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THE FOSSIL FLORAS OF KACHCHH — IV. TERTIARY PALYNOSTRATIGRAPHY

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ABSTRACT

The palynological work so far done on the various Tertiary sediments of Kachchh has been reassessed and new information added. Many genera have been redefined and new genera, viz., *Intrareticulites*, *Retitribrevicolporites*, *Dermatobrevicolporites*, *Triangulorites*, *Arengapollenites*, *Minutitricolporites*, *Acanthotricolpites*, *Angulocolporites*, *Pseudonyssapollenites*, *Pilatricolporites*, *Tribrevicolporites*, *Triangulotricolporites*, *Retitetrabrevicolporites*, *Tripilaorites*, *Ligulifloraedites*, *Spinulotetradites*, *Verrudandotiaspora*, *Tricolporopilites*, *Tricolporocolumellites*, *Ratariacolporites*, *Plicatiaperturites*, *Palaeomalvaceaepollis*, *Pilapanporites*, *Verrupolyporites*, *Khariasporites*, *Magnamonocolpites* and *Hibisceaepollenites* have been proposed. On the basis of relative frequency of all taxa the Matanomadh Formation (Palaeocene) has been divided into (i) Barren Zone, (ii) *Dandotiaspora dilata* Cenozone, (iii) *Tricolpites minutus* Cenozone, (iv) *Couperipollis kutchensis* Cenozone, and (v) Sponge spicules Zone; Naredi Formation (Lower Eocene) has been divided into (i) *Lakiapollis ovatus* Cenozone, and (ii) *Lygodiumsporites lakiensis* Cenozone. The Middle Eocene palynological assemblage has been divided into *Proxapertites microreticulatus* Cenozone for Harudi Formation and *Cheilanthoidspora enigmata* Cenozone for the Rataria bore-core. Maniyara Fort Formation (Oligocene) has been divided into (i) *Operculodinium centrocarpum* Cenozone, (ii) *Trisyncolpites ramanujamii* Cenozone, and (iii) *Aplanosporites robustus* Cenozone and Khari Nadi Formation (Miocene) has been classified into (i) *Cordosphaeridium cantharellum* Cenozone, (ii) *Striatriletes susannae* Cenozone, and (iii) *Operculodinium israelianum* Cenozone. Thus in total, there are approximately 179 spore-pollen species in Palaeocene, Lower and Middle Eocene, Oligocene and Miocene. Of them, 42 species are confined to Palaeocene, 39 species to Eocene, 25 species to Oligocene and 21 species to Miocene. The Lower Eocene has maximum number (113) of spore-pollen species. The population gradually decreases and in Miocene only three species of angiosperms are recorded. On the basis of morphological characters of spores and pollen grains the families Parkeriaceae, Amaranthaceae-Chenopodiaceae, Clusiaceae, Bombacaceae, Malvaceae, Acacieae, Caesalpiniaceae, Rhizophoraceae, Lecythidaceae, Meliaceae, Ctenolophonaceae, Polygalaceae, Alangiaceae, Apiaceae, Asteraceae, Poaceae and Arecaceae could be recognized. The palynological cenozones proposed in this paper have also been compared with other known assemblages from India.

Key-words — Morphotaxonomy, Palynostratigraphy, Kachchh, Tertiary (India).

साराँश

कच्छ के अश्मित वनस्पतिजात – 4. तृतीयक युगीन परागाणुस्तरिक अध्ययन – रंजीत कुमार कर

कच्छ के विभिन्न तृतीयक युगीन अवसादों पर अभी तक किये गये परागाणविक अध्ययन का पुनर्मूल्यॉंकन किया गया है तथा नवीन जानकारी समाविष्ट की गई है। बहुत से वंशों को पुन: परिभाषित किया गया है तथा इन्ट्रारेटिकुलाइटिस, रेटिट्राईब्रेविकॉल्पोराइटिस, डर्मेटोब्रेविकॉल्पोराइटिस, ट्राईऐंगुलोराइटिस, ऍरेंगापोलिनाइटिस, माइनुटिट्राईकॉल्पोराइटिस, ऍकेन्थोट्राईकॉल्पाइटिस, ऐंगुलोकॉल्पोराइटिस, स्यूडोनिस्सापोलिनाइटिस, पाइलाट्राईकॉल्पोराइटिस, ट्राईब्रेविकॉल्पोराइटिस, ट्राईऐंगुलोट्राईकॉल्पोराइटिस, रेटिटेट्राब्रेविकॉल्पोराइटिस, ट्राईपाइलाग्रोराइटिस, लिगुलिफ्लोरिडाइटिस, स्पाइनुलोटेट्राडाइटिस, वेरूडेन्डोटियास्पोरा, ट्राईकॉल्पोरोपाइलाइटिस, ट्राईकॉल्पोरोकॉल्यूमेलाइटिस, रतरियाकॉल्पोराइटिस, प्लिकेटिएपरचुराइटिस, पेलियोमाल्वेसीपॉलिस, पाइलापैनपोराइटिस, वेरूपॉलिपोराइटिस, खारियास्पोराइटिस, मैग्नामोनोकॉल्पाइटिस एवं हिबिस्सीपोलिनाइटिस नामक नवीन वंश प्रस्तावित किये गये हैं। सभी वर्गकों की आपेक्षिक बारम्बारता के आधार पर मातानोमढ़ शैलसमूह (पुरानूतन) को (अ) बैरन मंडल, (आ) डैन्डोटियास्पोरा डाइलेटा नवमंडल, (इ) ट्राईकॉल्पाइटिस माइन्यू-

टस नवमंडल, (ई) काउपेरिपॉलिस कच्छेन्सिस नवमंडल, तथा (उ) स्पंज कंटिका मंडल में विभक्त किया गया है; नरेडी शैल-समूह (अधरि आदिनूतन) को (अ) लाकीयापॉलिस ओवेटस नवमंडल तथा (आ) लाइगोडियम-स्पोराइटिस लाकीयेन्सिस नवमंडल में विभक्त किया गया है। मध्य आदिनूतन परागाणविक समुच्चय हरुड़ी शैल-समूह के लिए प्रोक्सापर्टाइटिस माइक्रोरेटिकुलेटस नवमंडल में तथा रतरिया वेध-क्रोड़ हेतु चीलेन्थोइडस्पोरा एनिग्मेटा नवमंडल में विभक्त किया गया है। मनियाराफोर्ट शैल-समूह (पश्चनूतन) को (अ) ओपरकुलोडीनियम् सैन्ट्रोकार्पम् नवमंडल, (आ) ट्राइसिन्कॉल्पाइटिस रामानुजमाई नवमंडल तथा (ई) एॅप्लेनोस्पोराइटिस रोबस्टस नवमंडल में बाँटा गया है, जबकि खारी नदी शैल-समूह (मध्यनूतन) को (अ) कोर्डोस्फेयरीडियम् कैन्थेरेल्लम्, (आ) स्ट्रआट्राइलिटीज़ सुसान्नॅ नवमंडल, तथा (इ) ओपरकुलोडीनियम् इज़राइलियानम् नवमंडल में वर्गीकृत किया गया है। इस प्रकार पुरानूतन, अधरि एवं मध्यआदिनूतन, पश्चनूतन एवं मध्यनूतन में कुल मिलाकर परागकण-बीजाणुओं की लगभग 179 जातियाँ हैं। इनमें से 42 जातियाँ पुरानूतन से, 39 जातियाँ आदिनूतन से, 25 जातियाँ पश्चनूतन से तथा 21 जातियाँ मध्यनूतन से हैं। अधरि आदिनूतन में परागकण-बीजाणुओं की सबसे अधिक संख्या (113) है। यह संख्या शनैः शनैः कम होती जाती है तथा मध्यनूतन में आवृतबीजीयों की केवल तीन जातियाँ मिली हैं। बीजाणु एवं परागकणों के बाह्यआकारिकीय संलक्षणों के आधार पर पार्करिएसी, अमॅरेन्थेसी-कीनोपोडिएसी, क्लूसिएसी, बॉम्बेकेसी, माल्वेसी, ॲकेसी, सेसलपिनेसी, राइज़ोफ़ोरेसी, लेसिथीडेसी, मिलीएसी, टीनोलोफ़ोनेसी, पोलीगैलेसी, एॅलेन्जिएसी, एॅपिएसी, एॅस्टरेसी, पोएसी एवं ॲरेकेसी नामक कुलों की पहचान की जा सकी है। इस शोध-पत्र में प्रस्तावित परागाणविक नवमंडलों की तुलना भारत से अन्य ज्ञात समुच्चयों से भी की गई है।

INTRODUCTION

THE district of Kachchh lies on the extreme west of India and is very well known for its Mesozoic and Tertiary fossils. This district is in Gujarat State and is situated between the 22° and 24° of north latitude, and 68° and 70° of east longitude. It is bound to the north by the great Rann beyond which is the famous Thar desert, to the south-west and south by the Gulf of Kachchh and the Indian Ocean, to the east and south-east by the district of Banaskantha of Gujarat State and to the north-west by one of the eastern branches of the Indus and Sind State of Pakistan. The province is generally hilly, rocky, undulated and has a desertic look except the southern part which is a flat land with a rich and fine soil. Three distinct low ranges of hills with easternly and westernly direction can be recognized in the district.

The basement complex of Kachchh comprises syenites, gneisses and granites. This provided a platform for the deposition of sedimentary rocks during Mesozoic Era. It is generally postulated that Kachchh was a high land throughout the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Triassic and Lower Jurassic periods as no rocks assignable to these periods are found.

Wadia (1957), however, believed the presence of Purana sediments in association with peninsular gneisses below the recent deposits of the Rann of Kachchh. Poddar (1959) also suspected the existence of sediments like the Saline Series of Salt Range beneath the Mesozoic rocks. He further thought that these sediments provided a lubricant medium for the folding of Mesozoic rocks over the Precambrian basement complex through the process of décollement. Biswas and Deshpande (1969), on the other hand, ruled out any possibility of the occurrence of any older rocks between the two, as they were able to observe direct contact between the Precambrian and Bathonian rocks in the north-western region of the great Rann.

The Tertiary strata of Kachchh is a small part of an extensive geological province which also included Sind and Baluchistan areas of Pakistan. This in contrast with the Mesozoic Era where Kachchh formed a part of a geological province comprising other parts of Gujarat and Rajasthan.

The Tertiary of Kachchh is represented by sedimentary sequence from Palaeocene to Pliocene. These sediments are best developed in the south western coastal plain of Kachchh between Guvar and Khari rivers. The credit for providing the first comprehensive geological report on Kachchh goes to Grant (1840) who included a reasonably fair description and structure of the Tertiary rocks. He divided the whole sedmentary deposits of Kachchh into the ifollowing units:

Volcanic and trappean rocks, including all such as bear evident marks of a perfectly igneous origin, as basalt, etc.

1. Syenite and quartz rocks
2. Sandstone and clay with beds of coal
3. Red Sandstone
4. Upper secondary formation, consisting of slate clay, limestone slate, and slaty sandstone, and containing *Ammonites* with other fossils characteristic of the secondary formations of Europe.
5. Nummulitic limestone and marl
6. Tertiary strata
7. Alluvial or recent deposits

It may be mentioned here that Grant (1840) placed the rocks around Matanomadh (Mhurr) between the Red Sandstone (3) and Sandstone and clay, with beds of coal (2). He observed that the ground on which Mhurr is built consists of high, irregular banks of marl of every variety of colour, but in a most confused and shattered state. It is composed of a ferruginous sandstone near the base, on which the variegated marl rest, the latter being covered in some places, with a bed of coarse gravelly detritus, two to three meter thick. A large quantity of alum is manufactured at this place from the blue clay obtained in the variegated marl. Regarding the Nummulitic Limestone and marl (5) which he placed below the Tertiary strata (6) Grant (1840) remarked that the embedded fossils of the Nummulitic group resemble those of some Tertiary beds of England and France, still the strata it contains differ so totally in minerological character and general look from any of the other formations in Kachchh that it deserves a separate notice. This bed extends from Lakhpat to Wagapadhar covering about thirty miles. Wynne (1872) also observed that the Nummulitic beds around Lakhpat forms singularly barren ground of undulated waste overspread by a white gravel composed of *Nummulites* resulting form extensive decomposition of the calcareous rocks crowded with these fossils.

The Tertiary strata (6) of Grant (1840) consists generally of a hard argillaceous grit, interspersed with fossil shells and covered by beds of pebbles or conglomerate. A calcareous grit also occurs in patches and contains innumerable small shells.

At the village of Soomrow about ten miles north-east of Juckow, the banks of a river are made up of partly of a very hard, compact, calcareous rock and below this rock is a coralline limestone. Some places of this region, specially near the village of Kotra, have a very particular appearance as if they had been subjected to a violent flood, which has washed away the soil up to 30-40 ft leaving a broad, shallow valley, two or three miles across, with numerous isolated and rounded hills of gravel, scattered about its bed. One of the hillocks is entirely covered with *Ostrea callifera* lying olosely or cemented into a solid rock.

The invertebrate fossils collected by Grant were investigated by Sowerby (1840) and resulted in some of the earliest descriptions and illustrations of larger foraminifers, molluscs and echinoderms of the Indo-Pakistan region. Some of the important forms are *Nummulites acutus*, *Discocyclina dispansa*, *D. sowerbyi* and *Alveolina elliptica*.

Wynne (1872) provided for the first time a complete account of the geology of Kachchh with a geological map. The rock formations of Kachchh were divided by him as follows:

FORMATION	SUBDIVISION	PERIOD
Tertiary	Alluvium, blown sands, etc.	Pleistocene
	Upper Tertiary	Probably both Plio-Miocene
Tertiary	(Unconformity) Argillaceous Group (fossiliferous)	Miocene to Upper Eocene
	Arenaceous Group Nummulitic Group Gypseous shales	

—contd

FORMATION	SUBDIVISION	PERIOD
Volcanic Tertiary	Subnummulitic Stratified traps and associated intertrappean beds	Eocene
	Infratrappean beds (Unconformity)	
Jurassic	Upper Jurassic Group Lower Jurassic Group	Oolite
Metamorphic Crystalline	Syenite	

Regarding the base of the Tertiary rocks Wynne (1872) observed that immediately overlying the stratified traps and resting on a crystalline concretionary amygdaloidal flow having often an irregular surface and weathering colour, a particularly mixed and varied band of rock is found. It is found as a narrow belt on the upper portion of the traps to the west but rarely traced at the eastern part.

It is made up of soft variegated pseudobrecciated or concretionary unctuous aluminous rocks of pale purple colours interspersed with white clay. Besides, pure white variety also occurs which soils the fingers and occasionally contains disseminated grains of white quartz. This associated with strong red and mottled laterites in places veined with haematite, in others containing agates. Coarse sandstones largely comprising semitransparent quartz grains are found irregularly with purple or brown bands of siliceous and ferruginous rocks resembling quartzite. This group also contains leaf impressions in white sandy shale, resinous lumps and carbonaceous layers. All these form a series beautifully variegated both in texture and colour, white or red, delicate lavender, strong purple and warm orange.

Wynne (1872) thinks that this group presents many appearances of conformity to the traps though the lowest beds are often very soft. These beds are of white or variegated unctuous breccia sometimes with large concretionary structures with which the uppermost underlying traps coalesce in a peculiar way. These brecciated spheroid soft beds have centres of same nature as the trap below and approaching the character of the latter. No case of unconformity to the traps is known.

The laterites, in the opinion of Wynne (1872), are earthy or nodular and sometimes highly ferruginous as to become the iron ore. They are variable in texture but often brown in colour and glazed. In many cases they are very much nodular resembling conglomerate and some of them are blended with the overlying unctuous rock.

In eastern Kachchh only the laterites and white beds are present and they yield rapidly to the atmospheric action. According to Wynne (1872) the relation between this group and the overlying Tertiary rocks are obscure because the junction or transition often taking place among soft gypseous shales. When these beds are largely developed together with certain beds of dark ferruginous or coarse whitish grit it becomes very difficult to separate the subnummulitic beds from the Mesozoic beds in the absence of traps.

In Tertiary, Wynne (1872) placed several groups, each characterized either by some petrological peculiarity or the abundance of certain fossils. However, he also realised that these rocks are subject to irregularities very likely to lead astray because not only the whole groups are wanting in some cases, but individual beds vary along their extension or die out altogether. These rocks present a large and varying series of alternations of shales and clays with sands and sandstones, marly and sandy aluminous beds, calcareous marls and grits with conglomerates and gravels in the upper part. Wynne (1872) subdivided the Tertiary rocks provisionally as follows:

F {

Pliocene: Variable and inconstant deposits, include concrete beds of great thickness ...... 66-166 m

Miocene: Soft sandstones, shelly, calcareous and quartzite grits, gravels and conglomerates with trap pebbles and agates.

E { *Upper Eocene-Miocene* — A great thickness of clay and shales alternating with sandy shales and harder bands of shelly limestones or marls; a few nodular clay or conglomeratic beds ...... 260-400 m
In upper part fossils are most abundant, often forming whole beds.
The lower part is often rusty brown and sandy with ferruginous and lateritic bands and some conglomerates. Some of the sands are richly mottled and in parts white. Some large bones, etc. occur in one of the lower conglomerates.

D { *Eocene* — Mottled white, iron stained, streaky, fine silty sandy shales, soft and friable obliquely laminated, irregularly bedded and often lenticular, contain impression of leaves ...... 32 m
Dun coloured and blue silty clays and blue shales, contain the carapace of a minute crab etc. ..... 9 m

C { Marly beds with a few fossil casts and *Nummulites* in lower part
Nummulitic marls and limestones ...... 225 m

B { ?*Operculina* gypseous shales with nodular bands and laterite above and below. An oyster bed sometimes occur on this horizon ... 32 m

A { Finely laminated shales, upper part rusty brown and friable, lower argillaceous and bituminous and pyritous with small lumps of mineral resin, bitumen etc. ......16-32 m
Small horny plates, possibly belonging to crustacean and woody fragments and leaf impressions but preserved in the lower part ...

Total ..... 500-660 m

Wynne (1872) did not include the last named beds (A) in Eocene but remarked that these beds are intimately associated and sometimes seem to form a part of the subnummulitic and ?volcanic beds. He also observed that the fossiliferous and shaly portion of this group (A) is not consistent and occur only in few places. He could find fossil leaves in these beds of several kinds and occurring locally in great numbers, mostly small and lanceolate but sometimes are of large size. The fine deposition which contain them might have been local river, lacustrine or estuarine accumulation.

The gypseous shales unit ?*Operculina* (B) in the opinion of Wynne (1872) is also comparatively of local character, occurring below the nummulitic group round the western curve of the beds which flank the Gaira hills anJ in a few other places. Its nodular clay stone and marl bands and some of the shales are full of little *Nummulites*, *Operculina* and a few other marine fossils like *Corbula*, *Ostrea*, etc. Besides, they contain bones, reptilian remains and fish vertebrae and teeth.

The nummulitic group (C) of Wynne (1872) comprises pale yellow and white marly impure limestones with some sandy beds and shaly marls. Wynne could recognize that some of the nummulites are peculiar to certain zones and at the time when these deposits ceased corals seem to have flourished and large coral masses are found whenever the upper bed occurs. They are generally the brain corals and are so crystalline that a very little of the organic structures could be found in them.

Wynne (1872) recognized the regular and parallel stratification of the nummulitic beds as might be expected in pelagic deposits and the whole group dies out or disappears with much obscurity at the eastern limit.

The beds which succeed the nummulitic group (D) in different parts of Kachchh according to Wynne (1872) are also variable and inconstant. The upper beds consist of very irregular and false bedded sand or friable sandy shales and occasionally streaked by iron stained laminae. These beds are found on dun coloured and blue finely laminated clays with few fossils.

Wynne (1872), however, marked the argillaceous group (E) as by far the most important of the Kachchh Tertiary deposits in thickness, lateral extension and the number and variety of its fossils. The lower beds resemble the upper portion of the preceding beds, variable and false bedded on a large scale but not found to contain the fossil leaves. Highly ferruginous bands are also occasionally found and the lower beds in general have a rusty appearance. Soft, brownish, yellowish or mottled sandstones with ill-defined laminations generally occur and are often characterized by cylindrical, concretionary, ferruginous or white ramification or casts of burrows.

Above these beds are calcareous grits and sandstones with sandy beds and flaggy bands. At about the middle of this argillaceous beds, the most fossiliferous beds of the whole of Tertiaries are found. They occur in yellow marls and marly limestones and hard, muddy beds, some being almost entirely made up of fossil shells or distinguished by a great abundance of pectens or oysters while on the whole the gastropods predominate.

The argillaceous beds immediately succeeding the highly fossiliferous zone comprise mainly soft, sandy clays and muddy shales with a few compact sandstone layers thinly laminated, ripple marked and a narrow band largely made up of fragmentary shells with bunches of barnacles on the surface.

The uppermost group (F) is characterized by a conglomeratic bed at its base which in places may be ferruginous. This bed is succeeded by thick bedded brown sands or in coherent sandstone which are partially at the base connected by a carbonate of lime, calcareous segregations also occur throughout the rock and the only organic remains are found consisting of large logs of fossil woods. The upper members of this group are ill-defined, of which the most recognizable unit is a great thickness of obliquely laminated concretes sometimes nodular and kunkury with large fossil oysters.

From the above description, it is thus clear that Kachchh is very rich in different kinds of Tertiary fossils. But at first, attention was mainly given to larger foraminifera. The first important contribution of the stratigraphic distribution of the Indian species of *Nummulites* and *Lepidocyclina* was by Vredenburg (1906) followed by Nuttall (1925a, 1925b, 1926a, 1926b). In recent years Tewari (1952, 1956a, 1956b, 1957), Tewari and Bhargava (1959), Tewari and Tandon (1960), Tewari, Bhargava and Khanna (1964), Tewari and Singh (1969), Tewari and Singh (1969), Rao (1956), Poddar (1959, 1963, 1964), Sen Gupta (1959, 1964), Tandon (1962, 1976), Tandon and Srivastava (1980), Tandon, Mathur and Saxena (1980), Tandon, Saxena and Mathur (1980), Mohan and Gupta (1968), Mohan and Bhatt (1968), Mohan and Soodan (1969, 1970), Chatterjee and Mathur (1966), Bhatt (1968), Biswas (1971), Biswas and Deshpande (1970), Biswas and Raju (1971, 1973), Hardas and Biswas (1973), Sahni and Mishra (1975), Satsangi and Mukhopadhyay (1975), Mishra (1980) and others have made significant contribution on the palaeontology and stratigraphy of Kachchh. Sen Gupta (1959, 1964) studied the biostratigraphy around Lakhpat in detail. He remarked that the incompleteness of stratigraphic record in this area is specially obvious at the lower part of foraminiferal limestone. There is no evidence of Palaeocene-Lower Eocene sedimentation in this area and Sen Gupta (1964) thinks that the first fossils are indicators of a Middle Eocene marine transgression. He, however, confesses that the duration of the early Tertiary stratigraphic break cannot be determined with certainty.

Sen Gupta (1959) proposed the following biostratigraphic zones for the Palaeogene of Lakhpat and adjacent areas:

	Zone E	Subzone E3 — Sparsely fossiliferous Subzone E2 — Scleractinian corals Subzone E1 — Mainly *Nummulites clipeus* Nuttal. Also many echinoids and molluscs
Oligocene	Zone D	Subzone D2 — *Discocyclina* sp.; *Nummulites stamineus* Nuttal and *Dictyoconoides cooki* (Carter) Subzone D1 — *Discocyclina* sp.; rarely with *D. atticostata* (Nuttal) in the upper portion
	Zone C	*Assilina exponens* (Sowerby) (and *A. mammillata* d'Arch)
Eocene	Zone B	*Discocyclina sowerbyi* (Schlotheim) Nuttal, *D. dispansa* (Sowerby) and *D. javana* (Verbeek) var. *indica* Nuttal
	Zone A	*Nummulites obtusus* Sowerby
? Cretaceous	—	Eocene : Laterite

According to Sen Gupta (1964) the only evidence of a hiatus between the Eocene and the Oligocene sedimentation is marked by the abrupt change in the fossil record. The Oligocene is characterized by the abundance of *Nummulites fichteli* and one of thel arger foraminifera does not cross the Eocene-Oligocene boundary. The good amount of molluscs, echinoids and the occasional corals that are present in the Oligocene are in no case preceded by the ancestral forms in the older strata. He is also of the opinion that there is no significant differences between the lithologies of the Eocene and the Oligocene limestones. Along most of the observable contacts between the Eocene and Oligocene, the strata are mostly horizontal and no erosional surfaces are discernible. So he opines that the break between the two is the nature of paraconformity.

Sen Gupta (1964) noticed the Oligocene-Miocene unconformity in both faunal and lithic changes. *Nummulites* dies out in the Miocene together with rare '*Operculina*' and *Lepidocyclina*. The Miocene limestone has a high percentage of terrigenous material and occasionally the base of the strata is by conglomerates or thin post Oligocene laterite bands.

Biswas and Raju (1971, 1973) proposed a new rock-stratigraphic classification for the Tertiary sediments of Kachchh. They remarked that the classification of Wynne (1872) of the Tertiary sediments of Kachchh into seven groups was too general and without any designated type sections and definition of the contacts between the groups. They revised Wynne's classification and proposed the following eight formations:

FORMATION	MEMBER		AGE
Sandhan			Pliocene
Vinjhan Shale	Siltstone	Miocene	Langhian
	Chhasra		Burdigalian
Khari Nadi			Aquitanian
	Ber Moti		Chatian
Maniyara Fort	Coral	Oligocene	Rupelian
	Limestone		
	Lumpy Clay		Latterfian
	Basal Member		
Fulra Limestone			Lutetian
		Eocene	
Harudi			Ypresian
Naredi			
Matanomadh			Palaeocene
Deccan trap			

Matanomadh Formation — This formation has been named by Biswas and Raju (1971, 1973) after the village Matanomadh (23°32′30″; 68°59′10″) in western Kachchh, which initiates the Tertiary sedimentary deposition in the area. The irregular outcrop pattern of this formation running parallel to the post trappean topography is eloquent to advocate this contention. This formation is best developed and exposed around the village Matanomadh and the type section is exposed in the Bhuj-Lakhpat road section, on the southern side of the village. The lithological succession is extremely variable and this formation is mainly made up of trap wash breccia tuff, ash and agglomerates derived from the erosion of the bauxite, lateritic trap-pebble-conglomerate, variegated grey and white tuffaceous shales, red tuffaceous sandstones and occasional layers of lignite.

On the basis of lithology, Saxena (1977) thinks that this formation is divisible into two members. The lower member consists of chalky white kaolinitic lithomargic clay in its lower part and pink, grey and variegated bauxitic laterite in the upper. The laterite and clay conformably overly the trap. The nature of their contact is suggestive of alternation of basaltic traps and pyroclastic ejections. The upper member is mostly made up of sandstones, grits, tuffaceous and carbonaceous shales, alum shales, bentonitic and ferruginous clays, volcanic ash and shale with lignitic bands.

According to Biswas and Raju (1971, 1973) the upper contact of this formation is conformable and marked by a lignitic band in the type locality. Elsewhere, this contact is unconformable and separates the overlying gypseous shales of the Naredi Formation from the brightly coloured clays. The formation is generally devoid of any characteristic fauna but very rich in palynological fossils.

Naredi Formation — The formation was christened by Biswas and Raju (1971, 1973) after the village Naredi (23°34′30″; 68° 39′00″) situated in the western part of Kachchh. The type section is exposed in the cliff sections along Kakdi River near Naredi and in some parts along Guvar River to the north-north-west of Naredi.

Biswas and Raju (1971, 1973) recognized three distinct members of this formation. The lower Gypseous Shale Member comprises grey, brown and olive green, splintery, glauconitic claystone and shale with occasional thin layers of gypsum, yellow limonite and also a few layers of calcareous concretion occasionally containing fossils at the centre. This member is about 25 m thick. The middle Assilina Limestone Member is made up of dirty white argillaceous limestone and yellowish, grey marlite studded with *Assilina*. This is about 6 m thick. The upper Ferruginous Claystone Member is about 11 m thick having grey, yellowish brown claystone with layers of gypsum; red lateritic bed is found at the uppermost part of the sequence. The lower and upper members occasionally develop black shale facies comprising black pyriteous shales and lignitic beds.

The Naredi Formation, in the type locality, rests on the Deccan trap or its derivatives, but in some cases it also overlies unconformably on the Matanomadh Formation. The lower and upper members of this formation are poorly fossiliferous whereas the middle member is studded with fossils. The microfauna indicates a Lower Eocene age (Ypressian) and the environment of deposition is supposed to be lagoonal to marine inner shelf and becoming non-marine, towards the upper part.

Tandon (1971), on the otherhand, placed the lower member of this formation into Palaeocene on the presence of *Venicardia beaumonti* d'Archaic & Haime and *Venicardia* cf. *V. vredenburgi* Douville. He also thinks that at the advent of Palaeocene period in Kachchh there was a marine transgression from the side of Sind across the region into Cambay as far as Surat-Broach. The Naredi Formation according to Tandon (1971) represents an estuarine condition of deposition. The presence of pyrites indicates reducing environment due to which the fauna became restricted in size and variety. The presence of bitumen is also indicative of deposition under stagnant condition.

Regarding the presence of *Venicardia beaumonti* in the Indian subcontinent Rutsch (1936) after studying many specimens from the region commented that most of the so-called *Cardita* (*Venecardia*) *beaumonti* is really not exactly like the holotype as described by d'Archaic and Haime. According to Rutsch (1936) they seem to be a variety or species closely resembling the original specimen but still different and distinct. So he placed all the specimens including the holotype into '*Cardita beaumonti* group' and it ranges, in the opinion of Dutta (1974), from the Maestrichtian to Middle Eocene.

Harudi Formation — This formation is well exposed in an escarpment on the north western side of the village Harudi (23° 30'30"; 68°41'10") after which Biswas and Raju named it. They have designated the type section to an exposure along the escarpment at a locality about 2 km north-west of Harudi on the Nalia-Narayan Sarovar road.

The formation comprised green-greenish grey, splintery shale with yellow limonitic partings in the basal part and calcareous claystone and siltstone with occasional layers of gypsum and carbonaceous matter in the upper part. A thin coquina bed generally occurs at the lower part with concretionary fossiliferous marlite band. According to Biswas and Raju (1971, 1973), 0.5 m thick ferruginous gypseous clayey marlite band studded with large *Nummulites* is a characteristic marker bed.

The basal contact is disconformable and fixed on top of the laterite bed of the Naredi Formation. The upper contact is, however, conformable and is placed at the base of the lowest massive foraminiferal limestone bed having saddled to undulated *Discocyclina*.

The lower part of the formation is generally devoid of any microfauna. But the marlite beds, coquina beds and the gypseous clayey marlite beds are very rich in animal fossils. On the basis of foraminiferal assemblage, a Middle Eocene (Lutetian) age is ascribed to this formation.

Fulra Limestone — This formation is named by Biswas and Raju (1971, 1973) after the village Fulra (23°42'30"; 68° 47'12"). The type section is best observed along the southern flank of the Babia hill, about 2 km south-west of Fulra. The upper part is also exposed in the nala to the south of Fulra.

The entire formation consists of massive to thickly bedded, cream to dirty white foraminiferal limestone and is studded with animal fossils. They comprise large saddled to undulated *Discocyclina*, large flat *Nummulites* and other foraminifera, The lower contact of this formation is conformable and is fixed at the base of the massive foraminiferal limestone. The upper contact is paraconformable and is well developed in all stream sections.

Besides foraminifera, this formation is also rich in macrofossils. The basal beds have giant conch shells like *Bolis* sp. and *Xancus* sp. In the upper part, echinoids are common and found generally in association with *Alveolina elliptica*. The microfauna points towards a Middle Eocene (upper part of Lutetian) age. The animal fossils and the physical aspects of the sediments indicate a stable middle shelf environment of deposition.

Maniyara Fort Formation — This formation has been christened after the Maniyara Fort (23°28′05″; 68°37′00″). Biswas and Raju (1971, 1973) divided this formation into four members.

The Basal Member is only about 4 m thick and is made up of alternating beds of foraminiferal, glauconitic, brownish to yellowish siltstone and calcareous, gypseous claystone studded with reticulate *Nummulites*, *N. intermedius fichteli*, *Pecten* and other fossils. According to Biswas and Raju (1971, 1973), the presence of green pellets of glauconite readily differentiates this member from the underlying Fulra Limestone.

The second in the ascending order is the Lumpy Clay Member. It is about 4.5 m thick and comprises cement coloured to brownish calcareous lumpy claystone with occasional thin bands of limestone and marlite bands. Foraminifera are not very common except *El. phidium* and a few other forms.

The next is the Coral Limestone Member which is about 9 m thick and comprises dirty white nodular limestone alternating with the calcareous claystone. The upper part consists of grey to dirty white massive limestone with predominance of corals. This member abounds in fossils. The larger foraminifera include *Lepidocyclina* (*Eulepidina*) sp. and *Nummulites fichteli-intermedius*. *Schizaster granti*, the heart shaped echinoids are also common while the corals are mostly restricted in the upper part. The above mentioned three members are well exposed in the stream west of Ramania (23°27′35″; 68°47′50″).

The uppermost member of this formation is known as Ber Moti and is best exposed in the stream south-east of Ber Moti Village and north-north-east of Waior (23°24′ 00″; 68°41′45″). The lower part of this member is well exposed near Waior and comprises rusty brown, friable glauconitic argillaceous sandstone. The upper part consists of thinly bedded, very hard, grey to yellowish foraminiferal limestones with intercalation of silty marlite full of *Spiroclypeus*. The important foraminifera found in the assemblage are: *Miogypsina complanata*, *Spiroclypeus ranjanae* and *Globorotalia opima nana*.

The lower contact of this formation, in the opinion of Biswas and Raju (1971, 1973) is paraconformable. The sudden occurrence of green glauconite pellets at the lower part is very characteristic. The upper contact is not observed in the type section but seems to be conformable in other sections. This formation is very rich in animal fossils and have pelecypods, gastropods, echinoids, corals, fish scales, teeth, etc.

Biswas and Raju (1971, 1973) assigned a Lower Oligocene age to the Basal and Lumpy Clay members, whereas for the coral limestone and Ber Moti members they ascribed Middle Oligocene and Upper Oligocene age respectively. So far the environment of deposition is concerned, Biswas and Raju (1971, 1973) were in favour of an inner shelf to littoral and locally lagoonal condition of deposition.

Khari Nadi Formation — This formation is named after the Khari River. The type sections, designated by Biswas and Raju (1971, 1973), are the cliff sections on the banks of the Khari River. It is situated between the confluence of Khari with Sugandhi river near the village Goyela-Mokhra (23°25′45″; 68°49′40″) and the prominent elbow bend (23°23′00″; 68° 48′00″) about one and half miles north of Laiyari-Rampar cart track.

The lithology is composed of laminated to very thin bedded red and yellow mottled to variegated siltstone with occasional bands of grey and brown gypseous claystone. At the lower part, a bluish grey claystone bed is persistently found. Fine grained micaceous sandstone is generally found in the middle part and a few fossiliferous marl and limestone beds are frequently encountered in the middle and upper part.

The lower contact is conformable and fixed on top of the *Spiroclypeus* limestone bed. The upper contact is also conformable and gradational. It is generally fixed at the base of a thick marlite bed full of *Turritella* and echinoids.

The basalmost one foot calcareous clay in the type section has *Miogypsina complanata*. Angiospermic leaves are also known from this clay bed. Lakhanpal and Guleria (1982) described the following new species of fossil leaves from this bed: *Murraya khariensis* of Rutaceae; *Millettia asymmetrica*, *M. miocenica*, *Bauhinia kutchensis*, *Cassia miokutchensis*, *Leguminocarpon kutchensis*, *Leguminophyllum kutchensis*, *Leguminosites khariensis of* Leguminosae; *Cinnamomum miokutchensis* of Lauraceae; *Ficus khariensis* of Moraceae and *Palmacites khariensis* of Palmae.

Biswas and Raju (1971, 1973) think that the environment of deposition of this formation varies from tidal flat to littoral and shallow marine environment of a slowly transgressive sea.

Vinjhan Shale — The village Vinjhan (23° 07′13″; 69°01′30″) provides the name for this formation. The type section is best exposed along the Kankawati River between a locality (23°06′07″; 69°03′03″) north of Vinjhan and a locality (23°05′23″; 69°01′13″) about one mile south of Vinjhan. The formation is divisible into two distinct members.

Biswas and Raju (1971, 1973) called the basal one as the Chhasra Member after the village Chhasra (23°21′20″; 68°46′40″). The type section is exposed along the Khari River from the top of the marlite bed full of *Turritella* to a locality about one mile south of Chhasra Village. The lithology is made up of grey and khaki coloured, laminated, gypseous shales and claystones with alternation of thin, hard, yellowish, highly fossiliferous, argillaceous limestones.

The upper siltstone member is most developed along the Kankawati River from a locality just east of Vinjhan to a locality about one mile south of Vinjhan. This member comprises micaceous siltstone alternating with laminated khaki coloured silty shales. This member is poor in animal fossils but rich in fossil woods.

The lower contact of this formation is conformable with the Khari Nadi Formation. The upper contact is, however, marked by a prominent disconformity. The environment of deposition seems to be shallow marine to littoral, whereas the siltstone member represents a regressive phase.

Sandhan Formation — This formation is named after Sandhan Village (23°01′15″; 68°59′35″). Biswas and Raju (1971, 1973) designated the type section to the exposures along the Kankawati River near the village Sandhan. It is also observed in the coastal plain of southern Kachchh in river cuttings. The basalt part of this formation is composed of coarse grained, massive sandstones, laminated siltstone and thin fossiliferous marlite bands. The middle part contains conglomerates and coarse grained sandstone. The upper part is generally hard, calcareous grits overlain by pink and mottled silty sandstones with calcareous nodules producing ‘kankars’ on weathering.

Dipterocarpoxylon malavii Ghosh & Ghosh (1959) and other angiospermic fossil woods are known from the basal member. Lakhanpal, Guleria and Awasthi (1975) described a new species of fossil wood of *Podocarpus*, viz., *P. kutchensis* from Dhaneti near Bhuj. Awasthi, Guleria and Lakhanpal (1980) described a new dicotyledonous fossil wood, i.e. *Pterospermoxylon kutchensis* resembling the modern wood of *Pterospermum*. They also described two sapindaceous woods from the same bed. Foraminifera, ostracoda and other animal fossils are also recorded from this formation.

This formation lies disconformably on the Vinjhan Shale and is overlain by alluvium and Recent flood plain deposit. Biswas and Raju (1971, 1973) attributes a probable Pliocene age for this formation. Biswas (1971) proposed a detailed chronostratigraphic classification for the Tertiary sediments of Kachchh in the tabular form. His classification has been given below with slight modifications (Table 1).

Biswas and Deshpande (1975) also produced a chronostratigraphic classification of the Tertiary rocks of Kachchh. This classification is essentially the same as was introduced by Biswas (1971) except

TABLE 1 — TERTIARY CHRONOSTRATIGRAPHY OF KACHCHH (AFTER BISWAS, 1971)

Epoch	Age	Series	Stage	Lithostratigraphy	Biota: Microfauna	Biota: Microfauna/Flora	Sedimentary facies and environment/Tectonic environment	Biostratigraphic units, zones defining boundaries	Strato-types
Holocene to Pleistocene				Rann silt, alluvium, blown sand, etc. partly consolidated Conglomerates, grits, kankars, etc. Oyster beds, raised beaches, terrace beds, etc.			Mostly arenaceous facies. Marine fluvial and aeolian		
				----- Unconformity ---					
		Miliolite Formation 16 m (+)		Pelletoidal calcareous sandstones, sandy pelmicrites and sandy comicrites	Species of Lagenidae, Rotalidae, Miliolidae	None	Calcareous arenites Aeolian		Saurashtra coasts. In Kachchh best outcrops are seen in Charwar and Dhola ranges
				--- Disconformity ---					
Pliocene to ?Pleistocene		Kankawati Series 300 m (+)		Grey sandstones, pink fossiliferous calcareous grits and conglomerates with subordinate shales	*Textularia* sp., *Quinqueloculina* sp., *Spiroloculina* sp., *Nonion* sp., *Rotalla* sp., *Elphidium* sp. etc.	*Balanus* (?) sp., *Ostrea* sp., *Dipterocarpoxylon malavii* and tricolpate pollen	Mostly arenaceous with minor shales and carbonate rocks. Transitional environment — estuarine to deltaic	Poorly fossiliferous to locally fossiliferous	Kankawati River in south-western Kachchh from one mile south of Vinjhan to Sandhan
				--- Disconformity ---					
Miocene	Helvetian to Burdigalian		Vinjhan Stage 140 m	Grey and khaki clay whit fossiliferous marls	*Miogypsina globulina*, *M. droogeri*, *Austrotillina howchini*, *Archais* sp. and several ostracodes	*Ostrea latimarginata*, *O. angulata*, *Breynia carinata*, *Glypeaster* sp., *Turritella*, *Conus*, *Cipris*, *Physa*, *Murex* and other gastropods, corals, bryozoa, crabs, shark teeth, etc.	Lutites and marlites. Epineritic to neritic environment	4. Poorly fossiliferous zone 3. *Ammonia* assemblage zone 2. *M. excentrica*/*M. globulina* zone 1. *M. globulina* zone	For the Series: Khari River Section of the south-western Kachchh between Goyela and Chhasra. For the Vinjhan Stage: In Kankawati river between Vinjhan and Khirasra. For the Aida Stage: Aida section of Khari River between lat. 23°25′ 50″; long. 68°49′30″
				- - Transgressive overlap - -					
	Aquitanian	Khari Series 200 m		Variegated siltstones	*M. tani*, *M. dehaarti*, *Operculina* sp., *Lipidocyclina* sp. and Ostracodes			2. *M. tani*/*M. dehaarti* zone 1. Poorly fossiliferous zone	
				- - Disconformity (feeble) - -					
Oligocene	Chattian	Ber Moti Series 38 m	Waior Stage 10 m	Banded cream coloured fossiliferous silty marls, silty shales and glauconitic sandstones and green sand beds	*Spiroclypeus ranjanae*, *Miogypsina complanata*, *M.* sp., *Bairdoppilata* sp. and several other ostracodes	*Pecten*, *Ostrea*, echinoid and sarpula common, varieties of gastropods, corals and broken bones of reptiles	Marlite facies. Epineritic environment	*Miogypsina complanata*/*M.* cf. *bermudizi* zone	Series is well exposed in stream section near Ber Mota. Waior nala cliff section about 500 yards north of Waior Village, is the type section for the Waior Stage
				--- Diastem (erosional) -					
	Lattorfian to Rupelian		Ramania Stage 30 m	Dirty white to yellowish banded marlites and impure limestones with glauconitic pellets, calcareous claystones. Presence of glauconite pellets very characteristic	*Nummulites intermedius*, *N. clipeus*, *N. fichteli*, *Operculina* sp., *Asterigerina* sp., *Lepidocylina* sp.	Varieties of gastropods and lamellibranchs, echinoid spines of *Porocidaris* and bones of reptiles. Coral bioherms common near the top	Silty carbonate facies. Epineritic environment	2. *N. fichteli-intermedius*/*Eulepidina* zone 1. *N. fichteli-intermedius* zone	The stream west of Ramania flowing between Jhulrai and Aida (tributary of Khari River), between the crossings of the Ramania-Fulrai and Goyela-Walasar cart tracks
				----- Paraconformity ---					
Eocene	Lutetian	Berwali Series	Babia Stage 35-56 m	Upper 22-40 ft Cream and buff massive silty limestone packed with foraminifera Lower 13 m Greenish grey fossiliferous calcareous clay, sandstone	*Nummulites acutus*, *N. obtusus*, *N. stemineus*, *N. beaumonti*, *Discocylina javana*, *D. dispansa*, *Alveolina elliptica* *Assilina exponens*, *Halkyardia minima*, *Dictyoconoides cookie*, *Orbulinoides beckmanni*, *G. frontosa*, *Truncorotaloides rohri*, *T. topilensis* and *Globigerapsis kugleri*	*Ostrea* sp. and other lamellibranchs, echinoids. *Eupatagus* sp., *Echinolampous* sp. etc. *Porocidaris* spines, corals, several species of lamellibranchs, gastropods including giant *Bolis* sp., *Xancus* sp. and shark teeth	Bioclastic limestones in neritic environment	4. *T. rohri* zone 3. *O. beckmanni* zone 2. *N. perforatus*-*T. topilensis* zone 1. Poorly fossiliferous zone	The series strato-type is Berwali Nadi flowing from 2 miles south of Baranda to Ber Nana. The Babia Stage is well exposed in Babia hill section
				----- Disconformity ---					
	Ypresian		Kakdi Stage 40 m (+)	Upper 14 m Grey shales and laterites Lower 25 m Brown gypseous shales and green glauconitic shales with thin fossiliferous marls and mud balls. Locally, gypseous shales with red ochre and black shales with lignite	Rare *Nummulites atacicus*, *Assilina granulosa*, *A. subspinosa*, *A. leymerie*, *N. thalicus*, *Globigerina aquiensis* and *G. wilcoxensis*	None *Vautilus* sp., *Turritella* sp., *Cardita* sp., *Mytilus* sp., *Ostrea* sp. Fossil angiospermic leaves	Mainly argillites: Littoral to lagoonal environment	3. Poorly fossiliferous zone 2. *A. granulosa*-*N. atacicus* zone 1. Poorly fossiliferous zone First appearance of marine fossils	Kakdi nadi section from Naredi to a point lat. 23°37′50″ long. 68°37′30″
				----- Disconformity ---					
Palaeocene		Madh Series 50 m (+)		Lateritic conglomerates, laterites, bauxites, tu faceous shales, sandstones, grits, bentonitic and ferruginous clays wtih volcanic ash	None	Only plant fossils: Angiospermic leaf impressions and palynological fossils	Trap-wash and volcano clastic sediments. Continental to supralittoral environment	Marine fossils absent	The area around Matanomadh. Madhwali Nadi exposes a good section of this series just south of the villages
				----- Unconformity ---					
Upper Cretaceous to ?Palaeocene		Deccan Trap Formation 450 m (+)		Dark green basalts: Alternating flows of columnar and amygdaloidal basalt. Locally intertrappean beds are present	Seen only in intertrappean beds. Only ostracodes: *Eucypris*, *Illiocypris*, *Cypris*, *Paracypria*, *Candona*, *Eucandona*	Seen only in intertrappean bed: Mainly *Physa* cf. *prinsepii*, *Paludina* sp., *Lymnea* sp.	Terrestrial lava flows		

they also compared the various stages of Kachchh with those of Sind-Baluchistan. They correlated the Madh Series of Kachchh with ?Ranikot; Berwali Series with Laki and Middle Kirthar Series; Ber Moti Series with Nari Series and Kankawati Series with Manchar Series.

PREVIOUS PALYNOLOGICAL WORK IN KACHCHH

Mathur (1963) was the pioneer worker in Kachchh who described algae, fungi, spores, pollen grains and microplanktons from the gypseous shales of western Kachchh. Among the algae, he described *Botryococcus* sp. and amongst fungi *Dyadosporites* van der Hammen (1956). The pteridophytic spores comprise monoletes as well as triletes. Besides the angiospermic pollen, he also reported number of bisaccate pollen as *Disaccites* spp. Mathur (1963) for the first time also described microplanktons as the different species of *Hystrichosphaeridium*. On the basis of palynomorphs, he ascribed a Middle Eocene for the assemblage.

It may be mentioned here that Mathur (1963) confined his studies only to the upper part of the gypseous shales exposed at Matanomadh (23°32′:68°50′) to Chhasra (23°21′:68° 48′). The gypseous shales and claystones with alternations of thin, yellowish, fossiliferous limestones which are exposed around Chhasra were placed by Biswas and Raju (1971, 1973) under Chhasra Member of the Vinjhan Shale Formation of Miocene age (Halvetian to Burdigalian). The frequent presence of bisaccate pollen and some of the types of microplanktons (Mathur, 1963, pl. 21, figs 32, 33) figured by him shows close resemblance with the assemblage described here from the Khari Nadi Formation (Miocene-Aquitanian) and Chhasra Member of the Vinjhan Shale Formation. The bisaccate pollen grains are almost absent in Eocene and Oligocene but they are quite occasionally met with in Miocene.

Mathur (1966) also described miospore from the rocks exposed around Matanomadh. The assemblage consists of a number of species of fungi, pteridophytes, gymnosperms and angiosperms. Based on the number of colpi he also instituted many new genera and species. He postulated that this polycolpate pollen grain belongs to some extinct (?) species of *Nothofagus*. The living pollen grains of *Nothofagus* are generally anguloperturate and the exine is generally bedecked with spines. These two characters are generally not met with in the specimens illustrated by Mathur (1966, pl. 2, figs 21-26). He, however, mentioned that the polycolpate pollen grains are also found in the families: Oleaceae, Rubiaceae, Euphorbiaceae, etc. So the affinity of these pollen grains may not be traced with certainty.

Mathur and Mathur (1969) recorded spores and pollen grains from the Pliocene sediments of Naera-Baraia area in south-western Kachchh. They recorded 21 species belonging to 15 genera. The assemblage comprises fungi, pteridophytic spores, gymnospermous and angiospermic pollen The pteridophytes are generally represented by *Lycopodiumsporites*, *Polypodiisporites*, (*Verrucosisporites*) and *Striatriletes* (*Cicatricosisporites*) and the angiosperms are contributed by *Palmaepollenites*, *Liliacidites* and *Graminidites*.

Venkatachala and Kar (1969a) described palynological assemblage from the bore hole no. 14 drilled near Matanomadh from the Naredi Formation (Lower Eocene). The miospores comprise 32 spore-pollen genera and 45 species out of which 9 genera are new, viz., *Rostriapollenites*, *Umbelliferoipollenites*, *Polybrevicolporites*, *Sastriipollenites*, *Pseudonothofagidites*, *Sonneratioipollis* and *Lakiapollis*. Venkatachala and Kar (1969b) also reported epiphyllous fungal remains mostly belonging to the Microthyriaceae from the same bore-hole core.

Venkatachala and Kar (1969c) pointed out the occurrence of *Barringtonia* pollen in the Naredi Formation which they assigned to *Rostriapollenites*. It may, however, be pointed out here that the genus *Rostriapollenites* is now regarded as the junior synonym of *Marginipollis* as the latter has nomenclatural priority.

Sah and Kar (1969) described pteridophytic spores consisting of 21 genera and 30 species; of them 2 genera, viz., *Lakiasporites* and *Seniasporites* and 14 species are new. Sah and Kar (1970) recovered a good miospore assemblage from the bore-holes drilled by the Directorate of Geology & Mining, Government of Gujarat around Jhulrai, Baranda and Panandhro. They described gymnospermous and angiospermic pollen grains consisting of 43 genera and 68 species. Out of these 7 genera, viz., *Dracaenoipollis*, *Verrucolporites*, *Striacolporites*, *Pellicieroipollis*, *Meliapollis*, *Ghoshiacolpites* and *Thymelaepollis* and 33 species are new.

Mathur, Soodan, Mathur, Bhatia, Juyal and Pant (1970) claimed the presence of Cenomanian-Turonian, Senonian, Lower Palaeocene and Middle Palaeocene in Kachchh on the basis of palynoflora and foraminiferal assemblages. It may be mentioned here that according to Biswas (1977) the Mesozoic sediments of Kachchh range from Bathonian (Middle Jurassic) to Aptian (Lower Cretaceous) though Rajnath (1942) mainly on structural evidences postulated Middle Cretaceous or even younger age for the upper part of the Bhuj Series.

Similarly, Mathur (1972) reported micro- and megafossils from the Kuar Bet, Pachchham Island. The palynological fossils include Lower Eocene forms, whereas the megafossils consist of *Onychiopsis* sp. and *Sphenopteris* sp. The megafossils described by Mathur (1972) from the hill point 144 belong to *Pachypteris*, according to Dr M. N. Bose (personal communication). In view of this it seems probable that the angiospermic pollen and nannofossils described by Mathur (1972) from the hill point 113 may be the contaminated ones.

Mathur and Pant (1973) also described angiospermic pollen from about 9 m, 4.5 m and 35 m thick beds exposed at the northern flank of Kanthkote dome, western flank of Torania temple dome and at the southern flank of Washtawa dome respectively. These beds according to Biswas (1971, 1977) belong to Washtawa Formation which is equivalent to Jhurio Formation of Biswas or Patcham Series of Rajnath (1942) or Pascoe (1959) in the Kachchh mainland. It may be pointed out here that Mitra, Bardhan and Bhattacharya (1979) objected the various names proposed by Biswas (1971, 1977) in his lithostratigraphic classification of Mesozoic rocks in Kachchh. They feel that the original units being based on physical contrast virtually qualify them to be regarded as rock stratigraphic units according to modern concept.

Mathur and Pant (1973) also recorded angiospermic palynomorphs from about 45 m, 9 m and 16 m thick beds exposed at the northern flank of Adhoi dome, Wanka dome and Kanthkote dome respectively which was so far considered to be a part of Wagad Sandstone Formation (Tithonian to Kimmeridgian) by Biswas (1971, 1977). As these beds have *Ammonites* at the base so the presence of typical Lower Eocene miospores in them may easily be questioned.

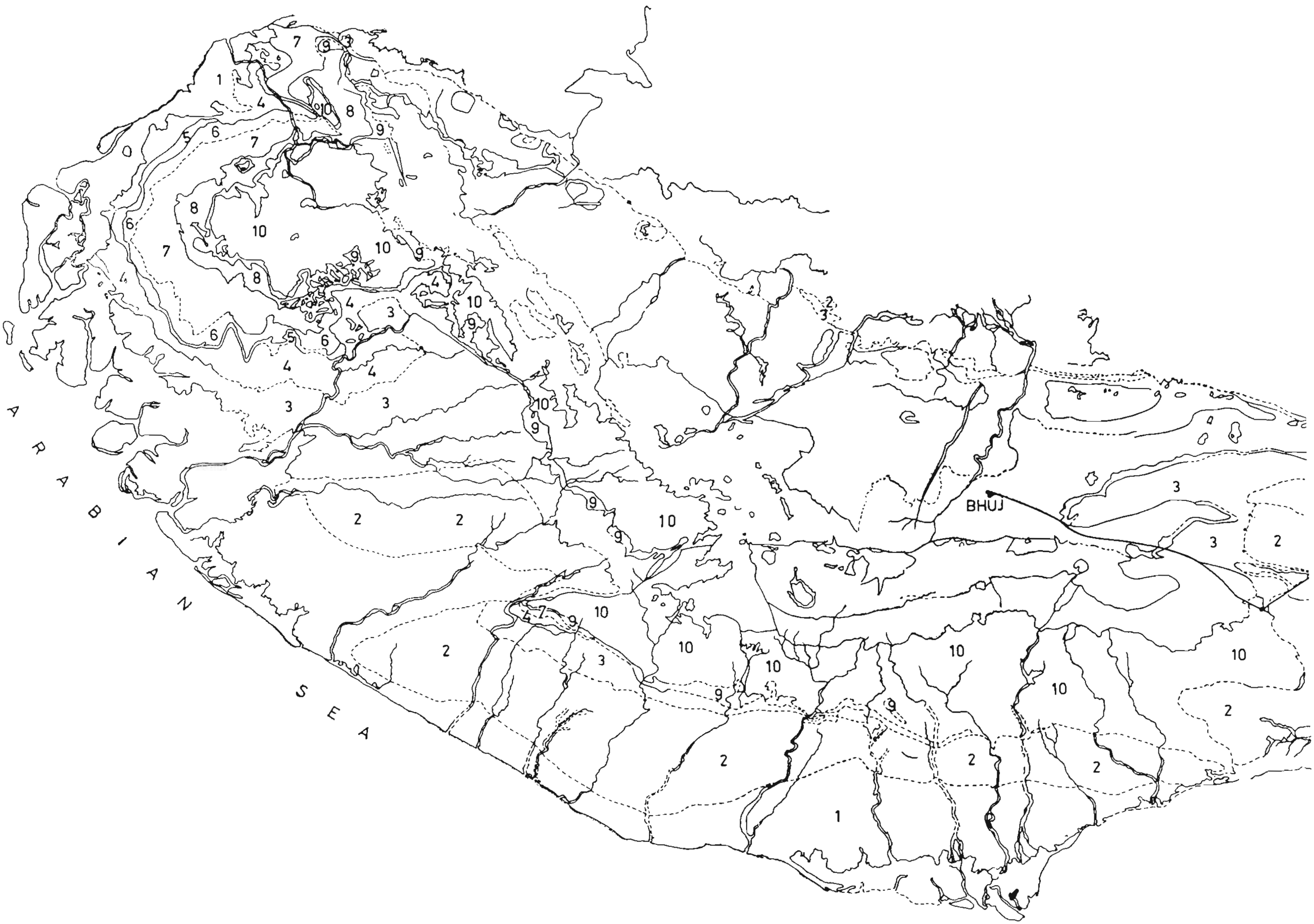
Sah and Kar (1972) while evaluating the Lower Eocene palynomorphs from the different sedimentary basins of India enumerated the stratigraphically important palynological taxa from the Palaeocene and Lower Eocene of Kachchh. They could also distinguish them on the basis of microspores.

Kar (1978) investigated the spores and pollen grains from the Naredi (Lower Eocene) and the Harudi (Middle Eocene) formations in Kachchh. He proposed *Triorites triangulus* Cenozone for the lower gypseous shale member of the Naredi Formation and *Proxapertites microreticulatus* Cenozone for the Harudi Formation.

Kar and Saxena (1976) described algal and fungal remains from the type area of Matanomadh Formation (Palaeocene) comprising 20 genera and 27 species. Out of these, 10 genera and 13 species belong to algae and the rest 10 genera and 14 species to fungi. They also inferred on the good percentage of microthyriaceous fungi that during Palaeocene, Matanomadh and its vicinity were witnessing a tropical and humid climate favouring a luxuriant vegetation of pteridophytes and angiosperms.

Kar (1977, 1979) worked out the palynostratigraphy of the Maniyara Fort Formation (Oligocene) and reported 39 genera and 33 identifiable species. On the basis of palynological fossils he divided the whole formation into 3 cenozones, viz., *Polysphaeridium microtriainum* Cenozone, *Trisyncolpites ramanujamii* Cenozone and *Aplanosporites robustus* Cenozone.

