ACTA PALAEOBOTANICA
30(1,2): 23-30, 1990

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PALYNOLOGICAL ASSEMBLAGE FROM THE DANIAN OF SOUTH-WEST NIGERIA

Palinologia danianu południowo-zachodniej Nigerii

ABSTRACT. No data on the palynology of the Nigerian Danian is available at present. This report is a palynological study of some core samples from the Danian section of the Gbekebo-1 well in the coastal western flank of the Niger delta. The samples yielded dinoflagellate cysts, pollen, spores and associated elements such as algae, fungal spores and chitinous microfaraminiferal test linings.

The identification of the dinocysts, pollen and spores, their relative diversity and abundances provide data on which the age, palaeoenvironmental and palaeoclimatic interpretation were based. The dinocyst zones recognised are based on the use of first occurrences of two or more species.

INTRODUCTION

On the basis of macrofossils (ammonites) and microfossil (foraminifera, ostracods) evidence the upper part of the Nkporo Shale is generally dated Danian (Reyment 1965). No data on the palynology of the Nigerian Danian is available at present. This report is a palynological study of some core samples from the Danian section of the Nkporo Shales in the Gbekobo-1 well.

The core samples from Gbekebo-1 well which is located in the coastal western flank of the Niger delta (Fig. 1) yielded rich palynomorph assemblage and other associated elements of Danian age. The well was drilled by Shell-BP Petroleum Development Company of Nigeria. The samples examined comprise of black to grey shale, the silty variety being spotted with white calcareous material (Table 1). The lithologic sequence represents the top section of the Nkporo Shale which was deposited during the second cycle (Uppermost Cretaceous – Lower Paleocene transgression) of the sedimentary filling of the Anambra Basin.

The determination of the relative abundance of the species was based on a count of 250 palynomorpha from each of the four samples and the percentage distribution of species was based on this.

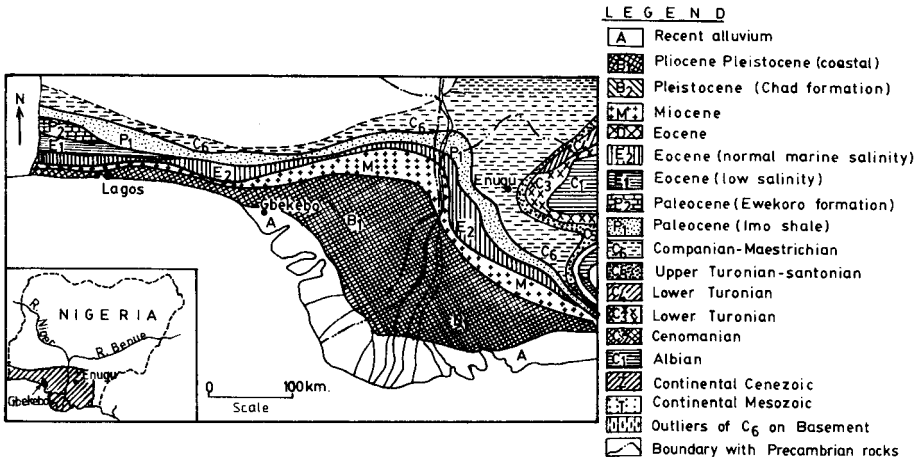

Fig. 1. Geological sketch map of Nigeria showing location of Gbekebo and Enugu

Table 1. Lithologic description

Sample No	Depth in m	Lithology
42	830-831	shale, dark grey
43	844-845	shale, black
44	869-870	shalle, silty, black, spotted whit white (calcareous) material
45	886-887	shale, silty, black, spotted with white (calcareous) material

PALYNOLOGY

The samples yielded dinoflagellate cysts, pollen, spores and associated elements like algae, fungal spores and chitinous microformainiferal test linings. The microflora is composed of a mixture of long ranging Late Masstrichtian palynomorphs with typical Danian assemblages. The taxonomic part of this paper is mainly confined to an alphabetic listing of all species including in many instances a reference to published species. Some of the dinoflagellate cyst species occurring include: *Alterbidinium* cf. *pentaradiata* (Pl. III, fig. 1), *Andalusiella mauthei* (Pl. IV, fig. 16), *Andalusiella polymorpha* (Pl. IV, fig. 5), *Areoligera coronata* (Pl. III, fig. 4), *A. senonesis* (Pl. I, fig. 2), *Ceratiopsis diebelli* (Pl. I, fig. 3), *Ceratiopsis*

granulostriata (Pl. IV, fig. 17). *C. leptoderma* (Pl. IV, fig. 15), *Chytroeisphaeridia* sp. (Pl. I, fig. 9), *Chytroeisphaeridia* sp. (Pl. IV, fig. 10), *Cometodinium whitei* (Pl. I, fig. 4), *Cyclapophysis monomouthensis* (Pl. II, fig. 4), *Cyclonephylium deconinckii* (Pl. I, fig. 6), *Danea abbreviata* (Pl. II, fig. 7), *D. calibornica* (Pl. IV, fig. 3), *D. manicata* (Pl. III, fig. 7), *Downisphaera nitida* (Pl. I, fig. 10), *Fibrocysta lappacea* (Pl. II, fig. 5), *Glaphyrocysta divaricata* (Pl. I, fig. 2), *Hafniasphaera cryptovessiculata* (Pl. III, fig. 5), *Lejeunecysta sp.* (Pl. II, fig. 1), *Palaeocystodinium austrialinum* (Pl. II, fig. 3), *P. golzowense* (Pl. IV, fig. 1), *P. stockmansii* (Pl. IV, fig. 2), *Palynodinium grallator* (Pl. IV, fig. 7), *Phelodinium boloniensis* (Pl. I, fig. 5), *Ph. gaditanum* (Pl. IV, fig. 6), *Ph. magnificum* (Pl. II, fig. 2), *Phthanoperidinium amoenum* (Pl. I, fig. 7), *Senegalinium psilatum* (Pl. I, fig. 8), *Senoniasphaera inornata* (Pl. II, fig. 6), *Spiniferites ramosus subsp. gracilis* (Pl. I, fig. 1).

