

*Full Length Research Paper*

# Palynostratigraphy and depositional palaeoenvironment of Cretaceous-Palaeogene (K-Pg) boundary deposits on Abidjan margin (Côte d'Ivoire)

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Palynological analysis were performed on 49 samples of cuttings from the interval 6020' to 4460 ' of an oil well Dino -1x located on Abidjan offshore margin in Côte d'Ivoire. This study proposed a palynostratigraphy and inferred a depositional environment, of which 1,560 feet thickness is mainly of gray clays. The samples first described for a lithological synthesis were then subjected to conventional chemical treatment with strong acids. The interval consisted of dark-gray clay becoming slightly calcareous towards the top. Incidentally, the glauconite and pyrite were observed. Palynological species identified revealed three intervals namely Maastrichtian, Paleocene and Eocene. Vertical distribution of this palynoflora shows two depositional environments: the first of marine neritic type with predominantly marine dinocysts from Maastrichtian to the base of Eocene, and the second of nearshore type with dominant terrestrial spores and pollen (Upper part of Eocene). The poor preservation of dinocysts along the interval was interpreted as related to many factors (physical and chemical conditions). Presence of calcareous dinoflagellates assemblages indicates a relatively warmer climate from Maastrichtian to the base of Eocene and a colder one during Upper part of Eocene whereas pollen of palms suggested tropical humid climate.

**Key words:** Palynostratigraphy, palaeoenvironment, Maastrichtian, Palaeocene, Eocene, sedimentary basin, Côte d'Ivoire.

## INTRODUCTION

Structural, tectonical and stratigraphical synthesis of Côte d'Ivoire sedimentary basin was recently established (Digbehi, 1987; Chierici, 1996; Sombo, 2002). Models of structural and sedimentary evolution of this basin include four phases running from rifting phase (Early Cretaceous) to complete oceanisation (late tertiary):

a) The rifting phase (Barremian-Albian) with more than 5000 m of margino-marine-continental sands and clays accumulated during subsidence period, fracturing the basement in horsts and grabens. The first marine sediments are of Albian age. The absence of evaporites on Côte d'Ivoire continental margin shows that this Northern part of the Gulf of Guinea lied under humid

equatorial zone during lower Cretaceous;

b) The initial ocean opening phase (Cenomanian to Senonian) began by a marine transgression and a rapid decrease of subsidence during Cenomanian. Black clays and Oligostegenid limestones covered faulted blocks crests, while thick turbiditic sequences covered half-grabens. In lower Senonian, the blocks of peaks suggested shallow marine erosion;

c) The maximum opening phase took place from Campanian to Maastrichtian. Transgressive Campanian marine clays covered the blocks of peaks and half-grabens. The Lower Senonian unconformity partly separates transgressive Campanian and underlying Cenomanian series;

d) During the final opening phase (Tertiary), the Gulf of Guinea was completely open in North and South Atlantic because the equatorial fracture zones ceased acting on the barrier topography during Lower Tertiary.

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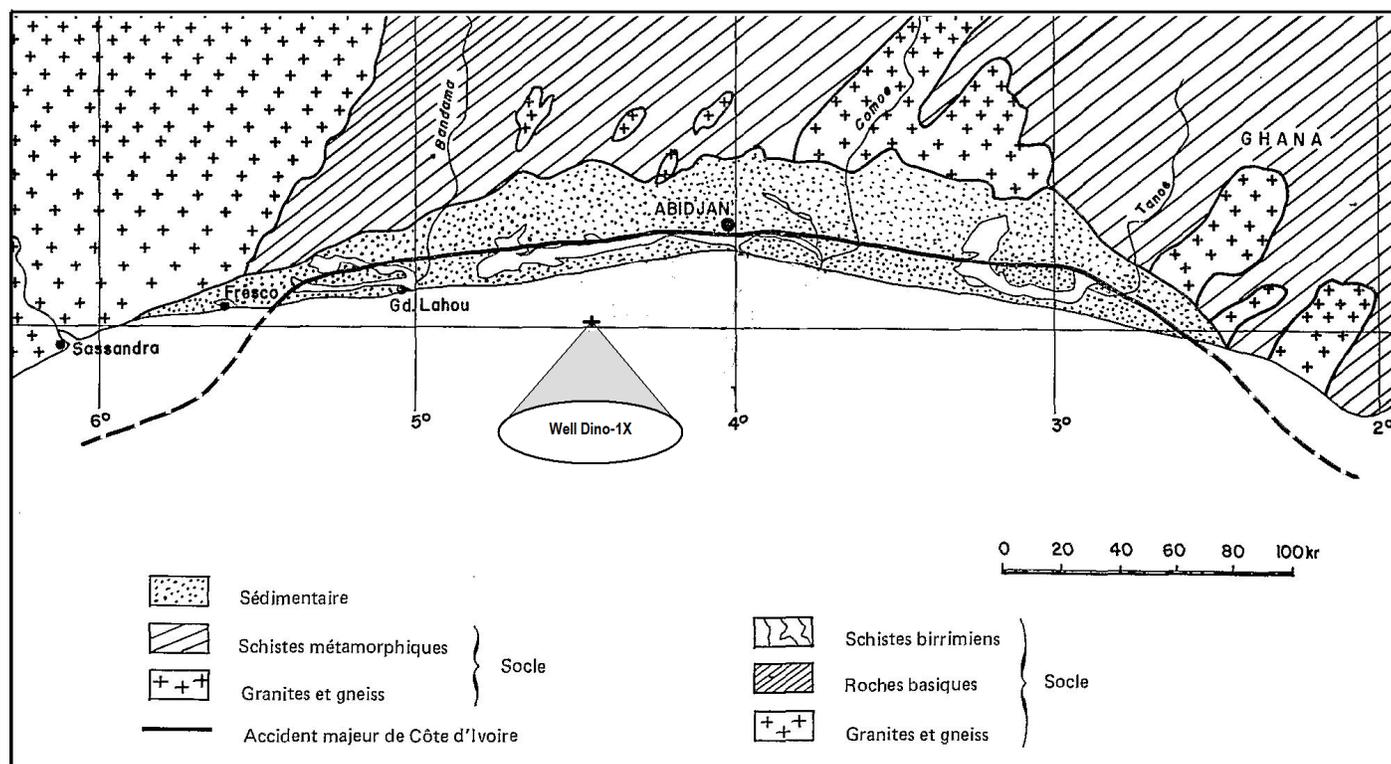


Figure 1. Location of oil well Dino-1X studied.