Saxena (1977a, 1977b) provided the lithostratigraphic classification and defined



TEXT-FIG. 1 — Showing the different Tertiary stages in Kachchh. 1, Recent and Pleistocene deposits; 2, Kankawati Series; 3, Vinjhan Stage; 4, Aida Stage; 5, Waior Stage; 6, Ramonia Stage; 7, Babia Stage; 8, Kakdi Stage; 9, Madh Series; and 10, Deccan Trap.

the stratigraphic status of the Matanomadh Formation. Saxena (1978) reported 14 genera and 27 species of pteridophytes from the same formation. He in 1979 also pointed out the occurrence of reworked Mesozoic miospores, viz., *Concavissimisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes (1963), *Impardecispora* Venkatachala, Kar & Raza (1969), *Klukisporites* Couper (1958), *Boseisporites* (Dev) Bharadwaj & Kumar (1972), *Contignisporites* Dettmann (1963), *Callialasporites* (Dev) Bharadwaj & Kumar (1972) and *Schizosporis* Cookson & Dettmann (1959) in the Matanomadh Formation.

Kar (1979) described few species of fossil algae, viz., *Lithothamnium* sp. cf. *L. validium*, Foslie (1895), *Lithothamnium* sp., *L. bofilli* Lemoine (1939) and *Lithophyllum* from the Fulra Limestone Formation (Middle Eocene).

Saxena (1980) recorded the gymnospermous and angiospermic pollen grains comprising 31 genera and 59 species from the Matanomadh Formation.

Kar and Saxena (1982) recovered 60 genera and 66 species of palynomorphs from the bore-hole core no. 27, drilled near Rataria by the Directorate of Geology and Mining, Government of Gujarat. The assemblage consists of microplanktons, fungal spores and microthyriaceous bodies, pteridophytic spores, gymnospermic and angiospermous pollen. This bore core was dated as Lower Eocene by the above mentioned organisation, while others ascribed Miocene age to the adjacent sedimentary outcrops. On the basis of the palynological assemblage, it was inferred that the bore-core should be of Middle Eocene in age.

PRESENT WORK

The slides deposited carlier in the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow by Venkatachala and Kar (1969a, 1969b, 1969c), Sah and Kar (1969, 1970), Kar and Saxena (1976, 1982), Kar (1977, 1979) and Saxena (1978, 1980) were restudied. Besides, the slides were also prepared from fresh collection from the different Tertiary type localities of Kachchh to verify the previous observations. Many bore-cores supplied by the Directorate of Geology and Mining, Government of Gujarat from the Naredi Formation were also studied.

PALYNOLOGICAL FOSSILS FROM MATANOMADH

Genus — *Cyathidites* Couper, 1953

Cyathidites australis Couper, 1953
C. minor Couper, 1953

Genus — *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, 1956

Lygodiumsporites lakiensis Sah & Kar, 1969
L. eocaenicus Dutta & Sah, 1970
L. pachyexinus Saxena, 1978

Genus — *Todisporites* Couper, 1958

Todisporites major Couper, 1958
T. minor Couper, 1958
T. kutchensis Sah & Kar, 1969

Genus — *Dandotiaspora* Sah, Kar & Singh, 1971

Dandotiaspora dilata (Mathur) Sah, Kar & Singh, 1971
D. plicata (Sah & Kar) Sah, Kar & Singh, 1971
D. telonata Sah, Kar & Singh, 1971
D. pseudoauriculata Sah, Kar & Singh, 1971

Genus — *Dictyophyllidites* (Couper) Dettmann, 1963

Dictyophyllidites granulatus Saxena, 1978

Genus — *Intrapunctisporis* Krutzsch, 1959

Intrapunctisporis intrapunctis Krutzsch, 1959
I. apunctis Krutzsch, 1959

Genus — *Osmundacidites* Couper, 1953

Osmundacidites microgranifer Sah & Jain, 1965
O. minutus Sah & Jain, 1965
O. cephalus Saxena, 1978

Genus — *Leptolepidites* Couper, 1953

Leptolepidites major Couper, 1958

Genus — *Foveosporites* Balme, 1957

Foveosporites sp.

Genus — *Lycopodiumsporites* Thiergart, 1938

Lycopodiumsporites bellus Sah & Kar, 1969
L. umstewensis Dutta & Sah, 1970

Genus — *Cicatricosisporites* Potonié & Gelletich, 1933

Cicatricosisporites australiensis (Cookson) Potonié, 1956
Cicatricosisporites sp.

Genus — *Gleicheniidites* (Ross) Delcourt & Sprumont, 1955

Gleicheniidites senonicus Ross, 1949

Genus — *Polypodiaceaesporites* Thiergart, 1938

Polypodiaceaesporites levis Sah, 1967
P. major Saxena, 1978

Genus — *Polypodiisporites* Potonié, 1934

Polypodiisporites repandus Takahashi, 1964
P. mawkmaensis Dutta & Sah, 1970
Polypodiisporites sp.

Genus — *Retipilonapites* Ramanujam, 1966

Retipilonapites cenozoicus Sah, 1967

Genus — *Couperipollis* Venkatachala & Kar, 1969a

Couperipollis wodehousei (Biswas) Venkatachala & Kar, 1969a
C. brevispinosus (Biswas) Venkatachala & Kar, 1969a
C. rarispinosus (Sah & Dutta) Venkatachala & Kar, 1969a
C. kutchensis Venkatachala & Kar, 1969a
C. achinatus Sah & Kar, 1970
C. robustus Saxena, 1979

Genus — *Matanomadhiasulcites* gen. nov.

Matanomadhiasulcites (*Liliacidites*) *maximus* (Saxena) comb. nov.
Matanomadhiasulcites (*Liliacidites*) *kutchensis* (Saxena) comb. nov.

Genus — *Arecipites* Wodehouse, 1933

Arecipites (*Liliacidites*) *matanomadhensis* (Saxena) comb. nov.

Genus — *Palmidites* Couper, 1953

Palmidites maximus Couper, 1953

Genus — *Palmaepollenites* Potonié, 1951

Palmaepollenites kutchensis Venkatachala & Kar, 1969a
P. nadhamunii Venkatachala & Kar, 1969a
P. ovatus Sah & Kar, 1970
P. plicatus Sah & Kar, 1970

Genus — *Dracaenoipollis* Sah & Kar, 1970

Dracaenoipollis circularis Sah & Kar, 1970

Genus — *Spinizonocolpites* Muller, 1968

Spinizonocolpites echinatus Muller, 1968

Genus — *Proxapertites* van der Hammen, 1956

Proxapertites microreticulatus Jain, Kar & Sah, 1973
P. assamicus (Sah & Dutta) Singh, 1975

Genus — *Tricolpites* (Erdtman) Potonié, 1960

Tricolpites reticulatus Cookson, 1947
T. parvireticulatus Sah, 1967
T. crassireticulatus Dutta & Sah, 1970
T. minutus Sah & Kar, 1970
T. baculatus Jain, Kar & Sah, 1973
T. retibaculatus Saxena, 1979
T. matanomadhensis Saxena, 1979

Genus — *Intrareticulites* gen. nov.

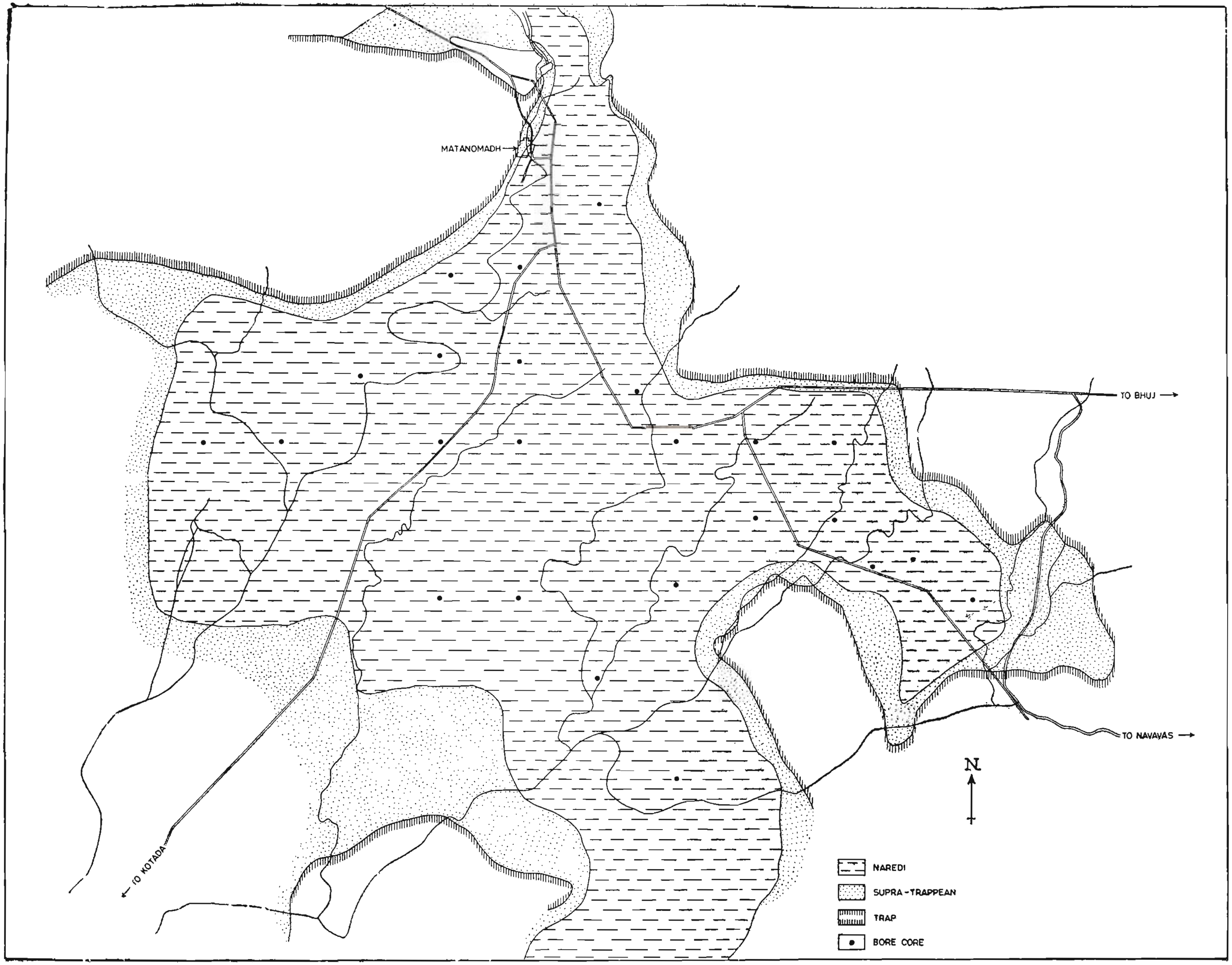
Intrareticulites (*Tricolpites*) *brevis* (Sah & Kar) comb. nov.

Genus — *Verrutricolpites* Pierce, 1961

Verrutricolpites perverrucatus Ramanujam 1966

Genus — *Platoniapollenites* Sah & Kar, 1974

Platoniapollenites sp.



TEXT-FIG. 2 — Showing the location of bore-cores studied around Matanomadh.

Genus — *Psilastephanocolpites* Leidelmeyer, 1966

Psilastephanocolpites guaduensis (van der Hammen) Saxena, 1980

Genus — *Ghoshiacolpites* Sah & Kar, 1970

Ghoshiacolpites globatus Sah & Kar, 1970

Genus — *Retistephanocolpites* Leidelmeyer emend. Saxena, 1982

Retistephanocolpites kutchensis Saxena, 1979

Retistephanocolpites (*Polycolpites*) *granulatus* (Sah & Kar) comb. nov.
Retistephanocolpites (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov.

Genus — *Lakiapollis* Venkatachala & Kar, 1969a

Lakiapollis ovatus Venkatachala & Kar, 1969a

Genus — *Retitribrevicolporites* gen. nov.

Retitribrevicolporites (*Lakiapollis*) *matanomadhensis* (Venkatachala & Kar) comb. nov.

Genus — *Paleosantalaceaepites* (Biswas) Dutta & Sah, 1970

Paleosantalaceaepites elipticus Sah & Kar, 1970
P. minutus Sah & Kar, 1970

Genus — *Verrucolporites* Sah & Kar, 1970

Verrucolporites verrucus Sah & Kar, 1970

Genus — *Striacolporites* Sah & Kar, 1970

Striacolporites cephalus Sah & Kar, 1970
S. ovatus Sah & Kar, 1970

Genus — *Favitricolporites* Sah, 1967

Favitricolporites retiformis Sah, 1967

Genus — *Palaeocoprosmadites* Ramanujam, 1966

Palaeocoprosmadites arcotense Ramanujam, 1966

Genus — *Meliapollis* Sah & Kar, 1970

Meliapollis ramanujamii Sah & Kar, 1970
M. navelei Sah & Kar, 1970
M. quadrangularis (Ramanujam) Sah & Kar, 1970
M. meliodes (Ramanujam) Sah & Kar, 1970

Genus — *Dermatobrevicolporites* gen. nov.

Dermatobrevicolporites (*Meliapollis*) *triangulus* (Saxena) comb. nov.

Genus — *Triangulorites* gen. nov.

Triangulorites (*Triorites*) *bellus* (Sah & Kar) comb. nov.
Triangulorites (*Triorites*) *triradiatus* (Saxena) comb. nov.

Genus — *Proteacidites* Cookson, 1950

Proteacidites protrudus Sah & Kar, 1970

Genus — *Triporopollenites* (Pflug) Thomson & Pflug, 1953

Triporopollenites multiformis (Ramanujam) Saxena, 1979

Genus — *Trilatiporites* Ramanujam, 1966

Trilatiporites cooksoni Ramanujam, 1966
T. kutchensis Venkatachala & Kar, 1969a

Genus — *Sonneratioipollis* Venkatachala & Kar, 1969a

Sonneratioipollis bellus Venkatachala & Kar, 1969a

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

Pseudonothofagidites kutchensis Venkatachala & Kar, 1969a

Genus — *Kielmeyerapollenites* Sah & Kar, 1974

Kielmeyerapollenites eocenicus Sah & Kar, 1974

SYSTEMATIC DESCRIPTION

Genus — *Cyathidites* Couper, 1953

Type Species — Cyathidites australis Couper, 1953.

Cyathidites australis Couper, 1953

Pl. 1, fig. 1

1978 *Cyathidites australis* Couper: Saxena, p. 449, pl. 1, fig. 1.

Diagnosis — (*after Couper, 1953*) — Free anisopolar, trilete, laesurae clearly defined, long, always over two-thirds of the radius of spore. Spores triangular, apices broadly rounded and sides concave between apices in polar view. Both proximal and distal surfaces convex, distal markedly so. Exine psilate, size range 54-(60)-77 μm.

Remarks — Couper (1953) thought that the spores assignable to *Cyathidites australis* may belong to a tree fern. The extant to which spores of *Cyathea dealbata* closely resemble *C. australis* except of their smaller size. Besides, the fossil spores of *Cladophlebis lobifolia* Phill. and *Thyrsopteris elegans* are very much similar to *C. australis*. Couper (1953) remarked that the possibility of *Cyathidites australis*, to be the spores of *Cladophlebis*, cannot be ruled out. The spores comparable to *C. australis* have also been reported by Harris (1961) are: *Coniopteris simplex* L. & H., *C. burejensis* Zal., *C. bella* Harris and *C. murrayana* Brong.

Holotype — Couper, 1953, pl. 2, fig. 11.

Type Locality — Ohika beds, L 12, Jurassic, New Zealand.

Occurrence — Exposures near the road, Matanomadh.

Cyathidites minor Couper, 1953

Pl. 1, fig. 2

1978 *Cyathidites minor* Couper : Saxena, p. 449, pl. 1, fig. 1.

Diagnosis (*after Couper, 1953*) — Free anisopolar, trilete, laesurae distinct, long. Spores triangular to subtriangular, apices very broadly rounded and sides concave in polar view. Exine psilate, 1.5 μm thick, appears more delicate than in *C. australis* as the spores crumple readily, size range 31-(35)-45 μm.

Remarks — Couper (1953) opined that the spore of *Cyathidites minor* is similar to the spores of *Coniopteris hymenophylloides* Brong. illustrated by Hamshaw-Thomas (1912). He also observed that amongst the spores of the present day fern, growing in New Zealand, *Cyathea smithii*, *C. colensoi* and *C. novae-zealandie* broadly resemble *C. minor*. The extant spores of *Lophosoria quadripinnata* figured by Kremp and Kawasaki (1972, p. 63, fig. 124) and *Pteridanetium citrifolium* (Kremp & Kawasaki, 1972, p. 137, fig. 272) are also similar to *C. minor* in general organisation.

Holotype — Couper, 1953, pl. 2, fig. 13.

Type Locality — Ohika beds, L 12, Jurassic, New Zealand.

Occurrence — Exposures near the road and on the western side of the village Matanomadh.

Genus — *Lygodiumsporites* Potonié, Thomson & Thiergart emend. Potonié, 1956

Type Species — Lygodiumsporites adriensis (Potonié & Gelletich) Potonié, Thomson & Thiergart, 1950.

Lygodiumsporites lakiensis Sah & Kar, 1969

Pl. 1, fig. 3

1978 *Lygodiumsporites lakiensis* Sah & Kar : Saxena, p. 449, pl. 1, fig. 3.

Diagnosis (*after Sah & Kar, 1969*) — Spores subtriangular size range 50-60 μm, trilete distinct, extending up to two-thirds the radius; exine laevigate. Spores mostly subtriangular, sometimes triangular.

Occurrence — Exposures near the tank, and the road, Matanomadh.

Holotype — Sah & Kar, 1969, pl. 1, fig. 16.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Lygodiumsporites eocenicus Dutta & Sah, 1970

1978 *Lygodiumsporites eocenicus* Dutta & Sah : Saxena, p. 449, pl. 1, fig. 4.

Diagnosis (*after Dutta & Sah, 1970*) — Size range 60-90 μm, holotype 73 μm, amb convexedly triangular with broadly rounded angles; trilete mark usually distinct, laesurae reaching about half of the spore radius or slightly less, with occasionally open lips. Exine uniformly thick, ornamentation finely scabrate.

Holotype — Dutta and Sah, 1970, pl. 2, fig. 33; size 73 μm; slide no. 8/3.

Type Locality — Cherra Sandstone, Lower Eocene, Umstew, Meghalaya.

Occurrence — Exposures near the road, Matanomadh.

Lygodiumsporites pachyexinus Saxena, 1978

Pl. 1, figs 4, 5, 16

1978 *Lygodiumsporites pachyexinus* Saxena, p. 449, pl. 1, figs 5, 6.

Diagnosis (*after Saxena, 1978*) — Spores triangular-subtriangular in polar view, 40-65 μm. Trilete, rays extending up to two-thirds radius, commissure distinct. Exine up to 6 μm thick, laevigate.

Holotype — Saxena, 1978, pl. 1, fig. 5; size 52 μm; slide no. 4766/12.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Todisporites* Couper, 1958

Type Species — *Todisporites major* Couper, 1958.

Remarks — Couper (1958) instituted *Todisporites* to accommodate the dispersed spores of *Todites*, viz., *T. goeappertianus* (Munster) Krasser illustrated by Harris (1931) from the Rhaetic-Liassic of Greenland; *T. williamsonii* Brong. from the Yorkshire (Middle Jurassic) of U.K. and *Todites princeps* (Presel.) Goth. *Todisporites major*, the type species of the genus as seen from the illustration, is subcircular, laevigate with prominent trilete rays extending up to two-thirds radius. The labra seem to be quite broad and raised in some specimens (Couper, 1953, pl. 16, fig. 8).

Todisporites major Couper, 1958

Pl. 1, fig. 6

1978 *Todisporites major* Couper : Saxena, p. 449, pl. 1, fig. 7.

Diagnosis (*after Couper, 1958*) — Trilete, laesurae distinct, long (ratio length laesurae to radius of spore ±0.72 to 0.88, mainly 0.83); equatorial contour circular but frequently folded; exine 1-1.5 μm thick and unsculptured. Size range 52-78 (60) μm in equatorial diameter.

Holotype — Couper, 1958, pl. 16, fig. 6.

Type Locality — Yorkshire, Middle Jurassic, U.K.

Occurrence — Exposures near the road and in front of Dak Bungalow, Matanomadh.

Todisporites minor Couper, 1958

Pl. 1, figs 7, 17

1978 *Todisporites minor* Couper : Saxena, p. 449, pl. 1, fig. 8.

Diagnosis (*after Couper, 1958*) — Smaller in size but otherwise as for *T. major*. Size range 32 (45)-50 μm in equatorial diameter.

Remarks — *Todisporites minor* illustrated by Couper (1958) seems to have an incipient inner body. The trilete rays are well developed and extend up to three-fourths of radius. The spore assigned to *T. minor* by Saxena (1978, pl. 1, fig. 8) has no incipient inner body and the trilete rays extend only half of the radius.

Holotype — Couper, 1958, pl. 16, fig. 9.

Type Locality — Yorkshire, Middle Jurassic, U.K.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Todisporites kutchensis Sah & Kar, 1969

Pl. 5, figs 3, 11

1978 *Todisporites kutchensis* Sah & Kar: Saxena, p. 449, pl. 1, fig. 9.

Diagnosis (*after Sah & Kar, 1969*) — Spores circular, size range 70-85 μm, trilete, rays extending up to two-thirds of radius; exine laevigate.

Holotype — Sah and Kar, 1969, pl. 1, fig. 8; size 80 μm; slide no. 3347/1.

Type Locality — Bore-core no. 36, Lower Eocene, Kachchh.

Occurrence — Exposures near the road and tank at Matanomadh.

Genus — *Dandotiaspora* Sah, Kar & Singh, 1971

Type Species — *Dandotiaspora dilata* (Mathur), Sah, Kar & Singh, 1971.

Remarks — Sah, Kar and Singh (1971) instituted this genus after Dandot, Pakistan from where Vimal (1952) first reported its occurrence. This genus is characterised by triangular-subcircular shape, trilete rays, laevigate and occasionally intrastructured exine which is thickened on distal side in various ways opposite to the haptotypic mark. They proposed five species, viz. *Dandotiaspora dilata*, *D. plicata*, *D. telonata*, *D. pseudoauriculata* and *D. densicorpa* mostly on the basis of thickening of the exine on distal side.

Regarding the thickening on the distal side Mahabale (1978) thought that they might be oil bearing cavities coalescing together at suitable places on the distal surface. He observed oil bearing globules in the spores of *Schizoloma heterophylla*. This species is found in numerous thickets along the water courses and muddy banks of fast flowing streams at high altitude of Assam and Western Ghats restricting itself to moisture laden rocky areas or humus rich forest floor.

It may be pointed out here that the photo-illustration of the spores of *Schizoloma encifolia* (Mahabale, 1978, pl. 2, figs 9, 10) provided by him shows some globular bodies distributed all over and not coalescing in a particular place. The distal thickening in the spores assignable to *Dandotiaspora* is very regular and is always found in particular place, in association with the haptotypic mark. Whether the thickening are cell organelles or globular bodies containing oil cannot be said with certainty. Besides *Schizoloma*, oil globules are also found in *Schiostege lydgatei* (Kremp & Kawasaki, 1972, p. 43, fig. 83), *Anopteris hexagona* (Kremp & Kawasaki, 1972, p. 44, fig. 85), *Neurocallis praestanissima* (Kremp & Kawasaki, 1972, p. 45, fig. 87) and others. Mahabale (1978) also opined that *Dandotiaspora* may not be a single genus but a genus complex and its different species may represent different genera and in some cases species of the same genus.

The spores of *Gymnosphaera glabra* illustrated by Kremp and Kawasaki (1972, p. 66, fig. 129) closely resemble *Dandotiaspora dilata* in the presence of exinal thickening at the ray ends. According to Kremp and Kawasaki (1972) the exine in *G. glabra* is, however, more thickened at the apices providing a triquete condition. The size range is also much smaller (31-34 $\times$ 24-31 μm) than the *Dandotiaspora dilata*.

Working on dispersed fossil spores has its inherent draw backs and the classification is mostly based on the morphographic characters. So in the case of all the form genera this question may be raised but cannot be solved. Singh, Singh and Sah (1979) emended the diagnosis of *Dandotiaspora* believing that the exine is variably thickened along the haptotypic mark or near ray-ends. A number of specimens have been restudied by the present author on this point and it has been reaffirmed that the thickening is present always on the distal side. The investigation of Mahabale (1978) and Saxena (1978) on this genus and its allied living forms also corroborates the above statement. So the emendation made by Singh, Singh and Sah (1979) has not been followed.

Besides, they also included *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh (1971) and *D. pseudoauriculata* Sah, Kar & Singh (1971) as junior synonyms of *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh (1971). *Dandotiaspora plicata* has crescent-shaped thickenings at the ray ends on the distal side, whereas *D. dilata* has subcircular thickenings at the ray ends. In Kachchh, *D. dilata* is restricted only to Palaeocene while *D. plicata* is found from Palaeocene to Miocene in many places (Saxena, 1978; Kar, 1979; Kar & Jain, 1981). If *D. plicata* is merged with *D. dilata* then the stratigraphic importance of the latter is lost. Moreover, both the species occur together in Matanomadh Formation (Palaeocene) but *D. dilata* is absent in the Eocene sediments. It obviously indicates that these two species are different from one another; otherwise both the species should be found from Palaeocene to Eocene together in the same sediments. Similarly, *D. pseudoauriculata* is also not found in association with *D. plicata* in Oligocene and Miocene. *D. pseudoauriculata* is distinguished from *D. dilata* by its presence of distal exinal thickenings only at species to provide a pseudoauriculate appearance.

Singh, Singh and Sah (1979) mentioned in the emended diagnosis of *D. dilata* that the trilete rays are bifurcating at tips and the trilete rays are enclosed within the elevated lips. They also stated that the exinal thickening is intimately associated with the abnormally thickened labra, raised terminating as semi-circular to globular feature at the ray ends.

It may be mentioned here that in most of the specimens assignable to *D. dilata* the ray ends are not bifurcating. The photomicrographs provided by them (Singh, Singh & Sah, 1979; pl. 1, figs 4, 9) clearly show the ray ends without bifurcation. The same illustrations also clearly show that the trilete rays are not enclosed within the elevated lips. Singh, Singh and Sah (1979) observed exinal thickening intimately associated with the abnormally thick labra but they did not mention whether it is found on the proximal or distal side. Similarly, in the emended diagnosis proposed by them they also did not elucidate on this matter. Singh and Singh (1978), however, while studying the Palaeocene subsurface assemblages from the Garo hills, Meghalaya commented that in *D. dilata* the globular thickening at the ray end is on the proximal face of the exine. They also believed that the labra is thickened all along the trilete mark and is sharply dilated into a more or less circular configuration at the end of each ray.

The abnormally thickened labra is, however, not found in the specimens illustrated by them. The photomicrographs provided by Singh, Singh and Sah (1979, pl. 1, figs 4, 7, 9, 14 etc.) do not show any thickening of the labra along the trilete rays except the globular thickening of the exine on the distal surface. So their statement is not corroborated by their illustration of the specimens assigned to *D. dilata*.

Guzmán (1967) recorded some trilete spores (pl. 30, figs 4-4b) from the Upper Los Cuervos and Mirador formations (Lower and Middle Eocene), Tibu' area, Colombia which closely resembles *Dandotiaspora dilata*.

Dandotiaspora dilata (Mathur) Sah, Kar & Singh, 1971

Pl. 1, fig. 8

1978 *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh: Saxena, p. 450, pl. 1, figs 10, 11.

Diagnosis (*after Sah, Kar & Singh, 1971*) — Spores triangular-subtriangular in polar view, 56-93 μm. Trilete, rays up to three-fourths of radius. Exine laevigate, sometimes intrapunctate, roundly thickened on distal side opposite to ray ends.

Remarks — This species is quite wide spread in the Indian subcontinent. It was first reported by Vimal (1952) from the Dandot lignites, Pakistan. Subsequently, this species was found in Laitryngew, Daranggiri and Rongrenggiri coalfields and Tura Formation of Meghalaya. In Kachchh, it is restricted only to the Matanomadh Formation and hence is generally regarded as an index fossil for the Palaeocene in Kachchh.

Holotype — Mathur, 1966, pl. 1, fig. 6.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road and in front of the Dak Bungalow, Matanomadh.

Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh, 1971

Pl. 2, fig. 1

1978 *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh: Saxena, p. 450, pl. 1, fig. 12.

Diagnosis (*after Sah, Kar & Singh, 1971*) — Spores triangular-subtriangular in polar view, 45-75 μm. Trilete, rays extending half to three-fourths of radius. Exine 1.4-3 μm thick, laevigate, sometimes intrastructured at contact area, may be more thickened at apices, exine on distal surface forms crescent-shaped thickening at ray ends, sometimes they are hardly perceptible.

Remarks — It has already been stated that this species has a long vertical range and wide horizontal distribution. Sah and Kar (1969) first reported this from the Lower Eocene of Kachchh. They also reported it from the Palana lignites (Lower Eocene) of Rajasthan. Kar and Jain (1981) found the same species from the Neogene sediments of Kerala.

Holotype — Sah and Kar, 1969, pl. 1, fig. 11; size 45 μm; slide no. 3364/8.

Occurrence — Exposures near the road, in front of the Dak Bungalow, western side of the village Matanomadh.

Dandotiaspora telonata Sah, Kar & Singh, 1971

Pl. 1, fig. 9

1978 *Dandotiaspora telonata* Sah, Kar & Singh: Saxena, p. 450, pl. 1, fig. 13.

Diagnosis (after Sah, Kar & Singh, 1971) — Spores triangular-subtriangular in polar view, 56-87 μm. Trilete, rays extending up to three-fourths of radius. Exine 2-3.5 μm thick, sometimes more thickened at apices, laevigate, sometimes intrapunctate at inter-radial areas, exine distally thickened opposite to trilete rays throughout, sometimes bifurcating or producing globular heads at ray ends.

Remarks — This species is more common in Meghalaya and Assam than in Kachchh. Singh, Singh and Sah (1975) proposed *Dandotiaspora telonata* Cenozone to demarcate the Middle Palaeocene assemblage from the subsurface samples of Garo hills, Meghalaya. Within this cenozone they also proposed various subzones. *Dandotiaspora pseudoauriculata* and *D. densicorpa* are also found in good percentage in this cenozone.

Holotype — Sah, Kar & Singh, 1971, pl. 2, fig. 8; size 64 μm; slide no. 3665.

Type Locality — Damalgiri, Lower Eocene, Garo hills, Assam.

Occurrence — Exposures near the road, western side of the village Matanomadh.

Dandotiaspora pseudoauriculata Sah, Kar & Singh, 1971

1978 *Dandotiaspora pseudoauriculata* Sah, Kar & Singh: Saxena, p. 450, pl. 1, fig. 14.

Diagnosis (after Sah, Kar & Singh, 1971) — Spores triangular-subtriangular in polar view, 49-86 μm. Trilete rays up to three-fourths of radius. Exine laevigate, 2-4 μm thick, sometimes intrapunctate, puncta more prominent in contact area, distally exine thickened opposite to ray ends, thickenings extend at apices to form pseudoreticulate structure.

Holotype — Sah, Kar & Singh, 1971, pl. 1, fig. 14; size 66 μm; slide no. 3661.

Type Locality — Damalgiri, Lower Eocene, Garo hills, Meghalaya.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Dictyophyllidites* Couper emend. Dettmann, 1963

Type Species — *Dictyophyllidites harrisii* Couper, 1958.

Remarks — This genus is generally found in the Mesozoic and is very much similar to the spores of *Dictyophyllum rugosum* L.H., *Phlebopteris angustiloba* Presl. and *Matonidium goepperti* Ettingh. Couper (1958), however, instituted this genus for the dispersed spores of the Jurassic fern *Dictyophyllum*. Kar and Bose (1976) reported ?*Dictyophyllidites* sp. from the *assise a' couches de houille* (Permian) of Zaire.

Mention may be made here that the genera *Dictyophyllidites* Couper emend. Dettmann (1963) and *Toroisporis* Krutzsch (1959) closely resemble each other. Both are triangular in shape, laevigate and having thickening all along the haptotypic mark. Though Krutzsch (1959) described *Toroisporis* to accommodate the Tertiary spores from the brown coal it is very difficult to distinguish from *Dictyophyllidites*. As Couper validly published this genus in 1958 so *Toroisporites* Krutzsch (1959) is regarded here as a junior synonym of *Dictyophyllidites*.

Amongst the living ferns, triangular-subtriangular spores with laevigate exine and kyrtome are found in *Cheiropleuria bicuspis* (Kremp & Kawasaki, 1972, fig. 215, p. 109), *Trichopteris corcovadensis* (Kremp & Kawasaki, 1972, fig. 127, p. 65), *Hicriopteris glauca* (Devi, 1977, fig. 119, p. 82) and *Schizocaena moluccana* (Kremp & Kawasaki, 1972, fig. 131, p. 66).

In the opinion of Kar and Jain (1981) the presence of kyrtome in a number of unrelated genera in the extant pteridophytes indicates that the thickening around the haptotypic mark evolved many times independently. In the dispersed state, these spores are very difficult to identify the living one because the spores apparently look alike and they have more or less same size range.

Dictyophyllidites granulatus Saxena, 1978

Pl. 1, fig. 10

1978 *Dictyophyllidites granulatus* Saxena, p. 450, pl. 1, fig. 15.

Diagnosis (*after Saxena, 1978*) — Spores triangular-subtriangular in polar view, 52-70 μm. Trilete, rays distinct, extending up to three-fourths radius and surrounded by thickened, raised, granulose kyrtome, commissure distinct. Exine 1-2.5 μm thick, granulose, grana more concentrated towards the contact area.

Remarks — Most of the species belonging to *Dictyophyllidites* have laevigate exine. But *D. pectinataeformis* (Bolkhovitina) Dettmann (1963) possesses granulose and very thick exine (3.5-5 μm).

Holotype — Saxena, 1978, pl. 1, fig. 15; size 68 μm; slide no. 4777/10

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — West side of the village Matanomadh.

Genus — *Intrapunctisporis* Krutzsch, 1959

Type Species — *Intrapunctisporis intrapunctis* Krutzsch, 1959.

Intrapunctisporis intrapunctis Krutzsch, 1959

1978 *Intrapunctisporis intrapunctis* Krutzsch: Saxena, p. 450, pl. 1, fig. 18.

Diagnosis (*after Krutzsch, 1959*) — Triangular-subtriangular spores. Exine 1-2 μm thick with intrapunctate structure. Size more or less 75 μm.

Holotype — Krutzsch, 1959, pl. 5, fig. 30.

Type Locality — Brown Coal, Tertiary, Germany.

Occurrence — Exposures near the road, west side of the village Matanomadh.

Intrapunctisporis apunctis Krutzsch, 1959

Pl. 21, figs 5, 6

1978 *Intrapunctisporis apunctis* Krutzsch: Saxena, p. 450, pl. 1, fig. 19.

Diagnosis (*after Krutzsch*, 1959) — Spores triangular-subcircular. Exine 1.5-2 μm thick, laevigate-weakly intrapunctate. Trilete, rays extending up to two-third radius. Size more or less 60 μm.

Holotype — Krutzsch, 1959, pl. 5, fig. 32.

Type Locality — Brown Coal, Tertiary, Germany.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Osmundacidites* Couper, 1953

Type Species — *Osmundacidites wellmanii* Couper, 1953.

Remarks — Couper (1953) instituted this genus from the Jurassic of New Zealand to accommodate the dispersed spores of *Osmunda*. The type species of the genus, *Osmundacidites wellmanii* resembles closely the spores of *Osmunda claytoniana*.

The spores assignable to *Osmundacidites* is quite common in the Tertiary sediments of India. They have been recorded from Palaeocene to Miocene by Saxena (1978), Sah and Kar (1969), Kar and Jain (1981) and others.

It may be pointed out here that apart from the extant fern *Osmunda* there are number of unrelated living genera which produce circular-subcircular, trilete spores with granulose exine. The spores of *Amphipterum fuscum*, *Vandenboschia radicans*, *Crepidomanes humilis*, *Microgonium cuspidatum*, *Nesopteris grandis*, *Macroglena meifolia* and other ferns (see Kremp & Kawasaki, 1972) also produce spores like *Osmundacidites*.

Osmundacidites minutus Sah & Jain, 1965

Diagnosis (*after Sah & Jain, 1965*) — Size range 19-27 μm, holotype 19 μm, amb circular to oval, trilete mark distinct, rays extending almost up to the equator, laesurae thin and low, exine very thin, covered with minute and regularly spaced grana.

Holotype — Sah and Jain, 1965, pl. 1, fig. 36; size 19 μm; slide no. 33/8.

Type Locality — Sakrigalighat, Rajmahal Hills, Jurassic, Bihar.

Occurrence — Exposures in front of the Dak Bungalow, Matanomadh.

Osmundacidites cephalus Saxena, 1978

Pl. 1, figs 11, 12

1978 *Osmundacidites cephalus* Saxena, p. 450, pl. 2, fig. 20.

Diagnosis (*after Saxena 1978*) — Spores subcircular-circular, 49-72 μm. Trilete, rays distinct, extending up to three-fourths radius with raised commissure. Exine 2.5-4 μm thick, granulose, grana closely placed, 1.5-3 μm in size, sometimes imparting a verrucose appearance.

Holotype — Saxena, 1978, pl. 2, fig. 20; size 68 μm; slide no. 4945/8.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road and west side of the village Matanomadh.

Genus — *Leptolepidites* Couper, 1953

Type Species — *Leptolepidites verrucatus* Couper, 1953.

Leptolepidites major Couper, 1958

Pl. 1, fig. 13

1978 *Leptolepidites major* Couper: Saxena, p. 451, pl. 2, fig. 22.

Diagnosis (*after Couper, 1958*) — Trilete, laesurae not always distinct but when developed are greater than two-thirds of radius; equatorial contour rounded-triangular, both proximal and distal surfaces convex and sculptured with closely spaced, more or less spherical verrucae, some 5-8 μm in diameter; exine thickness not determinable because of the nature of sculpture, size range 38-(45)-53 μm.

Remarks — Couper (1953) remarked that *Leptolepidites verrucatus*, the type species of the genus, resembles the spores of the living fern *Leptolepia novae-zelandiae* (Col.) Metten. in size, shape and nature of ornamentation. Later, while working on the British Mesozoic microspores, Couper (1958), however, thought that the affinities of *L. verrucatus* with *L. novae-zealandiae* is not very certain and there may be other ferns which could produce this type of spores.

Holotype — Couper, 1958, pl. 21, fig. 27.

Type Locality — Yorkshire, Middle Jurassic, U.K.

Occurrence — Exposures near the road at Matanomadh.

Genus — *Foveosporites* Balme, 1957

Type Species — *Foveosporites canalis* Balme, 1957.

Foveosporites sp.

1978 *Foveosporites* sp. Saxena, p. 451, pl. 2, fig. 23.

Description (*after Saxena, 1978*) — Spores subcircular, 60-77 μm. Trilete, rays extending up to three-fourths radius. Exine up to 1.5 μm thick, foveolate, foveolae closely placed and uniformly distributed all over the exine.

Genus — *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955

Lectotype — *Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

Lycopodiumsporites bellus Sah & Kar, 1969

Pl. 1, fig. 14; Pl. 6, figs 10-13

1978 *Lycopodiumsporites bellus* Sah & Kar: Saxena, p. 451, pl. 2, fig. 24.

Diagnosis (*after Sah & Kar, 1969*) — Spores triangular, size range 24-36 μm; trilete distinct, rays extending up to three-fourths the radius; exine 2-4 μm thick, reticulate, proximal muri ill-developed, do not anastomose to form regular meshes, distal muri form a regular reticulum.

Holotype — Sah & Kar, 1969, pl. 2, figs 9a-9b; size 36 μm; slide no. 3353/23.

Type Locality — Bore core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Diagnosis (*after Dutta & Sah, 1970*) — Size range 34-46 μm, holotype 41 μm; amb triangular, apices broadly rounded; trilete fairly distinct; laesurae measuring 8-10 μm in length, lips thin; exine thin, reticulate, distal reticulum composed of straight muri which usually coalesce to form small, angular lumina of varying shapes, proximal surface having a comparatively reduced reticulum.

Holotype — Dutta & Sah, 1970, pl. 2, fig. 47; size 41 μm; slide no. 6/6.

Type Locality — Umstew, South Shillong Plateau, Palaeocene, Meghalaya.

Genus — *Cicatricosiiporites* Potonié & Gelletich, 1933

Type Species — *Cicatricosisporites dorogensis* Potonié & Gelletich, 1933.

Remarks — Thomson and Pflug (1952) remarked that the genus *Cicatricosisporites* instituted by Potonié and Gelletich (1933) is canaliculate and not circatricos as has been advocated by them. Potonié (1956) admitted that *Cicatricosisporites dorogensis*, the type species of the genus is canaliculate but he rightfully retained the name of the genus as it was validly published before the correct detection of the nature of ornamentational pattern.

Germeraad, Hopping and Muller (1968) observed the pantropical distribution of *Cicatricosisporites dorogensis* Potonié & Gelletich (1933) and its related forms. They recorded the presence of this type of spore in the Albian-Senonian of West Africa. The species is also quite abundant in the Lower Cretaceous of Borneo but is rare in the Upper Cretaceous sediments. In Europe, the species is occasionally found in Cretaceous and continues up to Oligocene and disappears in Miocene. Cookson (1954) reported some spores assignable to *Cicatricosisporites* from the Cretaceous of Australia and Drugg (1967) recorded its occurrence in the Upper Cretaceous-Palaeocene of California, U.S.A.

According to Potonié (1956); Germeraad, Hopping and Muller (1968) and others the spores belonging to *Cicatricosisporites* very much resemble the extant spores of *Mohria* and *Anemia* of Schizaeaceae. In *Anemia adiantifolia* (L.) Sw., in the opinion of Devi and Nayar (1969), the laesural ridges on either side of the trilete rays coalesce beyond the tip of the ray and continue as a radial ridge on to the distal surface, the three radial ridges extend close to the distal pole where they unite with the three corners of triangular ridge around the distal pole. Devi and Nayar (1969) also observed the costate condition in *Mohria caffrorum* (L.) Desv. The costae in this species are paired but the two costae of the same pair is being separated from one another by a narrow depression and the juxtaposed pairs are separated from one another by markedly broader depressions. Dettmann (1963) thinks that *Cicatricosisporites* has close resemblance to the living spores of *Anemia jaliscana* Max. and *A. dregeana* Kunze. The costae in these two species terminate along the amb-angle bisectors where they fuse with alternate muri. The termination of the equatorial costae in these spores simulates radial exinal thickenings and seems to be comparable to *Appendicisporites* Weyland & Krieger (1953). The latter is, however, distinguished by its fusion of equatorial muri with one another and thus produce only one projecting appendix in each equatorial radial region.

Cicatricosisporites australiensis (Cookson) Potonié, 1956

Pl. 4, fig. 13

1978 *Cicatricosisporites pseudotripartitus* (Bolkhovitina) Dettmann : Saxena, pl. 2, fig. 27.

1978 *Cicatricosisporites* sp. Saxena, pl. 2, fig. 28.

Diagnosis (*after Cookson, 1954*) — Spores triangular, apices rounded, interapical margins more or less straight. Trilete, rays broad, extending up to three-fourths radius. Exine about 2 μm thick, costate, costae closely placed, proximal set does not traverse on distal side.

Remarks — Saxena (1978) in addition to *Cicatricosisporites australiensis* also recorded *C. pseudotripartitus* and *Cicatricosisporites* sp. from the Matanomadh Formation. According to Dettmann (1963), *C. pseudotripartitus* has membraneous elevated rays and the exine is sculptured distally and equatorially with three series of four to five, weakly sinuous costae and on the proximal side it is reduced to two to three, inconspicuous costae. These characters are not seen in the specimen illustrated by Saxena (1978) but has more or less same characters as found in *C. australiensis*.

Holotype — Cookson, 1954, pl. 122, fig. 4.

Type Locality — Bore core no. 1, Birregurra, Upper Cretaceous, Victoria.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Gleicheniidites* Ross ex Delcourt & Sprumont emend. Dettmann, 1963

Type Species — *Gleicheniidites senonicus* Ross, 1949.

Remarks — Delcourt and Sprumont (1955) provided the generic status to *Gleicheniidites* originally described by Ross (1949) from the Cretaceous Bearing Clay deposit of Scania. This genus is characterized by triangular, laevigate, trilete spores with peculiar thickening in the inter-radial region at the equator. Potonié (1956) did not mention the latter character and differentiated *Cyathidites* Couper (1953) from *Gleicheniidites* only on the basis of the extension of trilete rays. Both *Concavisporites* (Pflug) Delcourt & Sprumont (1955) and *Dictyophyllidites* Couper emend. Dettmann (1963) have thickenings around the haptotypic mark. Krutzsch (1959) included psilate as well as spinose forms in *Gleicheniidites* and Dettmann (1963) excluded the latter from this genus. According to Potonié (1956), the spores of *Gleichenites nitida* Harris (1931) described from the Rhaetic-Jurassic of Greenland approximate the genus *Gleicheniidites*. Dettmann (1963) thinks that the spores of modern *Gleichenia circinata* Swartz and *G. laevissima* are comparable morphologically to *Gleicheniidites*. The spores of *G. polypodioides* illustrated by Kremp and Kawasaki (1972, p. 10, fig. 17) growing in Australia-Africa is very much similar to *Gleicheniidites*.

Gleicheniidites senonicus Ross, 1949

1978 *Gleicheniidites senonicus* Ross: Saxena, p. 451, pl. 2, fig. 29.

Diagnosis (after Potonié, 1956) — Holotype 27 μm, triangular, apices more or less pointed, interapical margins concave or sometimes slightly convex. Trilete rays almost reaching up to equator. Exine more or less laevigate, thickened in the interapical region at the equator.

Remarks — The spore assigned to *Gleicheniidites senonicus* by Saxena (1978) is about 44 μm in size. The apices are angular and the trilete rays are distinct extending up to the equator. The interradial thickening of exine at the equator is ill-developed.

Holotype — Ross, 1949, pl. 1, fig. 3.

Type Locality — Bearing clay deposit, Cretaceous, Scania.

Occurrence — Exposures near the tank, Matanomadh.

Genus — *Polypodiaceaesporites* Thiergart, 1938

Type Species — *Polypodiaceaesporites haardti* (Potonié & Venitz) Thiergart, 1938.

Remarks — The genus *Polypodiaceaesporites* was instituted by Thiergart (1938) from the Miocene sediments of Ville to accommodate monolete, bean-shaped spore with laevigate exine. Potonié (1956) remarked that the genus might have some structural pattern but it is devoid of any sculptural elements. Sah and Dutta (1968) and Dutta and Sah (1970) placed some faintly discernible verrucoid forms under this genus as *P. tertiarus* Sah & Dutta (1968) from the Tertiary sediments of South Shillong Plateau, Meghalaya. The verrucoid forms should not be placed in this genus as this would cause overlapping with the genus *Polypodiisporites* Potonié (1934). Similarly, *Polypodiaceaesporites* sp. described by Saxena (1978) should not be placed in this genus as it has granulose ornamentation. *Polypodiaceaesporites* is quite common in most of the Tertiary sediments of India. It is, however, more frequently found in Assam and adjacent region than in Kachchh. Besides Tertiary, bean-shaped, monolete, laevigate spores are also occasionally found in the Mesozoic and Palaeozoic strata and these are generally assigned to *Laevigatosporites* (*Ibrahim*) Schopf, Wilson & Bentall (1944). The *in situ* spores of *Bowmanites bifurcatus* Andrews & Mamay (1951) and figured by Potonié (1962, pl. 6, fig. 152) from the Carboniferous resemble the spores assignable to *Laevigatosporites*.

It may be mentioned here that besides Polypodiaceae, there are number of ferns which also produce psilate, bean-shaped, monolete spores. This type of spore is found in *Schizea dichotoma* (Kremp & Kawasaki, 1972, p. 8, fig. 13), *Stromatopteris moniliformis* (Kremp & Kawasaki, 1972, p. 10, fig. 18), *Sticherus laevigatus* (Kremp & Kawasaki, 1972, p. 11, fig. 19), *Tapeinidium pinnatum* (Kremp & Kawasaki, 1972, p. 33, fig. 64), *Hypolepis tenuifolia* (Kremp & Kawasaki, 1972, p. 38, fig. 73), *Arthopteris tenella* (Kremp & Kawasaki, 1972, p. 62, fig. 122), and others.

It is evident from these examples that spores assignable to *Polypodiaceaesporites* may also not belong to the extant family Polypodiaceae.

Polypodiaceaesporites levis Sah, 1967

1978 *Polypodiaceaesporites levis* Sah: Saxena, p. 452, pl. 2, fig. 30.

Diagnosis (*after Sah, 1967*) — Size range 27-35×45-60 μm, amb elongate, more or less reniform, extremities well-rounded; monolete, laesura thin, more than half of the longer axis. Exine laevigate to infrastructured.

Remarks — The specimen placed under *Polypodiaceaesporites levis by* Saxena (1978, pl. 2, fig. 30) is not markedly bean-shaped as in the spores illustrated by Sah (1967, pl. 3, figs 13, 15).

Holotype — Sah, 1967, pl. 3, fig. 13; size 45×27 μm; slide no. 11/2.

Type Locality — Bore core no. RU 231, Burundi, Rusizi Valley, Neogene.

Occurrence — Exposures on the western side of the village, near the tank, Matanomadh.

Polypodiaceaesporites major Saxena, 1978

1978 *Polypodiaceaesporites major* Saxena, p. 452, pl. 2, figs 31-33.

Diagnosis (*after Saxena, 1978*) — Spores bean-shaped, 58-86×38-56 μm. Monolete, laesura not well discernible, extending up to three-fourths of the longer axis. Exine 1.5-2.5 μm thick, laevigate, proximal exine thinner than distal.

Holotype — Saxena, 1978, pl. 2, fig. 31.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Polypodiisporites* Potonié, 1934

Type Species — *Polypodiisporites favus* (Potonié) Potonié, 1934.

Remarks — Thomson and Pflug (1953) opined that the genus *Polypodiisporites* is invalid as it was published without proper diagnosis. Potonié (1956), however, refuted this statement and maintained *Polypodiisporites* as a valid genus. This genus closely resembles *Polypodiidites* Ross (1949) and *Verrucatosporites* Pflug (1952) emend. Potonié (1956). All these genera are supposed to have polypodiaceous affinity and are bean-shaped, monolete spores with verrucose ornamentation. *Polypodiisporites* and *Polypodiidites* are very much similar to each other and have been differentiated in the presence of flat, rounded and pointed verrucae respectively. In *Verrucatosporites*, the verrucae are rounded and sparsely distributed as is found in the living spores of *Stenochlaena palustris* (Kremp & Kawasaki, 1972, p. 102, fig. 202). Verrucose, monolete, bean-shaped spores resembling *Polypodiisporites* are also known from the Palaeozoic. The spores of *Acitheca longifolia* Brongn. described from the Carboniferous of Saar and illustrated by Potonié (1962, pl. 9, fig. 218) are granulose. *Scolecoopteris oliveri* Scott reported from the Permo-Carboniferous of northern hemisphere is verrucose, bean-shaped, monolete spores (see Potonié, 1962, pl. 9, fig. 248).

Verrucose, monolete, bean-shaped spores apart from Polypodiaceae are also found in a number of other families. Kremp and Kawasaki (1972) found this type of spore in *Araiostegia hymenophylloides* (p. 58, fig. 113), *Leucostegia immersa* (p. 58, fig. 114), *Davalloides hirsutum* (p. 59, fig. 115), *Trogostolon falcinellus* (p. 59, fig. 116), *Davallia canariensis* (p. 60, fig. 117), *Humata ophioglossoides* (p. 61, fig. 119) and others. The spores of *Polypodium vulgare* illustrated by Kremp and Kawasaki (1972, p. 110, fig. 218) have closely placed, big, flat verrucae providing pseudoreticulum in surface view. It seems from the illustrations of them that the spores are laevigate or partially verrucosed on the proximal surface. The same type of spores also seem to be present in *Lemmaphyllum spathulatum* (Kremp & Kawasaki, 1972, p. 117, fig. 232).

Polypodiisporites repandus Takahashi, 1964

Pl. 1, fig. 15

1978 *Polypodiisporites repandus* Takahashi: Saxena, p. 452, pl. 2, fig. 35.

Diagnosis (*after Takahashi, 1964*) — Monolete spores, 40-52 μm in size, bean-shaped. Exine sculptured with warts, generally 2 μm in height, sometimes up to 3 μm forming negative reticulum in surface view.

Holotype — Takahashi, 1964, pl. 30, fig. 5.

Type Locality — Hatsune-Sowa Ooyubari, Yubari-Kohlenfeld, Upper Cretaceous, Hokkaido.

Occurrence — Exposures in front of Dak Bungalow, near the road, Matanomadh.

Polypodiisporites mawkmaensis Dutta & Sah, 1970

1978 *Polypodiisporites mawkmaensis* Dutta & Sah: Saxena, p. 452, pl. 2, fig. 36.

Diagnosis (*after Dutta & Sah, 1970*) — Size range 28-36×40-51 μm; amb elliptical in polar view; monolete, laesura narrow, prominent ridge, extending half to three-fourths of the longer axis; exine up to 1 μm thick, surface ornamentation verrucate, verrucae very low, with flat tops, margin more or less smooth.

Holotype — Dutta & Sah, 1970, pl. 3, fig. 29; size 90×60 μm; slide no. 3/5.

Type Locality — Cherrapunjee, Therria Formation, Palaeocene, Meghalaya.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Polypodiisporites sp.

Pl. 4, figs 2, 3

1978 *Polypodiisporites* sp. Saxena, p. 452, pl. 2, figs 37, 38.

Description — Spores oval, 68-92×58-68 μm. Monolete, laesura extending up to two-thirds of the longer axis. Exine up to 2 μm thick, verrucose, verrucae very closely placed.

Genus — *Retipilonapites* Ramanujam, 1966

Type Species — *Retipilonapites arcotense* Ramanujam, 1966.

Retipilonapites cenozoicum Sah, 1967

Pl. 2, fig. 5

1979 *Retipilonapites cenozoicus* Sah: Saxena, p. 131, pl. 1, fig. 5.

Diagnosis (*after Sah, 1967*) — Size range 40-54 μm; amb more or less spheroidal; nonaperturate; exine finely reticulate in surface view, simplibaculate, bacula with rounded heads.

Remarks — Sah (1967) described this species as *Potamogetonacidites cenozoicus*. This was the type species for the genus *Potamogetonacidites* Sah (1967). He however, in a foot note remarked that since *Retipilonapites* Ramanujam (1966) has nomenclatural priority so this species may be referred as *Retipilonapites cenozoicus*.

Holotype — Sah, 1967, pl. 4, fig. 18; size 50 μm; slide no. 7/1.

Type Locality — Burundi,, Neogene, Rusizi Valley.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Genus — *Couperipollis* Venkatachala & Kar, 1969a

Type Species — *Couperipollis perspinosus* (Couper) Venkatachala & Kar, 1969a.

Remarks — Venkatachala and Kar (1969a) proposed *Couperipollis* to accommodate subcircular-elliptical, monosulcate pollen grains ornamented with verrucae, bacula and spines. These pollen were formerly placed by Couper (1953) in *Monosulcites* Erdtman (1947) which is essentially a laevigate, monocolpate genus. *Echimonocolpites* Mathur (1966) described from the Supratrappeans of western Kachchh resembles *Couperipollis* in monocolpate condition and spinose ornamentation but *Echimonocolpites* as stated by Mathur

(1966) is distinguished by its scabrate nature of the exine. *Spinizonocolpites* Muller (1968) also approximates *Couperipollis* in having spinose ornamentation but the former genus is radially symmetrical with a continuous equatorial colpus which splits the pollen grains into two slightly unequal parts: suboblate-spherical.

Lakhanpal (1970) suggested that some of the pollen grains described by Venkatachala and Kar (1969a) as *Couperipollis* could be related to the living genus *Arenga*. Muller (1980), however, mentioned that the pollen grains of *Arenga* are monosulcate and echinate with a structureless exine but it may be distinguished by its peculiar row of spines along the margin of the aperture, which will interlock upon invagination, closing the manner of sharply toothed jaws.

Amongst the living palms there are many genera which produce pollen grains comparable to *Couperipollis*. The pollen grains of *Wettiniicarpus fascicularis* (Thanikaimoni, 1970, pl. 7, figs 112-114), *Korthalsia rigida* (Thanikaimoni, 1970, pl. 21, figs 411-414) and *K. scaphigera* (Thanikaimoni, 1970, pl. 21, figs 415-418) have monocolpate, spinose pollen grains.

Couperipollis is quite common in the Matanomadh Formation. In the overlying Naredi Formation it is occasionally met with but it gradually declines in the upper horizons. The various species attributed to this genus may belong to different groups of palms. The difference in many species is subtle and hence it can not be said with certainty whether the different morphographical groupings have any bearing on the living ones.

Mathur (1966) as has already been stated proposed *Echimonocolpites* for the spinose monocolpate pollen and selected *Echimonocolpites scabratus* Mathur (1966) as the type species. This name is a synonym of *Echimonocolpites* van der Hammen & de Mutis (1965). It may be mentioned here that van der Hammen (1954) originally instituted *Monocolpites* and he proposed in 1956 the pollen of a living plant *Orthrosanthus multiforus* Sweet as lectotype. Since this species has already designated as the type species of *Orthrosanthus* Sweet, this was regarded as invalid. Van der Hammen and de Mutis (1965) published *Echimonocolpites* — a new genus selecting the type species from a new combination based on illegitimate *Monocolpites rudae* but validated with a nomenclaturally acceptable holotype. This procedure is again considered as invalid according to the International Code of Botanical Nomenclature since this new combination does not give full and direct reference to the basionym [*Catalog Fossil Spores Pollen*, 34: 247].

Thanikaimoni (personal communication) feels that a merger of *Echimonocolpites* into *Couperipollis* would be more a case of taxonomic procedure than nomenclatural procedure.

Nicolson (personal communication) also thinks that *Echimonocolpites* van der Hammen & Gracia (1965) is validly published, apparently based on *Monocolpites rudae* van der Hammen (1954) but invalidly publishing the new combination. Since a name once rejected as illegitimate could not be used again for a new combination except by conservation, *Couperipollis* is maintained here.

Recently Venkatachala and Kar (1984) emended *Couperipollis* as follows: Pollen grains more or less elliptical, monosulcate, spinulate; sulcus extending from one end to the other along the longer axis; spines pointed with nexinal thickening at base.

