

Palynology of the Cretaceous-Tertiary transition in an Atlantic bore-core, off Senegal Coast, West Africa

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Palynological investigations on the Cretaceous-Tertiary transition in the bore-hole no. CM 5 drilled in the Atlantic Ocean, off Senegal Coast, West Africa have been carried out. According to the stratigraphic data the top of the Maestrichtian is marked approximately at 952 m. The present study is aimed to detail out palynological data and correlate with stratigraphic information. Samples of the sediments between 1002-944 m levels have been investigated in detail. It is observed that palynological assemblage recovered from sediments at 1002-958 m show an almost uniform distribution of taxa. Significant Maestrichtian marker taxa namely *Diporoconia iszkazentgyoergyi*, *Ariadnaesporites ariadnae*, *Gabonsporites vigourouxii*, *Periretisyncolpites magnosagenatus*, *Tercissus grandis*, *Longapertites marginatus* etc., are recorded. These marker taxa disappear at 958 m level and an abundance of pteridophytic spores is noticed. Thus a major change in floral composition is recorded at this level marking K/T transition, which is characterised by the disappearance of Maestrichtian marker taxa and presence of a fern-spike. Such major floral change is attributed to possible influence of K/T events.

Key-words—Palynology, Cretaceous-Tertiary Transition, Atlantic Ocean, West Africa.

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सारांश

पश्चिमी अफ्रीका के सेनेगल समुद्र तट के निकट अटलान्टिक के आन्तरिक छिद्र में क्रिटेसियस-टर्शियरी संक्रमण की परागाणविकी

बंगलूर श्रीनिवास वेंकटचाला, रंजीत कुमार कर, अन्नमराजु रजनीकांथ तथा ए. लाई

पश्चिमी अफ्रीका के सेनेगल समुद्रतट के आन्तरिक छिद्र संख्या सी.एम. 5 में क्रिटेसियस-टर्शियरी संक्रमण का परागाणविक अध्ययन किया गया। स्तरिकीय आँकड़ों के अनुसार मास्ट्रिख्ट का शिखर लगभग 952 मीटर पर अंकित है। वर्तमान शोध का उद्देश्य परागाणविक आँकड़ों को विस्तृत करना तथा स्तरिकीय सूचनाओं से अन्तर्सम्बन्धित करना है। 1002-944 मीटर स्तर पर प्राप्त अवसादों के प्रादुर्भावों को विस्तृत रूप से विश्लेषित किया गया और यह पाया गया कि 1002-958 मीटर पर प्राप्त अवसादों के परागाणविक समुच्चय में वर्गकों का एक समान वितरण है। कुछ महत्वपूर्ण वर्गक अंकित किए गए, जिनके नाम डिपोरोकोनिया इज़कैन्टग्योएर्गी, एरियडनैस्योराइटिस एरियाडनी, गैबोनीस्योराइटिस विगारॉक्सार्ई, पेरिरेटिसिनकोलपाइटिस मेग्नोसैजिनेटस, टर्सिसस ग्रैण्डिस, लांगएपरटाइटिस मार्जिनेटस आदि हैं। ये अंकित वर्गक 958 मीटर स्तर पर विलुप्त हो जाते हैं तथा इनमें टेरिडोफाइटिक बीजाणुओं की प्रचुरता अंकित की गई है। अतः इस स्तर पर वनस्पतिजात के विन्यास में एक बड़ा परिवर्तन अंकित किया है, जो इस स्तर पर के/टी संक्रमण को परिलक्षित करता है, जिसे मास्ट्रिख्ट अंकित वर्गकों के विलुप्त होने तथा पर्णांग की अभिवृद्धि (स्पाइक) से अभिलक्षणित किया जा सकता है। ये वनस्पतिजात सम्बन्धी बड़े परिवर्तन सम्भावित के/टी घटनाओं के प्रभाव से सम्भव हुए हैं।

THE Cretaceous-Tertiary boundary is one of the most controversial topics of the geological sciences today. Many hypotheses have been put forward to explain the total extinction of some of the animals. Dinosaurs, that ruled the earth almost for the entire Mesozoic Era, disappeared by the end of Maestrichtian. The K/T extinction of calcareous nannoplankton in the marine realm too was called a "biotic crisis" (Percival & Fisher, 1977). While working on the K/T calcareous

microplankton and related isotope stratigraphy, Perch-Nielson, McKenzie and He (1982) recognised catastrophic event". Alvarez *et al.* (1980) suggested collision of an extraterrestrial body with the earth resulting in large scale extinction of animals. The shocked quartz found in many parts of the world (including India) is regarded as the signature of this impact. It is also suggested that the Deccan volcanic activity at the K/T boundary released toxic gases such as CO₂,

NO₂ and SO₂ and affected profound changes in the biotic realm (Sahni *et al.*, 1996).