The absence of *Dinogymnium* indicates that the section studied is not Maastrichtian. Hansen (1977) published the occurrpence of many characteristic Danian species which include *Danea californica*, *Senoniasphaera inornata*, *Hafniasphaera cryptoversiculata* amongst others. Drugg (1967) in a study of the palynomorphs of the Upper Moreno formation of Maastrichtian – Danian age, noted that *Dinogymnium* does not extend into the Danian. Benson (1976) described *Cyclapophysis monmouthensis* (Pl. II, fig. 4) from the Cretaceous – Tertiary boundary of Round Bay, Maryland. Based on the dinoflagellate cyst data, samples 42 to 45 between 830 m and 887 m of the Nkporo Shale in the Gbekebo-1 well are dated as Danian.

TAXONOMY

Division *Pyrrhophyta* Pascher 1914
Class *Dinophyceae* Fritsch 1929
Order *Peridiniales* Haechel 1894
Chytroeisphaeridia (Sarjenant 1962) Downie & Sarjenant 1965: emend. Pocock 1972; emend. Davey 1979
Chytroeisphaeridia sp. A.
Pl. I, fig. 9.

Comment. Cyst sphaerical, autophragm smooth to finely granular. Along with many similar forms without visible archaeophyle, a few others were found cleary showing hexagonal P-type archeaophyles with partly detached operculum. The species differs from *Chytroesphaeridia euteiches* (Davey 1969) by its hexagonal precingular type of archaeophyle and finely granular to smooth surface.
Dimensions. 37-49 μm.

The pollen and spore species occurring include: *Verrucatosporites* cf. *favus pseudosecundus* (Pl. IV, fig. 11), *Verrucatosporites* sp. (Pl. III, fig. 2), *Inaperturopollenites scabratus* (Pl. III, fig. 3), *Inaperturopollenites* sp. (Pl. IV. fig. 9), *Elaterosporites klaszi* (Pl. III, fig. 10), *Liliacidites variegatus* (Pl. IV, fig. 12), *Longaoertites marginatus* (Pl. III, fig. 11), *Loranthaeites nataliae* (Pl. III, fig. 8), *Mauritiidites crassibaculetus* (Pl. III, fig. 6), *Monolites* sp. (Pl. III, fig. 9), *Retidiporites magalensis* (Pl. IV, fig. 13).

Hoeken-Klinkenberg van (1964) recorded a sudden high number of *Longapertites marginatus* and the appearance of *Mauritiidites crassibaculatus* and interpreted this occurrence as indicating a transition from the Cretaceous into the Tertiary. This transition was also observed in Columbia (Hammen van der 1957) and similary in the present study in sample 43 at a depth of 844-845 m.

PALYNOSTRATIGRAPHY

The zonal divisions are based on the distribution of species in the core samples of Gbekebo-1 well. Three dinocyst zones are recognised based on the use of first occurrences of two or more species. Two pollen and spore assemblage zones are recognised. They are compared with those of Germeraad et al. (1968).

Dinofalagellate cyst assemblage zone

Danian – Zone G

Reference section. Gbekebo-1 well, 886-887 m. Sample number 45 (Fig. 2).

Definition. Species first appearing at the base of the zone – *Alterbidinium pentaradiata* (Pl. III, fig. 1), *Cyclonephylium deconinckii* (Pl. I, fig. 6), *Glaphyrocysta divaricata* (Pl. I, fig. 11), *Areoligera senonensie* (Pl. I, fig. 2), *Cyclapophysis monmouthensis* (Pl. II, fig. 4), *Areoligera coronata* (Pl. III, fig. 4), *Palaeocystodinium golzowense* (Pl. IV, fig. 1). Species last occurring at the top of zone – *Phelodinium gaditanum* (Pl. IV, fig. 6).

Discussion. This zone is equivalent to the lower part of *Danea californica* (Pl. IV, fig. 3). Zone of Hansen (1977) and probably part of the *Senoniasphaera inornata* (Pl. II, fig. 6) sub-zone (Hansen 1977).

Danian – Zone H

Reference section. Gbekebo-1 well, 869-870 m. Sample number 44 (Fig. 2).

Definition. Species first appearing at the base of the zone – *Senoniasphaera inornata* (Pl. II, fig. 6), *Phelodinium magnifica* (Pl. II, fig. 2), *Danea abbreviata* (Pl. II, fig. 7), *Phelodinium boloniensis* (Pl. I, fig. 5). Species last occurring at the top of the zone – *Phelodinium magnifica*, *Senoniasphaera inornata*, *Cyclapophysis monmouthensis*, *Areoligera senonensis*, *Andalusiella polymorpha* (Pl. IV, fig. 5), *Ceratiopisis leptoderma* (Pl. IV, fig. 15).