Couperipollis wodehousei (Biswas) Venkatachala & Kar, 1969a

1979 *Couperipollis wodehousei* (Biswas) Venkatachala & Kar: Saxena, p. 131, pl. 1, fig. 6.

Diagnosis (after Biswas, 1962)— Exine rather thick, distinctly though rather faintly reticulate, spines 9-11 μm long, longitudinal distance 49 μm.

Holotype — Biswas, 1962, pl. 12, fig. 30.

Type Locality — Sylhet Limestone, Eocene, Assam.

Occurrence—Exposures in front of the Dak Bungalow, near the road, Matanomadh.

Couperipollis brevispinosus (Biswas) Venkatachala & Kar, 1969a

Pl. 2, figs 3, 4

1979 *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar: Saxena, p. 131, pl. 1, fig. 7.

Diagnosis (*after Baksi, 1962*) — Oblique equatorial compression; longitudinal diameter 44 μm (without spines); spines short, characteristically very broad at the base, slightly curved sides with sudden termination to a point, densely packed.

Holotype — Baksi, 1962, pl. 2, fig. 22.

Type Locality — Tura Formation, Eocene, Assam.

Occurrence — Exposures near the tank on the western side of the village, near the road, Matanomadh.

Couperipollis rarispinosus (Sah & Dutta) Venkatachala & Kar, 1969a

Diagnosis (*after Sah & Dutta, 1966*) — Size range 44-56 μm, amb spheroidal to subspheroidal. Monosulcate, sulcus usually distinct, long (extending almost up to the poles) and usually broad. Exine thin, less than 2 μm undifferentiated, spinose, spines sparse, small (less than 2 μm) and with pointed tips.

Holotype — Sah and Dutta, 1966, pl. 1, fig. 28; size 52 μm; slide no. 17/2.

Type Locality — Laitryngew, South Shillong Plateau, Palaeocene, Meghalaya.

Occurrence — Exposures near the road, in front of Dak Bungalow, Matanomadh.

Couperipollis kutchensis Venkatachala & Kar, 1969a

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains more or less subcircular in shape, 35-65×30-60 μm. Monosulcate, sulcus ill-developed, hardly discernible, extending from one end to other. Exine spinose, spines with bulbous base and pointed tip.

Holotype — Venkatachala & Kar, 1969a, pl. 1, fig. 16; size 50×48 μm; slide no. 3314.

Type Locality — Bore hole no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Couperipollis achinatus Sah & Kar, 1970

Pl. 15, fig. 10; Pl. 17, figs 1, 2

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval, 38-46×26-34 μm. Monocolpate, colpus extending end to end. Exine spinose baculate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 8; size 42×30 μm; slide no. 3351.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Couperipollis robustus Saxena, 1979

Pl. 2, figs 26, 27

1979 *Couperipollis robustus* Saxena, pp. 131, 132, pl. 1, fig. 8.

Diagnosis (*after Saxena, 1979*) — Pollen grains circular-oval, 16-55 μm. Monosulcate, sulcus distinct-indistinct, extending from pole to pole. Exine about 2 μm thick, sculptured with robustly built coni, verrucae, baculae and other elements.

Holotype — Saxena, 1979, pl. 1, fig. 8; size 49×45 μm; slide no. 4766/3.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene.

Occurrence — Exposures near the tank, in front of the Dak Bungalow, Matanomadh.

Genus — *Matanomadhiasulcites* gen. nov.

Type Species — *Matanomadhiasulcites* (*Liliacidites*) *maximus* (Saxena) comb. nov.

Diagnosis — Pollen grains oval-elliptical in shape. Monosulcate, sulcus distinct to indistinct, almost extending end to end. Exine retipilate-retibaculate.

Description — Pollen grains mostly with equally broad lateral ends, very large in size, 63-205×38-145 μm. Sulcus mostly distinct, sometimes very broad, tapering at ends, in folded specimens sulcus not clearly discernible. Exine 2-4 μm thick, pila 3-8 μm long, 1-2.5 μm broad, sometimes interspersed with bacula, pila closely placed, 1.5-2.5 μm apart, forming negative reticulum in surface view.

Comparison — *Liliacidites* Couper (1953) is closely comparable to the present genus in oval-elliptical shape and monosulcate condition, but the former is distinguished by its clearly reticulate exine. The type species of *Liliacidites*, viz., *L. kaitangataensis* Couper (1953) has clear beaded reticulum, lumina of reticulum vary in diameter from 5 μm at centre of grain to 1 μm at ends. *Monosulcites minimus*, the genotype of *Monosulcites* Cookson (1947) is comparatively smaller in size (29-34 μm), possesses well-defined, boat-shaped sulcus and laevigate exine. *Palmidites* Couper (1953) is also laevigate. *Pinjoriapollis* Saxena & Singh (1981) is elliptical in shape, length of pollen is generally two and a half times of breadth and the exine laevigate to faintly intrapunctate. *Matanomadhiasulcites* proposed here is distinguished from other monocolpate-monosulcate pollen grains by its large size range, very broad sulcus and retipilate-baculate sculptural elements.

Matanomadhiasulcites (*Liliacidites*) *maximus* (Saxena) comb. nov.

Pl. 3, figs 1, 2; Pl. 10, fig. 3

1979 *Liliacidites maximus* Saxena, p. 132, pl. 1, figs 9, 10.

Diagnosis (*after Saxena, 1979*) — Pollen grains oval-elliptical, 135-205 × 90-145 μm. Monosulcate, sulcus may be distinct or indistinct, wide extending from pole to pole. Exine 2-3 μm thick, generally retipilate to retibaculate, pila/bacula 3-8 μm long.

Holotype — Saxena, 1979, pl. 1, fig. 9; size 150 × 113 μm; slide no. 4955/5.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road at Matanomadh.

Remarks — Saxena (1979) described this species as *Liliacidites maximus*. *Liliacidites* is restricted here for those species which exhibit clear reticulation of two kinds — bigger ones at centre and smaller ones at ends. As *L. maximus* does not show this character so it has been selected as the type species for *Matanomadhiasulcites*.

Matanomadhiasulcites (*Liliacidites*) *kutchensis* (Saxena) comb. nov.

Pl. 3, fig. 3; Pl. 10, fig. 5

1979 *Liliacidites kutchensis* Saxena, p. 132, pl. 2, fig. 11.

Diagnosis (*after Saxena, 1979*) — Pollen grains oval-elliptical, 63-100 × 38-58 μm. Monosulcate, sulcus mostly indistinct, wide, generally extending from pole to pole. Exine 1.5-2.5 μm thick, retipilate to retibaculate, sculptural elements 3-4 μm long, closely placed.

Holotype — Saxena, 1979, pl. 2, fig. 11; size 105 × 60 μm; slide no. 4956/1.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Genus — *Arecipites* Wodehouse, 1933

Type Species — *Arecipites punctatus* Wodehouse, 1933.

Arecipites (*Liliacidites*) *matanomadhensis* (Saxena) comb. nov.

1979 *Liliacidites matanomadhensis* Saxena, p. 132, pl. 2, fig. 12.

Diagnosis (*after Saxena, 1979*) — Pollen grains oval-elliptical, 86-150 × 58-94 μm. Monosulcate, sulcus broad, extending from one end to the other. Exine 2-3 μm thick, foveo-reticulate, foveola up to 2 μm wide, closely placed and evenly distributed.

Remarks — Saxena (1979) described this species as *Liliacidites matanomadhensis*. This species, however, comes more close to *Arecipites* than *Liliacidites* by its ornamentation pattern, so it has been transferred to *Arecipites*.

Holotype — Saxena, 1979, pl. 2, fig. 12; size 110 × 88 μm; slide no. 4774/3.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road in front of Dak Bungalow, Matanomadh.

Genus — *Palmidites* Couper, 1953

Type Species — *Palmidites maximus* Couper, 1953.

Palmidites maximus Couper, 1953

Pl. 4, fig. 4

1979 *Palmidites maximus* Couper: Saxena, p. 132, pl. 2, fig. 14.

Diagnosis (*after Couper, 1953*) — Free, anisopolar, bilateral, monosulcate, sulcus long, broad. Grain elongate. Exine 1.5-2 μm thick, faintly flecked to psilate.

Holotype — Couper, 1953, pl. 7, fig. 103.

Type Locality — Wanganuian, Pliocene, New Zealand.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Palmaepollenites* Potonié, 1951

Type Species — *Palmaepollenites tranquillus* (Potonié) Potonié, 1951

Remarks — *Palmaepollenites* as the name implies, was instituted by Potonié to accommodate dispersed laevigate, monocolpate pollen grains belonging to the family Palmae. The exine in this genus may be intragranulose but is never punctate as found in *Arecipites* Wodehouse (1933) or granulose as in *Sabalpollenites* Thiergart (1937). *Monocolpopollenites* Pflug (1952) is very much similar to *Palmaepollenites* and hence may be regarded as its synonym.

Palmaepollenites is a common genus in the Tertiary sediments of India. This genus had been reported from the Palaeocene of Kachchh and Assam and many species are found in abundance even at the present day. It may be mentioned that Corner (1966) thought the palms gave rise to other monocotyledons. This hypothesis was, however, opposed by Mahabale (1974) on the lack of fossil evidences. Thanikaimoni (1970) after studying the various recent palm pollen and other major monocotyledonous groups also refuted the hypothesis of Corner.

On the basis of fossil pollen analysis of palm, Muller (1980) thought that there was a vigorous evolution of palms during Senonian in the American-African tropics. Raven and Axelrod (1974) also opined that the palm originated in South America and Africa combined with a part of Antarctica. Moore (1973) also supported this contention after investigating the problem of palm origin by a detailed analysis of present day distribution of palm and careful evaluation of the fossil record and an interpretation within the framework of the plate tectonics (see Muller, 1980).

According to Muller (1980) the Senonian history of palm appears to indicate two evolutionary phases; first there is a diversification in the early Senonian in the monosulcate, extended sulcate and trichomosulcate groups followed by a second phase in which more coarsely ornamented types appear including *Nypa* pollen and *Proxapertites*. Muller (1980) also postulated the migration route of early palm, probably characterized by a monosulcate — finely reticulate pollen type via Africa to Laurasia and along with the Tethys shore of South-east Asia. It may, however, be recorded here that this route is actually reverse what was commonly assumed by Lakhanpal (1970).

Amongst the living palms, pollen grains of many genera closely resemble *Palmaepollenites*. The pollen of *Pinanga wrayii* (Thanikaimoni, 1970, pl. 3, figs 44, 45), *Calyptronoma dulcis* (Thanikaimoni, 1970, pl. 5, figs 74-77), *Iguanura geonomaeformis* (Thanikaimoni, 1970, pl. 6, figs 86, 87), *Ptychosperma angustifolium* (Thanikaimoni, pl. 9, figs 155, 156), *Ptychosperma hospitum* (Thanikaimoni, pl. 9, figs 157, 158), *Attalea macrocarpa* (Thanikaimoni, 1970, pl. 12, figs 221, 222) and *Syagrus ecuadorensis* (Thanikaimoni, 1970, pl. 15, figs 283-287).

Palmaepollenites kutchensis Venkatachala & Kar, 1969a

Pl. 2, fig. 8; Pl. 11, figs 1-3

1979 *Palmaepollenites kutchensis* Venkatachala & Kar: Saxena, p. 133, pl. 2, fig. 15.

Diagnosis (after Venkatachala & Kar, 1969a) — Pollen grains oval with more or less equally broad lateral ends, 25-30 × 10-15 μm. Monocolpate, colpus broad, boat-shaped, not reaching up to margins. Exine more or less laevigate.

Holotype — Venkatachala & Kar, 1969a, pl. 1, fig. 9.

Type Locality — Bore core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Palmaepollenites nadhamunii Venkatachala & Kar, 1969a

Pl. 2, fig. 9; Pl. 19, fig. 5

1979 *Palmaepollenites nadhamunii* Venkatachala & Kar: Saxena, p. 133, pl. 2, figs 16, 17.

Diagnosis (after Venkatachala & Kar, 1969a) — Pollen grains elliptical-spindle in shape, 25-30 × 15-22 μm. Monocolpate, colpus narrow, extending from one margin to other. Exine laevigate.

Holotype — Venkatachala & Kar, 1969a, pl. 1, fig. 11; size 29 × 17 μm; slide no. 3313.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road on the western side of the village, Matanomadh.

Palmaepollenites ovatus Sah & Kar, 1970

Pl. 12, fig. 2

Diagnosis (after Sah & Kar, 1970) — Pollen grains roundly oval, 38-45 × 35-40 μm. Monocolpate, colpus restricted in middle region. Exine intragranulose.

Holotype — Sah & Kar, 1970, pl. 1, fig. 13; size 41 × 38 μm; slide no. 3364.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the tank in front of Dak Bungalow, Matanomadh.

Palmaepollenites plicatus Sah & Kar, 1970

1979 *Palmaepollenites plicatus* Sah & Kar: Saxena, p. 133, pl. 2, fig. 18.

Diagnosis (after Sah & Kar, 1970) — Pollen grains elliptical, 48-60 × 20-40 μm. Monocolpate, colpus end to end, associated with folds. Exine more or less laevigate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 15; size 54 × 27 μm; slide no. 3365.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Genus — *Dracaenoipollis* Sah & Kar, 1970

Type Species — *Dracaenoipollis circularis* Sah & Kar, 1970.

Remarks — Nair and Sharma (1965) studied the pollen grains of Liliaceae and it seems that the present genus comes close to the pollen grains of *Dracaena surculosa* in shape and exine thickness, except that the latter has a bigger size range. The pollen of *Dracaena thalioides* are circular and the aperture is also circular in shape and the exine is 2-2.5 μm thick (Nair & Sharma, 1965).

Dracaenoipollis also resembles some of the pollen grains of Palmae, particularly *Cocos*, *Pritchardia* and *Areca*. The pollen grains of *Pritchardia pacifica* illustrated by Thanikaimoni (1966, pl. 17, fig. 103) shows a circular opening, laevigate ornamentation but a very thick exine. The pollen grains of *Areca caliso* (Thanikaimoni, 1970, pl. 1, figs 1-3) have also circular opening but the exine is thick and scrobiculate.

Dracaenoipollis circularis Sah & Kar, 1970

Pl. 12, fig. 1; Pl. 8, fig. 3

1979 *Dracaenoipollis circularis* Sah & Kar: Saxena, p. 133, pl. 2, fig. 19.

Diagnosis (after Sah & Kar, 1970) — Pollen grains circular-subcircular, 22-36 × 19-34 μm. Aperture circular-subcircular, distinct. Exine more or less laevigate, weakly granulose or intrastructured.

Holotype — Sah & Kar, 1970, pl. 1, fig. 1.

Type Locality — Bore-core no. 36, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, in front of Dak Bungalow, Matanomadh.

Genus — *Spinizonocolpites* Muller, 1968

Type Species — *Spinizonocolpites echinatus* Muller, 1968.

Spinizonocolpites echinatus Muller, 1968

Pl. 12, figs 3, 4

Description — Pollen grains subcircular, 30-38 × 28-36 μm, zonisulcate, pollen grains generally split into two slightly unequal halves as the figured specimen. Exine up to 2.5 μm thick, sexine thicker than nexine, spinose, spines with bulbous base and pointed tip, 6-9 μm long, 2-3 μm broad at base, 3-7 μm apart, interspinal space microreticulate.

Remarks — This species closely resembles the living pollen of *Nypa fruticans*.

Holotype — Muller, 1968, pl. 3, fig. 3.

Type Locality — Indonesia, Eocene.

Occurrence — Exposures in front of Dak Bungalow, near the road, Matanomadh.

Genus — *Proxapertites* van der Hammen, 1956

Type Species — *Proxapertites operculatus* van der Hammen, 1956.

Remarks — Van der Hammen (1954) described *Monocolpites operculatus* A and *M. operculatus* B from Lisama Formation (Palaeocene) of Columbia. The former variety is microreticulate and the latter is microfoveolate. Under the genus *Monocolpites* he also described many other species from the same formation. Van der Hammen (1956) instituted *Proxapertites* and transferred *Monocolpites operculatus* to *Proxapertites* to make the type species for the genus. He included in this genus the pollen grains with a big and wide aperture. Sometimes the pollen grains are found in dyads but generally they are found partly or completely separated. The ornamentation pattern is microfoveolate, aperture is large, round to oval and the margin relatively irregular. According to van der Hammen (1956) this aperture is not homologous with the colpi of the majority of monocotyledons because the former is located on the proximal side whereas the latter is on the distal side. On the basis of this circular aperture van der Hammen (1956) separated *Proxapertites* from other monocolpate forms. Singh (1975) emended *Proxapertites* and included *Potamogetonaceaepites* Biswas (1962), *Microreticulatipites* Baksi (1962), *Weylandipollis* Takahashi (1964) and *Nymphaeoipollis* Venkatachala & Kar (1969a) in it. The emended diagnosis of Singh (1975) runs as follows "pollen grains circular to subcircular in shape, zonisulcate, sulcus more or less parallel to margin, resulting into breaking of the pollen into two more or less equal halves. Size range 20-70 × 25-50 μm. Exine tectate, variable in ornamentation and sculpture generally ranging from punctate, psilate, granulose, to microfoveolate and reticulate ".

From the above description it is apparent that except the inclusion of a variety of ornamentational pattern in *Proxapertites*, the diagnosis is more or less same as that of diagnosis and description of van der Hammen (1956). The granulose and reticulate forms should not be included in this genus as this would provide a suprageneric status. If the reticulate forms are accommodated then *Schizosporis* Cookson & Dettmann (1959) should be treated as junior synonym of *Proxapertites*. But the former is quite distinct and hence the treatment of Singh (1975) is not acceptable. Besides, he also proposed *Assamialetes* for the hitherto known genus *Retialetes* Sah & Dutta (1966). It may be mentioned here that Staplin (1960) already proposed *Retialetes* for some alete, reticulate spores which sometimes split along a few fine grooves originating at one end and parallel the long axis from the Golata Formation, Alberta, Canada. Obviously, *Retialetes* Sah & Dutta (1966) turns to be a homonym of *Retialetes* Staplin (1960).

Singh (1975) selected *Assamialetes* (*Retialetes*) *emendatus* (Sah & Dutta) Singh (1975) as the type species of *Assamialetes*. The specimen figured by Sah and Dutta (1966, pl. 1, fig. 16) as the type species of *Retialetes emendatus* seems to be half portion of a circular pollen which has splitted into more or less two equal halves. Such splitted specimens are abundant in the slides representing either the proximal or distal halves. The intact specimens with zonisulcate condition have been described by them as *Schizosporis crassimurus* Sah & Dutta (1966, pl. 1, figs 18, 19) which was later transferred by Singh (1975) to *Proxapertites*. It seems that spores assigned to *Assamialetes* by Singh (1975) might have been also zonisulcate resulting the splitting of pollen into two more or less equal halves. This also easily explains the occurrence of splitted, circular halves of pollen in the slides. If this is so, then *Assamialetes* is nothing but a junior synonym of *Proxapertites*.

Van der Hammen (1956) opined that *Proxapertites* closely resembles the living pollen of *Astrocaryum accule* of the family Palmae. Thanikaimoni (1970) figured pollen grains of four species of *Astrocaryum*, in some e.g. *A. vulgare*, the aperture seems to be circular or broadly triangular. *Proxapertites* is a cosmopolitan genus of immense stratigraphic importance and it seems unlikely that only *Astrocaryum* used to produce them. According to Corner (1966) the most striking points about the palm distribution are that with one possible exception no genus is pantropical and with two exceptions the genera belong either to the Old or the New World and that with four exceptions those of the Old World are either African or Asian. In other words, most palm genera are restricted to the three main tropical continents. The present day distributional pattern of palm naturally goes against the contention that *Astrocaryum* used to grow in all the tropical regions during the Palaeogene. Corner (1966) opined that the fossil record tests the knowledge of living palms which test the interpretation of rocks. Knowledge in all respects is too incomplete to answer satisfactorily any question about the past history of palm.

Muller (1968, 1979) thinks that *Proxapertites* is somehow related to the genus *Nypa* because both of them have zonisulcate pollen grains. The difference between the two is *Proxapertites* is microfoveolate-microreticulate, whereas *Nypa* is spinose. He also points out that *Proxapertites* and *Nypa* coexisted during Upper Cretaceous-Palaeogene in North and South Americas, western Africa and India. *Proxapertites* pollen dwindle down in Neogene but *Nypa* continues to live in south-east Asia. Muller (1979) also thinks that the ecological distribution of *Proxapertites* and *Nypa* must have been comparable in view of their occurrence in deltaic and shallow marine sediments. As has already been stated, Muller (1979) thinks *Proxapertites* and *Nypa* evolved in the second phase of the evolutionary ladder of palm pollen in association with the other coarsely ornamented forms.

Proxapertites microreticulatus Jain, Kar & Sah, 1973

Pl. 2, fig. 6

1979 *Proxapertites microreticulatus* Jain, Kar & Sah: Saxena, p. 133, pl. 2, fig. 20.

Diagnosis (*after Jain, Kar & Sah, 1973*) — Spores medium-sized, equatorial diameter 40-60 μm, amb circular to subcircular or oval splitting into saucer-shaped halves. Exine 1-1.5 μm thick, intramicroreticulate.

Holotype — Jain, Kar & Singh, 1973, pl. 1, fig. 19; size 46×40 μm; slide no. 4279/3.

Type Locality — Barmer hill, Barmer, Palaeocene, Rajasthan.

Occurrence — Exposures near the road, Matanomadh.

Proxapertites assamicus (Sah & Dutta) Singh, 1975

Pl. 2, fig. 7; Pl. 9, fig. 9

1979 *Proxapertites assamicus* (Sah & Dutta) Singh: Saxena, p. 133, pl. 2, fig. 21.

Diagnosis (*after Sah & Dutta, 1966*) — Size range 41-50 μm, amb circular to slightly elliptical; usually found to be splitting subequatorially into two equal disc-like halves. Exine up to 1.5 μm thick, unsculptured, but a faint 1.0 pattern seen under oil immersion.

Holotype — Sah & Dutta, 1966, pl. 1, fig. 20; size 45×43 μm; slide no. 22/1.

Type Locality — Laitryngew, South Shillong Plateau, Palaeocene, Meghalaya.

Occurrence — Exposures on the western side of the village, Matanomadh.

Genus — *Tricolpites* (Erdtman) Potonié, 1960

Lectoholotype — *Tricolpites reticulatus* Cookson, 1947.

Tricolpites reticulatus Cookson, 1947

Pl. 2, fig. 12

1979 *Tricolpites reticulatus* Cookson, p. 133, pl. 2, fig. 22.

Diagnosis (*after Cookson, 1947*) — Circular-ovoid, isopolar, tricolpate, 35-40 μm, colpi broad, exine thick, finely reticulate.

Holotype — Cookson, 1947, pl. 15, fig. 45; size 38 μm.

Type Locality — Kerguelen, Tertiary.

Occurrence — Exposures near the road, in front of Dak Bungalow, Matanomadh.

Tricolpites parvireticulatus Sah, 1967

Diagnosis (*after Sah, 1967*) — Size range 36-42 μm, amb prolate-spheroidal to subprolate; tricolpate, colpi deep; exine sculpture finely reticulate.

Holotype — Sah, 1967, pl. 6, fig. 11; size 40 μm; slide no. 20/2.

Type Locality — Burundi, Rusizi Valley, Neogene, Kundava.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Tricolpites crassireticulatus Dutta & Sah, 1970

Pl. 4, fig. 6

1979 *Tricolpites crassireticulatus* Dutta & Sah: Saxena, p. 133, pl. 2, fig. 23.

Diagnosis (*after Dutta & Sah, 1970*) — Size range 25-37 μm; holotype 32 μm; amb roundly triangular to subspheroidal; tricolpate, colpi with bulging mesocolpia; exine rather thick, sexine as thick as nexine, pilate, tegillate, surface sculpture coarsely reticulate, crassimurate.

Holotype — Dutta & Sah, 1970, pl. 6, fig. 9; size 32 μm; slide no. 1/3.

Type Locality — Laitryngew, South Shillong Plateau, Palaeocene, Meghalaya.

Occurrence — Exposures near the road, in front of Dak Bungalow, Matanomadh.

Tricolpites minutus Sah & Kar, 1970

Pl. 8, fig. 7

1979 *Tricolpites minutus* Sah & Kar: Saxena, p. 133, pl. 2, fig. 25.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains subcircular-subtriangular, 18-25×17-24 μm, tricolpate, brevicolpate. Exine thin, laevigate-finely scrobiculate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 7.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road on the western side of the village Matanomadh.

Tricolpites baculatus Jain, Kar & Sah, 1973

1979 *Tricolpites baculatus* Jain, Kar & Sah: Saxena, p. 133, pl. 2, fig. 26.

Diagnosis (*after Jain, Kar & Sah, 1973*) — Pollen grains tricolpate, spherical, 30-35 μm, colpi long. Exine moderately thick, tegillate, surface baculate-spinose. Sculptural elements up to 3 μm high.

Holotype — Jain, Kar & Sah, 1973, pl. 1, fig. 24; size 30×29 μm; slide no. 4279/8.

Type Locality — Barmer hill, Barmer, Palaeocene, Rajasthan.

Occurrence — Exposures on the western side of the village, near the tank, Matanomadh.

Tricolpites retibaculatus Saxena, 1979

Pl. 3, fig. 7

Diagnosis (*after Saxena, 1979*) — Pollen grains subcircular-subtriangular in polar view, 58-114 μm. Tricolpate, colpi long, well developed, mesocolpia wide. Exine 2.5-7 μm thick, sexine thicker than nexine, retibaculate to retipilate, bacula/pila thick and strongly built, tegillate, sculptural elements provide pseudoreticulum on surface view.

Holotype — Saxena, 1980, pl. 2, fig. 27.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Intrareticulitis* gen. nov.

Type Species — *Intrareticulitis* (*Tricolpites*) *brevis* (Sah & Kar) comb. nov.

Diagnosis — Pollen grains subcircular-subtriangular in polar view. Tricolpate, colpi distinct, long. Exine intrareticulate-intraretibaculate, structural elements restricted to base of exine.

Description — Pollen grains almost invariably found in polar view, generally smaller in size, 23-35×20-34 μm, slightly angular, apertures found in middle region, colpi mostly closed, slit-like, when open funnel-shaped. Exine 1-3 μm thick, sexine much thicker than nexine, intrabaculate, bacula found only at basal part forming intrareticulation, sometimes reticulation not very clear and it appears as retibaculate.

Comparison — *Tricolpites* (Erdtman) Potonié (1966) resembles *Intrareticulitis* in general characters and tricolpate nature but the former is distinctly reticulate and the meshes are found on the surface of the pollen grain. *Retitricolpites* Pierce (1961) is also tricolpate but is broadly reticulate on the surface. *Retitrescolpites* Sah (1967) is variously ornamented with clava bacula, etc. and they unite together to form the reticulation pattern. *Intrareticulitis* is distinguished from all the tricolpate genera by its intrareticulate-intraretibaculate ornamentation and the restriction of the bacula only to the lower part of the exine.

Intrareticulitis (*Tricolpites*) *brevis* (Sah & Kar) comb. nov.

Pl. 2, fig. 13; Pl. 14, figs 1, 2

1979 *Tricolpites brevis* Sah & Kar: Saxena, p. 133, pl. 2, fig. 24.

Diagnosis — Pollen grains subcircular-subtriangular in polar view, 23-34×20-32 μm. Tricolpate, colpi distinct, long. Exine 1-3 μm thick, sexine much thicker than nexine, intrareticulate-intraretibaculate, ornamentation confined only to basal part of exine.

Holotype — Sah & Kar, 1970, pl. 1, fig. 5; size 33×31 μm; slide no. 3348/4.

Type Locality — Bore-core no. 36, depth 63 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Verrutricolpites* Pierce, 1961

Type Species — *Verrutricolpites spaeroides* Pierce, 1961.

Verrutricolpites parverrucatus Ramanujam, 1966

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, prolate, trizonicolpate, 26×22 μm. Amb rounded. Colpi short, with ends blunt. Exine 1.5 μm thick, loosely verrucate. Verrucae not much raised from the surface, 1.5 μm high.

Holotype — Ramanujam, 1966, pl. 2, fig. 29; size 26×22 μm.

Type Locality — Neyveli lignite, Miocene, South Arcot District, Tamil Nadu.

Occurrence — Exposures in front of Dak Bungalow, near the tank, Matanomadh.

Genus — *Platoniapollenites* Sah & Kar, 1974

Type Species — *Platoniapollenites iratus* Sah & Kar, 1974.

Remarks — Tetracolporate pollen grains are mostly found in the families Cucurbitaceae, Guttiferae, Loganiaceae, Meliaceae, Rutaceae and Violaceae. The pollen grains of *Platoniapollenites* come close to the living pollen grains of *Platonia insignis* of Guttiferae in size range, tetracolporate condition, thin colpi margin and thickened mesocolpate region. It may, however, be mentioned here that we do not have any *Platonia* growing in India though it is a common element in the tropical forest of Brazil.

Platoniapollenites sp.

Pl. 2, fig. 11

1979 *Platoniapollenites* sp. Saxena, p. 135, pl. 2, fig. 36.

Description — Pollen grains subtriangular in polar view, 36 μm. Tricolpate, colpi long, distinct. Exine 2 μm thick, laevigate, uneven, very thin along apertural margin.

Occurrence — Exposures near the road at Matanomadh.

Genus — *Psilastephanocolpites* Leidelmeyer, 1966

Type Species — *Psilastephanocolpites maia* Leidelmeyer, 1966.

Psilastephanocolpites quaduensis (van der Hammen) Saxena, 1979

Pl. 2, fig. 10

1979 *Psilastephanocolpites quaduensis* (van der Hammen) Saxena, p. 134, pl. 2, fig. 30.

Diagnosis (*after van der Hammen, 1954*) — Stephanocolpate (tetracolpate), size 15 μm; exine psilate-scabrate.

Remarks — While transferring *Stephanocolpites quaduensis* van der Hammen to *Psilastephanocolpites*, Saxena (1979) remarked that *Stephanocolpites* has already been raised to an infraturma status by Potonié (1970). This is, however, not correct. Potonié (1970) gave *Stephanocolpati*, *Stephanorugati* the status of infraturma and not the genus *Stephanocolpites* van der Hammen (1954) emend. Potonié (1960).

Holotype — van der Hammen, 1954 emend. pl. 7, fig. 7.

Type Locality — Suesca Cogontá, Capa 7, no. 2.

Genus — *Ghoshiacolpites* Sah & Kar, 1970

Type Species — *Ghoshiacolpites globatus* Sah & Kar, 1970.

Ghoshiacolpites globatus Sah & Kar, 1970

Pl. 2, fig. 19; Pl. 18, figs 9, 10

1979 *Ghoshiacolpites globatus* Sah & Kar: Saxena, p. 134, pl. 2, fig. 31.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains circular-subcircular in polar view, 30-40×28-36 μm. Polycolpate, mostly hexacolpate. Mesocolpia thickened to form star-shaped appearance. Exine more or less laevigate.

Remarks — Polycolpate pollen grains are found in number of families, viz., Acanthaceae, Didieraceae, Euphorbiaceae, Scrophulariaceae, Labiatae and others. Germeraad, Hopping and Muller (1968) illustrated various species of *Ctenolophonidites* van Hoeken-Klinkenberg (1968) which outwardly resemble *Ghoshiacolpites*. The latter is polycolpate, subcircular and is characterized by a solid shield-like meridional thickening which projects a ridge in each apocolpate region. This kind of exinal thickening is not found in any of the types described by Germeraad, Hopping and Muller (1968). Kar and Jain (1981) think that *Ghoshiacolpites* may be regarded as an intermediate form between *Ctenolophon engleri* type and *C. parvifolius* type.

It may be stated here that *Ctenolophonidites* pollen are first found in the Upper Cretaceous of Nigeria but in Palaeocene-Eocene they are ill represented and again found in good percentage in Neogene.

Holotype — Sah & Kar, 1970, pl. 2, fig. 43; size 34×33 μm; slide no. 3365.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Retistephanocolpites* Leidelmeyer emend. Saxena, 1982

Type Species — *Retistephanocolpites angeli* Leidelmeyer, 1966.

Remarks — Saxena (1982) ventured a critical discussion on the taxonomy and nomenclature of the Indian Tertiary polycolpate pollen grains. He observed that in spite of the stratigraphic importance of the polycolpate pollen this group has not been handled carefully by the palynologists. As a result, a number of genera have been instituted on minor differences whereas in other cases many species having diversified characters have been placed together to raise the genus into suprageneric level. He also remarked that many of the 31 polycolpate pollen genera described so far from India are either invalidly published or their diagnosis and status are not properly understood. He has taken exine ornamentation and its thickenings as generic characters while number, nature and length of the colpi, overall shape and size of the pollen have been considered for specific delimitation. He has restricted *Polycolpites* to include only the clavate, polycolpate pollen grains and *Retistephanocolpites* to accommodate reticulate, foveolate or foveoreticulate polycolpate pollen grains.

Saxena (1982) has heavily depended on van der Hammen and de Mutis (1965), Leidelmeyer (1966), Guzmán (1967), Wijmstra (1971) and others to select the different polycolpate genera. The diagnosis of most of these genera are almost telegraphic which do not convey much meaning and the description of the genus has also not been given. *Psilastephanocolpites* Leidelmeyer (1966) has been advocated to include stephanocolpate pollen grains with a psilate sculpture and *Scabrastephanocolpites* van der Hammen & de Mutis (1965) to accommodate stephanocolpate pollen grains with scabrate exine. The other genera also have been based on ornamentation without any consideration of the shape and other characters. Thus a square, rectangular, oval, elliptical, polygonal, subtriangular and subcircular pollen grains with more than three colpi and psilate exine should only be accommodated in *Psilastephanocolpites*. Similarly, any verrucate, stephanocolpate pollen grains can be included under *Verrustephanocolpites* van der Hammen & de Mutis (1965). This oversimplified generic circumscription would also make much confusion. Besides, Saxena (1982) did not study most of the genotypes and holotypes and he depended mainly on the description of others which may be inaccurate in some of the cases.

Retistephanocolpites kutchensis Saxena, 1979

Pl. 2, fig. 21

1979 *Retistephanocolpites kutchensis* Saxena, pp. 134-135, pl. 2, fig. 33.

Diagnosis (*after Saxena, 1979*) — Pollen grains pentagonal-subcircular in polar view, 22-34 μm. Pentacolpate, colpi long, mesocolpia broad. Exine 1.5-3.5 μm thick, foveoreticulate, muri very thin.

Holotype — Saxena, 1979, pl. 2, fig. 33; size 33×31 μm; slide no. 4772/2.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures on the western side of the road at Matanomadh.

Genus — *Lokiapollis* Venkatachala & Kar, 1969a

Type Species — *Lakiapollis ovatus* Venkatachala & Kar, 1969a.

Lakiapollis ovatus Venkatachala & Kar, 1969a

Pl. 17, figs 7-9

1979 *Lakiapollis ovatus* Venkatachala & Kar: Saxena, p. 135, pl. 2, fig. 37

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains subcircular, 40-50× 35-45 μm. Tribrevicolporate, colpi inconspicuous, hardly discernible in most specimens. Pores well-developed, oval-elliptical, outer margin thickened, pores mostly situated subequatorially. Exine up to 2.5 μm thick, generally psilate.

Remarks — Saxena (1979) proposed *Lakiapollis spinosus* (pl. 2, fig. 29) for the subcircular, tricolporate, spinose and retibaculate pollen grains from the Matanomadh Formation. The species was restudied and it was found that three colpi though short are easily distinguishable, the pores are not distinct though some thickened, circular areas are observed around the colpi. The spines are about 6-10 μm apart, with bulbous base and pointed tip, exine is tegillate, sexine thicker than nexine and its columellate. Since *Lakiapollis* is now restricted only to laevigate and weakly intrastructured exine, this species should be transferred somewhere else.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 77; size 43×37 μm; slide no. 3318.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Muller (1980) thinks that *Lakiapollis ovatus* comes close to the pollen of *Durio* type of the family Bombacaceae.

Genus — *Retitribrevicolporites* gen. nov.

Type Species — *Retitribrevicolporites* (*Lakiapollis*) *matanomadhensis* (Venkatachala & Kar) comb. nov.

Diagnosis — Pollen subcircular, tribrevicolporate, colpi and pore more or less of same size, pore margin thickened. Exine reticulate.

Description — Apertures generally found in subequatorial view, sometimes they are not discernible due to heavy ornamentation, 30-58×36-56 μm. Colpi generally 6-10 μm long, ill-developed, elliptical in shape, often appear as slits. Pore easily recognizable due to their thickened margin, in some specimens thickening more pronounced on both lateral ends. Exine 2-4 μm thick, sexine usually thicker or as thick as nexine. Exine pilate and baculate, together forming reticulate pattern, meshes of different sizes and shapes.

Comparison — *Lakiapollis* Venkatachala & Kar (1969a) closely resembles *Retitribrevicolporites* in subcircular shape, size range and tribrevicolporate condition, however, the former is distinguished by its laevigate exine. *Subtriporopollis* Sah (1967) is also subcircular and reticulate but is triporate. *Faguspollenites* Raatz (1937) also resembles *Lakiapollis* in circular-subcircular shape, size range and tricolporate nature but the pores in *Faguspollenites* are rounded and without any marginal thickening and situated along the margin in polar view. *Gyrillaceaepollenites* Murriger & Pflug (1951) emend. Potonié

(1960) is subcircular and tricolporate but has more or less laevigate exine. *Retitribrevicolporites* instituted here is differentiated from all other genera by its subcircular shape, reticulate ornamentation and tribrevicolporate condition. *Subtriporopollis* Sah (1967) is subcircular-subtriangular but is only triporate. *Tricolporopollis* Dutta & Sah (1970) is subcircular and tricolporate but the colpi are much longer than the present genus. Besides, the type slide of the genotype is also lost thus the detailed comparison is not possible.

Retitribrevicolporites (*Lakiapollis*) *matanomadhensis* (Venkatachala & Kar) comb. nov.

Pl. 3, fig. 5; Pl. 13, figs 1, 2; Pl. 9, fig. 7

1979 *Lakiapollis matanomadhensis* Venkatachala & Kar : Saxena, p. 135, pl. 3, figs 38, 39.

Diagnosis — Pollen grains subcircular, 40-60 × 38-59 μm. Tribrevicolporate. Colpi generally distinct, 6-10 μm long, elliptical, often obscure due to strong ornamentation. Pore distinct, 6-10 μm in diameter, margin thickened. Exine up to 4 μm thick, sexine thicker than nexine, tectate. Ornamentation reticulate, formed by pila and bacula, pila 1-2 μm long and 1 μm broad, bacula, slender, longer than pila.

Remarks — Venkatachala & Kar (1969a) described this species under *Lakiapollis* as *L. matanomadhensis*. *Lakiapollis* is restricted here for the subcircular-circular pollen with tribrevicolporate apertures and laevigate to slightly weakly intrastructured exine. *Subtriporopollis globosa* (pl. 8, figs 27, 28) and *S. reticulata* (pl. 8, figs 25, 26) described by Dutta and Sah (1970) from Cherra Sandstone of the South Shillong Plateau seems to belong to *Retibrevicolporites*.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 79; size 55 × 54 μm; slide no. 3353/2.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road in front of Dak Bungalow, Matanomadh.

Genus — *Paleosantalaceaepites* Biswas emend. Dutta & Sah, 1970

Type Species — *Paleosantalaceaepites dinoflagellatus* Biswas, emend. Dutta & Sah 1979.

Remarks — Germeraad, Hopping and Muller (1968) instituted *Zonocostites* to accommodate spherical to subprolate, tricolporate pollen, colpi relatively short, end exinous apertures equatorially elongated or almost fused, distinctly costate, wall tectate, finely perforate, thin, often almost psilate on equator, or thicker at poles, due to longer columellae. They selected *Zonocostites ramonae* as the type species and intended to accommodate fossil dispersed pollen of the *Rhizophora-Bruguiera* type.

This description as well as the illustration of type species (Germeraad, Hopping & Muller, 1968, pl. 15, fig. 6) closely resemble the description and illustrations of different species of *Paleosantalaceaepites* by Biswas (1962, pl. 5, fig. 10; pl. 6, fig. 28; pl. 8, fig. 51). Unfortunately, Germeraad, Hopping and Muller (1968) did not make any comments on *Paleosantalaceaepites* while proposing the new genus, viz., *Zonocostites*.

Subsequently, Dutta and Sah (1970) emended *Paleosantalaceaepites* to include pollen grains of small to medium in size, rounded triangular to sub-spheroidal in polar view, oblate spheroidal to spheroidal in equatorial; 3 colporate, brevicolpate to longicolpate, or a distinct, large, generally zonorate, sometimes lalongate-grandorate; exine thickness variable, sexine smooth or with columella, surface ornamentation smooth to minutely granulate to finely reticulate.

Dutta and Sah (1970) also commented that the genus is now extended to incorporate distinctly zonorate pollen grains with short colpi and a thick columellate exine as found in *P. miocenicus* Ramanujam (1966).

Paleosantalaceaepites ellipticus Sah & Kar, 1970

Pl. 2, fig. 16

1979 *Paleosantalaceaepites ellipticus* Sah & Kar : Saxena, p. 136, pl. 3, fig. 41.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains elliptical-oval in equatorial view, 46-55×25-40 μm. Tricolporate, colpi well-developed, pore lalongate. Exine thick, more or less laevigate-finely intrastructured.

Holotype — Sah & Kar, 1970, pl. 2, fig. 55; size 52×30 μm; slide no. 3363.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures on the western side of the village Matanomadh.

Paleosantalaceaepites minutus Sah & Kar, 1970

Pl. 2, fig. 17; Pl. 14, fig. 5

1979 *Paleosantalaceaepites minutus* Sah & Kar : Saxena, p. 136, pl. 3, fig. 42.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval-subcircular in equatorial view, 20-28×18-25 μm. Tricolporate, colpi ill-developed. Pore well-developed, bulging. Exine more or less laevigate-finely scrobiculate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 48; size 28×25 μm; slide no. 3357.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Verrucolporites* Sah & Kar, 1970

Type Species — *Verrucolporites verrucus* Sah & Kar, 1970.

Verrucolporites verrucus Sah & Kar, 1970

Pl. 14, fig. 7

1979 *Verrucolporites verrucus* Sah & Kar: Saxena, p. 136, pl. 3, fig. 43.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval-elliptical in equatorial and subcircular in polar view, 30-50×25-44 μm. Tricolporate, colpi long, pore, indistinct. Exine strongly verrucose.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Striacolporites* Sah & Kar, 1970

Type Species — *Striacolporites striatus* Sah & Kar, 1970.

Remarks — The pollen grains of Solanaceae, Nolanaceae and Scrophulariaceae resemble the genus *Striacolporites*. The pollen grains of *Atropa lutea*, *Cestrum smithii* and *Datura suaveolens* of Solanaceae are tricolporate and striato-reticulate but they differ from *Striacolporites* in having lalongate condition. Similarly, the pollen grains of *Alonsoa acutifolia* and *Aptosimum depressum* of Scrophulariaceae are also striato-reticulate and tricolporate but they are also lalongate (Erdtman, 1952).

Striacolporites closely resembles the genus *Striatricolporites* van der Hammen (1956). Potonié (1960) rejected this genus as invalid because the type species of *Striatricolporites* is based on the living pollen.

Baksi and Deb (1981), however, reported *Striatricolporites* from the Upper Cretaceous of Bengal Basin. Besides, they also described *Psittacopollis* van Ameron (1965) which seems to be tricolporate and striato-reticulate. Venkatachala and Sharma (1974) described striato-reticulate, triporate pollen as *Striatricolporites cauveriana* which was transferred to *Pulcheripollenites* Srivastava (1969) by Baksi and Deb (1981).

It is interesting to note that striato-reticulate, tricolporate and triporate pollen grains were prevalent in the Upper Cretaceous of Bengal Basin in the *Aquilapollenites indicus* zone of Baksi and Deb (1981).

Striacolporites ovatus Sah & Kar, 1970

Pl. 2, fig. 28; Pl. 18, fig. 5

1979 *Striacolporites ovatus* Sah & Kar: Saxena, p. 136, pl. 3, fig. 45.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval in equatorial view, 70-80 ×40-52 μm. Tricolporate, apertures ill-developed. Sexine thicker than nexine, striato-reticulate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 56; size 52×32 μm; slide no. 3362.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Striacolporites cephalus Sah & Kar, 1970

Pl. 4, fig. 12; Pl. 14, fig. 10

1979 *Striacolporites cephalus* Sah & Kar: Saxena, p. 136, pl. 3, fig. 44.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains subcircular in polar view, 70-75×58-65 µm. Tricolporate, colpi membrane faintly granular. Sexine thicker than nexine. Striato-reticulate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 68; size 74 × 48 µm; slide no. 3372.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Favitricolporites* Sah, 1967

Type Species — *Favitricolporites eminens* Sah, 1967.

Favitricolporites retiformis Sah, 1967

Diagnosis (*after Sah, 1967*) — Size range 30-34 µm, amb sub-oblate to broadly triangular, trizoniaperturate, colporate, colpi tenuimarginate, ora lalongate, sexine as thick as nexine, columella clear, distinctly reticulate.

Holotype — Sah, 1967, pl. 10, fig. 14; size 32 µm; slide no. 16/8.

Type Locality — Rusizi Valley, Neogene, Burundi.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Palaeocoprosmadites* Ramanujam, 1966

Type Species — *Palaeocoprosmadites arcotense* Ramanujam, 1966.

Palaeocoprosmadites arcotense Ramanujam, 1966

Pl. 2, fig. 14

1979 *Palaeocoprosmadites arcotense* Ramanujam : Saxena, p. 136, pl. 3, fig. 46.

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, oblate, 25×31 µm. Amb subtriangular, colpi three, pronouncedly brevicolpate, end blunt or pointed. Exine 1.5 µm thick, columellae indistinct, surface smooth.

Holotype — Ramanujam, 1966, pl. 3, fig. 61; size 31×25 µm.

Type Locality — Neyveli lignite, Miocene, South Arcot District, Tamil Nadu.

Occurrence — Exposures in front of Dak Bungalow, Matanomadh.

Genus — *Meliapollis* Sah & Kar, 1970

Type Species — *Meliapollis ramanujamii* Sah & Kar, 1970

Remarks — *Meliapollis* is quite common in the various Tertiary sediments of India. It was first reported from the Eocene of Kachchh and later was found in Assam and Meghalaya. Rao and Vimal (1950, figs 9-11) reported their occurrence from the Palana lignites (Eocene), Rajasthan. Navale (1961) and Ramanujam (1966) described them from the Neyveli lignites, Tamil Nadu.

Meliapollis resembles the pollen grains of Meliaceae. They come quite close to *Melia azedarach* in circular-subcircular shape, tetracolporate condition, pore with thickened margin and laevigate exine.

Navale and Misra (1979) emended *Meliapollis* and included *Platoniapollenites* Sah & Kar (1974) in it. This treatment is not commendable as *Platoniapollenites* is distinguished from *Meliapollis* and other tetracolporate pollen genera by its thinner margin of the colpi which generally dissolve to form a cross like appearance in the case of tetracolporate pollen grains and its thickened exine in the mesocolpate region. *Meliapollis*, it may be stated here, has comparatively shorter colpi and uniformly thickened exine.

Meliapollis ramanujamii Sah & Kar, 1970

Pl. 3, fig. 6; Pl. 18, fig. 3

1979 *Meliapollis ramanujamii* Sah & Kar: Saxena, p. 136, pl. 3, fig. 47

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains circular-subcircular, 50-65× 48-62 µm. Tetracolporate, brevicolpate, pore circular-lalongate, margin thickened. Exine 1.5-2.5 µm thick, laevigate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 62; size 60×56 µm; slide no. 3378.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Meliapollis navalei Sah & Kar, 1970

Pl. 14, fig. 13

Diagnosis — Pollen grains subcircular-circular, 60-75×57-70 μm. Pentacolporate, brevicolpate, pore distinct with thickened margin. Exine 1.5-3.5 μm thick, laevigate or weakly intrastructured.

Holotype — Sah & Kar, 1970, pl. 2, fig. 65; size 70×62 μm; slide no. 3379.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures on the western side of the village Matanomadh.

Meliapollis quadrangularis (Ramanujam) Sah & Kar, 1970

Pl. 4, fig. 11; Pl. 10, fig. 6

1979 *Meliapollis quadrangularis* (Ramanujam) Sah & Kar: Saxena, p. 136, pl. 3, fig. 48.

Diagnosis (*after Ramanujam*, 1966) — Pollen grains isopolar, prolate to subprolate, tetrazonicolporate, large, 54×33 μm. Amb four sided, quadrangular, colpi tenuimarginate, end portions rather faint, pointed long but not reaching poles, ora prominent, slightly lolongate with thickened rims. Exine 2.5 μm thick, columellae not distinct, surface psilate.

Holotype — Ramanujam, 1966, pl. 5, fig. 82; size 54×32 μm.

Type Locality — Neyveli lignite, Miocene, South Arcot District, Tamil Nadu.

Occurrence — Exposures on the road, in front of Dak Bungalow, Matanomadh.

Meliapollis melioides (Ramanujam) Sah & Kar, 1970

Pl. 2, fig. 20

1979 *Meliapollis melioides* (Ramanujam) Sah & Kar: Saxena, p. 136, pl. 3, fig. 49.

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, prolate spheroidal, tetrazonicolporate, 36×27 μm. Amb four sided, quadrangular. Colpi narrow tenuimarginate, almost straight, long but not reaching poles, ends blunt, ora conspicuous with thickened rims, lalongate. Exine 1.8 μm thick, columellae not found, surface giving a flecked appearance.

Holotype — Ramanujam, 1966, pl. 5, fig. 84; size 36×27 μm.

Type Locality — Neyveli lignite, Miocene, South Arcot District, Tamil Nadu.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Dermatobrevicolporites* gen. nov.

Type Species — *Dermatobrevicolporites* (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

Dermatobrevicolporites (*Meliapollis*) *triangulus* (Saxena) comb. nov.

Pl. 4, fig. 10

1979 *Meliapollis triangulus* Saxena, pp. 136-137, pl. 3, figs 50, 51.

Diagnosis (*after Saxena, 1979*) — Pollen grains triangular, subtriangular in polar view, 40-60 μm. Tricolporate, brevicolpate, pores distinct, pore margin thickened, Exine up to 4 μm thick, laevigate to finely intrastructured.

Remarks — Saxena (1979) described this species as *Meliapollis triangulus*. *Meliapollis* is characterized by subcircular-circular shape and the colpi are quite long. Since the pollen grains described by Saxena (1979) are typically triangular-subtriangular in shape they have been transferred to *Dermatobrevicolporites*. *D. dermatus* (Sah & Kar) comb. nov. and *D. exaltus* are distinguished from this species in the presence of pronounced anguloaperturate condition which are almost protruding in most of the cases.

Holotype — Saxena, 1979, pl. 3, fig. 50; size 58×56 μm; slide no. 4767/15.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Triangulorites* gen. nov.

Type Species — *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov.

Diagnosis — Pollen grains triangular-subtriangular in polar view, tri- to tetraorate, ora distinct, present on each extended arm. Exine granulose-conied, forming negative reticulum in surface view.

Description — Pollen grains almost always found in polar view, 50-78 × 48-75 μm, margin generally convex, sometimes more or less straight. Three ora distinct, circular, always found in extended arms, arms 10-30 μm long, 5-15 μm broad, in most specimens a tendency to form another ora noticed, this may be seen as a bulging of exine adpressed on main body, sometimes even sporting an ora on it, in others it appears just as a protrusion which appears as a fold on main body, sometimes an angular protrusion without ora on margin also observed. Exine 1.5-2.5 μm thick, sexine thicker than nexine, granulose-conied, sculptural elements about 1 μm in height, closely placed, sometimes sculptural elements more concentrated on extended part of arms.

Comparison — *Tripilaorites* resembles *Triangulorites* in triangular shape and triorate condition, but in the former the ora are never found in the protruded arms and is pilate and baculate. *Triorites* Cookson ex Couper (1953) has somewhat protruded ora but the exine is approximately 9-10.5 μm thick and consists of four clearly defined layers of exine. Besides, the apertures in *Triorites* appear to be situated at the base of cavities formed by forward annular extensions of the exine. *Proteacidites* Cookson (1950) approximates the present genus in shape and position of the apertures but is either baculate, clavate or tuberculate.

Remarks — *Grevilloideaepites eocenica* Biswas (1962, pl. 6, fig. 24) resembles some pollen grains of *Triangulorites*. But as *Grevilloideaepites* is an invalid genus it has not been considered here.

Triangulorites (*Triorites*) *bellus* (Sah & Kar) comb. nov.

Pl. 4, fig. 7; Pl. 19, figs 6-8

1979 *Triorites bellus* Sah & Kar: Saxena, p. 137, pl. 3, fig. 53.

Diagnosis — Pollen grains triangular-subtriangular in polar view, 65-75 × 60-73 μm, margin convex. Tri- or tetraorate, ora present on radiating arms, arms 15-30 × 8-15 μm broad, generally length of arms double the breadth, three ora distinct in all specimens, another incipient to well-developed ora also observed in most specimens, it generally adpressed in middle region, sometimes fourth ora is recognizable on margin (Pl. 19, fig. 7), sometimes it appears as mere angular projection. Exine 1-2.5 μm thick, granulose-conied, sculptural elements up to 1 μm high, closely placed, sometimes more concentrated on radiating arms, providing negative reticulum in surface view.

Holotype — Sah & Kar, 1970, pl. 2, fig. 70; size 70 × 68 μm; slide no. 3352/10.

Type Locality — Bore-core no. 13, depth 16 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Triangulorites (*Triorites*) *triradiatus* (Saxena) comb. nov.

Pl. 4, fig. 8

1979 *Triorites triradiatus* Saxena, p. 137, pl. 3, fig. 54.

Diagnosis (*after Saxena, 1979*) — Pollen grains triangular in polar view with pronounced protuberances, 48-57 μm. Triorate, ora distinct. Exine 2-3 μm thick, sexine thinner than nexine, finely scrobiculate to granulose.

Remarks — Saxena (1979) described this as *Triorites triradiatus*. As *Triorites* (*sensu* Cookson) is very much different from the present species, this has transferred to *Triangulorites*. It differs from *T. bellus* (Sah & Kar) comb. nov. by its smaller breadth of the middle region and its longer length of the triradiating arms.

Holotype — Saxena, 1979, pl. 3, fig. 54; size 55 × 53 μm; slide no. 4959/1.

Type Locality — Matanomadh, Matanomadh Formation, Palaeocene, Kachchh.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Proteacidites* Cookson, 1950

Type Species — *Proteacidites adenanthoides* Cookson, 1950.

Proteacidites protrudus Sah & Kar, 1970

1979 *Proteacidites protrudus* Sah & Kar: Saxena, p. 137, pl. 3, fig. 55.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains triangular, 50-60×48-55 μm. Triporate, pore distinct. Exine finely scrobiculate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 61; size 56×50 μm; slide no. 3365.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Triporopollenites* (Pflug) Thomson & Pflug, 1953

Type Species — *Triporopollenites coryloides* (Pflug) Thomson & Pflug, 1953.

Triporopollenites minutiformis (Ramanujam) Saxena, 1979

Pl. 2, fig. 15

1979 *Triporopollenites minutiformis* (Ramanujam) Saxena, p. 137, pl. 3, fig. 56.

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, flattened along both poles, 15-17.5 μm in equatorial diameter. Trizoniporate, pores rounded, surrounded by a distinct annulus, not much raised from the surface. Exine 1.5 μm thick, surface smooth.

Holotype — Ramanujam, 1966, pl. 5, fig. 94; size 16 μm.

Type Locality — Neyveli lignite, Miocene, South Arcot District, Tamil Nadu.

Occurrence — Exposures on the western side of the village Matanomadh.

Genus — *Trilatiporites* Ramanujam, 1966

Type Species — *Trilatiporites erdtmanii* Ramanujam, 1966.

Remarks — Biswas (1962) instituted *Dorreenipites* to include more or less similar pollen grains described later as *Trilatiporites* by Ramanujam (1966). Navale and Misra (1979) emended *Dorreenipites* and transferred all the hitherto known species of *Trilatiporites* Ramanujam (1966) into it. Perhaps, *Trilatiporites* is a synonym of *Dorreenipites*; however, as we could not study the type slide of Biswas (1962), the former is tentatively maintained here.

Trilatiporites cooksoni Ramanujam, 1966

Diagnosis (*after Ramanujam, 1966*) — Pollen grains markedly heteropolar, suboblate to oblate spheroidal, equatorial diameter 40-48 μm. Amb subtriangular. Pores three, prominently nonequatorial, 3.3-6.6 μm in diameter, surrounded by a slightly thickened rim, all in one hemisphere, aligned in a triangular contour. Exine 4.6 μm thick, slightly thicker than nexine, columellae fine, often faint. Surface smooth both at meso and apoporia.

Holotype — Ramanujam, 1966, pl. 6, fig. 100; size 45 μm.

Type Locality — Neyveli lignite, Miocene, South Arcot, District, Tamil Nadu.

Occurrence — Exposures in front of Dak Bungalow at Matanomadh.

Trilatiporites kutchensis Venkatachala & Kar, 1969a

1979 *Trilatiporites kutchensis* Venkatachala & Kar: Saxena, p. 138, pl. 3, fig. 57.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains roundly triangular, 30-35×27-33 μm. Triporate, pores more or less subequatorial in position, margin of pores not appreciably thickened. Exine thick, sexine thicker than nexine, finely microreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 81; size 34×33 μm; slide no. 3321.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, on the western side of the village Matanomadh.

Genus — *Sonneratioipollis* Venkatachala & Kar, 1969a

Type Species — *Sonneratioipollis bellus* Venkatachala & Kar, 1969a.

Remarks — *Sonneratioipollis* somewhat resembles the pollen grains of Sonneratiaceae. This is a small family having only two genera — *Duabanga* with two species and *Sonneratia* with five species. The pollen grains of Sonneratiaceae have been studied by Thanikaimoni and Jayaweera (1966). According to them, both in *Duabanga grandiflora* and *D. moluccana* the pollen grains are planaperturate, triporate, pore circular with distinct annulus, pore membrane protruding out with small verrucae. The pollen grains of *Sonneratia apetala* are subtriangular in polar and elliptical in equatorial view, triporate, pores without annulus and the exine is verrucose. *Sonneratia alba* pollen are similar to *S. apetala* except the former pollen having distinct annulus. The pollen grains of *S. caseolaris* according to Thanikaimoni and Jayaweera (1966) are conspicuous in the presence of three furrows with pores and six furrows without pores. *S. ovata* pollen is triporate with very well developed annulus. *Sonneratioipollis* comes close to the extant pollen of *Sonneratia apetala* in general organisation and triporate condition but the latter is distinguished by its verrucose exine.