Land plants were no exception to the K/T events. Evidences throughout the world indicate significant changes. It was shown that a discontinuity marked in composition of palynological assemblages at the K/T boundary in Gabon and Cameroun, West Africa (Boltenhagen & Salard, 1980). This was attributed to the cooling at the advent of Palaeocene. Nichols (1990) remarked that marked variations in palynoassemblages from New Mexico to Alberta at K/T boundary were due to disappearance/appearance of forms. Tschudy (1971) observed an impoverished palynological records from the Rocky Mountains and Mississippi regions. Tschudy and Tschudy (1986) observed an abrupt disappearance of *Proteacidites* and *Aquilapollenites* in the Western Interior basin at the K/T boundary. In the southern part *Tilia woodhousii* and *Trisectoris* along with *Proteacidites* were not found beyond Maestrichtian though some other species cross the K/T boundary. Boulter *et al.* (1988) illustrated four types of changes in pollen assemblages at the K/T boundary observed by Tschudy and Tschudy (1986). In the first type abrupt regional disappearance is marked. In the second type evolution of new types is noticed and in the third, extension of flora beyond the K/T boundary is observed only to disappear later. In the last type there is hardly any change at the K/T boundary, almost all the species continue in the Palaeocene. Dorf (1942) found a more

diversified fossil leaf flora in the Upper Cretaceous than in the Palaeocene in North America. Widespread paucity of flora corroborates the change in the climate at the advent of Palaeocene.

The Senegal Basin was known for its geological and palynological contribution. The surface and sub-surface geology of Senegal and Atlantic Ocean adjacent to it was worked out by Castelain (1964), Splengler *et al.* (1966), Templeton (1971), Sarr (1982), Mitchaud (1984), Ly (1985), Pritan (1986) and others. Palynological investigations were carried out by Jardine and Magloire (1965), Kieser (1967), Medus *et al.* (1988), Babinot *et al.* (1988), Caratini *et al.* (1991) and others. Jain and Milleped (1975) worked out systematics and biostratigraphy of phytoplankton ranging in age from Aptian to Maestrichtian in a number of bore core samples off Senegal Coast.

The present investigations are aimed to know the pollen behaviour at the K/T boundary in the samples of the bore hole core no. CM 5. The core was drilled in Atlantic Ocean about 61 km west of Senegal Coast (Text-figure 1) and is situated in the Senegal Basin. The samples were studied at 10 m interval approximately and are of Campanian (1550-1300 m), Maestrichtian (1300-952 m), Palaeocene (930-750 m), Eocene (750-450 m), Oligocene (450-380 m) and Miocene (380-90 m) age. The present report is, however, confined only to the K/T transition. The samples belonging to Upper Maestrichtian are grey-green clay, sandy with layers of sandy clay and occasionally calcareous and glauconitic. The

PLATE 1

(All photographs ca. x 500)

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|----------------|--|--|
| 1. | <i>Triporoletes</i> sp., Slide no. BSIP 11490 W 26/1. | 44/3. |
| 2. | <i>Todisporites minor</i> , Slide no. BSIP 11491 W43/3. | 9, 11, 16, 20. |
| 3. | <i>Proxapertites operculatus</i> , Slide no. BSIP 11493 V/26/4. | <i>Tercissus grandis</i> , Slide no. BSIP 11493 T 18/1 Slide no. BSIP 11491 F28/4; Slide no. BSIP 11490 E 19/3; Slide no. BSIP 11493 N 31/2. |
| 4, 15, 17, 18. | <i>Ariadnaesporites ariadnae</i> , Slide no. BSIP 11492 U 37/1; Slide no. BSIP 1492 T 25/4; Slide no. BSIP 11493 M23; Slide no. BSIP 11493 Q 33/3. | 10. <i>Bacutriporites orluensis</i> , Slide no. BSIP 11492 O 5/2. |
| 5. | <i>Matanomadbiasulcites maximus</i> , Slide no. BSIP 11490 H 29. | 12. <i>Cyathidites</i> sp., Slide no. BSIP 11490 O 13/1. |
| 6. | <i>Cyathidites minor</i> , Slide no. BSIP 11494 S 24. | 13. <i>Diporoconia</i> sp., Slide no. BSIP 11493 V 37/3. |
| 7. | <i>Dandotiaspora plicata</i> , Slide no. BSIP 11493 U 30. | 14, 22. <i>Phragmothyrites eocenicus</i> , Slide no. BSIP 11493 G 36; Slide no. 11492 G 30/1. |
| 8. | <i>Diporoconia iszkaszentyvoergyi</i> , Slide no. BSIP 11493 U | 19, 21. <i>Gabonisorites vigourouxii</i> , Slide no. BSIP 11493 T 28; Slide no. 11490 E 16/4. |

