

Palynological and Paleoenvironmental Characterization of the Campano-Maastrichtian Age Deposits of Adiake in the South-East of the Ivory Coast

OUATTARA Ismaël Ben^{1*}, KOFFI Kouassi Affoué Rachel², Yao Diby Ferdinand³

¹Department of Geosciences of Sedimentary Environments and Energy, University of Félix Houphouët-Boigny, P.O. Box 582 Abidjan 22, Côte d'Ivoire
Tel. (+225) 0748890520
Email: geologueben@hotmail.fr
Email: ismael.ouattara03@ufhb.edu.ci

²Laboratory of Geographical Sciences, Civil Engineering and Geosciences, Felix Houphouët Boigny National Polytechnic Institute de Yamoussoukro, BP 1093 Yamoussoukro Côte d'Ivoire
Tel : (+225) 0708939719
Email: affoue.kouassi@jiphb.ci

Department of Geosciences of Sedimentary Environments and Energy, University of Félix Houphouët-Boigny
P.O. Box 582 Abidjan 22, Côte d'Ivoire
Tel. (+225) 0709934906
Email : dibysisra@gmail.com

Abstract: 192 samples of drill cuttings from two wells MARRY 1 and MARRY 2 respectively 99m and 95m located in the onshore basin of south-eastern Ivory Coast 94km from Abidjan have been subject of palynological analyzes to determine the environments of deposition and age of the sediments. Samples were taken from clay and silty clay levels. The palynological treatment method used is the classic one involving strong acids such as 37% hydrochloric acid and 70% hydrofluoric acid. The results showed: 1) 1618 palynomorphs comprising dinoflagellate cysts in 1132 and 486 miospores. 70% dinoflagellate cysts and 30% of miospores. This study revealed two stages namely: 2) The Campanian between depths of 94m and 58m found only in the MARRY 1 well and dated by palynomorphs: *Dinogymnium acuminatum*, *Dinogymnium cretaceum undulocostata*, *Dinogymnium cooksonae*, *Dinogymnium westralium*, *Unipontidinium grande* and *Hystrichodinium pulchrum*, *Foveotrilletes margaritae* and *Ephedripites multicostatus*. 3) The upper Maastrichtian between ratings 58m and 47m for MARRY 1 and 91m and 13m for MARRY 2 characterized by the dinocysts of genre: *Andalusiella mauthei*, *Cerodinium granulostriatum*, *Cerodinium leptodermum*, *Senegalinium bicavatum* and *Senegalinium microspinosum*, *Foveotrilletes margaritae*, *Longapertites marginatus*, *Proteacidites longispinosum*, *Distaverrusporites simplex*, *Echitriporites trianguliformis*, *Zlivisporites blanensis*, *Ephedripites multicostatus*, and *Monocolpites marginatus*. These palynological data helped to define the paleoenvironment that was deltaic at Campanian and shallow marine that is to say coastal or estuarine at the upper Maastrichtian.

Mots clés : Palynology, Campanien, Maastrichtien, sédimentaire bassin of Côte d'Ivoire

1. Introduction

Ivory Coast, a West African country, belongs to the countries of the Gulf of Guinea, extending from southern Morocco to beyond Angola [1]. It has a basin which was created during the rifting which led to the separation of the continent called Gondwana to give birth to South America and Africa. Within this sedimentary basin, like those of most of the countries of the Gulf of Guinea, the maturation of organic matter took place which resulted in the accumulation of oil and gas. More than 45% of the energy that humanity needs to move around, warm up and light up is produced by fossil fuels (oil and gas). It therefore becomes imperative to seek to better understand the subsurface of the basins with a view to searching for oil and gas deposits. It is in this momentum that the Ivorian sedimentary basin has become the site of several investigations in the petroleum and scientific fields since the 1950s. Indeed, the emerged part (onshore) of the Ivory Coast basin delivered the first indications of bitumen near the border of Ghana in the Eboinda region (in 1896), which marked the

beginning of oil research. But it is in the submerged domain (offshore) that the first field was discovered in 1974 by ESSO and named "BELIER" in homage to the first president of Côte d'Ivoire. Other discoveries followed: this is notably the case of "Espoir" discovered by PHILLIPS in 1979 and since 1992, other significant accumulations of hydrocarbons have been discovered, in this case in blocks CI-11 "Lion, Panther", CI-27 "Foxtrot" and CI-40 "Baobab", the independence field in 2013 and finally the field "baleine" which is the latest discovered in 2021 by "ENI". All of these discoveries took place in the better-known Abidjan margin offshore area. The onshore basin is less explored. This work, which is a contribution to the knowledge of the onshore basin, is the result of a collaboration between the Earth Sciences and Mining Resources Training and Research Unit of the Felix Houphouët Boigny University and the national society of Oil operation (PETROCI). It aims to characterize on a dual level, biostratigraphic and paleoenvironmental, the Campano-Maastrichtian interval of the MARRY1 and MARRY2 oil

drilling (Table 1), located in Adiaké, in the South-East of the Ivorian onshore basin.