Sonneratioipollis bellus Venkatachala & Kar, 1969a

Pl. 2, fig. 18

1979 *Sonneratioipollis bellus* Venkatachala & Kar: Saxena, p. 138, pl. 3, fig. 58.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains oval-spindle oval, 18-30×10-15 µm. Triporate, zoniporate, pores margin do not show any marked thickening, lalongate. Exine more or less tectate, smooth.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 71; size 25×14 µm; slide no. 3318.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

Type Species — *Pseudonothofagidites kutchensis* Venkatachala & Kar, 1969a.

Remarks — Puri (1963a, 1963b) recorded some pollen grains similar to the living pollen of *Nothofagus* from the Senonian and Palaeocene of Nigeria. He thought that during Upper Cretaceous and Palaeocene *Nothofagus* was very widely distributed from Africa to Australia and these widely separated lands witnessed similar environmental condition. Ghosh, Srivastava and Sen (1964) postulated that *Nothofagus* was widely spread in India during Tertiary and extended far east via Assam and Burma.

The pollen grains of *Nothofagus* have been studied by Cranwell (1939), Cookson (1946), Couper (1953), Cookson and Pike (1955) and others. In general, the *Nothofagus* pollen are divided into *menziessi*, *fusca* and *brassi* types. All the types have meridionally elongated pores which are equally spaced around the equator. The exine is spinose.

The pollen grains assignable to *Pseudonothofagidites* apparently resemble *Nothofagus* pollen in shape and polyaperturate condition. But the *Nothofagus* pollen are anguloaperturate and spinose whereas in *Pseudonothofagidites* the apertures are found in depression and the exine is microgranulose. The position of the apertures in the two genera are very much dissimilar and this should be taken into account while identifying fossil *Nothofagus* pollen in India. In fact, in the Tertiary sediments of Kachchh there is no authentic record of *Nothofagus* pollen. The various polycolpate pollen grains described under many genera from the Tertiary sediments are not porate and the apertures are not situated at pointed ends. Besides typical spinose exine of *Nothofagus* pollen is also not encountered in the specimens.

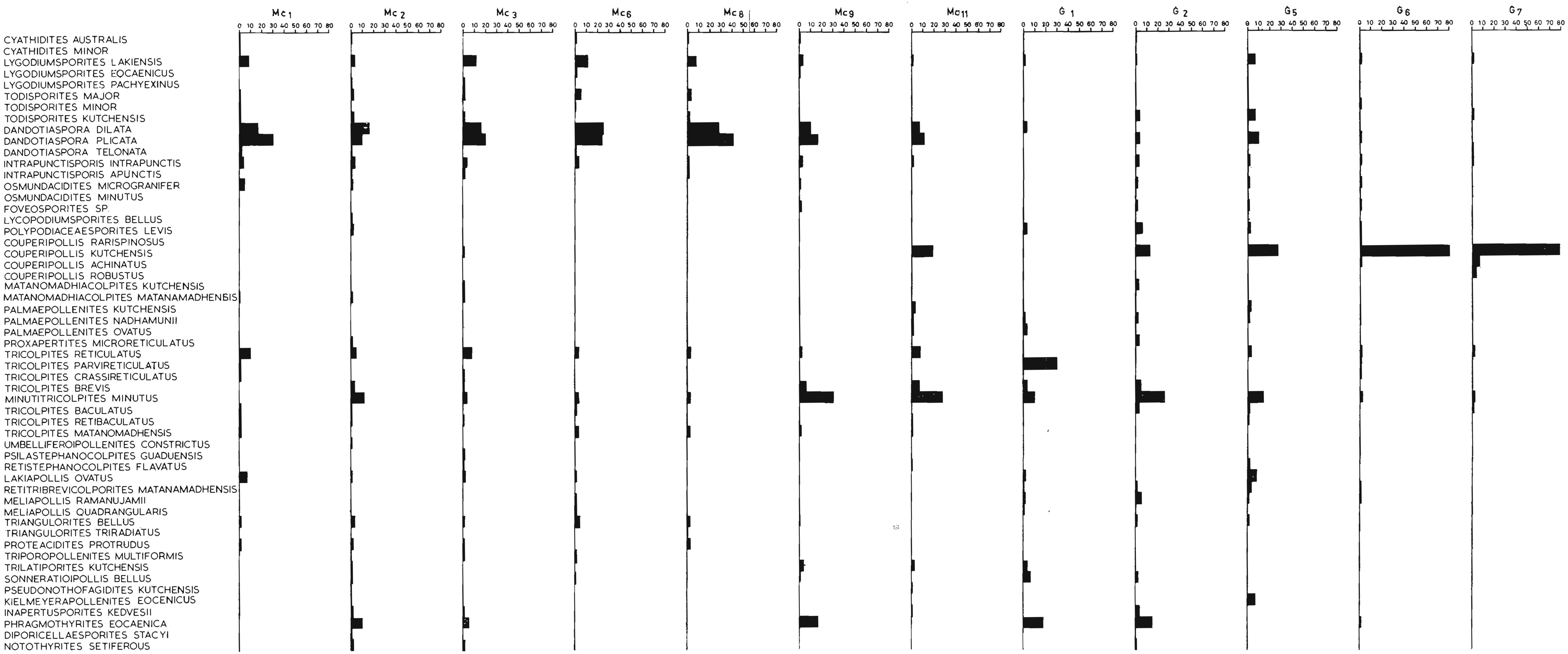
Pseudonothofagidites kutchensis Venkatachala & Kar, 1969a

Pl. 2, fig. 23

1979 *Pseudonothofagidites kutchensis* Venkatachala & Kar: Saxena, p. 138, pl. 3, fig. 59.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains more or less subcircular with regular lobed margins. Polyporate, pores rimmed, invaginated inwards. Exine up to 3 µm thick, finely granulose.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 73; size 26×25 µm; slide no. 3320.



TEXT-FIG. 3 — Showing the percentage of different spore-pollen species in Matanomadh Formation.

Occurrence — Exposures near the road, Matanomadh.

Genus — *Kielmeyerapollenites* Sah & Kar, 1974

Type Species — *Kielmeyerapollenites eocenicus* Sah & Kar, 1974.

Remarks — Tetrad pollen among the living angiosperms are found in Droseriaceae, Epacridaceae, Ericaceae, Gentianaceae, Guttiferae, Hydrostachyaceae, Monimiaceae, Orchidaceae, Saxifragaceae, Tiliaceae etc. *Kielmeyerapollenites* resembles the pollen grains of *Kielmeyera* of the family Cluciaceae (Guttiferae). The pollen grains in both of them are found in tetrahedral tetrads and the size range is also more or less same. Besides, the position of the apertures in both are also identical and are tricolporate. The thickness of the exine and nature of ornamentation is also similar except some minor details. *Kielmeyera*, however, does not grow now in India and is found in the tropical forest of Brazil.

Kielmeyerapollenites eocenicus Sah & Kar, 1974

Pl. 3, fig. 8

1979 *Kielmeyerapollenites eocenicus* Sah & Kar: Saxena, p. 138, pl. 3, fig. 60.

Diagnosis (*after Sah & Kar, 1974*) — Pollen grains mostly in tetrahedral tetrads. Tricolporate, colpi distinct, pore margin thickened. Exine thick, retipilate.

Holotype — Sah & Kar, 1974, pl. 2, fig. 60; size 60×58 μm; slide no. 4368/24.

Type Locality — Palana lignite, Lower Eocene, Rajasthan.

Occurrence — Exposures on the western side of the village, near the road, Matanomadh.

PALYNOSTRATIGRAPHIC ZONATION OF MATANOMADH FORMATION

The palynological succession of Matanomadh Formation is divisible into a number of biostratigraphic units based on the distributional pattern of the spores and pollen grains recovered from this formation. The maximum development of a particular taxon together with its associated forms, first and last appearance of taxa, and the gradual decline have all been taken into consideration for the delimitation of various palynological boundaries and to demarcate the different zones.

The spores and pollen grains were counted up to 200 specimens from the slides taking at random. All the productive samples collected from the different sections were studied and counted. The samples containing more or less same palynological assemblage were grouped together and average percentage of each individual taxon was worked out. As the complete thickness of Matanomadh Formation is not exposed in any of the sections, a composite section showing the more or less complete thickness was deduced from the different sections exposed in the locality. The palynological data obtained from the different sections were arranged in the composite section according to the vertical distribution. The relative frequency of different species have been shown under five categories, viz., 1-5, 6-10, 11-16, 17-20 and above 20 (Text-fig. 3).

On the basis of relative frequency of palynological taxa, the Matanomadh Formation has been divided into following five zones in ascending order:

Upper Member	5. Sponge spicules zone
	4. *Couperipollis kutchensis* Cenozone
	3. *Tricolpites minutus* Cenozone
	2. *Dandotiaspora dilata* Cenozone
Lower Member	1. Barren zone

The Lower Member of the Matanomadh Formation which is generally made up of laterites, lithomargic clay and trap wash did not yield any palynological fossils and therefore biostratigraphically constitutes a Barren Zone. This zone conformably overlies the green coloured basalt of the Deccan Traps. The Upper contact of this zone with the gritty sandstone bed of the overlying *Dandotiaspora dilata* Cenozone is unconformable.

Dandotiaspora dilata Cenozone

Type Section — Matanomadh, Kachchh, Gujarat.

Lithology — This zone is mainly characterized by sandstone with alternation of thin carbonaceous and tuffaceous shales. This zone is about 16 metre thick.

Lower Contact — This zone constitutes the lowermost palynostratigraphic unit of the Upper Member of Matanomadh Formation. This rests unconformably on the Barren zone of the Lower Member.

Upper Contact — The Upper contact is marked between the sandstone of this zone and the carbonaceous shale of the overlying *Tricolpites minutus* Cenozone. The contact is conformable.

Significant species of this Cenozone — *Dandotiaspora dilata*, *Dandotiaspora plicata*, *Lygodiumsporites lakiensis*, *Lygodiumsporites pachyexinus*, *Todisporites major*, *Intrapunctisporis apunctis*, *Proxapertites microreticulatus*, *Psilastephanocolpites guaduensis*, *Tricolpites retibaculatus*, *Tricolpites crassireticulatus*, *Proteacidites protrudus*, *Tricolpites reticulatus*, *Cyathidites australis* and *Liliacidites matanomadhensis*.

Species restricted to this zone — *Lygodiumsporites pachyexinus*, *Todisporites major*, *Intrapunctisporis apunctis*, *Proxapertites microreticulatus*, *Psilastephanocolpites guaduensis*, *Tricolpites retibaculatus*, *Tricolpites crassireticulatus*, *Proteacidites protrudus* and *Triporopollenites multiformis*.

Remarks — The cenozone is characterized by the dominance of pteridophytic spores. *Dandotiaspora* is the most common genus and is represented by two species, viz., *D. dilata* and *D. plicata*. The latter is most common in the zone but the cenozone has not been named after it as the species is long ranging. The angiospermic pollen grains are frequently found and the gymnospermic pollen are totally absent (Text-fig. 4).

Tricolpites minutus Cenozone

Type Section — Matanomadh, Kachchh, Gujarat.

Lithology — The predominant lithology of this zone is the sandstone alternating with carbonaceous and tuffaceous shales. The approximate thickness of this zone is 10 metre.

Lower Contact — The lower most shale band of this cenozone lies conformably on the sandstone of the underlying *Dandotiaspora dilata* Cenozone.

Upper Contact — The upper contact of the cenozone is also conformable with the overlying *Couperipollis kutchensis* Cenozone.

Significant species of this Cenozone — *Tricolpites minutus*, *Tricolpites brevis*, *Phragmothyrites eocaenica*, *Tricolpites reticulatus*, *Osmundacidites microgranifer*, *Cyathidites australis*, *Liliacidites matanomadhensis*, *Dandotiaspora plicata*, *Palmaepollenites nadhamunii*, *Palmaepollenites ovatus*, *Sonneratioipollis bellus* and *Inapertusporites kedvesii*.

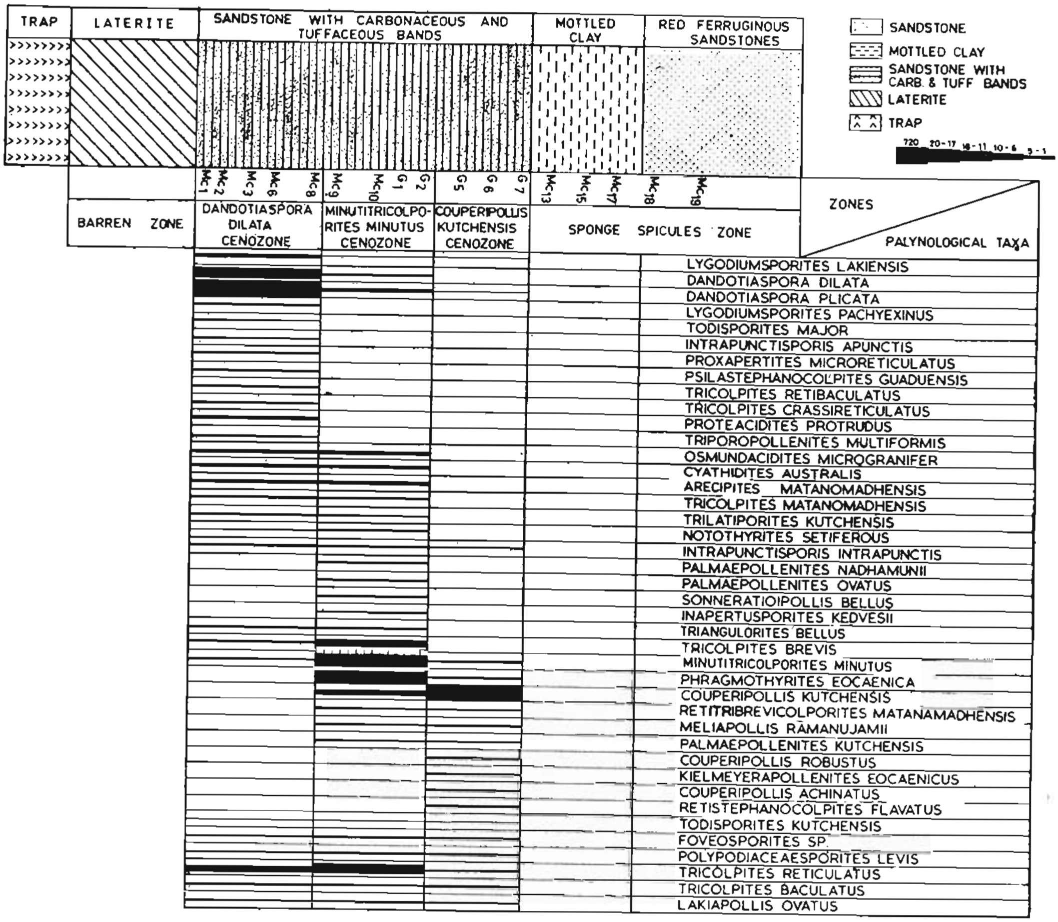
Species restricted to this Cenozone — *Palmaepollenites nadhamunii*, *Palmaepollenites ovatus*, *Sonneratioipollis bellus* and *Inapertusporites kedvesii*.

Remarks — In contrast to the previous cenozone, this zone is characterized by the dominance of angiospermic pollen, particularly the tricolpate types. Microthyriaceous ascostromata generally represented by *Phragmothyrites eocaenica* is also quite common. It may be mentioned here that some of the reworked Mesozoic taxa like *Concavissimisporites* (Delcourt & Sprumont), Delcourt, Dettmann & Hughes (1963), *Impardecispora* Venkatachala, Kar & Raza (1969), *Klukisporites* Couper (1958), *Boseisporites* (Dev) Bharadwaj & Kumar (1972), *Contignisporites* Dettmann (1963), *Callialasporites* (Dev) Bharadwaj & Kumar (1972), *Podocarpidites* (Cookson) Potonié (1958), *Laricoidites* Potonié, Thomson & Thiergart) Potonié (1956), *Araucariacites* (Cookson) Couper (1953) and *Schizosporis* Cookson & Dettmann (1959) are also found in some samples. These specimens were excluded while counting the percentage.

Sah and Singh (1977) could not detect this cenozone. Perhaps, they also counted the reworked Mesozoic palynofossils while calculating the percentage and it masked the real picture. The reworked nature of these taxa could easily be recognised by their colour, state of preservation and above all in the total absence of these forms in the lowermost cenozone.

Couperipollis kutchensis Cenozone

Type Section — Matanomadh, Kachchh, Gujarat.



TEXT-FIG. 4 — Showing the different palynological cenozones in Matanomadh Formation.

Lithology — This cenozone is also characterized by sandstone with alternation of carbonaceous and tuffaceous shales. The thickness of this cenozone is approximately 6 metre.

Lower Contact — The lowermost shale band of this cenozone rests conformably on the sandstone of the underlying *Tricolpites minutus* Cenozone.

Upper Contact — The Upper contact with the overlying Sponge spicule zone is also conformable and is marked between the topmost sandstone bed to this cenozone and mottled, arenaceous clay bed of the overlying Sponge spicule zone.

Significant species of this Cenozone — *Couperipollis kutchensis*, *Tricolpites minutus*, *Phragmothyrites eocaenica*, *Lakiapollis matanomadhensis*, *Meliapollis ramanujamii*, *Palmaepollenites kutchensis*, *Couperipollis robustus*, *Kielmeyerapollenites eocaenicus*, *Couperipollis achinatus*, *Polycolpites flavatus*, *Polypodiaceaesporites levis*, *Tricolpites reticulatus*, *Tricolpites baculatus* and *Lakiapollis ovatus*.

Species restricted to this Cenozone — *Couperipollis robustus*, *Kielmeyerapollenites eocaenicus*, *Couperipollis achinatus* and *Polycolpites flavatus*.

Remarks — This cenozone is dominated by palm pollen. Sah and Singh (1977) also included *Laricoidites punctatus*, *Podocarpidites grandis* and *P. novus* as characteristic species of this cenozone. As has already been mentioned these are the reworked Mesozoic taxa and should be excluded from the counting.

The presence of palm pollen in overwhelming percentage perhaps points towards a coastal deposition.

Sponge spicule zone

Type Section — Matanomadh, Kachchh, Gujarat.

Lithology — This zone consists of shale and mottled clay which is overtopped by a red ferruginous sandstone. The average thickness of this zone is about 15 metre.

Lower Contact — The arenaceous mottled clay — the lower bed of this zone — rests conformably over the sandstone bed of the underlying *Couperipollis kutchensis* Cenozone.

Upper Contact — The red ferruginous sandstone forming the top of this zone seems to be conformably overlain by gypseous shales of the Naredi Formation.

Remarks — This zone is conspicuous by its absence of any palynological taxa; but most of the samples are very rich in sponge spicules. By the help of these spicules, the top bed of Matanomadh Formation can easily be recognized.

SPORES AND POLLEN FROM NAREDI FORMATION

Genus — *Cyathidites* Couper, 1953

Cyathidites minor Couper, 1953

Occurrence — Bore-core no. 14, near Matanomadh; Panandhro.

Cyathidites cf. *C. minor* Couper, 1953

Occurrence — Bore-core no. 1, near Lakhpat, Akri.

Genus — *Alsophilidites* (Cookson) ex Potonié, 1956

Alsophilidites sp.

Genus — *Gleicheniidites* (Ross) Delcourt & Sprumont, 1955

Gleicheniidites sp.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Biretisporites bellus Sah & Kar, 1969

B. convexus Sah & Kar, 1969

Genus — *Todisporites* Couper, 1958

T. flavatus Sah & Kar, 1969

Todisporites kutchensis Sah & Kar, 1969

Occurrence — Bore-core no. 13, near Baranda; Panandhro.

T. flavatus Sah & Kar, 1969

Bore core nos. 1 and 2, Lakhpat, Akri

Genus — *Dandotiaspora* Sah, Kar & Singh, 1971

Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh, 1971

Occurrence — Bore-core no. 13, near Baranda, bore-core no. 141, near Jhulrai, bore core nos. 1 and 2, Lakhpat; Panandhro; Akri.

Genus — *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, 1966

Occurrence — Bore-core no. 13 near Baranda, bore-core no. 14 near Jhulrai; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Intrapunctisporis* Krutzsch, 1959

Intrapunctisporis apunctis Krutzsch, 1959

Occurrence — Bore-core no. 13 near Baranda, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Deltoidospora* (Miner) Potonié, 1956

Deltoidospora sp.

Genus — *Dictyophyllidites* Couper, 1958

Dictyophyllidites sp. A

Dictyophyllidites sp. B

Genus — *Foveosporites* Balme, 1957

Foveosporites sp.

Genus — *Osmundacidites* Couper, 1953

Osmundacidites kutchensis Sah & Kar, 1969

Genus — *Leptolepidites* Couper, 1953

Leptolepidites major Couper, 1953

Genus — *Lakiasporites* Sah & Kar, 1969

Lakiasporites triangulus Sah & Kar, 1969

Genus — *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955

Lycopodiumsporites parvireticulatus Sah & Dutta, 1966

L. bellus Sah & Kar, 1969

Occurrence — Bore-core no. 13 near Baranda, bore-core no. 1 near Lakhpat.

Genus — *Laevigatosporites* Ibrahim, 1933

Laevigatosporites lakiensis Sah & Kar, 1969

L. cognatus Sah & Kar, 1969

Laevigatosporites sp. A

Genus — *Monolites* (Erdtman) Potonié, 1956

Monolites sp.

Genus — *Polypodiaceaesporites* Thiergart, 1938

Polypodiaceaesporites sp.

Genus — *Polypodiisporites* Potonié, 1934

Polypodiisporites sp.

Genus — *Schizaeoisporites* Potonié, 1957

Schizaeoisporites sp.

Genus — *Seniasporites* Sah & Kar, 1969

Seniasporites verrucosus Sah & Kar, 1969

S. minutus Sah & Kar, 1969

Genus — *Clavatipollenites* Couper, 1958

Clavatipollenites cephalus Sah & Kar, 1970

Genus — *Arecipites* Wodehouse, 1933

Arecipites bellus Wodehouse, 1933

Genus — *Palmaepollenites* Potonié, 1951

Palmaepollenites kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh, bore-core no. 13 near Baranda, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

P. nadhamunii Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh, bore-core nos. 1 and 2 near Lakhpat.

P. ovatus Sah & Kar, 1969a

Occurrence — Bore-core nos. 13 and 15 near Baranda, Panandhro and Akri.

Occurrence — Bore-core nos. 1 and 2 near Lakhpat.

P. plicatus Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda, bore-core no. 1 near Lakhpat.

P. magnus Sah & Kar, 1970

Genus — *Spinizonocolpites* Muller, 1968

Spinizonocolpites echinatus Muller, 1968

Occurrence — Panandhro; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Proxapertites* (van der Hammen) van der Hammen, 1956

Proxapertites microreticulatus Jain, Kar & Sah, 1973

Occurrence — Bore-core no. 14 near Matanomadh, bore-core nos. 1 and 2 near Lakhpat.

Genus — *Dracaenoipollis* Sah & Kar, 1970

Occurrence — Bore-core no. 36 near Jhulrai and Panandhro.

Genus — *Retimonosulcites* gen. nov.

Retimonosulcites (*Liliacidites*) *ellipticus* (Venkatachala & Kar) comb. nov.

Retimonosulcites (*Monosulcites*) *ovatus* (Sah & Kar) comb. nov.

Genus — *Matanomadhiasulcites* gen. nov.

Matanomadhiasulcites (*Liliacidites*) *baculatus* (Venkatachala & Kar) comb. nov.

Genus — *Couperipollis* Venkatachala & Kar, 1969a

Couperipollis perspinosus (Couper) Venkatachala & Kar, 1969a

C. rarispinosus (Sah & Dutta) Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro.

C. kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh and Akri.

C. achinatus Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

C. brevispinosus (Biswas) Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh.

Genus — *Arengapollenites* gen. nov.

Arengapollenites achinatus sp. nov.

Genus — *Tricolpites* (Erdtman) Couper, 1953

Tricolpites reticulatus Cookson, 1947

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core nos. 1 and 2 near Lakhpat.

T. minutus Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

T. levis Sah & Dutta, 1966

Tricolpites sp.

Genus — *Intrareticulites* gen. nov.

Intrareticulites (*Tricolpites*) *brevis* (Sah & Kar) comb. nov.

Occurrence — Bore-core no. 36 near Jhulrai and Panandhro; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Minutitricolporites* gen. nov.

Minutitricolporites minutus sp. nov.

Genus — *Retitricolpites* Pierce, 1961

Retitricolpites robustus Sah & Kar, 1970

Genus — *Acanthotricolpites* gen. nov.

Acanthotricolpites bulbospinosus sp. nov.

Genus — *Marginipollis* Clarke & Frederiksen, 1968

Marginipollis kutchensis (Venkatachala & Kar) Kar, 1978

Genus — *Umbelliferoipollenites* Venkatachala & Kar, 1969a

Umbelliferoipollenites ovatus Venkatachala & Kar, 1969a

U. constrictus Venkatachala & Kar, 1969a

Genus — *Ailanthipites* Wodehouse, 1933

Ailanthipites sp.

Genus — *Araliaceoipollenites* Potonié, 1951

Araliaceoipollenites matanomadhensis Venkatachala & Kar, 1969a

Genus — *Cupuliferoipollenites* Potonié, 1951

Cupuliferoipollenites ovatus Venkatachala & Kar, 1969a

Genus — *Angulocolporites* gen. nov.

Angulocolporites microreticulatus sp. nov.

Genus — *Rhoipites* Wodehouse, 1933

Rhoipites kutchensis Venkatachala & Kar, 1969a

Genus — *Symplocoipollenites* Potonié, 1957

Symplocoipollenites kutchensis Venkatachala & Kar, 1969a

S. minutus Venkatachala & Kar, 1969a

S. constrictus Sah & Kar, 1970

Genus — *Pseudonyssapollenites* gen. nov.

Pseudonyssapollenites (*Nyssapollenites*) *kutchensis* (Venkatachala & Kar) comb. nov.

Genus — *Palaeocoprosmadites* Ramanujam, 1966

Palaeocoprosmadites arcotense Ramanujam, 1966

Genus — *Hippocrateaceadites* Ramanujam, 1966

Hippocrateaceadites sp.

Genus — *Margocolporites* Ramanujam, 1966

Margocolporites tsukadai Ramanujam, 1966

M. sitholeyi Ramanujam, 1966

M. sahnii Ramanujam, 1966

Genus — *Foveotricolporites* Pierce, 1961

Foveotricolporites reticuloidus sp. nov.

Genus — *Pilatricolporites* gen. nov.

Pilatricolporites eocenicus sp. nov.

Genus — *Tribrevicolporites* gen. nov.

Tribrevicolporites eocenicus sp. nov.

Genus — *Lakiapollis* Venkatachala & Kar, 1969a

Lakiapollis ovatus Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro; bore-core no. 36 near Jhulrai and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Retitribrevicolporites* gen. nov.

Retritribrevicolporites (*Lakiapollis*) *matanomadhensis* (Venkatachala & Kar) comb. nov.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 36 near Jhulrai, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Sastriipollenites* Venkatachala & Kar, 1969a

Sastriipollenites trilobatus Venkatachala & Kar, 1969a

Genus — *Verrucolporites* Sah & Kar, 1970

Verrucolporites verrucus Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Triangulotricolporites* gen. nov.

Triangulotricolporites triangulus sp. nov.

Genus — *Pellicieroipollis* Sah & Kar, 1970

Pellicieroipollis langenheimii Sah & Kar, 1970

Genus — *Meliapollis* Sah & Kar, 1970

Meliapollis ramanujamii Sah & Kar, 1970

M. raoi Sah & Kar, 1970

M. navalei Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 36 near Jhulrai.

M. quadrangularis (Ramanujam) Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core nos. 1 and 2 near Lakhpat.

M. melioides (Ramanujam) Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Akri; bore-core no. 1 near Lakhpat; bore-core no. 14, near Matanomadh.

Genus — *Striacolporites* Sah & Kar, 1970

Striacolporites striatus Sah & Kar, 1970

S. ovatus Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

S. cephalus Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 14 near Matanomadh.

Genus — *Paleosantalaceaepites* Biswas, 1962

Paleosantalaceaepites primitiva Biswas, 1962

P. ellipticus Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda and Panandhro.

P. minutus Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda and Akri.

Genus — *Retitetrabrevicolporites* gen. nov.

Retitetrabrevicolporites (*Stephanocolpites*) *globatus* (Venkatachala & Kar) comb. nov.

Retitetrabrevicolporites (*Stephanocolpites*) *granulatus* (Venkatachala & Kar) comb. nov.

Retitetrabrevicolporites sp.

Genus — *Polybrevicolporites* Venkatachala & Kar, 1969a

Polybrevicolporites cephalus Venkatachala & Kar, 1969a

P. antiquum (Ramanujam) Venkatachala & Kar, 1969a

P. (*Stephanocolpites*) *nadhamunii* (Venkatachala & Kar) comb. nov.

Genus — *Retistephanocolpites* Leidelmeyer emend. Saxena, 1982

Retistephanocolpites (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro.

Retistephanocolpites (*Polycolpites*) *granulatus* (Sah & Kar) comb. nov.

Genus — *Ctenolophonidites* van Hoeken-Klinkenberg, 1966

Ctenolophonidites costatus (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, 1966

Ctenolophonidites sp.

Genus — *Ghoshiacolpites* Sah & Kar, 1970

Ghoshiacolpites globatus Sah & Kar, 1970

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Polygalacidites* Sah & Dutta, 1966

Polygalacidites gujaratensis sp. nov.

Genus — *Monoporopollenites* Meyer emend. Potonié, 1960

Monoporopollenites sp.

Genus — *Trilatiporites* Ramanujam, 1966

Trilatiporites kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14, Matanomadh, Panandhro and Akri.

T. minutus Sah & Kar, 1970

Genus — *Sonneratioipollis* Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 13 near Baranda and Panandhro.

Genus — *Proteacidites* Cookson, 1950

Proteacidites protrudus Sah & Kar, 1970

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Tripilaorites* gen. nov.

Tripilaorites (*Triorites*) *triangulus* (Sah & Kar) comb. nov.

Genus — *Triangulorites* gen. nov.

Triangulorites (*Triorites*) *bellus* (Sah & Kar) comb. nov.

Triangulorites (*Triorites*) *minutus* (Sah & Kar) comb. nov.

Genus — *Dermatobrevicolporites* gen. nov.

Dermatobrevicolporites (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

D. exaltus sp. nov.

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

Pseudonothofagidites kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro; bore-core no. 1 near Lakhpat and Akri.

P. cerebrus Venkatachala & Kar, 1969a

Genus — *Thymelaepollis* Sah & Kar, 1970

Thymelaepollis crotonoides Sah & Kar, 1970

Genus — *Cryptopolyporites* Venkatachala & Kar, 1969a

Cryptopolyporites cryptus Venkatachala & Kar, 1969a

Genus — *Ligulifloraedites* gen. nov.

Ligulifloraedites pilatus sp. nov.

Genus — *Spinulotetradites* gen. nov.

Spinulotetradites juxatatus sp. nov.

Genus — *Alsophilidites* (Cookson) ex Potonié, 1956

Type Species — *Alsophilidites kerguelensis* Cookson, 1947.

Alsophilidites sp.

1969 *Alsophilidites* sp. Sah & Kar, p. 110, pl. 1, fig. 3.

Description (*after Sah & Kar, 1969*) — Spore triangular, 35 μm. Apices rounded, interapical margins straight-concave. Trilete, rays extending alomost up to the equator, lips uniformly thick. Exine 2.5 μm thick, laevigate.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Gleicheniidites* (Ross) Delcourt & Sprumont, 1955

Type Species — *Gleicheniidites senonicus* Ross, 1949.

Gleicheniidites sp.

Pl. 5, fig. 10

1969 *Gleicheniidites* sp. Sah & Kar, p. 110, pl. 1, fig. 28.

Description (*after Sah & Kar, 1969*) — Spore triangular, 30 μm. Apices rounded, interapical margins straight. Trilete, rays extending up to equator and accompanied by inter-radial thickenings.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 15 near Jhulrai.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Type Species — *Biretisporites potoniei* Delcourt & Sprumont, 1955.

Biretisporites bellus Sah & Kar, 1969

Pl. 5, fig. 1

1969 *Biretisporites bellus* Sah & Kar, p. 110, pl. 1, fig. 4.

Diagnosis (*after Sah & Kar, 1969*) — Spore triangular, size range 32-40 μm, exine laevigate, trilete, rays prominently raised, extending up to equator, lips bordered by a margo.

Holotype — Sah & Kar, 1969, pl. 1, fig. 4.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core no. 1 near Lakhpat and Panandhro.

Biretisporites convexus Sah & Kar, 1969

Pl. 5, fig. 2

1969 *Biretisporites convexus* Sah & Kar, p. 111, pl. 1, figs 6, 7.

Diagnosis (*after Sah & Kar, 1969*) — Spores subtriagnular, size range 50-65 μm, trilete rays raised, extending two-thirds the radial distance, exine laevigate.

Holotype — Sah & Kar, 1969, pl. 1, fig. 6.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Jhulrai; bore-core no. 1 near Lakhpat, Akri and Panandhro.

Genus — *Todisporites* Couper, 1958

Type Species — *Todisporites major* Couper, 1958.

Todisporites flavatus Sah & Kar, 1969

1969 *Todisporites flavatus* Sah & Kar, p. 111, pl. 1, figs 9, 10.

Diagnosis (*after Sah & Kar, 1969*) — Spores subcircular, size range 48-60 μm, trilete ill-developed, rays extending up to half the radius, exine laevigate.

Occurrence — Bore-core no. 15 near Jhulrai; bore-core nos. 1 and 2 near Lakhpat and Panandhro.

Genus — *Deltoidospora* (Miner) Potonié, 1956

Type Species — *Deltoidospora hallii* Miner, 1935.

Deltoidospora sp.

1969 *Deltoidospora* sp. Sah & Kar, pp. 112-113, pl. 1, fig. 20.

Description (*after Sah & Kar, 1969*) — Spore triangular, 35 μm. Apices unequally rounded, interapical margins convex. Trilete distinct, rays unequal in length, one of the arms extending up to the equator while the other two extend only up to three-fourths the radius; commissure distinct, pyramic area generally with folds, exine 2.5 μm thick, laevigate.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 15 near Jhulrai and Panandhro.

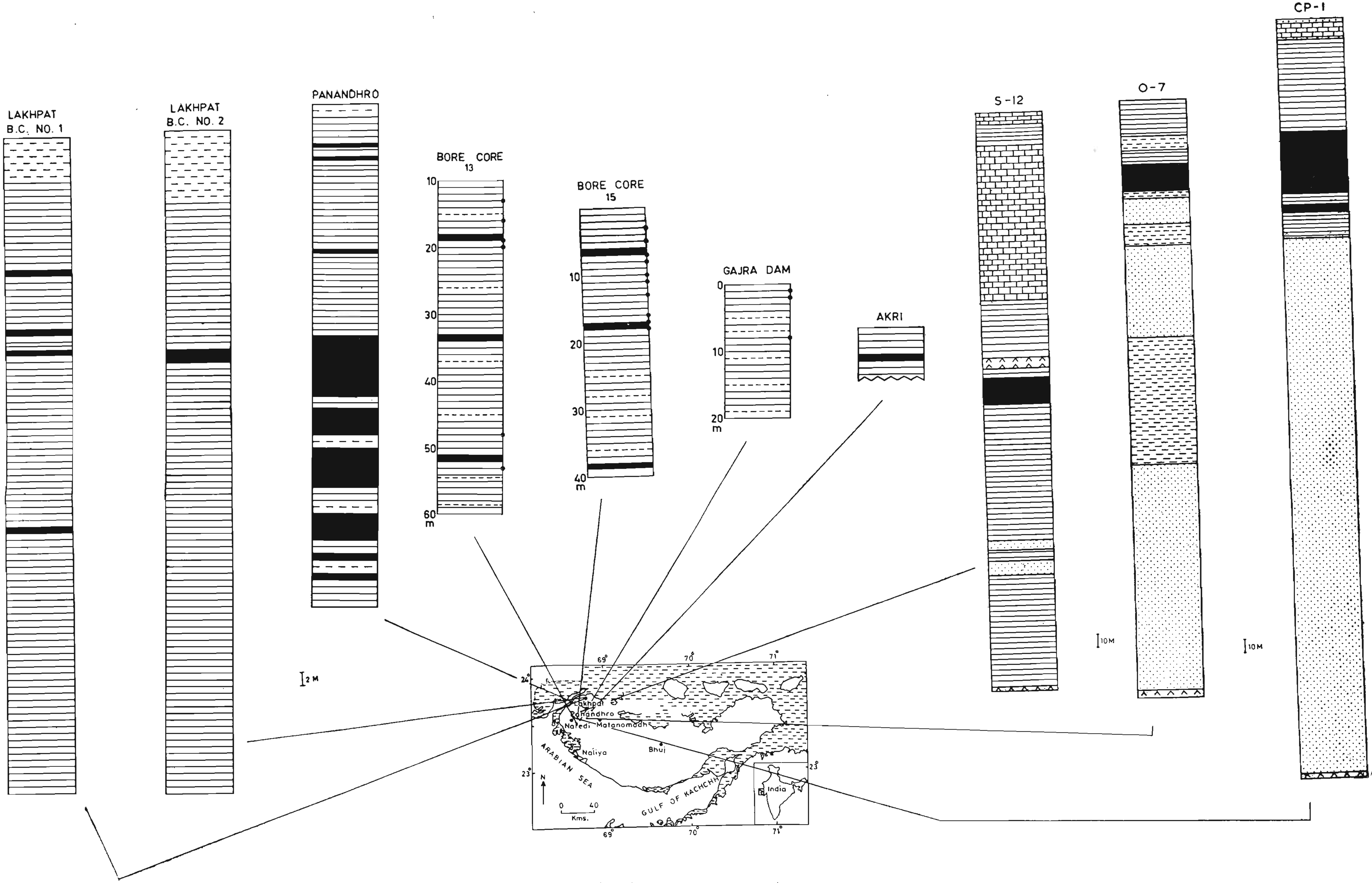
Genus — *Dictyophyllidites* Couper, 1958

Type Species — *Dictyophyllidites harrisii* Couper, 1958.

Dictyophyllidites sp. A

1969 *Dictyophyllidites* sp. A Sah & Kar, p. 113, pl. 1, fig. 21.

Description (*after Sah & Kar, 1969*) — Spore triangular, 42 μm. Apices rounded, interapical margins more or less convex.



TEXT-FIG. 5 — Showing the location of different bore-cores studied around Panandhro.

Trilete, rays extending more than three-fourths the radius, accompanied with raised inter-radial thickenings. Exine 4 μm thick, laevigate on both surfaces.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 15 near Jhulrai.

Dictyophyllidites sp. B

1969 *Dictyophyllidites* sp. B Sah & Kar, p. 113, pl. 1, fig. 22.

Description (*after Sah & Kar, 1969*) — Spore triangular, 45 μm. Trilete, rays extending up to three-fourths the radius, laesurae generally covered by associated inter-radial thickenings. Exine 2.5 μm thick, laevigate.

Occurrence — Bore-core no. 15 near Jhulrai.

Genus — *Osmundacidites* Couper, 1953

Type Species — *Osmundacidites wellmanii* Couper, 1953.

Osmundacidites kutchensis Sah & Kar, 1969

1969 *Osmundacidites kutchensis* Sah & Kar, p. 114, pl. 1, figs 24-27.

Diagnosis (*after Sah & Kar, 1969*) — Spores subcircular, 40-55 μm, trilete distinct, rays extending up to two-thirds the radius. Exine granulose, grana sparse.

Holotype — Sah & Kar, 1969, pl. 2, fig. 24.

Type Locality — Bore-core no. 36, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 and 36 near Baranda, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Leptolepidites* Couper, 1953

Type Species — *Leptolepidites verrucatus* Couper, 1953.

Leptolepidites sp. A

Pl. 6, fig. 2

1969 *Leptolepidites* sp. A Sah & Kar, p. 114, pl. 2, fig. 1a, 1b.

Description (*after Sah & Kar, 1969*) — Spore subcircular, 80 μm. Trilete rays not discernible. Exine 2.5 μm thick, proximally laevigate, distally verrucose, verrucae also present on the equatorial margin. Verrucae globular, 10-18 μm in height, closely placed and evenly distributed.

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Leptolepidites sp. B

Pl. 6, figs 3, 4

1969 *Leptolepidites* sp. B Sah & Kar, p. 114, pl. 2, figs 2, 3.

Description (*after Sah & Kar, 1969*) — Spore triangular, 78 μm. Trilete rays not clearly defined. Exine 2 μm thick, proximally laevigate, distally verrucose. Verrucae also present on the equatorial margin. Verrucae 6-10 μm in height, closely placed and evenly distributed.

Occurrence — Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Lakiasporites* Sah & Kar, 1969

Type Species — *Lakiasporites triangulus*, Sah & Kar, 1969.

Lakiasporites triangulus Sah & Kar, 1969

Pl. 6, figs 5-7

1969 *Lakiasporites triangulus* Sah & Kar, p. 115, pl. 2, figs 4-7.

Diagnosis (*after Sah & Kar, 1969*) — Spores triangular, size range 28-40 μm, trilete distinct, rays proximally associated with the thickened inter-radial areas, exine on proximal side laevigate or sparsely verrucose, distal side verrucose, verrucae robustly built, concentrated in middle region.

Holotype — Sah & Kar, 1969, pl. 2, fig. 5.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core nos. 1 and 2 near Lakhpat and Panandhro.

Genus — *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont, 1955

Type Species — *Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

Remarks — The genus *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont (1955) occurs from Permian to Pleistocene in India. Bharadwaj and Salujha (1964) recorded this genus from the Raniganj Formation (Upper Permian) of Raniganj Coalfield, W. Bengal. Maheshwari and Kumaran (1979) described it from the Tiki Formation (Triassic) of South Rewa Gondwana Basin, Madhya Pradesh. Sukh-Dev (1961) reported this genus from the Jabalpur Formation (Lower Cretaceous) of Madhya Pradesh. Vishnu-Mittre (1955) and Sah and Jain (1965) noted this genus from the Rajmahal Hills (Jurassic) of Bihar. Venkatachala (1969) and Venkatachala, Kar and Raza (1969) recorded this genus from Bhuj (Lower Cretaceous) and Katrol (Upper Jurassic) of Kachchh.

In the Tertiary sediments, this genus is more prevalent in Assam and Meghalaya in comparison to Kachchh. Sah and Dutta (1966) and Dutta and Sah (1970) recovered a number of species of *Lycopodiumsporites* from the Cherra Sandstone (Palaeocene) of Meghalaya. Singh (1975) and Singh and Singh (1976) also described various species of *Lycopodiumsporites* from the Tura Formation (Palaeocene-Eocene) of Garo Hills, Meghalaya. Mehrotra and Sah (1980) recovered them from the Mikir Formation (Palaeocene-Eocene) of Assam. Ramanujam (1967) noted their occurrence from the Cuddalore Series (Miocene) of Tamil Nadu while Potonié and Sah (1961) and Kar and Jain (1981) recorded them from Quilon and Warkala beds (Miocene) of Kerala. Baksi and Deb (1981) described them from the subsurface sample of West Bengal.

Kar and Mandal (1984) studied the living spores of *Lycopodium* found in India and compared them with the fossil ones. They observed that *Lycopodiumsporites austroclavatidites* (Cookson) Potonié (1956) recorded by Sah and Jain (1955, pl. 2, figs 61-63) from the Jurassic of Rajmahal Hills is very close to the living, reticulate spores of *Lycopodium clavatum*. Similarly, *Lycopodiumsporites assamicus* described by Mehrotra and Sah (1980) from the Mikir Formation of Assam closely resembles the extant spores of *Lycopodium annotinum* which even at present occurs in the hills of eastern Himalayas. Kar and Mandal (1984) also observed that some of the species hitherto described under *Lycopodiumsporites* from India do not show the same ornamentation as in the type species. *Lycopodiumsporites foveolatus* Mehrotra & Sah (1980) is foveolate and *Lycopodiumsporites* sp. illustrated by Singh (1974) is fossulate. Kar and Mandal (1984) commented that if these forms are included in *Lycopodiumsporites* then it goes against the original diagnosis of the genus.

It may be mentioned here that the type species of *Lycopodiumsporites*, viz., *L. agathoecus* (Potonié) Thiergart (1938) was never properly described. Potonié (1934) first described it as *Sporites agathoecus* from the Eocene brown coal. Kar and Mandal (1984) remarked that figured specimen provided by Potonié (1934, pl. 1, fig. 25) for *Sporites agathoecus* seems to be a broken specimen without any distinct trilete mark. Potonié (1956, pl. 5, fig. 52) while providing the text-figure of the specimen showed the trilete mark but did not specify about the nature of ornamentation on the proximal side. They also commented that the text-figure is not the exact representation of the type species illustrated by him. Studying the living and fossil spores of *Lycopodium* and its allied forms, Kar and Mandal (1984) concluded that the reticulate type of *Lycopodium* spores were more prevalent during the Lower Tertiaries of India. The reticulate type of spores produced mostly by the genera *Lycopodium*, *Diphasium* and *Palhinhaea* are at present generally confined to cold temperate-subalpine forest of India while the foveolate-fossulate spore producing taxa, viz., *Huperzia* and *Phlegmariurus* are found in tropical-subtropical forest. They postulated that India while moving northward leaving, Antarctica and Australia either had passed through temperate zone or the spores were coming from nearby continent where there was temperate climate. They also observed that in north-east India, *Lycopodium* was growing profusely from the early days of Tertiary to Recent. They remarked that the truncated apices of the spores of *Lycopodium selago* broadly resemble the Carboniferous spore genera of *Tripertites* Schemel (1950) and *Triquitrites* (Wilson & Coe) Sullivan & Neves (1964).

Lycopodiumsporites parvireticulatus Sah & Dutta, 1966

Pl. 6, fig. 9

1969 *Lycopodiumsporites parvireticulatus* Sah & Dutta: Sah & Kar, p. 116, pl. 2, fig. 8.

Diagnosis (*after Sah & Dutta, 1966*) — Size range 36-44 μm, trilete, laesure three-fourths of the radius, lips thin, exine also thin, ornamented on both the proximal and distal surfaces with perfect, regular reticulum, muri thin and membranous, up to 1 μm high, lumina small, more or less polygonal in outline.

Holotype — Sah & Dutta, 1966, pl. 1, fig. 1.

Type Locality — Laitryngew, South Shillong Plateau, Lower Eocene, Meghalaya.

Occurrence — Bore-core no. 15 near Jhulrai and Panandhro.

Genus — *Laevigatosporites* Ibrahim, 1933

Type Species — *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1953.

Laevigatosporites lakiensis Sah & Kar, 1969

1969 *Laevigatosporites lakiensis* Sah & Kar, p. 117, pl. 2, figs 13-18.

Diagnosis (*after Sah & Kar, 1969*) —Spores oval, size range 55-65 μm, monolete mark less than half the longer axis, exine laevigate.

Holotype — Sah & Kar, 1969, pl. 2, fig. 13.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Laevigatosporites cognatus Sah & Kar, 1969

Pl. 5, fig. 13

1969 *Laevigatosporties cognatus* Sah & Kar, p. 117, pl. 2, figs 19,20.

Diagnosis (*after Sah & Kar, 1969*) —Spores oval, size range 35-45 μm, monolete mark extending up to three-fourths the longer axis, exine laevigate.

Holotype — Sah & Kar, 1969, pl. 2, fig. 20.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene,

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Laevigatosporites sp. A

1969 *Laevigatosporites* sp. A Sah & Kar, p. 117, pl. 2, fig. 21.

Description (*after Sah & Kar, 1969*) — Spore bean-shaped, 32 μm in length. Monolete not discernible. Exine 1.5 μm thick, laevigate.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Monolites* (Erdtman) Potonié, 1956

Type Species — *Monolites major* Cookson, 1947.

Monolites sp.

Pl. 6 fig. 17

1969 *Monolites* sp. Sah & Kar, p. 118, pl. 2, fig. 24.

Description (*after Sah & Kar, 1969*) — Spore oval, 50 μm. Monolete mark extending half the longer axis. Exine 2.5 μm thick, laevigate, not folded.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Polypodiaceaesporites* Thiergart, 1938

Type Species — *Polypodiaceaesporites haardtii* (Potonié & Venitz) Thiergart, 1938.

Polypodiaceaesporites sp.

Pl. 6, fig. 18

1969 *Polypodiaceaesporites* sp. Sah & Kar, p. 118, pl. 2, fig. 26.

Description (*after Sah & Kar, 1969*) — Spore bean-shaped, 54 μm, monolete mark not perceptible. Exine 2 μm thick, exoexinous layer very thin, exine laevigate and weakly infrastructured.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Polypodiisporites* Potonié, 1934

Type Species — Polypodiisporites favus (Potonié) Potonié, 1934.

Polypodiisporites sp.

1969 *Polypodiisporites* sp. Sah & Kar, p. 118, pl. 2, fig. 26.

Description (after Sah & Kar, 1969) — Spore oval, 42 μm, monolete ill-developed, extending about three-fourths radius. Exine 2.5 μm thick, verrucose, verrucae present on both surfaces, closely placed and evenly distributed.

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Genus — *Schizaeoisporites* Potonié, 1951

Type Species — Schizaeoisporites dorogensis Potonié, 1934.

Schizaeoisporites sp.

1969 *Schizaeoisporites* sp. Sah & Kar, p. 118, pl. 2, fig. 27.

Description (after Sah & Kar, 1969) — Spore bean-shaped, 44 μm, monolete extending to half the longer axis. Exine finely striated on both surfaces.

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core nos. 1 and 2, near Lakhpat.

Genus — *Seniasporites* Sah & Kar, 1969

Type Species — Seniasporites verrucosus Sah & Kar, 1969.

Seniasporites verrucosus Sah & Kar, 1969

Pl. 6, figs 19-21

1969 *Seniasporites verrucosus* Sah & Kar, p. 119, pl. 2, figs 28-30, 33.

Diagnosis (after Sah & Kar, 1969) — Spores oval, size range 40-65 μm, monolete generally well developed, extending up to three-fourths the longer axis, exine proximally laevigate, distally verrucose.

Holotype — Sah & Kar, 1969, pl. 2, fig. 28.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 15 near Jhulrai and Panandhro.

Seniasporites minutus Sah & Kar, 1969

Pl. 6, figs 22, 23

1969 *Seniasporites minutus* Sah & Kar, pp. 119, 120, pl. 2, figs 31, 32, 34.

Diagnosis (after Sah & Kar, 1969) — Spores oval, size range 25-40 μm, monolete mark extending up to three-fourths the longer axis, exine proximally laevigate, distally verrucose.

Holotype — Sah & Kar, pl. 2, fig. 28.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore core nos. 1 and 2 near Lakhpat, Panandhro and Akri.

Genus — *Podocarpidites* (Cookson) Potonié, 1958

Type Species — Podocarpidites ellipticus Cookson, 1947.

Podocarpidites ellipticus Cookson, 1947

1970 *Podocarpidites ellipticus* Cookson: Sah & Kar, p. 127.

Description (after Sah & Kar, 1970) — Pollen grain 70×40 μm, central body not very distinct, intramicroreticulate. Sacci hemispherical, intrareticulate.

Occurrence — Bore-core no. 13 near Baranda.

Podocarpidites sp.

1970 *Podocarpidites* sp. 1 Sah & Kar, p. 127, pl. 1, fig. 24.

Description (after Sah & Kar, 1970) — Pollen grains bisaccate, bilaterally symmetrical, diploxylonoid, 60×52 μm, intramicroreticulate. Proximal attachment subequatorial, straight, associated with semilunar body fold. Sacci hemispherical, coarsely intrareticulate.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 15 near Jhulrai.

Podocarpidites sp. 2

1970 *Podocarpidites* sp. 2 Sah & Kar, p. 127, pl. 1, fig. 25.

Description (*after Sah & Kar, 1970*) — Pollen grain bisaccate, 160×48 µm. Central body horizontally oval, ill-defined, intramicroreticulate. Distal attachment of sacci to central body more or less straight. Sacci hemispherical, coarsely intrareticulate.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Clavatipollenites* Couper, 1958

Type Species — *Clavatipollenites hughesii* Couper, 1958.

Clavatipollenites cephalus Sah & Kar, 1970
Pl. 12, fig. 10

1970 *Clavatipollenites cephalus* Sah & Kar, p. 128, pl. 1, figs 10, 11.

Description (*after Sah & Kar, 1970*) — Pollen grains oval, 50-60 × 42-48 µm. Monocolpate, colpus not extending from end to end, clavate.

Holotype — Sah and Kar, 1970, pl. 1, fig. 10.

Type Locality — Bore-core no. 13 Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Arecipites* Wodehouse, 1933

Type Species — *Arecipites punctatus* Wodehouse, 1933.

Arecipites bellus Sah & Kar, 1970
Pl. 18, fig. 1

1970 *Arecipites bellus* Sah & Kar, p. 128, pl. 1, figs 19, 20.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval, 58-66×48-55 µm. Monocolpate, colpus extending end to end. Exine punctate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 19.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core no. 1 near Lakhpat.

Genus — *Palmaepollenites* Potonié, 1951

Type Species — *Palmaepollenites triangulus* Potonié, 1951.

Palmaepollenites magnus Sah & Kar, 1970

1970 *Palmaepollenites magnus* Sah & Kar, p. 129, pl. 1, fig. 18.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains roundly oval, 38-45×35-40 µm. Monocolpate, colpus restricted in middle region. Exine intragranulose.

Holotype — Sah & Kar, 1970, pl. 1, fig. 13.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Retimonosulcites* gen. nov.

Type Species — *Retimonosulcites* (*Liliacidites*) *ellipticus* (Venkatachala & Kar) comb. nov.

Diagnosis — Pollen grains anisopolar, oval elliptical in shape. Monosulcate, sulcus distinct, generally broad, extending almost one end to other. Exine microreticulate.

Description — Pollen grains generally oval-elliptical in shape with equally broad lateral ends, sometimes ends unequally broad, 30-68×25-50 µm. Sulcus mostly tapering at ends and broadest in middle region, in some specimens, sulcus unequally broad, funnel-shaped. Exine 1-2 µm thick, microreticulation generally distinct, sometimes indistinct.

Comparison — The most comparable genus to the present one is *Liliacidites* Couper (1953). This genus approximates in shape and ornamentational pattern, but differs in its nature of reticulations. In *Liliacidites*, the reticulation is broad and beaded, the meshes are larger in middle and smaller at ends. *Pinjoriapollis* Saxena & Singh (1981) is very large in size range (120-170 µm), monosulcate and is generally laevigate and sometimes weakly intrapunctate. *Monosulcites* Cookson (1947) is monosulcate, oval-elliptical in shape and the exine is laevigate. *Palmidites* Couper (1953) is monocolpate and the exine is laevigate. *Matanomadhiasulcites* has also larger size range (63-205 μm) and the exine is retipilate-retibaculate. *Retimonosulcites* is distinguished from all the genera by its oval-elliptical shape, monosulcate nature and microreticulate ornamentation.

Retimonosulcites (*Liliacidites*) *ellipticus* (Venkatachala & Kar) comb. nov.
Pl. 10, fig. 1

1969a *Liliacidites ellipticus* Venkatachala & Kar, p. 159, pl. 1, fig. 13.

Diagnosis (*after Venkatachala & Kar, 1969*) — Pollen grains oval elliptical in shape, 30-42×25-28 μm. Sulcus broad, ± boat-shaped. Exine finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 1, fig. 13; size 38×28 μm; slide no. 3319/3.

Type Locality — Bore-core no. 13, depth 19 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 14 near Matanomadh and Panandhro; bore-core no. 1 near Lakhpat.

Retimonosulcites (*Monosulcites*) *ovatus* (Sah & Kar) comb. nov.
Pl. 10, fig. 2

1970 *Monosulcites ovatus* Sah & Kar, p. 128, pl. 1, fig. 17.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval, 58-68×45-50 μm. Monosulcate, sulcus funnel-shaped. Exine weakly microreticulate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 17; size 64×48 μm; slide no. 3353/6.

Type Locality — Bore-core no. 13, depth 20 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Genus — *Matanomadhiasulcites* gen. nov.

Type Species — *Matanomadhiasulcites* (*Liliactdiies*) *maximus* (Saxena) comb. nov.

Matanomadhiasulcites (*Liliacidites*) *baculatus* (Venkatachala & Kar) comb. nov.

1969a *Liliacidites baculatus* Venkatachala & Kar, p. 160, pl. 1, fig. 17.

Diagnosis (*after Venkatachala & Kar, 1969*) — Pollen grains oval-elliptical in shape, 43-65×30-45 μm. Colpus well-developed, funnel-shaped. Exine retibaculate, forming negative reticulum in surface view.

Holotype — Venkatachala & Kar, 1969a, pl. 1, fig. 17; size 51×45 μm; slide no. 3312.

Type Locality — Bore-core no. 14, depth 45 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Akri; bore-core no. 1 near Lakhpat.

Genus — *Couperipollis* Venkatachala & Kar, 1969a

Type Species — *Couperipollis perspinosus* (Couper) Venkatachala & Kar, 1969a.

Holotype — Couper, 1953, pl. 8, fig. 133.

Type Locality — Wanganuian, Pliocene, New Zealand.

Diagnosis — (after Couper, 1953).

Occurrence — Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Arengapollenites* gen. nov.

Type Species — *Arengapollenites achinatus* sp. nov.

Diagnosis — Pollen grains monocolpate, oval-subcircular in shape, achinate, spines so arranged on margins of colpus that they interlock the aperture on invagination, interspinal exine laevigate.

Description — Pollen grains generally oval with equally broad lateral ends. Colpus distinct, extending from one end to other, mostly uniformly broad, in some specimens boat-shaped. Spines well developed, base thickened, tapering at end, spines sparsely placed except at apertural region; in this part spines at two margins of colpus arranged in alternate fashion to close the colpus arranged in a manner of sharply toothed jaws, particularly in middle portion. Exine 1-2.5 μm thick.