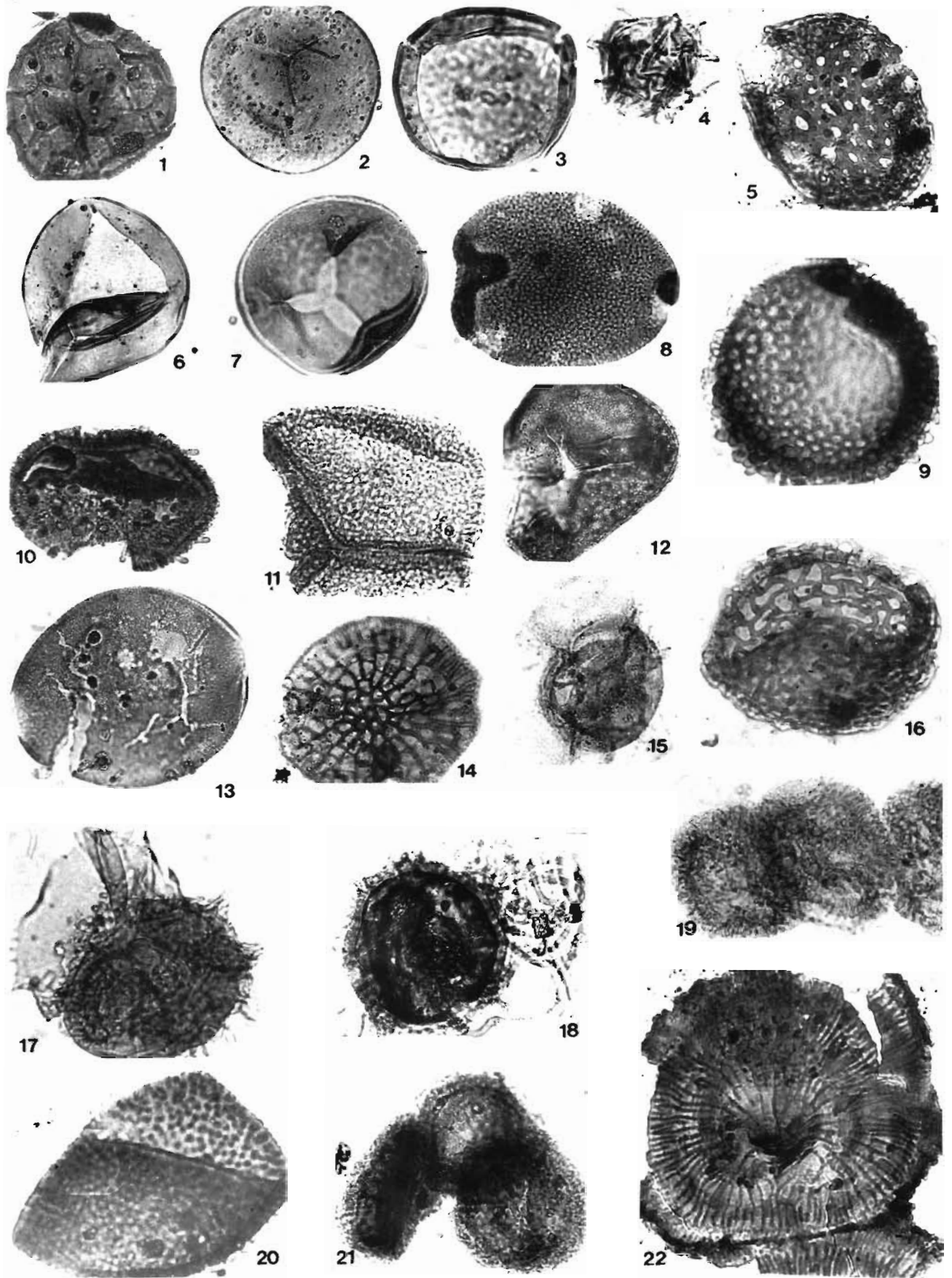


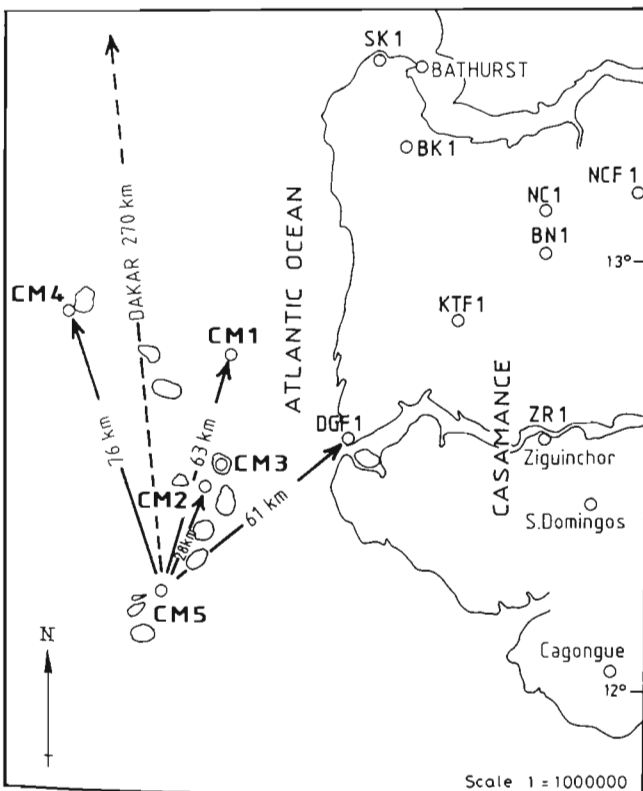
PLATE 1

samples at the basal part of Palaeocene are fine limestone and black marl. The samples were treated with HCl, HF and HNO₃ followed by a treatment of 5% KOH. The slides were prepared in Polyvinyle alcohol and mounted in Canada balsam. The slides are preserved at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow.

