Palynostratigraphy of the Late Cretaceous Nkporo Shale outcrop in the Anambra Basin, Nigeria

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The palynostratigraphy of the Nkporo Shale outcrop exposed at 84 km point along the Enugu-Umahia Express Way indicates a Late Campanian-Early Maastrichtian age. The spore-pollen/dinocysts ratio in the assemblage is suggestive of a brackish swamp (mangrove) environment of deposition. The relative abundance and dominance of marshy pteridophytes and palm pollen suggest the prevalence of humid tropical climate during the deposition of the Nkporo Shale.

Key words—Palynostratigraphy, Nkporo Shale, Campanian, Maastrichtian, Anambra Basin, Nigeria.

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साराँश

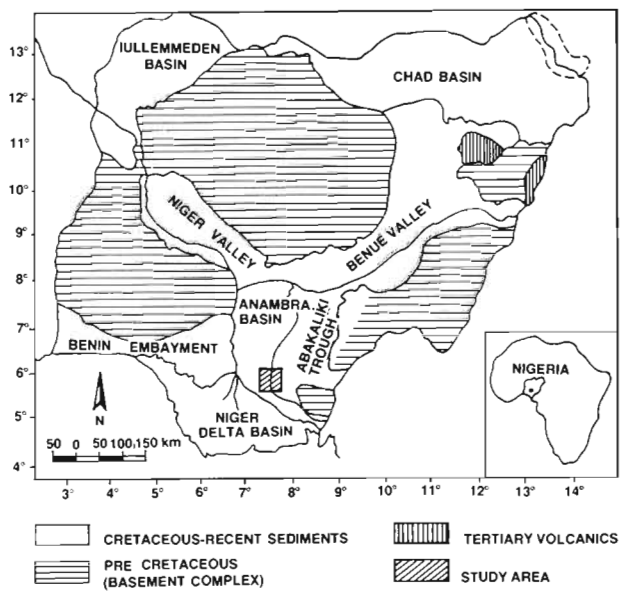
नाइजीरिया में अनाम्ब्रा द्रोणी में अनंतिम क्रीटेशी पोरो शेल दृश्यांश का परागाणुस्तरविन्यास

के०पी०एन० कुमारन एवं जेम्स जॉन ऐडिट

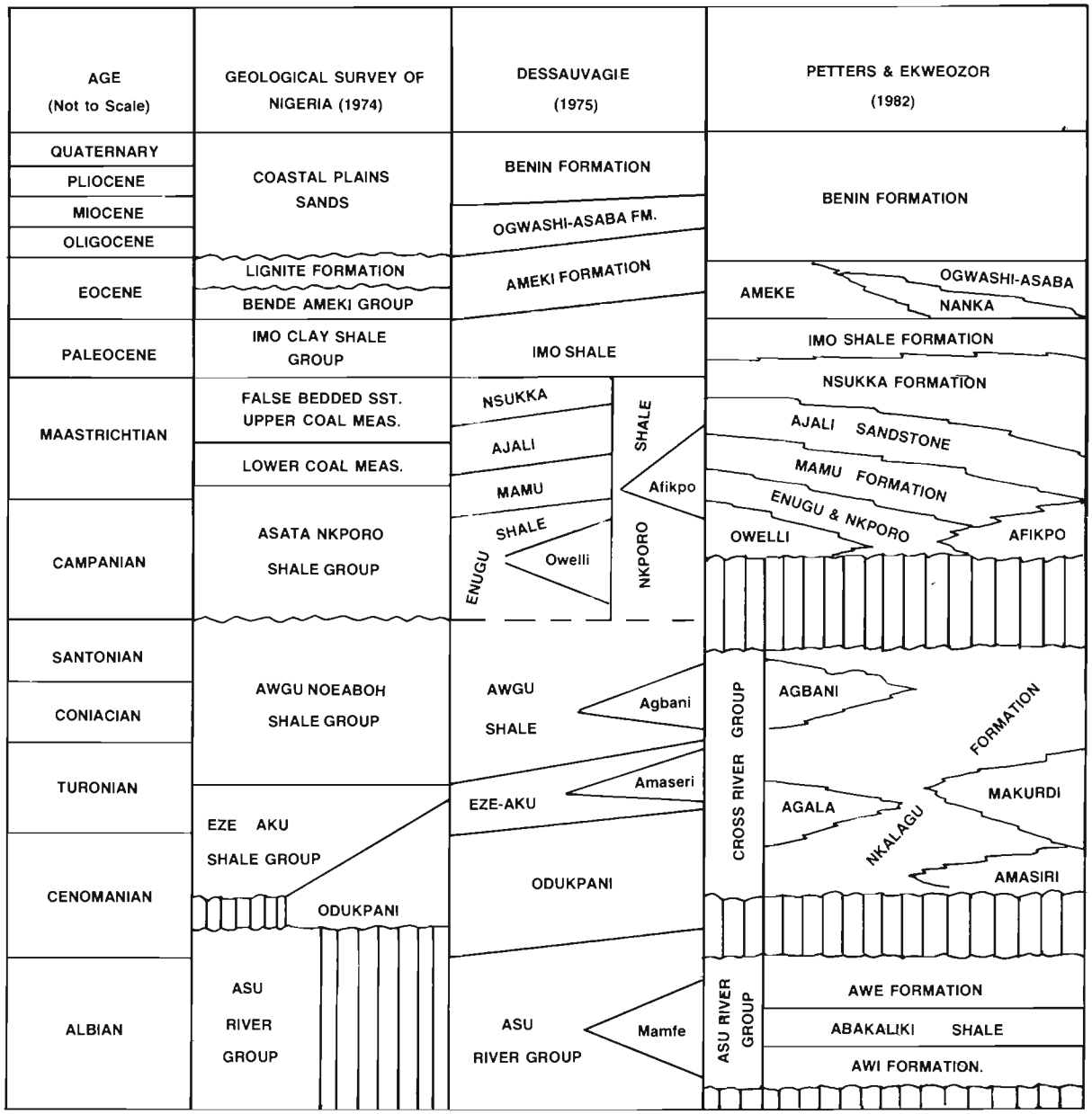
एनुगु-उमहिया एक्सप्रेस मार्ग के सग-संग 84 किलोमीटर पर अनावरित पोरो शेल दृश्यांश के परागाणविक अध्ययन से इन शेलों की अनंतिम कैम्पेनियन-प्रारम्भिक मॉस्ट्रिक्शियन आयु प्रदर्शित होती है। इन शेलो से उपलब्ध समुच्चय मे बीजाणु-परागकण/घूर्णिकशाभ पुटीयों के अनुपात से खारे जल वाले दलदली (मैंग्रोव) निक्षेपणीय वातावरण की विद्यमानता इंगित होती है। दलदली टेरीडोफ़ाइटीयो एवं ताडो के परागकणो की बाहुल्यता से पोरो शेल के निक्षेपण के समय नम उष्णकटिबन्धीय जलवायु का होना प्रस्तावित होता है।