The Tertiary most important geological event is a regression that began in Late Eocene and ended in Oligocene with partial overlapping of Miocene sediments over Early and middle Eocene series. Maastrichtian marine deposits consist of clays, but some sandy facies outcrop in the East. Paleocene marine series are well-developed (over 500 m) in the Western half part of the basin. They consist of argillites or glauconitic facies (Fresco) with underbedded sandy limestones, Northeast of the basin. The stratigraphy of this basin is mainly known from borehole and foraminiferal data, indicating a gradual transition at Cretaceous-Paleogene (K-Pg) boundary with very similar facies including the so-called "transitional" species (Goua, 1997; Digbehi et al., 1997). Only few palynostratigraphic published works were performed during recent decades are known (Jardiné and Magloire, 1965; Digbehi et al., 1996, 1997; Masure et al., 1996, 1998; Tea et al., 1999) and contribute significantly to a better knowledge of the subsurface stratigraphy. These results focused mainly on data from Cretaceous deposits which have oil interests.

However, the National Society of Petroleum Operations in Côte d'Ivoire (Petroci) conducted some unpublished palynological studies based on cuttings and /or drill cores.

Until present, very rare palynological investigations were conducted on K-Pg limit sediments from this basin except for also unpublished reports from students works,

that justifies the lack of data on K-Pg limit. The present study aims at investigating palynofloras from a section of an oil well Dino-1x (5° 01'20"N 4° 36' 14"W) located offshore off Abidjan, from a palynostratigraphical and palaeoenvironmental point of view.

#### MATERIALS AND METHODS

49 cuttings samples were processed according to standard palynological procedures as adopted in recent works (Prost, 2001; Pearson et al., 2004; Guastia et al., 2005). Palynomorphs assemblages were studied in these samples from the interval 6020' to 4460' of an oil well Dino -1x which was drilled in the sub-central part of Abidjan offshore margin (Figure 1). The sediments analyzed consist of 1 560 feet thick of mainly friable subfissile gray clays, finely micaceous and slightly enriched in carbonates towards the top. About 20 g of material were diluted in 37% HCl and treated with 37% HF. A treatment with KOH and HCl was performed to dissolve KF. To break up amorphous organic matter obscuring the palynomorphs, a short oxidation with 67% HNO<sub>3</sub> followed by neutralization with KOH was necessary. Subsequent to each chemical preparation step, the material was sieved through a 10 mm nylon screen. After each step involving the use of KOH or HNO<sub>3</sub> the samples were checked for the effect of these oxidation procedures on the dinocysts assemblages. Each sample necessitated a short ultrasonic treatment in order to achieve a better dispersion of the residue. Slides are stored in the collection of the Laboratory of Biostratigraphy at University of Cocody, Abidjan. Palynomorphs were counted up to 50 determinable specimen where possible. For qualitative and quantitative study, at least two permanent slides per productive sample were prepared