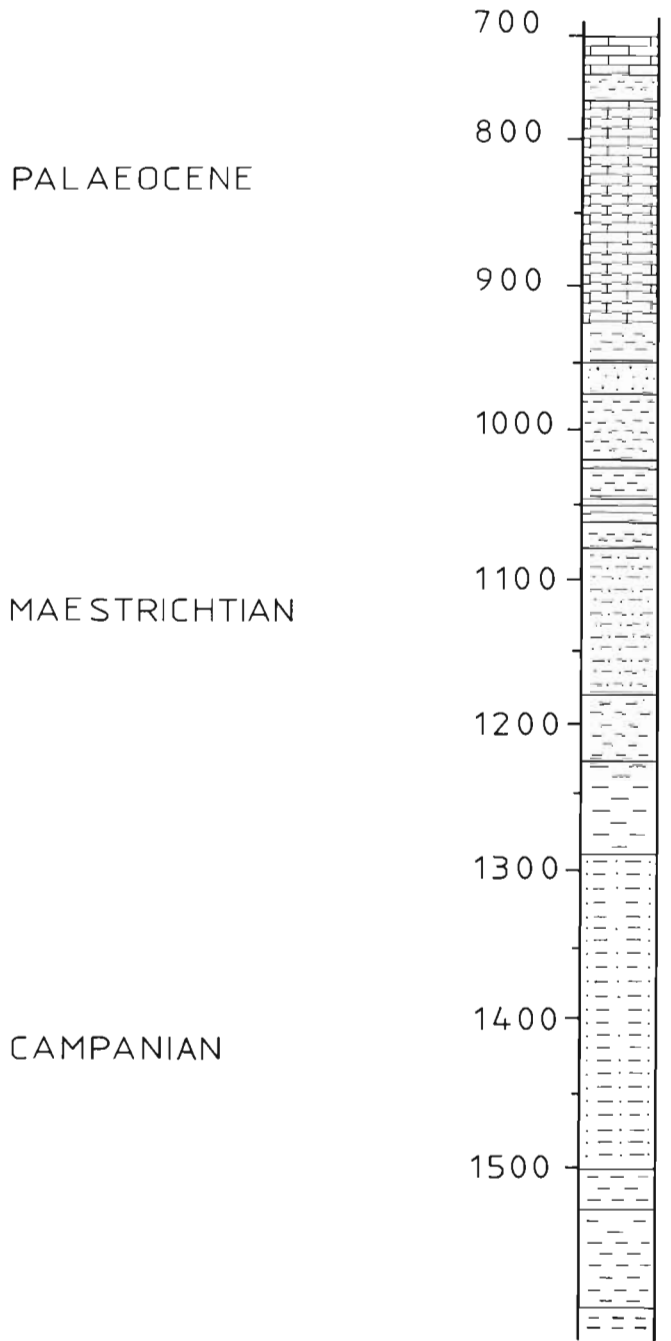
The top most Maestrichtian was marked approximately at 952 m and the Early Palaeocene at 930 m in the bore hole core. The depth between 950-935 m was kept uncertain between Maestrichtian to Palaeocene. The nature of the sediments between 1000-935 m is more or less same and consists of fine limestone and black marl (Text-figure 2).