THE Abakaliki and Anambra basins are tectonic subdivisions within the Southern Benue Trough with over 5,000 meters of Cretaceous sediments resting unconformably on the Precambrian complex (Text-figure 1). The sediments of these two basins consist of sandstones, limestones, paralic shales and coal measures. Detailed stratigraphic work has been presented by various workers (Reyment, 1964, 1965; Murat, 1972; Dessauvagie, 1975; Petters, 1982; Petters & Ekweozor, 1982; Benkhelil, 1988) for the Benue Trough. The views expressed by some of the workers regarding the stratigraphic succession in the Benue Trough are summarized and shown in Text-figure 2. In the Anambra Basin, the post-Santonian sequences, separated by unconformity from the underlying Cross River Group, are the fluvio-deltaic sandstones of Owelli, Afikpo and Ajali formations; and the paralic shales of Enugu, Nkporo formations and the Mamu and Nsukka coal measures.

The Nkporo Shale outcrop of the Anambra Basin, exposed in a section along the Enugu-Umahia Express Way at 84 km point (Text-figure 3), comprises alternating



Text-figure 1—Geological map of Nigeria showing southern Nigerian sedimentary basins (excluding Chad and Iullemmeden basins) and area of study.



Text-figure 2—Stratigraphic subdivision of southern Benue Trough (after Petters & Ekweozor, 1982).

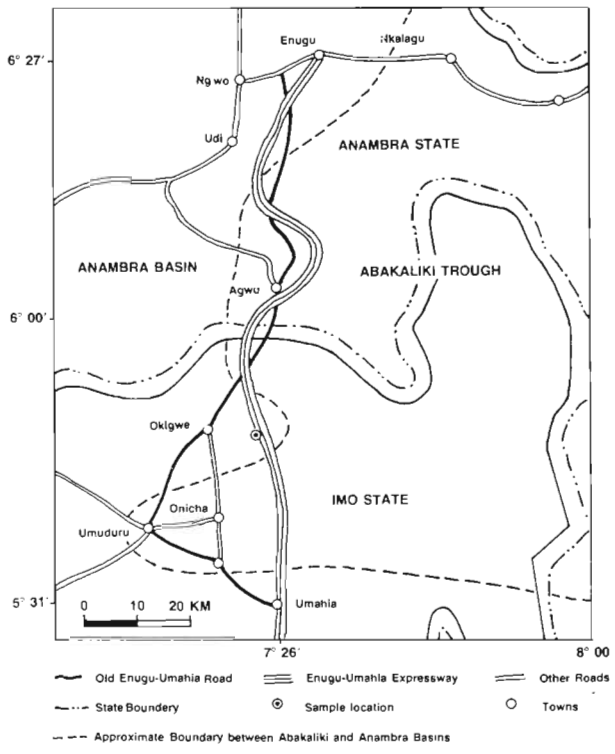
shales and sandstones. The shale samples yielded a rich assemblage of pollen and spores, dinoflagellate cysts, a few algae, and chitinous inner-tests (linings) of microforaminifera. We present here palynostratigraphy and interpret the depositional environment of the Nkporo Shale outcrop within the Anambra Basin.