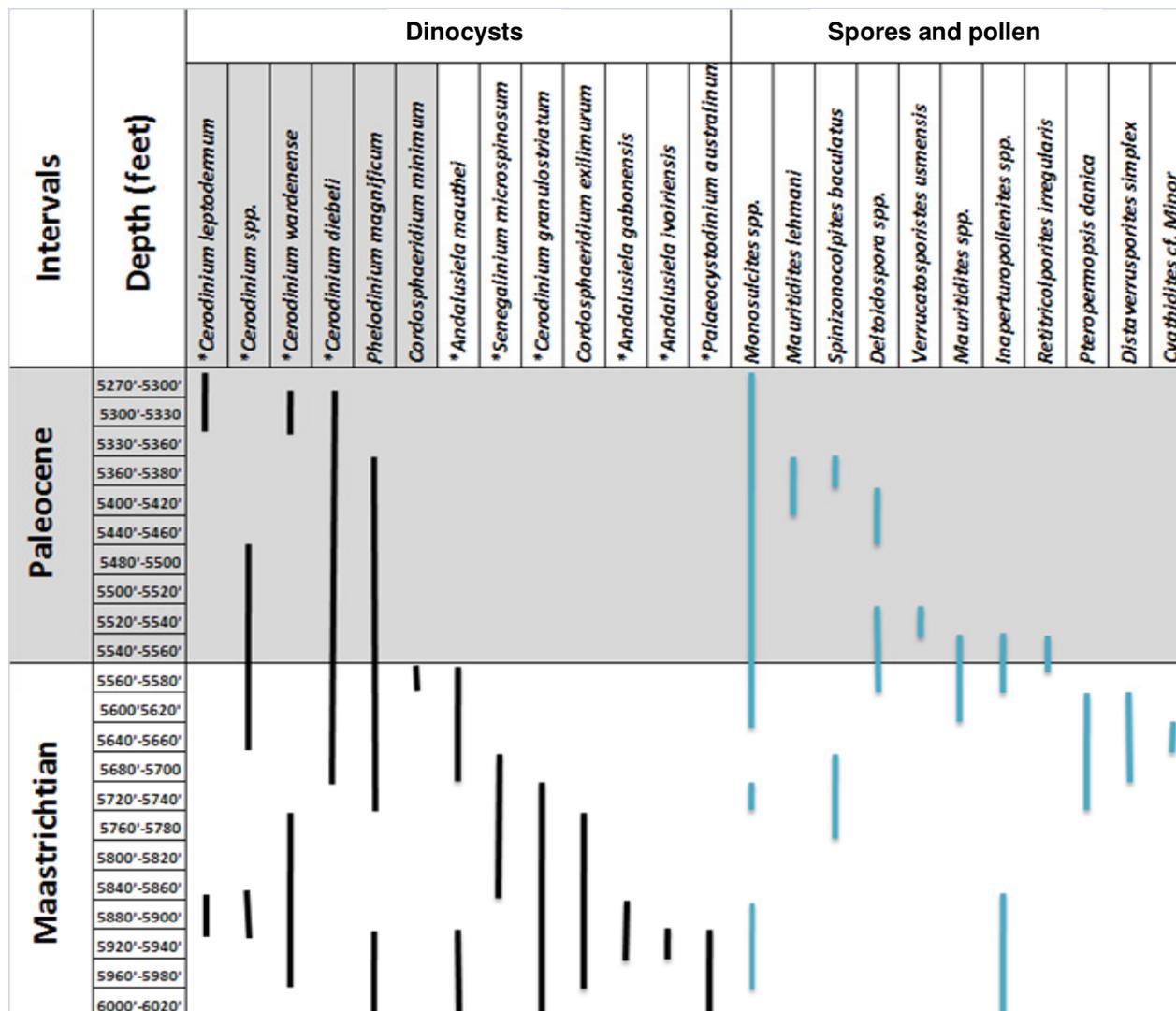


Figure 2. Vertical distribution of palynomorphs in the oil well Dino-1X during Maastrichtian and Paleocene.

using Canada balsam as mounting medium. The slides were examined using a Motic light microscope equipped with a Motic digital camera. Dinocysts taxonomy was in accordance with Williams et al. (1998) and other sporomorphs with Potonie morphological classification (1974). In order to obtain the main variations of the paleoecological signal along the succession, two models were combined (Chateauneuf and Reyre, 1974; Michoux, 2002 cited by Demchuck et al., 2008). In both models, depositional environments run from a continental shelf with terrestrial palynoflora dominant to an outer continental-shelf dominated by dinoflagellates cysts and inner walls of foraminifera.

## RESULTS

### Palynostratigraphy

The subfossil gray clays analyzed contain dominant marine dinocysts assemblage (87.56 pc) more or less

well preserved in regards to terrestrial pollen and spores. These dinocysts include diverse species of the genera *Andalusiella*, *Cerodinium*, *Senegalinium*, *Phelodinium* and *Homotryblium*. Terrestrial pollen and spores are represented by the genera *Distaverrusporites*, *Spinizonocolpites*, *Mauritiidites* and *Margocolporites*. This palynoflora reveals three stratigraphic intervals (Figures 2 and 3). A Maastrichtian age is suggested for the lower subfossil gray clays facies (6000' to 5560') based on the occurrence of well known Maastrichtian marine dinoflagellates *Andalusiella mauei* (Figure 5a), *Andalusiella gabonensis* (Figure 5b), *Cerodinium granulostriatum* (Figure 5c), *Senegalinium microspinosum* (Figure 5d). Associated with these forms also are some Maastrichtian spores and pollen: *Distaverrusporites simplex* and *Spinizonocolpites baculatus*. Paleocene (5560' to 5270') was suggested, for