Samples at the depth of 992 m, 982 m, 968 m, 958 m, 950 m and 944 m were studied critically to demarcate K/T transition through palynological investigations. Samples between 992-968 m yielded

Bacutriporites orluensis, *Echitriporites triangularis*, *Longapertites marginatus*, *Proxapertites cursus*, *Proxapertites operculatus*, *Matanomadhiasulcites maximus*, *Spinizonocolpites echinatus*, *Diporoconia*



Text-figure 1—Locality of the bore hole core no. CM 5.

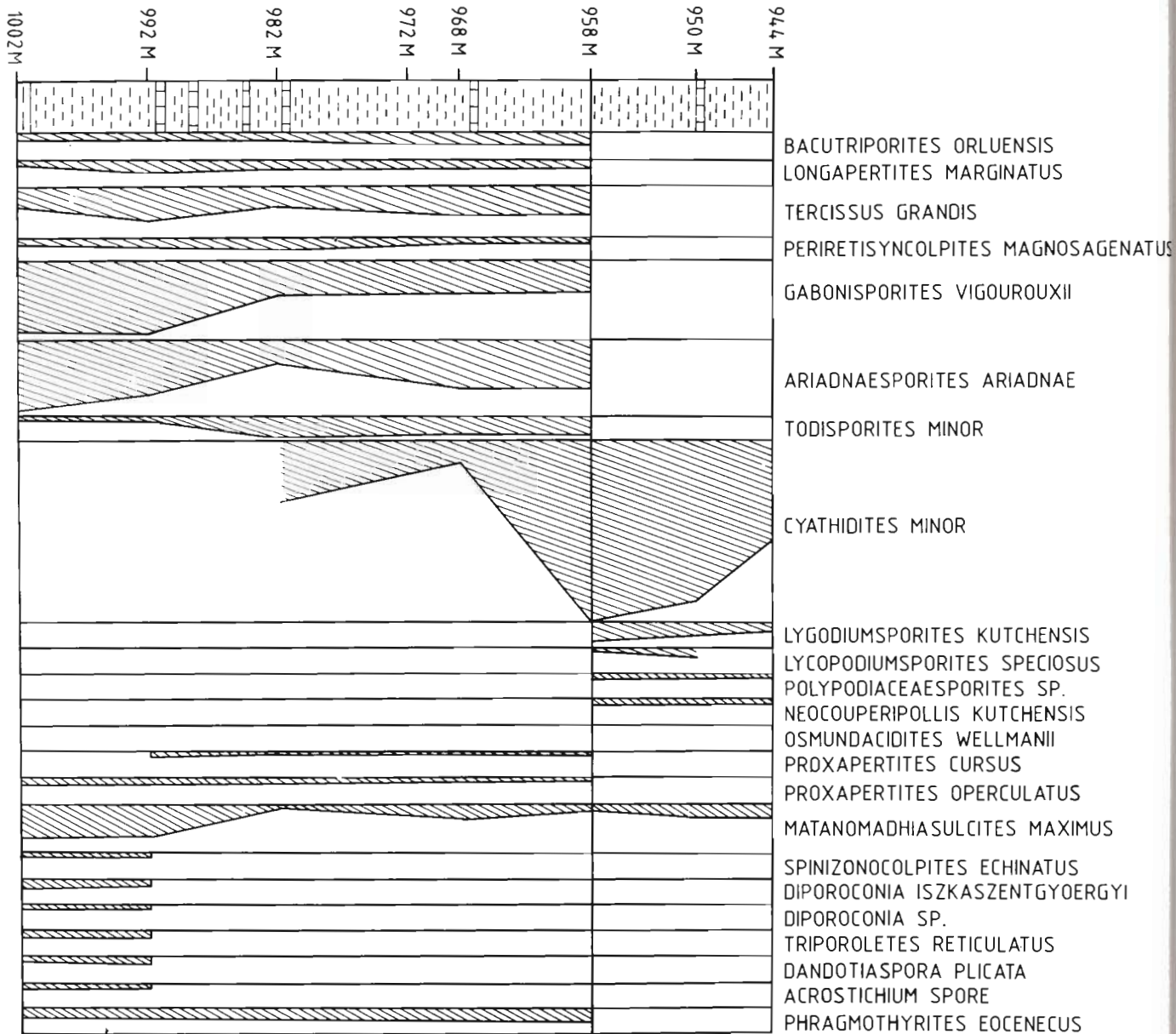


Text-figure 2—Litholog of the bore hole core no. CM 5.