LOCALITY AND LITHOSTRATIGRAPHY

Although several outcrops encountered along the Enugu-Umahia Express Way between latitudes 5°37′-6°27′ N and longitudes 7°30′-37°0′ E (Text-figure 3), only one section at 84 km point (5°47′51″ : 7°23′51″) was selected for the present communication because of its being relatively thicker (28 m) than the others (at km 1, 2 and 8), and less exposed due to the top soil cover. The basal part of about 20 m comprises highly fissile, carbonaceous, gypsiferous, black and grey shales with marl and siltstone nodules. The sequence is capped by about 8 m thik alluvium. Four samples, mostly carbonaceous shales, at an approximate interval of 4 m were collected for the present investigation. The details of the section, and sampling intervals are given in Text-figure 4.

PALYNOSTRATIGRAPHY

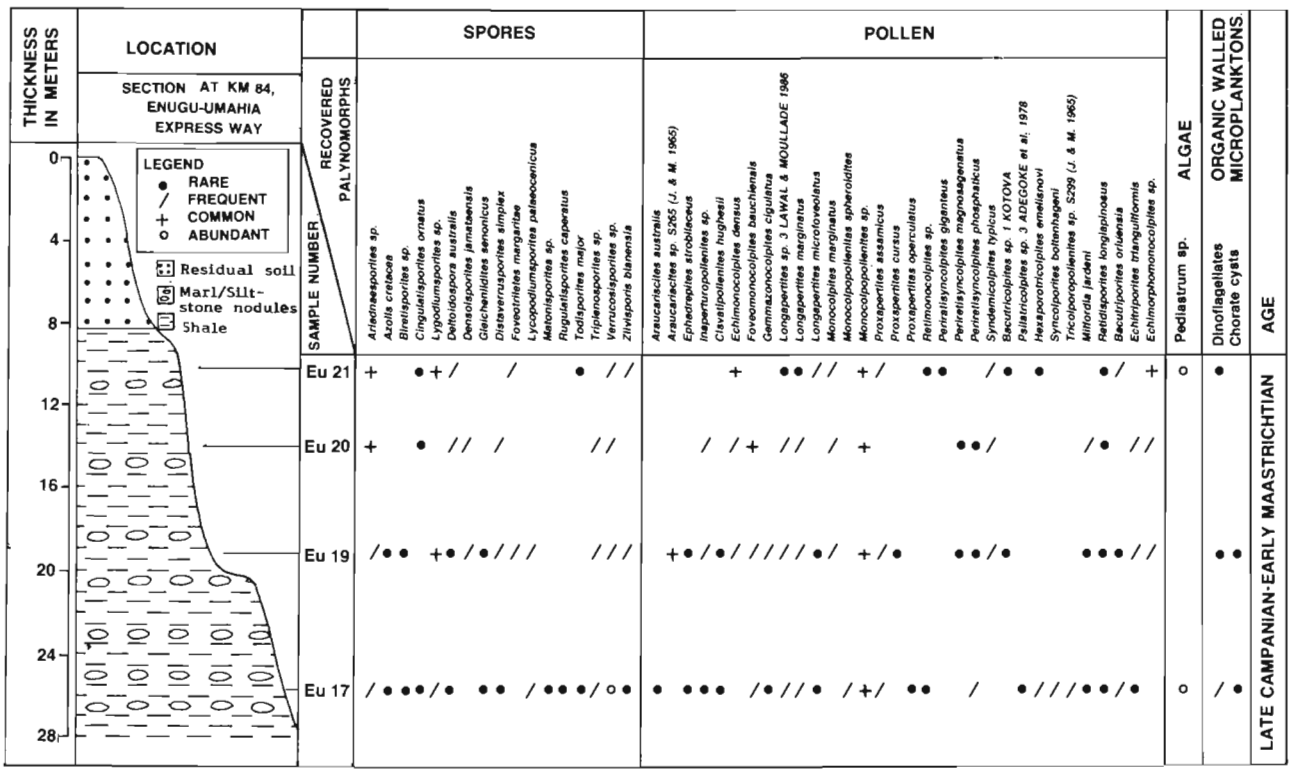
In recent years, palynology has gained increasing importance in Nigeria, especially in the oil industry



Text-figure 3—Map showing the sampling locality within Anambra Basin.

ever since its application in stratigraphy. In the Nigerian Petroleum Industry, bulk of the work, although largely unpublished (Evamy *et al.*, 1975), is concerned with Tertiary sediments of the Niger Delta. The pollen zones and subzones proposed for the Tertiary of the Niger Delta by Evamy *et al.* (1975) are actually represented by alphabetical-numerical codes (P200-P900) rather than the usual index-marker pollen species.

Recently, Rao and Kumaran (1988) reviewed the important published data on the Mesozoic and Cenozoic plant life in Nigeria documented from outcrops and bore-holes. The first palynological report on Late Cretaceous sediments of Nigeria is from the subsurface of the Anambra Basin (Van Hoeken-Klinkenberg, 1964). The subsurface samples were from the bore-holes that penetrated the uppermost Enugu Shale-Formation and the Lower and Upper Coal Measures. Other reports of Late Cretaceous palynofloras from Nigeria are mostly from other sedimentary basins (Benue Valley—Mebradu, 1982; Lawal & Moullade, 1986; Jan du Chêne *et al.*, 1978a; Benin Basin—Jan du Chêne, 1977; Jan du Chêne *et al.*, 1978b; southwestern Nigeria—Jan du Chêne, 1980; Okosun, 1990). Though there are a few palynological reports (Salami, 1985; Mbuk *et al.*, 1986) from the Anambra Basin proper, no detailed palynostratigraphic work has been done so far particularly on the outcrop sections and as such it serves to compliment the available data for biostratigraphy of this basin.