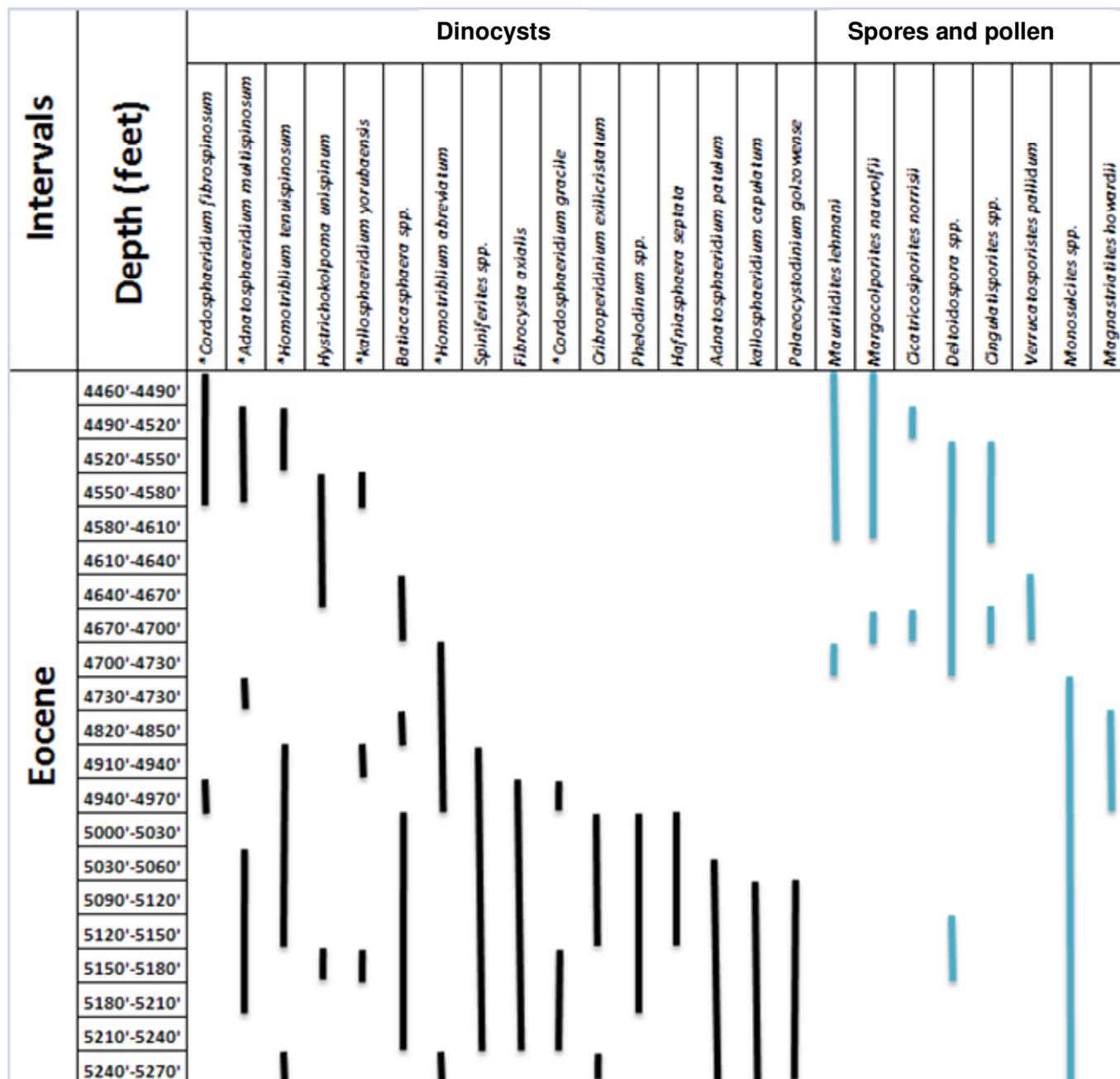


Figure 3. Vertical distribution of palynomorphs in the oil well Dino-1X during Eocene.

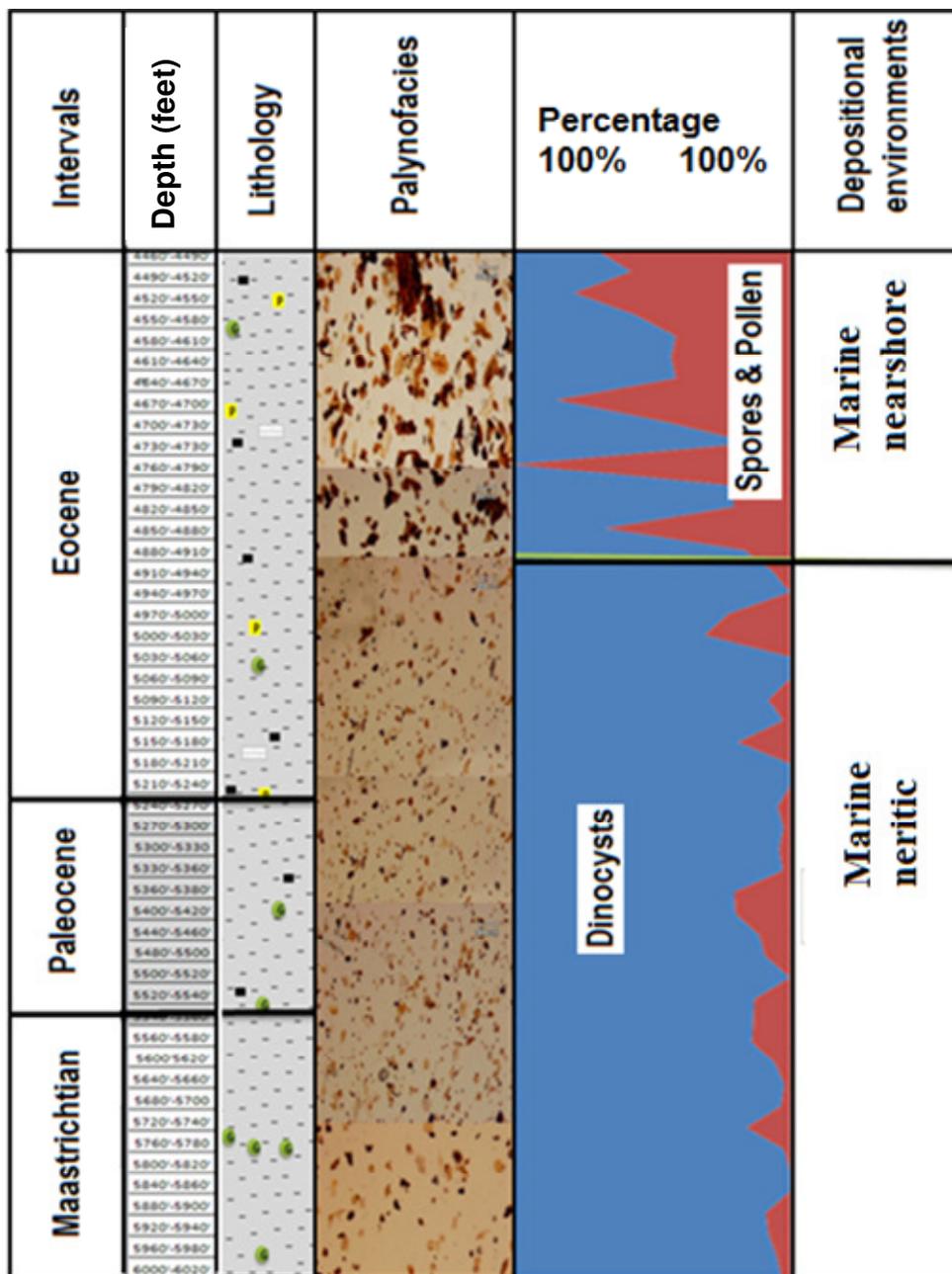
the middle relatively sandy layer, based on occurrence of dinocysts species *Cerodinium leptodermum* (Figure 5e) and *Phelodinium magnificum* associated to *Cerodinium diebeli* (Figure 5f).

Rare species of pollen grains as *Mauritidites lehmani* (Figure 6d) are encountered. An Eocene age was attributed to the uppermost slightly enriched in carbonates unit (5270' to 4460') by marine dinocysts assemblage based on the occurrence of various species of *Homotryblium* as *Homotryblium abbreviatum*,

*Homotryblium pallidum* (Figure 6a) and *Homotryblium tenuispinosum* (Figure 6b) associated to *Adnatosphaeridium multispinosum* (Figure 6c) and pollen species *Margocolporites nauvolfi* (Figure 6e and f).

