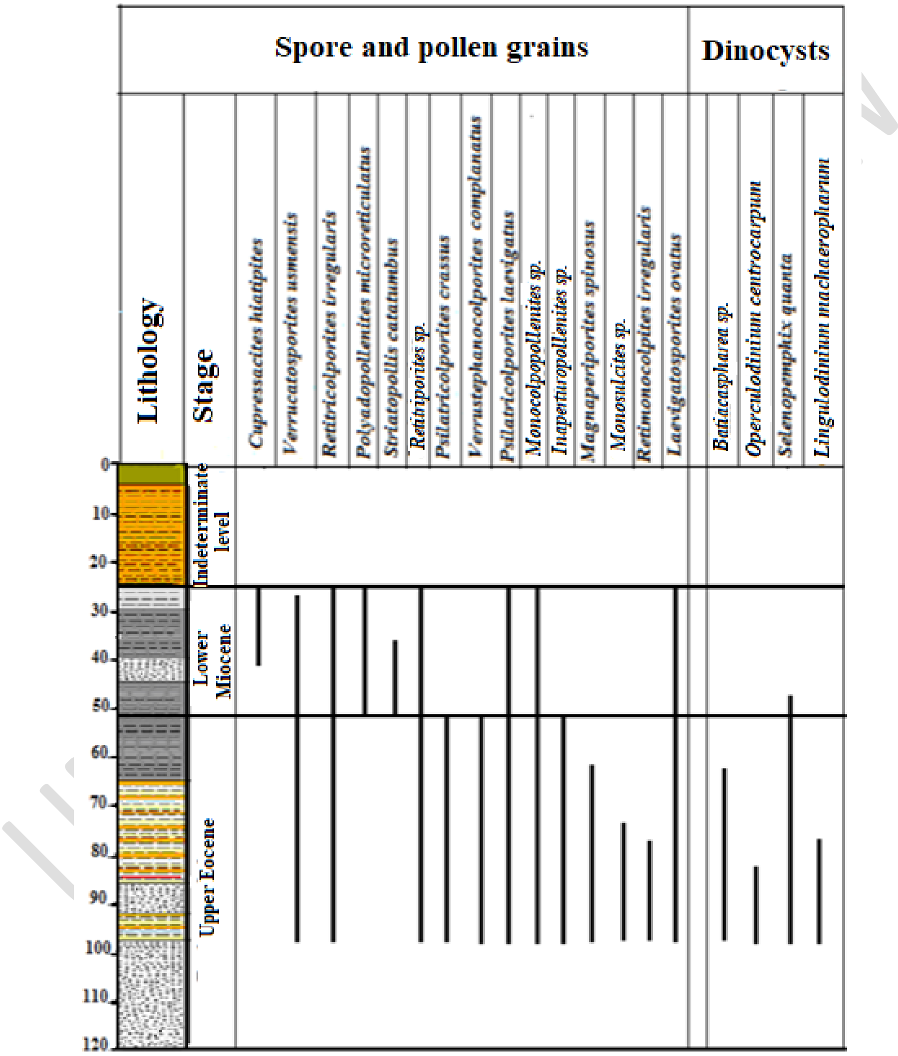

Fig. 4. Vertical distribution of the main Bingerville palynomorphs (P1)

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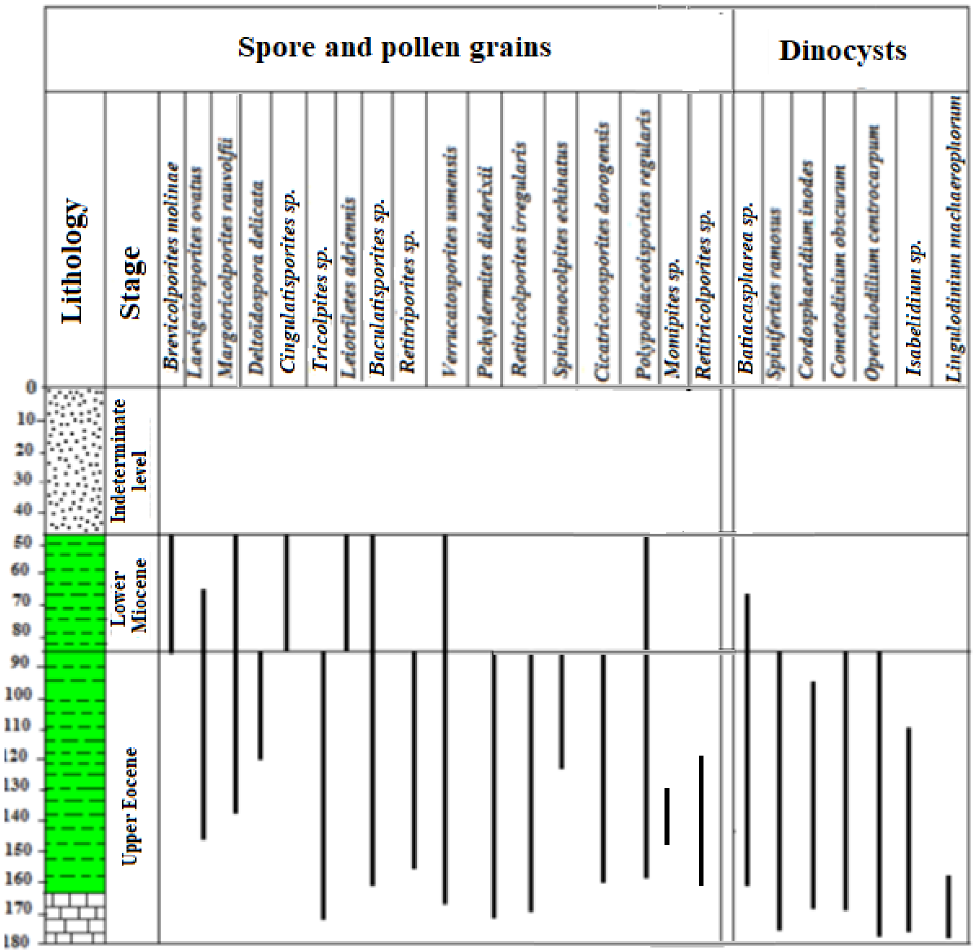