Discussion. Hansen (1977) defined his *Senoniasphaera inornata* sub-zone (of *Danea californica* zone) as sediments containing *Senoniasphaera inornata*, but excluding sediments containing *Palynodinium grallator* and *Hafniasphaera cryptovesiculata*. This zone consequently corresponds to the *Senoniasphaera inornata* sub-zone of Hansen (1977).

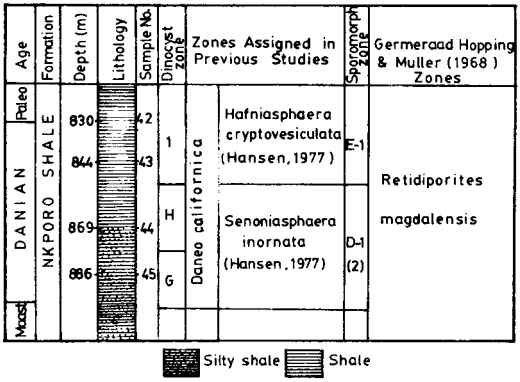

Fig 2. Palynomorph zones of Gbekebo borehole

Danian – zone I

Reference section. Gbekebo-1 well, 844-845 m. Sample number 43 (Fig. 2).

Definition. Species first appearing at the base of the zone – *Chytroeisphaeridia* sp. (Pl. I, fig. 9), *Danea manicata* (Pl. III, fig. 7), *Downisphaera nitida*, *Hafniasphaera cryptovesiculata*. Species last occurring at the top of the zone *Danea manicata*, *Downisphaera nitida* (Pl. I, fig. 10), *Hafniasphaera cryptovesiculata* (Pl. III, fig. 5), *Ceratiopsis granulostriata* (Pl. IV, fig. 17), *Phthanoperidinium amoenum* (Pl. I, fig. 7), *Palaeocystodinium australinum* (Pl. II, fig. 3).

Discussion. Hansen (1977) defined his *Hafniasphaera cryptovesiculata* sub-zone (of *Danea californica* zone) from the Upper Maastrichtian and Danian deposits of Denmark as that containing *Hafniasphaera cryptovesiculata*. This zone consequently corresponds to his *H. cryptovesiculata* sub-zone.

Pollen and spore assemblage zone

Retidiporites magdalensis zone E-1 and D-1 (2)

Reference sectdion. Gbekebo-1 well, 844-887 m. Sample numbers 43, 44, 45 (Fig. 2).

Definition. Species first appearing at the base of the zone E-1 *Elatersporites klaszi* (Pl. III, fig. 10), *Mauritiidites crassibaculatus* (Pl. III, fig. 6), *Longaperitites marginatus* (Pl. III, fig. 11). Species last occurring at the top of the zone – *Araucariacites australis*, *Elatersporites klaszi*, *Mauritiidites crassibaculatus*. Species last occurring at the top of the zone D-1 (2) – *Inaperturopollenites scabratus* (Pl. III, fig. 3).

Remarks. This zone is marked by the sudden abundance of *Longapertites marginatus*. The zone is equivalent to the dinocyst zones G, H and I of the present study.

The microfloral assemblages

In the Danian of the Gbekebo — 1 well two associations are present: the *Wetzeliella* and the *Spiniferites associations* (Downie et al. 1971). These associations occur in samples 45, 44, 42 (*Wetzeliella* association) and 43 (*Spiniferites* association). The samples represent the upper sequence of the Nkporo Shale (Tattam 1944). The sequence represents the dinoflagellates zons G to I (present study) which is equivalent to the *Danea californica* (Pl. IV, fig. 3), *Hafniaspaera cryptovesiculata* and *Senoniasphaera inornata* sub-zones (as indicated in Fig. 2). The sequence also represents the pollen/spore zones D-1(2) and E-1 (present study) which is equivalent to the lower section of the *Retidiporites magdalensis* zone of Germeraad et al. (1968).

Dinoflagellate cysts are abundant and make up 78-100% of the palynomorph in samples 45, 44, 43 and 42. The rest 1-22% are predominantly angiosperm and gymnosperm pollen. The abundance of dinoflagellate cysts indicates that the shoreline was relatively distant from the sample sites. The samples 42 up to 45 are characterised by a nearly progressive increase in dinoflagellate species from 18 to 38 respectively. Sample 45 is dominated by *Palaeocystodinium australinum* (Pl. II, fig. 3) and *Spiniferites ramosa* subsp. *gracilis* (Pl. I, fig. 1) which make up 33% and 29% respecively of the assemblage (Zone G). Other abundant species are *Ceratiopsis* cf. *granulostriata* (Pl. IV, fig. 17), *Cyclapophysis monmouthensis* (Pl. II, fig. 4), *Areoligera coronata* (Pl. III, fig. 4) and *Ceratiopsis diebelli* (Pl. I, fig. 3). They range from 6-11% of the sample 45 assemblage.