Table 1: Coordinates of well installation sites

Wells	Latitude	Longitude
MARRY 1	-3°25'33.13''	5°13'20.19''
MARRY 2	-3°24'8.78''	5°13'20.76''

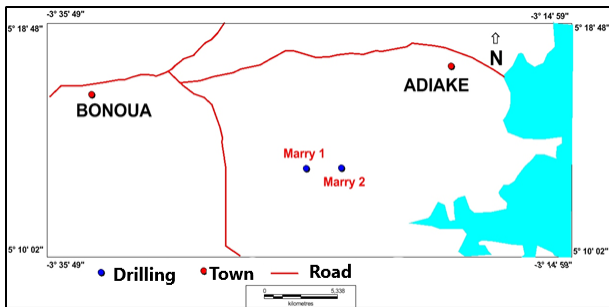


Figure 1: Presentation of the study area and location of drilling

Overview of the geology of the ivory coast

Ivory Coast belongs to the West African craton and more precisely to the Man Ridge [3], which according to some authors is a deep accident. It would be extended to the north by the Zedness fault in Mauritania and to the south by that of Guri in Venezuela in South America [6]. Côte d’Ivoire is marked by two very distinct geological groups of unequal area: a Precambrian base which occupies 97.5% of the Ivorian territory and a sedimentary basin covering 2.5% of the territory forming a thin coastal fringe.

i) The Precambrian basement is subdivided into two main domains by the North-South oriented Sassandra fault; the Liberian (Archaean) domain or MAN-LEO domain is located to the west of the fault and is characterized by ancient formations. and the Eburnian (Proterozoic) domain or BAOULE-MOSSI domain located to the east of the fault and which occupies almost the entire country, i.e. 73% of the total area.

ii) The coastal sedimentary basin represents only 2.5% of the territory. It is affected by a major tectonic accident called the “Lagunes Fault” which would be the extension in the continental domain of the Saint-Paul oceanic fracture [38]. Its release can reach 5000 m.

The “onshore” basin represents 2.5% of the Ivorian territory, i.e. an area of approximately 8,000 km² and is affected by a tectonic accident called the “Lagunes Fault” ([38]; [37]). This fault is the extension in the continental domain of the Saint-Paul fault [38]. Its discharge can reach 3500 to 5000m near Abidjan. It is within this fault that the various lagoon complexes of Côte d’Ivoire are housed.

The offshore basin represents the largest part of the basin. With a width varying from 80 to 150km it covers an area of 22,000km² (figure 2) (Blarez 1988 in [1]). This deep basin is delimited by two major transoceanic faults: the Romanche fault to the east and the Saint-Paul fault to the west which constitutes the major fault of the glacia [1]. The Ivorian offshore is subdivided into two margins which are the Abidjan margin and that of San Pedro.

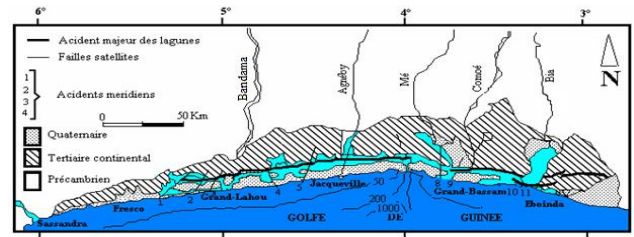


Figure 2: Ivory Coast sedimentary basin [1]

2. Materials and methods

The material used to carry out this study essentially consists of 192 drilling cuttings from the PETROCI core library. Sampling was carried out in clayey and silty levels and other fine formations in order to be able to set the dates of the formations crossed by the wells and determine the paleoenvironments. For each rating, 20g of sample is taken. For hardened samples, the attack begins with grinding in order to increase their attack surface and facilitate chemical reactions. The 20 grams taken are washed with liquid soap which allows the clay to be deflocculated, then the sample is immersed in 37% hydrochloric acid then in 70% hydrofluoric acid which have the role respectively of elimination on the one hand, of carbonates, nitrates and a good part of saline rocks and on the other hand the destruction of silicates in order to obtain a residue composed essentially of organic matter which will be used to make thin sections. The taxonomic determination of palynomorphs adopted is that of the morphographic classification of [35] for spores and pollen grains and the indices of [27] for dinoflagellate cysts. These taxa were compared to those resulting from palynological work carried out mainly on the Cretaceous and Tertiary of West Africa and to a lesser extent on the Cretaceous and Tertiary of South America and the world These works are those of the authors: [25]; [9]; [10]; [11]; [14]; [15]; [18]; [19]; [20]; [22]; [23]; [24]; [30]; We also used the catalogs and internal reports [33]; [34] of the PETROCI laboratory. As for the paleoenvironment, it represents the environment which prevailed at the time of the deposition of the sediments. To determine it, we based ourselves on the relationship between spores and pollen grains which are elements of continental origin and the dinocysts which live in the sea. A very high proportion of one group over another would lean towards the middle of the latter according to [7].