**Evolution of depositional settings**

The marine dinocysts assemblage from Maastrichtian up to the base of Late Eocene, (Figure 4) is poorly preserved,

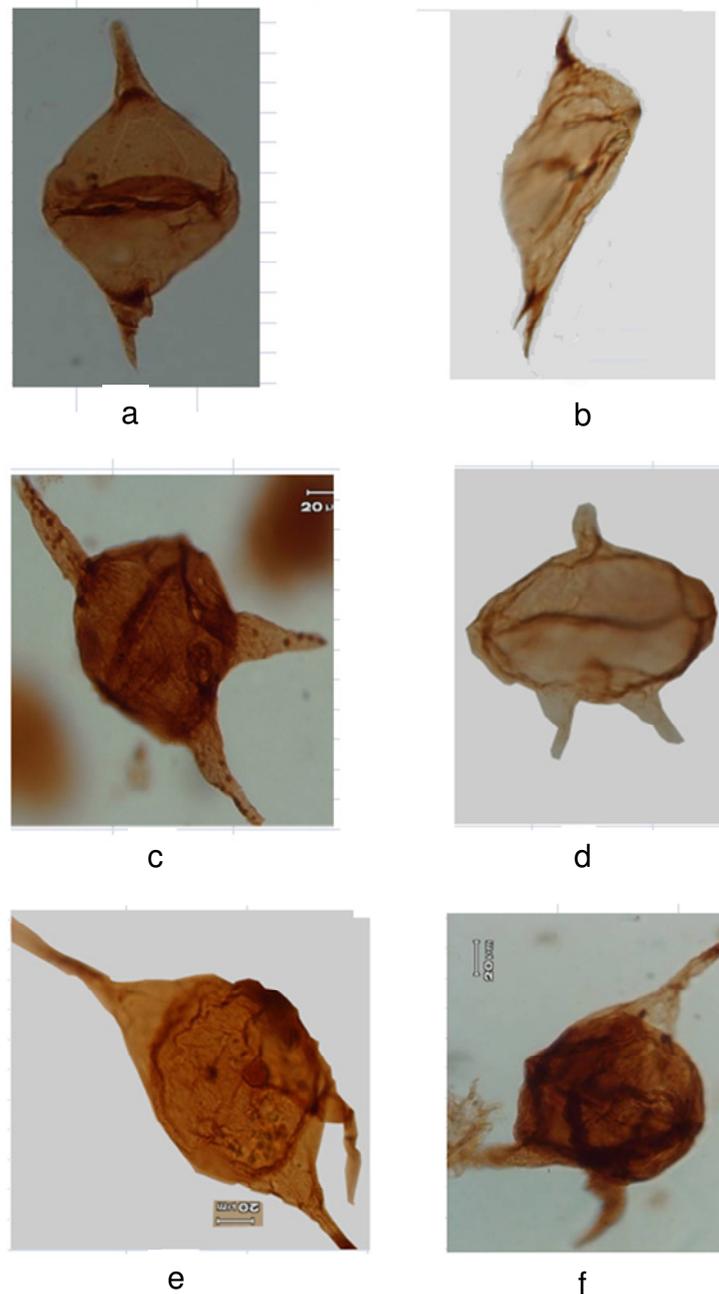


**Figure 4.** Synthesis of lithology, palynofacies and relative abundance of palynomorphs with associated depositional environments variation throughout study interval in oil well Dino-1X.

unlike terrestrial pollen and spores. This assemblage reflects influence of shallow marine process during deposition of these gray clays with organic matter that consists of small orange, brown to black wood debris. The presence of glauconite reflects a deposition under marine poorly oxygenated settings. During Late Eocene, the relative explosion of terrestrial pollen and spores (27%) reflects a stronger continental influence (nearshore) in this interval with large darker organic matter.

## DISCUSSION

Approaches of K-Pg boundary study are becoming more and more various and fine today. Some are based on chemotrigraphy (Ferro et al., 2011), others on purely biostratigraphical unitary data (palynology, micropaleontology) or combined (Crouch et al., 2003; Hildebrand-Habel and Streng, 2003; Galeoti et al., 2004; Rochon et al., 2008). In palynological plan, quantitative and qualitative changes in the composition of the