Fig. 5. Vertical distribution of the main Assinie palynomorphs (P2)

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4.4 Paleobotanical characterization

The paleobotanical study of these 2 wells shows the presence of pollen grains from the Arecaceae (*Retitricolporites Irregularis*, *Monocolpopollenites sp*.), Fabaceae (*Striatopollis catatumbus*), Schizeaceae (*Inaperturopollenites sp.*), Pelliceria (*Psilatricolporites crassus)*, Nypa (*Spinizonocolpites echinatus*, ~~r~~*Retimonocolpites irregularis*), Apocynaceae (*Margotricolporites rauvolfii*, *Brevitricolporites molinae*). These pollen grains are associated with spores of Polypodiaceae (*Laevigatosporites ovatus*, *Verrucatosporites usmensis*, *Polypodiaceiosporites regularis*), Schizeaceae (*Cicatricososporites dorogensis*, *Leiotriletes adriennis*), to Cyatheaceae (*Deltoidospora delicata*) and to Lygodium (*Crassoretitriletes vanraadshooveni*).

Palynoflora consists of angiosperm pollen grains ~~from~~ typical for tropical rainforests and coastal swamps ~~-~~(*Pachidermites diederixii, Retitricolporites irregularis* and *Stritapollis catatumbus*), ancestors of the present-day palm trees of the genus Nypa (*Spinizonocolpites* *echinatus, retimonocolpites irregularis*), fern spores basically hygrophilous freshwaters that develop in moist, swampy areas (*Laevigatosporites ovatus, Verrucatosporites usmensis, Polypodiaceiosporites regularis*).

This palynoflora indicates a tropical paleoclimate with alternating warm and humid periods. The association of coastal marine ecosystems (*Cordosphaeridium inodes, Spiniferites ramosus*) with this paleovegetation indicates a coastal marine ecosystem in this area.

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5. DISCUSSION

5.1.Palynostratigraphy~~ically~~

Palynological analysis revealed lower Miocene and upper Eocene age of the studied samples. Lower Miocene age has been identified through associations of *Cupressacites hiatipites, Laevigatosporites ovatus, Polyadopollenites microreticulatus, Psilatricolporites laevigatus, Striatopollis catatumbus, Retitricolporites irregularis, Verrucatosporites usmensis, Leiotriletes adriennis, Polypodiaceoisporites regularis, Retitriporites sp.*

Our results are consistent with those of [16, 17, 18], who used some of these sporomorphs respectively in Soudan and Côte d'Ivoire to ~~characterize~~ determine the lower Miocene age of palynomorph assemblage.

The species *Crassoretitriletes vanraadshooveni* extends from the Miocene to the Pliocene in Nigeria [19] and from the ~~m~~Middle Miocene to the Pleistocene in Venezuela [20]. As for *Verrucatosporites usmensis*, it characterizes the Eocene~~-~~ to Pleistocene interval in Nigeria and Borneo [19, 21].

Laevigatosporites ovatus is known ~~in~~ from the Neogene in Burundi [22] and Paleogene in Nigeria [23].

Striatopollis catatumbus characterizes the Paleocene-Pleistocene interval in Nigeria [19] and the Pleistocene-~~-~~Eocene range in Venezuela [20].

Brevicolporites molinae marks the Oligocene and the ~~l~~Lower Miocene in Cameroon [21] and the Miocene in Soudan [16].

The species *Retitriporites sp.* is a good marker of the ~~u~~Upper Oligocene and the ~~l~~Lower Miocene in Soudan [16]. However, the absence of *Lejeunecysta* (good marker of the Oligocene in Côte d'Ivoire) [7] in this interval restricts this age to the lower Miocene.