Sample 44 is dominated by *Palaeocystodinium australinum* (Pl. II, fig. 3), *Senegalinium psilatum* (Pl. I, fig. 8) and *Cometodinium white* (Pl. I, fig. 4) which make up 35%, 21% and 16% respectively, of the assemblage (Zone H). Other common species are *Danea abbreviata* (Pl. II, fig. 7), *Cyclapophysis monmouthensis*, *Spiniferites ramosa* subsp. *gracilis*.

Sample 43 is dominated by *Hafniasphaera cryptovesiculata* (Pl. III, fig. 5) and *Phthanoperidinium amoenum* (Pl. I, fig. 7) which make up 41% and 31% respectively, of the assemblage (Zone I). Other common species inculude *Downisphaera nitida* (Islam 1981 – unpubl. thesis) which make up 12% of the assemblage.

Sample 42 marks the boundary between the Danian and the overlying Paleocene is dominated by *Lejeunecysts* sp. III (Drugg 1967) which makes up 39% of the assemblage. Other common species include *Chytroeisphaeridia* sp. (8%) and *Fibrocysta lappaceum* (6%).

All the Danian samples, except sample 43, are dominated by peridiniacean dinoflagellate cyst species which constitute 53-59% of the total cyst assemblage. They are aquivalent to the *Wetzeliella* association of Downie et al. (1971) and indicate coastal lagoonal environment. Sample 43 is dominated by the *Spiniferites* association of Downie et al. (1971) and indicate shallow marine environment.

Pollen and spores are poorly represented in samples 44 and 45, with two species between them, while they are fairly represented in samples 43 and 42 where the number of species are 10 and 13 respectively.

Sample 44 is monospecific with *Inaperturopollenites scabratus* (Pl. III, fig. 3) making up 100% of the pollen assemblage (15 grains)

Sample 43 is dominated by *Longaperitites marginatus* (Pl. III, fig. 11) which make up 80% of the pollen/spore assemblage. Sample 42 is dominated by *L. marginatus* (Pl. III, fig. 11), *Verrucatosporites* sp. (Pl. III, fig. 2), *V.* cf. *favus pseudosecundus* (Pl. IV, fig. 11) which

each one making up 21% of the pollen/spore asseblage. Other common species include *Inaperturopollenites* sp. (12%) (Pl. IV, fig. 9) and *Monolites* sp. (14%) (Pl. III, fig. 9).

Longapertites marginatus (Hoeken-Klinkenberg van (1964) show some resemblance with *L. proxapertitoides*, (Hammen van der 1954) and *Proxapertites operculatus*, *P. terciaria* (Hammen van der 1956). They are of the palm family which implies that the prevailing climate was tropical. Their presence indicates proximity to a mangrove, near shore, depositional environment (Germeraad et al. 19668). The abundance of *Longapertites marginatus* in sample 43 indicates that the species is derived from a restricted flora growing near the shore or even in the marine water, that is, a mangrove plant, the assemblage reflects nearly in-situ deposition. This agrees with the shallow marine interpretation based on the dinoflagellate cyst assemblage.

Pediastrum is present in abundance in sample 43. Modern *Pediastrum* are found in freshwater ponds and lakes which lead to the assumption that *Pediastrum* is an indicator of fresh water environment. Fossil *Pediastrum* was earlier studied by Wilson and Hoffmeister (1953) and Cookson (1953) and from Tertiary sediments. A marine habitat for this green algae has not yet been found. Its abundance in the marine sample 43 suggests that the *Pediastrum* was probably transported from freshwater in which they lived into marine water where they were fossilised. The most likely environment of deposition for sample 43 is therefore an estuarine.

Chitinous microforaminiferal test linings (Pl. IV. figs 4 and 14) are present in the samples but are abundant in sample 42. They are composed of planispiral evolute and agglutinated uniserial forms. The linings are probably derived from benthonic formainifera (Muller 1959, Cross et al. 1966) which are indicative of near-shore shallow marine environment.

The presence of fungal spores in sample 43 also probably indicates transportation from a swamp to the estuarine environment.

CONCLUSION

The core samples studied yielded 16 genera and 38 species of dinoflagellalte cysts; and 8 genera and 13 species of pollen/spores. The palynologic analysis of the Gbekebo-1 well has permitted the recognision of 3 dinoflagellate cyst assemblages and 2 pollen/spore assemblage zones of Danian age.

The identification of the dinocystes, pollen and spores, their relative diversity and abundances provide data on which the age, palaeoenvironmental and palaeoclimatic interpretations were based. The presence of foraminfera test linings, *Pediastrum* and algae have been utilized and they correborate the interpretations based on the palynomorphs.

The Danian samples 42 to 45, the interval between 830 m and 887 m of the Nkporo Shales from the Gbekebo-1 well was deposited during a transgressive phase in an extensive shallow coastal lagoon environment. During the deposition of sample 43, there was a minor advance of the sea resuliting in the introduction of open marine elements. The dominance of *Hafniasphaera cryptovesiculata* (sample 43) however indicates that the condition was such as to inhibit the reproduction of other, perhapes more sensitive species. This horizon was interpreted as being estuarine. The prevailing climate was tropical as confirmed by the

presence of the pollen *Longapertites marginatus* (Hoeken-Klinkenberg van 1964) which belongs to the palm family.