iskaszentgyoergyi, *Diporoconia* sp., *Tercissus grandis*, *Periretisyncolpites magnosagenatus*, *Azolla cretacea*, *Gabonisorites vigourouxii*, *Ariadnaesporites ariadnae*, *Triporoletes reticulatus*, *Todisporites major*, *Cyathidites minor*, *Osmundacidites wellmanii*, *Dandotiaspora plicata*, *Phragmothyrites eocenicus* and spores of *Achrostichumsporites* (Pl. 1).

Of all these species *Ariadnaesporites ariadnae* is the most common particularly at the lower level samples. Other common species include *Tercissus grandis*, *Matanomadhiasulcites maximus*, *Periretisyncolpites magnosagenatus*, *Gabonisorites vigourouxii*, *Diporoconia iszkaszentgyoergyi*, *Bacutriporites orluensis* and *Longapertites marginatus* (Text-figure 3).

Jardine and Magloire (1965) recorded



DISTRIBUTION OF STRATIGRAPHICALLY IMPORTANT TAXA IN
CRETACEOUS - TERTIARY TRANSITION IN CM 5, SENEGAL

Text-figure 3—Distribution of stratigraphically important taxa in the Cretaceous-Tertiary transition in CM 5.

Aquilapollenites from the Late Maestrichtian of Senegal. They also observed the presence of *Proteacidites* in Senonian and Maestrichtian in the same region. Besides, Stover (1963) noted the occurrence of *Pembixipollenites* in the Middle Cretaceous of Senegal and Ivory coast. All these genera are, however, not recorded in the present assemblage.

At the depth of 958 m, a profound change is observed in the palynological assemblage. Common elements like *Ariadnaesporites ariadnae*, *Bacutripurites orluensis*, *Longapertites marginatus*, *Tercissus grandis*, *Gabonisorites vigourouxii* and *Periretisyncolpites magnosagenatus* are not recorded.

Matanomadhiasulcites maximus, *Azolla cretacea*, *Proxapertites operculatus* and *Proxapertites cursus* are rarely met with. The assemblage is dominated by pteridophytic spores represented mostly by *Cyathidites minor*, *Todisporites major* and *Lygodiumsporites lakiensis*. Other pteridophytic spores occasionally found are *Lycopodiumsporites speciosus*, *Pteridacidites* sp., and *Polypodiaceasporites* sp.

Neocouperipollis kutchensis is the other angiospermic pollen occasionally found in the assemblage. Almost all marker species of Late Maestrichtian and Early Palaeocene, viz., *Ariadnaesporites ariadnae*, *Gabonisorites vigourouxii*, *Tercissus grandis*, *Triporoletes reticulatus*, *Periretisyncolpites magnosagenatus*, *Proxapertites cursus*, *Proxapertites operculatus* and *Diporoconia iszkaszentgyoergyi* disappear at the depth of 950 m. *Matanomadhiasulcites maximus* and *Azolla cretacea* are the only two species which still continue. The assemblage is overwhelmingly dominated by laevigate, trilete pteridophytic spores. The commonest of these forms are *Cyathidites minor*, *Todisporites major* and *Lygodiumsporites lakiensis*. Other species are also occasionally met with which include *Lycopodiumsporites speciosus*, *Dictyophyllidites* sp., and *Cycas* pollen. Among angiosperms *Neocouperipollis kutchensis* is rarely found. Fastovsky (1987) studied the palaeoenvironmental

condition of deposition during Cretaceous-Palaeocene transition in eastern Montana and western north Dakota, U.S.A. and advocated that at the end of Cretaceous the water table presumably rose to the surface causing ponds and swamps. This condition was congenial for luxuriant growth of ferns.

At the depth of 944 m, the revival of some of the old species is recorded. *Ariadnaesporites ariadnae*, *Tercissus grandis*, *Gabonisorites vigourouxii*, *Bacutripurites orluensis*, *Longapertites marginatus*, *Periretisyncolpites magnosagenatus*, *Proxapertites cursus* and *Proxapertites operculatus* again appear. The assemblage is, however, continued to be dominated by pteridophytic spores. *Cyathidites minor*, *Todisporites major* and *Lygodiumsporites lakiensis* are found in good percentage.