The Upper Eocene age was ~~highlighted thanks~~determined due to the associations of *Psilatricolporites crassus, Verrustephanocolporites complanatus, Retitricolporites irregularis, Verrucatosporites usmensis, Retimonocolpites irregularis, Pachydermites diederixii, Spinizonocolpites echinatus, Cicatricosporites dorogensis, Margotricolporites rauvolfii.*

~~Indeed~~ Results can be compared with [24, 25, 26, 27] ~~with its same~~who described such palynomorph~~s~~ assemblage ~~has evidenced~~from the ~~u~~Upper Eocene in the Cameroun Basin. To these spores and pollen grains ~~of pollen~~ are associated dinocysts such as *Cometodinium obscurum, Spiniferites ramosus, Operculodi~~l~~nium centrocarpum, Batiacasphaera sp, Cordosphaeridium inodes*. [28], considers the species *Cordosphaeridium inodes* as an indicator of the Eocene in Germany, while [29] attributes it to the ~~m~~Middle Oligocene in Australia.

The species *Spinizonocolpites echinatus* ~~makes its last appearance~~last appears in the ~~u~~Upper Eocene, as stated in many works [19, 26, 30, 31, 32] in Nigeria, Cameroun, Soudan and Ghana.

Psilatricolporites crassus characterizes the ~~u~~Upper Paleocene and L~~l~~ower Eocene. In Cameroun, [26] identified it in the L~~l~~ower Eocene and M~~m~~iddle Eocene. In Nigeria this species has been used by [19] to characterize the late Pli~~e~~ocene-Pleistocene interval. In South America, this species characterizes the L~~l~~ower ~~Eocene~~ to Middle Eocene [30, 33].

The species *Pachydermites diederixi* present in this stage characterizes the Eocene and Miocene in Cameroon [26], Oligocene and Miocene in Soudan [16].

However, the presence in this stage of *Lingulodinium machaerophorum*, an Eocene marker in Egypt [34] and *Cordosphaeridium inodes* known from the Maastrichtian to the ~~u~~Upper Eocene [7, 23, 31, 35, 36] restricts this age to the ~~u~~Upper Eocene.

5.2. ~~Paleobotanically~~Paleoecology

Paleobotanically, our work is in agreement with ~~those~~ results of [18], considering ~~showed that~~ the assemblage composed of *Verrucatosporites usmensis, Retitricolporites irregularis, Laevigatosporites ovatus, Leiotriletes adriennis, Pachydermites diederixii, Polypodiaceoisporites regularis* ~~is~~ as a characteristic of tropical hot and humid climate~~s hot and humid~~.

The presence of the pollen grain *Brevitricolporites molinae* (Apocynaceae) typical of tropical forests [21] is confirmed in our work.

In addition, the results of [37], in conformity with ours, reveal that fern spores such as *Laevigatosporites ovatus*, *Leiotriletes adriennis*, and *Verrucatosporites usmensis* indicate a humid tropical climate. This author also states that the species *Psilatricolporites crassus* is a pollen grain from mangrove vegetation which has been verified by our work.

The results of [38] reported by [39] indicate, as in our work, that Polypodiaceae (*Polypodiaceoisporites regularis*) are derived from tree ferns that indicate a thick and closed tropical forest.

For [39, 40], the genus *Striatopollis catatumbus* encountered in our formations is a species of freshwater and coastal swamps. These results are verified by our work. These authors also claim that they can be found in the coastal plains ~~and also~~as well as in tree savannas.

Similarly, our work is verified by ~~those~~ results of [41]. They claim that dinocysts such as *Operculodinium centrocarpum, Spiniferites ramosus, Cordosphaeridium inodes* and *Batiacasphaera sp*. indicate a marine depositional environment near the coast.