However, when we are in the case of a mixed assemblage of pollen grains, spores and of dinoflagellates in which the organic matter is composed of figured organic matter and non-figured organic matter, we are in the case of a transitional environment intermediate between continental deposits and marine deposits. We will describe this environment as lacustrine or estuarine.

3. Results and interpretations

3.1. Palynology

3.1.1. Quantitative analysis

The quantitative analysis of the palynomorphs from these wells made it possible to count 1132 dinocysts and 486 spores and pollen grains. The details of the number of palynomorphs

per well are presented in the table below and in the palynomorph counting tables.

Table 2: Number of palynomorphs in the two wells studied

Well	Dinocysts	Spores and pollen grains
MARRY 1	1002	418
MARRY 2	130	68
TOTAL	1132	486

3.1.2. Qualitative analysis

The qualitative study of the palynomorphs in this well revealed numerous dinocysts in the fissile clays. It is :

Adnatosphaeridium multispinosum, *Andalusiella mauthei*, *Areoligera senonensis*, *Apectodinium homomorphum*, *Cerodinium granulostriatum*, *Cerodinium leptodermum*, *Cordosphaeridium fibrospinosum*, *Dinogynium acuminatum*, *Dinogymnium cooksonae*, *Dinogymnium cretaceum undulocostata*, *Dinogymnium westralium*, *Hafniasphaera septata*, *Hystrichodinium pulchrum*, *Kallosphaeridium sp.*, *Kallosphaeridium yorubaense*, *Operculodinium centrocarpum*, *Selenopemphix nephroides*, *Senegalinium bicavatum*, *Senegalinium microspinium*, *Senegalinium spp.*, *Spiniferites ramosus*, *Unipontidinium grande*. These dinocysts are associated with the following spores and pollen grains:

Cingulatisporites ornatus, *Cyathidites minor*, *Distaverrusporites simplex*, *Echitriporites trianguliformis*, *Ephedripites multicostatus*, *Foveotriletes margaritae*, *Laevigatosporites haardi*, *Laevigatosporites sp.*, *Longapertites marginatus*, *Margocolporites rauwolfii*, *Margocolporites umnhahiaensis*, *Monosulcites sp.*, *Periretisyncolpites giganteus*, *Proteacidites longispinosum*, *Rétimonocolpites abéocutanensis*, *Retimonocolpites abeokutaensis*, *Retimonocolpites sp.*, *Spinisonocolpites echinatus*, *Syncolporites ifensis*, *Syncolporites subtilis*, *Syncolporites lisamae*, *Tubistephanocolporites cylindricus*, *Verrucatosporites usmensis* and *Zlvisporites blanensis*.

3.2. Palynostratigraphy

The palynostratigraphic study of these wells shows that the palynomorphs encountered extend over two stages: the Campanian and the upper Maastrichtian.

3.2.1. Campanian

The Campanian is found only in the MARRY 1 well and covers the interval 94m -58m. It is characterized by dinocysts such as: *Dinogymnium acuminatum*, *Dinogymnium cretaceum undulocostata*, *Dinogymnium cooksonae*, *Dinogymnium westralium*, *Unipontidinium grande* and *Hystrichodinium pulchrum*.

Associated with these dinocysts are the spores and pollen grains: *Foveotriletes margaritae* and *Ephedripites multicostatus*.

Discussion of the campanian age

The species *Dinogymnium acuminatum*, very abundant by [13] to characterize Campanian-Maastrichtian age formations in California and Alabama. This same species is very abundant in the Maastrichtian formations of the Senegal basin

[19]. In India, in the Mahadeo formations the species *Dinogymnium acuminatum* and *Dinogymnium westralium* indicate a Maastrichtian age. According to [27] the species *Dinogymnium acuminatum* characterizes the Campanian and Maastrichtian. Furthermore, the species *Unipontidinium grande* is given to belong to the Campanian in the formations of the Ivory Coast and Ghana basin, [8]. [27] indicate that *Unipontidinium grande* characterizes the Campanian internationally. Also these two authors point out that the species *Dinogymnium cooksonae* and *Hystrichodinium pulchrum* are specific to the Campanian. The three species *Unipontidinium grande*, *Dinogymnium cooksonae* and *Hystrichodinium pulchrum* are used by PETROCI to date the Campanian formations in Ivory Coast (internal report 2000).

From the above we can conclude that the 94m-58m interval containing the species *Dinogymnium acuminatum*, *Dinogymnium cretaceum undulocostata*, *Dinogymnium cooksonae*, *Dinogymnium westralium*, *Unipontidinium grande* and *Hystrichodinium pulchrum* has a Campanian age.