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PLATES

PLATE I

1. *Spiniferites ramosa* subsp. *gracilis* (Davey & Williams) Lentin & Williams 1973, (869-870 m), M26/1 (1); Dorsal surface. x 1800
2. *Areoligera senonensis* Lejeune - Carpentier 1938, (869-870 m), Q 34/2 (3); Dorsal surface. x 1800
3. *Ceratiopsis diebelli* (Alberti) Vozzhennikova 1967, (886-887 m), L 22/1 (3). x 2200
4. *Comctodinium whitei* (Deflandre & Courtevilie) Stover Evitt 1978, (869-870 m), D 36/3 (1). x 1800
5. *Ceratopsis boloniensis* (Riegel) Lentin & Williams 1977, (830-831 m), J 24/4 (1), Dorsal surface. x 1800
6. *Cyclonephelium deconinskii* Baltenhagen 1977, (886-887 m), N 23/3 (2); Specimen with operculum attached. x 1800
7. *Phthanoperidinium amoenum* Drugg & Loeblich 1967, (8844-845 m), P 37/1 (2), Dorsal surface. x 1800
8. *Senegalinium psilatum* Jain & Millipied 1973, (869-870 m), Q 33/3 (2): Specimen with fewer spines. x 1800
9. *Chytroeishpaeridia* sp. A., (830-831 m), J 33/2 (2); Dorsal surface. x 1400
10. *Downisphaera nitida* Islam 1981, Ph. D. Thesis, (844-845 m), P 19 (1). x 1600
11. *Glaphyrocysta divaricatum* (Williams & Downie) Stover & Evitt 1979, (886-887 m), L 31/3 (1); Processes devoid of membrane. x 1800