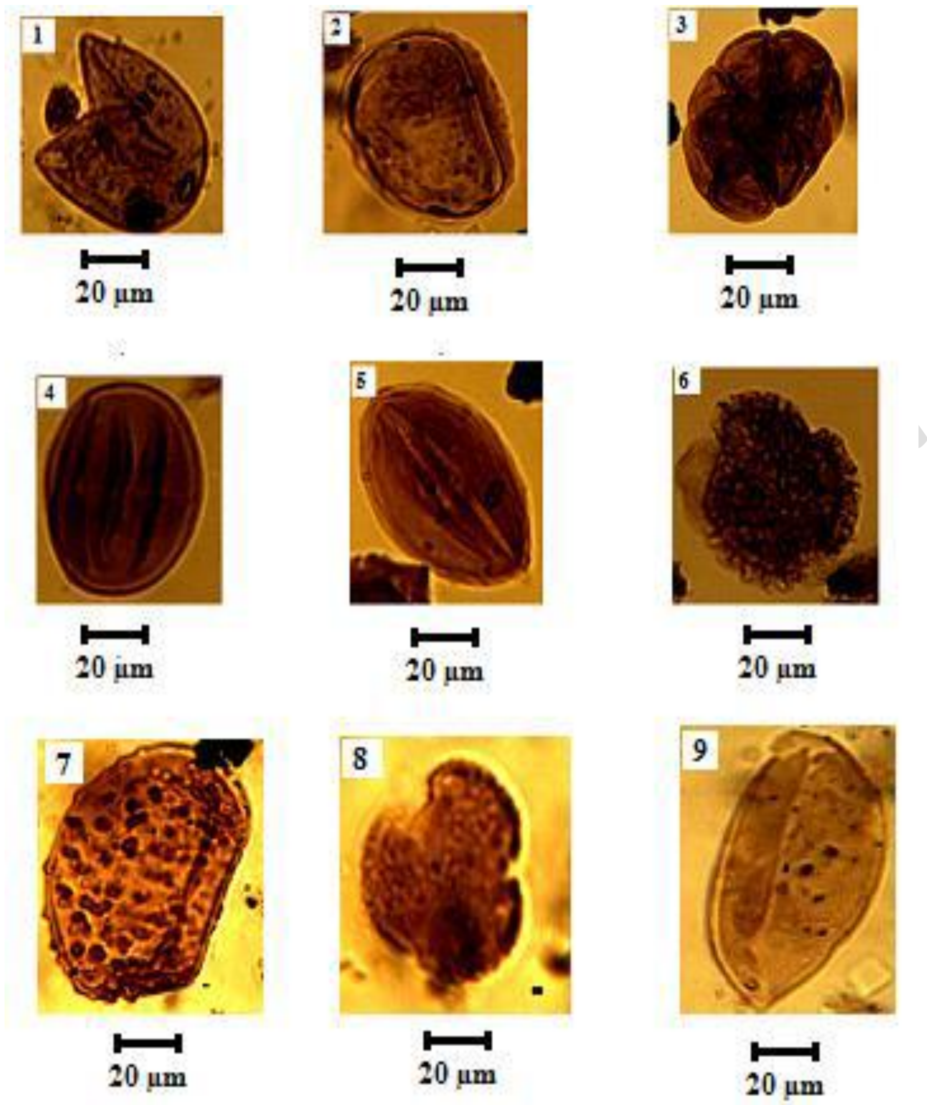
6. CONCLUSION

The palynostratigraphic and ~~paleobotanical~~ paleoecological study of ~~the sedimentary deposits~~plant fossils ~~of~~ from the ~~2~~ two wells of Bingerville and Assinie ~~revealed some characteristics~~reveal the age and the depositional environment of the studied samples.

~~The lithology indicates the presence of d~~Dark, variegated sands and clays occur in the Bingerville well, while

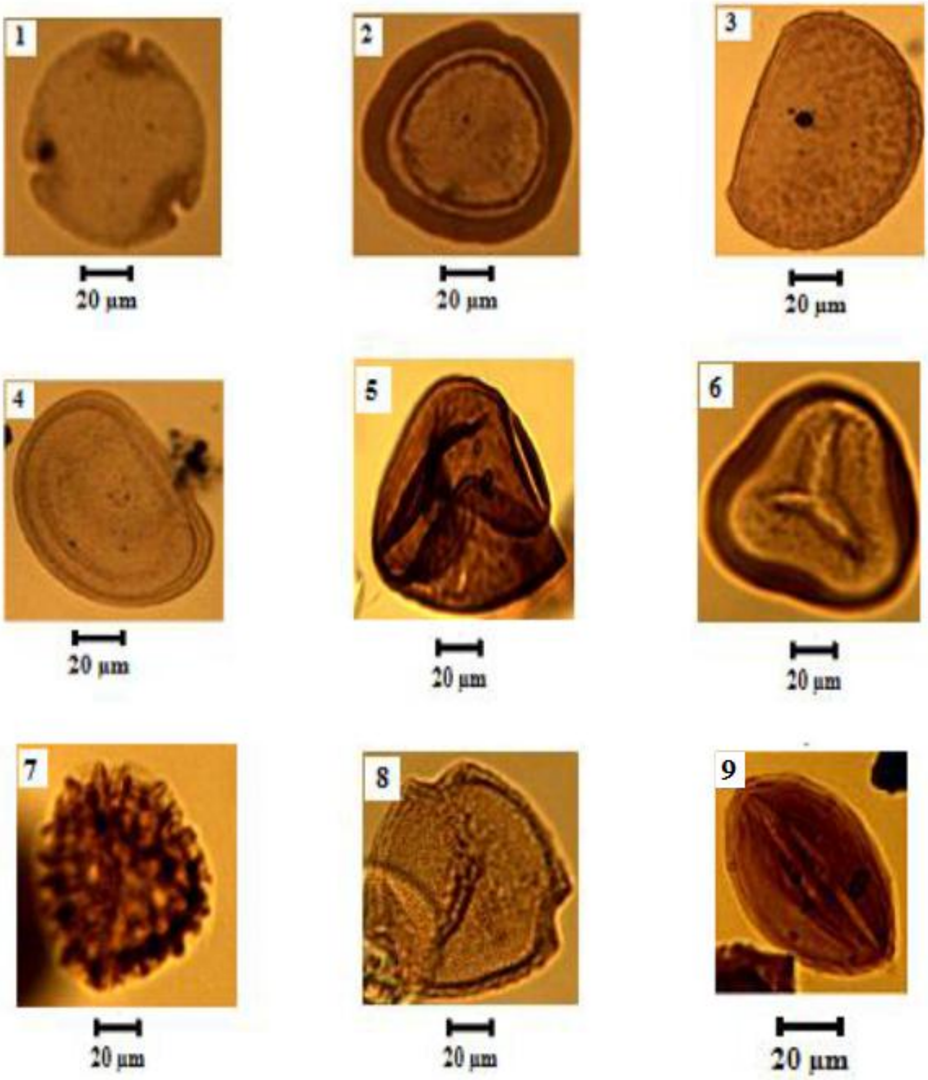
~~The presence of shell~~bioclastic sands, ~~glauconious~~ glauconite green clays and limestone in the Assinie well