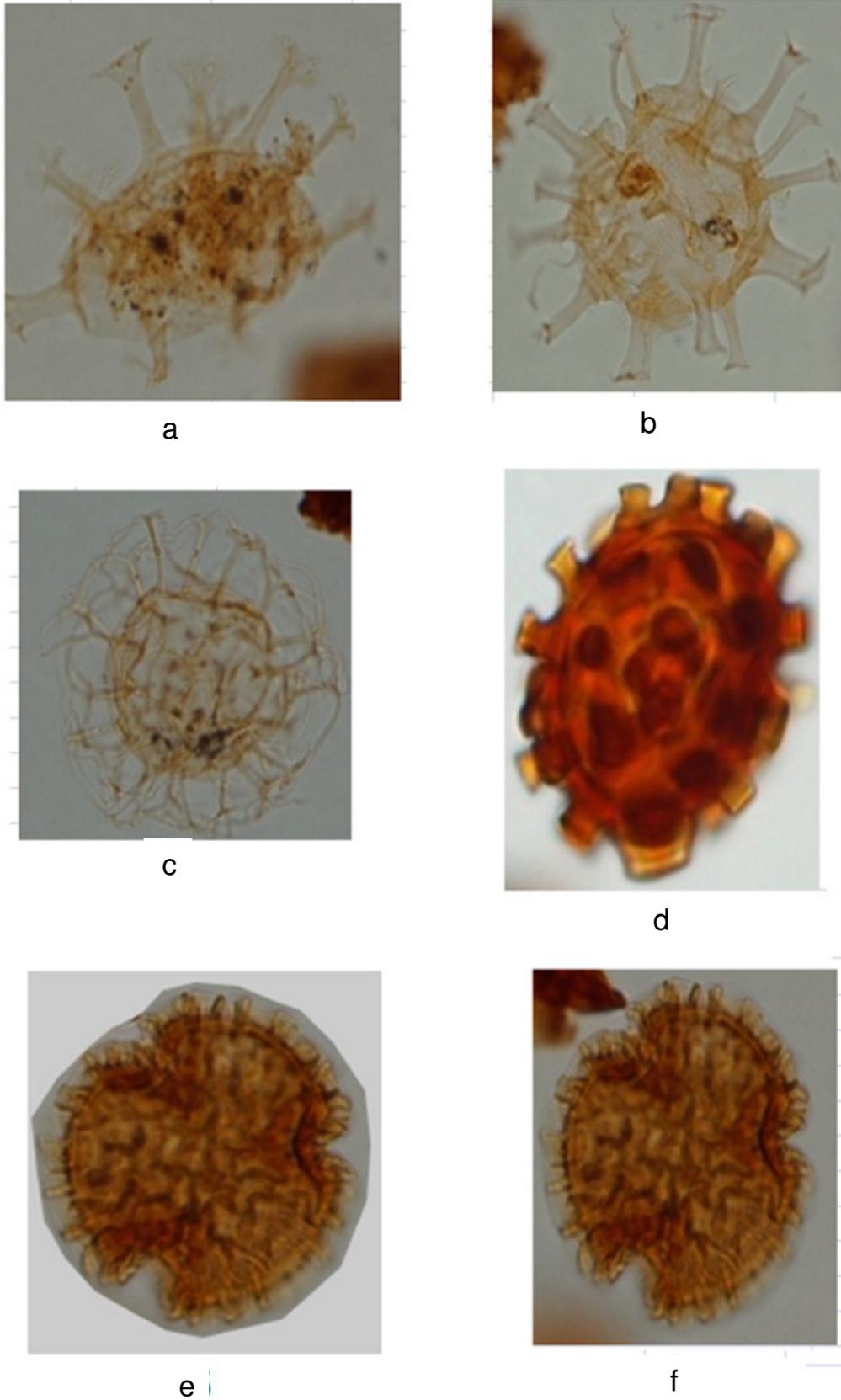


**Figure 5.** a) *Andalusia mauthei*, b) *Andalusia gabonensis*, c) *Cerodinium granulostriatum*, d) *Senegalinium microspinosum*, e) *Cerodinium leptodermum*, f) *Cerodinium diebeli*.

terrestrial (pollen and spores) and marine (dinoflagellates) palynofloras are usually controlled by a number of factors which are not easy to interpret in detail (Mahmoudi and Schrank, 2007; Richter, 2007). These include temperature of surface waters, salinity, shape of processes, mode of nutrition, climate, sedimentation rate, density, nitrate, phosphate and chlorophyll concentrations, etc. Because dinocysts notably exhibit high abundance in neritic settings, dinocyst-based

environmental and palaeoclimatic data, according to Sluijs (2005), is important and complementary to the data derived from typically more offshore groups as planktonic foraminifera and other microplankton.

Despite uncertainties about taxonomical identity and limitations due to taphonomical processes (Rochon et al., 2008), dinoflagellates cysts provide extremely useful and unique information on marine environments of the past. Based on nutritional plan, Powell et al. (1992) cited by



**Figure 6.** a) *Homotryblum pallidum*, b) *Homotryblum tenuispinosum*, c) *Adnatosphaeridium multispinosum*, d) *Mauritiidites lehmani*, e and f) *Margocolporites novaulfi*.

Sluijs (2005), indicated that Gerdinoids cysts (P-cysts) are considered to predominantly represent heterotrophic dinoflagellates whereas Gonyaulacoids-cysts (G-cysts) mainly represent autotrophic forms. Moreover, the dinocysts associations with high relative abundance of heterotrophic species are usually observed in neritic regions (Holzwarth et al., 2007), characterized by high chlorophyll and low salinity conditions in surface waters. Finally, the wide distribution of current calcareous dinoflagellates was recently illustrated by means of 61 charts by Marret and Zonneveld (2003) in recent sediments from the Atlantic and adjacent basins. In the present work and data collected, only palynostratigraphic and palaeoenvironmental aspects are discussed and alternative palaeogeographic and palaeoclimatologic aspects are approached.

### Palynostratigraphical context

Most of the Maastrichtian palynomorphs identified in the present work are known in basins along the East Atlantic coast including Côte d'Ivoire (Masure et al., 1996, 1998), Gabon (Boltenhagen, 1977), Nigeria (Lawal, 1982; Fazzari and Biffi, 1984; Oboh-Ikuenobe et al., 2005; Olusola, 2009) and Niger (Boudouresque, 1980) and Ghana (Atta-Peters and salami, 2004). This is especially Maastrichtian assemblage including *A. mauthei*, *A. gabonensis* and other *C. granulostriatum*. The extinction of these species marks the Cretaceous-Palaeogene (K-Pg) limit in 5560 feet deep. But here, a number of well known Maastrichtian dinocysts recently described in Southeastern Bida Basin, Nigeria (Olusola, 2009) are absent notably *Dinogymnium acuminatum*, *Dinogymnium digitus*, *Senegalinium bicavatum* and *Senegalinium psilatatum* as well as spores and pollen species including *Buttinia andreevi*, *Cristaeturites cristatus* and *Retidiporites magdalenensis*. Moreover, terrestrial pollen grains are mainly represented in our study by *S. baculatus* whereas three others lacked namely *Echitriporites trianguliformis*, *Auriculiidites reticulatus* and *Rhoipites hirtzii*.

Among dinocysts described in the present study, some biostratigraphically significant such as *Andalusiella* and *C. granulostriatum* began in Campanian as indicated by Mahmoud and Schrank (2007) in Aswan area, Southern Egypt. Similarly, during Paleocene, three of the main marine dinocysts species identified namely *P. magnificum*, *C. diebeli* and *C. leptodermum*, confirm this interval in Nigeria (Lawal, 1982; Fazzari and Biffi, 1984), but also elsewhere in the Northern Hemisphere (Graham et al., 1993; Williams et al., 2004; Fensome et al., 2008, 2009). Species such as *A. multispinosum*, *H. pallidum*, *H. abbreviatum*, *H. tenuispinosum* and *Apectodinium quinquelatum* (very rare), characterize Eocene (Williams et al., 2004; Fazzari and Biffi, 1984; Fensome et al., 2008, 2009). *Homotryblium* first occurred in the Early

Paleocene (Lakovleva and Kulkova, 2001) and has a last occurrence in the Mid-Miocene according to Brinkhuis (1994) cited by Sluijs (2005).