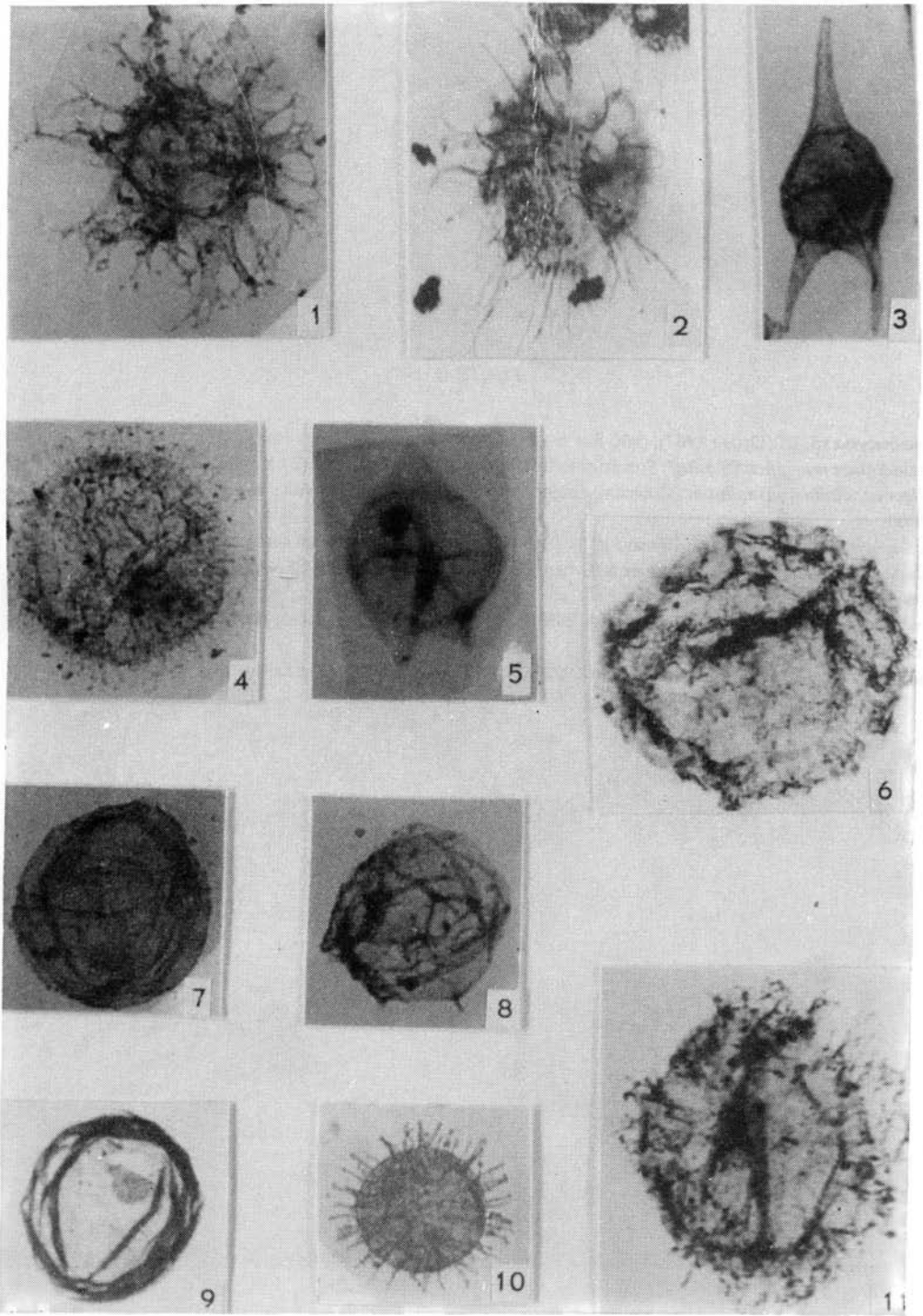

Plate I

PLATE II

1. *Lejeunecysta* sp. III (Drugg 1967), (830-831 m), N 26/4 (1); Dorsal surface. x 1800
2. *Phelodinium magnifica* (Stanley) Stover & Evitt 1978, (869-870 m), L 28/2 (2). x 3000
3. *Paleocystodinium australinum* (Cookson; emend. Malloy 1972) Lentin & Williams 1976/, (869-870 m), P 23 (2). x 3000
4. *Cyclapophysis monmouthensis* Benson 1976, (886-887 m), E 40/4 (2); Dorsal surface. x 3000
5. *Fibrocysta lappaceum* (Drugg) Stover & Evitt 1978, (830-831 m), 0 33/2 (4); Specimen with onger processes. x 1800
6. *Senoniasphaera inornata* (Drugg) Stove & Evitt 1978, (869-870 m), H 34/1 (4); Showing bi-lobed membraneous processes. x 1800
7. *Danea obbreviata* (Drugg) Stover & Evitt 1978, (869-870 m), L 32/3 (1); Dorsal surface. x 1800

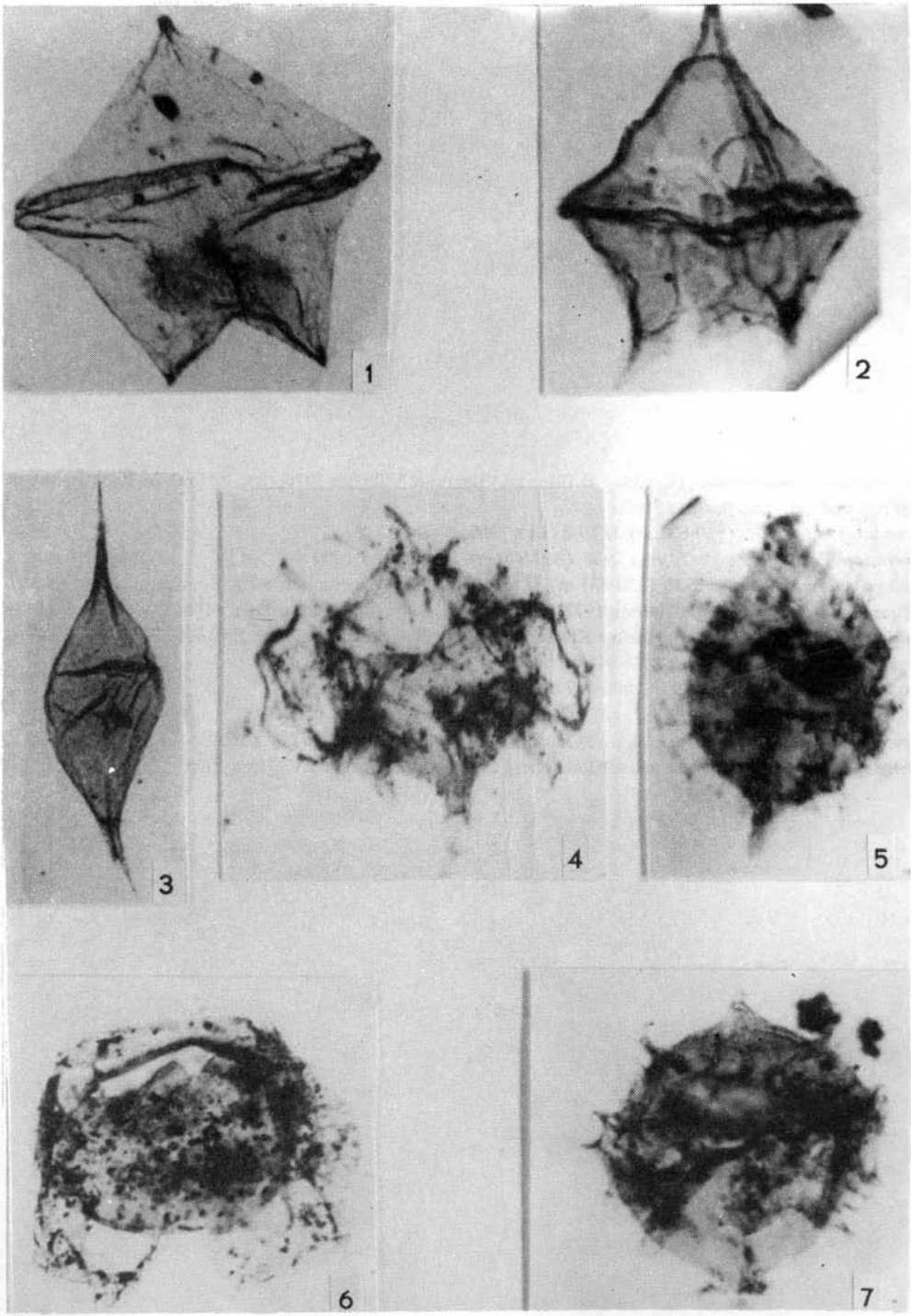
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PLATE III