~~These g~~Green clays contain remains of marine organisms, evidence of a transgressive sea at this time.The palynostratigraphic analyzes revealed a palynoflora characterizing the upper Eocene and the lower Miocene. Paleovegetation reveals the presence of species that develop in a mangrove environment with moist, lowland, partly marshy forest in a tidal estuarine coastal environment.



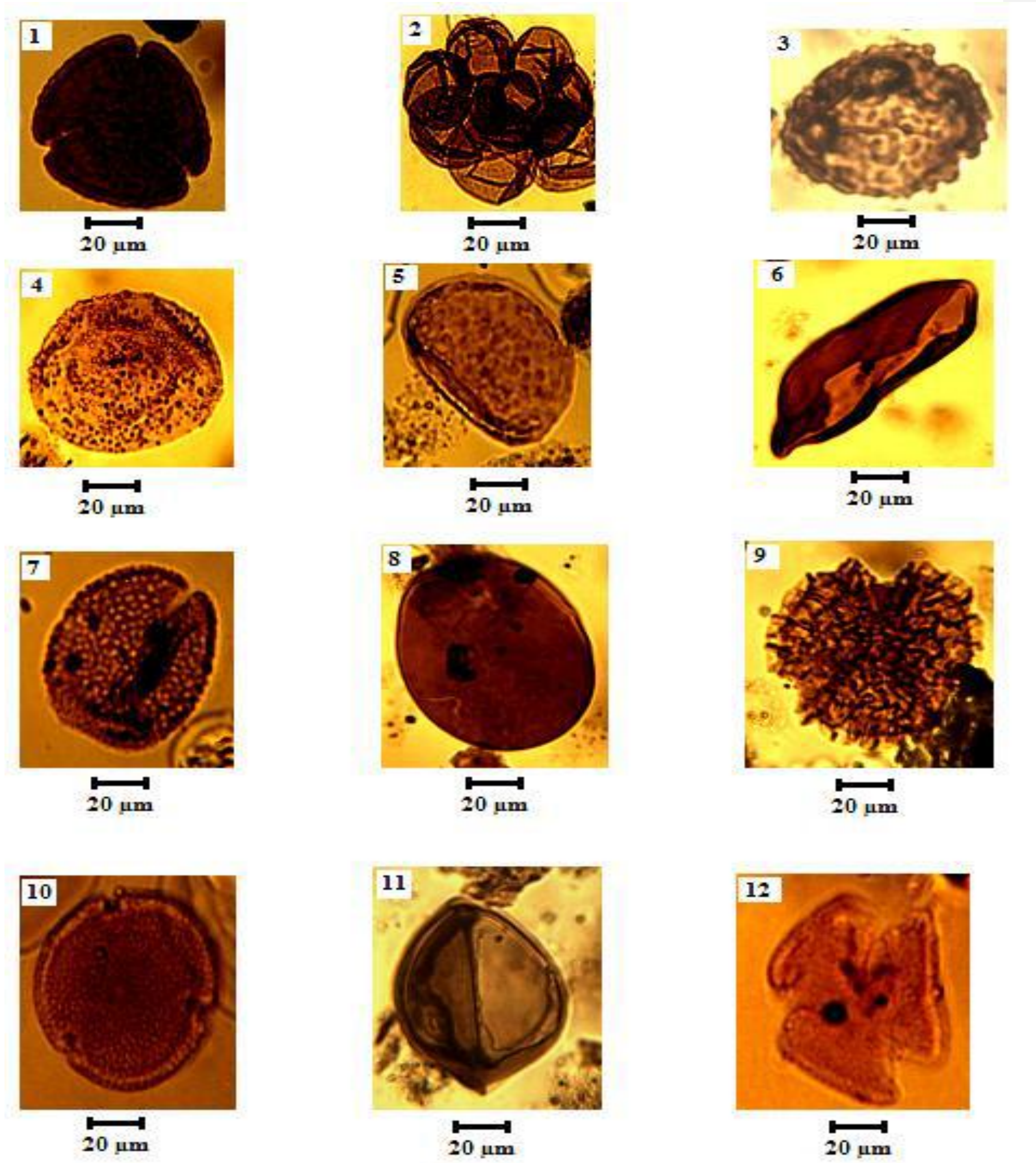
1. Cupressacites hiatipites; 2.Laevigatosporites ovatus ; 3.Polyadopollenites microreticulatus ; 4. Psilatricolporites laevigatus ; 5. Striatopollis catatumbus ; 6. Retitricolporites irregularis; 7. Verrucatosporites usmensis-; 8. Retitriporites sp.-; 9. Monocolpolleniites sp.