3.2.2. Upper Maastrichtian

The upper Maastrichtian was encountered in the MARRY 1 and MARY 2 wells and covers the interval 58-48m for the MARRY 1 well while at the MARRY 2 level covers the interval going from 91m to 13m. It was characterized by dinocysts of the genera *Andalusiella mauthei*, *Cerodinium granulostriatum*, *Cerodinium leptodermum*, *Senegalinium bicavatum* and *Senegalinium microspinosum*. These dinocysts are associated with spores and pollen grains like *Foveotriletes margaritae*, *Longapertites marginatus*, *Periretisyncolpites giganteus*, *Proteacidites longispinosum*, *Distaverrusporites simplex*, *Echitriporites trianguliformis*, *Zlvisporites blanensis*, *Spinizonocolpites baculatus*, and *Ephedripites multicostatus*, and *Monocolpites marginatus*

Discussion of the late maastrichtian age

The pollen grains of Angiosperms *Longapertites marginatus* and *Echitriporites trianguliformis* are ancestors of palm trees and suggest, according to [29] in: [4], the prevalence of humid tropical climatic conditions during the Maastrichtian.

According to [17], the association made up of *Distaverrusporites simplex*, *Foveotriletes margaritae*, *Longapertites marginatus*, *Echitriporites trianguliformis* and *Zlvisporites blanensis*, characterizes the Maastrichtian in the WASA (West African-South American) province.

For [2] the species *Ariadnaesporites spinosus*, *Buttinia andrevii* and *zlvsporites blanensis* are typical of the Maastrichtian. *Buttinia andrevii* and *Foveotriletes margaritae* characterize the Maastrichtian and are good markers, [16], [21]; [22]. [31] and [36] showed that *Zlvisporites blanensis* marks a late Maastrichtian and becomes extinct in this stage. It therefore does not appear in the Paleocene. [15] described *Foveotriletes margaritae* in the Maastrichtian and Lower Paleocene. For [30], *Andalusiella mauthei* is a good marker of the Maastrichtian in the Ivorian-Ghanaian basins and its disappearance marks the end of this stage. This is confirmed by [9] and [4] who also attribute the LAD of this species to the end of the Maastrichtian. *Cerodinium granulostritum* is defined by [18] and by [28] as typical of the Maastrichtian. His LAD was used by [30] to

mark the end of the Maastrichtian in the Ivorian-Ghanaian basins. [5] in Gabon and [26] in Nigeria, used it as a good marker of the Maastrichtian.

Senegalinium microspinosum is a marker of the Maastrichtian in Ivory Coast [33]. [5] also used it to mark the Maastrichtian in Gabon.

The species that we have defined are characteristic of the Maastrichtian and their disappearance marks the roof of this floor.

However; the absence of *Andalusiella ivoirensis* in this association shows that the lower Maastrichtian is absent. This leads us to restrict the age of this association to the upper Maastrichtian.

3.3. Paleoenvironment

3.3.1. Campanian paleoenvironment

a) Quantitative Analysis

The palynological analysis of the Campanian in the MARRY 1 well made it possible to count 108 spores and pollen grains, or 18% of the palynomorphs, and 500 dinocysts, or 82% (figure 3).

This study also shows that the organic matter is strongly oxidized and is largely made up of small brown phytoclasts, numerous cuticles and less numerous pyritized amorphous organic matter.

b) Interpretation

Palynologically, the presence of dinocysts in the sediments shows that the depositional environment is marine [7]. The predominance of dinocysts on spores and pollen grains could indicate a marine environment far from the coast. However, the strong presence of the genus *Dinogymnium* in this level associated with spores and pollen grains *Foveotriletes margaritae* and *Ephedripites multicostatus* indicates a shallow marine environment, i.e. coastal or estuarine [32]. However, the presence of Gonyaulacoids such as *Adnatosphaeridium multispinosum*, *Unipontidinium grande* and *Hystrichodinium pulchrum* which are present at 44% indicates that the depositional environment was slightly deep. The organic matter contained in these Campanian-age deposits is very rich in phytoclasts and cuticles. Amorphous organic matter is rare. This high proportion of phytoclasts and cuticles indicates proximity to the shore [12] showed that sediments containing such proportions of materials of terrestrial origin are deposited in shallow marine to fluvio-deltaic environments. The good conservation of organic matter shows that the deposition environment is anoxic. It follows that during the Campanian, the environment of sediment deposition was a deltaic environment.

3.3.2. Upper maastrichtian paleo environnement

a) Quantitative analysis

The palynological study of the Upper Maastrichtian in the MARRY 1 well made it possible to count 310 spores and pollen grains, or 38% of the palynomorphs, and 502 dinocysts, or 62% (figure 4).

In the MARRY 2 well there are 130 dinocysts or 67% and 64 spores and pollen grains or 33% (figure 5). The very scant organic matter, yellow-orange in color, is dominated by phytoclasts and cuticles. Wood debris from higher plants is rare. This organic matter is very little carbonized. We note a pyritization of the amorphous organic matter.

b) Interpretation

The palynological study shows the predominance of dinocysts on spores and pollen grains. The presence of dinocysts in the sediments shows that the depositional environment is marine [7]. (*Andalusiella mauthei*, *Cerodinium granulostriatum*, *Senegalinium bicavatum* and *senegalinium microspinosum*) in this floor associated with numerous spores and pollen grains such as *Foveotriletes margaritae*, *Longapertites marginatus*, *Zlavisporites blansensis* and *Proteacidites longispinosus* indicates a shallow marine environment, i.e. coastal or estuarine [32]. The organic matter of Maastrichtian deposits is very rich in cuticles and phytoclasts. Amorphous organic matter is rare and little pyritized. This high proportion of phytoclasts and cuticles indicates proximity to the shore. [12] showed that formations containing such proportions of material of terrestrial origin are deposited in shallow marine to fluvio-deltaic environments. The presence of lightly pyritized organic matter indicates an anoxic deposition environment with low sulfur content. However, the high proportion of carbonized phytoclasts would indicate an oxygenated environment. It follows that in the Upper Maastrichtian, the sediments would have been deposited in a poorly oxygenated deltaic environment.

