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BENIN FLANK OF THE NIGER DELTA: QUANTITATIVE DISTRIBUTION OF PALYNOMORPHS, PALAEOECOLOGIC AND PALAEOCLIMATIC INTERPRETATION

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ABSTRACT: *This study has reported on the palynomorphs and some associated elements encountered in the Abao Bore hole (BH) of the Maastritchian to the Tertiary of the Benin Flank of Niger Delta in the Southern Nigeria Sedimenatry Basin. Abao BH represented a continuous and complete sequences with total depth of about 3255 feet. The 51 core samples yielded 70 genera and 160 species of dinoflagellates cysts and 43 genera and 60 species of pollen and spores. The various analysis of lithologic formation recognized in the well are in order of succession: Nkporo shale (Maastrtician/Danian) Imo shale (Early Eocene), Ameki Formation (Middle Eocene –Late Eocene/Oligocene) and Ogwashi -Asaba Formation (Miocene) Benin Formation (Miocene/Pliocene). The Palynology analysis also permitted the recognition of 19 dinoflagellate cysts assemblages and 17 pollen/spores assemblages ranging in age from the Maastrticinan to the Miocene. Detailed Paleoenviromental and paleoclimatic interpretation was based on the fact that diversity, abundance and presence of some species reflect either local or regional ecological condition. In general, the paleoclimatic pattern appears to follow the scheme proposed by Van Der Hammen (1957) and there is a close correlation between dominant dinocyst association and pollen/spore percentage in the study area.*

KEYWORDS: Benin flank, Niger delta, quantitative distribution, palynomorphs, palaeoecologic, palaeoclimatic interpretation

INTRODUCTION

Core samples from Abao BH from the Southern Nigerian Sedimentary Basin yielded rich palynomorphs assemblages of late Maastrichtian to Pliocene ages. The Abao BH is located in the southern Nigeria Sedimentary basins. In this area of over 320,000km^2, a large amount of field work and stratigraphic studies have been carried out. There is an extensive literature on the fauna of the Cretaceous and Paleogene of Southern Nigerian Basin but information is limited on palynomorphs assemblages particularly, marine palynomorphs.

The Maastrichtian to the Miocene/Pliocene sediments of the Southern Nigeria sedimentary basin were deposited under widely variable environmental conditions, from normal marine to brackish water, lagoons and freshwater. The sea became gradually shallower towards the close of the Maastrichtian. This led to the formation of an extensive, low lying coastal area with lagoons and swamps, transgressing to the north and west on to the Precambrian basement. Sedimentation was again marine during the Paleocene and Lower Eocene, but during Miocene times there was widespread emergence of the coastline, with the reestablishment of conditions favourable for the deposition of freshwater sediments, carbonaceous beds and lignites (Swardt and Casey, 1963: Reyment. 1965). These environmental changes are reflected in the palynologic assemblages and are especially noticeable in the composition and the relative proportions of different classes of palynornorphs. The major components included dinoflagellates and pollen/spores. The associated elements include foraminifera test linings, *Pediastrum* and *Botryoccocus*, pyritized diatoms, fungal spores, and silicoflagellates

(II) METHODOLOGY

Core from Abao (BH) bore hole from southern Sedimentary Basin of Nigeria were analyzed. The samples examined comprise a wide variety of lithological types ranging from coals to fine grained sandstone and include continental, transitional, and marine sediments .Dinoflagellate Cysts, other aquatic palynomorphs, and terrestrial palynomorphs were concentrated by the standard palynological procedures.

In the Late Paleocene - Early Eocene of southeast England, Downie *et al* (1971) observed several long ranging species which displayed marked variations in abundances and permitted the recognition of assemblages termed associations". These four associations named after the genus to which the dominant species belonged, were:

1. The *Spiniferites* (as *Hystrichosphaera*) association dominated by species belonging to the genera *Achomosphaera* Evitt, *Cordosphaeridium* Eisenack, *Hystrichosphaeridium* Deflandre and *Spinferites*. These are all gonyaulacacean genera and interpreted as indicating open marine environment.
2. The *Micrhystridium* association dominated by the acritarch genera *Comasphaeridium* Staplin *et al* and *Micrhystridium* Deflandre and interpreted as indicating inner neritic' environment.
3. The Areoligera association dominated by the genera *Areoligera* Lejuene Carpentier and *Cyclonephelium* Deflandre and Cookson. These are gonyaulacacean genera with ceratiacean affinities and interpreted as indicating open marine environment.
4. The *Wetzeliella* association dominated by the species of *Wetzeliella* and (perhaps) *Deflandrea*. These are peridiniacean genera and interpreted as indicating lagoonal, estuarine or brackish water environment.

In the majority of the samples analyzed from the Abao BH, one or the other of the above associations was recognized and are indicated in table 1, and figure 1

Harland (1973) in a study of the Campanian Bearpaw Formation of southern Alberta recognized a parameter which is termed the gonyaulacacean ratio. This was the number of gonyaulacacean cysts divided by the number of peridiniacean cysts and was taken as a guide to the salinity. The higher the ratio, the more open marine the environment. The gonyaulacacean ratio is calculated, where possible, for the Abao BH. , samples and are indicated, in addition to the recognized associations, in table 1 and graphs are plotted (figs. 1,2 and 3) by utilizing the data from the palynological analysis in order to enhance a better palynological interpretation. The palynological analysis, palacoecologic and paleoclimatic interpretations are discussed in stratigraphic sequence from the oldest to the youngest.

Table 1: Data for the dinoflagellate cyst associations (Downie et al., 1971) and the gonyaulacacean ration (Harland, 1973) from the Abao BH

SAMPLE NO.	W%	S%	A%	I%	ASSOC.	GONYAULACACEAN RATIO
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	5	32	-	6	S	6
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
11	7	32	-	-	S	4.7
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	-
15	12	20	-	-	S	2.5
16	-	-	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	1	99	-	-	S	24. 0
20	-	-	-	-	-	-
21	-	-	-	-	-	-
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	4	4	62	-	A	21. 0
25	-	5	64	-	A	-
26	-	-	-	-	-	-
27	28	52	15	-	S	2.4
28	-	-	-	-	-	-

29	13	71	16	-	S	4.8
30	54	17	19	-	W	0.7
31	76	13	5	-	W	0.2
32	68	15	6	-	W	0.4
33	68	-	-	-	W	0.1
34	48	-	-	-	W	1.7
35	21	14	-	61	I	0.6
36	26	60	3	-	S	2.6
37	48	46	4	-	W	1. 0
38	22	49	25	-	S	3.6
39	13	52	21	13	S	5.3
40	16	46	27	12	S	4.4
41	X	-	-	-	-	-
42	53	31	3	6	W	0.4
43	31	62	3	2	S	2.2
44	59	6	21	16	W	0.2
45	54	34	15	-	W	0.5
46	68	22	-	10	W	0.2
47	99	1	-	-	W	0.1
48	68	35	-	-	W	0.5
49	64	2	-	2	W	0.2
50	70	14	-	-	W	0.3
51	52	-	-	-	W	0.1

W = Wetzeliella association
A = Areoligera association
S = Spiniferites association (= Hystrichosphaera (H))
I = Micrhystridium association (Downie et al, 1971)
(= Impletosphaeridium ligospinosum)

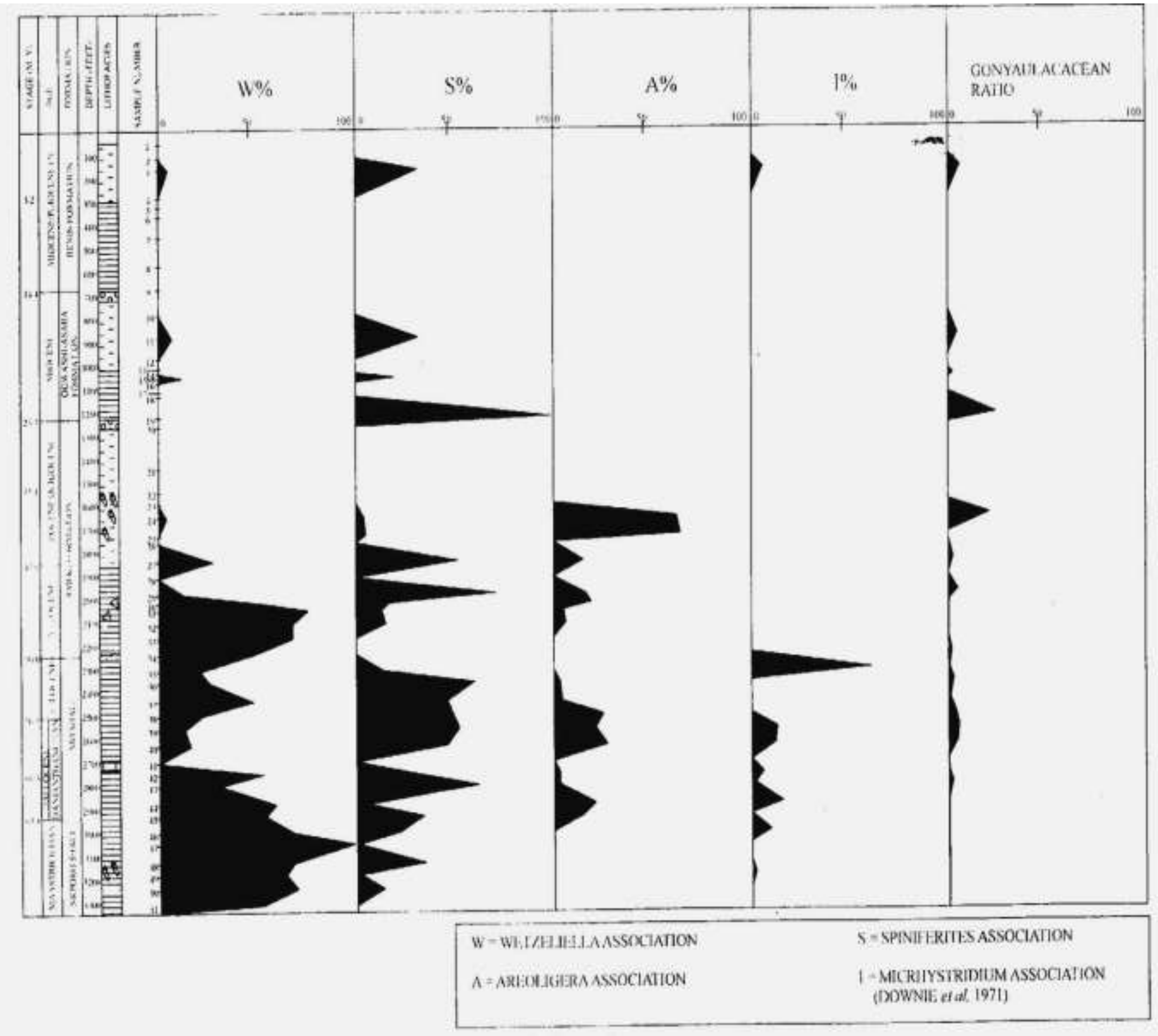


Figure 1: Dinoflagellate Cysts Association (Downie et al, 1971), and the Gonyaulacacean Ratio (Harland,1973)