Fig. 6. Spores and pollen grains from the lower Miocene of Bingerville (from Gbangbot 2012)



1. Brevicolporites molinae ; 2. Cingulatisporites sp. ; 3. Verrucatosporites usmensis ; 4. Laevigatosporites ovatus ; 5. Leiotriletes adriennis ; 6. Polypodiaceoisporites regularis ; 7. Baculatisporites sp.; 8. Margotricolporites rauvolfii ; 9. Striatopollis catatumbus

Fig. 7. Spores and pollen grains from the lower Miocene of Assinie (from Gbangbot 2012)



1. Psilatricolporites crassus ; 2. Inaperturopollenites sp. ; 3. Verrustephanocolporites complanatus ; 4. Magnaperiporites spinosus ; 5. Verrucatosporites usmensis ; 6. Monosulcites ; 7. Retimonocolpites irregularis ; 8. Laevigatosporites ovatus ; 9. Retitricolporites irregularis ;10. Retitriporites sp.; 11. Monocolpopollenites ; 12. Retitricolpites sp.

Fig. 8. Spores and pollen grains from the upper Eocene of Bingerville (from Gbangbot 2012)

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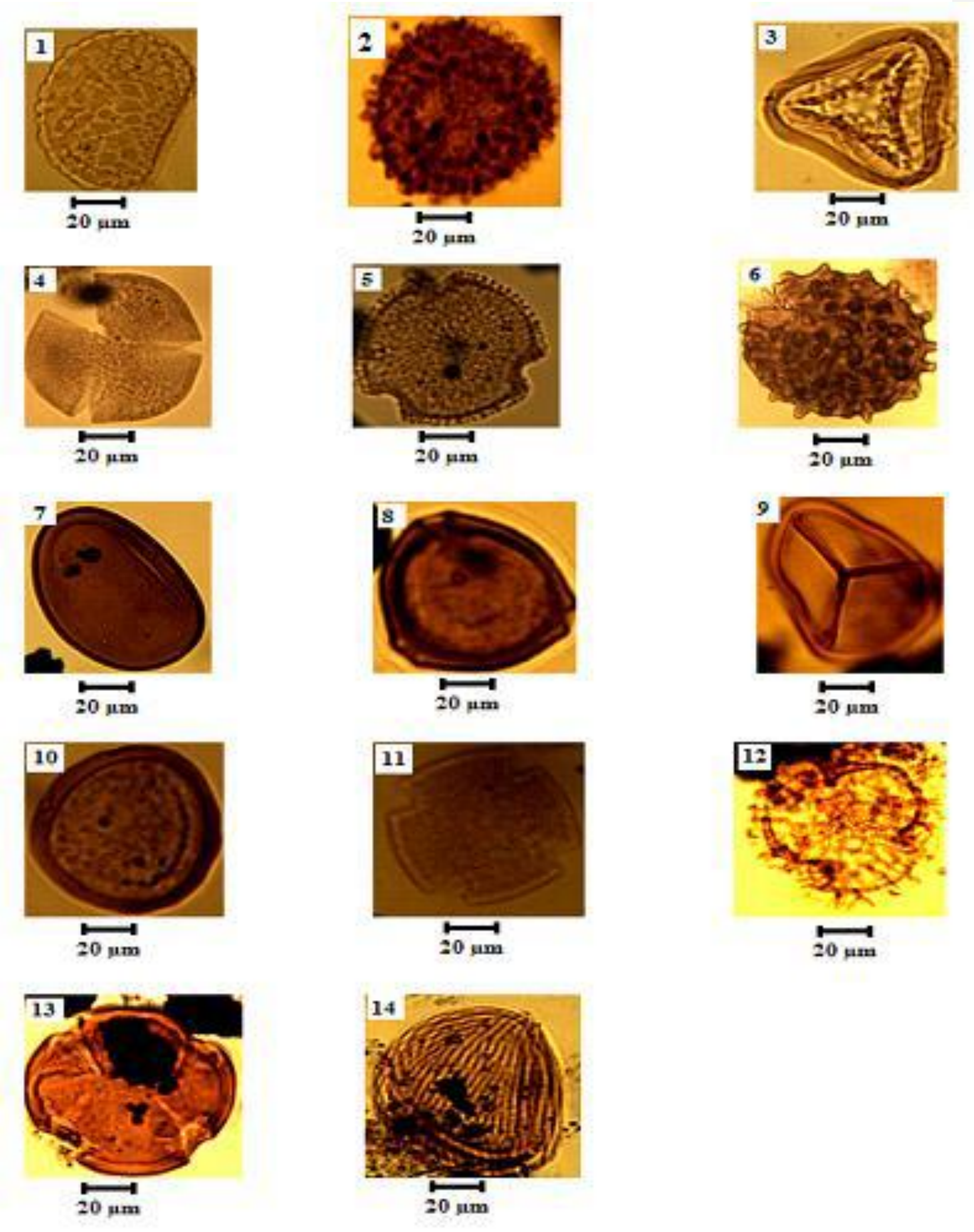
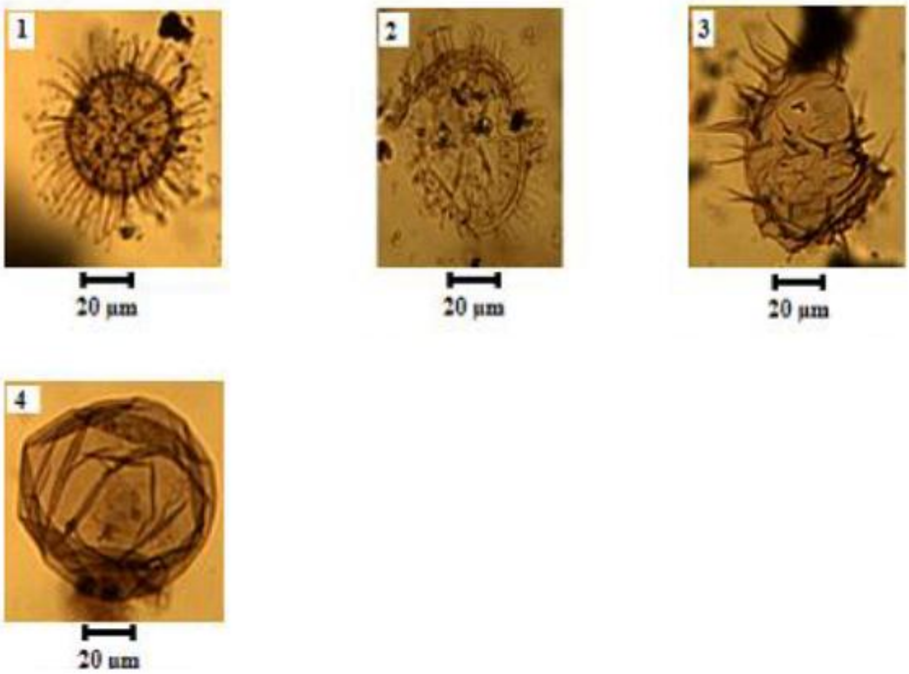