### Depositional palaeoenvironments

The dominance of dinoflagellates cysts in regards to spores and pollen within the lower interval (Maastrichtian-Basis of Late Eocene) evokes marine deposition, in agreement with Chateauneuf and Reyre (1974). In contrast, spores and pollen grains are virtually absent in this interval. Based on the model of Michoux (2002) cited by Demchuck et al. (2008), the marine origin of dinoflagellate cysts described here was supported by the lack of freshwater algae in assemblages. But when combined the two models, rarity of chitinous inner linings of foraminifera was recorded, and added to a poor conservation of dinocysts, compared to terrestrial spores and pollen. The causes of this poor conservation might lie in burial physico-chemical conditions in grabens or depocentres located often nearshore in Côte d'Ivoire sedimentary basin (Digbehi, 1987; Digbehi et al., 1996). The increase in the rate of terrestrial material within the Upper part of Eocene appears as the consequence of sea level drop occurred in Côte d'Ivoire sedimentary basin during K-Pg limit (Oboh-Ikuenobe et al., 1997).

Concerning this sharp deterioration of dinocysts, it is also possible that this drop causes decreasing of the water column and induces turbulences in depositional settings. Moreover, hydrothermal episodes induced by displacement of transform fractures zones, notably within Côte d'Ivoire-Ghana Ridge both sides of the Ivorian margin (Saint-Marc and N'da (1997) by releasing hot and acidified water, and could also lead to poor conservation of dinocysts (calcareous algae) of the pelagic marine part of the interval studied. This poor conservation might finally be due to oxidation of organic matter often intensive in open ocean settings with generally low sedimentation rates as observed Sluijs (2005). It is established that dinocysts are also among the most resistant organic particles and also represent important primary producers in the upper water column; so this poor conservation can be interpreted as due to only hydrodynamic turbulences. Moreover, Richter et al. (2007), indicated that in general, high accumulation rates of calcareous dinocysts were found with slightly lower accumulation rates in the upwelling-influenced areas.

In terms of phytoplanktonic productivity, the works of van Mourik et al. (2001) cited par Sluijs (2005), showed that high abundance of P-cysts were used to indicate phases of enhanced nutrient availability probably derived from stronger terrigenous input. Similarly, Sluijs et al. (2003) cited by Sluijs (2005), high relative abundance of P-cysts in Maastrichtian-Lower part of Eocene can be interpreted to reflect a supply of nutrients from land. According to Gedl (2007), the predominance of P-cysts

may indicate eutrophic conditions in the diluted offshore photic zone induced by upwelling phenomena. Mahmoudi and Schrank (2007), indicated that proximate cysts such as *Cerodinium* are abundant in a shallow marine (inner shelf) and normal salinity environment whereas dinoflagellates with complex processes (*Spiniferites*), which tend to become more common in open shelf environments are rare. Sluijs (2005), citing Brinkhuis (1994), showed that among Paleogene and Neogene dinocyst taxa, members of *Homotryblium complex* and other taxa of the family Goniodomaceae are widely considered to be characteristic of restricted settings with increased salinity. In the same way, Sluijs (2005) showed that high abundance of *H. tenuispinosum* and *Homotryblium floripes* (not identified in this study) reflected drier periods where reduced runoff, in combination with strong evaporation, led to increased salinity in nearshore. Kothe (1990) interpreted intervals of high *Homotryblium* abundance in the Oligocene and Miocene of northwest Germany to indicate high-salinity conditions.

Nevertheless, according to the same author, acmes of *H. tenuispinosum* were also recorded alongside high abundance of the freshwater algae *Pediastrum* spp. which indicates a brackish setting. They concluded that although most available records suggest an affinity of *Homotryblium* to hypersaline environments, there are indications that the genus may also have favoured abnormally low salinity conditions. The deepening of the ocean, immediately after the K-pg boundary as well as the softening extended climate phenomena are known elsewhere (Galeoti et al., 2004). In this work however, this deepening was quickly attenuated before the end of Eocene when the subsidence, according to Digbehi (1987) and Chierici (1996), was stabilized. This could partly explain the superposition of seashore deposition (dominated by terrestrial pollen and spores) on marine neritic deposits (dominated by dinoflagellate cysts).

#### **Botanical affinities and sketch of palaeoecological and palaeoclimatical evolution**

Palaeoecological and palaeoclimatical considerations here are mainly based on changes in the bulk composition of palynoflora and the botanical affinities of selected palynomorphs (Appendix). The relative frequency of some spores, mainly *Deltoidospora* indicates presence of pteridophytes. Within this palynoflora are represented P-cysts, mainly *C. granulostriatum* and *A. mauthei*, *A. gabonensis*, and G-cysts such as *Adnatosphaeridium* and *Spiniferites*. Gymnosperms are mostly represented by number of undetermined inaperturate pollen (*Inaperturopollenites* spp.). Angiospermous pollen are dominated by palms (*Monosulcites* spp. and *S. baculatus*). In accordance to Mahmoud and Schrank (2007) and to Eisawi and Schrank

(2008), Late Cretaceous Palmae province is mainly represented here by *S. baculatus* and suggests tropical humid climate areas as well as *Spinizonocolpites* traduces a mangrove belt.

Moreover, Hildebrand-Habel and Streng (2003) suggested that calcareous dinoflagellates assemblages indicate a relatively warmer climate during Maastrichtian and colder one during Neogene. Within such assemblages, Guasti et al. (2005) cited by Mahmoud and Schrank (2007) showed that high abundances of P-cysts were assumed to indicate a low salinity and/or high nutrient environment. Despite the absence of *Ariadnaesporites*, presence of palm pollen and pteridophytic spores related to water ferns (Vajda-Santivanez, 1999; Atta-Peters and salami, 2004; Rochon et al., 2008) confirmed this prevalence of humid tropical conditions during the deposition of the sediments examined. Moreover, mangrove pollen common in West African coastal basins are species *Spinizonocolpites* (*Nypa*) as described in works of Eisawi and Schrank (2008).