Text-figure 4—Distribution chart of palynomorphs recovered from the Nkporo Shale outcrop at 84 km point.

PALYNOFLORA OF THE NKPORO SHALE

All the four shale samples of the section were richly fossiliferous. The majority of the palynomorphs recorded from the outcrop section are angiosperm pollen (mostly of unknown botanical affinity) dominated by monocolpate genera such as *Longapertites* (Pl. 1, figs 5, 17), *Monocolpopollenites*, *Echimonocolpites* and *Retimonocolpites*. Others include *Foveomonocolpites*, *Proxapertites* and *Gemmazonocolpites*. Also significant are pollen of other groups, such as tricolpates, syncolpates, trichotomosulcates, demicolpates, hexaporotricolpates, stephanocolpates, tricolporates, syncolporates, monoporates, diporates and triporates. The gymnospermous pollen are represented by *Ephedripites*, *Monocolpites* and *Araucariacites* with pollen of uncertain gymnosperm or angiosperm affinities (Srivastava, 1975), such as *Inaperturopollenites* and *Clavatipollenites*.

The pteridophytic spores are dominated by trilete genera, such as *Lygodiumsporites*, *Gleicheniidites*, *Distaverrusporites*, *Dictyophyllidites*, *Densoisporites*, *Foveotriletes*, *Triplanosporites*, *Lycopodiumsporites*, *Verrucosisporites* and *Zlivisporis* (= *Triporoletes*). Only one monolete genus, *Verrucosisporites*, was recovered Spores of Salviniaceae (aquatic pteridophytes) were also recovered which include *Azolla* and *Ariadnaesporites*.

Green alga *Pediastrum* and the Prasinophycean (planktonic) alga—*Pterospermopsis* represent the algal contents of the palynological assemblage

Dinoflagellate cysts were also abundant in the palynological assemblages but with less diversity. Among the characteristic dinoflagellates, *Gonyaulacysta*, *Palaeocystodinium*, *Cerodinium Deflandrea* and *Spiniferites* dominate the microplankton assemblage.

Of the four samples of the section, the pollen assemblage of sample EU 17 is characterized by the occurrence of *Syncolporites boltenbageni* (Pl. 1, fig. 7), *Tricolporopollenites* sp. S-299 of Lawal and Moullade (1986), *Monocolpopollenites spheroidites* and *Periretisyncolpites phosphaticus* (Pl. 1, fig. 8). Significant spores include *Lycopodiumsporites palaeocenicus* with rare occurrence of *Zlivisporis blanensis* (Pl. 1, fig. 14). Spores of Salviniaceae (Pl. 1, fig. 18) are also rare, while algae occur abundantly. Peridinoid dinoflagellates have a greater frequency of occurrence than the chorate cysts (skolochorate).

Samples EU 19, 20 and 21 are almost similar in spore-pollen composition. The main characteristics are the frequent occurrence of *Echimonocolpites densus*, *Monocolpites marginatus* (Pl. 1, fig. 16), *Syndemicolpites typicus* (Pl. 1, fig. 10) and rare occurrences of *Periretisyncolpites magnosagenatus* (Pl. 1, fig. 12), *Echimorphomonocolpites* sp. (Pl. 1, fig. 20) is common in these samples especially in EU 21. *Foveotriletes margaritae*, *Distaverrusporites simplex* and *Densoisporites jamatensis* are the characteristic spores of the assemblages. *Ariadnaesporites* sp. is frequent to common in the samples. *Pediastrum* occurs abundantly in sample EU 21 while microplanktons are rare. The relative frequency of occurrence of palynomorphs from this outcrop section is shown in Text-figure 4.

Since most of the palynomorphs recovered from the Nkporo Shale are known and well illustrated in earlier palynological literature no separate attempt has been made to describe them individually However, selected forms along with their registration numbers are illustrated in Plate 1 The slides have been deposited in the palynological collection of the Department of Geology, University of Calabar, Nigeria

AGE OF THE NKPORO SHALE

The palynofloral assemblages recovered from four samples from different levels of the section show a close similarity in composition and therefore appear to be a single chronostratigraphic unit outcropping at 84 km point on the Enugu-Umahia Express Way The stratigraphically significant spore-pollen which dominate the assemblage are : *Cingulatisporites ornatus*, *Densoisporites jamatensis*, *Distaverrusporites simplex*, *Foveotriletes margaritae*, *Lycopodiumsporites palaeocenicus*, and *Echimonocolpites densus*, *Longapertites* sp. 3 of Lawal and Moullade (1986), *Monocolpites marginatus*, *Monocolpopollenites spheroidites*, *Periretisyncolpites phosphaticus*, *P magnosagenatus*, *Syndemicolpites typicus*, *Syncolporites boltenbageni*, *Tricolporopollenites* sp. S-299 of Jardiné and Magloire (1965), *Retidiporites magdalensis* and *Echitriporites trianguliformis*. These palynomorphs have been reported from the Campanian and Maastrichtian sediments of Nigeria, Senegal, Ivory Coast, Cameroon, Egypt and India (Jardiné & Magloire, 1965; Jan du Chêne, 1977, 1980; Jan du Chêne *et al.*, 1978c; Salard-Cheboldaeff, 1979; Baksi & Deb, 1981, Salami, 1984b, 1985; Lawal & Moullade, 1986; Schrank, 1987a, b, 1992; Schrank Perch-Nielsen, 1985; Okosun, 1990, Venkatachala *et al.*, 1993).