1. *Alterbidinium* cf. *pentaradiata* (Cookson & Eisenack) Lentin & Williams 1976, (886-887 m), M 39/3 (3); Shows much reduced antapical horns. x 3000
2. *Verrucatosporites* sp. B., (830-831 m), U 19/2 (1). x 1800
3. *Inaperturopollenites scrabatus* Muller 1968, (869-870 m), P 19/1 (2). x 1600
4. *Areoligera coronata* Wetzel 1933, (830-831 m), L 29/2 (3); Without operculum. x 1800
5. *Hafniasphaera cryptovesiculata* Hansen 1977, (844-845 m), U 19 (3); Dorsal surface. x 1600
6. *Mauritiidites crassibaculatus* van Hoeken Klinkenberg 1964, (844-845 m), J 27/4 (1). x 1600
7. *Danea manicata* Damassa 1984, (844-845 m), E 38/1 (1). x 1600
8. *Loranthacites natalise* Salard 1978, (886-887 m), K 33 (1). x 1800
9. *Monolites* sp. B, (830-831 m), M 19/1 (3). x 1400
10. *Elatersporites klaszi* (Jardine & Magloire) Jardine 1966, (844-845 m), N 26 (1). x 1600
11. *Longapertites marginatus* van Hoeken Klinkenberg 1964, (844-845 m), Y 23/3 (1). x 1600

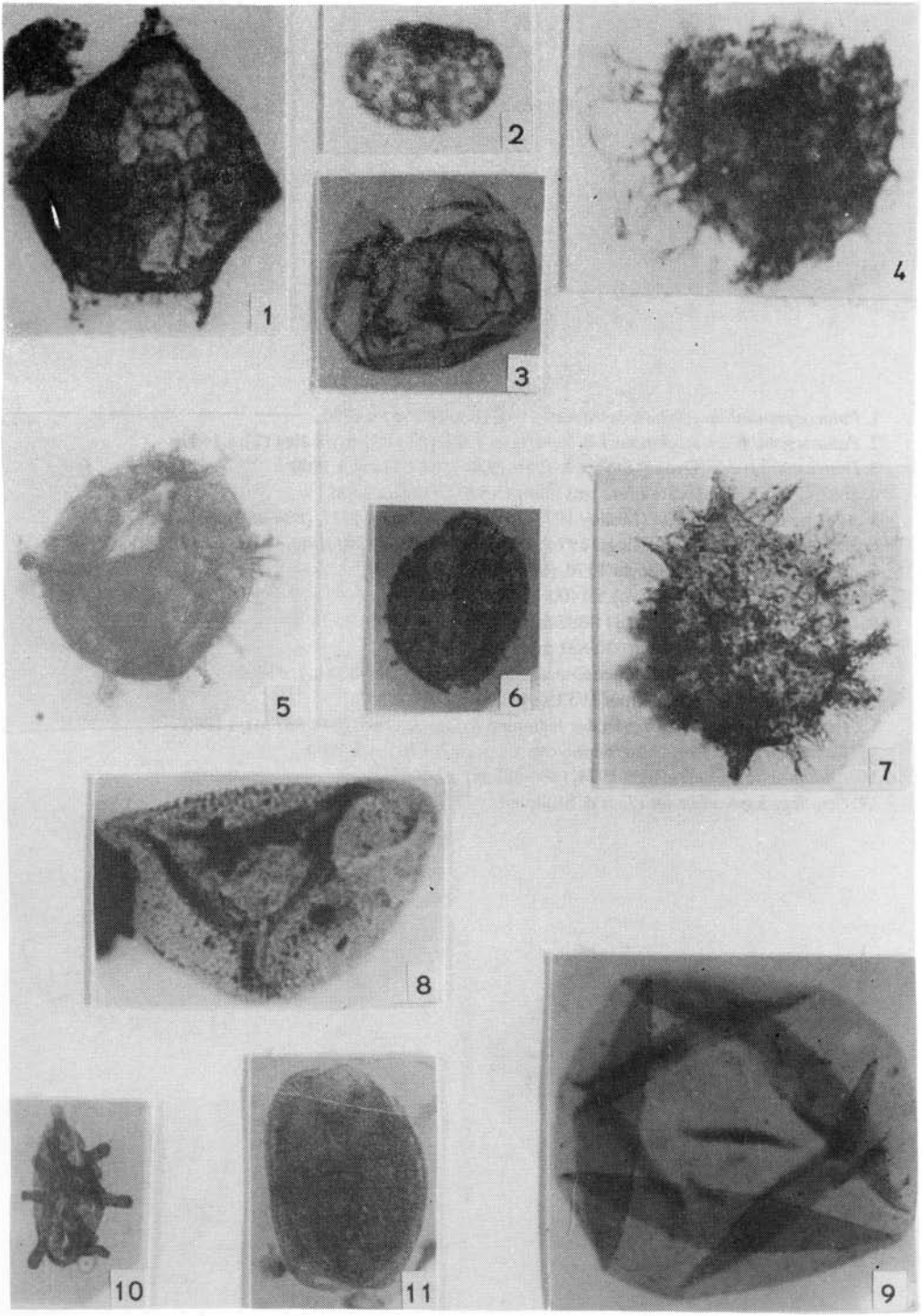
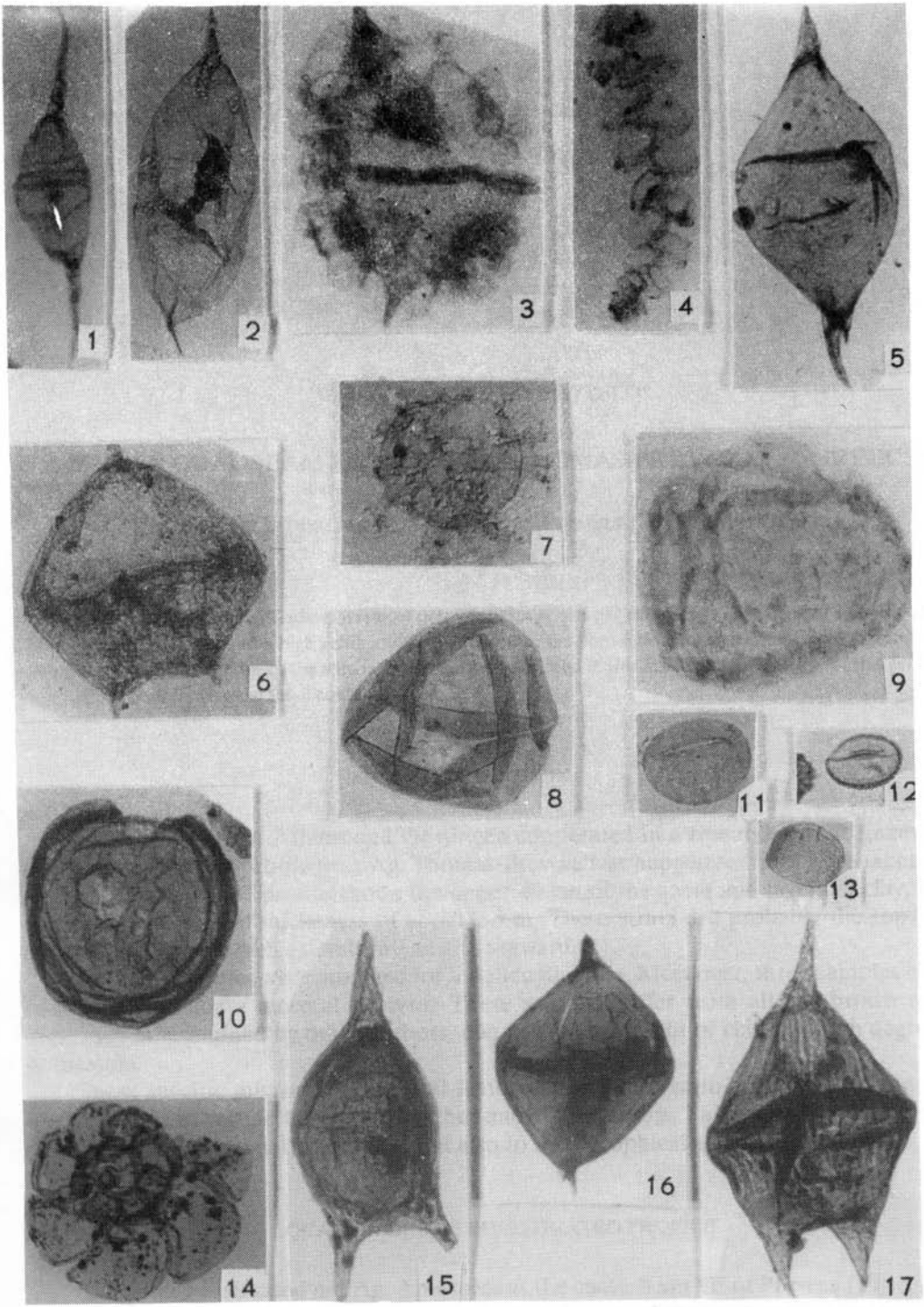