Comparison — *Couperipollis* Venkatachala and Kar (1969a) closely resembles *Arengapollenites* by its oval-subcircular shape and spinose ornamentation. The spines in *Couperipollis* are, however, uniformly distributed and they do not arrange in any special manner in the apertural region. *Echimonocolpites* Mathur (1966) has also spines which are uniformly spread over the exine and is also scabrate. *Spinizonocolpites* Muller (1968) is also spinose but zonisulcate resulting the splitting of the pollen grains into two equatorial halves. *Arengapollenites* instituted here is distinguished from all the achinate monocolpate genus by its presence of spines on the margins of the colpus in alternate fashion so as to interlock the aperture on invagination.

Remarks — The pollen grains assignable to *Arengapollenites* come very close to the living pollen of *Arenga*. The pollen of *A. pinnata*, *A. obtusifolia* (Thanikaimoni, 1966, pl. 6, fig. 32), and *A. candata* (Thanikaimoni, 1970, pl. 11, figs 200-202) are oval, spinose and monocolpate where the spines are arranged on the margins alternatingly to close to the colpus like a crocodile jaw.

The genus *Arenga*, according to Soekarjota and Mangindaan (1981), comprises 12 species and amongst them, *A. pinnata* is commonest. They think that the palm is indigenous to Indo-Malayasian archipelago with its centre of distribution in Indonesia. This species is distributed throughout the Malaya Peninsula, Thailand, Burma, Cambodia, Laos and Vietnam. It grows less commonly in Assam and Manipur, in north-eastern India, Sri Lanka, the Philippines and tropical Australia.

The genus *Arenga* belongs to the caryotoid group of palms and Muller (1980) thinks that the oldest fossil record of *Arenga* is from the Lower Miocene of Borneo or may be slightly earlier. Lakhanpal (1970) suggested that some pollen described by Venkatachala and Kar (1969a) as *Couperipollis* may belong to *Arenga*. Muller (1980), however, contradicted this statement. He further commented that so far the fossil history of *Arenga* is concerned there is no evidence for a former wide distribution outside its present day range.

The occurrence of *Arenga*-like pollen in the Lower Eocene of western India, however, bespeaks with eloquence that *Arenga* has an older fossil history than previously conceived and it had a wider distribution than the present day.

Arengapollenites achinatus sp. nov.

Pl. 7, figs 9-13

Diagnosis — Pollen grains monocolpate, colpus distinct, extending end to end, equally broad, oval-subcircular in shape, spinose, spines with broad base and pointed tip, sparsely placed except in apertural region where they are closely placed on two margins in alternate fashion so as to close the aperture on invagination. Exine 1-2 μm thick, interspinal exine laevigate.

Remarks — The extant pollen grains of *Arenga pinnata* has been studied for comparison. It has been observed that the shape of the pollen grains (oval) remains more or less constant while the size of the spines generally varies. In some, spines are quite robustly built with broad base and pointed tip while in others they are comparatively shorter in length and delicate in disposition. The spines in all the pollen grains are scantily placed and they always close the aperture in the same way as observed in the fossil ones.

Kedves (1980) described and illustrated the pollen grains of *Arenga saccharifera* Labill. In this species, the ornamentation is also spinose and seems to be granulose in interspinal region. The spines are comparatively closely placed around the colpus though alternate arrangement of spines could not be clearly ascertained.

Holotype — Pl. 7, fig. 9; size 59×41 μm; slide no. 8236/2.

Type Locality — Panandhro lignite, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Panandhro; bore-core no. 13 near Baranda; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Minutitricolporites* gen. nov.

Type Species — *Minutitricolporites minutus* sp. nov.

Diagnosis — Pollen grains subcircular in polar view, tricolporate-tricolporoidate, brevicolpate, pore distinct-indistinct. Exine finely reticulate.

Description — Pollen grains always found in polar view, apertures appear as slits on margin, 14-20×12-18 μm. Colpi short, 6-10 μm long, tapering at ends. Pores 1-2 μm in diameter, often indistinct and incipiently developed. Exine 1-1.5 μm thick, sexine thicker than nexine, meshes more or less of uniform size, often appear as minutely foveolate.

Comparison — *Psilatricolporites* van der Hammen (1956) is tricolporate but is readily separated by its laevigate exine. Besides, since the type species of *Psilatricolporites* is a recent pollen of *Bartsia santalinaefolia* of the family Scrophulariaceae this may be regarded as an invalid genus according to the International Code of Botanical Nomenclature. *Retibrevitricolpites* van Hoeken-Klinkenberg (1966) approximates the present genus in size range and brevicolpate condition but is devoid of pores. *Psilabrevitricolpites* van Hoeken-Klinkenberg (1966) is also of smaller size but has laevigate exine and only colpate. *Ladakhipollenites* Mathur & Jain (1980) has three long colpi and the exine is laevigate to faintly sculptured. *Minutitricolporites* proposed here is differentiated from all the genera by its smaller size range, subcircular shape, tribrevicolporate condition and finely reticulate structure.

Minutitricolporites minutus sp. nov.

Pl. 13, figs 5-8

Diagnosis — Pollen grains subcircular in polar view, 14-20×12-18 μm. Tricolporate-tricolporoided, colpi short, 7-9 μm long, pores not more than 1.5 μm in diameter, sometimes pores indistinct, even not traceable. Exine up to 2 μm thick, sexine thicker than nexine, finely reticulate, meshes often appear as foveolae.

Remarks — This species shows close similarity to the pollen grains of *Alchornea cordifolia* and *A. oborate* of Euphorbiaceae illustrated by Germeraad, Hopping and Muller (1968, pl. 15, figs 4, 5).

Holotype — Pl. 13, fig. 5; size 17×16 μm; slide no. 3350/10.

Type Locality — Bore-core no. 13, depth 19 μm, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 14 near Matanomadh and Panandhro; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Retitricolpites* Pierce, 1961

Type Species — *Retitricolpites vulgaris* Pierce, 1961.

Retitricolpites robustus Sah & Kar, 1970

1970 *Retitricolpites robustus* Sah & Kar, p. 131, pl. 1, fig. 30.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains subcircular, 40-54×38-52 μm. Tricolpate, colpi well-developed. Exine thick, reticulate, meshes duplibaculate.

Holotype — Sah & Kar, 1970, pl. 1, fig. 39.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda, Panandhro and Akri.

Genus — *Acanthotricolpites* gen. nov.

Type Species — *Acanthotricolpites bulbospinosus* sp. nov.

Diagnosis — Pollen grains subcircular in polar view. Tricolpate, colpi long. Exine spinose, spines with bulbous base and pointed tip, interspinal space densely covered with grana and bacula.

Description — Pollen grains almost always found in polar view, 38-55×36-54 μm. Colpi broad, position of colpi easily distinguishable at margin but length cannot be properly ascertained due to sculptural elements. Spines well-developed, 4-8 μm long, 1.5-2.5 μm broad at base, 4-9 μm apart. Interspinal grana-bacula 1-2 μm long, closely placed. Exine up to 2 μm thick, sexine as thick as nexine.

Comparison — *Couperipollis* Venkatachala & Kar (1969a) approximates the present genus in ornamentational pattern but the former is readily distinguished by its monocolpate nature. *Compositoipollenites* Potonié (1951) is spinose and subcircular in shape but seems to be triporate. *Tubulifloridites* Cookson (1947) is also subcircular and tricolpate but is smaller in size and devoid of interspinal sculptural elements. *Echitriporites* (van der Hammen) van Hoeken-Klinkenberg (1964) is strongly spinose and possesses interspinal sculptural elements but is triangular and triporate. *Acanthotricolpites* proposed here is distinguished from all other genera by its subcircular shape, tricolpate condition, presence of bulbous spines and grana-bacula in interspinal spaces.

Acanthotricolpites bulbospinosus sp. nov.
Pl. 11, figs 4-6

Diagnosis — Pollen grains subcircular in polar view, 42-55×40-53 μm. Tricolpate, colpi generally indistinct, broad. Exine 1-2 μm thick, sexine as thick as nexine, spinose, spines strongly built, 5-8 μm long, 1-2 μm broad at base, spines gradually taper to form pointed tip, spines sparsely placed, generally 4-8 μm apart. Interspinal space densely granulate-baculate.

Remarks — The general morphology of this species indicates towards the affinity of Palmae. The various palm pollen both with laevigate and spinose exine are found in abundance in the material. However, the extant palm perhaps does not show tricolpate nature though trichotomosulcate condition is found in number of genera, e.g. *Areca catechu* (Thanikaimoni, 1966, pl. 1, fig. 3), *Attalea humilis* (Thanikaimoni, 1966, pl. 7, fig. 38), *Orbignya urbaniana* (Thanikaimoni, 1966, pl. 7, fig. 41), *Bactris acanthocarpa* (Thanikaimoni, 1966, pl. 8, fig. 43), *Acrocomia totai* (Thanikaimoni, 1966, pl. 8, fig. 47) and *Elaeis guineensis* (Thanikaimoni, 1966, pl. 9, fig. 49). However, none of these species exhibits the character of *Acanthotricolpites bulbospinosus*.

Holotype — Pl. 11, fig. 4; size 46×44 μm; slide no. 3357/1.

Type Locality — Bore-core no. 13, depth 20 μm, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Marginipollis* Clarke & Frederiksen, 1968

Type Species — *Marginipollis concinnus* Clarke & Frederiksen, 1968.

Remarks — While instituting the genus, Clarke and Frederiksen (1968) knew that *Marginipollis concinnus*, the type species of the genus, resembles the pollen grains of *Planchonia* type of the family Lecythidaceae. They were, however, not inclined to give names after the modern taxa because such names may lead to problem in palaeoclimatic interpretations specially when morphologically similar but climatically different pollen are added to the genus.

Erdtman (1952) was first to study the pollen grains of Lecythidaceae and he pointed out that there is a clear demarcation of pollen morphology in the family, one part being characterized by the syntricolpate *Planchonia* pollen type, the other by tricolpate *Lecythis* type.

But according to Paynes (1957) who did monographic studies on the genus *Barringtonia*, there is no argument to divide the family Lecythidaceae on morphological characters into more than one family, as the members are too intricately and partly reticulately knit together and furthermore have too much intrinsic structural characters in common. However, Paynes (1957) noted that the pollen is diversified and is not of one type on the generic level. He remarked that there is a lack of correlation between taxonomy and palynology in the main division and in a number of specific cases.

According to Muller (1972) pollen of all species of the related genera, viz., *Careya*, *Chydenanthus*, *Combretodendron* and *Planchonia* resemble the pollen of *Barringtonia*. In the *Lecythis* main type, Muller (1972) also included Foetidioideae and Napoleonideae. He divided *Planchonia* main type into two: (i) *Barringtonia calyptra* type with no marginal grooves, and (ii) *B. asiatica* type with marginal grooves.

Croizat (1952) opined that *Barringtonia* is a comparatively large genus with abundance of narrow ranging species or similar forms. Muller (1972) after analysing the present day distribution of Lecythidaceae came to the conclusion that *Planchonia* main type is restricted to the Old World tropics ranging from Africa and Madagascar to the West Pacific. The *Lecythis* main pollen type is found in American tropics, tropical Africa and Madagascar. He postulated that the origin of *Planchonia* main type could have been in Africa, perhaps at a time when transatlantic migration was not possible any more. Muller (1972) also thought that *Planchonia* and *Lecythis* types probably reflect a Cretaceous split in the phylogeny with one branch finding its main development in South America and to lesser extent in Africa while the other branch probably migrated eastward from Africa, establishing a second centre of diversification in the Indo-Pacific area.

It is interesting to note in this connection that earliest fossil pollen similar to *Barringtonia asiatica* type is from the Palaeocene of Borneo by Muller (1970) and from the

Eocene of Kachchh, Gujarat by Venkatachala and Kar (1968). Shallom (1960) and Prakash and Dayal (1965) described *Barringtonioxylon deccanse* and *B. copterocarpum* respectively from the Deccan Intertrappean beds of Central India. It may also be mentioned here that Wolfe (1972) also recorded fossil leaves comparable to *Barringtonia* from the Eocene of Alaska. Muller (1973) studied the pollen morphology of the exine of *Barringtonia calyptrocalyx* in LM, SEM and TEM. He tried to provide an interpretation according to the function of the exine. He suggested that considerable mechanical stresses arising in the exine during shrinkage or expansion may partly explain the principal features. This hypothesis he based on a correlation of several specialized structures with stress fields in such a manner as to prevent the rupturing of the exine. In addition the protective function of the exine is clearly expressed in the structure of the marginal ridge in the region of the endoaperture.

So far the morphological evolution of pollen is concerned, Muller (1973) postulated that basic tricolpate prototype occurs in Foetidioideae, Napoleonoideae and Lecythydioideae. It gave rise to syntricolpate *Barringtonia calyptra* type and then syntricolpate type with marginal ridges and grooves found in *Careya* and *Planchonia*. The final evolutionary achievement is attained in *B. calyptrocalyx* type with marginal ridges, polar cushion and marginal grooves.

Sowunmi (1973) described the pollen grains of *Combretodendron macrocarpum* from Nigeria. She commented that these pollen grains are very distinctive and belong to the *Planchonia* type of Erdtman (1952, 1966).

Clarke and Frederiksen (1968) while describing fossil pollen grains assignable to *Barringtonia* from the Upper Tertiary of Nigeria observed that these pollen are rarely met with in the sediments. They are also poorly represented in the Teritary sediments of India. *Barringtonia*, in general, flower profusely and they mostly grow near the swamps or near water. So they have got a good chance of preservation in large numbers. But on the contrary they are always found in meagre number in fossil state.

Marginipollis kutchensis (Venkatachala & Kar) Kar, 1978

Pl. 10, fig. 8

1968 *Rostriapollenites kutchensis* Venkatachala & Kar, p. 336, pl. 1, figs 9-11.

1969a *Rostriapollenites kutchensis* Venkatachala & Kar, p. 161, pl. 1, figs 19-21a-c.

Diagnosis (*after Venkatachala & Kar, 1968*) — Pollen grains elliptical in equatorial view and circular to roundly triangular in polar view, 65×30 μm in equatorial view. This type of flattening is the most common condition observed. Tricolpate-colporoidate, syncolpate with crassimarginate colpi; colpi margins terminating near the poles in the form of extension appearing like beaked cuspidate projections. Sexine thicker than nexine. Mesocolpial sexine tegillate with irregular thickenings of the tegillum giving areoloidate appearance; in equatorial view these areoloidate areas border the colpi margins thus simulating a thick, broad spongiose zone along the colpi.

Holotype — Venkatachala and Kar, 1968, pl. 1, fig. 10.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 13 near Baranda.

Genus — *Umbelliferoipollenites* Venkatachala & Kar, 1969a

Type Species — *Umbelliferoipollenites ovatus* Venkatachala & Kar, 1969a.

Remarks — The genus *Umbelliferoipollenites* resembles some of the pollen grains of Apiaceae (Umbelliferae). Bicolporate pollen with a constriction in the middle are mostly found in Echinophoreae while in Hydrocotyloideae there is no constriction in middle. The present genus comes close to *Anisosciadum isosciadium*, *Echinophora sibthorpiana* and *Pycnocycla tomentosa* of Echinophoreae in spindle-oval shape with middle constriction, dicolporate condition and laevigate to finely intramicroreticulate exine.

Punt (1962) investigated the pollen morphology of Euphorbiaceae. According to him in *Antidesma* subtype the pollen grains are tricolporate, perprolate-prolate and the colpus mostly extending from one end to the other. This type is, however, easily distinguished from *Umbelliferoipollenites* by their tricolporate condition and in the absence of constriction in middle.

Venkatachala and Kar (1984) emended the diagnosis of *Umbelliferoipollis* as: Pollen grains tricolpate, oval to equatorially constricted with rounded ends, longiaxial, P = 20-35 μm; ectoaperture usually distinct, up to 3/4 of the polar axis; endoaperture more or less distinct at the middle of the ectoaperture, oval to rectangular, 3-6×2-3 μm; exine of uneven thickness, 2-3 μm, more or less smooth with ± columellate infratectum.

Umbelliferoipollenites ovatus Venkatachala & Kar, 1969a

Pl. 10, fig. 10

1969a *Umbelliferoipollenites ovatus* Venkatachala & Kar, p. 165, pl. 2, figs 29-32.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains oval with equally broad lateral ends, 25-35×10-18 μm. Two colporate, colpi extending more than three-fourths of pollen grains longitudinally. Pores distinct, lolongate. Exine 2-3 μm thick, laevigate and very finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1979a, pl. 2, fig. 31.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Umbelliferoipollenites constrictus Venkatachala & Kar, 1969a

Pl. 14, fig. 6; Pl. 17, figs 3-5; Pl. 18, fig. 2

1969a *Umbelliferoipollenites constrictus* Venkatachala & Kar, p. 165, pl. 2, fig. 33.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains oval with equally rounded lateral ends and marked constriction in middle, 25-30×8-14 μm. Bicolporate, colpi extending more than three-fourths the radius along longitudinal axis. Pores indistinct. Exine laevigate and intrastructured.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 33.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 13 near Baranda and Panandhro.

Genus — *Ailanthipites* Wodehouse, 1933

Type Species — *Ailanthipites berryi* Wodehouse, 1933.

1969a *Ailanthipites* sp. Venkatachala & Kar, p. 166, pl. 2, fig. 47.

Description (*after Venkatachala & Kar, 1969a*) — Pollen grain 32×28 μm. Tricolporate, colpi long, more or less uniformly broad, extending almost from one margin to other, more or less parallel to each other. Pores well recognizable, lolongate. Exine up to 4 μm thick, laevigate or finely intrabaculate.

Occurrence — Bore-core no. 14 near Matanomadh.

Genus — *Araliaceoipollenites* Potonié, 1951

Type Species — *Araliaceoipollenites euphorii* (Potonié) Potonié, 1951.

Araliaceoipollenites matanomadhensis Venkatachala & Kar, 1969a

1969a *Araliaceoipollenites matanomadhensis* Venkatachala & Kar, p. 166, pl. 2, fig. 46.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains subcircular, 10-28× 18-26 μm. Tricolporate, colpi long, narrow, sharply bending at equatorial region. Pores well-developed. Exine laevigate and finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 46.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Cupuliferoipollenites* Potonié, 1951

Type Species—*Cupuliferoipollenites pusillus* (Potonié) Potonié, 1951.

Cupuliferoipollenites ovatus Venkatachala & Kar, 1969a

1969a *Cupuliferoipollenites ovatus* Venkatachala & Kar, 1969a, p. 166, pl. 2, figs 44, 45.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains oval in polar view, 18-28×20-14 μm. Tricolporate, colpi long, narrow, extending from one end to other. Pores well recognizable. Exine intrapunctate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 44.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh, Panandhro and Akri.

Genus — *Angulocolporites* gen. nov.

Type Species — *Angulocolporites microreticulatus* sp. nov.

Diagnosis — Pollen grains triangular-subtriangular in polar view. Tricolporate, anguloaperturate, colpi long, pores distinct-indistinct. Exine microreticulate.

Description — Pollen grains always found in polar view, apertures situated at apices as slight depression, sometimes apertural region appear as big gaps. Colpi funnel-shaped, extend up to middle region. Pores generally indistinct, sometimes it is traceable in one of apertures, margin not thickened, Exine 1.5-3 μm thick, sexine thicker than nexine, laevigate, microreticulate structure distinct, meshes approximately of same size.

Comparison — *Hippocrateaceaedites* Ramanujam (1966) resembles the present genus in triangular-subtriangular shape and tricolporate condition; but is distinguished by the presence of sexine thickening along the colpi in polar view. The margin of pores is also markedly thickened and the exine is punctitegillate. *Talsipites* Wodehouse (1933) also approximates *Angulocolporites* in triangular-subtriangular shape and tricolporate apertures but the pores have distinct marginal thickening and the exine is granulose. *Vitipites* Wodehouse emend. Potonié (1960) is subtriangular but seems to be only tricolporate and the exine is finely pitted. *Pseudonyssapollenites* is tricolporate and triangular-subtriangular in shape but the exine is laevigate and pore margin is appreciably thickened. *Dermatobrevicolporites* has very short colpi, thickening of pore margin and more or less laevigate exine. *Margocolporites* Ramanujam (1966) is trizonimargocolporate and the exine is broadly reticulate or retipilate. *Triangulotricolporites* is triangular and tricolporate and the exine is variously ornamented with pila, bacula and verrucae.

Angulocolporites microreticulatus sp. nov.

Pl. 16, figs 3, 8, 9

Diagnosis — Pollen grains triangular-subtriangular in polar view, 30-45×29-44 μm. Tricolporate, anguloaperturate, colpi long, funnel-shaped, pores generally indistinct, margin not thickened. Exine 1.5-2.5 μm thick, sexine thicker than nexine, laevigate and microreticulate.

Holotype — Pl. 16, fig. 8; size 33×32 μm; slide no. 3353/6.

Type Locality — Bore-core no. 13, depth 20 μm, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Rhoipites* Wodehouse, 1933

Type Species — *Rhoipites bradleyi* Wodehouse, 1933.

Rhoipites kutchensis Venkatachala & Kar, 1969a

1969a *Rhoipites kutchensis* Venkatachala & Kar, p. 166, pl. 2, figs 41-43.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains oval in polar view, 15-25×10-18 μm. Colpi narrow, long, extending almost from one end to other. Pores easily recognizable. Exine thin, finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 42.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Symplocoipollenites* Potonié, 1957

Type Species — *Symplocoipollenites vestibulum* Potonié, 1931.

Symplocoipollenites kutchensis Venkatachala & Kar, 1969a

1969a *Symplocoipollenites kutchensis* Venkatachala & Kar, 1969a, p. 167, pl. 2, figs 38, 39.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains roundly triangular, 12-18×9-15 μm. Tricolporate, colpi very small, pores well developed. Exine finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 38.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro.

Symplocoipollenites minutus Venkatachala & Kar, 1969a

1969a *Symplocoipollenites minutus* Venkatachala & Kar, p. 167, pl. 2, figs 34-37.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains small in size, mostly roundly triangular in overall shape. Colpi small, not more than 3 μm, occasionally slit-like. Pores not always recognizable, outer margins of pores slightly thickened in some specimens. Exine up to 2 μm thick, finely intramicroreticulate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 35.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Akri.

Symplocoipollenites constrictus Sah & Kar, 1970

Pl. 8, figs 1, 2

1970 *Symplocoipollenites constrictus* Sah & Kar, p. 132, pl. 2, figs 31, 32.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains triangular-subtriangular, 30-40×28-38 μm. Tricolporate, colpi well-developed, pores without thickened margin. Exine thick, finely scrobiculate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 31.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda and Panandhro.

Genus — *Pseudonyssapollenites* gen. nov.

Type Species — *Pseudonyssapollenites* (*Nyssapollenites*) *kutchensis* (Venkatachala & Kar) comb. nov.

Diagnosis — Pollen grain triangular-subtriangular in polar view. Tricolporate, colpi long, pores distinct, margin thickened. Exine laevigate and weakly intrastructured.

Description — Pollen grains always found in polar view, 20-38×18-36 μm; anguloaperturate, apertures situated at apices forming three depression, intra-apertural margin convex. Colpi funnel-shaped, narrow, reaching up to middle region, pores more conspicuous than colpi, circular, 8-14 μm in diameter, marginal thickness 1-2 μm. Exine 1.5-3 μm thick, sexine thicker than nexine, generally laevigate, nature of intrastructure when present not clearly discernible.

Comparison — *Nyssapollenites* Thiergart (1937) resembles the present genus in tricolporate nature, however, the latter is distinguished by its triangular shape and appreciable thickened margin around the pores. The type species of *Nyssapollenites*, viz., *N. pseudocruciatus* shows its affinity towards Nyssaceae and is found in equatorial view, the pores are not very conspicuous in comparison to the colpi and the exine is infrapunctate. *Faguspollenites* Raatz (1937) is tricolporate but is subcircular in polar view and the exine is thin, intragranulate to intrabaculate. *Nyssoidites* Potonié, Thomson & Thiergart (1950) is bigger in size and found in equatorial view. *Vitipites* (Wodehouse) Potonié (1960) is triangular in shape, tricolporate but the pores are devoid of thickened margin. *Dermatobrevicolporites* comes close to *Pseudonyssapollenites* by its triangular-subtriangular shape, tricolporate conditon and laevigate exine, but is easily separated by its short nature of the colpi.

Pseudonyssapollenites (Nyssapollenites) kutchensis (Venkatachala & Kar) comb. nov.

Pl. 16, figs 4-7

1969a *Nyssapollenites kutchensis* Venkatachala & Kar, p. 167, pl. 2, figs 48, 49.

Diagnosis — (*after Venkatachala & Kar, 1969a with slight modification*) — Pollen grains triangular in polar view, 20-35×18-32 μm, anguloaperturate, apertures situated at apices as slight depression, inter-apertural margin convex. Tricolporate, colpi long, funnel-shaped, pores conspicuous, circular, 8-13 μm in diameter, margin thickened. Exine 2-3 μm thick, sexine thicker than nexine, laevigate and weakly intrastructured.

Remarks — Venkatachala and Kar (1969a) first reported this species as *Nyssapollenites kutchensis*. It has already been stated that *Nyssapollenites* is meant for the dispersed fossil pollen of *Nyssa*. As the present species does not belong to *Nyssa* so it has been accommodated into a new genus.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 48; size 27×25 μm; slide no. 3317/7.

Type Locality — Bore-core no. 14, depth 49 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Palaeocoprosmadites* Ramanujam, 1966

Type Species — *Palaeocoprosmadites arcotense* Ramanujam, 1966.

Palaeocoprosmadites arcotense Ramanujam, 1966

1969a *Palaeocoprosmadites arcotense* Ramanujam: Venkatachala & Kar, p. 167, pl. 2, figs 40-40a.

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, oblate, 31×25 μm. Amb subtriangular, tricolpate, pronouncedly brevicolpate, ends blunt or pointed. Exine 1.5 μm thick, columellae indistinct, surface smooth.

Holotype — Ramanujam, 1966, pl. 3, fig. 61.

Type Locality — Neyveli lignite, Tertiary, Tamil Nadu.

Occurrence — Bore-core no. 13 near Baranda and Panandhro.

Genus — *Hippocrateaceaedites* Ramanujam, 1966

Type Species — *Hippocrateaceaedites van campoae* Ramanujam, 1966.

Hippocrateaceaedites sp.

1969a *Hippocrateaceaedites* sp. Venkatachala & Kar, p. 167, pl. 2, fig. 59.

Description (*after Venkatachala & Kar, 1969a*) — Pollen grains subtriangular, 34 μm. Tricolporate, colpi long, easily distinguishable, tapered at ends. Exine intragranulose, pores not well-pronounced. Outer margin of pores not thickened. Exine more or less 2 μm thick, laevigate and finely intragranulose.

Occurrence — Bore-core no. 14 near Matanomadh.

Genus — *Margocolporites* Ramanujam, 1966

Type Species — *Margocolporites tsukadai* Ramanujam, 1966.

Margocolporites tsukadai Ramanujam, 1966

1969a *Margocolporites tsukadai* Ramanujam: Venkatachala & Kar, p. 168, pl. 3, figs 60-62.

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, suboblate, trizonimargocolporate, 54×48 μm. Amb prominently trilobed, lobes widely spaced because of large margocolpae. Margocolpus broad, 12-16 μm, gradually tapering towards poles (fusiform), microreticulate, rimmed by a thickened wall (margo), ora distinct, small lolongate. Exine 3.5 μm thick, sexine thicker than nexine, surface baculate-reticulate. Reticulum homobrochate, polygonal, muri simplibaculate, fairly thick lumina rounded or angular, smooth.

Holotype — Ramanujam, 1966, pl. 4, fig. 64.

Type Locality — Neyveli lignite, Tertiary, Tamil Nadu.

Occurrence — Bore-core no. 14 near Matanomadh, Panandhro and Akri.

Margocolporites sitholeyi Ramanujam, 1966

Diagnosis (*after Ramanujam, 1966*) — Pollen grains isopolar, oblate spheroidal, trizonimargocolporate, equatorial diameter 38 μm. Amb distinctly trilobed, lobes slightly bulging. Margocolpus long, but not reaching poles, straight, margin thickened, ends pointed, surface granular, ora lolongate, pouting as seen in polar view. Exine 3.3 μm thick, sexine thicker than nexine, prominently reticulate, columellae distinct, reticulum polygonal, homobrochate, muri simplibaculate, lumina smooth or with free bacula.

Holotype — Ramanujam, 1966, pl. 4, fig. 68.

Type Locality — Neyveli lignite, Tertiary, Tamil Nadu.

Occurrence — Bore-core no. 14 near Matanomadh, Panandhro and Akri; bore-core no. 1 near Lakhpat.

Margocolporites sahnii Ramanujam, 1966

1969a *Margocolporites sahnii* Ramanujam: Venkatachala & Kar, p. 168, pl. 3, figs 63-67.

Diagnosis (*after Ramanujam, 1966*)— Pollen grains isopolar, sub-oblate, trizonimargocolporate, equatorial diameter 56 μm. Amb subtriangular, distinctly trilobed. Margocolpi large, margin considerably thickened, surface finely granular locally coarsely so, ora faint lolongate. Exine 3.3 μm thick, columellae faint, reticulate, homobrochate, brochi hexa- to polygonal, simplibaculate, each lumen with a single baculum, the basal diameter of which is larger than mural bacula.

Holotype — Ramanujam, pl. 4, fig. 70.

Type Locality — Neyveli lignite, Tertiary, Tamil Nadu.

Occurrence — Panandhro, Akri; bore-core no. 1 near Lakhpat.

Genus — *Foveotricolporites* Pierce, 1961

Type Species — *Foveotricolporites rhombohedralis* Pierce, 1961.

Foveotricolporites reticuloidus sp. nov.

Pl. 15, figs 6-8

Diagnosis — Pollen grains oval in equatorial view, 36-44×34-41 μm, tricolporate, colpi long, pore distinct, lolongate. Exine 2-3 μm thick, sexine much thicker than nexine, tectate, reticuloid, reticulate appearance being formed by pila.

Comparison — *Foveotricolporites rhombohedralis* Pierce (1961) somewhat approximates the present species in size range but is distinguished by its foveolate ornamentation. *F. crassiexinus* van Hoeken-Klinkenberg (1966) is smaller in size range (31.5× 26.5 μm) and is also distinctly foveolate.

Holotype — Pl. 15, fig. 6; size 41×39 μm; slide no. 3364/13.

Type Locality — Bore-core no. 15, depth 3 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda and Panandhro.

Genus — *Pilatricolporites* gen. nov.

Type Species — *Pilatricolporites eocenicus* sp. nov.

Diagnosis — Pollen grains subcircular-subtriangular in polar and oval in equatorial view. Tricolporate, colpi long, extending almost pole to pole, pore margin thickened. Exine tectate, pilate, pila forms reticuloid appearance.

Description — Pollen grains in polar as well as equatorial view common, 32-43× 30-41 μm in polar view, margin of pollen grains in polar view continuous except three notches due to apertures. Colpi distinct, broad in middle region and narrow at ends, pores distinct, diameter of pores less than diameter of colpi. Exine 1.5-3 μm thick, sexine thicker than nexine, pila up to 2 μm long, 1 μm broad, placed 1.5-2 μm apart, providing reticuloid appearance but never forming true reticulum, interpilar exine laevigate.

Comparison — *Margocolporites* Ramanujam (1966) comes close to *Pilatricolporites* in size range and tricolporate condition, but the former is distinguished by the presence of margocolpus which is microreticulate in the type species. The ornamentation pattern in *Margocolporites* is reticulate or retipilate. In the type species, viz., *Mar-*

gocolporites tsukadai, reticulum is homobrochate, polygonal muri fairly thick, simplibaculate, lumina rounded or angular, smooth. The reticulation pattern in most of the other species is also heavy and the margocolpus variously ornamented. *Ailanthipites* Wodehouse (1933) is also tricolporate and the colpi extend almost pole to pole but is laevigate and weakly intrastructured. *Ilexipollenites* Thiergart (1937) approximates the present genus in shape and tricolporate nature but is heavily ornamented with pila and bacula.

Pilatricolporites eocenicus sp. nov.

Pl. 12, figs 5, 6; Pl. 15, figs 1-3

Diagnosis — Pollen grains subcircular-subtriangular in polar and oval-elliptical in equatorial view, 30-38×28-36 μm. Tricolporate, colpi long, extending almost pole to pole, broad in middle, narrow at ends, pores distinct, margin thickened. Exine tectate, pilate, pila 1.5-2 μm long, 1 μm broad, more or less 2 μm apart, exine 2-3 μm thick, sexine thicker than nexine, pila forming reticuloid pattern in surface view.

Holotype — Pl. 15, fig. 1; size 34×33 μm; slide no. 3357/2.

Type Locality — Bore-core no. 13, depth 19 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 1 near Lakhpat.

Genus — *Tribrevicolporites* gen. nov.

Type Species — *Tribrevicolporites eocenicus* sp. nov.

Diagnosis — Pollen grains subtriangular in polar view, tribrevicolporate, pore margin not thickened. Exine finely reticulate to scabrate.

Description — Pollen grains with three marked constriction at margin due to apertures, 40-55×36-50 μm. Brevicolpate, colpi distinct, funnel-shaped, 10-20 μm long. Pores mostly well defined, 5-10 μm in diameter. Exine 2-3 μm thick, sexine as thick as nexine, generally finely reticulate, sometimes meshes appear as pits.

Comparison — *Psilatricolporites* van der Hammen (1956) is comparable to the proposed genus in tricolporate nature and subtriangular shape but the former is readily separated by its longer colpi. *Verrucolporites* Sah & Kar (1970) is verrucose and the colpi are also quite long. *Dermatobrevicolporites* closely resembles *Tribrevicolporites* in shape, size range and tribrevicolporate condition but is distinguished by its thickened pore margin. *Magnatriporites* Guzmán (1967), *Suemegipollis* Góczán (1964) are triporate. *Brevicolporites* Anderson (1960) has smaller size (21 μm) and subcircular in shape. *Brevitricolporites* Guzmán (1967) is tricolpate to tricolporate and possesses very short colpi but the exine is gemmate-clavate-scabrate-verrucate. *Retibrevitricolporites* van Hoeken-Klinkenberg (1966) is reticulate but is only colpate.

Tribrevicolporites eocenicus sp. nov.

Pl. 13, figs 9-10; Pl. 9, figs 1-6

Diagnosis — Pollen grains subtriangular-triangular in polar view, tribrevicolporate, colpi 10-20 μm long, pores distinct, 4-10 μm in diameter, margin not appreciably thickened. Exine 2-3 μm thick, sexine as thick as nexine, finely reticulate, meshes appearing as pits in surface view.

Holotype — Pl. 13, fig. 9; size 46×44 μm; slide no. 3362/2.

Type Locality — Bore-core no. 15, depth 6.5 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda, Panandhro and Akri.

Genus — *Sastriipollenites* Venkatachala & Kar, 1969a

Type Species — *Sastriipollenites trilobatus* Venkatachala & Kar, 1969a.

Sastriipollenites trilobatus Venkatachala & Kar, 1969a

Pl. 16, figs 1, 2; Pl. 9, fig. 12

1969a *Sastriipollenites trilobatus* Venkatachala & Kar, p. 169, pl. 3, figs 68, 69.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains isopolar, trilobed in equatorial view. Tricolporate, margocolporate. Colpi well-developed, invaginated inwards, ora distinct to indistinct. Exine up to 2 μm thick, intrabaculate.

Remarks — The type species of *Sastriipollenites*, viz., *S. trilobatus* was re-examined. It was found that the slide no. 3320/18 is the type slide of this species and not slide no. 3321 as mentioned by Venkatachala and Kar (1969a, p. 169). It was observed that the specimen seems to be tricolpate and not colporate though other specimens kept in this genus are tricolporate. The colpi are long and in polar view reach up to middle region. The margin of colpi possesses sexinal thickening on both sides in polar view. The exine is up to 2.5 μm thick, sexine is thicker than nexine, granulose-conied. The sculptural elements are up to 1 μm high and closely placed. This genus is distinguished from all other tricolpate genera by its sexinal thickening of the colpus along the margin and granulose-conied exine.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 69.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Genus — *Triangulotricolporites* gen. nov.

Type Species — *Triangulotricolporites triangulus* sp. nov.

Diagnosis — Pollen grains subtriangular in polar view. Tricolporate, colpi long, pores generally distinct, margin thickened. Exine variously ornamented with verrucae, pila and bacula.

Description — Pollen grains with well marked three notches at margin, 30-43 × 28-41 μm. Colpi long, 20-28 μm long, occasionally appear as slits. Pores sometimes indistinct due to heavy sculptural elements closely placed forming negative reticulum in surface view.

Comparison — *Brevitricolpites* Guzmán (1967) is tricolpate-tricolporate and also like the present genus is variously ornamented. *Brevitricolpites* is, however, distinguished by its presence of very short colpi. *Verrucolporites* Sah & Kar (1970) is oval-elliptical in equatorial and subcircular in polar view and is ornamented only with verrucae. *Verrutricolpites* Pierce (1961) is verrucose but tricolpate. *Polotricolporites* Guzmán (1967) is subtriangular, tricolporate but is characterized by foveolate-reticulate-fossulate sculptural elements. *Hippocrateaceaedites* Ramanujam (1966) is also subtriangular and trizonicolporate but has got punctitegillate exine. Moreover, the aperture in *Hippocrateaceaedites* is surrounded by sexine on both sides. *Salicipollenites* Srivastava (1966) is tricolporate but the exine is ccarsely reticulate. *Retibrevitricolpites* van Hoeken-Klinkenberg (1966) is triangular but only brevicolpate and reticulate.

Triangulotricolporites triangulus sp. nov.

Pl. 12, figs 7-9

Diagnosis — Pollen grains subtriangular in polar view, 30-43 × 28-41 μm, tricolporate, colpi distinct, 20-26 μm long, tapering at ends. Pores mostly distinct, 4-8 μm in diameter, margin thickened. Exine 2-4 μm thick, sexine thicker than nexine, variously ornamented, verrucae, pila, bacula interspersed, forming negative reticulum in surface view.

Holotype — Pl. 12, fig. 7; size 40 × 39 μm; slide no. 3367/2.

Type Locality — Bore-core no. 15, depth 10 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Pellicieroipollis* Sah & Kar, 1970

Type Species—*Pellicieroipollis langenheimii* Sah & Kar, 1970.

Pellicieroipollis langenheimii Sah & Kar, 1970

Pl. 12, fig. 12; Pl. 13, figs 3, 4

1970 *Pellicieroipollis langenheimii* Sah & Kar, p. 133, pl. 2, figs 58-60.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains triangular-subtriangular, 58-75 × 55-70 μm. Tricolporate, brevicolpate, porelolongate with thickened margin. Exine thick, tegillate, bacula forming negative reticulum in surface view.

Remarks — This species is quite common in some samples of Naredi Formation. Sah and Kar (1970) thought this species approximates the extant pollen grains of *Pelliciera rhizophoreae* at present found around the Pacific coast. In India, this plant does not occur at present though we have many mangrove plants, viz., *Rhizophora*, *Kandelia*, *Ceriops*, *Bruguiera*, *Sonneratia*, and *Avicennia*. Langenheim *et al.* (1967) studied the living pollen of *Pelliciera* and traced its fossil history.

Morley (1982) after studying the fossil and living pollen grains of *Alangium* proposed three new fossil genera, viz., *Alangiopollis*, *Lonagiopollis* and form genus *A*. Of these, *Lonagiopollis* is generally characterized by zonotricolporate, radially symmetrical, oblate, circular to sub-angular pollen grains in polar view, colpi are of variable length, generally not markedly sunken at equator, pore with or without costae, nexine showing distinct thinning toward apertures, exine regularly or irregularly eureticulate or eurugulate, muri composed of distinct capita, each supported by a group of columellae, muri simpli-dupli or pluribaculate.

Morley (1982) remarked that *Pellicieroipollis* Sah & Kar (1970) is very similar to *Lonagiopollis* but bears a negative reticulum and photographs of some specimens of *Pellicieroipollis langenhimii* resemble *Alangium* pollen quite closely. Muller (1981) commented that the oldest record of *Pelliciera* pollen is still somewhat in doubt. Fuchs (1970), Wijmstra (1968) and Germeraad, Hopping and Muller (1968) assumed its first occurrence in Lower Eocene, Sah and Kar (1970) while instituting the genus *Pellicieroipollis* compared their fossil grains with those illustrated by Langenheim *et al.* (1967) and thought that the fossil pollen grain is comparable to the pollen grain of *Pelliciera rhizophorae* of the family Theaceae. *Ghoshiadites* Nandi (1981) described from the Neogene of Assam comes very close to *Pellicieroipollis* and may be regarded as a synonym of it. Wijmstra (1968) demonstrated that the fossil pollen *Psilatricolporites crassus* van der Hammen & Wijmstra (1964) described from the Oligocene-Miocene along the Atlantic and Pacific coasts closely resembles the extant pollen of *Pelliciera rhizophora* Planch & Triana. He also concluded that the area of distribution of *Pelliciera* appreciably diminished since Miocene and it also formerly occurred on both Atlantic and Pacific shore lines. At present, it is restricted to a narrow coastal strip along the Pacific Ocean between Colombia and Costa Rica as one of the components of the mangrove forests. The present day distribution of *Alangium* on the other hand, is restricted to the eastern coast of Central Africa and Indo-Malayan region. The first fossil pollen recognized as of *Alangium* was attributed to the new species, viz., *Alangium barghoonianum* Traverse (1955) and *A. javanicoides* Cookson (1957). Morely (1982) remarked that observing the variability exhibited by modern *Alangium* pollen, and since there is no relationship between pollen types and biological species, pollen types referring to both intraspecific variation and to related species groups, attribution of fossil pollen to new or existing within *Alangium* is considered misleading although has recently introduced by Trasevich (1975). Krutzsch (1962) was sceptical that fossil pollen could be attributed to *Alangium* with certainty and erected the form genus *Alangiopollis* to incorporate fossil pollen which closely matched with modern *Alangium*. Studies of modern *Alangium* pollen by Erdtman (1952), Eyde *et al.* (1969), Reitsma (1970) and Yaramyan (1967) show that the overall pollen variation within the genus is considerable and *Alangiopollis* can incorporate only the striate-reticulate pollen types within section *Marlea*.

Holotype — Sah & Kar, 1970, pl. 2, fig. 58.

Type Locality — Bore-core no. 13, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda, Panandhro and Akri; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Meliapollis* Sah & Kar, 1970

Type Species — *Meliapollis ramanujamii* Sah & Kar, 1970.

Meliapollis raoi Sah & Kar, 1970

Diagnosis (*after Sah & Kar, 1970*) —Pollen grains circular-subcircular, 50-60 × 50-58 μm. Tricolporate, brevicolporate, pore distinct with thickened margin, lalongate-circular. Exine 1.5-2.5 μm thick, laevigate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 67.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core no. 36 near Jhulrai, Panandhro and Akri.

Genus — *Striacolporites* Sah & Kar, 1970

Type Species — *Striacolporites striatus* Sah & Kar, 1970.

Striacolporites striatus Sah & Kar, 1970

Pl. 14, fig. 9

1970 *Striacolporites striatus* Sah & Kar, pp. 135, 136, pl. 2, fig. 54.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains oval in equatorial view, 45-57 ×30-48 μm. Tricolporate, lolongate. Exine 2-3 μm thick, exine thicker than nexine, striato-reticulate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 54.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda, Panandhro and Akri; bore-core no. 1 near Lakhpat.

Genus — *Paleosantalaceaepites* Biswas, 1962

Type Species — *Paleosantalaceaepites primitiva* Biswas, 1962.

Paleosantalaceaepites primitiva Biswas, 1962

Pl. 10, fig. 7

1970 *Paleosantalaceaepites primitiva* Biswas, Sah & Kar, p. 136, pl. 2, fig. 52

Diagnosis (*after Biswas, 1962*) — Equatorial compression; exine moderately thick, smooth; longitudinal furrows do not extend pole to pole, prominent, probably functional; width of the transverse furrow-ring 5 μm; 35×24 μm; has strong morphologic similarity with the pollen of modern *Exocarpus* with the exception that in the latter the longitudinal furrows are vestigeal.

Holotype — Biswas, 1962, pl. 5, fig. 10; size 35×24 μm.

Type Locality — Tura-Dalu road section, Tura Formation, Lower Eocene, Meghalaya.

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

Genus — *Retitetrabrevicolporites* gen. nov.

Type Species—*Retitetrabrevicolporites delicatus* sp. nov.

Diagnosis — Pollen grains subcircular in polar view. Tetracolporate, brevicolpate, pore margin thickened. Exine reticulate.

Description — Pollen grains always found in polar view, 18-32×16-30 μm, margin continuous except four slight notches due to apertures. Colpi distinct, slit-like, 8-14 μm long, pores generally ill-defined, sometimes not traceable, margin slightly thickened. Exine 1-3 μm thick, sexine thicker than nexine, finely reticulate.

Comparison — *Tetracolporites* Couper (1953) is comparable to *Retitetrabrevicolporites* in shape and general organization but the exine in the latter is thicker (6 μm) and the colpi are longer, pore margin is thicker and the ornamentation pattern is laevigate to finely pitted. *Sapotacepodeapollenites* Potonié, Thomson & Thiergart (1950) is generally preserved in equatorial view, tetra-to tricolporate, colpi are long extending from one end to the other and the exine is laevigate to finely intrastructured. *Quadripollenites* Stover (1966) also broadly resembles the present genus in circular-subcircular shape and tetracolporate condition but is distinguished by its thickened, margin of the colpi and laevigate exine. *Meliapollis* Sah & Kar (1970) is circular-subcircular, tri- to pentacolporate, exine 2-8 μm thick, laevigate-weakly intrastructured. *Retitetrabrevicolporites* is distinguished by its subcircular shape, tetrabrevicolporate condition and finely reticulate ornamentation.

Retitetrabrevicolporites delicatus sp. nov.

Pl. 14, figs 3, 4

Diagnosis — Pollen grains subcircular in polar view, 18-25×17-24 μm. Tetracolporate, brevicolpate, colpi 4-10 μm long, 2-6 μm broad, pores 2-4 μm in diameter, distinct, sometimes indistinct. Exine 1-2 μm thick, sexine thicker than nexine. Finely reticulate, meshes less than 0.5 μm in diameter.

Holotype — Pl. 14, fig. 3; size 20.5×20 μm; slide no. 3350/1.

Type Locality — Bore-core no. 13, depth 19 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core no. 1 near Lakhpat.

Retitetrabrevicolporites (*Stephanocolpites*) *globatus* (Venkatachala & Kar) comb. nov.

Pl. 11, figs 10, 11

1969a *Stephanocolpites globatus* Venkatachala & Kar, p. 169, pl. 2, figs 51, 52.

Diagnosis — Pollen grains subcircular, generally with four lobes in polar view, 22-30×20-26 μm, tetracolporate, brevicolpate, pores distinct-indistinct, margin not thickened. Exine 2-4 μm thick, sexine thicker than nexine, finely reticulate, lumina approximately 0.5 μm in diameter.

Holotype — Venkatachala & Kar, 1969, pl. 2, fig. 51.

Type Locality — Bore-core no. 14, depth 48 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro; bore-core no. 1 near Lakhpat.

Retitetrabrevicolporites sp.

Pl. 11, fig. 9

Description — Pollen grains tetracolporate, brevicolpate, 25×24 μm, colpi generally 8-13 μm long, colpi ruptured, pore distinct, margin not thickened. Exine finely reticulate.

Remarks — Venkatachala and Kar (1969a) described this specimen as *Stephanocolpites* cf. *S. arcotense* Ramanujam (1966). The specimen was reinvestigated and it was found to have colporate condition. It is distinguished from *Retitetrabrevicolporites delicatus* and *R. globatus* by its different type of reticulation.

Occurrence — Bore-core no. 14 near Matanomadh.

cf. *Retitetrabrevicolporites* (*Stephanocolpites*) *granulatus* (Venkatachala & Kar) comb. nov.

1969 *Stephanocolpites granulatus* Venkatachala & Kar, p. 170, pl. 2, figs 57, 58.

Diagnosis — Pollen grains subcircular, 24-30×22-25 μm, seem to be tetracolporate, colpi moderately long, pores traceable in some specimens, exine up to 2 μm thick, ±laevigate to weakly intrastructured.

Remarks — Venkatachala and Kar (1969a) described this species as *Stephanocolpites granulatus*. Most of the species described by them under *Stephanocolpites* have now been transferred to *Retitetrabrevicolporites* because of their tetracolporate condition and reticulate ornamentation. This species also seems to be tetracolporate as in some specimens pores are visible. The type species was restudied and it also appears to be colporate. The exine ornamentation is almost psilate and it is never heavily granulose. The intrastructure of the exine always present though its proper nature may not be discernible. Saxena (1979) instituted *Granustephanocolpites* to include subcircular-circular, polycolpate pollen grains with granulose exine. He selected *Stephanocolpites granulatus* Venkatachala & Kar (1969a) as the type species of the genus. Since the type species of *Stephanocolpites* now seems to be tetracolporate and without any pronounced granulose ornamentation, this species has been compared to *Retitetrabrevicolporites* and not placed under *Granustephanocolpites* Saxena (1979).

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 58; size 34×30 μm; slide no. 3314/12.

Type Locality — Bore-core no. 14, depth 48 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh.

Genus — *Polybrevicolporites* Venkatachala & Kar, 1969a

Type Species — *Polybrevicolporites cephalus* Venkatachala & Kar, 1969a.

Polybrevicolporites cephalus Venkatachala & Kar, 1969a

Pl. 11, fig. 7; Pl. 18, fig. 6

1969a *Polybrevicolporites cephalus* Venkatachala & Kar, p. 171, pl. 2, figs 55, 56.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains subcircular in equatorial view, 20-35×17-30 μm. Polycolporate, usually pentacolporate, brevicolpate, pores well-developed. Exine 3-6 μm thick, intrabaculate.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 55.

Type Locality — Bore-core no. 14 Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro; bore core no. 13 near Baranda.

Polybrevicolporites antiquum (Ramanujam) Venkatachala & Kar, 1969a

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains subcircular in equatorial view, 24-34 μm. Polybrevicolporate with six apertures. Exine thick, generally finely intramicroreticulate, sometimes seems to be granulose.

Holotype — Ramanujam, 1966, pl. 6, fig. 113.

Type Locality — Neyveli lignite, Tertiary, Tamil Nadu.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 13 near Baranda and Panandhro.

Polybrevicolporites (*Stephanocolpites*) *nadhamunii* (Venkatachala & Kar) comb. nov.

Pl. 11, fig. 8

1969a *Stephanocolpites nadhamunii* Venkatachala & Kar, 1970, p. 170, pl. 2, fig. 53.

Diagnosis — Pollen grains subcircular in polar view with five lobes on margin due to apertures, 28-35×25-32 μm. Pentacolporate, brevicolpate, intact colpi 8-12 μm long, pores distinct-indistinct, margin thickened. Exine 2-3 μm thick, sexine thicker than nexine, finely reticulate.

Remarks — Venkatachala and Kar (1969a) described this species as *Stephanocolpites nadhamunii*. The holotype was restudied and it was found to be colporate and so it has been transferred to *Polybrevicolporites*. It differs from *P. cephalus* by the presence of comparatively less thickened exine.

Holotype — Pl. 2, fig. 53; size 31×30 μm, slide no. 3311/7.

Type Locality — Bore core no. 14, depth 47 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro; bore-core no. 13 near Baranda.

Genus — *Retistephanocolpites* Leidelmeyer emend. Saxena, 1982

Type Species — *Retistephanocolpites angeli* Leidelmeyer, 1966.

Retistephanocolpites (*Polycolpites*) *granulatus* (Sah & Kar) comb. nov.

Pl. 11, fig. 15

1970 *Polycolpites granulatus* Sah & Kar, p. 137, pl. 2, fig. 41.

Diagnosis — Pollen grains circular-subcircular in polar view, 35-45×32-44 μm. Septa-octacolpate, colpi long, well-developed. Exine 1.5-2.5 μm thick, microreticulate.

Remarks — Sah and Kar (1970) described this species as *Polycolpites granulatus*. The specimens were reinvestigated and it was found that the exine is microreticulate. Saxena (1979) placed it under *Granustephanocolpites*. Since this species is microreticulate and not granulose, thus it has been placed under *Retistephanocolpites*.

Holotype — Sah & Kar, 1970, pl. 2, fig. 41; size 40×38 μm; slide no. 3372/32.

Type Locality — Bore-core no. 15, depth 7 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core no. 14 near Matanomadh and Panandhro.

Retistephanocolpites (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov.

Pl. 11, fig. 14

1970 *Polycolpites flavatus* Sah & Kar, p. 137, pl. 2, figs 42, 47.

Diagnosis — Pollen grains subcircular in polar view, 30-40×29-38 μm. Nonadecacolpate, colpi long. Exine up to 2.5 μm thick, sexine as thick as nexine, scrobiculate.

Remarks — Sah and Kar (1970) described this species as *Polycolpites flavatus*. This species has fine scrobiculation and so it fits well in *Retistephanocolpites*. They also mentioned the slide no. of the holotype as 3373. It is a printing mistake, and the slide no. of the holotype is 3353.

Holotype — Sah & Kar, 1970, pl. 2, fig. 47; size 32×30 μm; slide no. 3353/1.

Type Locality — Bore-core no. 15, depth 30 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 13 near Baranda and Panandhro.

Genus — *Ctenolophonidites* van Hoeken-Klinkenberg, 1966

Type Species — *Ctenolophonidites costatus* (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, 1966.

Remarks — The credit for first recognizing the occurrence of *Ctenolophon* type of pollen in Upper Cretaceous and Tertiary sediments of Nigeria goes to Kuyl, Muller and Waterbolk (1955). Van Hoeken-Klinkenberg (1964) described such pollen from the Lower Coal Measures (Maestrichtian) of Nigeria as *Stephanocolpites costatus*. He described the species as stephanocolpate (hexacolpate) with microreticulate structure. Between the furrows are endexinous thickenings which seem to be stripped by the reticulation on the ridges and they fuse at the poles forming an irregular ring-like pattern. Van Hoeken-Klinkenberg (1966) instituted *Ctenolophonidites* to accommodate stephanocolpate pollen grains with end-exinous thickenings fusing at the poles, forming an irregular ring-like pattern, as in recent Ctenolophonaceae. He selected *Stephanocolpites costatus* as the type species for the genus. Germeraad, Hopping and Muller (1968) accepted this treatment without any comment and illustrated one specimen from Nigeria as *Ctenolophonidites costatus* (pl. 14, figs 5, 6). They also provided the photographs of recent pollen of *Ctenolophon engleri* Mild. (pl. 15, figs 1, 2) which look very similar to the fossil ones — identified by them as *C. costatus*.

It may, however, be mentioned here that the original photograph of *C. costatus* given by van Hoeken-Klinkenberg (1964, photos 10a, b) is quite different from those of Germeraad, Hopping and Muller (1968, pl. 14, figs 5-6). Moreover, the photographs of the type species supplied by van Hoeken-Klinkenberg (1964, photos 10a, b) does not convincingly show the formation of ring-like ridges near the poles by the locally thickened exine.

Some of the specimens in the present material which approximate the type species in size range and general organization were studied in detail. It was observed that the exinal thickenings are present on both sides and they form irregular ridges mostly in the mesocolpial region without forming a ring around the poles. The other specimens in the same preparation form a ring-like exinal thickening at the poles and then proceed towards the mesocolpi. Germeraad, Hopping and Muller (1968) recognized three types of *Ctenolophon* in the fossil state: (i) *Ctenolophon engleri* type represented by *Ctenolophonidites costatus*, *Ctenolophon* type A represented by *Ctenolophonidites lismae* and *Ctenolophon parvifolius* type represented by *Retistephanocolpites williamsi*. Since the type species prescribed by van Hoeken-Klinkenberg (1964, photos 10a, b) does not exhibit ring-like thickening around the poles, it may be easily questioned whether it could stand for *Ctenolophon engleri* type.

According to Germeraad, Hopping and Muller (1968) *Ctenolophon engleri* is the oldest type as it occurs in the Senonian of Nigeria. It is, however, absent in Palaeocene and reappears in the younger Tertiary sediments. The presence of *Ctenolophonidites* in the Lower Eocene of Kachchh is very significant. It indicates that *Ctenolophon* migrated from west cost of Africa to west-coast of India during this time. Another genus which comes quite close to *Ctenolophonidites* is *Ghoshiacolpites* Sah & Kar (1970) which is also restricted to Lower

Eocene. The latter is, however, distinguished by the presence of a solid plate-like thickening of the exine on one side and then proceed as a rod-like thickening in the mesocolpial region. The margin of the colpi is also thickened.

Ctenolophonidites costatus (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg, 1966

Pl. 11, figs 12, 13; Pl. 18, figs 7, 8

Description — Pollen grains subcircular in polar view, 32-40×31-39 μm. Hexacolpate, colpi long, distinct. Ectexine thickened to form long, sinuous ridges on both sides, ridges overlap in polar and then extend towards mesocolpial region. Exine less than 2 μm thick, ± laevigate or weakly intrastructured.

Holotype — Van Hoeken-Klinkenberg, 1964, photos 10a, b.

Type Locality — G.S.N. bore-core no. 1001, Lower Coal Measures, Maestrichtian, Enugu, Nigeria.

Occurrence — Bore-core no. 13 near Baranda; bore-core no. 14 near Matanomadh and Panandhro.

Ctenolophonidites sp.

Pl. 12, fig. 11

Description — Pollen grain subcircular, 39 ×37 μm. Hexacolpate, colpi long, distinct, ectexinal thickening after forming a ring-like configuration on both sides proceed towards mesocolpial region, thickenings do not reach up to margin. Exine less than 2 μm thick, laevigate and weakly intrastructured.

Remarks — The specimen approximates *Ctenolophon engleri* type depicted by Germeraad, Hopping and Muller (1968, pl. 15, figs 1, 2). *Ctenolophonidites costatus* (*sensu* type species) is distinguished by its absence of ring-like thickening of the ectexine on the poles. The photographic illustration of *C. costatus* by Germeraad, Hopping and Muller (1968, pl. 14, figs 5, 6) also closely resembles the species described here.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Polygalacidites* Sah & Dutta, 1966

Type Species — *Polygalacidites clarus* Sah & Dutta, 1966.

Polygalacidites gujaratensis sp. nov.