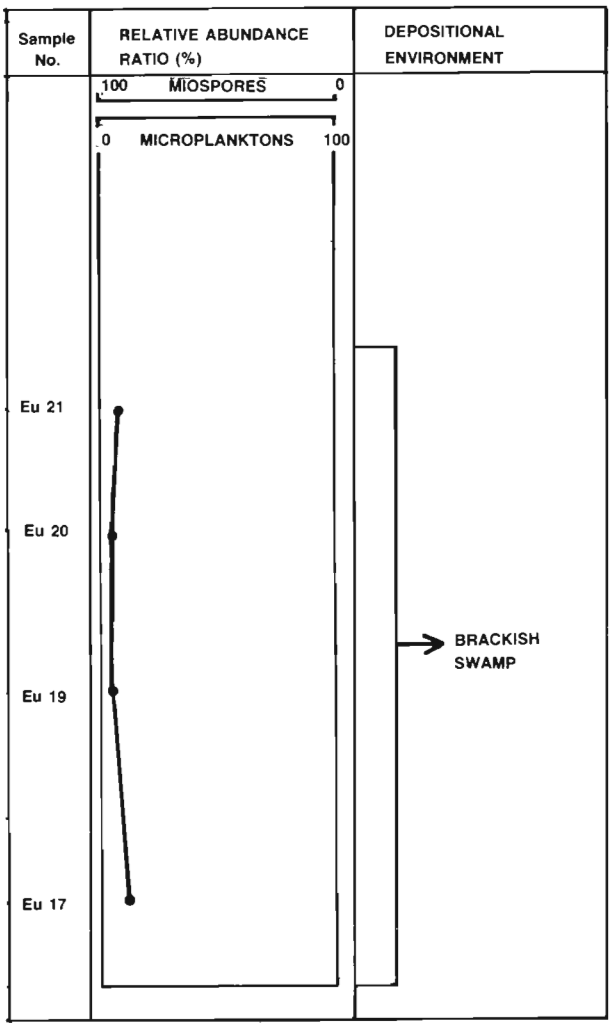
Jardiné and Magloire (1965) described a Campanian assemblage in their Sequence IV from the Senegal and the Ivory Coast basins characterized by the presence of *Syncolporites* forma B (S.Cl. 146), *Tricolpites* sp. (= S.261) and *Tricolporopollenites* sp. (= S.299). In western Nigeria, Jan du Chêne *et al* (1978c) described for the first time *Syncolporites boltenbageni* which resembles the Campanian specimens of *Syncolporites* forma B of Jardiné and Magloire (1965). *S. boltenbageni* occurs below the Maastrichtian which may indicate its appearance in the Late Campanian. In eastern Nigeria,

Lawal and Moullade (1986) described a Campanian-Early Maastrichtian assemblage as their *Longapertites* sp. 3 assemblage zone from the Upper Benue Valley *Monocolpites marginatus, Retidiporites magdalensis. Periretisyncolpites* spp. and rare specimens of *Buttinia andreeva* were considered characteristics of Early Maastrichtian, and *Syncolporites subtilis* (Pl. 1, fig. 19), *Auriculiidites reticulatus* and *Monocolpopollenites spheroidites* were considered as markers of the Campanian. Hence the assemblage from the outcrop of the Nkporo Shale studied here is assigned to a Late Campanian-Early Maastrichtian age.

DEPOSITIONAL ENVIRONMENT OF NKPORO SHALE

The palaeoecological interpretation is based on the spore-pollen composition and spore-pollen/dinocyst ratio (Text-figure 5). Based on the above criteria, a brackish swamp environment of deposition is suggested for the outcrop section of the Enugu-Umahia Express Way Although most of the palynomorphs encountered are of unknown botanical affinities, in general the assemblage has a dominance of angiospermous pollen. Pteridophytic spores and gynospermous pollen are less significant. The spores are less diverse, being mostly triletes with herbaceous mangrove fern (*Acrostichum* sp.) affinities. The more diverse pollen assemblage is dominated by monocolpates, such as *Longapertites* spp., *Monocolpopollenites* sp., and *Monocolpopollenites marginatus, Trichotomosulcites* sp., and *Proxapertites* spp. These pollen have been attributed to the mangrove palms (Adegoke *et al.*, 1978; Salami, 1984b; Frederiksen, 1985). *Echimonocolpites densus* has a close resemblance to '*Mauritia*' (*Mauritiidites* sp.) and '*Nypa*' (*Spinozonocolpites* sp.) pollen (Schrank, 1987b). This suggests a relationship of *E. densus* to core mangrove or peripheral mangrove palms.