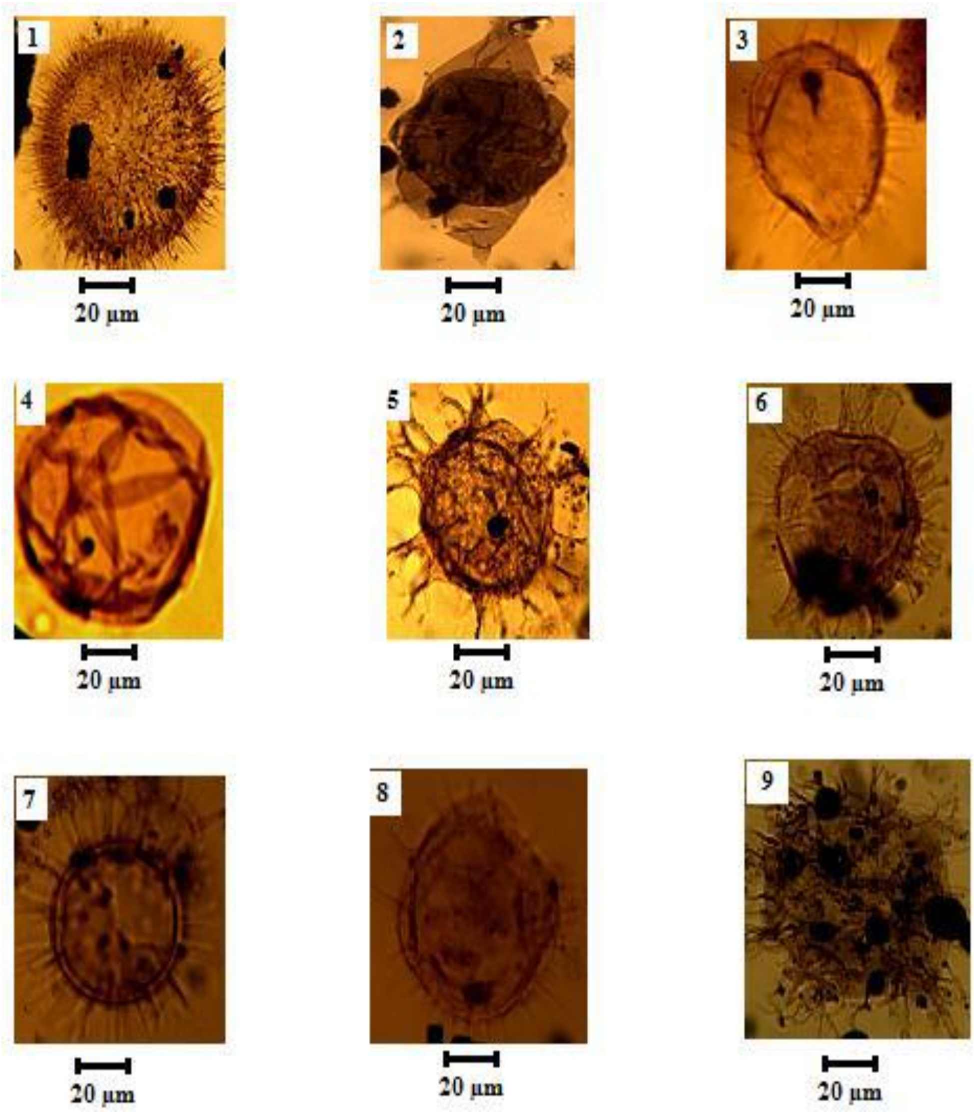
1. Verrucatosporites usmensis ; 2. Baculatisporites ; 3. Polypodiaceoisporites regularis ;4. Tricolpites ; 5. Retitriporites sp. ; 6. Spinizonocolpites echitanus ; 7. Laevigatosporites ovatus ; 8. Momipites sp. ; 9. Deltoidospora delicata ; 10. Cingulatisporites ; 11-13. Pachydermites diederixii ; 12. Retitricolporites irregularis ; 14. Cicatricososporites dorogensis.