The palynological study made it possible to highlight two stages which are: the Campanian and the upper Maastrichtian whose characteristic deposits took place in an environment close to the continent of deltaic or even estuarine type.

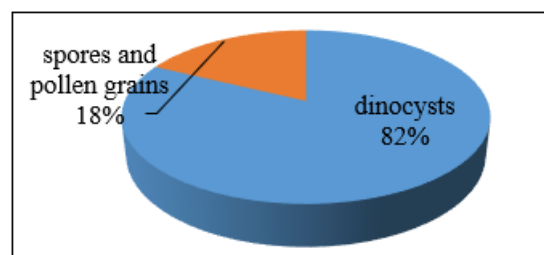


Figure 3: Relative proportion of groups of palynomorphs of marine (Dinocysts) and continental (spores and pollen grains) origin identified in the MARRY 1 well during the Campanian.

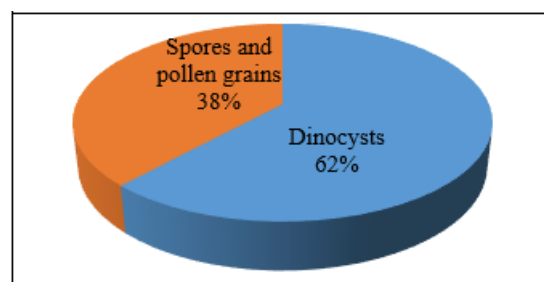


Figure 4: Proportion of dinocysts and spores and pollen grains in the MARRY 1 well in the late Maastrichtian

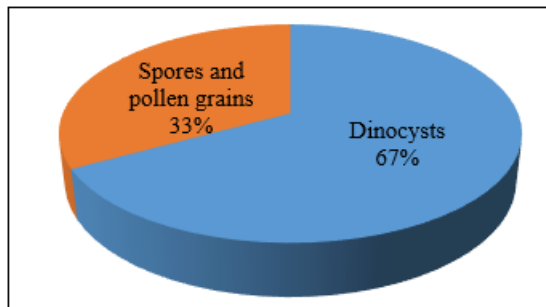


Figure 5: Proportion of dinocysts, spores and pollen grains in the MARRY 2 well in the late Maastrichtian

General conclusion

At the end of this study relating to the palynological study and the paleoenvironment of the Campano-Maastrichtian age deposits of Adiaké, we retain the following results:

On the palynostratigraphic level:

The palynostratigraphic study made it possible to highlight two stages in the MARRY 1 well, namely:

- The Campanian between 94m and 58m
- The upper Maastrichtian between 58m and 47m

Furthermore, in the MARRY 2 well we were able to identify only one stage:

- The upper Maastrichtian which outcrops from 13m depth between 91m and 13m

On the paleoenvironmental level:

Palynology made it possible to clarify:

- During the Campanian, the sediment deposition environment was a deltaic type environment;
- In the Maastrichtian, deposits took place in a shallow marine environment, i.e. coastal or estuarine.