Pl. 15, fig. 9; Pl. 19, fig. 3

Diagnosis — Pollen grains 38-46×36-44 μm in equatorial view, 5-6 colporate, colpi long, narrow, pore distinct or indistinct. Exine 2-3 μm thick, sexine thicker than nexine, weakly intrastructured.

Comparison — *Polygalacidites clarus* Sah & Dutta (1966) resembles *P. gujaratensis* in general organization but the latter is easily separated by its bigger size range.

Holotype — Pl. 15, fig. 9; size 42×40 μm; slide no. 3353/9.

Type Locality — Bore-core no. 13, depth 19 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda.

Genus — *Monoporopollenites* (Meyer) Potonié, 1960

Type Species — *Monoporopollenites gramineoides* Meyer, 1956.

Monoporopollenites sp.

1969a *Monoporopollenites* sp. Venkatachala & Kar, p. 172, pl. 3, fig. 75.

Description (*after Venkatachala & Kar, 1969a*) — Pollen grain circular, 32 μm. Monoporate, pore circular, diameter 6 μm. Exine 1.5 μm, exine as thick as nexine, psilate.

Occurrence — Bore-core no. 14 near Matanomadh.

Genus — *Trilatiporites* Ramanujam, 1966

Trilatiporites minutus Sah & Kar, 1970

1970 *Trilatiporites minutus* Sah & Kar, pp. 138-139, pl. 2, fig. 40.

Diagnosis (*after Sah & Kar, 1970*) — Pollen grains roundly triangular, 26-32×

24-27 μm. Tricolporate, pores subequatorially placed, margin not thickened, exine thin, scrobiculate.

Holotype — Sah & Kar, 1970, pl. 2, fig. 40.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore-core no. 1 near Lakhpat and Akri.

Genus — *Tripilaorites* gen. nov.

Type Species — *Tripilaorites* (*Triorites*) *triangulus* (Sah & Kar) comb. nov.

Diagnosis — Pollen grains triangular in polar and oval in equatorial view. Triorate, ora very large, distinct. Exine pilate-baculate.

Description — Pollen grains generally found in polar view, 32-45×28-40 μm, apertures provide three concavity on margin. Ora circular, 22-30 μm in diameter, apertures occupying more than two-thirds space along margin. Exine 1.5-3 μm thick, sexine much thicker than nexine, pila 3.5 μm long, head pin-shaped, often interspaced with bacula, pila 2-4 μm apart, interpilar space laevigate, sculptural elements provide negative reticulum in surface view.

Comparison — *Triorites* Cookson ex Couper (1953) is triorate, triangular in shape and psilate to variously ornamented. The present genus is, however, distinguished by its big ora and pilate-baculate ornamentation. *Proteacidites* Cookson (1950) is also triangular in shape, anguloaperturate and baculate, clavate and tuberculate to form negative reticulum in surface view.

Remarks — Cookson (1950) described *Triorites magnificus* from the Tertiary brown lignite (?Oligocene-Miocene) deposits of south-eastern Australia. She remarked that this species superficially resembles pollen of extant Proteaceae but is quite different in its general morphology and sclerine stratification. The exine is about 9-10.5 μm thick, composed of four clearly defined layers. Of these, the two inner are nexinous (ecto and endonexine) with an approximate width of 2.5 μm and the two onter are sculptinous (sexine and ?perine). The inner layer of the sculptine is broad, about 4.5 μm and pitted or somewhat spongy. The outer layer of the sculptine, which is about 2.5 μm thick, is highly refractive and does not take stain like the rest of the exine. It is baculate and in surface view appears reticuloid. The aperture appears to be situated at the base of cavities formed by forward annular extensions of the exine.

Couper (1953) provided *Triorites* the status of a form genus and selected *Triorites magnificus* Cookson (1950) as the type species. He prescribed the generic diagnosis as "free, isopolar, triorate, ora circular". Grain oblate to peroblate, triangular to subtriangular in polar view. Exine psilate to sculptured. Size very variable. From this diagnosis it is very clear that Couper (1953) did not follow Cookson (1950) though he designated *T. magnificus* Cookson (1950) as the type species for the genus. Couper (1953) also described three new species of *Triorites*, viz., *T. fragillis*, *T. harisii*, and *T. minor* ranging in age from Upper Cretaceous to Miocene of New Zealand. All these species have thin exine (1-2.5 μm) which are laevigate, finely granulate or flecked. It is obvious that these species have different type of exine ornamentation pattern from the type species of the genus. The later workers followed Couper (1953) without consulting Cookson (1950) and as a result many species were included in *Triorites* which has little similarity with the original description of the type species. *Triorites* should be restricted to those species which fall within the circumscription of the type species. The other species which have no reference with *Triorites* (*sensu* Cookson) should be accommodated in other genera.

Tripilaorites (*Triorites*) *triangulus* (Sah & Kar) comb. nov.

Pl. 19, figs 1, 2

1970 *Triorites triangulus* Sah & Kar, p. 139, pl. 2, fig. 53.

Diagnosis — Pollen grains triangular-subtriangular in polar view, 32-45×28-40 μm. Triorate, ora distinct, forming concavity and occupying two-third space on margin, circular, 20-30 μm in diameter. Exine 2-3 μm thick, sexine much thicker than nexine, pilate, pila 3-5 μm long, 1-2 μm broad, pin headed, bacula often interspersed with pila, pila-bacula 3-5 μm apart, interpilar space laevigate, sculptural elements provide negative reticulum in surface view.

Remarks — Sah and Kar (1970) described this species as *Triorites triangulus*. Since *Triorites magnificus*, the type species of *Triorites*, is very different (*sensu* Cookson, 1950) from the present one, the latter has been placed into a new genus.

Holotype — Sah & Kar, 1970, pl. 2, fig. 53; size 40×38 μm; slide no. 3358/4.

Type Locality — Bore-core no. 13, depth 51 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 13 near Baranda and Panandhro; bore-core no. 36 near Jhulrai; bore-core nos. 1 and 2 near Lakhpat.

Genus — *Triangulorites* gen. nov.

Type Species — *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov.

Triangulorites (*Triorites*) *minutus* (Sah & Kar) comb. nov.

1970 *Triorites minutus* Sah & Kar, p. 139, pl. 2, fig. 51.

Diagnosis — Pollen grains triangular with radiating arms in polar view, 45-58×40-55 μm, margin straight-slightly convex. Tri- or tetraorate, three ora distinct, another developing or developed ora also observed in most specimens, adpressed in middle region or appearing as fold, ora circular, length of arms double the breadth. Exine 1-2 μm thick, sexine thicker than nexine, granulose-conied, sculptural elements 1 μm high, forming negative reticulum in surface view.

Comparison — *Triangulorites bellus* (Sah & Kar) comb. nov. comes close to the species described here in general organization and shape but is easily separated by its bigger size range.

Holotype — Sah & Kar, 1970, pl. 2, fig. 51; size 54×50 μm; slide no. 3374/13.

Type Locality — Bore core no. 15, depth 13 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda; bore-core no. 36 near Jhulrai and Panandhro; bore core nos 1 and 2 near Lakhpat.

Genus — *Dermatobrevicolporites* gen. nov.

Type Species — *Dermatobrevicolporites* (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

Diagnosis — Pollen grains triangular-subtriangular, tricolporate, brevicolpate, pore large, margin thickened, exine thick, laevigate-finely intrastructured.

Description — Pollen grains with three marked constriction due to apertures, size range 35-46×32-40 μm, apertures placed on margin, often beak-like in appearance. Colpi distinct, 10-20 μm in length, tapering at ends. Pores well-defined, margin thickened. Exine 2-8 μm thick, sexine as thick as nexine or sometimes thicker. In some specimens, exine exhibits differential thickening, it is thicker in apertural region. Exine mostly laevigate, sometimes weakly intrastructured.

Comparison — *Psilatricolporites* van der Hammen (1956) comes closer to the present genus in having psilate exine and tricolporate condition but the latter is distinguished by its thicker exine, brevicolpate aperture and thickened margin of pores. *Verrucolporites* Sah & Kar (1970) is also tricolporate but the colpi are long and the exine is strongly verrucose. *Verrutricolpites* Pierce (1961) is only tricolpate and is also verrucose. *Ilexipollenites* Thiergart (1937) approximates *Dermatobrevicolporites* in tricolporate nature but is differentiated by its long colpi and sculptural elements. *Dermatobrevicolporites*, proposed here, is differentiated by all tricolporate genera by its triangular shape, thick and laevigate exine, short colpi and appreciably thickened pore margin.

Dermatobrevicolporites (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

Pl. 15, figs 4, 5

1970 *Triorites dermatus* Sah & Kar, p. 140, pl. 2, figs 49, 50.

Diagnosis — Pollen grains triangular-subtriangular, 30-38×28-35 μm, always found in polar view, tricolporate, colpi short, 10-15 μm in length, pore well-developed, 5-10 μm in diameter. Exine 2-4 μm thick, sexine thicker than nexine, more or less psilate or sometimes weakly intrastructured.

Remarks — Sah and Kar (1970) described the same specimen as *Triorites dermatus*. The specimen was reinvestigated and it was found to be tricolporate. As *Triorites* (Erdtman) Couper (1953) accommodates only the triorate pollen grains, this species has been transferred and placed under a new genus.

Holotype — Sah and Kar, 1970, pl. 2, fig. 49; size 34×33 μm; slide no. 3365/20.

Type Locality — Bore-core no. 15, depth 7 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 15 near Baranda and Panandhro; bore core no. 14 near Matanomadh.

Dermatobrevicolporites exaltus sp. nov.

Pl. 15, figs 11, 12

Diagnosis — Pollen grains subtriangular in polar view, 40-48×36-45 μm. Tricolporate, brevicolpate, colpi 10-20 μm, pore mostly distinct, margin thickened, 4-8 μm in diameter. Exine at interapertural region, 4-8 μm and at apertural region 8-12 μm thick. Sexine as thick as nexine, generally laevigate, sometimes weakly intrastructured.

Comparison — *Dermatobrevicolporites dermatus* (Sah & Kar) comb. nov. resembles the species described here in shape and approximates in size range but is distinguished by its uniform thickening of the exine.

Holotype — Pl. 15, fig. 11; size 45×43 μm; slide no. 3377/2.

Type Locality — Bore-core no. 13, depth 9 m, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore - core no. 13 near Baranda; bore-core no. 36 near Jhulrai and Panandhro.

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

Type Species — *Pseudonothofagidites kutchensis* Venkatachala & Kar, 1969a.

Pseudonothofagidites cerebrus Venkatachala & Kar, 1969a

Pl. 19, fig. 4

1969a *Pseudonothofagidites cerebrus* Venkatachala & Kar, p. 174, pl. 3, fig. 74.

Diagnosis (after Venkatachala & Kar, 1969a) — Pollen grains subcircular with broadly lobed margins. Pores 8 in number, situated at the intermarginal area of the lobe, rimmed, sexine roughly granulose.

Holotype — Venkatachala & Kar, 1969a, pl. 3, fig. 74.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh and Panandhro.

Genus — *Thymelaepollis* Sah & Kar, 1970

Type Species — *Thymelaepollis crotonoidis* Sah & Kar, 1970.

Thymelaepollis crotonoidis Sah & Kar, 1970

Pl. 14, fig. 11

1970 *Thymelaepollis crotonoidis* Sah & Kar, p. 140, pl. 2, fig. 71.

Diagnosis (after Sah & Kar, 1970) — Pollen grains circular-subcircular, 42-54×40-53 μm, polyporate. Exine 2-4 μm thick, mostly baculate, sometimes with excrescences at top.

Remarks — The pollen grains assignable to *Thymelaepollis* resemble the pollen of Thymelaeaceae in circular shape, polyporate nature and thick exine provided with excrescences on bacular-spinose processes. This ornamentational pattern has been named as 'croton-pattern' by Erdtman (1952). The pollen grains of *Pimelia longifolia* described and illustrated by Cranwell (1953, pl. 2, fig. 11) come more or less close to *Thymelaepollis* in shape, size, apertural nature and ornamentational pattern.

Holotype — Sah & Kar, pl. 2, fig. 71.

Type Locality — Bore-core no. 15, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore - core no. 15, near Baranda and Panandhro.

Genus — *Cryptopolyporites* Venkatachala & Kar, 1969a

Type Species — *Cryptopolyporites cryptus* Venkatachala & Kar, 1969a.

Remarks — The genus shows similarity with some of the pollen grains of *Linum* of Lineaceae. The palynology of *Linum* has been studied by Saad (1961) and he found polyporate pollen grains in *Linum heterosepalum*, *L. multicaule*, *L. olgae*, *L. rigidum* and *L. stelleroides*. The pores in all these species are covered with the sculptural elements. The pores could only be recognized by careful analysis of the exine pattern and such pores have been termed as "cryptopore" by Saad (1961). The pores of *Cryptopolyporites* closely resemble the 'cryptopores' found in some species of *Linum*.

Cryptopolyporites cryptus Venkatachala & Kar, 1969a

1969a *Cryptopolyporites cryptus* Venkatachala & Kar, p. 175, pl. 2, fig. 28.

Diagnosis (*after Venkatachala & Kar, 1969a*) — Pollen grains circular in overall shape, 30-35 μm. Panporate, pores are concealed by the ornamentational pattern of the exine, aperturate as well as nonaperturate regions ornamented by closely set bacula.

Remarks — Most of the pores are pseudoaperturate but it seems that there are 3 real pores in the holotype with thickened margin.

Holotype — Venkatachala & Kar, 1969a, pl. 2, fig. 28; size 35×30 μm; slide no. 3324.

Type Locality — Bore-core no. 14, Naredi Formation, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 14 near Matanomadh; bore-core no. 1 near Lakhpat.

Genus — *Ligulifloraedites* gen. nov.

Type Species — *Ligulifloraedites pilatus* sp. nov.

Diagnosis — Pollen grains generally subcircular, radially symmetrical, apertures indistinct, probably tricolpate-tricolporate. Exine thick, roughly differentiated into a pattern of intectate lacunae and tectate — columellate cristae, columellae bearing pila.

Description — Pollen grains generally with undulate margin due to projection of lacunae, 45-55×43-50 μm. Apertures not decipherable due to heavy sculptural elements, one furrow (?colpus) observed in holotype, judging its position it may be inferred that pollen grains should be tricolpate-tricolporate. Exine 5-8 μm thick, nexine only 1-2 μm thick, lacunae 8-10 μm long, 6-8 μm broad, columella 4-6 μm broad, bearing single rows of pila, pila pin-headed, strongly built, not very closely placed.

Comparison — *Fenestrites* (van der Hammen) Germeraad, Hopping & Muller (1968) closely resembles *Liguliofloraedites* in shape and presence of exinal intectate lacunae and tectate columellate cristae but is spinose. It may be indicated here that van der Hammen (1956) indicated a recent pollen as a type species for *Fenestrites*. Germeraad, Hopping and Muller (1968) wanted to validate it by selecting a fossil specimen as a lectogenotype for the genus. This treatment is perhaps not proper as according to Nicolson (personal communication) once a name rejected as illegitimate cannot be legitimated unless it is conserved. Same is true for *Echitricolporites* (van der Hammen) Germeraad, Hopping & Muller (1968). This genus is, however, distinguished from the present one by its absence of intectate lacunae and columellate cristae. Sah (1967) instituted *Cichoreacidites* to accommodate fenestrate, 3-zonaperturate, oblate-spheroidal, lophate, echinate, dupli-tertipilariate pollen grains which can also easily include the pollen grains hitherto assigned to *Fenestrites* (van der Hammen) Germeraad, Hopping & Muller (1968). *Compositoipollenites* Potonié (1951) and *Tubulifloridites* Cookson (1947) are distinctly aperturate and spinose. *Ligulifloraedites* instituted here is distinguished from all the compositoid pollen by its presence of intectate lacunae, tectate-columellate cristae and presence of pin headed pila in columellae.

Remarks — This genus closely resembles the pollen architecture of the liguliflorae of the family Asteraceae (Compositae).

Ligulifloraedites pilatus sp. nov.

Pl. 7, figs 18, 19; Pl. 9, fig. 8

Diagnosis — Pollen grains radially symmetrical, subcircular with slight undulated margin, 45×54—44×53 μm. Apertures not distinct, seem to be tricolpate - tricolporate. Exine 5-7 μm thick, sexine much thicker than nexine, differentiated into a pattern of intectate lacunae and tectate-columellate cristae, columella 4-6 μm broad, bearing single rows of pin-headed pila, pila robustly built.

Holotype — Pl. 7, fig. 18; size 52×50 μm; slide no. 8230/3.

Type Locality — Panandhro lignite field, Panandhro, Lower Eocene, Kachchh.

Occurrence — Panandhro.

Genus — *Spinulotetradites* gen. nov.

Type Species — *Spinulotetradites juxtatus* sp. nov.

Diagnosis — Pollen grains mostly found in tetrads, tricolpate-tricolporoidate. Exine spinulose.

Description — Out of four, three pollen are found in the same plane, tetrads 30-38× 28-36 μm, individual grain oval in equatorial view. Colpi long, narrow, appear as slit, sometimes incipient pore may be found in some specimens, minor irregular folds also occasionally met with. Exine 1-2 μm thick, sexine much thicker than nexine, spinules up to 2 μm high, broader at base, pointed at tip, interspinal space laevigate, spinules 2-4 μm apart.

Comparison — *Ericipites* Wodehouse (1933) comes closer to *Spinulotetradites* in size range; but is distinguished by its different orientation of the tetrads. In the type species of *Ericipites* as shown by Potonié (1960, pl. 9, fig. 194) two pollen are found in one plane and the rest two are found in another and perpendicular to the former one. Besides, the pollen grains are only colpate and the ornamentation is laevigate-granulose. *Ericaceoipollenits* (Potonié) Potonié (1960) resembles the present genus in orientation of the tetrads but is much larger in size (61 μm) and the exine is intrabaculate. *Dicotetradites* Couper (1953) is tricolporate, the exine 2.5-4 μm thick, clavate-baculate forming a clear reticulate-pitted sculpture in surface view. *Kielmeyerapollenites* Sah & Kar (1974) is much bigger in size (60-77 μm) and the exine is thick, tegillate and retipilate. *Droseridites* Cookson (1974) is bedecked with 2-6 μm long spines and no aperture could be traced.

Spinulotetradites juxtatus sp. nov.

Pl. 16, figs 10-12

Diagnosis — Pollen grains in tetrads, 30-36×28-34 μm, tricolpate-tricolporoidate, colpi long, distinct, ill-developed pores recognizable in some specimens. Exine 1-2 μm thick, sexine thicker than nexine, spinulose, spines up to 2 μm high, 2-4 μm apart, spines broader at base and narrow at tip.

Remarks — Ramanujam (1966) described *Ericipites sahnii* from the Neyveli lignites of South India. The orientation of the tetrads in this species is that three pollen found on one plane and the fourth in another, while in the type species of *Ericipites* as mentioned earlier two pollen are in one plane and the rest in different plane. However, Potonié (1960) also accepted species in *Ericipites* which has different orientation of the tetrads (Potonié, 1960, pl. 8, fig. 192). Since the orientation of tetrads is a very important character, thus proper attention be paid to it before assigning it to any genus.

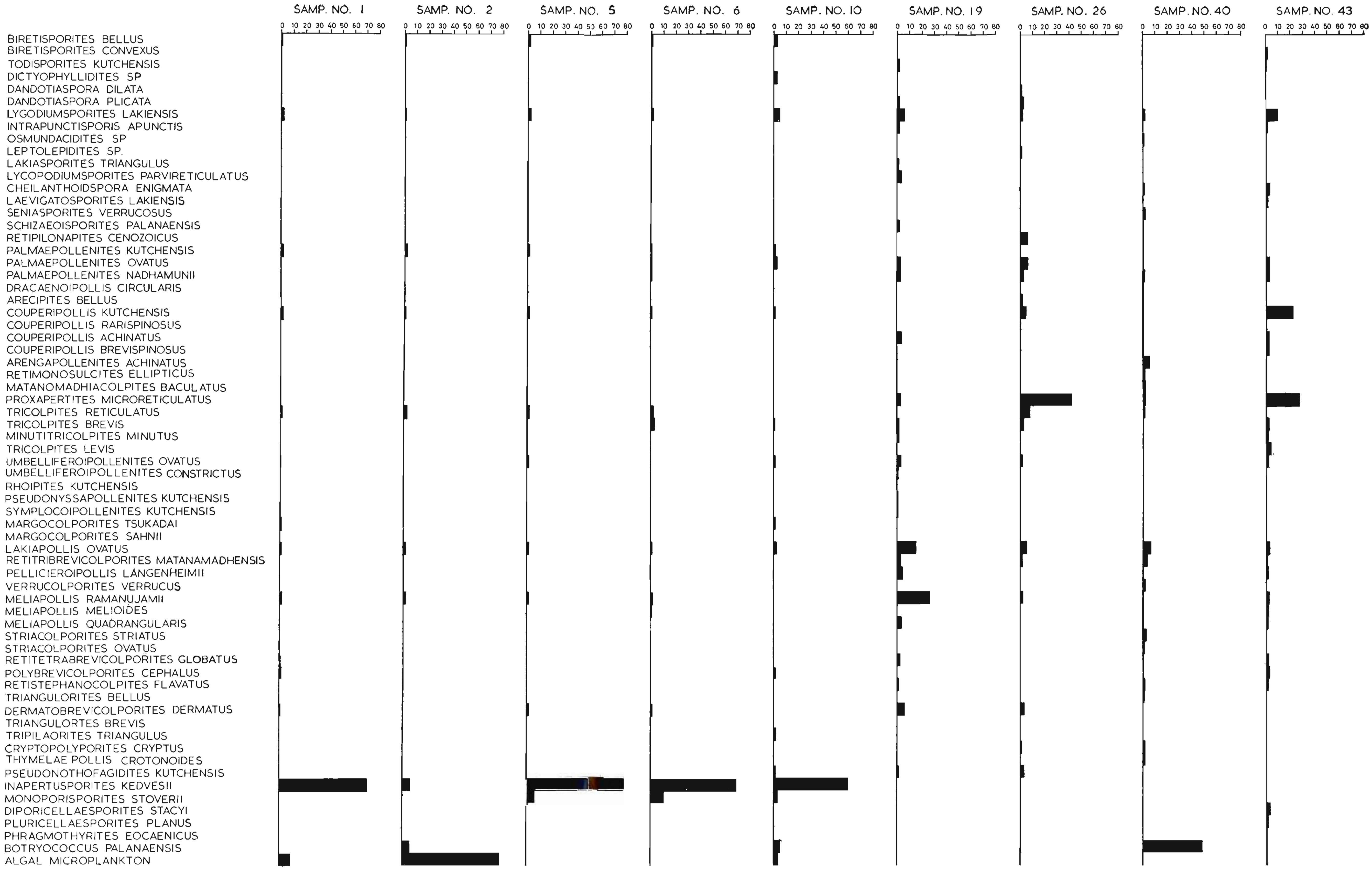
Holotype — Pl. 16, fig. 10; size 32×31 μm; slide no. 3353/16.

Type Locality — Bore-core no. 13, depth 19 m, Naredi Formation, Lower Eocene, Kachchh.

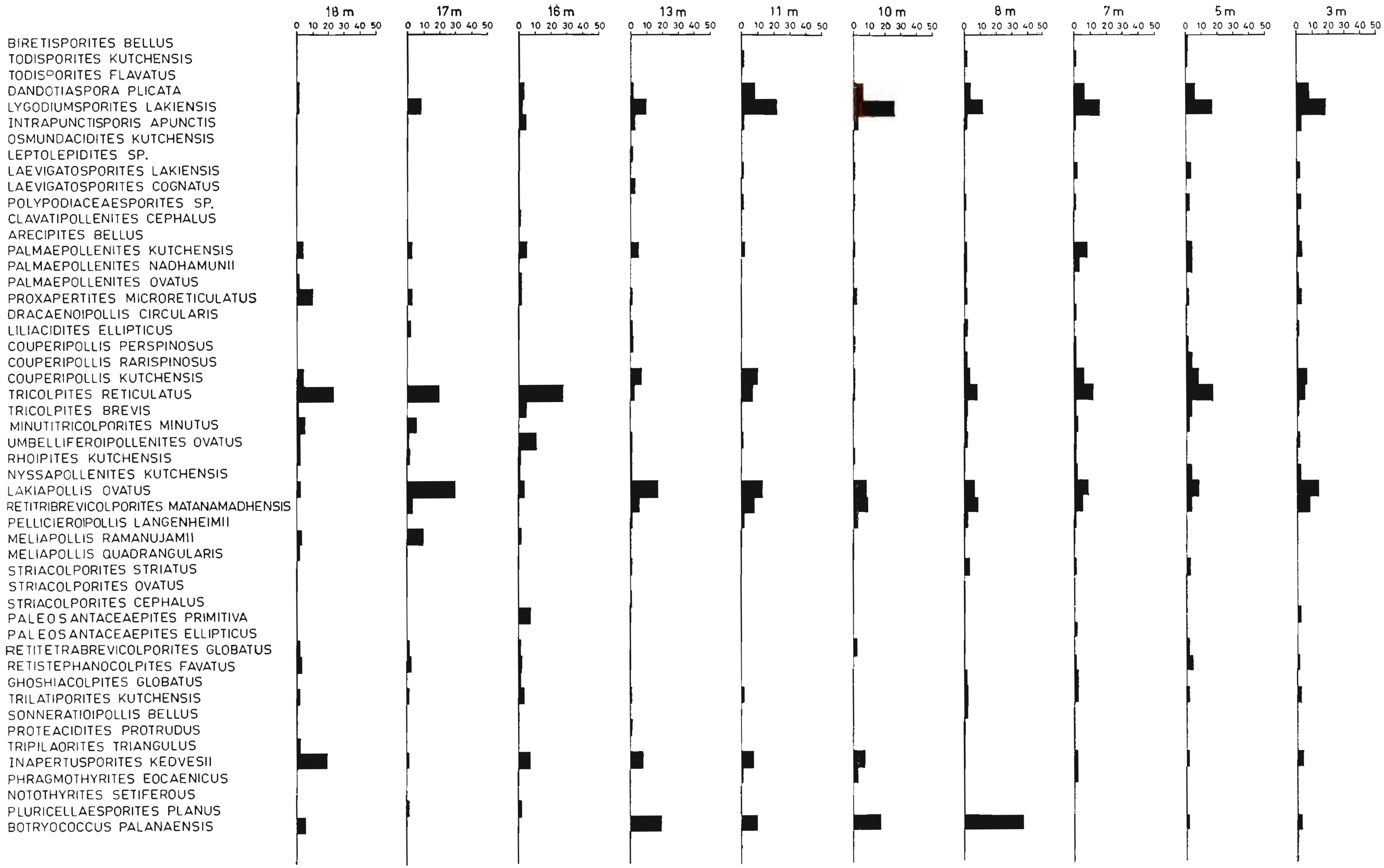
Occurrence — Bore - core no. 13 near Baranda and Panandhro.

PALYNOLOGICAL SUCCESSION IN PANANDHRO LIGNITE FIELD

Panandhro lignite field as has already been stated is the thickest deposit of Eocene lignite in the area. There are generally two workable lignite seams in the area which are separated by carbonaceous shale and clay. The maximum thickness of the lower seam is 4 m while the upper one may be up to 23 m, with minor intercalation of shale and clay. Apart from this, a few lenses of lignite are also observed at the bottom and topmost grey shale/clay.



TEXT-FIG. 6 — Showing the percentage of different spore pollen species in Panandhro lignite field.



TEXT-FIG. 7 — Showing the percentage of different spore pollen species in bore-core no. 13.

Fifty samples were collected approximately at an interval of 0.75 m from the Panandhro open cast lignite quarry. Amongst them, 15 samples are quite rich in miospores. The productive samples, fortunately, represent bottom, middle and top horizons and thus depict the general palynological succession of the lignite field.

The palynological assemblage consists of algal bodies and phytoplankton, fungal spores, stromata, hyphae and other elements, pteridophytic spores and angiospermic pollen. The gymnospermic pollen are conspicuous by their absence in the assemblage. Though the Lower Eocene palynological assemblage in Kachchh is represented by one hundred odd species and approximately 80 dispersed genera, only 47 genera and 67 species are encountered in the percentage count in Panandhro lignite field. The percentage count has revealed that in samples where the fungal elements are abundant the pteridophytic spores and angiospermic pollen are found in less percentage and when the latter are very common the fungal elements are hardly encountered.

The fungal spores generally represented by *Inapertusporites kedvesii* are numerous in sample nos. 1, 5, 6 and 10. This species in these samples represent 59-78%. However, in sample no. 2 its contribution is only 6%. The phytoplankton (79%) is overwhelmingly dominating in this sample. The pteridophytic spores and angiospermic pollen commonly found in association with fungal spores are: *Biretisporites bellus*, *Lygodiumsporites lakiensis*, *Palmaepollenites kutchensis*, *Couperipollis kutchensis*, *Tricolpites reticulatus*, *Umbelliferoipollenites ovatus*, *Margocolporites tsukadai*, *Lakiapollis ovatus*, *Meliapollis ramanujamii*, *Retitetrabrevicolporites globatus*, *Polybrevicolporites cephalus* and *Dermatobrevicolporites dermatus* (Text-fig. 6).

Sample no. 19 ushers new elements in the assemblage and fungal spores hitherto dominant play a very insignificant role. Angiospermic pollen are dominant and generally represented by *Meliapollis ovatus* (26%) and *Lakiapollis ovatus* (15%). Other common angiospermic elements are *Dermatobrevicolporites dermatus*, *Meliapollis quadrangularis*, *Pellicieroipollis langenheimii*, *Umbelliferoipollenites ovatus*, *Couperipollis achinatus*, *Proxapertites microreticulatus*, *Palmaepollenites ovatus* and *Palmaepollenites nadhamunii*. The pteridophytic spores are generally represented by *Lygodiumsporites lakiensis*, *Lycopodiumsporites parvireticulatus* and *Intrapunctisporis apunctis*.

Sample nos. 26 and 43 are also dominated by angiospermous pollen. In sample no. 40 though the angiosperm pollen are frequently found, the assemblage is dominated by *Botryococcus palanaensis*. The pollen species common to these samples are *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Tricolpites reticulatus*, *Lakiapollis ovatus*, *Palmaepollenites nadhamunii*, *Palmaepollenites ovatus*, *Tricolpites brevis* and *Meliapollis ramanujamii*. Pteridophytic spores are contributed by *Lygodiumsporites lakiensis*, *Cheilanthoidspora enigmata*, *Dandotiaspora plicata* and *Seniasporites verrucosus*.

Palynological succession in bore-core no. 13 — The bore-core samples start yielding microfossils from the depth of 18 m and continues to be productive upto 3 m. From 18 to 13 m, the pteridophytic spores are less represented than the angiosperms and fungal spores are also frequently represented by *Inapertusporites kedvesii* and is found up to 20% at the depth of 18 m, but in other samples they are not found in more than 9%. *Botryococcus palanaensis* contributes up to 20% at the depth of 13 m but from 18 to 16 m it is meagrely represented. Similarly, *Meliapollis ramanujamii* (10%) is common at the depth of 17 m but rarely encountered at the depth of 18 m, 16 m and 13 m. *Lakiapollis ovatus* (30%) is most common at the depth of 17 m but its representation dwindles down in other samples. *Tricolpites reticulatus* is, however, more or less uniformly represented (20-28%) except at the depth of 13 m where it is found in 3% only. *Lygodiumsporites lakiensis* is not found in appreciable numbers in this horizon (Text-fig. 7).

Samples from 11 to 3 m are rich in pteridophytic spores and *Lygodiumsporites lakiensis* is well represented. Besides, *Dandotiaspora plicata* is also frequently met with. Amongst angiospermic pollen, *Couperipollis kutchensis*, *Tricolpites reticulatus*, *Lakiapollis ovatus* and *Retitribrevicolporites matanomadhensis* are occasionally found. *Botryococcus palanaensis* in some samples are also common and at the depth of 8 m, it represents up to 38%.

The bore-core can be thus divided into two palynological zones. The lower one is confined in between 18 m, 13 m and the characteristic species in this zone are *Tricolpites reticulatus*, *Meliapollis ramanujamii* and *Inapertusporites kedvesii*.

Palynological succession in bore-core no. 15 — The bore-core is productive from the depth of 53 m to 13 m. Most of the species are consistent in their representation in the bore-core except a few. *Lygodiumsporites lakiensis* (28%) is dominant at the depth of 20 m, whereas in other samples it is not found in more than 11%. Similarly at the level of 19 m, *Pluricellaesporites planus* contributes up to 29%, while in other samples it is meagrely represented. As a whole, the bore-core of the assemblage is dominated by angiospermic pollen and the pteridophytic and fungal spores are less represented. The characteristic species are: *Palmaepollenites kutchensis*, *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Tricolpites minutus*, *Umbelliferoipollenites ovatus*, *Lygodiumsporites lakiensis*, *Pluricellaesporites planus* and *Lakiapollis ovatus* (Text-fig. 8).

Palynological succession in Gujra dam section — The palynological succession in this section is based on three samples only. The sample no. G 5 more or less represents the middle, whereas sample nos. G 9 and G 10 represent the top parts. The three samples exhibit similar assemblages except minor variations. In sample no. G 5 *Polypodiaceaesporites levis* (28%) is very common while in others it is found in insignificant percentage. Similarly, *Tripilaorites triangulus* contributes 11% to the assemblage in sample no. G 10 but in rest they are not found within the count. Common elements in these samples are *Tricolpites reticulatus*, *Tricolpites minutus*, *Couperipollis kutchensis*, *Lygodiumsporites kutchensis*, *Inapertusporites kedvesii*, *Meliapollis ramanujamii*, etc. (Text-fig. 9).

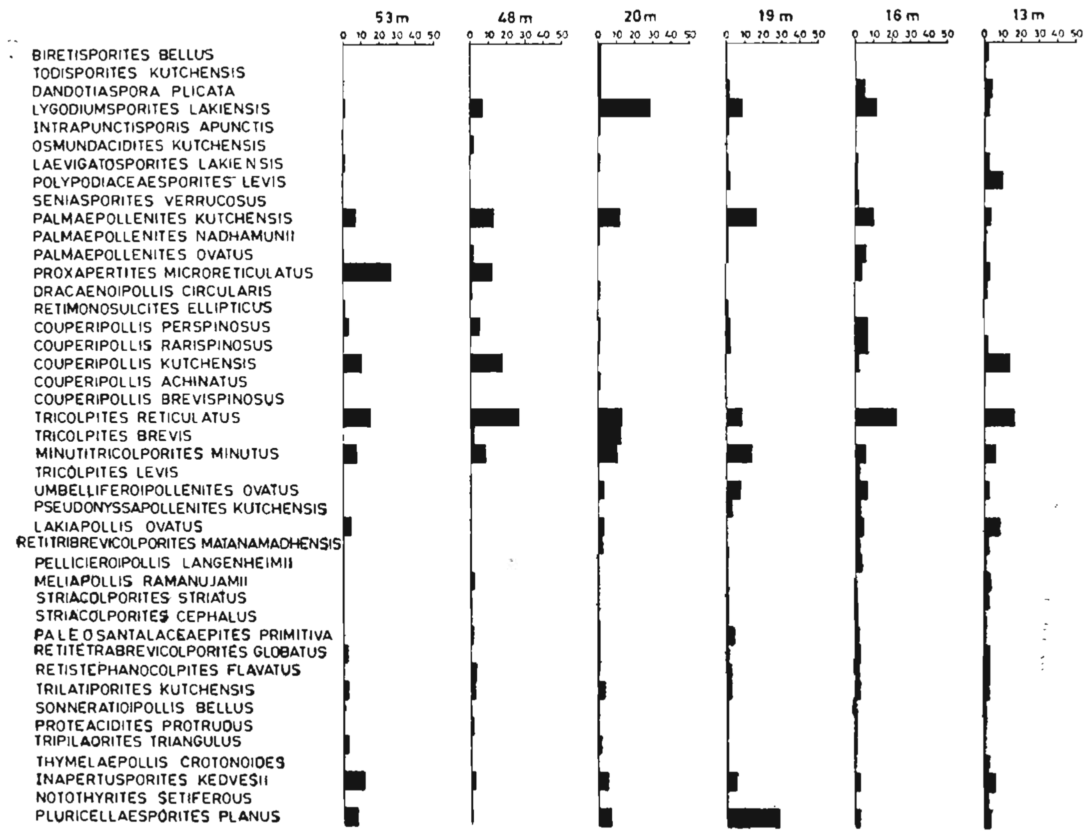
Palynological succession in bore-core no. 1 near Lakhpat — The bore-core no. 1 drilled near Lakhpat is about 101 m thick and palynological fossils were obtained at the depth of 77.5, 62, 48, 47, 46, 44.5, 39, 38, 37, 29.8, 29.42, 24.5, 15, 14, 13, 10.5, 9, 5, 4.5 and 3.3 metres. In most of the samples, spores, pollen grains and fungal bodies are dominant but those at the depth of 62 m, 48 m, 46 m, 15 m, 14 m, and 10.5 m are rich in microplanktons (90%, 92%, 58%, 43%, 64%, and 75%) respectively.

At the level of 77.5 m, spores, pollen and fungal bodies are found in 76% and the microplanktons 24%. *Lakiapollis ovatus* is most common followed by *Couperipollis kutchensis* (15%), *Retitribrevicolporites matanomadhensis* (5%), *Inapertusporites kedvesii* (5%) and *Proxapertites microreticulatus* (4%). The percentage of these genera considerably dwindles down at the depth of 62 m, 48 m and 46 m due to the dominance of microplanktons and one fungal genus, viz., *Pluricellaesporites planus*. At the depth of 44.5 m, *Phragmothyrites eocaenicus* (33%) is most common and seconded by *Couperipollis kutchensis* (23%). *Lakiapollis ovatus* (6%), *Tricolpites reticulatus* (5%), and *Couperipollis rarispinosus* (4%) are occasionally found (Text-fig. 10).

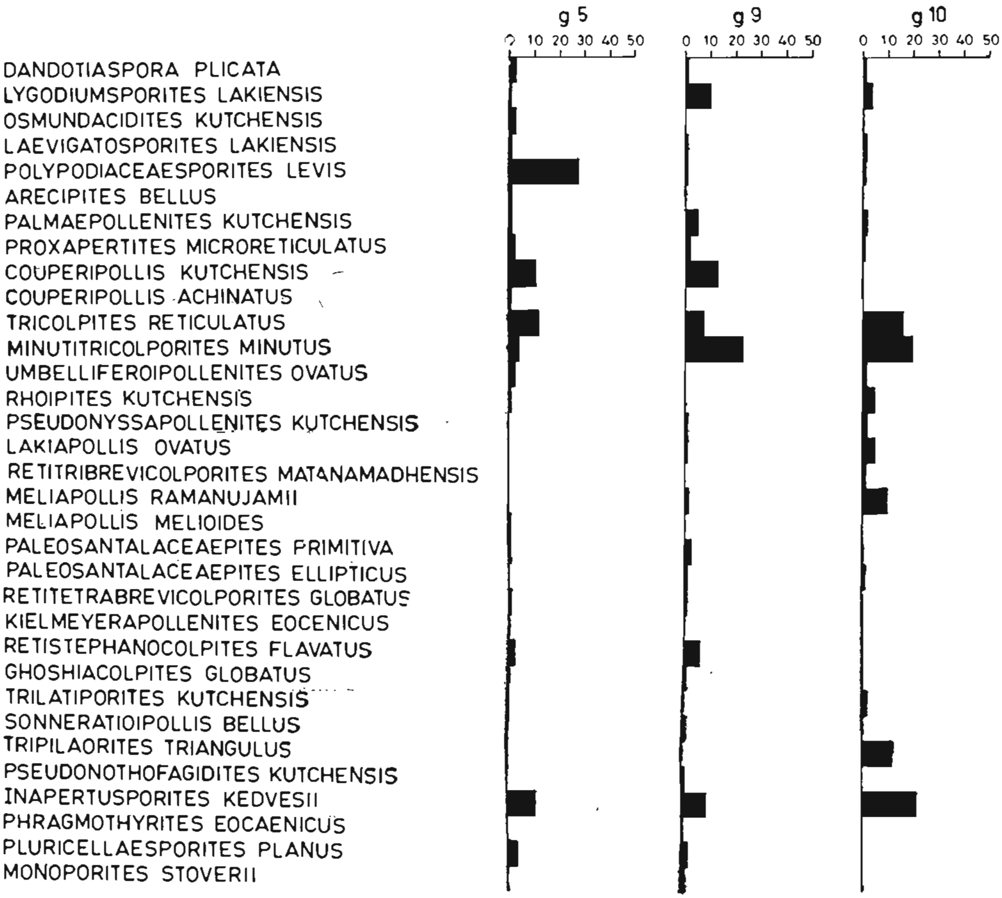
From 39 m to 13 m, *Lakiapollis ovatus*, *Couperipollis kutchensis*, *Retitribrevicolporites matanomadhensis*, *Pellicieroipollis langenheimii*, *Lygodiumsporites lakiensis* and *Meliapollis ramanujamii* are found in fairly good percentage. At 10.5 m level these species except *Couperipollis kutchensis* (14%) are found due to overwhelming dominance of microplanktons. From 9-3.3 m, *Lygodiumsporites lakiensis* (15-66%), together with *Intrapunctisporis apunctis*, *Dandotiaspora plicata*, *Lakiapollis ovatus*, *Couperipollis kutchensis*, and *Retitribrevicolporites matanomadhensis* dominate the assemblage.

Thus on the basis of spores and pollen grains, the entire bore-core can be divided into two palynological zones. The lower palynological zone ranges from 77.5-10.5 m and is characterized by the presence of *Lakiapollis ovatus*, *Couperipollis kutchensis*, *Tricolpites reticulatus*, *Retitribrevicolporites matanomadhensis*, *Meliapollis ramanujamii* and *Pellicieroipollis langenheimii*. Besides, at certain levels fungal elements represented by *Phragmothyrites eocaenicus* and *Pluricellaesporites planus* are also found in good percentages.

In the upper palynological zone (9-3.3 m) the pteridophytic spores are more represented than the angiospermic ones. *Lygodiumsporites lakiensis* is the most common species in this zone. Other common species are: *Dandotiaspora plicata*, *Intrapunctisporis*



TEXT-FIG. 8 — Showing the percentage of different spore pollen species in bore-core no. 15.

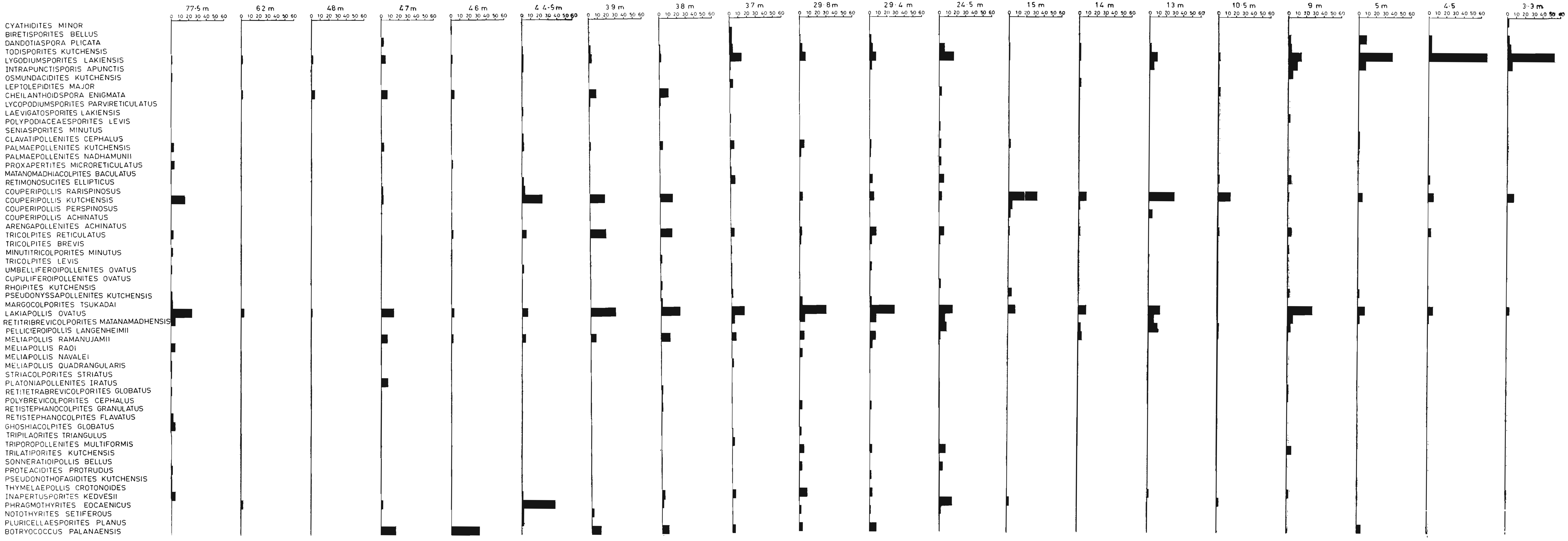


TEXT-FIG. 9 — Showing the percentage of different spore-pollen species in Gujra dam section.

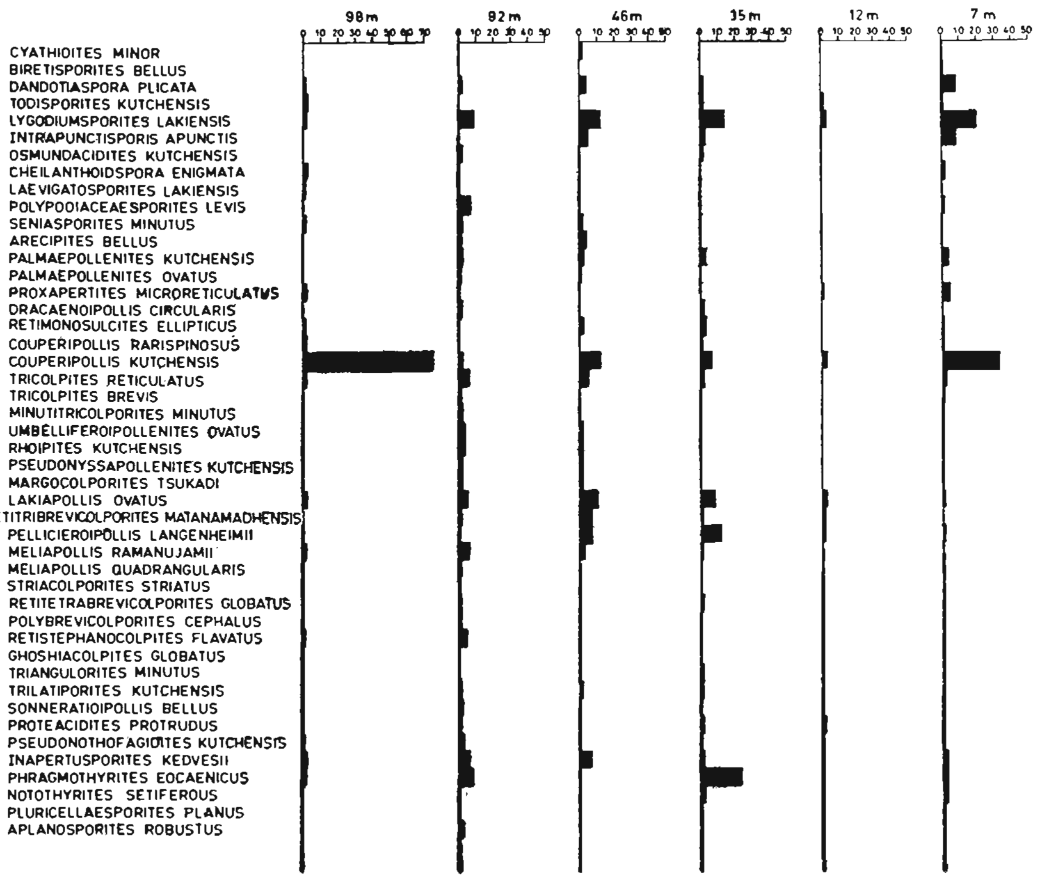
apunctis, *Lakiapollis ovatus* and *Couperipollis kutchensis*.

Palynological succession in bore-core no. 2 near Lakhpat — This bore-core is also more than 100 m thick but only six samples at the depth of 98 m, 92 m, 46 m, 35 m, 12 m and 7 m yielded good amount of palynological fossils. Microplanktons are dominant only at the depth of 12 m and the rest of the samples are rich in spores and pollen grains. This bore-core, however, yielded microfossils at the depth of 98 m which is so far the lowermost depth of the Lower Eocene sediments in Kachchh. *Couperipollis kutchensis* (75%) is most significant species in this level and *Inapertusporites kedvesii* (3%), *Lygodiumsporites lakiensis* (2%), *Cheilanthoidspora enigmata* (2%), *Proxapertites microreticulatus* (2%), *Couperipollis rarispinosus* (2%) and *Tricolpites reticulatus* (2%) are also frequently found.

From 92-35 m not a single species is singularly dominant over the others. However, *Lakiapollis ovatus*, *Couperipollis kutchensis*, *Lygodiumsporites lakiensis*, *Pellicieroipollis langenheimii*, *Meliapollis ramanujamii*, *Phragmothyrites eocaenicus* and *Inapertusporites kedvesii* are found in considerable percentage. At 12 m level, the microplanktons are found in 84% and *Couperipollis kutchensis* (4%), *Lygodiumsporites lakiensis* (3%) and *Lakiapollis ovatus* (3%) are occasionally found. Spores are very common at the depth of 7 m and are mostly represented by *Lygodiumsporites lakiensis* (20%), *Dandotiaspora plicata* (9%), *Intrapunctisporis apunctis* (9%) and *Cheilanthoidspora enigmata* (3%). However, in this assemblage *Couperipollis kutchensis* (32%) is most common and the other angiospermic pollen like *Palmaepollenites kutchensis* (4%), *Proxapertites microreti-*



TEXT-FIG. 10 — Showing the palynological succession in bore-core no. 1, near Lakhpat.

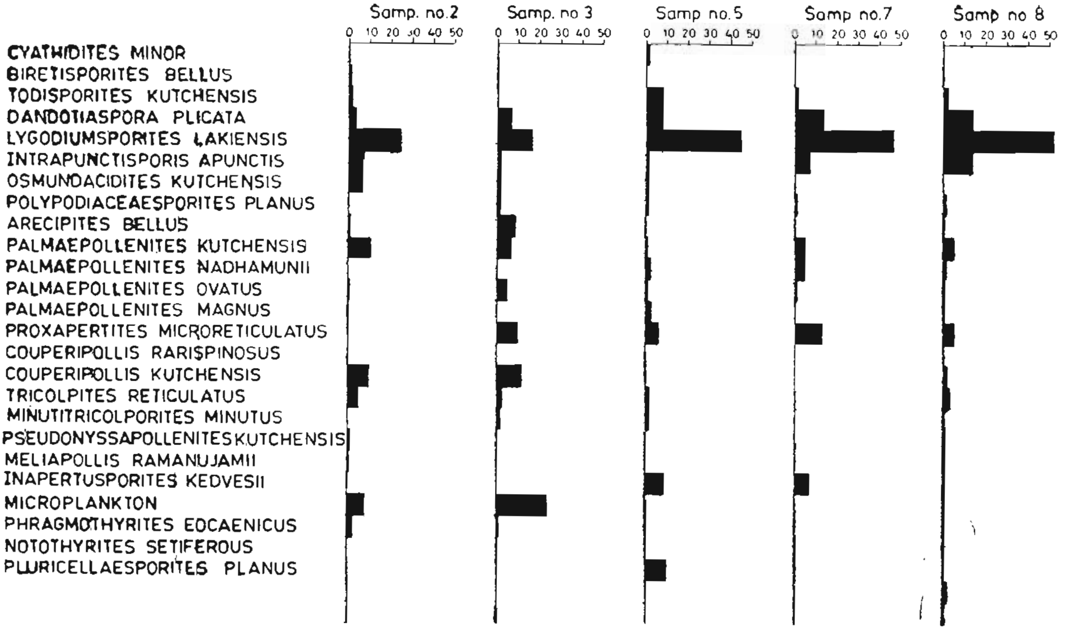


TEXT-FIG. 11 — Showing the palynological succession in bore-core no. 2 near Lakhpat.

culatus (5%) and *Tricolpites reticulatus* (3%) are frequently found (Text-fig. 11).

The palynological assemblage of this bore-core can be conveniently divided into three zones. The lower one comprises the depth of 98 m where the palm pollen *Couperipollis kutchensis* (75%) is very much dominant. The middle palynological zone ranges from 92-12 m and can be delimited by the presence of *Lakiapollis ovatus*, *Couperipollis kutchensis*, *Pellicieroipollis langenheimii*, *Meliapollis ramanujamii* and *Lygodiumsporites lakiensis*. The upper palynological zone is restricted only to the depth of 7 m and the characteristic species of this zone are *Lygodiumsporites lakiensis*, *Dandotiaspora plicata*, *Intrapunctisporis apunctis* and *Couperipollis kutchensis*.

Palynological succession at Akri — The palynological assemblage recovered at Akri is not much diversified and only 25 species are met with amongst the counted specimens. The pteridophytic spores are more common than the angiospermic, algal and fungal ones. In sample nos. 2 and 3, microplanktons are frequently found where *Couperipollis kutchensis* is also found in good percentage. *Proxapertites microreticulatus* is more or less consistently found in all the samples but its percentage does not exceed more than 10%. *Palmaepollenites kutchensis* and *Arecipites bellus* are more common in lower than upper strata. Amongst the pteridophytes, *Lygodiumsporites lakiensis* is most dominant and found 16-52%. The other common species are *Dandotiaspora plicata* and *Intrapunctisporis apunctis*. The fungal elements are generally represented by *Pluricellaesporites planus*



TEXT-FIG. 12 — Showing the percentage of different spore pollen species at Akri.

and is frequently found in sample no. 5 (Text-fig. 12).

Palynological Zonation of Naredi Formation — The Lower Eocene palynological assemblage of Kachchh has been investigated from a number of bore-cores drilled near Lakhpat, Panandhro, Baranda, Matanomadh and Jhulrai areas. Besides, sections exposed near Panandhro, Matanomadh, Naredi, Jhulrai, Akri and Wagapadar have also been considered. The bore-core drilled near Lakhpat show unmistakable marine transgressions while in the bore-cores from Panandhro, Baranda and Jhulrai, marine influence is not apparent. The section exposed near the abandoned Akri Village at the lower level also exhibit some microplanktons while in others except sporadic representation of *Botryococcus* and some other type of algal remains, the processed microplanktons are not observed. Incidentally, *Botryococcus palanaensis* also occurs in typical marine sediments in the bore-cores near Lakhpat. Since *Botryococcus* thrives both in fresh and brackish water so it may be present in both kinds of sediments.

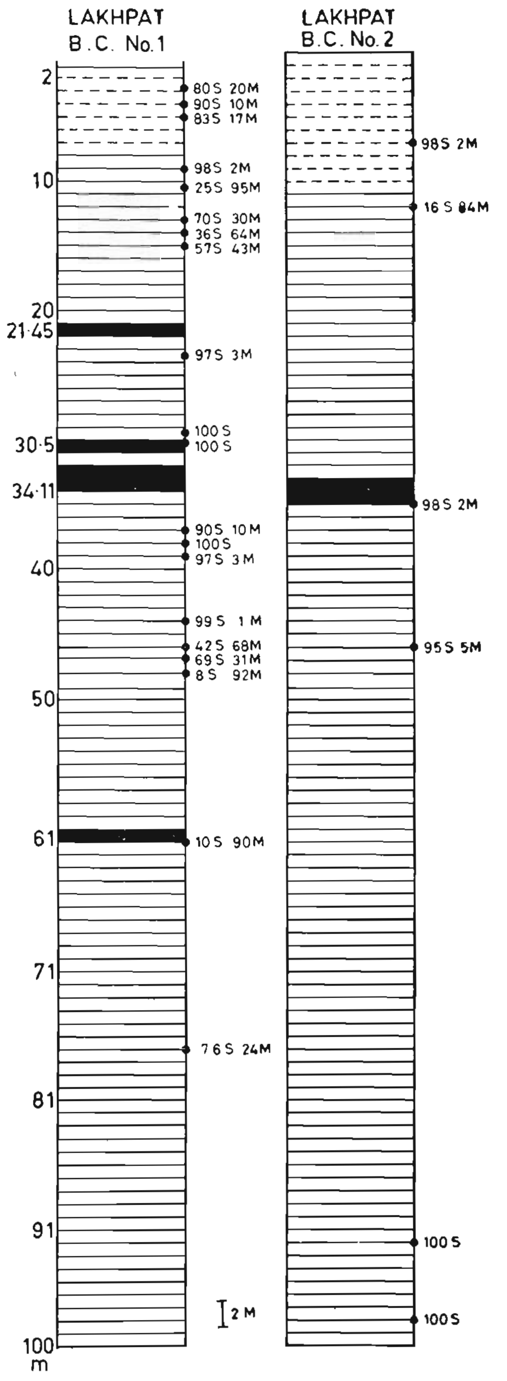
Nagy (1980) while studying the Tertiary sediments of Hungary noted that *Botryococcus braunii* lasted during the whole span of Tertiary. She commented that because of its euryhaline character, the salinity enduring character of the associated aquatic organisms have to be taken into consideration. Nagy (1980) observed that *Botryococcus* occurred in low percentage in the strictly marine environmental condition but it obtained its acme in the fresh water phase forming oil shale in Palaeocene. Regarding correlation of the strata on the basis of palynological data and its relation with distance of the coast line she emphasized that many factors should be taken into consideration.

As the palynological assemblages of Lower Eocene in Kachchh comprise typical marine to fresh water environment it is rather difficult to correlate and interpret them. Koreneva (1980) advocated that in order to interpret correctly the spectra from old marine sediments, it is necessary to compare them with the well studied spectra from the upper layer of the deposits of the present day seas. Koreneva (1957, 1966, 1980), Muller (1959), Vronsky and Panov (1963), Panov *et al.* (1964), Cross *et al.* (1966), Groot and Groot (1966), Traverse and Ginsburg (1965), Malgina and Maev (1966), Malysova and Spiridonov (1968), Abramova (1971) and others worked on the modern sediments of estuaries, gulfs, seas and oceans.