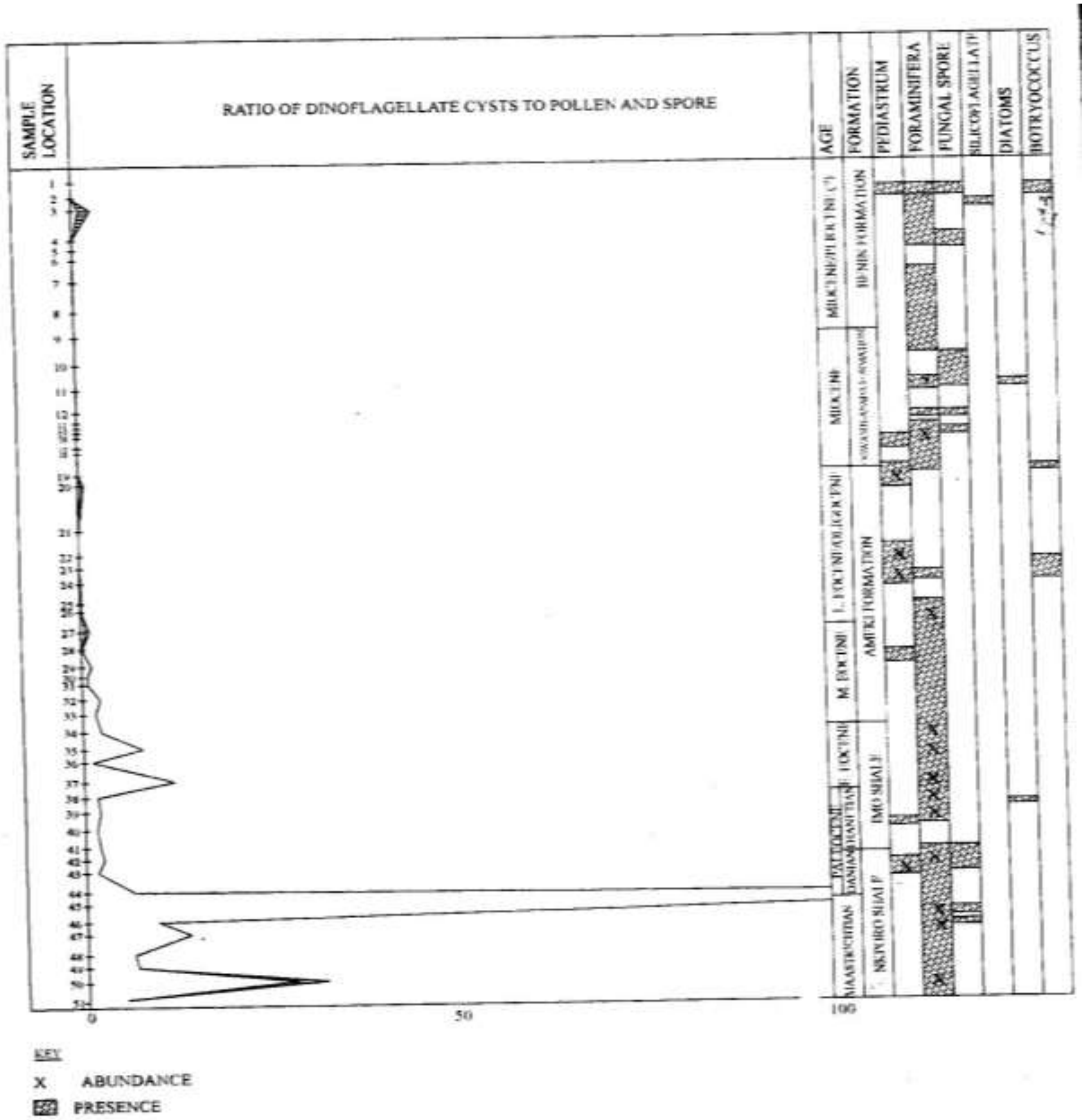


Figure 2: Ratio of dinoflagellates cysts to pollen and spores in Abao cores (reworked portion shaded on the graph) accompanied by distribution of other associated Elements.

RESULTS AND DISCUSION

MAASTRICHTIAN/EARLY EOCENE TRANSGRESSIVE PHASE. MAASTRICHTIAN SUB – PHASE

In the Maastrichtian of the Abao BH., only the *Wetzeliella* association of Downie *et al* (1971) is present (Table 1). This association occurs in samples 5 to 46, which represent the lower sequence of the Nkporo Shale (Tattam, 1944). The sequence represents the dinoflagellate zone A to F which is equivalent to the *Palynodinium gratlator* zone Hansen, 1977) and zone IV (Jain and Millepied, 1975). The sequence also represents the pollen spore zone A - 1 to D - 1 which is equivalent to the Proteacidites dehaani zone of Germeraad *et al*, 1968 **(Table 2)**.

Dinoflagellate cysts are abundant and make up 93 - 97% of the palynomorphs in samples 51 to 46. They are characterized by assemblages with 11 to 30 dinoflagellate species. Sample 46 is dominated by *Svatbardella* sp. D Boltenhagen, 1977) which makes up 30% of the microplankton assemblage. Sample 51, 50 and 47 are dominated by *Palaeocystodinium austratis* which makes up 36 - 49% of the microplankton assemblages.

Sample 48 is dominated by *Cerodinium (Ceratiopsis) d ebelli and Andalusietta taevigata (Senegalinium laevigatum)* which make up 21 % and 20% respectively of the microplankton while sample 49 is dominated by *Cerodinium (Ceratiopsis) diebelli* with 44%. All these samples are dominated by peridinacean dinoflagellate cyst species which constitute 52 99% of the total dinoflagellate cyst assemblage. They are equivalent to the *Wetzeliella* association of Downie *et al* 1971). This association indicates that the interval between depths 3013 feet (sample 46 and 3329 feet sarnple 51) was probably deposited in an inshore, lagoonal environment.

The Campanian of southern Spain (Riegel, 1974), Senegal (Jam and Millepied, 1973), Gabon (Malloy, 1192; Boltenhagen, 1977), Brazil (Herngreen, 95), Venezuela (Lentin, 1980) and the Campanian/Maastrichtian of Egypt (Schrank, 1984) are characterized by the genera *Andalusietla*, *Cerodinium (Ceratiopsis)*, *Lejeunecysta*, and *Senegalinium*. Diagnostic species include *Andatusielta laevigata, A. mauthei, A. polvmoipha, Senegalinium orei = (Ceratiopsis) botoniensis, C. diebetti, C. granutostriata, C. leptoderina, Phelodinium gaditana, Senegalinium bicavaturn*. Specimens are commonly dark brown. The above species suite was named the Malloy suite (Lentin and Williams, 1980) and interpreted as characteristic of the Campanian of tropical regions. The Maastrichtian of the Abao BH., is assignable to the subtropical to tropical Malloy suite since it contains the diagnostic species (Oloto, 1989). The gonyaulacacean ratio gave very low values of 0.1 to 0.5 (Table 1).

This ratio is the number of gonyaulacacean cysts divided by the number of peridiniacean cysts and was taken as a guide to salinity, the higher the ratio, the more open marine the environment. The low values recorded in the Maastrichiaiin, therefore denotes a near shore marine environment. This confirms the findings of Downie *et al* (1971) since their lagoonal/estuarine *Wetzeliella* association was predominantly composed of peridiniacean dinoflagellate cysts.