References

- [1] **Aka K. (1991):** La sédimentation quaternaire sur la marge de la Côte d'Ivoire: essai de modélisation. Thèse de Doctorat d'Etat ès Sciences Naturelles. Univ. Abidjan, n° 146, 320 p.
- [2] **Eisawi A. & Schrank E. (2008):** Upper Cretaceous to Neogene palynology of the Melut Basin, Southeast Sudan. *Palynology*, vol.32, n°1, pp. 101-129.
- [3] **Bessoles B., (1977) :** Géologie de l'Afrique : le craton ouest africain. *Mém. BRGM.*, n°88 402p.
- [4] **Bié G. R., Digbehi Z. B., Yao K. R., Téa Y. J., Kangah K. D. & Tahi I., (2012) :** Stratigraphie Palynologique du Maastrichtien Supérieur-Éocène Supérieur du Bassin Sédimentaire Offshore de Côte d'Ivoire, Afrique de l'Ouest. *International Journal of African Studies* Issue 6, pp.40-57. Blarez 1988 in Aka, 1991
- [5] **Boltenhagene (1977):** Microplancton du Crétacé supérieur du Gabon. *Cah. Paléont.* pp 1-150.
- [6] **Caen-Vachette M. (1988):** Le craton Ouest-africain et le bouclier guyanais: un seul craton au protérozoïque inférieur ? *J. Afr. Earth Sci* 7 (2), pp. 479-488.
- [7] **Chateaufort J. J. et Reyre Y. (1974):** Eléments de palynologie. Applications géologiques. Cours de 3ème cycle en Science de la Terre, 345 p
- [8] **Davey, R. J., (1970):** Non-calcareous microplankton from the Cenomanian of England, northern France and North America, part II. *British Museum (Natural History) Geology Bulletin* 18, 333-397, pls.1-10.
- [9] **Digbehi Z. B., Tea J., Aka K. (1996):** Palynoflore de la formation d'Ebocco. Essai de reconstitution paléogéographique de la limite Maastrichtien-Paléocène du bassin sédimentaire de Côte d'Ivoire. In *Géologie de l'Afrique et de l'Atlantique Sud, actes des colloques d'Angers*, 16-20 Juillet, 1994, Mém.16, Elf Aquitaine, 704p.
- [10] **Digbehi Z. B., N'da L.V., Yao K. R. et Atteb A Y. A. (1997):** Principaux foraminifères et palynomorphes crétaqués du bassin sédimentaire de Côte d'Ivoire, Golfe de Guinée septentrional: propositions pour une échelle biostratigraphique locale. *Revue Afrique Géoscience*, Vol.4 n°3&4, pp.461-473.
- [11] **Digbehi Z. B., Kahou K. K., Adopo K. L., Guede K. E., Tahi I., Yao K. R. (2011):** Palynologie et environnement de dépôt des sédiments d'âge Cénomanién supérieur-Maastrichtien inférieur dans le bassin offshore de Côte d'Ivoire (Afrique de l'Ouest). *Sciences et Nature*, 8(1): 95-105.
- [12] **El-Beialy S. Y & Al-Hitmi H. H (1994):** Micropaleontology and palynology of the Lower and Middle Cretaceous Thamama and Wasia groups, DK-C well, Dukhan oil Field, Western Qatar. *Sci Géol. Bull.*, 47: 67-95, Strasbourg.
- [13] **Evitt, W. R., Clarke, R. F. A. & Verdier, J-P., (1967):** Dinoflagellate studies III. *Dinogymnium acuminatum* n. gen., n.sp. (Maastrichtian) and other fossils formerly referable to *Gymnodinium* Stein. *Stanford University Publications, Geological Sciences* 10 (4): pp.1-27.
- [14] **Evitt W. R. (1985):** Sporopollenin Dinoflagellate cysts. Their morphology and interpretation. *Americ. Assoc. Stratig. Palynologists Foundation, Dallas*, 333p.
- [15] **Germeraad J. H., Hopping C. A., Muller J. (1968):** Palynology of Tertiary sediment from tropical areas. *Rev. Palaeobot. Palynol.* vol. 6, pp 189-348.
- [16] **Helenes, J. et Cabrera, D. (2003) "Oligocene-Miocene palynomorph assemblages from eastern Venezuela,"** *Palynology* Volume 27 (2003), pp. 5-25.
- [17] **Herngre, G.F.W. et Chlonova, A.F. (1981)** ENCretaceous Microfloral Provinces. *Pollen et Spores*, 23, pp.441-557.
- [18] **Jain, K.P. et Millepied, P. (1973)** Cretaceous microplankton from Senegal Basin, NW Africa, 1. Some new genera, species and combinations of dinoflagellates. *Palaeobotanist*, 20: pp.22-32.
- [19] **Jain K. P., Millepied P. (1975):** Cretaceous microplankton from Senegal Basin, N.W. Africa I. Some new genera, species and combinations of dinoflagellates. *Revue Paleobotanists*, vol. 20 pp. 22-32.
- [20] **Jan Du Chene R. E. (1977):** Some new pollen species of the upper Maastrichtian, Tar Sand Abeokuta formation, Southern Nigeria. *Rev. Espag.Micropal.* vol. 9, n°2, pp. 191-201.
- [21] **Jan Du Chene, R. (1977):** Etude Palynologique du Miocene supérieur Andalou (Espagne). *Revista Española de Micropaleontología*, 9: pp.97-114.
- [22] **Jan Du Chene R.E., De Klasz I. & Archibong E. E. (1978):** Biostratigraphic study of the borehole Ojo-1,