At the higher level, *Ariadnaesporites ariadnae* is no more found though the rest of the species enumerated above continue up to Palaeocene. It is significant that *Ariadnaesporites* equipped with prominent acrolamelle and distally profuse hair like outgrowth which provided the buoyancy to float, should perish while the angiosperms after initial set back could regenerate. *Ariadnaesporites* being a hydrophyte depended much on the nature of water for propagation and survival whereas the angiospermic plants mostly inhabited terrestrial environments.

Why the angiosperms started disappearing at the depth of 958 m and almost completely disappeared at 950 m is a question to ponder. Perhaps the environment was not congenial for their growth between 958-950 m. The reappearance of most of the forms at 944 m indicates that condition was returning to normal.

Emergence of pteridophytic spore as the dominant element during this period also indicates the large scale destruction of the then existing angiosperms in the surrounding area. After their deterioration, the land was void and invaded by the pteridophytes and other plants. This change in plant community is reflected in the

palynological constituents of the samples.

Similar pteridophytic spore peak period was also observed in the Raton Basin and Hell Creek, Western Interior, U.S.A. at the K/T boundary by Tschudy *et al.* (1984). They observed the dominance of fern spores from 70-100% and mostly represented by *Cyathidites*. Similar "fern-spike" was also noticed by others in many localities in the U.S.A. though Lerbeckmo *et al.* (1987) failed to observe it in Canada. Saito *et al.* (1986) also observed the dominance of fern spores in a marine sequence at the K/T boundary at Hokkaido, Japan. Wolfe and Upchurch (1986) who studied the leaf assemblage across the K/T boundary in the Raton Basin observed the dominance of ferns at this juncture and depauperation of early existing flora gradually gave rise to diversified assemblage later. As many ferns are rhizomatous, they may survive in volcanic areas covered by ash for many years. Besides in ferns and monocots the aerial stems are protected by retained leaf bases which could save apical meristems from burning upto a great extent. If we consider these adaptable characters for ferns then it would be easy to understand why this group should dominate at the terminal Cretaceous event.

The temporary disappearance of existing flora during Cretaceous-Tertiary transition and the evolution of a new one perhaps point out an abrupt change in the environment. The cause might be attributed to any catastrophic event. The critical period is represented by sediments between 958-950 m which witnessed abrupt destruction of the previous flora and appearance of new taxa. Since extinction of flora started at 958 m, this may be regarded as terminal level of the Maestrichtian in the bore hole core.

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REFERENCES

- Alvarez LW, Alvarez W, Asaro F & Michel HV 1980. Extraterrestrial cause of Cretaceous-Tertiary extinction. *Science* 208 : 1095-1108.
- Babinot JF, Michaud L & Flicoteauxdupin F 1988. Etude micropalaeontologique (Ostracodes, palynoflora) et sedimentologique du Cretace superior des forages de Djifere et Nemading (Senegal). *Bull. Centre Rech. Explor. Prod. Elf. Aquitaine* 12 : 143-163.
- Boltenhagen E & Salard-Cheboldaeff M 1980. Essai de reconstitution climatique du Cretace et Tertiaire du Gabon et du Camiroun d apres la palynologic. *Mem. Museum nation. hist. nat. Paris* 27 : 203-210.
- Boulter MC, Spicer RA & Thomson BA 1988. Patterns of plant extinction from some palaeobotanical evidence. In : Larwood GP (Editor)—*Extinction and survival in the fossil record, Systematics Association Special Volume No 34* : 136.
- Caratini J, Tissot C, Kar RK, Venkatachala BS & Sarr R 1991. Palaeocene flora from Walalane bore-hole Senegal. In : Klause H (Editor)—*Palaeoecology of Africa and the surrounding islands. Proc. First Symp. African Palynology Rabat* 122 : 123-133.
- Castelain J 1964. Apercu stratigraphique et micropalaeontologique sur le basin du Senegal. *Proc. Ist Afr. Micropaleont. Colloq. Dakar Mem BRGM* 32 : 135-161.
- Dorf 1942. Upper Cretaceous floras of the Rocky Mountain region II : Flora of the Lance Formation at its type locality Nidobra Country Wyoming. *Carnegie Instn. Wash. Publ.* (508) : 70-159.
- Fastovsky DE 1987. Palaeoenvironments of vertebrate bearing strata during the Cretaceous -Palaeogene Transition, eastern Montana and western north Dakota. *Palaeos* 2 : 282-295.
- Jain KP & Millipied P 1975. Cretaceous microplankton from Senegal Basin, West Africa Pt II Systematics and biostratigraphy. *Geophytology* 5(2) : 126-171.
- Jardine S & Magloire L 1965. Palynologie et stratigraphie du Cretace des bassins du Senegal et de Coted Ivoire. *Proc. Ist Afr. Micropal. Collo. Dakar Mem. BRGM* 332 : 187-245.
- Kieser G 1967. Quelques aspects particuliers de la palynologie du Cretace superier du Senegal. *Rev. Palaebot. Palynol.* 5 : 199-210.
- Lerbeckmo JF, Sweet AR & St Louis RM 1987. The relationship between the iridium anomaly and palynological floral events at three Cretaceous-Tertiary boundary localities in western Canada. *Geol. Soc. Am. Bull.* 99 : 325-330.
- Ly I 1985. Le Tertiaire de Casamance : biostratigraphic (foraminiferes) et sedimentologie d apres les donnees de subsurface. *These Sci. uni. Ax. Marseille III* 215 pp.
- Medus J, Feist R, Rocchia DJ, Batten D, Boclet F, Colombo Y, Tambareau Y & Villate J 1988. Prospects for recognition of the palynological Cretaceous-Tertiary boundary and iridium anomaly in non-marine facies of the eastern Spanish Provinces : a preliminary report. *Newsl. Stratigr.* 18 : 123-138.