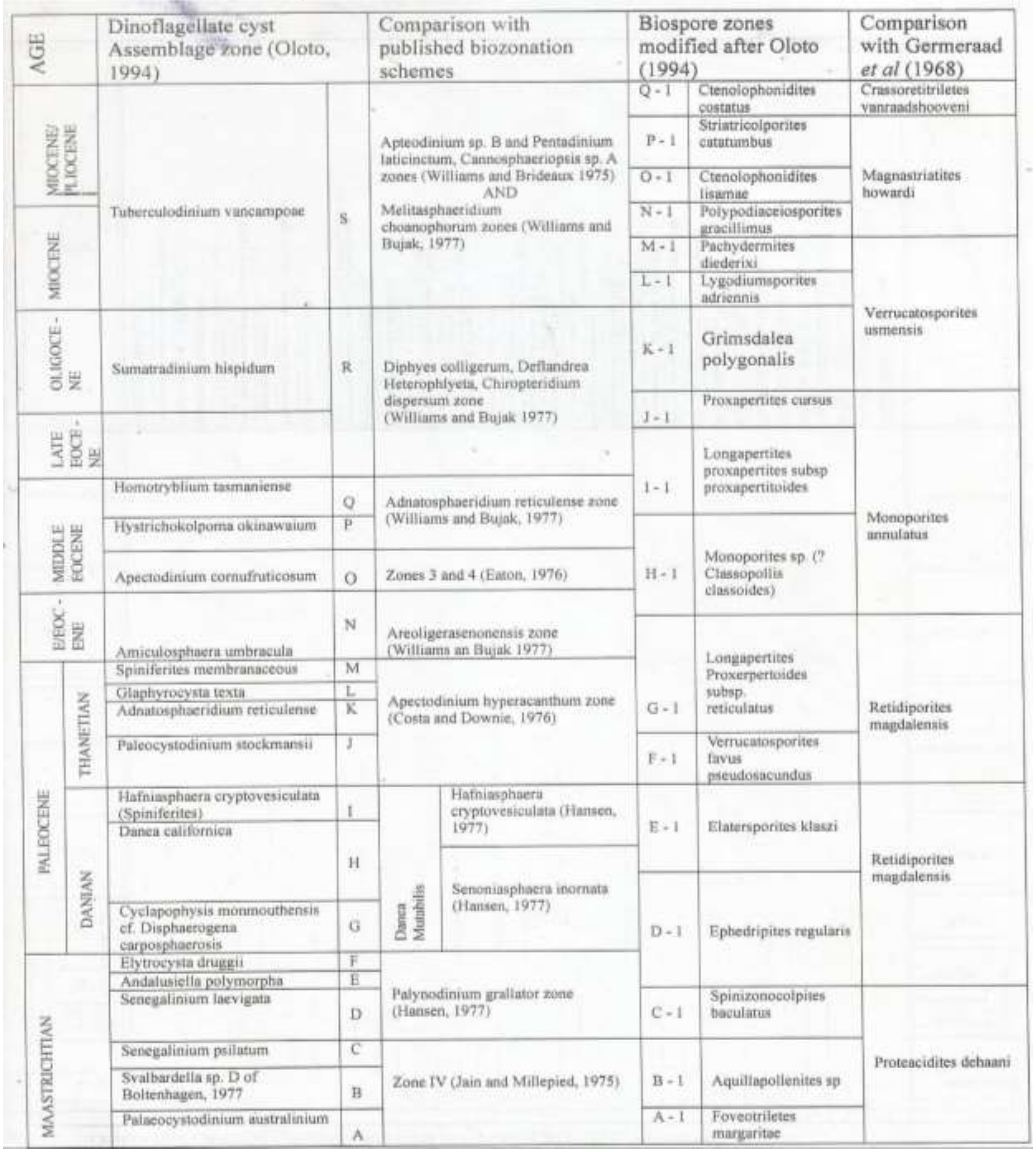
Pollen and spores are poorly represented (figure 3) and consist of only 3 to 7 species. The percentage dominance of the pollen arid spores for the Maastrichtian is very relative because they are based on only few (not exceeding 15) sporomorph grains. This under representation of the pollen and spores is due to the swamping effect of dominant dinoflagellate species.
Chitinous foraminiferal test linings are present in the samples but are most abundant in samples 51. 47 and 46. They are composed of single chambered and uniserial agglutinated forms, in addition to planispiral evolute test linings. The linings are probably derivied from benthic foraminifera (Muller, 1959; Cross *et al*, 1966) and are probably indicative of near shore shallow water environment.

Extensive black shales indicate poor oxidation (Tappan and Loeblich, 1966). The Maastrichtian samples (46 - 51) consist of black shales and this probably indicates that the *Wetziella* association (Malloy suite type) was deposited in an environment of impoverish oxygen. This is consistent with a restricted water circulation to enclosed environment.

EARLY EOCENE SUB PHASE

The Early Eocene of the Abao BH., represent a mixed type of association composing of the Spinferites, Wetzeliella association (Downie et at, 1971) and the *Impletosphaeridium ligospinosum* association. These associations occur in samples 38, 37, 36, 35 and 34. Sample 38 marks the Paleocene/Early Eocene boundary. These samples represent the upper sequence of the Imo Shale. This sequence represents the dinoflagellate zones M and N which is equivalent to the upper part of the *Apectodinium hyperacanthum* zone of Costa and Downie (1976) and the *Areoligera senonensi*s zone of Williams and Bujak (1977). The sequence also represents the pollen/spore zones G - 1 (2) and H - 1 which is equivalent to the upper *Retidiporites magdatensis* and lower *Monoporites annutatus* zone of Germeraad *et al*, (1968)

Table 2: Zones and their symbols



AGE		Dinoflagellate cyst Assemblage zone (Oloto, 1994)		Comparison with published biozonation schemes	Biospore zones modified after Oloto (1994)		Comparison with Germeraad *et al* (1968)
MIOCENE/ PLIOCENE		Tuberculodinium vancampoae	S	Apteodinium sp. B and Pentadinium laticinctum, Cannosphaeriopsis sp. A zones (Williams and Brideaux 1975) AND Melitasphaeridium choanophorum zones (Williams and Bujak, 1977)	Q - 1	Ctenolophonidites costatus	Crassoretitriletes vanraadshooveni
					P - 1	Striatricolporites catatumbus	Magnastriatites howardi
					O - 1	Ctenolophonidites lisamae	
MIOCENE					N - 1	Polypodiaceoisporites gracillimus	
					M - 1	Pachydermites diederixi	Verrucatosporites usmensis
					L - 1	Lygodiumsporites adriennis	
OLIGOCENE		Sumatradinium hispidum	R	Diphyes colligerum, Deflandrea Heterophlyeta, Chiropteridium dispersum zone (Williams and Bujak 1977)	K - 1	Grimsdalea polygonalis	
					J - 1	Proxapertites cursus	Monoporites annulatus
LATE EOCENE					I - 1	Longapertites proxapertites subsp proxapertitoides	
MIDDLE EOCENE		Homotryblium tasmaniense	Q	Adnatosphaeridium reticulense zone (Williams and Bujak, 1977)			
		Hystrichokolpoma okinawaium	P		H - 1	Monoporites sp. (? Classopollis classoides)	
		Apectodinium cornufruticosum	O	Zones 3 and 4 (Eaton, 1976)			
E/EOCENE		Amiculosphaera umbracula	N	Areoligerasenonensis zone (Williams an Bujak 1977)	G - 1	Longapertites Proxerpertoides subsp. reticulatus	Retidiporites magdalensis
PALEOCENE	THANETIAN	Spiniferites membranaceous	M	Apectodinium hyperacanthum zone (Costa and Downie, 1976)			
		Glaphyrocysta texta	L				
		Adnatosphaeridium reticulense	K				
		Paleocystodinium stockmansii	J		F - 1	Verrucatosporites favus pseudosacundus	
	DANIAN	Hafniasphaera cryptovesiculata (Spiniferites)	I	Danea Mutabilis Hafniasphaera cryptovesiculata (Hansen, 1977)	E - 1	Elatersporites klaszi	Retidiporites magdalensis
		Danea californica	H	Senoniasphaera inornata (Hansen, 1977)	D - 1	Ephedripites regularis	
		Cyclapophysis monmouthensis cf. Disphaerogena carposphaerosis	G				
MAASTRICHTIAN		Elytrocysta druggii	F	Palynodinium grallator zone (Hansen, 1977)			
		Andalusiella polymorpha	E				
		Senegalinium laevigata	D		C - 1	Spinizonocolpites baculatus	Proteacidites dehaani
		Senegalinium psilatum	C	Zone IV (Jain and Millepied, 1975)	B - 1	Aquillapollenites sp	
		Svalbardella sp. D of Boltenhagen, 1977	B				
		Palaeocystodinium australinium	A		A - 1	Foveotriletes margaritae	

The palynornorph assemblage is represented by 73 - 97% dinoflagellate cysts and 3 - 27% of pollen and spores. The dinoflagellate species show a progressive reduction in number from 56 (sample 38) down to 12 (sample 34) indicating a progressive shallowing of the sea.

Sample 37 is dominated by *Apectodinium homomorphum* which makes up 45% of the dinoflagellate assemblage (zone M). Other common species include *Polysphaeridium subtile* (12%), *Kleithriasphaeridium* sp. A (10%), *Cleitosphaeridium spinulastrum* (10%) and *Spiniferites ramosa* subsp. *Multibrevis* (7%). About 33 of the 55 dinoflagellate cyst species are present in very low number (less than I %). These consist of probably reworked gonyaulacacean cysts. the peridiniacean cysts make up 48% of the assemblage and this is equivalent to the Wetzeliella association of Downie *et al*. (1971) which was interpreted to indicate estuarine or lagoonal environment. The high gonyaulacacean species diversity accompany log very low number of cysts count indicate direct influence of the open sea, probably in an environment more estuarine than lagoonal.

The gonyaulacacean ratio calculated for sample 37, shows a higher value of 1 .0 than those previously recorded for the *Wetzeliella* association u Maastrichtian and the Danian. This indicates a more saline depositional environment.

Pollen and spores are poorly represented and make up only 3% of the palynomorph assemblage. This under representation is due to the swamping effect by *Apectodinium homomorphum* and the other marine elements. The only common species being *Proxapertites tertiaria*.Chitihous foraminifera test linings are abundant though most are crushed. They are different from the previously recorded forms in that they consist of glassy - lustred, thick walled, planispiral involute and evolute forms. These represent the planktonic foraminifera linings which indicate open marine environment. Their highly crushed state probably indicate deposition involving a highly turbulent strong hydrodynamic environment. Their abundance in sample 37 indicates an environment in direct contact with the open sea as is obtainable in an estuarine environment.