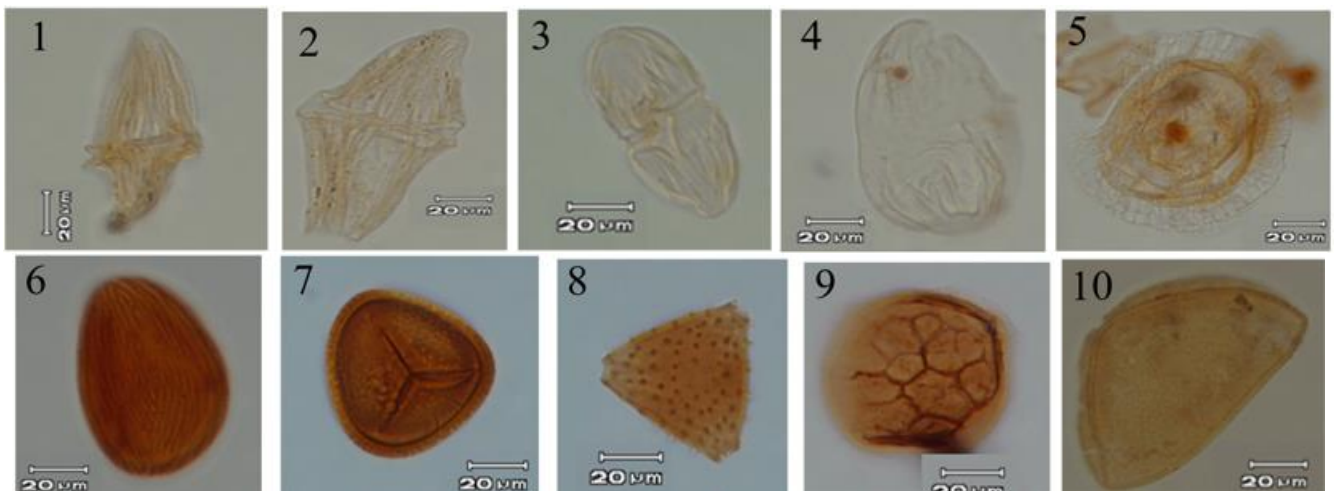
SW Nigeria, with special emphasis on the Cretaceous microflora. *Revue de Micropaléontologie*, no 21, pp.123-139.

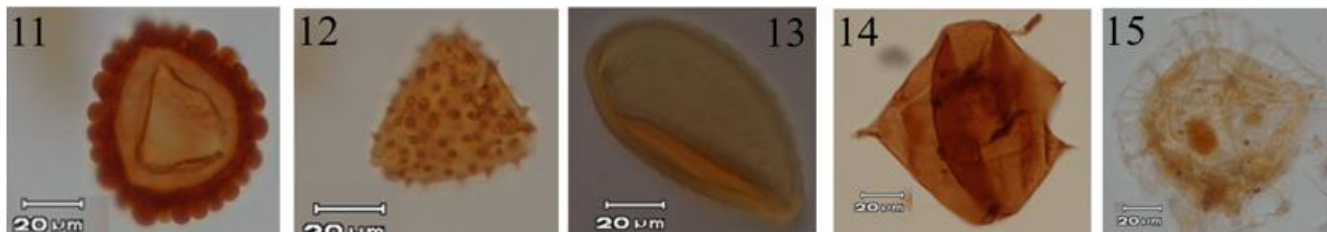
- [23] **Jan Du Chene R.E. & Adediran S.A. (1985):** Late Paleocene to Early Eocene dinoflagellates from Nigeria. *Cahiers de Micropaléontologie*, no3, pp. 1-38.
- [24] **Jan Du Chene R.E., Stover L. E. & De Coninck J. (1985):** New observations on the dinoflagellate cyst genus *Kallosphaeridium* De Coninck 1969. *Cahiers de Micropaléontologie*, no 4, pp. 1-18.
- [25] **Jardine S. & Magloire L. (1965):** Palynologie et stratigraphie du crétaé des bassins du Sénégal et de Côte d'Ivoire. *Mém. Bur. Rech. Geol. et Min.*, vol.32, pp. 187-245.
- [26] **Lawal. O (1982):** palynological biostratigraphy and paleoenvironment of cretaceous formation of upperbenu north east Nigeria speciality PhD Thesis, University of Nice. pp 614;199
- [27] **Lentin J. k & Williams G. L. (1987):** Fossil Dinoflagellates. Index to Genera and species. Bedford Ins. Oceanogr. Report B2Y4A2 Canada, 470 p.
- [28] **Lentin J. K. & Williams G. L. (1989):** Fossil dinoflagellates: index to genera and species, 1989 edition. American Association of Stratigraphic Palynologists Contributions. Series 20, 473p.
- [29] **Mahmoud M. S. & Schrank E. (2007):** Late Cretaceous spores, pollen and dinoflagellates from two boreholes (Nuqra-1 and 3) in the Aswan area, Southeast Egypt. *Revue de Paléobiologie*, vol.26, n° 2, pp. 593-613
- [30] **Masure E., Tea-Yassi J. & Yao K. R. (1996):** The Dinoflagellate *Andalusiella emendation* of the genus, revision of species, *Andalusiella ivoirensis*. *Rev. Palaeobot. and Palynol.*, vol. 91, pp. 171-186.
- [31] **Muller, J.; De Di Giacomo, E., And Van Erve, A. W. (1987):** A palynological zonation for the Cretaceous, Tertiary and Quaternary of Northern South America. American Association of Stratigraphic Palynologists Contribution Series, 19, pp.7-76.
- [32] **Onuigbo E. N., Etu-Efeotor J. O. & Okoro A. U. (2012).** Palynology, paleoenvironment and sequence stratigraphy of the Campanian/Maastrichtian deposits in the Anambra Basin, South eastern Nigeria. *European Journal of Scientific Research*, vol. 78, n°3, pp. 333-348.
- [33] **PETROCI (1990):** Synthèse pétrolière de Côte d'Ivoire (Rapport interne non publié), 32p.
- [34] **PETROCI (2000):** Sédimentologie et palynologie des argiles noires et grises de Bregbo (Rapport interne non publié), 27p.
- [35] **Potonie R. (1970):** Synopsis der Gattungen der *Sporae dispersae*, V.- Ibidem, vol. 87 pp.1-156.
- [36] **Schrank E. (1994):** Palynology of the Yeseomma Formation in northern Somalia: A study of pollen, spores and associated phytoplankton from the Late Cretaceous Palmae Province. *Revue Palaeontographica*, n°231, pp. 63-112.
- [37] **Spengler A. & Delteil J. R. (1966):** Le bassin sédimentaire secondaire-tertiaire de Côte d'Ivoire. In Les bassins sédimentaires du littoral africain. *Rev. Géol. Afri. Paris*, pp. 99-113.
- [38] **Tastet J. P. (1979):** Environnements sédimentaires et structuraux quaternaires du littoral du golfe de Guinée (Côte d'Ivoire, Togo et Bénin). Thèse de Doctorat d'Etat ès.Sci .Nat., Université de Bordeaux I, n°621, 175p.