It should be mentioned here that Hoffmeister as early as (1954) claimed that ancient shore lines could be detected on the basis of pollen content per gram of sedimentary rocks and the size of the pollen grains therein. He advocated that 7500 grains in a sample and a ratio of large to small pollen of about 1/4, points out the proximity of a shore line in the ancient basins with regularly decreasing amounts of pollen per gram and ratio of large to small pollen as one goes away from the shore line. However, Groot and Groot (1966) commented that in deep sea sediment the distance between the pollen sources and the site of deposition is generally 100-1000 km; and as a result the transportation history of the pollen grains can become long and complex. They further remarked that the interpretation of a pollen diagram of deep-sea sediments requires some assessment of the impact made by number of factors; configuration of the ocean floor, the atmospheric and oceanic circulation and the geographical distribution of the vegetation.

Cross *et al.* (1966) experienced that the distribution and accumulation of spores and pollen, together with other degraded detritus such as cuticles and tracheids and a wide variety of plankton is remarkably similar to some pattern of sedimentation of terrigenous clastics and biogenous marine sediments. They observed the concentration of cuticles near the estuaries and in general concentration is much higher towards shore. Regarding the concentration of fungi in the sediments they postulated that either they were terrigenous or marine in origin. Observing the striking similarity between the profiles of absolute frequency of dinoflagellates and relative frequency of the fungal spores in certain offshore modern sediments they strongly felt that these could be marine fungi which were in some way associated with dinoflagellates (Text-fig. 13).

To show the behaviour of cuticles, tracheids, algal and fungal elements, spores, pollen grains and microplanktons in the Lower Eocene sediments of Kachchh, bore-cores drilled near Lakhpat were chosen. Both the bore-cores are more than 100 m thick and show distinct marine transgression. The two bore-cores were consolidated and



TEXT-FIG. 13 — Showing the general frequency of spores and microplankton in bore-cores 1 and 2 near Lakhpat.

represented in one and the relative percentage of the above mentioned entities was worked out. At first, the relative frequency of spores-pollen and microplankton was studied. Amongst spores and pollen, fungal bodies and their spores were also included. Up to the depth of 92 m the spores and pollen grains are found in cent per-cent. After this, the percentage of this dwindles down and from the depth of 62-58 m it hardly presents 10 % to the total assemblage. The frequency of microplankton in this level is maximum (90 %). From the pattern f two elements, it can easily be inferred that during this time almost total marine condition prevailed. Gradually, however, the sea receded and the spores and pollen grains are found in overwhelming dominance betwen 44-26 m (90-98 %). The percentage of microplankton gradually again rises and from 15-11 m this group is found in dominance; but the spores are also quite common and as a result a mixed type of assemblage is obtained. Perhaps, during this period, the coast was not very far from the site. After this again the sea retreated and the terrigenous elements became dominant (Text-fig. 14).

The relation of fungal spores, microthyriaceous ascostromata and hyphae in relation to pteridophytic spores, angiospermic pollen and microplanktons was also investigated in these bore-cores. It was found that fungal elements are found in association with spores and pollen grains rather than the microplanktons indicating thereby their terrigenous origin. This is also evidenced by the fact that the epiphyllous fungal genus *Phragmothyrites* generously contributes to this assemblage at certain depths. Fungal elements are, however, found in insignificant percentage at the lower level of the bore-cores (100-77 m) though spores and pollen grains are found in abundance. Fungi are, however, well represented from 47-25 m in association with spores and pollen grains. Approximately, at the depth of 47 m, 35 m, 25 m they are found in more than 40 %, 27 % and 17 % respectively. Their percentage again goes down at the higher level. The presence of fungi in between

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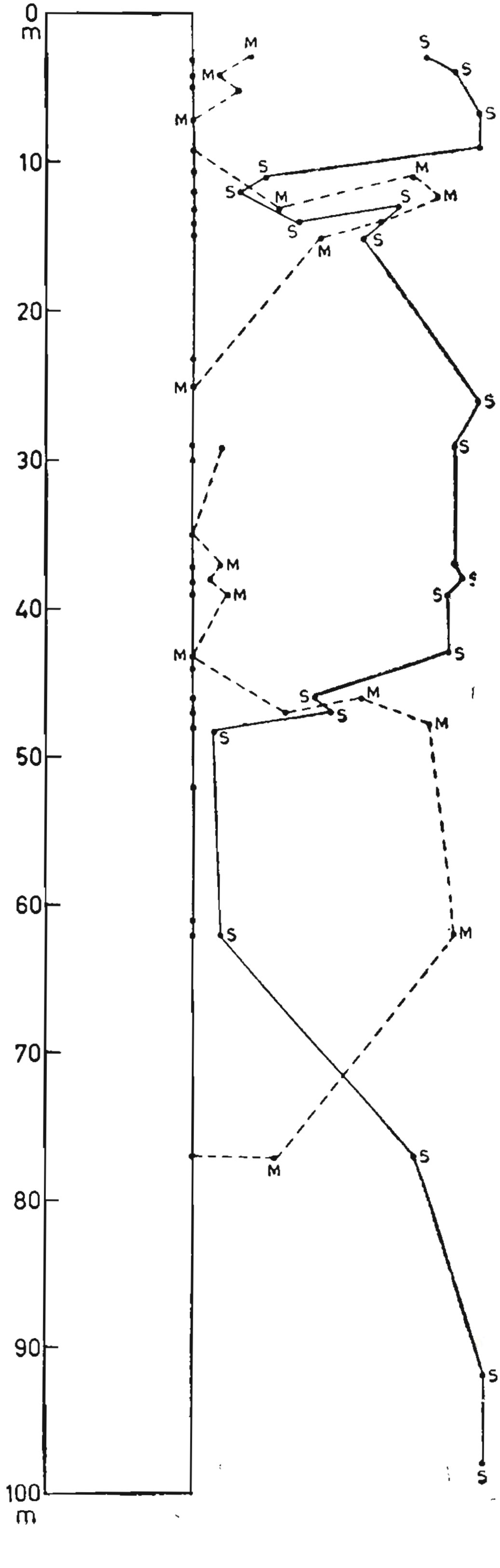
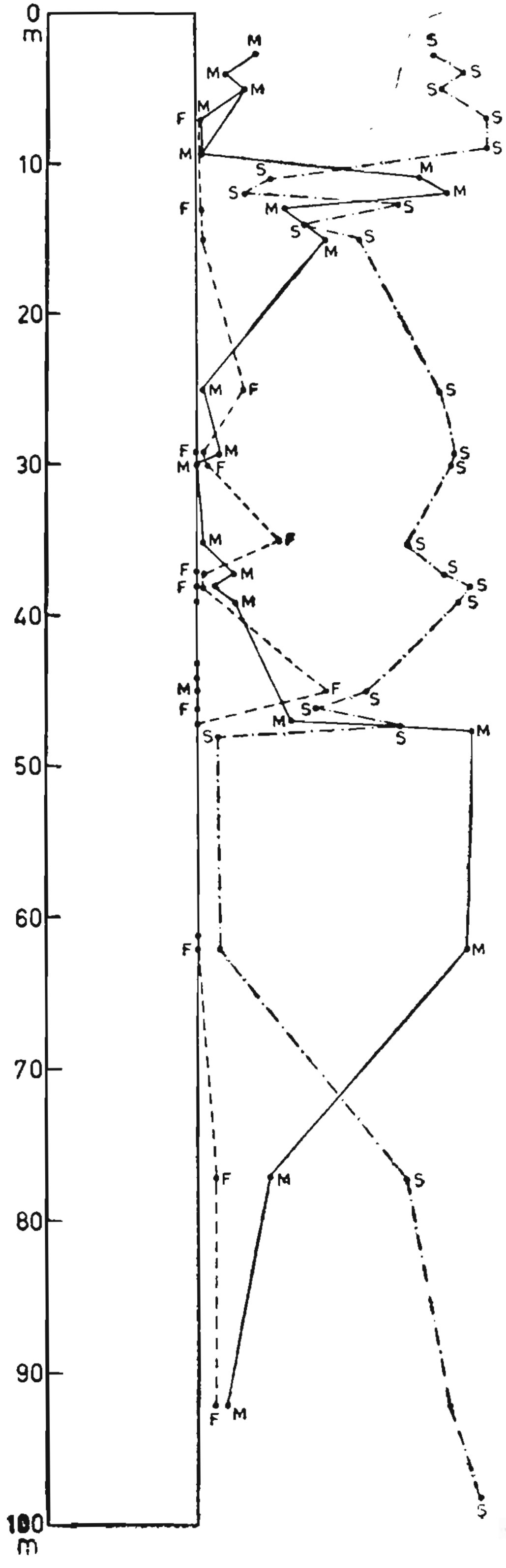


TEXT-FIG. 14 — The histogram showing the behaviour of spores and microplankton in bore-cores 1 and 2 near Lakhpat.



47-25 m in good percentage needs some explanation. In this depth, a few thin lignite seams are also present. This points towards a luxuriant type of vegetation and it seems that fungal elements thrived on them. Absence of any lignite at the lower level and meagre representation of fungi also perhaps corroborate this contention. Moreover, when microplanktons are in abundance, the fungi are hardly encountered in the assemblage indicating thereby that the marine environment was not congenial for their development (Text-fig. 15).

The percentage of cuticles, tracheids in relation to spores, pollen grains and microplanktons was also worked out. It was noted that up to the level of 77 m, cuticles and tracheids completely eclipsed the spores, pollen and microplanktons and the latter elements are hardly met with amongst the counted specimens. Their percentage, however, slightly diminished between 77-46 m and the microplanktons are found in considerable percentage (17-24%). At the upper level again, particularly the cuticles are found in more than 90% and the other elements are rarely found (Text-fig. 16).

The behaviour of cuticles and tracheids in the bore-cores corroborates the observation of Muller (1959), Cross *et al.* (1966), Nagy (1980), Koreneva (1980) and others. In the near shore sediments they are found in abundance while away from the shore in marine environment they are comparatively less represented. In this context, Muller (1959) concluded that the data on the distribution of microfossils originating from the delta such as cuticles, fungi and reworked tracheids, on one hand, and on the distribution of planktonic hystrichosphaerids on the other, add information on the location of estuaries and salinity.

Correlation of different bore-cores and exposures studied here poses a problem as they represent different environment of deposition ranging from marine to fresh water. Some of the spores and pollen grains were transported from long distance either by air or water or by both, others specially the mangrove ones were more or less locally

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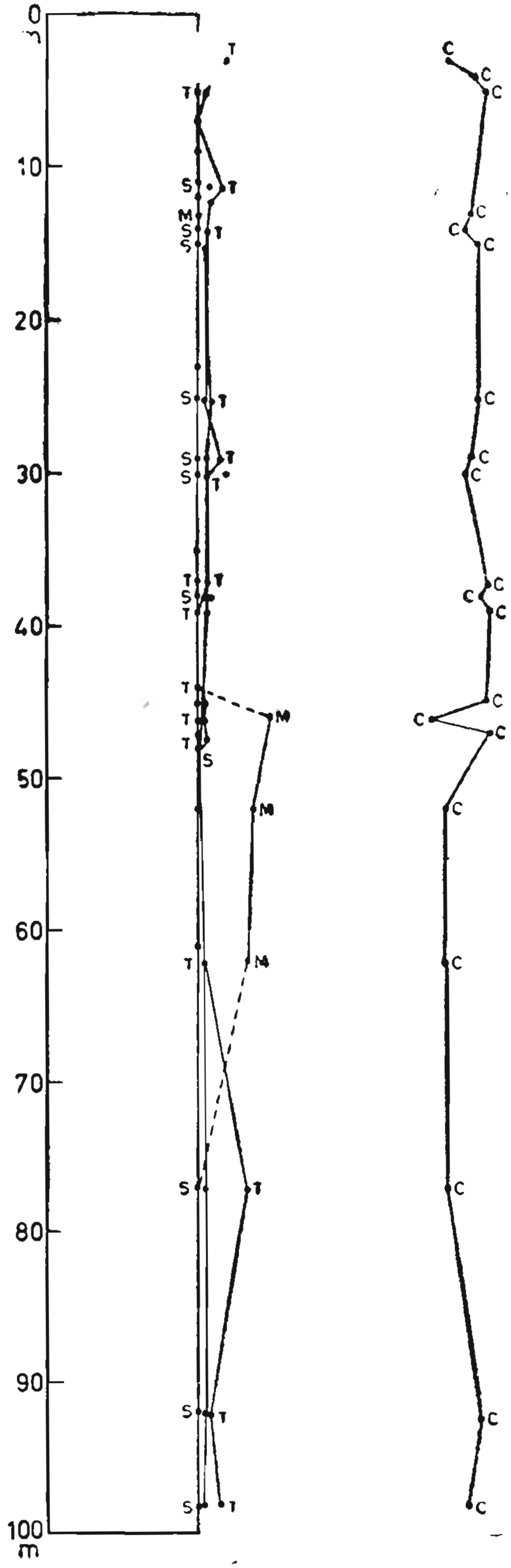
TEXT-FIG. 15 — Showing the behaviour of fungal and pteridophytic spores and microplankton in bore-cores drilled at Lakhpat.



deposited while others could be reworked. Besides, in the back water swamp area there could have been many subprovinces of vegetation which obviously influenced the local deposits. Muller (1959) while working on the recent sediments of Orinoco delta was able to detect many subprovinces there influencing the pollen spectra. In addition, the difference in pollen spectrum between levee and back swamp provinces makes the problem more complicated. But since the sediments were deposited more or less in the same time plane, common elements should be given more preference and the difference in pollen spectra should be explained on the basis of the palaeoecology of the deposits. The presence of microplanktons in some and absence in others should be explained owing to the variability of the facies.

The bore-core no. 1 drilled near Lakhpat has been taken as a standard to correlate other bore-cores and sections for its varied and well representation of algal and fungal elements, spores and pollen grains. In this bore-core, as has already been mentioned, at certain level microplanktons are found in abundance while in others fungal bodies, spores and pollen grains are dominant. In association with the microplanktons, *Lakiapollis ovatus*, *Cheilanthoidspora enigmata* and *Lygodiumsporites kutchensis* are also found in small percentage. *Cheilanthoidspora enigmata* more or less consistently found up to 38 m and then it is hardly witnessed in the counted specimens. In Panandhro lignite field this species is poorly represented in the upper level, in other samples this species is generally not observed. From this, it may be inferred that the pteridophytes producing *Cheilanthoidspora* like spore was restricted to coastal swamp. *Lakiapollis ovatus* and *Lygodiumsporites lakiensis* are important constituents not only of this bore-core but also in other bore-cores and sections studied here.

Pellicieroipollis langenheimii is occasionally found in 24.5 m (8%) and 13 m (10%) in bore-core no. 1, whereas in bore-core no. 2 near Lakhpat it is represented at the level of 46 m (7%) and 35 m (11%). In

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TEXT-FIG. 16 — Showing the behaviour of spores, tracheids and cuticles in bore-cores drilled at Lakhpat.

Panandhro, it is found in the upper level and maximum representation is 5% in sample no. 19. In other samples, it is rarely found. Langenheim, Hackner and Bartleit (1967) while studying the Oligocene-Miocene amber from Mexico recovered pollen grains assignable to *Pelliciera rhizophoreae* of the family Theaceae. Sah and Kar (1970) already mentioned that *Pellicieroipollis langenheimii* somewhat resembles the extant pollen of the above mentioned plant. This is a typical mangrove species and found around the Pacific in the present day. The other mangrove taxa like *Paleosantalaceaepites primitiva*, *P. ellipticus* and *Sonneratioipollis bellus* are not found in appreciable percentage in any of the bore-cores or sections. Muller (1959) observed the abundance of mangrove pollen mostly represented by *Rhizophora* in the bottom sediments offshore from the Orinoco delta but Cross and his associates (1966) noted that though *Rhizophora* is extensively developed along the coasts of the gulf of California, its pollen is not found in any large numbers in the bottom sediments of the gulf. They also remarked that in spite of its low frequency, its distribution closely approximates its range along the coast.

It would be apparent from the above discussion that fossil mangrove pollen are helpful in deciphering environment of deposition but not very useful in long range correlation of varied deposits. In general, as the present investigation reveals the Lower Eocene assemblage in Kachchh can be divided into two broad palynological zones.

The lower one is generally dominated by angiospermic pollen while the upper one exhibits generous representation of the pteridophytic spores. It may be mentioned here that in the upper level of Matanomadh Formation (Palaeocene) the angiospermic pollen are also found in dominance. The assemblage is generally represented by *Couperipollis kutchensis*, *Lakiapollis ovatus*, *Retitribrevicolporites matanomadhensis*, *Meliapollis ramanujamii*, *Tricolpites reticulatus*, *T. baculatus*, *Retistephanocolpites flavatus*, *Palmaepollenites kutchensis*, *Todisporites kutchensis*, etc.

The bore-core no. 2 drilled near Lakhpat at the depth of 98 m yielded an assemblage dominated by *Couperipollis kutchensis* (75%). The other species generally found within the count are: *Lakiapollis ovatus*, *Meliapollis ramanujamii*, *Retistephanocolpites flavatus*, *Tricolpites reticulatus*, *Proxapertites microreticulatus*, *Cheilanthoidspora enigmata*, *Todisporites kutchensis*, *Lygodiumsporites lakiensis*, *Inapertusporites kedvesii*, etc. The assemblage enumerated above is very much similar to the one reported from the upper part of Matanomadh Formation and it seems probable that this part of the bore also belongs to the Matanomadh Formation.

The lower palynological assemblage zone of the Lower Eocene in the present context may be named as *Lakiapollis ovatus* Cenozone as this species is more or less constantly found in good percentage in all the bore cores and sections.

Lakiapollis ovatus Cenozone

Type Section — Bore-core no. 1, drilled near Lakhpat represented in Lakhpat Section bore-core no. 1 of Text-fig. 5, Kachchh, Gujarat.

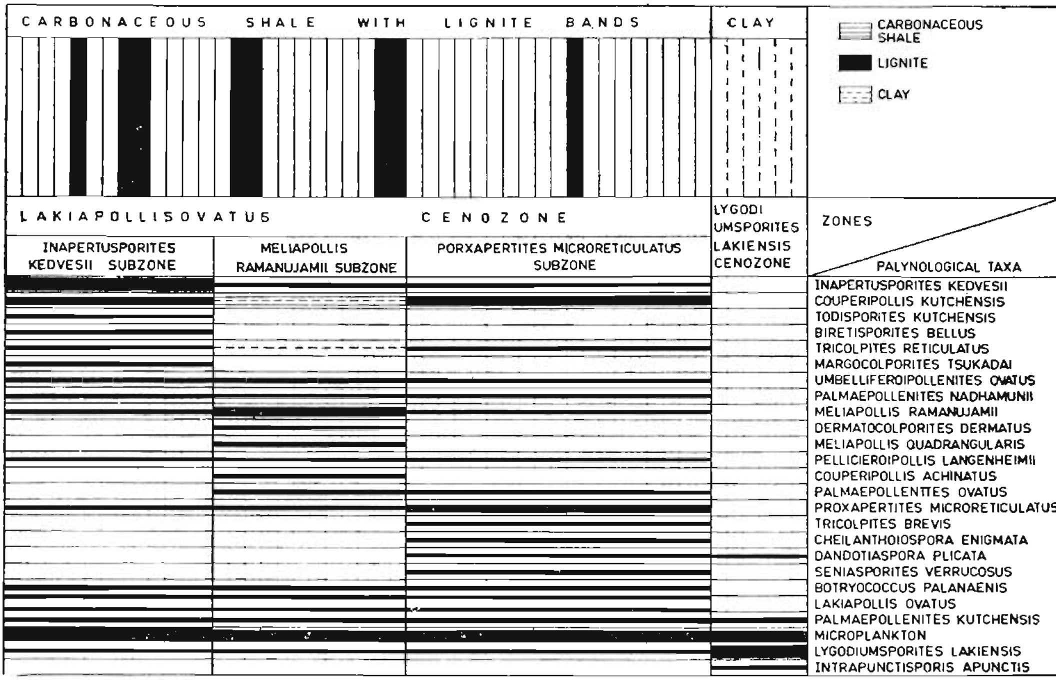
Lithology — This zone is recognized by the presence of carbonaceous shale, clay and occasional presence of lignite. The approximate thickness of this zone in this bore-core is roughly 70 metres.

Lower Contact — The lower contact of this cenozone is also made up of carbonaceous shale and silty clay in the bore-core. In Panandhro, this lies conformably on whitish-light grey and fine-coarse grained sand (Text-fig. 17).

Upper Contact — This is marked by the carbonaceous grey shales, clay and silty clay of the overlying *Lygodiumsporites lakiensis* Cenozone. The contact between the two cenozones is conformable.

Important species of the cenozone — *Couperipollis kutchensis*, *Proxapertites microreticulatus*, *Tricolpites reticulatus*, *Meliapollis ramanujamii*, *Palmaepollenites kutchensis*, *Umbelliferoipollenites ovatus*, *Inapertusporites kedvesii*, *Botryococcus palanaensis*, *Pellicieroipollis langenheimii*, *Lygodiumsporites lakiensis* and algal microplankton.

Remarks — This cenozone covers a varied type of deposits ranging from marine to fresh water. Some of the species present in some sections may not even present in others. The bore-core nos. 1 and 2 exhibit



TEXT-FIG. 17 — Showing the palynological cenozones of the Lower Eocene sediments in Kachchh.

good assemblage of microplanktons in certain depths which are not even recorded in most of the other sections. Similarly, fungal spores and other elements are found in abundance in the lower part of this cenozone, specially in Panandhro lignite field. In bore-core no. 15, at some level *Proxapertites microreticulatus* and *Tricolpites reticulatus* out number others in percentage representation. In Gujra dam section, *Polypodiaceaesporites levis* is well-represented at the lower level. *Lakiapollis ovatus* thus comprises several subzones in different areas. In Panandhro, this cenozone is divided into the following three subzones:

3. *Tricolpites reticulatus* subzone
2. *Meliapollis ramanujamii* subzone
1. *Inapertusporites kedvesii* subzone

Inapertusporites kedvesii subzone

Type Section — Panandhro Section of Text-fig. 5, Panandhro, Kachchh, Gujarat.

Lithology — This zone is characterized by lignite and highly carbonaceous shale. The approximate thickness of this subzone is 15 metres.

Lower Contact — This is the basalmost palynological zone of Panandhro lignite, which rests conformably on whitish-light grey, fine-coarse grained sand.

Upper Contact — The upper contact is marked by clay and carbonaceous shale of the overlying *Meliapollis ramanujamii* subzone. The contact between the two zones is conformable.

Significant species of this subzone — *Biretisporites bellus*, *Lygodiumsporites lakiensis*, *Palmaepollenites kutchensis*, *Couperipollis kutchensis*, *Tricolpites reticulatus*, *Umbelliferoipollenites ovatus*, *Margocolporites tsukadai* and algal phytoplankton.

Species restricted to this subzone — *Inapertusporites kedvesii*, *Monoporisporites stoverii*, algal phytoplanktons, *Tripilaorites triangulus*, *Biretisporites bellus* and *Dictyophyllidites* sp.

Remarks — The subzone is overwhelmingly dominated by *Inapertusporites kedvesii* except in sample no. 2 where the algal phytoplankton takes its place. However, in other samples of this zone the latter is either absent or found in negligible percentage.

Meliapollis ramanujamii subzone

Type Section — Panandhro Section of Text-fig. 5, Panandhro, Kachchh, Gujarat.

Lithology — This zone consists of black to dark greyish brown, friable lignite with minor inter-relation of shale and clay. This is about 20 m thick.

Lower Contact — This zone lies on the shale which is green when dry and dark grey when wet with lenses of clay. The contact is conformable.

Upper Contact — The grey shale of the overlying *Proxapertites microreticulatus* subzone is the upper contact of this zone.

Significant species of this subzone — *Lakiapollis ovatus*, *Dermatobrevicolporites dermatus*, *Meliapollis quadrangularis*, *Pellicieroipollis langenheimii*, *Umbelliferoipollenites ovatus*, *Couperipollis achinatus*, *Proxapertites microreticulatus*, *Palmaepollenites*, *ovatus* and *Palmaepollenites nadhamunii*.

Species restricted to this subzone — *Lakiasporites triangulus*, *Lycopodiumsporites parvireticulatus*, *Schizaeoisporites palanaensis*, *Pseudonyssapollenites kutchensis* and *Symplocoipollenites kutchensis*.

Remarks — Unlike the previous zone, no species is found in very much dominance in this zone. *Melliapollis ramanujamii* after which the zone has been named contributing 26% to the assemblage.

Tricolpites reticulatus subzone

Type Section — Panandhro Section of Text-fig. 5, Panandhro, Kachchh, Gujarat.

Lithology — Grey shale/clay with few lenses of lignite. The approximate thickness is 30 metres.

Lower Contact — The black-dark greyish brown lignite of the *Meliapollis ramanujamii* subzone conformably underlies this zone.

Upper Contact — Yellowish, nummulitic, weathered limestone constitutes the upper contact of this zone.

Significant species to this subzone — *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Lakiapollis ovatus*, *Palmaepollenites nadhamunii*, *Palmaepollenites ovatus*, *Tricolpites brevis*, *Meliapollis ramanujamii*, *Lygodiumsporites lakiensis*, *Cheilanthoidspora enigmata*, *Dandotiaspora plicata*, *Seniasporites verrucosus* and *Botryococcus palanaensis*.

Species restricted to this zone — *Biretisporites convexus*, *Laevigatosporites lakiensis*, *Arecipites bellus*, *Arengapollenites achinatus*, *Liliacidites ellipticus*, *Liliacidites baculatus*, *Striacolporites striatus*, *Triangulorites bellus*, *Diporicellaesporites stacyi* and *Pluricellaesporites planus*.

Remarks — *Proxapertites microreticulatus* is found in abundance in all the samples except in sample no. 40, where *Botryococcus palanaensis* is dominant. This subzone has, however, not been named after it as one cenozone in the Middle Eocene has already been proposed after it.

The upper palynological zone may be named as *Lygodiumsporites lakiensis* Cenozone. This cenozone is, however, not much diversified as the previous one and is best developed at Akri. This cenozone mostly comprises spores and pollen grains and less microplanktons.

Lygodiumsporites lakiensis Cenozone

Type Section — The exposure near the deserted village Akri on the bank of nala, Kachchh, Gujarat.

Lithology — This zone is characterized by the presence of carbonaceous-grey shale, clay and occasional lignite.

Lower Contact — The lower contact at the Akri Section lies unconformably on the trap derivatives and laterites.

Upper Contact — The upper contact lies conformably on the carbonaceous buff coloured shale.

Important species of the cenozone — *Dandotiaspora plicata*, *Intrapunctisporis apunctis*, *Palmaepollenites kutchensis*, *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Lakiapollis ovatus* and *Inapertusporites kedvesii*.

Remarks — This cenozone has a restricted distribution and is found besides Akri in the bore-core no. 1, drilled near Lakhpat in between 9 and 3.3 m, in the bore-core no. 2 of the same locality at the depth of 7 m and in the bore-core no. 13 between 11 and 3 m. It may be mentioned here that only at the exposure near Akri the lower contact of this cenozone is unconformable. In all the other bore-cores, the lower contact is conformable and it rests on the carbonaceous-grey shale, clay of the underlying cenozone, i.e., *Lakiapollis ovatus* Cenozone.

Kar (1978) after studying some of the bore-cores drilled near Baranda and Jhulrai proposed *Triorites* (= *Tripilaorites*) *triangulus* Cenozone for the Naredi Formation (Lower Eocene). The other characteristic species of this cenozone enumerated by him are: *Cupuliferoipollenites ovatus*, *Tricolpites reticulatus*, *Lakiapollis ovatus*, *Cyathidites minor*, *Tricolpites levis*, *T. brevis*, *Rhoipites kutchensis*, *Symplocoipollenites constrictus*, *Meliapollis ramanujamii* and *Pseudonothofagidites kutchensis*. While counting, the fungal spores were excluded and this is the reason for the over representation of the angiospermic taxa. In the present count, algal and fungal bodies in addition to spores and pollen grains have been counted and even then in some samples *Triorites* (= *Tripilaorites*) *triangulus* is well represented. But in Panandhro, bore-cores drilled near Lakhpat, Akri and other places this species is hardly encountered. However, *Lakiapollis ovatus*, *Meliapollis ramanujamii*, *Tricolpites reticulatus*, *Tricolpites levis* and *T. brevis* are found in considerable numbers in most of the sections.

Recently, Saxena (1981) while proposing the palynological cenozones for the Matanomadh Formation (Palaeocene) also mentioned some palynological taxa recovered from the Lower Eocene exposures from Matanomadh.

SPORES AND POLLEN GRAINS FROM RATARIA AND HARUDI

Genus — *Cyathidites* Couper, 1953

Cyathidites australis Couper, 1953

Occurrence — Bore-core no. 27 near Rataria and Harudi.

C. minor Couper, 1953

Occurrence — Harudi.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Biretisporites convexus Sah & Kar, 1969

Occurrence — Bore-core no. 27 near Rataria and Harudi.

Genus — *Todisporites* Couper, 1958

Todisporites kutchensis Sah & Kar, 1969

Occurrence — Bore-core no. 27 near Rataria and Harudi.

Genus — *Intrapunctisporis* Krutzsch, 1959

Intrapunctisporis apunctis Krutzsch, 1959

Occurrence — Bore-core no. 27 near Rataria.

I. harudiensis Kar, 1978

Genus — *Stereisporites* Pflug, 1953

Stereisporites assamensis Dutta & Sah, 1970

Genus — *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, 1956

Lygodiumsporites lakiensis Sah & Kar, 1969

Occurrence — Bore-core no. 27 near Rataria and Harudi.

Genus — *Dandotiaspora* Sah, Kar & Singh, 1971

Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh, 1971

Occurrence — Bore-core no. 27 near Rataria and Harudi.

Genus — *Verrudandotiaspora* gen. nov.

Verrudandotiaspora (*Dandotiaspora*) *verrucata* (Kar & Saxena) comb. nov.

Genus — *Todisporites* Couper, 1958

Todisporites kutchensis Sah & Kar, 1969

Occurrence — Harudi.

Genus — *Osmundacidites* Couper, 1953

Osmundacidites kutchensis Sah & Kar, 1969

Occurrence — Harudi,

cf. *Osmundacidites* sp.

Occurrence — Bore-core no. 27 near Rataria.

Genus — *Lophotriletes* (Naumova) Potonié & Kremp, 1954

Lophotriletes tertiarus Kar & Saxena, 1981

Occurrence — Bore-core no. 27 near Rataria.

Genus — *Scantigranulites* Kar, 1978

Scantigranulites triangulus Kar, 1978

Scantigranulites sparsus Kar, 1978

Genus — *Foveosporites* Balme, 1957

Foveosporites splendus Kar & Saxena, 1981

Occurrence — Bore-core no. 27 near Rataria.

Foveosporites sp.

Occurrence — Bore-core no. 27 near Rataria.

Genus — *Striatriletes* van der Hammen emend. Kar, 1979

Striatriletes susannae van der Hammen, emend. Kar, 1979

S. multicostatus Kar & Saxena, 1981

S. microverrucosus Kar & Saxena, 1981

Striatriletes sp.

Genus — *Cheilanthoidspora* Sah & Kar, 1974

Cheilanthoidspora enigmata Sah & Kar, 1974

C. monoleta Sah & Kar, 1974

Occurrence — Bore-core no. 27 near Rataria.

Genus — *Laevigatosporites* Ibrahim, 1933

Laevigatosporites cognatus Sah & Kar, 1969

Occurrence — Harudi.

L. lakiensis Sah & Kar, 1969

Occurrence — Bore-core no. 27 near Rataria.

Laevigatosporites sp.

Genes — *Biswasiaspora* Kar & Saxena, 1981

Biswasiaspora baculata Kar & Saxena, 1981

B. pseudoreticulata Kar & Saxena, 1981

enus — *Polypodiaceaesporites* Thiergart, 1938

Polypodiaceaesporites strictus Kar & Saxena, 1981

Genus — *Polypodiisporites* Potonié, 1934

Polypodiisporites constrictus Kar, 1979

Polypodiisporites sp.

Occurrence — Bore-core no. 27 near Rataria.

Genus — *Seniasporites verrucosus* Sah & Kar, 1969

Occurrence — Bore-core no. 27 near Rataria end Harudi.

Genus — *Schizaeoisporites* Potonié, 1951

Schizaeoisporites sp.

Genus — *Palmaepollenites* Potonié, 1951

Palmaepollenites kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 near Rataria and Harudi.

P. nadhamunii Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 near Rataria.

P. ovatus Sah & Kar, 1970

Occurrence — Harudi.

P. plicatus Sah & Kar, 1970

Occurrence — Harudi.

Genus — ***Palmidites*** **(Chitaley) ex Couper, 1953**

Palmidites naviculatus Kar & Saxena, 1981

Genus — ***Dracaenoipollis*** **Sah & Kar, 1970**

Dracaenoipollis circularis Sah & Kar, 1970

Occurrence — Harudi.

Genus — ***Arecipites*** **Wodehouse, 1933**

Arecipites bellus Sah & Kar, 1970

Occurrence — Bore-core no. 27 near Rataria and Harudi.

A. intrapunctatus Kar & Saxena, 1981

Arecipites sp.

Genus — ***Longapertites*** **van Hoenken-Klinkenberg, 1964**

Longapertites retipilatus sp. nov.

Genus — ***Couperipollis*** **Venkatachala & Kar, 1969a**

Couperipollis brevispinosus (Biswas) Venkatachala & Kar, 1969a

Occurrence — Harudi.

Couperipollis kutchensis Venkatachala & Kar, 1969a

Occurrence — Harudi.

Genus — ***Spinizonocolpites*** **Muller, 1968**

Spinizonocolpites echinatus Muller, 1968

Genus — ***Psiloschizosporis*** **Jain, 1968**

Psiloschizosporis psilata Kar & Saxena, 1981

P. punctata Kar & Saxena, 1981

Genus — ***Proxapertites*** **van der Hammen, 1956**

Proxapertites microreticulatus Jain, Kar & Sah, 1973

Occurrence — Bore-core no. 27 near Rataria and Harudi.

P. (*Assamialetes*) *reticulatus* (Kar & Saxena) comb. nov.

Occurrence — Bore-core no. 27 at Rataria.

Genus — ***Tricolpites*** **(Erdtman) Potonié, 1960**

Tricolpites reticulatus Cookson, 1947

Occurrence — Bore-core no. 27 at Rataria and Harudi.

T. crassireticulatus Dutta & Sah, 1970

Occurrence — Bore-core no. 27 at Rataria and Harudi.

T. retibaculatus Saxena, 1980

Occurrence — Bore-core no. 27 at Rataria and Harudi.

T. levis Sah & Dutta, 1966

Occurrence — Harudi.

Genus — ***Tricolporopilites*** **gen. nov.**

Tricolporopilites (*Retitrescolpites*) *robustus* (Kar & Saxena) comb. nov.

T. pseudoreticulatus sp. nov.

Genus — ***Tricolporocolumellites*** **gen. nov.**

Tricolporocolumellites pilatus sp. nov.

Genus — *Dermatobrevicolporites* gen. nov.

Dermatobrevicolporites (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

D. (*Myricipites*) *globatus* (Kar & Saxena) comb. nov.

Genus — *Ratariacolporites* gen. nov.

Ratariacolporites plicatus sp. nov.

R. foveolatus sp. nov.

Genus — *Plicatiaperturites* gen. nov.

Plicatiaperturites retipilatus sp. nov.

Plicatiaperturites sp.

Genus — *Echitricolporites* van der Hammen, 1956

Echitricolporites sp.

Genus — *Marginipollis* Clarke & Frederiksen, 1968

Marginipollis kutchensis (Venkatachala & Kar) Kar, 1979

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Trisyncolpites* Kar, 1979

Trisyncolpites sp.

Genus — *Umbelliferoipollenites* Venkatachala & Kar, 1969a

Umbelliferoipollenites ovatus Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Cupuliferoipollenites* Potonié, 1951

Cupuliferoipollenites ovatus Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Paleosantalaceaepites* Biswas, 1962

Paleosantalaceaepites primitva Biswas, 1962

Occurrence — Bore-core no. 27 at Rataria.

P. minutus Sah & Kar, 1970

Occurrence — Harudi.

Genus — *Symplocoipollenites* Potonié, 1957

Symplocoipollenites kutchensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Araliaceoipollenites* Potonié, 1951

Araliaceoipollenites matanamadhensis Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Striacolporites* Sah & Kar, 1970

Striacolporites ovatus Sah & Kar, 1970

Occurrence — Bore-core no. 27 at Rataria and Harudi.

S. cephalus Sah & Kar, 1970

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Pellicieroipollis* Sah & Kar, 1970

Pellicieroipollis langenheimii Sah & Kar, 1970

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Lakiapollis* Venkatachala & Kar, 1969a

Lakiapollis ovatus Venkatachala & Kar, 1969a

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Retitribrevicolporites* gen. nov.

Retibrevicolporites (*Lakiapollis*) *matanamadhensis* (Venkatachala & Kar) comb. nov.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Parumbelliferoipollis* Kar, 1978

Parumbelliferoipollis dulcis Kar, 1979

Genus — *Verrucolporites* Sah & Kar, 1970

Verrucolporites verrucosus Sah & Kar, 1970

Genus — *Retitetrabrevicolportes* gen. nov.

Retitetrabrevicolporites (*Stephanocolpites*) *globatus* (Venkatachala & Kar) comb. nov.

Genus — *Retistephanocolpites* Leidelmeyer emend. Saxena, 1982

Retistephanocolpites (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov.

Genus — *Polybrevicolporites* Venkatachala & Kar, 1969a

Polybrevicolporites (*Stephanocolpites*) *nadhamunii* (Venkatachala & Kar) comb. nov.

Genus — *Diporites* van der Hammen, 1954

Diporites sp.

Genus — *Pseudonothofagidites* Venkatachala & Kar, 1969a

Pseudonothofagidites kutchensis Venkatachala & Kar, 1969a

Occurrence — Harudi.

Genus — *Triangulorites* gen. nov.

cf. *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Varispinitriporites* gen. nov.

Varispinitriporites (*Semitectotriporites*) *ratariensis* (Kar & Saxena) comb. nov.

Genus — *Palaeomalvaceaepollis* gen. nov.

Palaeomalvaceaepollis paucispinosus sp. nov.

P. mammilatus sp. nov.

Genus — *Pilapanporites* gen. nov.

Pilapanporites jspinosus sp. nov.

Genus — *Spinulotetradites* gen. nov.

Spinulotetradites juxtatus sp. nov.

Genus — *Stereisporites* Pflug, 1953

Type Species — *Stereisporites stereoides* (Potonié & Venitz) Pflug, 1953.

Stereisporites assamensis Dutta & Sah, 1970

Pl. 21, fig. 3

Diagnosis (*after Dutta & Sah, 1970*) — Size range 36-48 μm, amb deltoid, trilete distinct, laesurae 18-20 μm in length, lips elevated, exine up to 2 μm thick, ornamentation psilate.

Holotype — Dutta & Sah, 1970, pl. 2, fig. 7.

Type Locality — Umstew, Cherra Sandstone, Lower Eocene, Assam.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Intrapunctisporis* Krutzsch, 1959

Intrapunctisporis harudiensis Kar, 1978

Pl. 39, fig. 2

Diagnosis (*after Kar, 1978*) — Spores triangular, 41-64 μm. Trilete, rays well-developed, extending mostly up to equator. Exine 1-2.5 μm thick, intrapunctate, apices rounded, interapical margin generally convex.

Holotype — Kar, 1978, pl. 1, fig. 3.

Type Locality — Harudi, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — Harudi.

Genus — *Verrudandotiaspora* gen. nov.

Type Species — *Verrudandotiaspora* (*Dandotiaspora*) *verrucata* (Kar & Saxena) comb. nov.

Diagnosis — Spores triangular-subtriangular, trilete. Exine proximally laevigate, distally verrucose-warty.

Description — Fully proximo-distally flattened specimens rare, spores generally folded partially, sometimes proximal part caves in, size range 47-75 × 48-67 μm. Apices rounded, interapical margin mostly convex. Trilete rays distinct, narrow, uniformly broad, sometimes with bifurcating ends, extending more than half radius to margin. Exine on proximal side seems to be thinner than distal one, 1-2.5 μm thick. Verrucae on distal side sparsely placed, one big verrucae/wart situated at each ray end, other verrucae comparatively smaller in size, concentrated more on equator to provide a wavy appearance.

Comparison — *Dandotiaspora* Sah, Kar & Singh (1971) is closely comparable to the present genus in major characters and that is why specimens assignable to *Verrudandotiaspora* were previously described under *Dandotiaspora*. However, the former is distinguished by its presence of verrucae all over the distal surface instead of restriction at each ray end as observed in *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh (1971), The other known species of *Dandotiaspora* are devoid of any sculptural elements.

Verrudandotiaspora (*Dandotiaspora*) *verrucata* (Kar & Saxena) comb. nov.

Pl. 20, figs 1, 2

1978 *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh: Saxena, p. 450, pl. 1, fig. 11.

1981 *Dandotiaspora verrucata* Kar & Saxena, p. 107, pl. 1, figs 7, 8.

Diagnosis — Spores triangular-subtriangular, while proximo-distally flattened, shapes variable due to folding tendency, 55-70 × 50-64 μm. Apices rounded, interapical margin convex, trilete, rays distinct extending up to three-fourths radius. Exine 1-2 μm thick, proximal exine seems to be thinner than distal one, sometimes proximal side caves in, verrucae-warts found only on distal side, one big verrucae found at each ray end, sculptural elements concentrated more on equator to provide an undulated margin.

Holotype — Kar & Saxena, 1981, pl. 1, fig. 7; size 67 × 60 μm; slide no. 6360/11.

Type Locality — Bore-core no. 27, depth 36 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Lophotriletes* (Naumova) Potonié & Kremp, 1954

Type Species — *Lophotriletes gibbosus* (Ibrahim) Potonié & Kremp, 1954.

Lophotriletes tertiarus Kar & Saxena, 1981

Pl. 21, figs 1, 2

1981 *Lophotriletes tertiarus* Kar & Saxena, p. 108, pl. 1, figs 16, 17.

Diagnosis (*after Kar & Saxena, 1981*) — Spores triangular, 25-30 × 20-27 μm, interapical margins concave. Trilete rays distinct, extend up to margin. Exine up to 2 μm thick, conied, coni more or less 1 μm high, closely placed.

Holotype — Kar & Saxena, 1981, pl. 1, fig. 16; size 28 × 22 μm; slide no. 6370/5.

Type Locality — Bore-core no. 27, depth 33 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Foveosporites* Balme, 1957

Type Species — *Foveosporites canalis* Balme, 1957.

Foveosporites splendus Kar & Saxena, 1981

Pl. 20, fig. 3;

Diagnosis (*after Kar & Saxena, 1981*) — Spores triangular-subtriangular, 60-80 × 50-75 μm. Trilete mostly distinct, extending up to three-fourths radius. Exine 1-2 μm thick, foveolate, foveola closely placed.

Holotype — Kar & Saxena, 1981, pl. 1, fig. 12; size 77 × 71 μm; slide no. 6351/7.
Type Locality—Bore-core no. 27 at Rataria, Eocene, Kachchh.
Occurrence — Bore-core no. 27 at Rataria.

Foveosporites sp.

Pl. 22, fig. 3

Description (after Kar & Saxena, 1981) — Spore triangular, 46 × 43 μm. Trilete not traceable, exine about 2 μm thick, foveolate, foveolae closely placed.
Occurrence — Bore-core no. 27 at Rataria.

Genus — *Scantigranulites* Kar, 1978

Type Species — Scantigranulites triangulus Kar, 1978.

Scantigranulites triangulus Kar, 1978

Diagnosis (after Kar, 1978) —Spores mostly subtriangular with bluntly rounded apices and convex interapical margin, 59-74 μm. Trilete distinct, rays extending up to three-fourths radius. Exine 2-3 μm thick, granulose, grana 1 μm high, sparsely placed, uniformly distributed.
Holotype — Kar, 1978, pl. 1, fig. 6.
Type Locality — Harudi, Harudi Formation, Middle Eocene, Kachchh.
Occurrence — Harudi.

Scantigranulites sparsus Kar, 1978

Pl. 39, figs 8-11

Diagnosis (after Kar, 1978) — Spores triangular with straight-convex interapical margin, 35-55 μm. Trilete distinct, rays extending up to three-fourths radius. Exine 1-2.5 μm thick, granulose, grana scantily spread.
Holotype — Kar, 1978, pl. 1, fig. 8.
Type Locality — Harudi, Harudi Formation, Middle Eocene, Kachchh.
Occurrence — Harudi.

Genus — *Striatriletes* van der Hammen emend. Kar, 1979

Type Species — Striatriletes susannae van der Hammen emend. Kar, 1979.
Remarks — *Striatriletes* is one of the most common genera in Oligocene and Miocene sediments of India. Meyer (1958) first reported this type of spore as *Ceratopteris* from the Oligocene of Nahorkatiya, Assam. Biswas (1962) described them as *Parkeriaceaesporites* and noted that this type begins at Barail (Oligocene) and continues up to Surma (Miocene). But since van der Hammen (1956) already validly published *Striatriletes* to accommodate trilete spores with triangular-subcircular shape and costae on both surfaces, *Parkeriaceaesporites* having the same characters should be regarded as junior synonym of *Striatriletes*. Baksi (1962, 1965), Banerjee (1964), Ghosh, Jacob and Lukose (1964), Sah and Dutta (1968), Salujha, Kindra and Rehman (1972, 1975), Nandi (1975) and Kar (1979a, 1979b) reported this type of spores from the various Tertiary sediments of India. The earliest record of *Striatriletes* is from the Kopili Formation (Upper Eocene) of Assam.

Van der Hammen (1954) thought that *Striatriletes* resembles the extant spores of *Anemia* in some features. He, however, also did not rule out its relationship to the spores of Parkeriaceae. It has been observed by Nayar (1967) that in the extant spores of *Anemia* and *Mohria* there are two distinct sets of costae on proximal and distal surfaces. One set of costae does not enter into the other side but is confined within the respective inter-radial area. They may, however, sometimes join with each other to form triangular area. The morphological character of the spores of *Mohria caffrorum* (Linn.) Dev is more or less similar to *Anemia* for they have also distinct sets of costae for proximal and distal sides. In *Mohria*, the costae are generally paired and each pair is separated from the other by a narrow depression simulating a slit-like appearance while the adjacent pairs have larger space.

It has been observed that *Striatriletes* resembles closely the spores of *Ceratopteris* of the family Parkeriaceae. In *C. thalictroides*, like *Striatriletes*, the costae arise on the proximal side at the inter-radial area or at least at ray ends and proceed on the distal side forming more or less successive concentric rings. There are no separate sets of costae for the proximal and distal surfaces like *Anemia* and *Mohria* but the same sets are present on both surfaces of each inter-radial area producing thereby only three sets of costae.

Germeraad, Hopping and Muller (1968) proposed *Magnastriatites* to include fossil spores of Parkeriaceae and restricted *Cicatricosisporites* Potonié & Gelletich (1933) for schizeaceous spores like *Anemia* and *Mohria*. As has already been stated that van der Hammen (1954, 1956, 1957) already validly published *Striatriletes* to accommodate Parkeriaceous spores, so *Magnastriatites* Germeraad, Hopping & Muller (1968) should be regarded as a synonym of *Striatriletes*.

The original description of *Striatriletes* by van der Hammen (1956) does not cover all the characters of the parkeriaceous spores and hence Kar (1979a) has emended that genus as "Spores triangular, trilete distinct-indistinct; costate. Costae 3-7, generally arise at inter-radial area or at ray ends and continue on respective distal side as successive concentric rings, costae sparsely or closely placed, laevigate or ornamented".

Analysing the existing fossil literature, Kar (1983) came to the conclusion that the genus *Ceratopteris* which produces *Striatriletes* like spores originated in India during Middle-Upper Eocene. India, during that time, according to Smith and Briden (1977) and Smith, Hurley and Briden (1981) was in the equatorial zone and enjoying a tropical climate. The western coast of India in this period was not very far from the eastern coast of Africa and was more or less parallel to each other. Kar (1983) postulated that during this time from the western coast of India, *Ceratopteris* migrated towards equatorial Africa and from there to the tropical region of South and North America by crossing the Atlantic Ocean. When north-east India approximated Malayasia during Upper Eocene-Oligocene, *Ceratopteris* invaded that country and tropical Australia and ultimately reached Japan. *Ceratopteris* evolved in India is evidenced by the fact that in other countries like Venezuela, Caribbean, Nigeria and Malayasia, *Striatriletes* started its occurrence only from the Lower Oligocene. The abundance of *Striatriletes* in Oligocene-Miocene times in India, Venezuela, Caribbean, Nigeria and Malayasia led Kar (1983) to propose a pantropical palaeogeographical province after this genus.

At present, *Ceratopteris* in the opinion of Hooker and Baker (1868) is found throughout the tropics in quiet water, Mexico and West Indies southward in Brazil and up to Florida in North America, Punjab and southward in tropical Australia, Madagascar, Angola, west tropical Africa particularly Nigeria and up to Japan in the east.

Striatriletes susannae (van der Hammen) Kar, 1979a

Pl. 20, figs 5, 6

Diagnosis (*after Kar, 1979a*) — Spores anisopolar, triangular-subcircular in polar view with rounded apices and slightly convex interapical margin, 77-113 μm. Trilete rays extending up to two-thirds radius. Exine costate, costae 4-7, a few arising at inter-radial area and rest at ray ends and continue on distal side forming continuous, successive, parallel concentric rings. Costae of each inter-radial area never coalesce with other on proximal as well as on distal side. Costae ribbon-like, sometimes branched, not very closely placed, more or less laevigate.

Holotype — van der Hammen, 1956, pl. 2, fig. 5.

Type Locality — Sample Ha-607 Colombia (Lower-Middle Oligocene).

Occurrence — Bore-core no. 27 at Rataria, Aida, Mepasa and Qairiani.

Striatriletes multicostatus Kar & Saxena, 1981

Pl. 20, figs 7-9

Diagnosis (*after Kar & Saxena, 1981*) — Spores triangular-subtriangular in polar view, 70-80 × 68-78 μm, anisopolar, distal side distinctly convex. Apices bluntly rounded, interapical margins straight to convex. Trilete rays distinct, extending half of radius. Exine costate, costae 6-9, arising at ray ends, extend on distal side, laevigate.

Holotype — Kar & Saxena, 1981, pl. 1, fig. 15; size 78 × 70 μm; slide no. 6358/6.

Type Locality — Bore-core no. 27, depth 35 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria and Aida.

Striatriletes microverrucosus Kar & Saxena, 1981

Pl. 20, figs 10, 11

Diagnosis (after Kar & Saxena, 1981) — Spores triangular, 68-82 × 54-79 μm. Trilete rays distinct-indistinct, extending up to two-thirds radius. Exine costate, microverrucose, 1-2 sets of costae generally present in inter-radial areas, others originate at ray ends extending distally in three concentric rings.

Holotype — Kar & Saxena, 1981, pl. 1, fig. 20; Size 80 × 76 μm; slide no. 6352/11.

Type Locality — Bore-core no. 27, depth 27 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Striatriletes sp.

Pl. 20, fig. 12

Description — Spore triangular, 52 × 50 μm, apices rounded, interapical margins more or less straight. Trilete, rays extend half of radius. Exine 1-5 μm thick, costate, costae narrow, arising at ray ends extend distally in three concentric rings.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Cheilanthoidspora* Sah & Kar, 1974

Type Species — *Cheilanthoidspora enigmata* Sah & Kar, 1974.

Cheilanthoidspora enigmata Sah & Kar, 1974

Pl. 22, fig. 2

Diagnosis (after Sah & Kar, 1974) — Spores subtriangular-subcircular, 42-59 μm. Trilete, rays almost reaching up to margin. Exoexine well-developed, forming broad reticulation on both sides.

Holotype — Sah & Kar, 1974, pl. 1, fig. 7.

Type Locality — Palana lignite field, Palana, Lower Eocene, Rajasthan.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Biswasiaspora* Kar & Saxena, 1981

Biswasiaspora baculata Kar & Saxena, 1981

Pl. 21, figs 14-16

Diagnosis (after Kar & Saxena, 1981) — Spores oval, 60-84 × 52-60 μm. Haptotypic mark not discernible but spores generally split open along a longitudinal axis to look like a colpus. Exine up to 2 μm thick, baculate, bacula 6-10 μm long and 3-7 μm broad, closely placed. Incipient inner body may be present in some spores.

Holotype — Kar & Saxena, 1981, pl. 2, fig. 27; size 78 × 64 μm; silde no. 6363/12.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Biswasiaspora pseudoreticulata Kar & Saxena, 1981

Pl. 21, figs 17, 18

Diagnosis (after Kar & Saxena, 1981) — Spores oval, 60-72 × 52-60 μm. Distinct monolete absent, spores sometimes split longitudinally. Exine up to 2 μm thick, baculate, bacula 2-4 μm high, closely placed, providing pseudoreticulate appearance in surface view, exine sometimes wrinkled.

Holotype — Kar & Saxena, 1981, pl. 2, fig. 28; size 77 × 60 μm; slide no. 6363/12.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Polypodiaceaesporites* Thiergart, 1938

Type Species — *Polypodiaceaesporites haardti* Thiergart, 1938.

Polypodiaceaesporites strictus Kar & Saxena, 1981

Pl. 20, fig. 4

Diagnosis (after Kar & Saxena, 1981) — Spores oval, 55-70 × 40-51 μm. Monolete distinct-indistinct, extending up to three-fourths radius. Exine 1-2 μm thick, laevigate and intrastructured, seems to be intrabaculate.

Holotype — Kar & Saxena, 1981, pl. 2, fig. 30; size 70×44 μm; slide no. 6366/14.
Type Species — Bore-core no. 27, depth 34 m, Rataria, Eocene, Kachchh.
Occurrence — Bore-core no. 27 at Rataria.

Genus — *Polypodiisporites* Potonié, 1934

Polypodiisporites constrictus Kar, 1979

Pl. 39, fig. 13

Diagnosis (*after Kar, 1979a*) — Spores bean-shaped, 33-58 μm, monolete extending up to three-fourths along longitudinal axis. Exine closely verrucose, verrucae 2-4 μm long, sometimes coalesce together.
Holotype — Kar, 1979, pl. 2, fig. 20; size 48 μm; slide no. 5087/4.
Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.
Occurrence — Harudi.

Polypodiisporites sp.

Pl. 22, fig. 6

Description (*after Kar & Saxena, 1981*) — Spore bean-shaped, 59×38 μm, ends unequally broad. Monolete distinct, extending up to three-fourths along longitudinal axis. Verrucae 2-4 μm high, closely placed, give false reticulate appearance in surface view.
Occurrence — Bore-core no. 27 at Rataria.

Genus — *Schizaeoisporites* Potonié, 1951

Type Species — *Schizaeoisporites phaseolus* Delcourt & Sprumont, 1955.

Schizaeoisporites sp.

Pl. 39, fig. 14

Description (*after Kar, 1978*) — Spore elliptical, 65×40 μm. Monolete distinct, straight, extending up to three-fourths radius. Costae prominent, parallel to each other, intercostate exine laevigate.
Occurrence — Harudi.

Genus — *Podocarpidites* (Cookson) Potonié, 1958

Type Species — *Podocarpidites ellipticus* Cookson, 1947.

Podocarpidites khasiensis Dutta & Sah, 1970

Pl. 24, fig. 4

Diagnosis (*after Dutta & Sah, 1970*) — Overall size range 60×80-90×125 μm including sacci; body outline appears to be oval to circular, median longitudinal furrow indistinct, about 39-44 μm in diameter, body wall fairly thick, sacci diploxylonoid, reniform, attached on the distal side of the body, sculptural elements of both body and sacci composed of fine reticulum, muri thin and irregular, lumina generally small near the body attachment, gradually becoming larger towards the periphery, surface of the body cap appears to be minutely reticulate.
Holotype — Dutta & Sah, 1970, pl. 4, fig. 1.
Type Locality — Laitryngew, Theriaghat Formation, Lower Eocene, Assam.
Occurrence — Bore-core no. 27 at Rataria.

Genus — *Palmidites* (Chitaley) ex Couper, 1953

Type Species — *Palmidites maximus* Couper, 1953.

Palmidites naviculus Kar & Saxena, 1981

Pl. 22, figs 14, 15

Diagnosis (*after Kar & Saxena, 1981*) — Pollen grains monocolpate, one end broader than other, 80-110×40-56 μm; colpus well developed, extends from end to end, broader at one side. Exine 1-2 μm thick, laevigate.
Holotype — Kar & Saxena, 1981, pl. 2, fig. 38; size 110×56 μm; slide no. 6358/11.
Type Locality — Bore-core no. 27, depth 35 m, Rataria, Eocene, Kachchh.

Genus — *Arecipites* Wodehouse, 1933

Type Species— *Arecipites punctatus* Wodehouse, 1933.

Arecipites intrapunctatus Kar & Saxena, 1981

Pl. 22, fig. 7

Diagnosis (*after Kar & Saxena, 1981*) — Pollen grains oval, 62-75×40-51 μm. Monocolpate, colpus end to end, distinct-indistinct. Exine 1-2 μm thick, intrapunctate.

Holotype — Kar & Saxena, 1981, pl. 3, fig. 41; size 70×47 μm; slide no. 6369/1.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Arecipites sp.

Pl. 24, fig. 5

Description (*after Kar & Saxena, 1981*) — Pollen grain monocolpate, 97×60 μm, colpus distinct, extends one end to other. Exine about 2 μm thick, closely punctate.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Longapertites* van Hoeken-Klinkenberg, 1964

Type Species — *Longapertites marginatus* van Hoeken-Klinkenberg, 1964.

Longapertites retipilatus sp. nov.

Pl. 22, fig. 9

1981 *Proxapertites microreticulatus* Jain, Kar & Sah: Kar & Saxena, pl. 3, fig. 50.

Diagnosis — Pollen grains bilaterally symmetrical, anisopolar, distally arched to provide a long colpus, covering more than two-thirds of greater circumference, 48-60×40-53 μm. Exine about 2.5 μm thick, sexine thicker than nexine, retipilate.

Comparison — This species is comparable to *Longapertites marginatus* van Hoeken-Klinkenberg (1964) in general organisation but the latter has coarser reticulate pattern on the proximal side. *L. vaneendenburgi* Germeraad, Hopping & Muller (1968) is bigger in size range (59-83 μm) and the exine is finely perforate.

Holotype — Pl. 22, fig. 9; size 60×44 μm; slide no. 6365/4.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Spinizonocolpites* Muller, 1968

Type Species — *Spinizonocolpites echinatus* Muller, 1968.