No clearly dominant species was present in sample 36 (zone N), the commonest being *Palaeocysrodinium golzowense* (17%), *Polysphaeridium subtile* 15 %), *Trivalvadinium plenum* (13%), *Chytroeisphaeridia* sp. A (11%), *Spiniferites ramosa* subsp. *multibrevis* (8%). The gonyaulacacean cysts make up 60% of the assemblage and therefore equivalent to the *Spiniferites* association of Downie *et al* (1971). This association was interpreted to indicate an open marine, but the presence of *Palaeosrodinium golzowense* in a reasonable amount indicates a gradual return to a more restricted near shore marine environment.

The gonyaulacacean ratio for sample 36 gave a value of 2.6. This value is much lower than a similar *Spiniferites* association for the Paleocene (samples 40, 39, 38) interpreted as open shallow marine environment. The lower the value the less open marine and the lower the salinity of the environment. This agrees with the near shore marine environment interpretation based on the Spinferites association (Downie *et al*, 1971).

The pollen and spore of sample 36 (zone G -2) is dominated by the monoporate pollen *Classopollis classoides* (45%). The commonest species include the Palmae group monocolpate species *Proxapertites tertiaria* (17%) and *Longapertites proxapertitoides* var. *reticutatus* (14%), which imply that the prevailing climate was probably tropical. The dominance of a single species (*Classopollis classoides*) indicates reworking of and redeposition of Cretaceous rocks into Tertiary sediments.

Chitinous foraminifera test linings are profusely abundant (sample 36), dominated by the uniserial forms. These are benthonic forms (Muller, 1959; Cross *et al*, 1966) and their profuse abundance indicates a flourishing environment, most probably an inner neritic. Thus further confirming the near shore marine environment based on the palynomorphs.

Sample 35 is dominated by *Impletosphaeridium ligospinosum* (61 %) almost to the exclusion of other dinoflagellate cyst species. Other common species are *Pataeocystodinium golzowense* (20%), *Spinferites* (*Hafniasphaera*) *septata* (8%). It is difficult to equate this assemblage to any of the Downie *et al*, (1971) association because it is profusely dominated by *Impletosphaeridium ligospinosum*. The profuse presence of this dinoflagellate cyst species is, however, significant in that the disappearance is abrupt and also marks the end of the extensive transgressive phase of the Maastrichtian to the Early Eocene. In this wise, the *Impletosphaeridium ligospinosum* association is equated to the *Micrhystridium* association (Downie *et* al, 1971) which .is interpreted to indicate inner neritic environment and to mark the initial and closing stages of a marine transgression.

The gonyaulacacean ratio gave a low value of 0.6 which indicates low salinity and close proximity to the shore line. Thus confirming the inner neritic environment based on the *Micrhystridium* association of Downie *et al.* (1971). The dominance in the dinoflagellate cyst assemblage is also observed in the pollen/pore assemblage which is dominated by *Monoporites* Sp. (cf. *Classopollis classoides*) (85%), almost to the exclusion of the other pollen/spores. This gramineae pollen characterize savannah and montane area, an interpretation by Germeraad *et al*, (1968) based on the present day abundance of grass in the tropics. The abundance of *Monoporites* sp. (*Classopollis classoides*) in sample 35, therefore, suggests the source to be from a coastal savannah. Since further offshore this “over representation” by a local source is less apparent and sporomorphs transported into the sea from upload regions are relatively more abundant, thus producing a more diverse assemblage. This agrees with the inner neritic interpretation based on dinoflagellate cysts.

Chitinous foraminiferal test linings are abundant. They are dominated by planispiral evolute forms and lesser numbers of biserial and uniserial forms. The linings are benthonic forms (Muller, 1959); Cross *et al*, 1966) and probably indicate an inner neritic environment. Thus; further confirming the interpretation based on the palynomorphs.

The palynomorph content for sample 34 (zone N) was poor (30 cysts and 5 pollen/spores). The dinoflagellate assemblage is however dominated by *Apectodinium homomorphum* indicating a *Wetzieliella* association (Downie *et al*, 1971) which is interpreted as indicating an estuarine environment. The gouyaulacacean ratio gave a value of 1.7 which is comparable with that of sample 37. The association was interpreted to indicate an estuarine environment.

Chitinous foraminifera test lining content for sample 34 was also poor. The general improverished nature of sample 34 might be connected with a temporary emergence of the land considering the fact that this horizon is the recognized boundary between the Early Eocene and the Middle Eocene. This interpretation is further corroborated in that the sample is composed of silty shale while the underlying Imo Shale and the overlying sequence of the Ameki Formation are characteristically shale. The silty shale represents a period of temporary emergence of the shoreline resulting in the deposition of silty material and submergence resulted in the overlying shale.

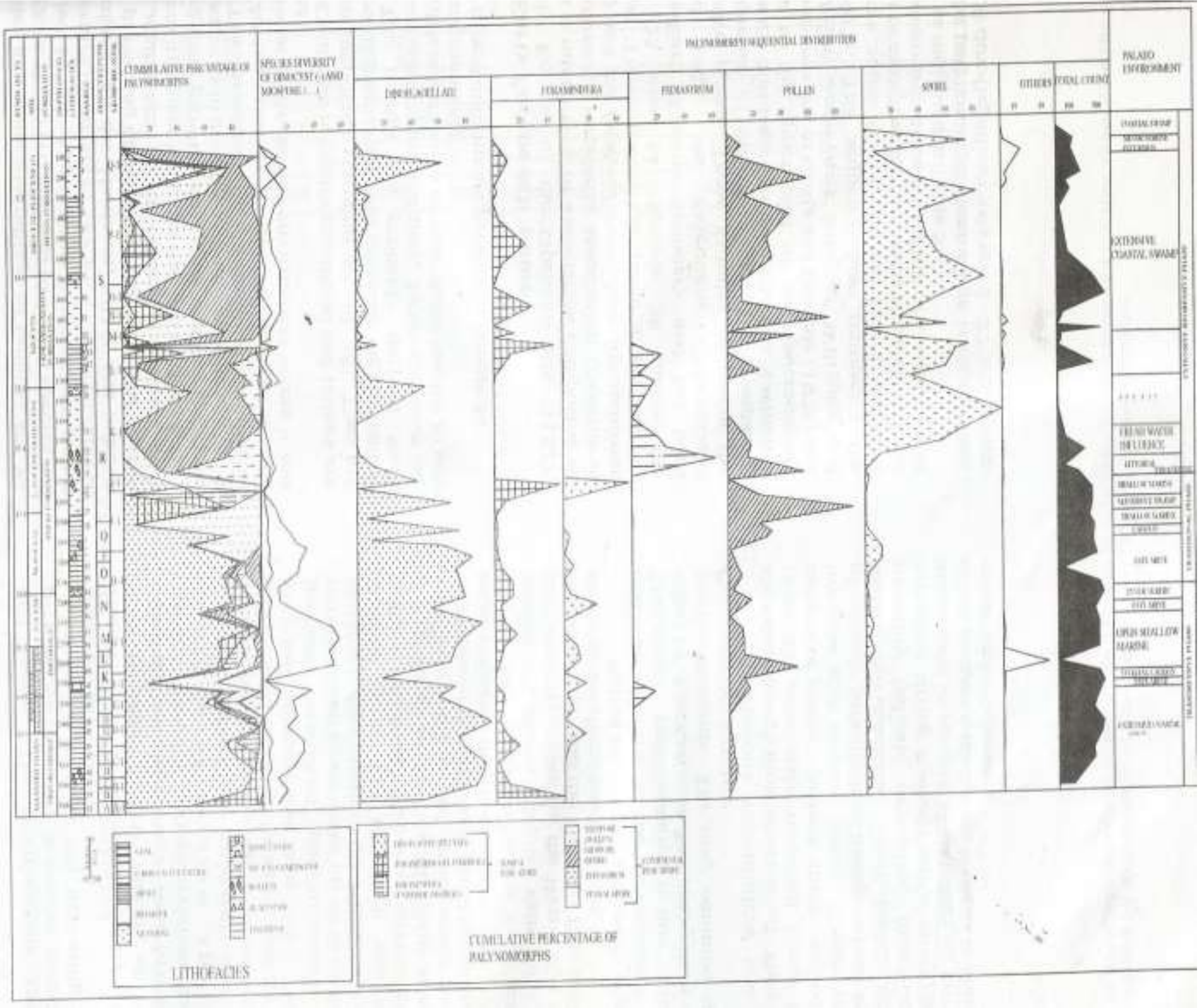


Figure 3: Summary of palynomorphs characteristics of the rock succession in Abao Bore hole

MIDDLE EOCENE TRANSITIONAL PHASE

The Middle Eocene of the Abao BH., represents a transitional phase. Two associations are present: the *Wetzeliella* and the *Spiniferites* associations (Downie *et al*, 1971). These associations occur in sample 34, 33, 32, 31, 30, 29, 28, and 27. Sample 34 marks the Early Eocene/Middle Eocene boundary and has been discussed under the Early Eocene transgressive phase. These samples represent the lower sequence of the Ameki Formation. The sequence represents the dinoflagellate cyst zones 0, P. Q and the basal part of zone R. These zones are equivalent to the southern England zones 3 and 4 (Eaton, 1976), *Adnatosphaeridium reticulense* zone (Williams and Bujak, 1977) and the basal part of *Diphyes coltigerum, Deflandrea heterophtycta, Chiropteridium dispersum* zone (Williams and Bujak, 1977). The sequence also represents the pollen/ spore zones H - 1 (2), I - 1 (1), which is equivalent to the middle part of the *Monoporites annulatus* zone of Germeraad *et al*, (1968) as indicated in Table 2.Sample 33 is rich in palynomorphs and composed of 8l % dinoflagellate cysts, 6% pollen and 13% spores.