Consistent occurrence of dinocysts in association with spore-pollen is usually indicative of brackish to marine conditions (Upshaw, 1964; Tschudy & Scott, 1969). In addition, the majority of dinoflagellate cysts



Text-figure 5—Relative abundance count and depositional environment of the Nkporo Shale outcrop.

PLATE 1 →

(All magnifications *ca* × 500)

1. *Retidiporites magdalensis* Van der Hammen & Garcia de Mutis 1965; Slide no. EU 17.22.
2. *Milfordia jardinei* Hochuli 1979. Slide no. EU 17.15.
3. *Periretisyncolpites giganteus* Kieser & Jan du Chêne 1979; Slide no. EU 21.2.
4. *Bacutriporites orluensis* Jan du Chêne *et al.* 1978; Slide no. EU 19.8.
5. *Longapertites* sp. 3 sensu Lawal and Moullade, 1986; Slide no. EU 21.4
6. *Tubistephanocolpites cylindricus* Salami 1984; Slide no. EU 17.5.
7. *Syncolporites boltenhageni* Jan du Chêne 1978; Slide no. EU 20.1.
8. *Periretisyncolpites phosphaticus* Schrank 1987; Slide no. EU 20.3.
9. *Trichotomosulcites* sp. 1 sensu Lawal & Moullade, 1986.
10. *Syndemicolpites typicus*, V.H.K. 1964; Slide no. EU 19.6.
11. *Echitricolpites* sp., Slide no. EU 17.5.
12. *Periretisyncolpites magnosagenatus* (V.H.K.) Kieser & Jan du Chêne 1979; Slide no. EU 20.2.
13. *Ephedrepites strobilaceus* (Kuyl *et al.*) Salami 1984; Slide no. EU 19.5.
14. *Zlivisporis blanensis* Pacltova 1961; Slide no. EU 19.9.
15. *Echitriporites trianguliformis* V.H.K 1964; Slide no. EU 17.7
16. *Monocolpites marginatus* Van der Hammen 1954; Slide no. EU 19.6.
17. *Longapertites marginatus* V.H.K. 1964; Slide no. EU 17.9.
18. *Ariadnaesporites spinosus* (Elsik) Hills 1967; Slide no. EU 19.1.
19. *Syncolporites subtilis* Boltenhagen 1976; Slide no. EU 17.3.
20. *Echimorphomonocolpites* sp., Slide no. EU 21.5.