Plate III

PLATE IV

1. *Palaeocystodinium golzowense* Alberti 1961, (886-887 m). x 1800
2. *Palacocystodinium stockmansii* Boltenhagen 1977, (830-831 m), x 40/4 (2). x 1400
3. *Danea californica* (Drugg) Stover & Evitt 1978, (886-887 m). x 1800
4. and 14. Benthonic foraminfera test linings. (830-831 m). x 1800
5. *Andalusiella polymorpha* (Molloy 1972) Lentin & Williams 1977, (886-887 m). x 1800
6. *Phelodinium gaditanum* (Riegel 1974) Lentin & Williams 1981, (886-887 m). x 1800
7. *Palynodinium grallator* Gocht 1970, (869-870 m). x 1800
8. *Monolites* sp. B., (844-887 m). x 1400
9. *Inaperturopollenites* sp. A., (844-887 m). x 1400
10. *Chytroeisphaeridia* sp. C., (830-831 m). x 1800
11. *Verrucatosporites* cf. *favus pseudosecumdus* Krutzsch, (844-887 m). x 1800
12. *Liliacidites variegatus* Couper 1953, (844-887 m). x 1800
13. *Retidiporites magdalenisis* van der Hammen & Garcia 1965, (844-887 m). x 1800
15. *Ceratiopsis leptoderma* Vozzhennikova 1963, (869-870 m). x 1800
16. *Andalusiella mauthei* Rigel 1974, (886-887 m). x 3000
17. *Ceratiopsis granulostriata Jain* & Millipied 1973, (844-845 m). x 1800

Plate IV



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Acta Palaeobotanica 30/1,2