The dinoflagellate cyst assemblage contains 26 species, the most dominant being *Apectodinium homomorphum* (59%). Other common species include *Apectodinium quinquelata* (14%), *Chytroeisphaeridia* sp. A. (9%). The peridiniacean cysts make up 68% of the dinoflagellate cyst assemblage and this is equivalent to the Wetzeliella association (Downie *et al*, 1971) which was interpreted to indicate a lagoonal or estuarine environment.The gonyaulacacean ratio calculated gave a low value of 0.1, indicating a more brackish water environment than in sample 37 (*Wetzeliella* association).

The pollen and spore assemblage is dominated by the pteridophyte spore *Cyathidites minor* (39%). Other common species include *Longapertites proxapertitoides* var. *reticulatus* (22%), *Cyathidites australis* (9%). The relative abundance of pollen/spore in a marine environment indicates a closer proximity to the land.

Chitinous foraminifera test lining is present and include planispiral and uniserial forms. They represent benthonic foraminifera test linings (Muller, 1959; Cross *et al*, 1966) and probably indicate an inner neritic, possibly estuarine in agreement with the palynomorph interpretation.
Sample 32 is composed of 86% dinoflagellate cysts, 2% pollen and 12% Spore. The dinoflagellate cyst assemblage is composed of 28 species which is dominated by *Apectodinium quinquetata* (40%). The only common species being *Apectodinium homomorphum* (19%). The peridiniacean cysts make up 68% of the dinoflagellate cyst assemblage and thus equates this sample to the *Wetzeliella* association of Downie et al (1971). This association indicates an estuarine environment.

The gonyaulacacean ratio calculated gave a low value of 0.4 similar to sample 33. The environment of deposition is therefore equated to be near shore, possible estuarine.The pollen and spore assemblage is composed of 5 species and dominated by Cyathidites minor. The dominance by pteridophyte spore probably indicate slight cooling in the prevailing climate.

Chitinous foraminifera test lining is present in low number. The linings represent benthonic forms and the low distribution probably indicates a less favourable environment.

Sample 31 shows a marked reduction in the number of *Apectodinium homomorphum* and the disappearance of *Apectodinium quinquetata*. The sample also marks the beginning of a gradual decline in the number of dinocyst species. Sample 31 is composed of 33 species with *Trivalvadinium ptenum* (24%) and *Downisphaerapisinna* (Islam, 1981) with 23%, as the dominant species. Other common species include *Cerodinium* (*Ceratiopsis*)cf. *granutostriata* (6%), *Chytroeisphaeridia* sp. A (6%), *Gtaphyrocysta microfenestrata* (5%), *Apectodinium homomorphum* (5%).

It would be difficult to place this assemblage in one of the associations of Downie *et al* (1971). If *Trivalvadinium plenum* is related to Apectodinium, it would then constitute a *Wetzeliella* association. This would indicate that this interval was deposited in a lagoonal or estuarine environment. The presence of *Cerodinium* (*Ceratiopsis*)cf. *granulostriata* which is recorded from the Maastrichtian/Danian lagoonal environment (samples 47, 46, and 45) is indicative that this ecologic condition prevailed at the time of deposition. The presence of open marine elements mixed within this ecologic condition indicates contact with the sea.The gonyaulacacean ratio calculated, gave a low value of 0.2 indicating low salinity and near shore marine environment which could he estuarine or lagoonal.

The pollen and spore assemblage is composed of 6 species with *Longapertites proxapertitoides* var. *proxapertitoide* having a dominance of 67%. This species is not the Palmae family (Van der Hammen, 1956) and probably indicate that the prevailing climate as tropical. Other common species include *Monoporites (cf. Classopollus classoides)* (14%), *Laevigatosporites ovatus* (10%). The dominance of *Longapertites proxapertitoides* var. *proxapertitoides* indicates that it was a restricted flora growing near the shore or even in the marine water that is, a mangroove plant. This confirms the restricted lagoon environment based on the dinoflagellate cysts assemblage. Chitinous foraminifera test linings are few and composed of planispiral and uniserial benthonic forms.

Sample 30 is composed of 64% dinofiagellate cysts. 34% pollen and 3% spore. The dinofiagellate cyst assemblage is composed of 25 species with *Trivalvadinium plenum* having a dominance of 55 %. Other common species include *Muralodinium fimbriatum* (18%), *Operculodiniun centrocarpum* (6%), *Homotryblium tasmaniense*. The dominance by *Trivalvadinium plenum* indicates that the sample was deposited near shore where the condition was such as to inhibit the reproduction of other perhaps more sensitive species. This probably was a lagoonal environment in contact with the open sea.

The gonyaulacacean ratio calculated gave a value of 0.7 indicating a low salinity environment that was close to the coast. The pollen and spore assemblage is composed of 5 species with *Longapertites proxapertitoides* var. *reticulatus* having a dominance of 90%. This indicates that this species was derived from a restricted flora growing near the shore or even in the marine waters, that is, a mangrove plant. Such an assemblage reflects nearly in situ deposition. The dominance of *Longapertites proxapertitoides* var. *reticulatus* which is of the Palmae family (Van der Hammen, 1956) probably indicates that the prevailing climate was tropical.

Chitinous foraminifera test linings are few and consist of mainly round flask shaped and planispiral forms.Sample 29 consists of 7% dmorlagellaie cysts. 23% pollen and 3% spore.The dinoflagellate cyst assemblage is composed of 22 species with *Spiniferites* membranaceous having a dominance of 41 %. Other common species include *Muratodinium finibriaruin* (11%), *Dapsilidinium pastielsii* (8%), *Spiniferites pseudofurcatus* (7%). *Emmetrocysta urnaformis* (5%). This assemblage is a *Spiniferites* association (Downie *et al*, 1971) which normally indicates an open marine environment.

The dominance of *Spiniferite membranaceous* however denotes a more restricted near shore, probably lagoonal environment with direct contact with the sea. The condition was such is to inhibit the reproduction of perhaps more sensitive species. Since sediments further offshore contain a much richer and more stable flora as observed in the study or deep sea cores from the Caribbean Sea (Wall, 1967).The gonyaulacacean ratio gave a high value of 4.8 indicating a more saline, open marine environment. This agrees with the *Spiniferites* association (Downie et al, 1971). The dominance of *Spinferites membranaceous* however, makes this restricted environment with strong marine influence.

The pollen and spore assemblage is composed of 4 species. The dominant species include *Longapertites proxapertitoides* var. *reticulatus*, (57%) and *Longapertites proxapertitoides* var. *proxapertitoides* (38%). The dominance of these two species indicates a restricted flora growing near shore and agrees with the interpretation based on dinoflagellate cysts. These pollen species are of the Palmae family (Vander Hammen, (1956) and probably indicate that the prevailing climate as tropical.

Only one colony of *Pediastrum* was present. This was probably transported from a freshwater environment into the marine site for sample 29.Chitinous forarninifera test linings are few and composed of planispiral forms. The low number probably indicates that the environment of deposition was not favourable.The abundance of glauconite supports a restricted inland sea tidal flat, a marine environment as determined from the dinoflagellate assemblage.

Sample 28 (zone Q) is composed of 7% dinoflagellate cysts, 92% pollen and 1% spore. The dinoflagellate cyst assemblage consists of 14 species which do not attain any numerical importance, being present only as single specimens. It is therefore difficult to assess environmental condition except that the impoverish nature implies a more terrestrial condition of deposition. The presence of dinoflagellate cysts indicates infiltration of marine water.

Conversely, the pollen and spore assemblage is rich consisting of 4 species and dominated by the angiosperm pollen *Psilamonocolpites medius* (60%). The only common species is *Longapertites proxapertites* var. *reticulats* (38%). The dominance by these two angiosperm pollen species almost to the exclusion of other palynomorphs indicate that they were derived from a restricted flora growing near the shore or even in the marine water as in case of mangrove plants. Such an assemblage reflects nearly in situ deposition probably in a mangrove swamp. *Psilamonocolpites medius* and *Longapertites proxapertitoides* var. *reticulatus* belong to the palmae family (Van der Hammen, 1956) and their abundance probably indicate that the prevailing climate was tropical.

Sample 27 (zone R) is composed of 74% dinoflagellate cysts, 25% pollen and 1% spore. The abundance and dominance of marine dinoflagellate cysts in the palynomorph assemblage indicate a return to normal marine environment. The dinoflagellate cyst assemblage consist of 10 species with *Kenleyia lophophora* having a dominance of 38%. Other common species include *Chytroeisphaeridia* sp. A (28%), *Emmetrosta urnaformis* (15%), *Fibrocysta lappaceum* (14%). This assemblage is equivalent to the *Spiniferites* association (Downie *et al,* 1971) and normally indicates open marine environment. The dominance by only a few species to the exclusion of others, however, indicates proximity to the shore in such a condition that inhibit the reproduction of other perhaps more sensitive species; probably estuarine or lagoonal.

The gonyaulacacean ratio calculated gave a value of 2.4 comparable with that of sample 36 (zone N) which was interpreted to indicate an inner neritic environment. This agrees with the interpretation based on the dominant dinoflagellate cyst species.The pollen and spore assemblage consists of 3 species and dominated by *Longapertites proxapertitoides* var. *proxapertitoides* (78%). The only common species being *Longapertites proxapertitoides* var. *reticulatus* (19%). These species represent the Palm group (Van der Hammen, 1956) and their abundance probably indicates that the prevailing climate was tropical. The dominance of *Longapertitoides proxapertitoides* var. *proxapertiroides* indicates that it was derived from a restricted flora growing near the shore or even in the marine water, that is, a mangrove plant. It is observed (samples 27 to 40) that *Longapertites proxapertitoides* var. *reticulatus* occurs in abundance with *Psilamonocolpites medius* (sample 28; zone Q) similarly with *Langapertites proxapertitoides* var. *proxapertitoides* (sample 27, 29, 31). But the later two species do not occur together in any appreciable amount. This implies that the flora that produced *Longapertites proxapertitoides* var. *reticulatus* probably thrived in an intermediate ecologic condition between those of *Monocolpites medius* and *Longaperrites proxapertitoides* var. *proxapertitoides*.