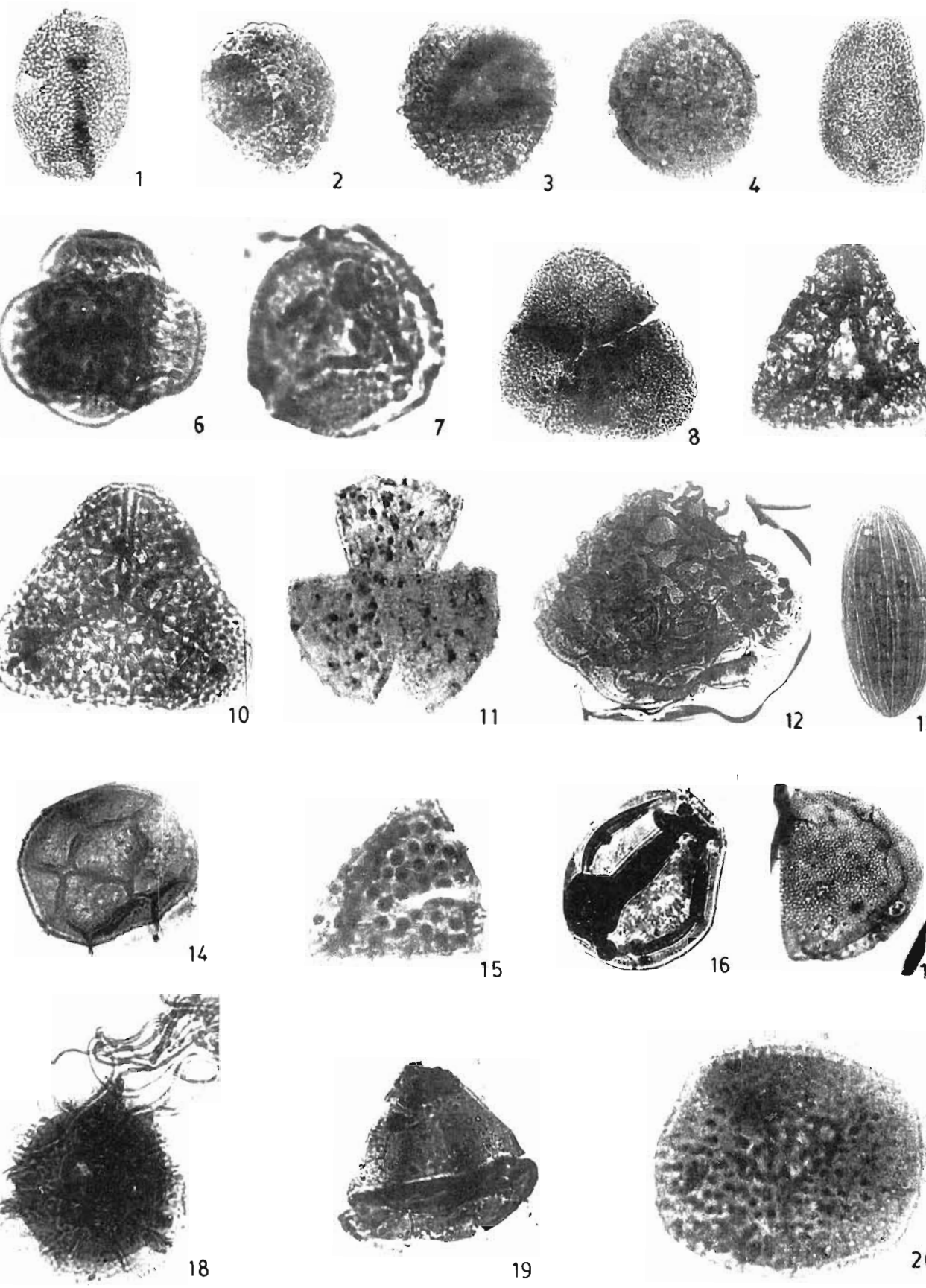


PLATE 1

recovered possess short apical processes which are considered (Mebradu, 1982) to be characteristic of dinoflagellate cysts in the brackish-swamp environment.

The presence of aquatic ferns *Azolla cretacea* and *Ariadnaesporites* spp. (*A nigeriensis* and *A longiprocessum*) of Salviniaceae in association with green alga *Pediastrum* in the Nkporo Shale indicates a freshwater source and they were probably transported to the brackish swamp environment through channels at the time of deposition. Recent forms of these plants inhabit fresh water lakes, ponds and rivers. Such an environment is further supported by the presence of grey shales with abundance of rootlets, cuticles and other organic fragments (Griggs, 1966; Mebradu, 1982).

Among 50 palynomorphs (excluding dinoflagellates and acritarchs) recorded from the Nkporo Shale outcrop, the majority of them belong to the mangrove palms and fern taxa, which have been previously reported from the Late Cretaceous to Early Tertiary sediments of the tropical-subtropical regions in West Africa, northern South America and the Indian subcontinent (Germeraad *et al.*, 1968; Frederiksen, 1985; Schrank, 1987b; Baksi & Deb, 1981). Thus, it has been concluded that Nkporo Shale was deposited in a mangrove swamp under the prevailing humid tropical climate with terrestrial and freshwater sources.

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REFERENCES

Adegoke OS, Jan du Chêne RE, Agumanu AE & Ajayi PO 1978. Palynology and age of the Kerri-Kerri Formation, Nigeria. *Rev. Esp. Micropal.* **10**(2) : 267-283.

Baksi SK & Deb U 1981. Palynology of the Upper Cretaceous of the Bengal Basin, India. Rev. *Palaeobot. Palynol* **31**(3/4) : 335-365.

Benkhelil J 1988. Structure et evolution geodynamique du Bassin Intracontinental de la Benoue (Nigeria). *Bull. Centres Rech. Explor. Prod. Elf-Aquitaine* **12**(1) : 29-128.

Dessauvagie TFJ 1975. Explanatory note to the geological map of Nigeria. *J. Min. Geol.* **9**(1-2) : 3-28.

Evamy BD, Haremboure J, Kamerling P, Knapp AW Malloy FA & Rowlands PH 1975. Hydrocarbon habitat of Tertiary Niger Delta. *Amer Assoc. Petrol. geol. Bull.* **62**(1) : 1-39.

Frederiksen NO 1985. Review of Early Tertiary sporomorph palaeoecology. *Amer Assoc Stratigr. Palynol. Contr.* ser. **15** : 1-92.

Germeraad JH, Hopping CA & Muller J 1968. Palynology of Tertiary sediments from tropical areas. *Rev. Palaeobot. Palynol.* **6** : 189-349.

Griggs PH 1966. Palynological interpretation of the type section, Chucknut Formation, northwestern Washington. *In* : Kosanke RM & Cross AT (Editors)—*Symposium on Palynology of the Late Cretaceous and Early Tertiary. Geol. Soc. Amer. Spec. paper* **127** 169-212.

Hall JW 1974. Cretaceous Salviniaceae. *Annals Mo. bot. Gdn* **61**(2) : 354-367

Jan du Chêne RE 1977 Some new pollen species of the Upper-Maastrichtian Tar Sand, Abeokuta Formation, southern Nigeria. *Rev. Esp. Micropal.* **9**(2) : 191-201

Jan du Chêne RE 1980. Palynological study of the Tar Sands, Upper Maastrichtian of the south-west Nigeria. *Proc IV Int. palynol. Conf., Lucknow (1976-77)* **2** : 794-799. Birbal Sahni Institute of Palaeobotany, Lucknow.

Jan du Chêne RE, Adegoke OS, Adediran SA & Petters SW 1978a. Palynology and foraminifera of the Lokoja Sandstone (Maastrichtian), Bida Basin, Nigeria. *Rev Esp. Micropal.* **10**(3) : 379-393.