- Michaud L 1984. Les milieux de sedimentation Cretaces du Senegal et leur evolution disaginitique (Etude de sub surface). *These 3 eme. eyeb. univ. Aix-Marseille III* 285 pp.
- Nichols DJ 1990. Geologic and biostratigraphic framework of the non-marine Cretaceous-Tertiary boundary interval in western north America. *Rev. Palaeobot. Palynol.* 65 : 75-84.
- Perch-Nielsen K, McKenzie J & He Q 1982. Biostratigraphy and isotope stratigraphy and the "catastrophic" extinction of calcareous microplankton at the Cretaceous-Tertiary boundary events. *New Mexico Geology* 5 : 353-371.
- Percival SF & Fisher AG 1977. Changes in calcareous nannoplankton in the Cretaceous/Tertiary biotic crisis at Zumaya Spain. *Evol. Theory* 2 : 135.
- Pritan JP 1986. Geologie de la bordure meridionale du golfe Tertiaire de Casamance (Senegal Guinee Bissan). *Proc. BRGM Orteans* no.101 : 130.
- Sahni A, Venkatachala BS, Kar RK, Rajanikanth A, Prakash T, Prasad GVR & Singh RY 1996. New palynological data from the Deccan intertrappeans : implications for the latest record of dinosaurs and synchronous initiation of volcanic activity in India. *Mem. geol. Soc. India* 37 : 267-284.
- Saito T, Yamanoi T & Kaiho K 1986. Devastation of the terrestrial flora at the end of the Cretaceous in the Boreal Far East. *Nature* 323 : 253-256.
- Sarr R 1982. Etude geologique et hydrologique de la region de Joel-Fadiouth (Senegal). *These Univ. Dakar* 191 pp.
- Spengler A, Castolain J, Cauvin J & Leroy M 1966. Le bassin secondaire-tertiare du Senegal. In : Reyre D (Editor)—'Bassins sedimentaires du littoral Africain. Assoc. Serv. géol. afr.' 80-94.
- Stover LE 1963. Some Middle Cretaceous palynomorphs from West Africa. *Micropalaeontology* 9 : 185.
- Templeton RSM 1971. The geology of the continental margin between Dakar and Cape Palmas. In : Delany FM (Editor) —'The geology of the east Atlantic continental margin, 4, Africa. Inst. Geol. Soc. Rep. 70(16) : 43-60.
- Tschudy RH 1971. Palynology of the Cretaceous-Tertiary boundary in the northern rocky mountain and Mississippi embayment regions. In : Kosanke KH & Cross AT (Editors)—*Symposium on Palynology of the Late Cretaceous and Early Tertiary. Geol. Soc. Am. Spec. Pap.* 127 : 65-111.
- Tschudy RH, Pillmore CL, Orth CJ, Gilmore JS & Knight JD 1984. Disruption of the terrestrial plant ecosystem at the Cretaceous-Tertiary boundary Western Interior. *Science* 225 : 1030-1032.
- Tschudy RH & Tschudy BD 1986. Extinction and survival of plant life following the Cretaceous-Tertiary boundary event, Western Interior North America. *Geology* 14 : 667-670.
- Wolfe JA & Upchurch GR 1986. Vegetation, climatic and floral changes at the Cretaceous-Tertiary boundary. *Nature* 324 : 148-152.