The chitinous foraminifera test lining also showed an increase in number and consist of planispiral benthonic forms (Muller, 1959; Cross *et al,* 1966). This relative increase probably confirms a return to a favourable environment as observed in the dinoflagellate cyst assemblage.

LATE EOCENE/RECENT REGRESSIVE PHASE

LATE EOCENE/OLIGOCENE SUB PHASE.

The late Eocene/Oligocene of the Abao well marked the beginning of an obvious swing from the extensive marine environment of the older sediments to the extensive terrestrial swamps of the younger sediments. It is difficult to apply the associations of Downie et al, (1971) because most of the dinofiagellate cysts on which the associations were based are lacking or impoverished. Most of the environmental interpretations here and of subsequent ages are based mainly on the affinities of the pollen and spore species or groups with modern flora as discussed by Germeraad *et al,*(1968) . The presence of *Pediastrum*, fresh water green algae is also useful in determining the depositional environment. The Late Eocene/Oligocene sediments include samples 27, 26, 25, 24, 23, 22, 21,20 and 19. Sample 27 marks the boundary between the Middle Eocene and the Late Eocene/Oligocene. This sample has been discussed under the Middle Eocene regressive phase (transitional). The other samples represent the upper silty sequence of the Ameki Formation (Reyment, 1965).

The sequence represents the dinoflagellate cyst zone R and the basal part of zone S which is equivalent to the *Diphyes colligerum, Deflandrea heterophlycta, Chiropteridium dispersum* zone of Williams and Bujak 1977). The sequence also represents the pollen and spore zones I -1 (2), J - 1, K - 1, L - 1 (1) which are equivalent to the top of *Monoporites annulatus* and lower part of the Verrucatosposmenensis zones of Germeraad *et al* (1968) as indicated in Table 2.

Sample 26 is almost barren of palynomorphs being present as single specimens. In contrast, chitinous foraminiferal test linings are profusely abundant and consist of thick walled, biserial *Heterohelix* and planispiral involute forms. They process glassy lustre and most probably represent test linings of planktonic foraminifera. The profuse abundance of planktonic foraminifera test linings in an assemblage almost barren of palynomorphs is difficult to explain. However, a similar occurrence of foraminiferous rocks crowded with the tests of mainly planktonic foraminifera was recorded in a foraminiferal and sedimentologic study of the Ameki Formation by Reyment (1967). He suggested that the Ameki Formation were deposited in shoal water and the rock marked part of an ancient strandline as indicated by both the sedimentologic evidence as well as the evidence of the fossil vertebrates. He further suggested that the formation was (during Eocene time) marked by long sandbars aligned parallel to the coast in a region of low runoff. The lagoons behind the sandbars contained a rich euryhaline fish fauna. On the seaward side of the sandbars, foraminiferas, including many stenohaline species, occurred at times in enormous numbers in the shallow inner shelf area. Sample 26 which is part of the Ameki Formation was probably deposited in a similar environment. The sample contained a single probable fish tooth and profuse foraminifera test linings including *Heterohelix*, a Cretaceous form. This represents an ancient strandline as suggested by Reyment (1965). The presence of the Cretaceous index fossil (*Heterohelix*) in the Late Eocene/Oligocene sediment implies uplift, exposure and reworking of the ancient Cretaceous strandline into the Late Eocene/Oligocene basin. The near absence of palynomorphs, dinoflagellate cysts in particular, might indicate the absence of preservable organic cysts or differential destruction of cysts due to temporary exposure at the strandline.

In sample 25, pollen grains show a relative dominance over dinoflagellate cysts, and spores are absent. No comprehensive environmental interpretations are made because of the low palynomorph counts. Only 4 dinoflagellate cyst species are present and include the following in decreasing order of abundance: *Thalassiphora pelagica*, *Chytroeisphaeridia* sp. A, *Nematosphaeropsis balcombiana*, *Impletosphaeridium multispinosum*. Their presence in a pollen dominated assemblage may indicate an infiltration of marine water/redeposition into the depositional environment.

The pollen is composed of 5 species. The most common is the monocolpate pollen *Proxapertites cursus*. It is included in the *Proxapertities operculatus* group (Germeraad *et al*, 1968 and indicate mangroove environment Chitinous foraminifera test lining are absent. The rock sample 25 which is mudstone contains abundant macrofossils (calcareous shell of mollusks). Present day ecologic habit for these macrofossils is littoral zone (tidal flat) between the regions of high and low water tide marks where they lead a benthonic existence. Their abundance in sample 25 therefore implies that the environment of deposition was probably littoral (tidal flat), thus confirming the interpretation based on the palynomorphs. Sample 24 is poor in palynomorphs but the numerical counts show that they are dominated by pollen and spore.

The dinoflagellate cyst assemblage consists of 7 species and the common cysts include *Thalassiplzora pelagica*, *Dipirves colligerum*. Their presence in a pollen and spore dominated assemblage probably indicate an infiltration of marine water into the depositional environment.
The pollen and spore assemblage consists of 10 species. The most dominant being pteridophyte spore *Cyathidites minor*. The common species is *Classopollis classoides* an early Cretaceous monoporate pollen. Their presence indicates reworking. The dominance of spores probably imply a cooling of the climate.

The profuse number of *Pediastrum* and the presence of *Botiyoccocus braunhi*, however indicate that the depositional environment of sample 24 had a fresh water influx.
The presence of calcareous macrofossil (molluses) probably indicate a littoral (tidal flat) depositional zone.

Samples 23 and 22 lack dinoflagellate cysts. Pollen and spores are scarse arid contain 6 to 7 species. The dominant species being the monolete spores *Verrucatusporites usmensis*. Other common species include the trilete spore *Cyathidites minor* and the monolete spore *Laeigatosporites ovatus*. The absence of dinofiagellate cysts and the presence of *Pediastrum* probably indicate a fresh water environment for samples 23 and 22.

Calcareous shells of macrotossils (molluses) ,are abundant in the mudstone sample 23. Their abundance probably implies deposition in a littoral zone.The palnomorphs debris, except the pollen spore are observed to be deeply stained by the safranin O and the samples are also non-pyritic which might indicate exposure and weathering of sediment leading to the destruction of palynomorphs, subsequent deposition probably resulted in the unstained pollen and spore assembly.It is more difficult to assess environmental conditions in samples 2l and 20 because the palynomorphs do not attain any numerical importance, being 3 to 5 specimens.
The presence of *Pediastrum* probably implies that samples 20 were deposited in fresh water environment. Sample 19 contains abundant palynomorphs which is made up of 10% dinoflagellate

cysts. 26% pollen and 64% spores. Plant cuticle are also abundant, probable indicating a more terrestrial environment

No comprehensive environmental interpretations are made on the basis of dinoflagellate cysts because of the low number of indigenous species. These are however, dominated by *Operculodinium centrocarpum*, *Lingulodinium macheorophorum.* The dominance of L. Macheorophorum may signal the on set of temperate climatic conditions (Wall and Dale, 1968).
The pollen and spore assemblage consists of 14 species which is dominated by pteridophyte spores. The dominant species is *Cyathidites minor* (30%). Other common species include *Verrucatosporite usmensis* (18%), *Laevigatosporires ovatus* (11 %). The presence of a dominant species (*Cyathidites minor*) indicates it was derived from a restricted flora and reflects nearly an in situ deposition. The dominance by pteridophyte spores probably indicates cooling of the climatic conditions. This corroborates the Interpretation based on the dinoflagellate cysts.
The presence of *Pediastrum* and *Botryoccocus braunii* indicate a fresh water depositional environment (Wilson and Hoffmeister, 1953. Cookson, 1953 and Weiler, 1971) for sample 19. The presence of dinoflagellate in a spore dominated environment indicates infiltration of marine water into a fresh water environment.

MIOCENE SUB PHASE

The rocks of the Miocene regressive phase of the Abao BH. are found in samples 19, 18, 17, 16, 15, 14, 13, 12, 11, 10 and 9. Sample 19 marks the Late Eocene/Oligocene Miocene boundary and has been discussed under the Late Eocene/Oligocene regressive phase. These samples represent the (Ogwashi Asaba Formation (Reyment, 1965). The sequence represents the lower half of the dinoflagellate cysts zone S (Oloto, 1994) which is equivalent to the *apteodinium* sp. B, *pentadinium laticinctum, Cannosphaeropsis* sp. A, zones (Williams and Bujak 1977). The sequence also represents the pollen and spore L - 1 (2), M - 1.- 1. O - 1 and P - 1 (1) (Oloto. 1994) which is equivalent to the top of *Verrucutosporites usmensis* and the lower part of *Wagnasrriatites howardi* of Germeraad et al (1968) as indicated in Table 2.

Samples 18, 17 and 16 are devoid of dinoflagellate cysts and pollen and spores are scarce. The palvnomorph residues are observed to be deeply stained by the dye safranin O and are also non-pyitic, which might indicate exposure and weathering of sediment. This had subsequently led to the destruction or non-preservation of palynomorphs at these horizons.The presence of *Pediastrum* probably indicates a fresh water depositional environment (Wilson and Hoffmeister, 1953; Cookson, 1953; Weiler, 1971) for samples 18,17, and 16.Chitinous foraminitera test linings are also very rare. Samples 15 is rich in palynomorphs which consist of 20% dinolagellate cysts, 62% pollen and 18% spores. The dominance of pollen/spores and the abundance of plant cuticle indicates a more terrestrial depositional environment.

The dinoflagellate cyst assemblage contains 9 species and is dominated by *Chytroeisphaeridia* sp. A. Other common species include *Operculodinium centrocarpum Tuberculodinium vancampoae*.