Fig. 9. Spores and pollen grains of the upper Eocene of Assinie (from Gbangbot 2012)



1. Lingulodinium machaerophorum ; 2. Operculodinium centrocarpum ;3. Selenopemphix quanta ; 4 Batiacasphaera sp.;

Fig. 10. Dinocysts of the upper Eocene -of Bingerville (from Gbangbot 2012)



1. Com~~o~~etodinium obscurum; 2. Isabelidinium sp.; 3-8. Operculodi~~l~~nium centrocarpum; 4. Batiacasphaera sp.; 5-9. Spiniferites ramosus; 6. Cordosphaeridium inodes; 7. Lingulodinium machaerophorum

Fig. 11. Dinocysts of the upper Eocene of Assinie

APPENDIX

Spore and pollen grains

Baculatisporites sp. (Jaramillo & Dilcher, 2001)
Brevicolporites molinae (Schuler & Doubinger 1970) Salard-Cheboldaeff 1978
Cicatricosisporites dorogensis (Potonié&Gelletich, 1933)
Cingulatisporites sp.
Cupressacites hiatipites (Wodehouse,1933) Krutzsch, 1971
Deltoidospora delicata (Sah, 1967)
Inaperturopollenites sp.
Laevigatosporites ovatus (Wilson & Webster, 1947)
Leiotriletes adriennis (Krutzsch, 1959)
Magnaperiporites spinosus (Gonzalez, 1967)
Margotricolporites rauvolfii (Salard-Cheboldaeff, 1978)
Monocolpollenites sp.
Monosulcites sp.
Pachydermites diederixii (Germeraad, & Muller, 1968)
Polyadopollenites microreticulatus (Salard, 1974)
*Polypodiaceoisporites regularis (*Zhang, 1981)
Psilatriporites sp.
Psilatricolporites crassus (Van der Hammen *&* Wijmstra 1964)
Psilatricolporites laevigatus (Van der Hammen and Wijmstra, 1964)
Retimonocolpites irregularis (Van der hammen & Wijmstra 1964)
Retitricolpites sp.
Retitricolporites irregularis (Van de Hammen & Wijmstra, 1964)
Retitriporites sp.
Spinizonocolpites echinatus (Muller, 1968)
Striatopollis catatumbus (Gonzàlez Guzmàn, 1967) Ward, 1986
Tricolpites sp.
Verrucatosporites usmensis (Van der Hammen, 1956) Germeraad et al., 1968
Verrustephanocolporites complanatus (Salard-Cheboldaeff, 1978)

Dinocyst

Batiacasphaera sp. (Jaramillo & Dilcher, 2001)
Cometodinium obscurum (Deflandre & Courteville, 1959) Monteil, 1991
Cordosphaeridium inodes (Klumpp, 1953) Eisenack, 1963
Isabelidinium sp.
Lingulodinium machaeropharum (Deflandre and Cookson, 1955) Wall, 1967
Operculodinium centrocarpum (Deflandre & Cookson, 1955) Wall, 1967
Selenopemphix quanta (Bradford, 1975) Harland, 1981
Spiniferites ramosus (Ehrenberg, 1838) Mantell, 1854

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