#### **Conclusions**

The palynological study of the interval 6020' to 4460' of the oil well Dino-1x was documented by sediments consisting mainly of dark clays slightly upward carbonated sequence. It led to propose a palynostratigraphic scale and a depositional environment model from Maastrichtian to Eocene. Many taxa characterizing Maastrichtian (6020' to 5560'), Paleocene (5560' to 5270') and Eocene (5270' to 4460' ) were identified. Most of these species well known in peri-Atlantic basins confirmed the palynostratigraphical scale proposed. Two depositional environments were identified: the one (Maastrichtian-Base of Eocene), rich in small marine neritic organic matter dominated by neritic marine dinoflagellates cysts; the other (Upper part of Eocene), nearshore is rich in large particles of organic matter with a relative explosion of terrestrial spores and pollen grains. The poor preservation of dinocysts along the interval was interpreted as related to physical and chemical conditions which prevailed in the depositional settings during a probably drop of sea level that caused decreasing of the water column and induced turbulence. Presence of calcareous dinoflagellates assemblages indicates a relatively warmer climate during Maastrichtian-Base of Eocene and a colder one during Upper part of Eocene whereas pollen of palms suggests tropical humid climate.

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## APPENDIX

Index of different species of palynomorphs identified in this study (NB the diagnostic species are marked with an asterisk \*).

### Dinoflagellate cysts (dinocysts)

\**Adnatosphaeridium huenickenii* (Archangelsky, 1969)  
 \**Adnatosphaeridium multispinosum* (Williams and Downie, 1966)  
 \**Adnatosphaeridium patulum* (Williams and Downie, 1966)  
 \**Andalusiella gabonensis* (Stover and Evitt, 1978)  
*Andalusiella ivoirensis* (Masure, Tea et Yao, 1996)  
 \**Andalusiella mauthei* (Riegel, 1974; emend Masure et al., 1996)  
*Areoligera gippingensis* (Jolley, 1992) *Batiacasphaera* spp.  
 \**Cerodinium diebelii* (Alberti, 1959; Lentin and Williams, 1987)  
 \**Cerodinium granulostriatum* (Jain and Milleped, 1973)  
 \**Cerodinium leptodermum* (Vozzhennikova, 1963)  
 \**Cerodinium wardenense* (Williams and Downie, 1966c; Lentin and Williams, 1987).  
*Cleistosphaeridium diversispinosum* (Davey et al., 1966)  
*Cordosphaeridium exilimurum* (Davey and Williams, 1966)  
 \**Cordosphaeridium fibrospinosum* (Davey and Williams, 1966)  
 \**Cordosphaeridium gracile* (Eisenack, 1954; Davey et Williams 1966)  
*Cordosphaeridium inodes* (Eisenack, 1963; emend Davey, 1969).  
*Cordosphaeridium minimum* (Morgenroth, 1966; Benedek, 1972)  
*Cribroperidinium exilicristatum* (Davey, 1969; Stover and Evitt, 1978)  
*Dapsilidinium pseudocolligerum* (Stover, 1977; Bujak et al., 1980)  
 \**Diphyes colligerum* (Deflandre and Cookson, 1955; Cookson, 1965)  
*Fibrocysta axialis* (Eisenack, 1965; Stover and Evitt, 1978)  
 \**Homotryblium abbreviatum* (Batton, 1976)  
 \**Homotryblium pallidum* (Davey and Williams, 1966b)  
 \**Homotryblium tenuispinosum* (Davey et al., 1966b)  
*Hafniasphaera septata* (Cookson and Eisenack, 1967; Hansen, 1977)  
*Hystrichokolpoma cf. unispinum* (Williams and Downie, 1966a)  
*Kallosphaeridium capulatum* (Stover, 1977)  
*Kallosphaeridium cf. brevibarbatum* (De Coninck, 1969)  
 \**kallosphaeridium yorubaensis* (Jan du Chêne and Adediran, 1985)

*Palaeocystodinium australinum* (Cookson, 1965b; Lentin and Williams, 1976)  
*Palaeocystodinium golzowense* (Alberti, 1961)  
*Phelodinium africanum* (Biffi and Grignani, 1983)  
 \**Phelodinium magnificum* (Stanley, 1965; Stover and Evitt, 1978)  
*Phelodinium nigericum* (Biffi and Grignani, 1983)  
*Phelodinium* spp.  
 \**Senegalinium microspinosum* (Boltenhagen, 1977)  
*Spiniferites mirabilis* (Rossignol, 1964; Sarjeant, 1970)  
*Spiniferites ramosus* (Ehrenberg, 1938; Mantell, 1954)  
*Spiniferites splendidus* (Harland, 1979)

### Spores and pollen grains

*Cicatricosporites norrisii* (Srivastava, 1971)  
*Cingulatisporites* spp.  
*Cyathidites minor* (Couper, 1953)  
*Deltoidospora australis* (Couper, 1953 ; Pocock, 1970).  
*Deltoidospora* spp  
*Distaverrusporites simplex* (Muller, 1968)  
*Inaperturopollenites* spp.  
*Magnastriatites howardii* (Germeraad et al., 1968)  
*Margocolporites nauvoifii* (Ramanujan, 1966 ex Potonie, 1970)  
*Mauritiidites crassibaculatus* (Van Hoeken Klinkenberg, 1964)  
*Mauritiidites lehmani* (Van Hoeken Klinkenberg, 1964)  
*Monosulcites* spp.  
*Pterospermopsis danica* (Wetzel, 1952)  
*Retitricolporites irregularis* (Van der Hammen and Wijmstra, 1964)  
*Spinizonocolpites baculatus* (Muller, 1968)  
*Verrucatosporites usmensis* (Van der Hammen) Germeraad et al., 1968