The presence of dinoflagellate cysts in a pollen and spore dominated sequence indicates a marine incursion at this horizon. The pollen and spore assemblage contains 3 species and is dominated by the tricolporate pollen *Retitricolporites irregularis* (52%). The only other common species being *Psilatricolporites crassus* (21 %). The dominance of these two species indicates that they were derived from a restricted flora and imply nearly in situ deposition, probably a mangrove swamp. Chitinous foraminiferal test linings are abundant and consist of planispiral forms. They represent benthonic foraminifera linings (Muller, 1959; Cross et at, 1966). Their abundance in sample 15 implies a favourable environment, probably inner neritic. This supports the interpretation based on palynomorphs.

Sample 14 is composed of claystone/coal and is barren of palynomorphs or any other miscellaneous element. The presence of coal implies a swampy depositional environment. The absence of pollen/spores probably indicates that the deposition was not in situ, but were derived from plant debris transported from different sources and deposited at the site for sample 14. Sample 13 and 12 are devoid of dinoflagellate cysts while pollen/spores are sparse and contain 7 species. The relatively common species include monolete spore *Laevigatosporites ovatus* and the tricolporate pollen *Retitricolporites irregularis*. The samples contain abundant plant debris and implies a terrestrial swampy depositional environment, devoid of marine influence.
Chitinous foraminiferal test linings are very sparse to absent.

Sample 11 is rich in palynomorphs and is composed of 12% dinoflagellate cysts, 15% pollen and 73% spores. The dinoflagellate cyst assemblage consists of 9 species. The common species include *Chytroeisphaeridia* sp. A, *Operculodinium centrocarpum, Tuberculodinium vancampoae*. The presence of a few dinoflagellate cysts in a pollen/spores dominated assemblage probably indicates infiltration of marine water.The pollen and spore assemblage consists of 15 species which is dominated by the monolete spore *Laevigatosporites ovatus* (52%). The only common species being the monolete spore *Verruatosporites usmensis* (19%). The dominance by *Laevigatosporites ovatus* indicates that it was derived from a restricted flora, that is, a mangrove swamp, and reflects nearly in situ deposition in a cool ecologic condition. The abundance of plant debris also confirms a swamp condition. Chitinous foraminiferal test linings are abundance and consist of planispiral forms which are benthonic (Muller, 1959: Cross *et al.* 1966). Their abundance indicate a favourable environment for their survival.

Sample 10 is devoid of dinoflagellate cysts but rich in pollen and spores. This indicates a terrestrial depositional environment. It is further supported by the abundance of plant debris. The pollen and spore assemblage Consists of 15 species is dominated by *Verrucatosporites usmensis* (50%) and *Laevigatosporites ovatus* (38%). The dominance of these two species indicates a nearly in situ deposition, most probably in a cool swamp environment with a lot of flesh water runoffs. The presence of fungal spores probably further confirms a swamp depositional environment.In sample 9 palynomorphs are sparse. The assemblage consists of a few dinoflagellate cysts, and dominated by pollen and spores. The dominance of pollen and spores, in addition to the presence of abundant plant debris, probably indicates a swamp environment. The common species include spores, *Laevigatosporites ovatus, Lygodiumsporites adriennis, Leotriletes sphaerotriangulus and pollen Psilatricolporites crassus, Retitricolporites irregularis*. Chitinous foraminifera test linings are scarse.

MIOCENE/PLIOCENE (REGRESSIVE PHASE)

The Miocene/Pliocene regressive phase is represented in samples 9, 8, 7, 6, 5, 4, 3, 2, and 1. Sample 9 marks the Miocene Miocene/Pliocene (?) boundary and has been discussed under the Miocene regressive phase. These samples represent the Benin Formation (Reyment, 1965). The sequence represents the top half of the dinoflagellate cyst zone S which is equivalent to the *Apteodinium* sp. B, *Pentadinium laticinctum, Cannosphaeropsis* sp. A, zones (Williams and Brideaux, 1975) and the *Hystrichosphaeridium choanophorum* zone of Williams and Bujak (1977). The sequence also represents the pollen and spore zones P - 1 (2) and Q - 1 (Oloto, 1994) which is equivalent to the top of the *Magnastriatites howardi* and the *Crassoretitriletes vanraadshooveni* zones of Germeraad et al (1968).No comprehensive environmental interpretations are made on samples 8. 7. 6. 5 because of the low palynomorph counts. However, the relative percentage of the pollen/spores does indicate dominance over the dinoflagellate cysts in addition to the abundance of plant debris, suggesting a swamp environment with little or no marine incursion. Sample 7 is however, composed of black fine grained debris.

Sample 4 is devoid of dinoflagellate cysts but rich in pollen and spores. The abundant plant debris contained, probably suggesting a swamp depositional environment. The pollen and spore assemblage consists of 18 species which is dominated by the angiosperm pollen. There is no clear species dominance, the common ones, being *Retitriporites boltenhagenii* (19%), *Retitricolporites irregularis* (19%), *Verrucarosporites usmensis* (14%), *Laevigatosporites ovatus* (11 %). The relatively high species diversity, with no clear dominant species, probably indicates transportation of sporomorphs from upland regions into the swamp environment where they are fossilized. In sample 3 palynomorph is sparse and the sample contains a mixture of plant debris and round concretions. The only common dinoflagellate cyst is *Operculodinum centrocarpum*. Its presence indicates that the prevailing climate was probably temperate in outer neritic deposition environment (Harland, 1983). The presence of high percentage of reworked Maastrichtian and Paleogene dinoflagellate cysts shows that sediments of this age must have been exposed and were undergoing active erosion during this interval.

The presence of silicoflagellates, however, indicates a marine environment of an open and deep sea (Baltes, 1970). This probably implies a minor marine incursion accompanied by the deposition of eroded material from old rocks.Sample 2 is almost devoid of dinoflagellate cysts Pollen and spore assemblage consists of 13 species being dominated by the pteridophyte spore *Laevigatosporites ovatus* (67%). The common species include *Cyathidites minor* (11 %), *Verrucatosporites usmensis* (8%). The dominance by a single species (*Laevigatosporites ovatus*) indicates it was derived from a restricted flora and probably reflect in situ (mangroove) depositional environment.

Sample 1 is composed of black debris and devoid of palynomorphs. This is understandably so, since the original white claystone sample is iron stained implying that it had been oxidized and weathered.

CONCLUSION

The study indicated that dinocyst and pollen/spore populations reflect cycles of sedimentation including trangressive and regressive phases. Detailed Paleoenviromental and paleoclimatic interpretation was based on the fact that diversity ,abundances, and presence of some species reflect either local or regional ecologic conditions as recognized in the technique of Downie et al 1971 and Harland (1973) for pollen/spores.

In general, the paleoclimatic pattern appears to follows the scheme proposed by Van der Hammen (1957). There is a close correlation between the dominant dinocyst associations and pollen/spore percentage in the samples.

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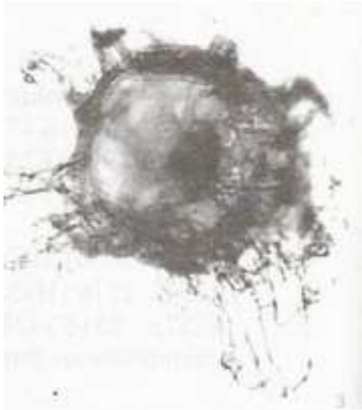
PLATE 1 (1X800)

1. Emmetracysta Urnaformis (Cookson 1953)
2. Areoligera senonensis (Carpentier 1938)
3. Oligosphaeridium cf. anthophorum (Cookson & Eisenack) Davey 1969
4. Glaphyrocyst ORDINATA (Williams and Downie, 1966)
5. Adnatosphaeridium vittatum Williams & Downie 1966
6. Adnatosphaeridium multispinosum Williams & Downie 1966
7. Cordospaeridium cantharellum (Brosius 1963)
8. Senoniasphaera inornata (Drugg, 1970)
9. Amiculospaera umbracula Harland 1979



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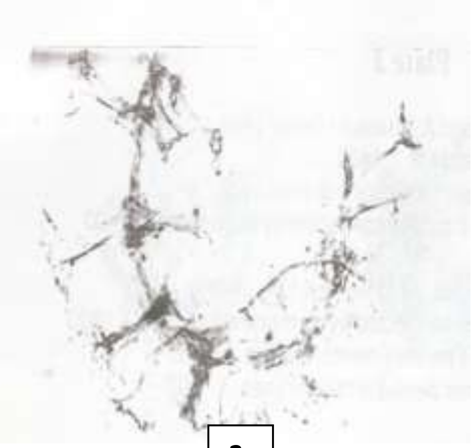

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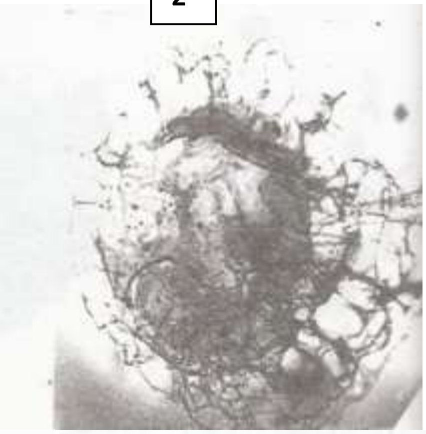

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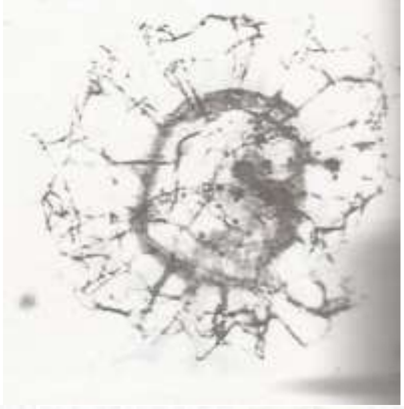