Plank 1: Palynomorphs from Ca

Plank - Palynomorphs:

1: *Dinogymnium westralinium*, **2:** *Dinogymnium acuminatum*, **3:** *Dinogymnium cretaceum undolocostata*
4: *Dinogymnium cooksonae*, **5:** *Adnatosphaeridium multispinosum*, **6:** *Ephedripites multicostatus*
7: *Foveotriletes margaritae*, **8:** *Echitriporites trianguliformis*, **9:** *Zlivisporites blanensis*, **10:** *Longapertites* sp, **11:** *Distaverusporites simplex* **12:** *Proteacidites longispinosum*, **13:** *Monosulcites* sp., **14:** *Senegalinium microspinosum*, **15:** *Adnatosphaeridium multispinosum*.



**SPORES AND POLLENS GRAINS**

Chenopodipollis multiplex (Weyland & Pflug 1957; Krutzsch 1966d)

Cingulatisporites ornatus (Germeraad, Hopping and Muller, 1968)

Cyathidites minor (Couper, 1953)

Deltoidospora australis (Couper, 1953 ; Pocock, 1970)

Deltoidospora minor (Couper, 1953) Pocock, 1970

Echitriporites trianguliformis (Van Hoeken-Klinkenberg, 1964)

Ephedripites multicostatus (Brenner, 1963)

Foveotriletes margaritae (Van Der Hammen, 1954 ; Germeraad and al., 1968)

Laevigatosporites sp

Longapertites marginatus (Van Hoeken-Klinkenberg, 1964)

Longapertites sp

Margocolporites rauwolfii Salard, 1978

Mauritiidites crassibaculatus Van Hoeken-Klinkenberg, 1964

Monocolpites marginatus (Van Der Hammen, 1954)

Monocolpites sp

Periretisyncolpites magnosagenatus (Kieser & Jan du Chene, 1979)

Proteacidites dehaani (Germeraad, Hopping and Muller, 1968)

Proteacidites longispinosm

Proteacidites sp

Retimonocolpites abeokutaensis

Retimonocolpites sp

Spinizonocolpites echinatus (Muller, 1968)

Syncolporites ifeensis

Syncolporites lisamae

Syncolporites subtilis

Tricolpites sp

Tubistephanocolpites cylindricus

Verrucatosporites usmensis (Van Der Hammen, 1956; Germeraad, Hopping & Muller, 1968)

Zlivisporis blanensis Pacltova, 1959.

DINOCYSTS

Adnatosphaeridium multispinosum (Williams & Downie, 1966)

Andalusiella mauthei (Riegel, 1974)

Apectodinium homomorphum (Deflandre & Cookson, 1955; Lentin & Williams, 1977)

Areoligera senonensis (Lejeune-Carpentier, 1938)

Cerodinium granulostriatum (Jain & Millepied ; Lentin & Williams, 1987)

Cerodinium leptodermum (Vozzhennikova, 1963)

Cordosphaeridium fibrospinosum (Davey & Williams, 1966)

Dinogymnium acuminatum (Evitt and al., 1967)

Dinogymnium cretaceum undulocostata (Boltenhagen, 1977)

Dinogymnium westralium (Cookson & Eisenack, 1958)

Hafniasphaera septata (Cookson & Eisenack, 1967) Hansen, 1977

Kallosphaeridium yorubaense Jan du Chêne & Adediran, 1985

Operculodinium centrocarpum (O. Wetzel, 1933a; Deflandre & Cookson, 1955)

Selenopemphix nephroides (Benedek, 1972; emend. Bujak and al., 1980)

Senegalinium bicavatum (Jain & Millepied, 1973)

Senegalinium microspinosum (Boltenhagen 1977; Lentin & Williams, 1980)

Spiniferites ramosus (Ehrenberg, 1838; Mantell, 1854).