Jan du Chêne RE, De Klasz I & Archibong EE 1978b. Biostratigraphic study of the bore-hole Ojo-1, S.W. Nigeria, with special emphasis on the Cretaceous microflora. *Rev Micropal.* **21**(3) 123-139.

Jan du Chêne RE, Onyike MS & Sowunmi MA 1978c. Some new Eocene pollen of the Ogwashi-Asaba Formation, southeastern Nigeria. *Rev. Esp. Micropal.* **10**(2) : 285-322.

Jardiné S & Magloire L 1965. Palynologie et stratigraphie du Cretace des Bassins du Senegal et de Cote d'Ivoire. *Mem. Bur. Recb. geol. Min.* **32** : 187-245.

Lawal O & Moullade M 1986. Palynological biostratigraphy of Cretaceous sediments in the Upper Benue Basin, N.E. Nigeria. *Rev. Micropal.* **29**(1) : 61-83.

Mbuk IN, Rao VR & Kumaran KPN 1985. The Upper Cretaceous-Palaeocene boundary in the Ohafia Ozu-Abam area, Imo State, Nigeria. *Nigerian J. Min. Geol.* **22** : 105-113.

Mebradu S 1982. Stratigraphic palynology of Obi (Lafia), Plateau State of Nigeria. *Rev. Palaeobot. Palynol.* **36**(3/4) : 317-323.

Murat RC 1972. Stratigraphy and palaeogeography of the Cretaceous and Lower Tertiary in southern Nigeria. *In* Dessauvagie TFJ & Whiteman AJ (Editors)—*African Geology, Univ. Ibadan, Nigeria* : 251-266.

Okosun EA 1990. A review of the Cretaceous stratigraphy of the Dahomey Embayment, West Africa. *Cretaceous Res.* **11**(1) : 17-27.

Petters SW 1982. Central West African Cretaceous-Tertiary benthic foraminifera and stratigraphy. *Palaeontographica* **179** : 1-104.

Petters SW & Ekweozor CM 1982. Petroleum geology of Benue Trough and southeastern Chad Basin, Nigeria. *Amer. Assoc. Petrol. Geol.* **66** : 1141-1149.

Rao VR & Kumaran KPN 1988. A short survey of palaeobotanical studies (Cretaceous and Tertiary) in Nigeria. *Rev. Palaeobot. Palynol.* **54** : 151-158.

Reyment RA 1964. Review of Nigerian Cretaceous-Cenozoic stratigraphy. *J. Min. Geol.* **2**(2) : 61-80.

Reyment RA 1965. *Aspect of the geology of Nigeria.* Ibadan Univ. Press, Ibadan, Nigeria.

Salami MB 1984a. Three new sporomorph form genera from the Late Cretaceous and Palaeogene of southwestern Nigeria. *Grana* **23** : 163-166.

Salami MB 1984b. Late Cretaceous and Early Tertiary palynofacies of southern Nigeria. *Rev. Esp. Micropal.* **16** : 415-423.

Salami MB 1985. Upper Senonian and Lower Tertiary pollen grains from the southern Nigeria sedimentary basin. *Rev. Esp. Micropal.* **17**(1) : 5-26.

Salard-Cheboldaeff M 1979. Palynologie Maastrichtienne et Tertiaire du Cameroun-Etude qualitative et repartition Verticale des principales especes. *Rev. Palaeobot. Palynol.* **28**(3/4) : 365-387

Schrank E 1987a. Biostratigraphic importance of microfloras from the Late Cretaceous clastic series of northwestern Sudan. *Cretaceous Res.* **8** : 29-42.

Schrank E 1987b. Palaeozoic and Mesozoic palynomorphs from Northeast Africa (Egypt and Sudan) with special reference to Late Cretaceous pollen and dinoflagellates. *Berliner Geowiss. Abh.* **75.1** : 249-310.

Schrank E 1992. Nonmarine Cretaceous correlations in Egypt and northern Sudan palynological and palaeobotanical evidence. *Cretaceous Res.* **13** : 351-368.

Schrank E & Perch-Nielsen K 1985. Late Cretaceous palynostratigraphy in Egypt with comments on Maastrichtian and Early Tertiary calcareous nannofossils. *Newsletter Stratigr* **15**(2) : 81-99.

Srivastava SK 1975. Miospores from the Fredericksburg Group (Albian) of the Southern United States. *Palaeobiol Continentale* **6**(2) : 1-119.

Tschudy RH & Scott RA 1969. *Aspects of palynology*. John Wiley & Sons, Inc., U.S.A.

Upshaw CF 1964. Palynological zonation of the Upper Cretaceous Frontier Formation near Dubois, Wyoming. *In* : Cross AT (Editor)—*Palynology in oil exploration. Soc Econ. Palaeont. Miner Spec. Pub* **11** : 1-200.

Van Hoeken-Klinkenberg PMJ 1964. A palynological investigation of some Upper Cretaceous sediments in Nigeria. *Pollen Spores* **6**(1) : 209-231.

Venkatachala BS, Kar RK & Rajanikanth A 1993. Comparative palynological studies of African and Indian Upper Cretaceous-Palaeocene sediments. *Annual Report 1991-92* : 39-40. Birbal Sahni Institute of Palaeobotany, Lucknow.