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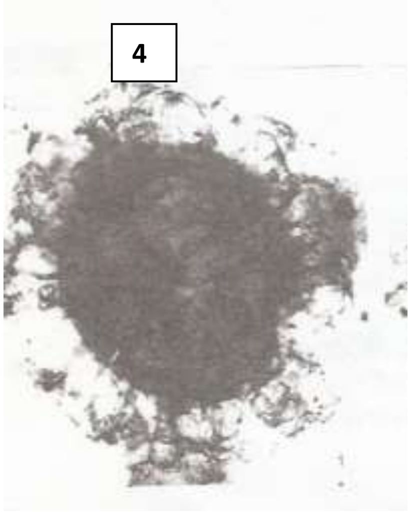

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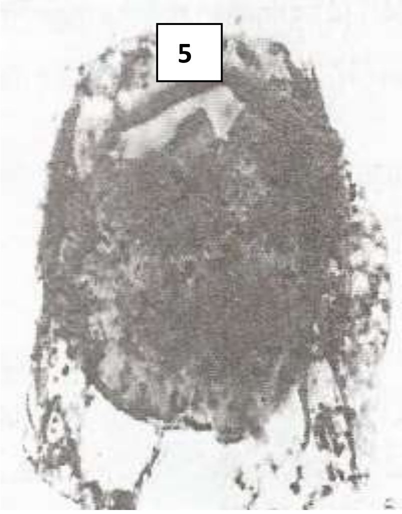

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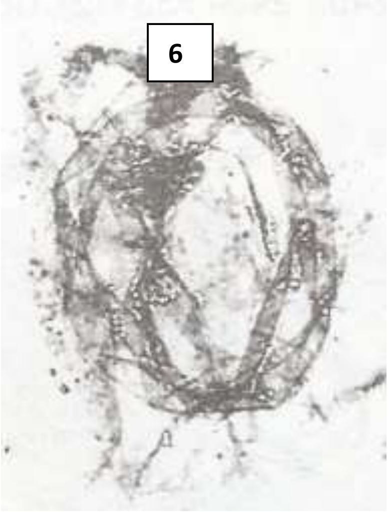

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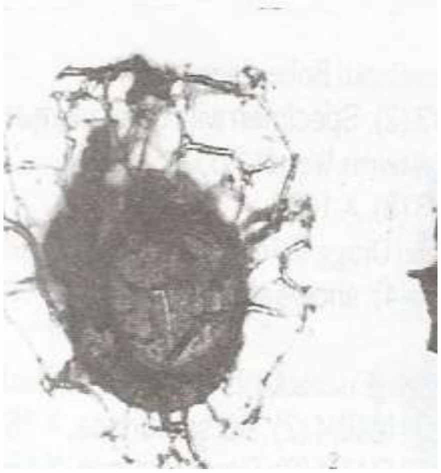
PLATE 2 (1X800)

1. Fibrocysta radiata (Morgenroth 1966)
2. Fibrocysta lappacea (Drugg 1970)
3. Cyclapophysis monmouthensis (Benson 1976
4. Homotryblium palladium (Dvey and Williams 1966)
5. Cordospaeridium multispinosum (Davey and Williams 1966)
6. Melitasphaeridium sp
7. Homotrybilum palladium (Davey and Williams 1966)
8. Hystrichosphaeridium tubiferum (Davey and Williams 1966)
9. Homotrybilum tenuispinosum (Davey and Williams 1966)



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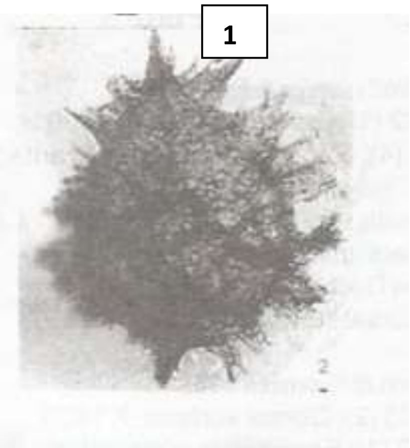

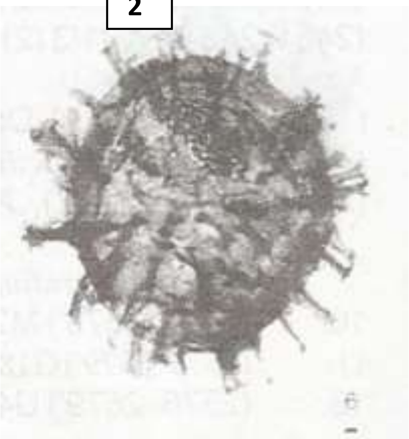

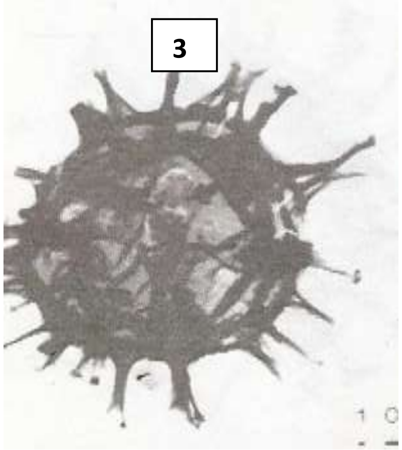

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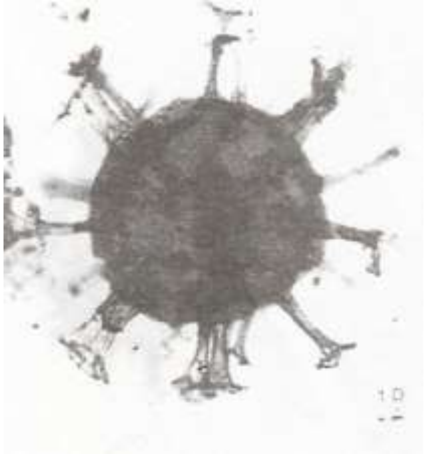

PLATE 3 (1X800)

1. Homotrybilum sp
2. Elytrocysta druddi (Drugg 1967)
3. Implestosphaeridium densicomatum (Maier 1959)
4. Operculodinium nonaconulum (Islam 1983)
5. Downiespaer pisinna (Isalm 1981)
6. Operulodinium hirsutum (Morgenroth 1966)
7. Operculodinium centrocarpum
8.Eocladopysxis peniculatum
9. Downiesphaera pisinna Islam

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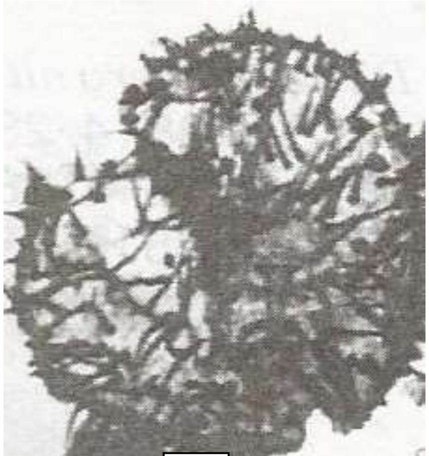

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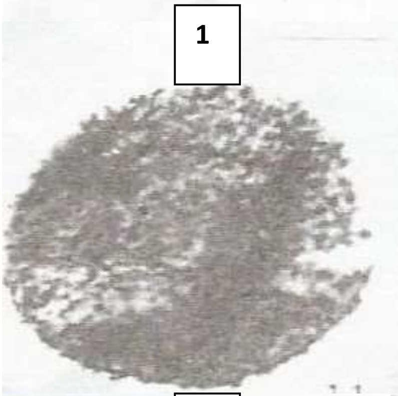

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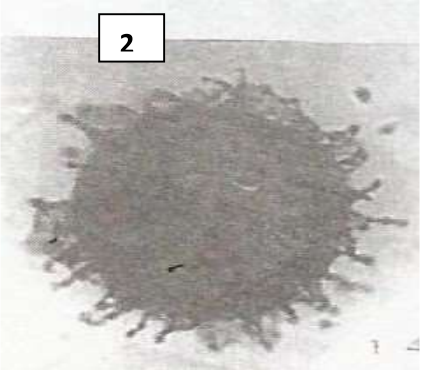

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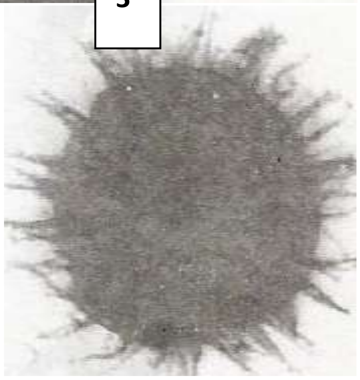

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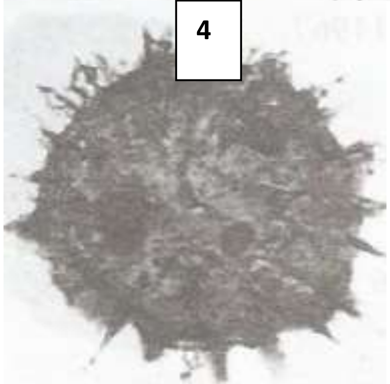

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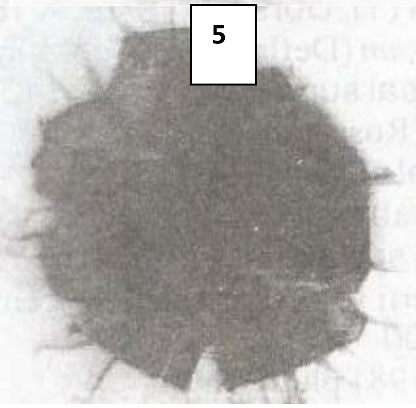

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