Spinizonocolpites echinatus Muller, 1968

Pl. 23, fig. 11

1981 *Couperipollis kutchensis* Venkatachala & Kar: Kar & Saxena, pl. 3, fig. 44; size 60×57 μm; slide no. 6367/8.

Remarks — The specimen was re-examined and it was found to have microreticulate structure besides the typical spines of *Spinizonocolpites*. The specimen is also at the verge of splitting into two slightly unequal halves. All these characters led it to transfer to *Spinizonocolpites echinatus*.

Holotype — Muller, 1968, pl. 3, fig. 3.

Type Locality — Indonesia, Eocene.

Occurrence — Bore-core no. 27 at Rataria.

Spinizonocolpites sp.

Pl. 23, fig. 12

Description — Pollen grains subcircular, 58×54 μm, zonicolpate. Exine about 1.5 μm thick, spinose, 6-10×4-6 μm, spines with broad base, spines slightly constricted in middle and then again broadened and gradually tapered at ends, spines placed 6-10 μm apart, interspinal space microreticulate.

Comparison — The specimen is distinguished from *Spinizonocolpites echinatus* Muller (1968) and *S. baculatus* Muller (1968) by the nature of spines.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Proxapertites* van der Hammen, 1956

Type Species — *Proxapertites operculatus* van der Hammen, 1956.

Proxapertites (*Assamialetes*) *reticulatus* (Kar & Saxena) comb. nov.

Pl. 25, figs 12, 13

1981 *Assamialetes reticulatus* Kar & Saxena, p. 113, pl. 3, fig. 53.

Diagnosis — Pollen grains subcircular-oval, 40-52×36-50 μm, zonisulcate, pollen often split into two slightly unequal halves along aperture. Exine up to 2 μm thick, reticulate, meshes of two types, larger one found in outer and smaller one inside.

Comparison — The present species is distinguished from *Proxapertites operculatus* van der Hammen (1956) and *P. cursus* van Hoeken-Klinkenberg (1966) by its two types of meshes.

Holotype — Kar & Saxena, 1981, pl. 3, fig. 53; size 48×46 μm; slide no. 6364/16.

Type Locality — Bore-core no. 27, depth 35 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Psiloschizosporis* Jain, 1968

Type Species — *Psiloschizosporis cacheutensis* Jain, 1968.

Psiloschizosporis pilata Kar & Saxena, 1981

Pl. 24, figs 6-8

Diagnosis (*after Kar & Saxena, 1981*) — Pollen grains oval, 64-100×40-60 μm. Exine 1-2 μm thick, laevigate. Furrow distinct, pollen grains sometimes divide into two equal parts.

Holotype — Kar & Saxena, 1981, pl. 3, fig. 48; size 104×48 μm; slide no. 6355/2.

Type Locality — Bore-core no. 27, depth 27 m, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Proxapertites* van der Hammen, 1956

Proxapertites microreticulatus Jain, Kar & Sah, 1973

Proxapertites (*Assamialetes*) *reticulatus* (Kar & Saxena) comb. nov.

Pl. 25, figs 12, 13

Diagnosis (*after Kar & Saxena, 1981*) — Pollen grains subcircular, 40-52×36-50 μm, sometimes split equatorially into two halves, reticulate, meshes may be bigger in size in equatorial and smaller in middle region.

Holotype — Kar & Saxena, 1981, pl. 4, fig. 51.

Type Locality — Bore-core no. 27, Rataria, Eocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria and Harudi.

Genus — *Tricolpites* (Erdtman) Potonié, 1960

Type Species — *Tricolpites reticulatus* Cookson, 1947.

Tricolpites crassireticulatus Dutta & Sah, 1970

Diagnosis (*after Dutta & Sah, 1970*) — Size range 25-37 μm, holotype 32 μm, amb roundly triangular to subspheroidal, tricolpate, colpi with bulging mesocolpia, exine rather thick, sexine as thick as nexine, pilate, tegillate, surface sculpture coarsely reticulate, crassimurate.

Holotype — Dutta & Sah, 1970, pl. 6, fig. 9.

Type Locality — Laitryngew, Cherra Sandstone, Lower Eocene, Meghalaya.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Tricolporopilites* gen. nov.

Type Species — *Tricolporopilites* (*Retitrescolpites*) (Kar & Saxena) *robustus* comb. nov.

Diagnosis — Pollen grains triangular-subcircular in polar and subcircular-oval in equatorial views. Tricolporate, colpi short-long, pore well-developed, margin generally thickened. Exine heavily pilate, pila robustly built, interpilar space granulate, sculptural elements furnish negative reticulum in surface view.

Description — Pollen grains generally found in polar view, 56-96×50-85 μm. Colpi in some specimens short whereas in others moderately long. Pore distinct, circular-oval, margin thickened, in others thickening indistinct. Exine 1.5-3.5 μm thick, sexine much thicker than nexine, pilate, pila 4-7 μm long, 2-4.5 μm broad at top, base comparatively slender, interpilar space granulate, in closely placed heavily ornamented specimens sculptural elements provide mud-crack like pattern, in others they form negative reticulum in surface view.

Comparison — *Retitrescolpites* Sah (1967) is closely comparable to *Tricolporopilites* in triangular-subcircular shape and retipilate appearance. *Retitrescolpites* is, however, tricolpate or tricolporoidate and never distinctly colporate. Besides, the type species of *Retitrescolpites*, viz., *R. typicus* Sah (1967) is distinctly retipilate having large meshes. In the present genus, the pila are closely placed but they never anastomose to form reticulum. *Triangulotricolporites* is tricolporate but is triangular in shape with three marked constriction due to colpi and is verrucose. *Verrucolporites* Sah & Kar (1970) is subcircular in shape, tricolporate but is verrucose.

Tricolporopilites (*Retitrescolpites*) *robustus* (Kar & Saxena) comb. nov.

Pl. 23, figs 1-3

1981 *Retitrescolpites robustus* Kar & Saxena, p. 113, pl. 3, figs 59, 60.

Diagnosis — Pollen grains subtriangular in polar and subcircular in equatorial views, 53-70×49-68 μm. Tricolporate, brevicolpate, pore generally distinct, margin thickened. Exine up to 3.5 μm thick, sexine much thicker than nexine, pilate, pila closely placed, broad at top, gradually tapered at base, interspinal space granulose, sculptural elements appear as mud-crack in surface view.

Holotype — Kar & Saxena, 1981, pl. 3, fig. 60; size 62×60 μm; slide no. 6364/17.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Tricolporopilites pseudoreticulauts sp. nov.

Pl. 24, figs 2, 3

Diagnosis — Pollen grains subtriangular in polar and subcircular in equatorial views, 80-96×79-90 μm. Tricolporate, colpi long, pore generally distinct, sometimes not traceable due to ornamentation, margin thickened. Exine 2-3.5 μm thick, sexine much thicker than nexine, pilate, pila 5-8 μm long, 3-6 μm broad, narrower at base, interpilar space granulose, ornamentation closely placed providing negative reticulum in surface view.

Comparison — *Tricolporopilites* (*Retitrescolpites*) *robustus* comb. nov. resembles the species described here in shape and ornamentational pattern but the latter is differentiated by its bigger size range and longer colpi.

Holotype — Pl. 24, fig. 2; size 90×80 μm; slide no. 6359/1.

Type Locality — Bore-core no. 27, depth 36 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Tricolporocolumellites* gen. nov.

Type Species — *Tricolporocolumellites pilatus* sp. nov.

Diagnosis — Pollen grains subcircular-oval. Tricolporate, brevicolpate, pore margin thickened. Exine columellate, pila forming negative reticulum in surface view.

Description — Pollen grains generally subcircular, sometimes oval, 72-89×70-87 μm. Colpi short, elliptical, 10-18×6-14 μm, pore distinct, circular-oval, more or less of same size, margih slightly thickened, in some indistinct. Exine 2-4 μm thick, sexine much thicker than nexine, columellate, pila closely placed, parallel to each other, in rest part it provides negative reticulum.

Comparison — *Retitribrevicolporites* comes closest to the present genus in shape and tribrevicolporate nature. However, the former is distinctly scrobiculate, whereas the latter is columellate and the pila never forms true reticulation. *Lakiapollis* Venkatachala & Kar (1969a) is also subcircular and tricolporate but is laevigate and occasionally weakly intrastructured. *Tricolporocolumellites* is distinguished from all the known tricolporate genera by the combination of various characters, e.g. subcircular-oval shape, brevitricolporate condition and columellate sexine.

Tricolporocolumellites pilatus sp. nov.

Pl. 23, figs 4, 5

1981 *Lakiapollis matanamadhensis* Venkatachala & Kar: Kar & Saxena, p. 106, pl. 4, fig. 68.

Diagnosis — Pollen grains circular-oval, 78-90×76-85 μm. Tricolporate, brevicolpate, colpi oval-elliptical in shape, length almost equal to colpi, colpi and pore placed cross wise, pore margin generally thickened. Exine 2-3.5 μm thick, sexine much thicker than nexine, columellate, pila 4-6 μm long, about 1 μm broad, pila provides negative reticulum in surface view.

Holotype — Pl. 23, fig. 4; size 80×78 μm; slide no. 6359/9.

Type Locality — Bore-core no. 27, depth 36 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Dermatobrevicolporites* gen. nov.

Type Species — *Dermatobrevicolporites* (*Triorites*) *dermatus* (Sah & Kar) comb. nov.

Dermatobrevicolporites dermatus (Sah & Kar) comb. nov.

Pl. 25, fig. 1

Remarks — In some specimens, apertures are less prominent and somewhat depressed and appear as beak.

Dermatobrevicolporites (*Myricipites*) *globatus* (Kar & Saxena) comb. nov.

Pl. 23, fig. 7

1981 *Myricipites globatus* Kar & Saxena, p. 114, pl. 4, figs 71, 72.

Diagnosis — Pollen grains subcircular, 60-89×56-78 μm. Tricolporate, brevicolpate, colpi 8-12 μm long, pore distinct, margin thickened. Exine 1-2 μm thick, sexine thicker than nexine, laevigate-granulose.

Comparison — *Dermatobrevicolporites dermatus* is triangular-subtriangular in shape and thus is easily separated from this species. *D. exaltus* is subcircular in shape but *D. ratariensis* is much bigger in size range.

Holotype — Kar & Saxena, 1981, pl. 4, fig. 72; size 74×68 μm; slide no. 6368/2.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Ratariacolporites* gen. nov.

Type Species — *Ratariacolporites plicatus* sp. nov.

Diagnosis — Pollen grains triangular-subtriangular in polar view. Tribrevicolporate, apertures situated at angles, generally associated with folds, exine ± laevigate to intrastructured.

Description — Pollen grains generally triangular with broad apices and straight to slightly convex interapical margin. Pore distinct, circular, 8-12 μm in diameter, margin dense, thickened. Colpi mostly indistinct, sometimes even not traceable, colpi short. Exine 1-2.5 μm thick, foldings regular in some specimens, folds run from one aperture to other, quite broad in some specimens. Exine generally laevigate sometimes sparsely granulose. Intrastructure weakly developed in most specimens, in others it may be foveolate.

Comparison — *Dermatobrevicolporites* is comparable to *Ratariacolporites* in triangular-subtriangular shape and tribrevicolporate condition; the former is, however, distinguished by its well-developed pore forming notches at margin and thicker exine without any regular fold. *Tribrevicolporites* is subtriangular-subcircular in shape and brevicolporate but without any thickening of the pore margin. *Tribrevicolporites* is also tribrevicolporate and subtriangular in shape; but the margin of pore is not thickened and the exine is finely reticulate to scabrate. *Triangulotricolporites* has long colpi and the exine is variously ornamented with verrucae, pila and bacula.

Derivation of Name — After the village Rataria, where the bore-core was drilled.

Ratariacolporites plicatus sp. nov.

Pl. 25, figs 6, 7

1981 *Myricipites* sp. Kar & Saxena, p. 114, pl. 4, fig. 73.

Diagnosis — Pollen grains triangular-subtriangular in polar view, 50-60×48-58 μm. Tricolporate, brevicolpate, colpi 10-18 μm, colpi generally indistinct, pore circular-oval. Exine 1-2.5 μm thick, more or less laevigate, sometimes weakly granulose, feebly intrastructured. Exine folded regularly in interapertural region, folds originate in one apertural region and end in other, ± run parallel to margin.

Holotype — Kar & Saxena, 1981, pl. 4, fig. 73; size 61×60 μm; slide no. 6368/19.

Type Locality — Bore-core no. 27, depth 34 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Remarks — Kar and Saxena (1981) described this species as *Myricipites* sp. Since *Myricipites* is only triporate so the specimens described under this species have been transferred to *Ratariacolporites*.

Ratariacolporites foveolatus sp. nov.

Pl. 25, fig. 5

Diagnosis — Pollen grains triangular, anguloaperturate, interapertural margin convex, 55-62 × 54-60 μm. Tricolporate, brevicolpate, colpi mostly indistinct. Pores easily recognizable, circular, 8-14 μm in diameter, margin thickened. Exine up to 2.5 μm thick, sexine thicker than nexine, foveolate, generally folded in interapertural region.

Comparison — This species is distinguished from *Ratariacolporites plicatus* by its foveolate ornamentation.

Holotype — Pl. 25, fig. 5; size 59 × 58 μm; slide no. 6359/10.

Type Locality — Bore-core no. 27, depth 36 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Plicatiaperturites* gen. nov.

Type Species — *Plicatiaperturites retipilatus* sp. nov.

Diagnosis — Pollen grains subcircular in polar and oval in equatorial views. Tricolporate, pore distinct, margin thickened, colpi long with thickened margin. Exine 1.5-2.5 μm thick, retipilate-reticulate, ornamentation more in mesocolpial than in apertural region.

Description — Pollen grains found both in polar and equatorial views. In polar view, pollen grains have three slight constriction due to apertures, 20-30 × 18-28 μm in equatorial view, they exhibit equally rounded lateral ends. Pores well-defined, margin considerably thickened in equatorial view, pores appear as lalongate. Colpi conspicuous due to accompanied exinal folds, in equatorial view, colpi appear slit like and heavily guarded by one fold on each side. Exine thicker in mesocolpial region, sexine thicker than nexine, generally retipilate, sometimes pila form true reticulation, sculptural elements more robustly built in mesocolpial region, in apertural region ornamentation weakly built, sparsely placed and much smaller in size.

Comparison — *Drassipollenites* Mathur & Jain (1980) comes close to the present genus in triangular-subtriangular shape, in tricolporate condition and reticulate ornamentation but is distinguished by its very short colpi which has no thickening along the margin. *Hippocrateaceaedites* Ramanujam (1966) has sexinal thickening on either side of the colpus and the pore margin is thickened but the exine is punctitegillate and has bigger size range than the present genus. *Triangulotricolporites* is triangular with marked apertural constriction and the exine is strongly verrucose. *Symplocoipollenites* Potonié (1951) has granulate-rugulate exine and very small colpi. *Plicatiaperturites* instituted here is distinguished from all the tricolporate genera by its subcircular shape, smaller size range, thickening of the colpi around the margin and retipilate-reticulate ornamentation which is more prominent in the mesocolpial region.

Plicatiaperturites retipilatus sp. nov.

Pl. 25, figs 14, 15

1981 *Symplocoipollenites kutchensis* Venkatachala & Kar: Kar & Saxena, pl. 3, fig. 61.

Diagnosis — Pollen grains subcircular in polar and oval in equatorial views, 20-30 × 18-28 μm. Tricolporate, pores distinct, margin thickened, pores lalongate in equatorial view. Colpi distinct, long, bordered by exinal thickening on both sides. Exine up to 2.5 μm thick, sexine thicker than nexine, retipilate-reticulate ornamentation more on mesocolpial than in apertural region.

Holotype — Kar & Saxena, 1981, pl. 3, fig. 61; size 21 × 20 μm; slide no. 6373/4.

Type Locality — Bore-core no. 27, depth 30 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

cf. *Plicatiaperturites* sp.

Pl. 25, fig. 16

Description — Pollen grains subtriangular in polar view, 40 × 36 μm. Tricolpate, colpi with thickening of exine on both sides, pores not discernible. Exine about 2 μm thick, laevigate, weakly intrastructured.

Remarks — The specimen does not exhibit distinct pore and retipilate-reticulate ornamentation, hence it has only been compared with *Plicatiaperturites*.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Echitricolporites* van der Hammen, 1956

Type Species — *Echitricolporites spinosus* van der Hammen, 1956.

Echitricolporites sp.

Pl. 25, fig. 17

Description — Pollen grain originally subcircular, 48 × 40 μm, tricolporate, apertures indistinct due to sculptural elements. Colpi long, narrow, exine about 2 μm thick, sexine thicker than nexine, spinose, spines 6-10 μm long, 2-4 μm broad, 6-9 μm apart, tips not very pointed, interspinal space granulose.

Comparison — *Echitricolporites spinosus* van der Hammen (1956) is tricolporate and spinose but is distinguished from the present species by its strongly built spines with sharply pointed tips.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Trisyncolpites* Kar, 1979

Type Species — *Trisyncolpites ramanujamii* Kar, 1979.

Trisyncolpites sp.

Pl. 25, fig. 18

Description — Pollen grain subcircular, 30 × 28 μm. Trisynmargocolporate, colpi uniformly broad, joined together to provide the appearance of a triradiate ridge. Exine granulose-pilate.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Parumbelliferoipollis* Kar, 1978

Type Species — *Parumbelliferoipollis dulcis* Kar, 1978.

Parumbelliferoipollis dulcis Kar, 1978

Pl. 39, figs 20-24

Diagnosis — Pollen grains only found in equatorial view, elliptical, without any marked constriction in middle region. Tricolpate, colpi long, distinct to indistinct, extending up to three-fourths along longer axis. Exine 2-5 μm thick at polar region, 6-10 μm broad at equator, sexine as thick as nexine at equator, pila closely placed and fused to form rugulate to scrobicular structures.

Holotype — Kar, 1978, pl. 1, fig. 20; size 42 × 23 μm; slide no. 3254/13.

Type Locality — Harudi, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — Harudi.

Genus — *Diporites* van der Hammen, 1954

Type Species — *Diporites grandiporus* van der Hammen, 1954.

Diporites sp.

Pl. 39, fig. 25

Description — Pollen grains elliptical, diporate, 38 × 30 μm. Ora distinct, margin thickened, exine 3 μm thick, scrobiculate.

Occurrence — Harudi.

Genus — *Varispinitriporites* gen. nov.

Type Species — *Varispinitriporites* (*Semitectotriporites*) *katariensis* (Kar & Saxena) comb. nov.

Diagnosis — Pollen grains subcircular-circular. Triporate, pore margin thickened, exine ornamented with two kinds of spines. bigger one sparsely placed, smaller one closely placed.

Description — Pollen grains generally subcircular, minor folds may sometimes alter original shape, 40-67 × 38-65 μm. Pores distinct, circular, 7-14 μm, margin appreciably thickened, distance between pores ± equal. Exine up to 2 μm thick, spinose, bigger spines 3-6 μm long, slightly tapering at ends, 8-12 μm apart, small spines 2-3 μm long, slender, very closely placed.

Comparison — *Semitectotriporites* Guzmán (1967) approximates *Varispinitriporites* in the presence of three pores but is differentiated by the presence of semitectate exine. Besides, the size range in *Semitectotriporites* is also much smaller (22-28 μm) than the present genus and due to incomplete tectum provides foveolate and/or verrucate sculpture. *Annutriporites* Guzmán (1967) is subcircular-circular in shape, triporate with thickened margin but the exine is laevigate-microverrucose. *Foveotriporites* also proposed by Guzmán (1967) is triporate but distinctly foveolate. *Scabratriporites* (van der Hammen) van Hoeken-Klinkenberg (1964) is either scabrate or psilate. *Jussitriporites* Guzmán (1967) is triporate with psilate-microverrucose exine and has very conspicuous pores of *Jussiaea* type. *Varispinitriporites* proposed here is readily separated by all the triporate genera by its two types of spines, the bigger one is sparsely and the smaller one is very closely placed.

Varispiniporites (*Semitectotriporites*) *ratariensis* (Kar & Saxena) comb. nov.

Pl. 25, figs 8-10

1981 *Semitectotriporites ratariensis* Kar & Saxena, p. 114, pl. 4, fig. 75.

Diagnosis — Pollen grains subcircular, 55-62×50-60 μm. Triporate, pore distinct, 8-15 μm, equally spaced, margin thick, spinose, spines of two types, bigger one 3-6 μm long, 2-3 μm broad, tips somewhat pointed, spines placed 8-12 μm apart, smaller spines 2-3 μm long, about 1 μm broad, very closely placed.

Remarks — Kar and Saxena (1981) mentioned the slide no. of the holotype of *Semitectotriporites ratariensis* as 6352/9. The holotype was re-examined and it was found as 6352/8.

Holotype — Kar & Saxena, 1981, pl. 4, fig. 75; size 60×58 μm; slide no. 6352/8.

Type Locality — Bore-core no. 27, depth 27 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus —*Palaeomalvaceaepollis* gen. nov.

Type Species — *Palaeomalvaceaepollis* (*Malvacearumpollis*) *rudis* (Kar) comb. nov.

Diagnosis — Pollen grains subcircular-circular, panporate, pore margin generally thickened. Exine spinose, spines with bulbous base and pointed tip, spines elevated on a wart-like extension to provide mammilate appearance, columellate, interspinal space microreticulate-granulate.

Description — Pollen grains mostly subcircular with some irregular folds, 50-79×48-77 μm. Pores 15-22 in number, a few clearly visible, 12-20 μm apart, circular, 2-4 μm in diameter, pore margin in some specimens thickened, in others thickening not detectable. Spines strongly built, 5-9 μm apart, base columellate, in some specimens pila restricted only at base of spines, in others it covers completely the bulbous base, spines in general with pointed tips, tips may be straight, curved or acuminate, spines 5-9 μm long, base 3-6 μm broad. Spines look like mammilate processes due to elevated position, broad base and abruptly narrowing at tips. Pila well-developed, in some specimens they join together to form microreticulation whereas in others it appears as granulate.

Comparison — *Echiperiporites* van der Hammen & Wijmstra (1964) is periporate but the holotype is much smaller in size (16-24 μm). Besides, the spines are only 1 μm long and so the type species of *Echiperiporites* is very much different from *Palaeomalvaceaepollis*. Germeraad, Hopping and Muller (1968) described *Echiperiporites estelae* which in comparison to the type species of *Echiperiporites* is much bigger in size (55-87 μm) and the species is very much different from the type species both in nature of spines and size and should be transferred to somewhere else. *Malvacearumpollis* Nagy (1962) and *Malvacipollis* Harris (1965) are only 4-5 porate. *Hibisceaepollenites* is panporate with thickened margin but is readily separated by its longer spines without any columellae at base. In *Pilapanporites*, the base of spines is also not columellate. *Palaeomalvaceaepollis* is distinguished from all the above mentioned genera by its shape of the spines which are elevated on a wart-like extension to furnish mammillate appearance.

Palaeomalvaceaepollis paucispinosus sp. nov.

Pl. 23, figs 8, 9

1981 *Malvacearumpollis rudis* Kar: Kar & Saxena, p. 114, pl. 4, fig. 76.

Diagnosis — Pollen grains subcircular, generally irregularly folded, 62-76 × 60-75 μm. Panporate, pores about 20, circular, 3-5 μm in diameter, margin not thickened, situated on both sides, 10-16 μm apart, spines situated on elevated wart-like extension of sexine, 8-15 μm apart, 8-12 μm long, base bulbous, 5-8 μm broad, 4-6 μm long, covered with pila, abruptly tapered to form pointed, acuminate tips. Exine up to 2 μm thick, sexine thicker than nexine columellate, interspinal space ± granulate.

Holotype — Kar & Saxena, 1981, pl. 4, fig. 76; size 70 × 68 μm; slide no. 6351/10.

Type Locality — Bore-core no. 27, depth 27 m, Rataria, Kachchh.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Pilapanporites* gen. nov.

Type Species — *Pilapanporites spinosus* sp. nov.

Diagnosis — Pollen grains subcircular-circular. Panporate, pore margin not thickened. Exine spinose, spines broad at base, tapering at ends, interspinal space densely pilate.

Description — Pollen grains with minor folds only observed, 70-89 × 65-85 μm. Pores distinct, 25-35 in number, uniformly spread on both sides, circular, 4-8 μm in diameter, 8-13 μm apart. Spines sparsely placed, 10-16 μm apart, 10-15 μm long, base 4-7 μm broad, gradually tapered to form pointed ends, generally curved. Pila very well-developed, 3-6 μm long, 1-1.5 μm broad, closely placed as minute roads.

Comparison — *Hibisceaepollenites* resembles *Pilapanporites* in shape, size range and panporate condition; but the pores in the former are with thickened margin and the spines are longer, more strongly built with rather blunt ends. The columellae are also less developed than the present genus. *Echiperiporites* van der Hammen & Wijmstra (1964) is also panporate but the margin of pores is thickened and the spines are only about 1 μm long and the base of the spines is also slightly thickened. The holotype of *Echiperiporites* is also much smaller (16-24 μm) than *Pilapanporites*. *Malvacearumpollis* has not more than 4 pores and the spines are projected from a bulging base. *Malvacipollis* Harris (1965) is also 4-5 porate and the sculptural elements consist of spinules and or spines. *Pilapanporites* proposed here is readily separated from the other panporate genera by its large number of pores without thickened margin, spines with broad base and pointed tips and very well-developed columellate structure.

Remarks — The general organization of *Pilapanporites* comes close to the pollen grains of Malvaceae. It is, however, difficult to say that which particular genus it could have belonged.

Pilapanporites spinosus sp. nov.

Pl. 24, fig. 1

Diagnosis — Pollen grains generally subcircular, 70-87 × 65-83 μm. Panporate, pores 25-35 in number, distributed on both sides, circular-subcircular, 4-8 μm in diameter. Spines strongly built, sparsely placed, 10-15 μm long, broad at base (4-7 μm) and tapered to form sharp ends, sometimes curved. Interspinal space pilate, pila 3-6 μm long, 1-1.5 μm broad, very closely placed.

Holotype — Pl. 24, fig. 1; size 79 × 71 μm; slide no. 6358/12.

Type Locality — Bore-core no. 27, depth 35 m, Rataria, Kachchh.

Genus — *Spinulotetradites* gen. nov.

Type Species — *Spinulotetradites juxtatus* sp. nov.

Spinulotetradites juxtatus sp. nov.

Pl. 25, fig. 2

Remarks — The tetrads studied here are larger in size range (50-62 μm) than the Lower Eocene specimens. Along with spines some coni and bacula are also interspersed.

Occurrence — Bore-core no. 27 at Rataria.

Incertae Sedis

Dicolpate pollen type 1

Pl. 22, fig. 10; Pl. 25, fig. 4

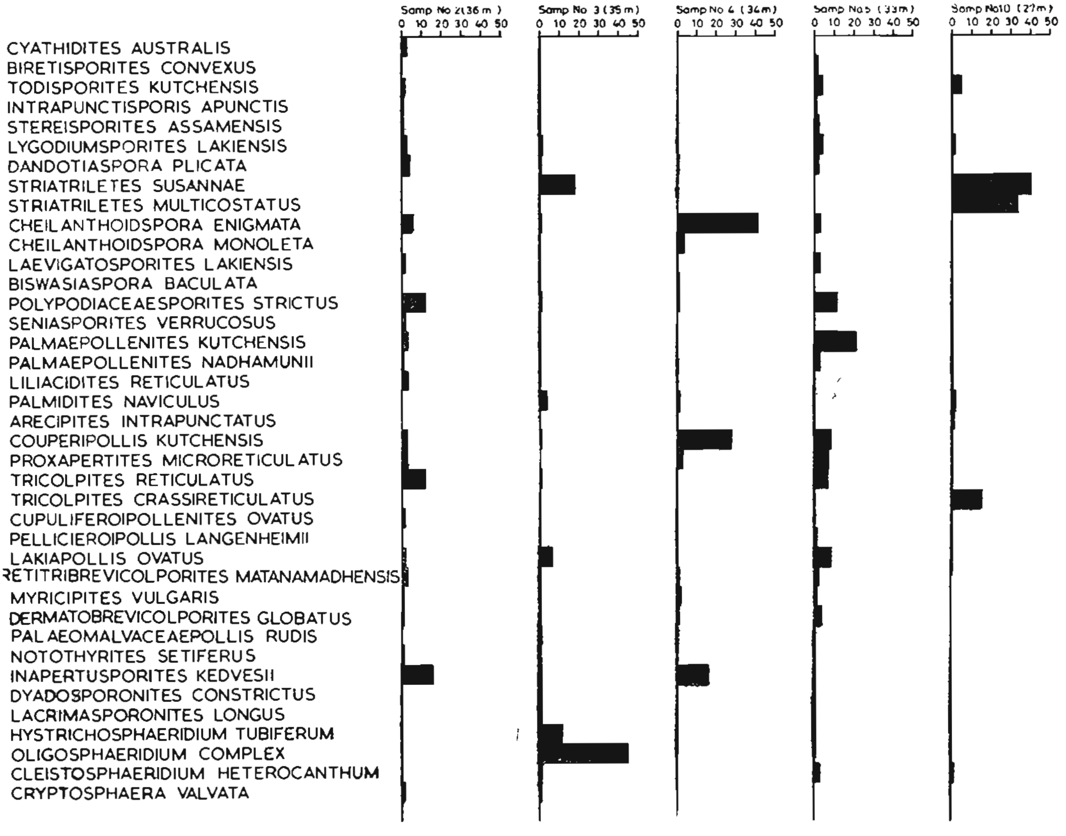
1981 *Liliacidites reticulatus* Sah & Kar: Kar & Saxena, pl. 2, fig. 36.

Description — Pollen grains bisymmetrical, 60-72×40-50 μm, dicolpate, colpi distinct, V-shaped. Exine about 1-5 μm thick, sexine thicker than nexine, retipilate.

Occurrence — Bore-core no. 27 at Rataria.

The palynological assemblage of Middle Eocene- ?Upper Eocene comprises 61 genera and 79 species. Of them, Harudi assemblage provides 27 genera and 35 species. The Rataria assemblage is more diversified as besides spores and pollen it has also a number of microplankton genera. In Harudi Formation, following 15 species are found in the percentage count: *Cyathidites minor*, *Laevigatosporites cognatus*, *Couperipollis brevispinosus*, *Tricolpites levis*, *Palmaepollenites kutchensis*, *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Scantigranulites sparsus*, *Palmaepollenites ovatus*, *Seniasporites verrucosus*, *Polypodiisporites constrictus*, *Scantigranulites triangulus*, *Retitetrabrevicolporites globatus*, *Symplocoipollenites minutus* and *Paleosantalaceaepites minutus*. Amongst them, *Proxapertites microreticulatus* and *Palmaepollenites kutchensis* contribute more than others (Text-fig. 18).

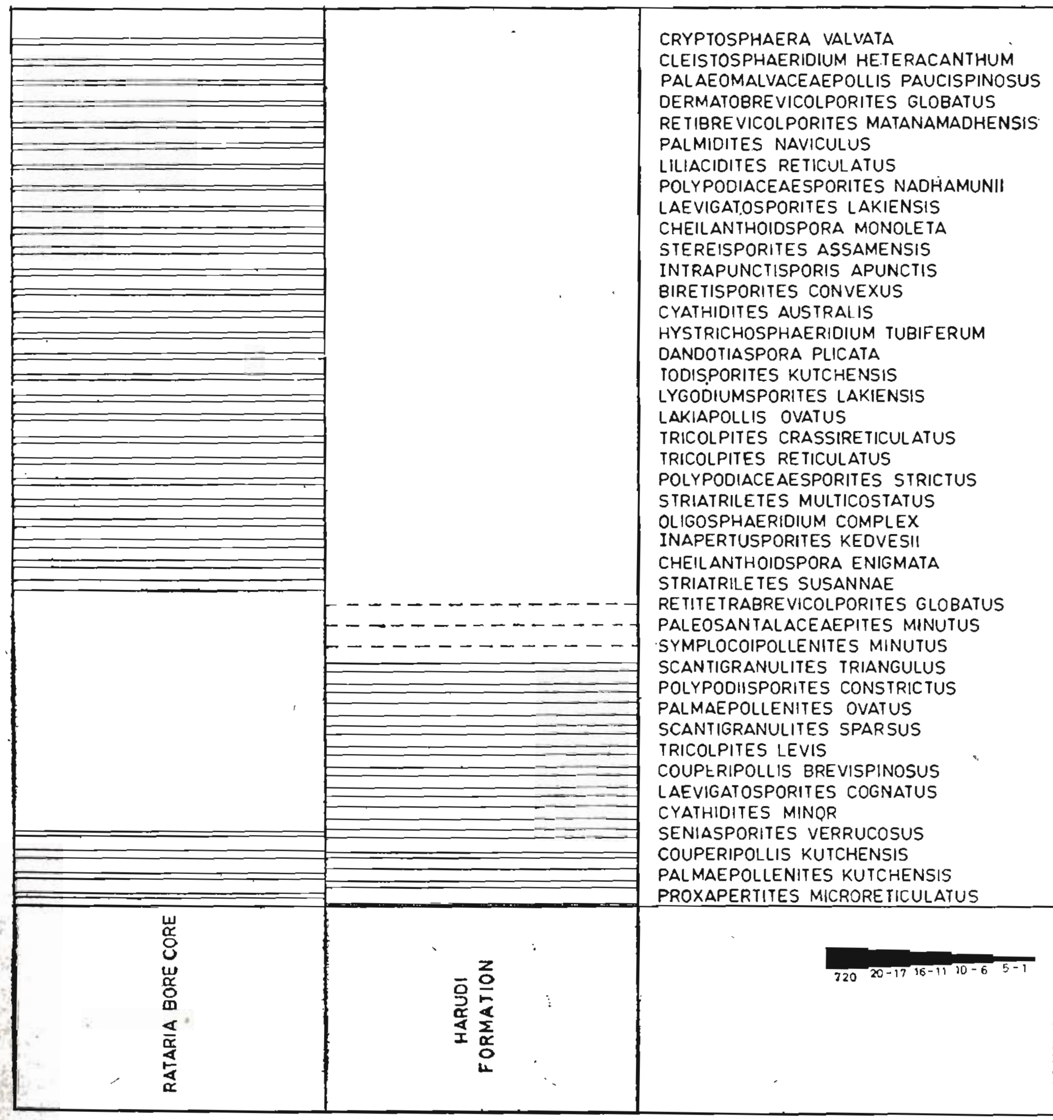
In Rataria bore-core, 31 species more or less consistently found in the percentage count. They are: *Cyathidites australis*, *Biretisporites convexus*, *Todisporites kutchensis*, *Intrapunctisporis apunctis*, *Stereisporites assamensis*, *Lygodiumsporites lakiensis*, *Dandotiaspora plicata*, *Striatriletes susannae*, *S. multicostatus*, *Cheilanthoidspora enigmata*, *C. monoleta*, *Laevigatosporites lakiensis*, *Polypodiaceaesporites strictus*, *Seniasporites verrucosus*, *Palmaepollenites kutchensis*, *P. nadhamunii*, *Liliacidites reticulatus*, *Palmidites naviculus*, *Couperipollis kutchensis*, *Proxapertites microreticulatus*, *Tricolpites reticulatus*, *T. crassireticulatus*, *Lakiapollis*



TEXT-FIG. 18 — Showing the percentage of different spore-pollen species in Rataria bore-core.

ovatus, *Retitribrevicolporites matanomadhensis*, *Dermatobrevicolporites globatus*, *Palaeomalvaceaepollis paucispinosus*, *Inapertisporites kedvesii*, *Hystrichosphaeridium tubiferum*, *Oligosphaeridium complex*, *Cleistosphaeridium heteracanthum* and *Cryptosphaera valvata*. Of them, *Striatriletes susannae*, *Cheilanthoidspora enigmata*, *Couperipollis kutchensis*, *Oligosphaeridium complex*, *Striatriletes multicostatus*, *Inapertisporites kedvesii*, *Polypodiaceaesporites strictus* and *Palmaepollenites kutchensis* contribute more to the assemblage than others. Amongst all these species, only *Proxapertites microreticulatus*, *Couperipollis kutchensis*, *Palmaepollenites kutchensis* and *Seniasporites verrucosus* are found common in both the assemblages.

The Middle Eocene palynological assemblage can be conveniently divided into



TEXT-FIG. 19 — Showing the palynological cenozones of the Middle Eocene sediments in Kachchh.

two palynological cenozones: *Proxapertites microreticulatus* Cenozone for Harudi Formation and *Cheilanthoidspora enigmata* Cenozone for the Rataria bore-core (Text-fig. 19).

Proxapertites microreticulatus Cenozone

Type Section — Exposure about 2 km north-west of the village Harudi.

Lithology — Mostly grey shale with yellow limonitic partings and occasional thin lignitic bands.

Lower Contact — The shales lie unconformably on the laterites.

Upper Contact — This comprises calcareous claystone and siltstone with thin layers of gypsum.

Significant Species of the Cenozone — *Palmaepollenites kutchensis*, *Cyathidites minor*, *Couperipollis kutchensis*, *Scantigranulites sparsus*, *Palmaepollenites ovatus*, *Seniasporites verrucosus*, *Laevigatosporites cognatus* and *Tricolpites levis*.

Remarks — The cenozone is easily differentiated by the well representation of *Proxapertites microreticulatus*, *Palmaepollenites kutchensis*, *Couperipollis kutchensis* and *Scantigranulites sparsus*.

Cheilanthoidspora enigmata Cenozone

Type Section — Bore-core no. 27, depth 34-36 m, Rataria.

Lithology — This zone is characterized by the presence of carbonaceous shale.

Lower Contact — The carbonaceous shale lies conformably on the lithomargic clay.

Upper Contact — This consists of grey shale and siderite.

Significant Species of the Cenozone — *Striatriletes susannae*, *Couperipollis kutchensis*, *Oligosphaeridium complex*, *Inapertusporites kedvesii*, *Striatriletes multicostatus*, *Polypodiaceaesporites strictus*, *Palmaepollenites kutchensis*, *Tricolpites reticulatus*, *Proxapertites microreticulatus* and *Lakiapollis ovatus*.

Remarks — This zone is very well recognized by common occurrence of *Cheilanthoidspora enigmata*, *Striatriletes susannae*, *Couperipollis kutchensis*, *Oligosphaeridium complex* and *Inapertusporites kedvesii*.

FUNGI FROM RATARIA

Genus — *Phragmothyrites* Edwards emend. Kar & Saxena, 1976

Phragmothyrites eocaenicus Edwards emend. Kar & Saxena, 1976

Genus — *Parmathyrites* Jain & Gupta, 1970

Parmathyrites sp.

Genus — *Kutchiathyrites* Kar, 1979a

Kutchiathyrites eccentricus Kar, 1979a

Genus — *Notothyrites* Cookson, 1947

Notothyrites setiferus Cookson, 1947

N. amorphous Kar & Saxena, 1976

Genus — *Inapertusporites* (van der Hammen) Elsik, 1968

Inapertusporites kedvesii Elsik, 1968

Genus — *Dyadosporonites* Elsik, 1968

Dyadosporonites constrictus Kar, 1979a

Genus — *Lacrimasporonites* (Clarke) Elsik, 1968

Lacrimasporonites longus Kar, 1979a

Incertae Sedis

Genus — *Tetraporina* (Naumova) Naumova, 1950

Tetraporina sp.

Genus — *Parmathyrites* Jain & Gupta, 1970

Type Species — *Parmathyrites indicus* Jain & Gupta, 1970.

Parmathyrites sp.

Description (after Kar & Saxena, 1981) — Dimidiate, ascostromata with processes 50 μm, pseudoparenchymatous cells in middle region dark, non-ostiolate. Marginal cells spinose, spines radiating.

Genus — *Tetraporina* (Naumova) Naumova, 1950

Type Species — *Tetraporina antiqua* Naumova, 1950.

Tetraporina sp.

Description — Spore folded, 44 μm. Tetraporate, pore distinct, exine laevigate.

SPORES AND POLLEN GRAINS FROM OLIGOCENE

Genus — *Cyathidites* Couper, 1953

Cyathidites cf. *C. australis* Couper, 1953

Cyathidites cf. *C. minor* Couper, 1953

Genus — *Intrapunctisporis* Krutzsch, 1959

Intrapunctisporis sp.

Genus — *Punctatisporites* (Ibrahim) Potonié & Kremp, 1954

Punctatisporites sarangwaraensis Kar, 1979a

Punctatisporites sp.

Genus—*Dictyophyllidites* (Couper) Dettmann, 1963

Dictyophyllidites (*Toroisporites*) *dulcis* (Kar) comb. nov.

Genus — *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié, 1956

Lygodiumsporites lakiensis Sah & Kar, 1969

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Todisporites* Couper, 1958

Todisporites kutchensis Sah & Kar, 1969

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Biretisporites convexus Sah & Kar, 1969

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Leptolepidites* Couper, 1953

Leptolepidites chandrae Kar, 1979a

Leptolepidites sp.

Genus — *Striatriletes* van der Hammen emend. Kar, 1979a

Striatriletes susannae van der Hammen emend. Kar, 1979a

Pl. 28, figs 15, 16

Occurrence — Barkhana nala cutting near the village Sarangwara; Mepasa gorge section nala cutting on the eastern side of the village Kaiyari.

Striatriletes microverrucosus Kar & Saxena, 1981

Pl. 28, figs 17, 18

Occurrence — Barkhana nala cutting near the village Sarangwara; Mepasa gorge section nala cutting on the eastern side of the village Kaiyari.

Genus — *Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall, 1944

Laevigatosporites lakiensis Sah & Kar, 1969

Occurrence — Barkhana nala cutting near the village Sarangwara; nala cutting on the eastern side of the village Kaiyari.

Genus — *Polypodiaceaesporites* Thiergart, 1940

Polypodiaceaesporites chatterjii Kar, 1979a

Genus — *Polypodiisporites* Potonié, 1934

Polypodiisporites constrictus Kar, 1979a

Occurrence — Barkhana nala cutting near the village Sarangwara Mepasa gorge section.

Genus — *Cheilanthoidspora* Sah & Kar, 1974

Cheilanthoidspora monoleta Sah & Kar, 1974

Occurrence — Barkhana nala cutting near the village Sarangwara; nala cutting on the eastern side of the village Kaiyari.

Genus — *Podocarpidites* (Cookson) Potonié, 1958

Podocarpidites cognatus Kar, 1979a

Genus — *Proxapertites* (van der Hammen) van der Hammen, 1956

Proxapertites scabratus Jain, Kar & Sah, 1973

P. microreticulatus Jain, Kar & Sah, 1973

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Spinizonocolpites* Muller, 1968

Spinizonocolpites echinatus Muller, 1968

Genus — *Tricolpites* (Erdtman) Couper, 1953

Tricolpites sp. 1

Tricolpites sp. 2

Genus — *Retitricolpites* Pierce, 1961

Retitricolpites delicatus Kar, 1979a

Genus — *Trisyncolpites* Kar, 1979a

Trisyncolpites ramanujamii Kar, 1979a

Genus — *Araliaceoipollenites* Potonié, 1951

Araliaceoipollenites sp.

Genus — *Paleosantalaceaepites* Biswas, 1962

Paleosantalaceaepites minutus Sah & Kar, 1970

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Monoporopollenites* (Meyer) Potonié, 1960

Monoporopollenites sp.

Genus — *Triporopollenites* (Pflug) Thomson & Pflug, 1953

Triporopollenites sp.

Genus — *Stephanoporopollenites* Pflug, 1953

Stephanoporopollenites sp.

Genus — *Bombacacidites* Couper, 1960

Bombacacidites triangulatus sp. nov.

Genus — *Compositoipollenites* Potonié, 1951

Compositoipollenites tricolporatus sp. nov.

Genus — *Graminidites* Cookson, 1947

Graminidites granulatus sp. nov.

Genus — *Tristriopollenites* (Pflug) Thomson & Pflug, 1953

Tristriopollenites sp.

Genus — *Verrupolyporites* gen. nov.

Verrupolyporites globosus sp. nov.

Genus — *Polyporina* (Naumova) Potonié, 1960

Polyporina multiporosa sp. nov.

Genus — *Palaeomalvaceaepollis* gen. nov.

Palaeomalvaceaepollis (*Malvacearumpollis*), *rudis* (Kar) comb. nov.

Palaeomalvaceaepollis mammilatus sp. nov.

Genus — *Cyathidites* Couper, 1953

Type Species — *Cyathidites australis* Couper, 1953.

Cyathidites cf. *C. australis* Couper, 1953

Pl. 28, fig. 1

Description — Spores triangular with broadly rounded apices, 47-59 µm. Trilete well-developed, rays extending up to three-fourths radius, exine up to 2.5 µm thick, laevigate, exoexine sometimes present.

Remarks — *Cyathidites australis* Couper (1953) is very common in the Upper Mesozoic strata (Potonié & Gelletich, 1933; Bolkhovitina, 1953; Dettmann, 1963; Venkatachala, 1967, 1969, 1970; Venkatachala & Kar, 1969, 1972 & others). It is, however, uncommon in the Palaeogene sediments. For this reason, though the specimens studied here come closest to *Cyathidites australis*, they have only been compared with this species.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Cyathidites cf. *C. minor* Couper, 1953

Pl. 28, fig. 2

Description — Spores subtriangular, 51-69 µm, apices bluntly rounded. Trilete distinct, rays extending up to two-thirds radius, exine laevigate.

Remarks — *Cyathidites minor* Couper (1953) has smaller size range than the specimens investigated here. Besides, they have also concave-straight interapical margin.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Intrapunctisporis* Krutzsch, 1959

Type Species — *Intrapunctisporis intrapunctis* Krutzsch, 1959.

Intrapunctisporis sp.

Pl. 27, fig. 1

Description — Spore triangular, 70 µm, apices acutely rounded, interapical margin straight. Trilete well-developed, rays extending up to equator. Exine about 1.5 µm thick, laevigate and intrapunctate.

Remarks — The present species is distinguished from *Intrapunctisporis intrapunctis* Krutzsch (1959) by its well-developed trilete rays.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Punctatisporites* (Ibrahim) Potonié & Kremp, 1954

Type Species — *Punctatisporites punctatus* Ibrahim, 1933.

Punctatisporites sarangwaraensis Kar, 1979a

Pl. 28, figs 3, 4

Diagnosis (*after Kar, 1979a*) — Spores circular, 68-93 µm, trilete well-developed, extending up to two-thirds equator. Exine laevigate and closely intrapunctate.

Holotype — Kar, 1979a, pl. 1, fig. 4.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Punctatisporites sp.

Pl. 28, fig. 5

Description (*after Kar, 1979a*) — Subcircular, spore 48 µm. Trilete, rays extending up to two-thirds radius. Exine 1 µm thick, weakly intrapunctate.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Dictyophyllidites* (Couper) Dettmann, 1963

Type Species — *Dictyophyllidites harrisii* Couper, 1958.

Remarks — Krutzsch (1959) instituted *Torosporis* to include triangular-subtriangular, laevigate, trilete spores with thickened tori along the trilete rays. He noted that the spores assignable to *Toroisporis* occur from Upper Triassic to Oligocene. Couper (1958) proposed *Dictyophyllidites* which was later emended by Dettmann (1963) for the triangular, laevigate to faintly patterned trilete spores with thickenings around the laesurate margin. The type species of *Dictyophyllidites*, viz., *D. pectinataeformis* closely resembles *Toroisporis irregularis* (Pflug) Krutzsch (1959, pl. 10, figs 73, 74). If the two genera are merged together then *Dictyophyllidites* should get the priority.

Dictyophyllidites (*Toroisporites*) *dulcis* (Kar) comb. nov.

Pl. 28, figs 7, 8

Diagnosis (*after Kar, 1979a*) — Spores triangular, 53-78 μm. Trilete distinct, extending up to three-fourths radius, bifurcating at tips. Exine thickened around trilete, laevigate.

Holotype — Kar, 1979a, pl. 1, fig. 7.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Leptolepidites* Couper, 1953

Type Species — *Leptolepidites verrucatus* Couper, 1953.

Leptolepidites chandrae Kar, 1979a

Pl. 28, figs 10, 11

Diagnosis (*after Kar, 1979a*) — Spores triangular-subtriangular, 34-56 μm, trilete, rays extending up to three-fourths equator. Exine verrucose, verrucae smaller in contact area but robustly built at margin and on distal side.

Holotype — Kar, 1979a, pl. 1, fig. 10.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Leptolepidites sp.

Pl. 28, figs 12, 13

Description (*after Kar, 1979a*) — Spores triangular, 36 μm, trilete distinct, rays extending up to two-thirds radius. Exine about 2 μm thick, proximally laevigate, distally verrucose, verrucae smaller in size, interspersed with pila and bacula.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Polypodiaceaesporites* Thiergart, 1940

Type Species — *Polypodiaceaesporites haardti* Thiergart, 1940.

Polypodiaceaesporites chatterjii Kar, 1979a

Pl. 28, figs 4, 5

Diagnosis (*after Kar, 1979a*) — Spores bean-shaped, 61-87 μm. Monolete generally ill-developed, extending not more than two-thirds along longer axis. Exine up to 2.5 μm thick, laevigate.

Holotype — Kar, 1979a, pl. 28, fig. 18.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Genus — *Podocarpidites* (Cookson) Potonié, 1958

Type Species — *Podocarpidites ellipticus* Cookson, 1947.

Podocarpidites cognatus Kar, 1979a

Pl. 27, figs 14-16

Diagnosis (*after Kar, 1979a*) — Haploxylonoid, bilateral, disaccate pollen grains 51-84×33-45 μm. Central body distinct, microreticulate. Proximal attachment of sacci to central body equatorial, distal attachment straight, covering major part of central body. Sacci hemispherical, intrareticulate.

Holotype — Kar, 1979a, pl. 28, fig. 24.

Type Locality — Barkhana nala cutting near the village Sarangwara Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Proxapertites* (van der Hammen) van der Hammen, 1956

Proxapertites scabratus Jain, Kar & Sah, 1973

Pl. 27, figs 11, 12

Diagnosis (*after Jain et al.*, *1973*) — Size 60×30 μm, amb oval to elliptical, flattened at poles, dividing subequatorially into two equal boat-shaped halves. Exine 1 μm thick, scabrate.

Holotype — Jain, Kar & Sah, 1973, pl. 1, fig. 18.

Type Locality — Barmer Hill, Barmer, Palaeocene, Rajasthan.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Spinizonocolpites* Muller, 1968

Type Species — *Spinizonocolpites echinatus* Muller, 1968.

Spinizonocolpites echinatus Muller, 1968

Pl. 27, fig. 17

Diagnosis (*after Kar*, *1979a*) — Pollen grains more or less subcircular-broadly oval, 53-75 μm. Sulcus broad, extending from one end to other. Spines with broad base and pointed tip, sparsely placed, exine finely microreticulate.

Holotype — Muller, 1968, pl. 3, fig. 3.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Tricolpites* (Erdtman) Couper, 1953

Lectoholotype — *Tricolpites reticulatus* Cookson, 1947.

Tricolpites sp.

Description (*after Kar*, *1979a*) — Pollen grains subcircular, tricolpate, 60 μm, colpi well-developed, funnel-shaped. Exine thick, baculate, bacula sparsely placed, interbacular exine laevigate.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Tricolpites sp. 2

Description (*after Kar*, *1979a*) — Pollen grain subcircular, tricolpate, 59 μm, colpi wide at equator, constricted at polar region. Exine retibaculate.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Retitricolpites* Pierce, 1961

Type Species — *Retitricolpites vulgaris* Pierce, 1961.

Retitricolpites delicatus Kar, 1979a

Diagnosis (*after Kar*, *1979a*) — Pollen grains mostly found in equatorial view, 18-36×14-30 μm. Tricolpate, colpi narrow, extending almost from one margin to anoother. Exine microreticulate.

Holotype — Kar, 1979a, pl. 2, fig. 31.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Trisyncolpites* Kar, 1979a

Type Species — *Trisyncolpites ramanujamii* Kar, 1979a.

Trisyncolpites ramanujamii Kar, 1979a

Pl. 29, figs 1-3

Diagnosis (*after Kar*, *1979a*) — Pollen grains subcircular in polar and elliptical in equatorial view, 51-87 μm. Trisynmargocolporate, margocolpi broad, thickened, united to provide a pseudotriradiate ridge-like pattern. Exine pilate-baculate, in some specimens retipilate-retibaculate, nexine almost double than sexine, intrapunctate. Pores lolongate.

Remarks — Trisyncolpate pollen grains are found in Acanthaceae, Caryocaraceae, Gentianaceae, Hernandiaceae, Lecythidaceae, Myrtaceae, Sapindaceae, Leguminosae and others. *Trisyncolpites* resembles closely in living pollen grains of *Poinciana pulcherima* of Eucaesalpiniaeae described and photo-illustrated by Tsukada (1963, pl. 10, figs 173-175). *Poinciana pulcherima* also grows in India and Nair and Sharma (1962) have described its pollen grains.

Holotype — Kar, 1979a, pl. 2, fig. 33.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Araliaceoipollenites* Potonié, 1951

Type Species — *Araliaceoipollenites euphorii* (Potonié) Potonié, 1951.

Araliaceoipollenites sp.

Pl. 29, fig. 8

Description (after Kar, 1979a) — Pollen grain oval in equatorial view, 56 μm, seems to be pentacolporate, pore distinct, circular colpi extending three-fourths along longitudinal axis. Exine laevigate.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Monoporopollenites* (Meyer) Potonié, 1960

Type Species — *Monoporopollenites gramineoides* Meyer, 1956.

Monoporopollenites sp.

Pl. 31, fig. 1

Description (after Kar, 1979a) — Pollen grain subcircular, 56 μm. Pore distinct, circular, margin thickened. Exine about 1 μm thick, irregularly folded, granulose.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Triporopollenites* (Pflug) Thomson & Pflug, 1953

Type Species — *Triporopollenites coryloides* Thomson & Pflug, 1953.

Triporopollenites exactus Salujha, Kindra & Rehman, 1972

Pl. 29, fig. 9

Diagnosis (after Salujha et al., 1971) — Golden yellow, roundly triangular-subcircular with usually convex sides, size 14.4-32 μm, sometimes folded, triporate, pores 1.5-3 μm wide, exine more or less 1.2 μm thick, granulate, grana less than 1 μm in diameter, occasionally interspersed with grana, few coni are observed.

Holotype — Salujha, Kindra & Rehman, 1971, pl. 3, fig. 88.

Type Locality — Garo Hills, Meghalaya.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Triporopollenites sp.

Pl. 31, fig. 9

Description (after Kar, 1971a) — Pollen grain subcircular, 56 μm. Triporate, pores distinct. Exine laevigate.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Stephanoporopollenites* Pflug, 1953

Type Species — *Stephanoporopollenites hexaradiatus* (Thiergart) Thomson & Pflug, 1953.

Stephanoporopollenites sp.

Pl. 31, fig. 2

Description (after Kar, 1979a) — Pollen grain subcircular, 56 μm. Tetraporate, pore distinct, elliptical, margin thickened. Exine about 1 μm thick, granulose.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Bombacacidites* Couper, 1960

Type Species — *Bombacacidites bombaxoides* Couper, 1960.

Remarks — Fuchs (1967) studied in detail the pollen of Bombacaceae and grouped them into six pollen types: *Bombax*, *Rhodognaphalon*, *Catostemma attsonii*, *C. praecox*, *Durio* and *Camptostemon* types. Of them

Bombax type is the oldest and recorded by Elsik (1968), Stover and Partridge (1973) and Wolfe (1975, 1976).

Bombacacidites triangulatus sp. nov.

Pl. 30, figs 1, 2

Diagnosis — Pollen grains triangular in polar view, 56-80 × 55-79 μm. Tricolpate, colpi situated midway between sides, margin thickened, brevicolpate, pores not traceable. Exine 1.5-2.5 μm thick, sexine thicker than nexine, reticulate, reticulum broader in middle and shorter at apices.

Comparison — This species resembles *Bombacacidites africanus* Sah (1967) in shape and reticulate pattern but the latter has smaller size range (56-64 μm). Reticulation in *B. clarus* also described by Sah (1967) is very much restricted in middle. *B. annae* (van der Hammen) Germeraad, Hopping & Muller (1968) is subtriangular-subcircular in shape and possesses coarser reticulation.

Holotype — Pl. 30, fig. 1; size 72 × 71 μm; slide no. 8248/4.

Type Locality — Nala cutting on the eastern side of the village Kaiyari, Oligocene, Kachchh.

Occurrence — Nala cutting on the eastern side of the village Kaiyari, Mepasa gorge section.

Genus — *Compositoipollenites* Potonié, 1951

Type Species — *Compositoipollenites rhizophorus* (Potonié) Potonié, 1951.

Compositoipollenites tricolporatus sp. nov.

Pl. 30, figs 3, 4

Diagnosis — Pollen grains more or less subcircular both in polar and equatorial views, 20-28 × 18-26 μm. Tricolporate, colpi pore distinct, lolongate. Exine up to 2 μm thick, spinose, spines robustly built with bulbous base and pointed tip, base of spines pilate, rest part of exine also pilate.

Comparison — *Compositoipollenites argutus* Sah (1967) approximates the present species in size range and nature of the spines but the former has short colpi and the pores are also indistinct. *C. africanus* Sah (1967), *C. spinulosus* Sah (1967), *C. conicus* Sah (1967) and *C. sentis* Sah (1967) are all much bigger in size than the present species.

Holotype — Pl. 30, fig. 3; size 23 × 21 μm; slide no. 8243/10.

Type Locality — Nala cutting on the eastern side of the village Kaiyari, Oligocene, Kachchh.

Occurrence — Nala cutting on the eastern side of the village Kaiyari.

Genus — *Graminidites* Cookson, 1947

Type Species — *Graminidites media* Cookson, 1947.

Graminidites granulatus sp. nov.

Pl. 30, figs 5-7

Diagnosis — Pollen grains originally subcircular but due to irregular foldings may be oval, 55-63 × 53-61 μm. Monoporate, pore subcircular, 5-7 μm in diameter, annulus well-developed. Exine 1-1.5 μm thick, granulose, grana about 5 μm high, closely placed, 2-4 μm apart, evenly distributed.

Comparison — *Graminidites media* Cookson (1947) compares very well with the present species in shape, granulose ornamentation and nature of the pore but is smaller in size (42 μm). *G. anulatus* (van der Hammen) Potonié (1960) is also much smaller in size (32 μm).

Holotype — Pl. 30, fig. 5; size 58 × 57 μm; slide no. 8245/1.

Type Locality — Nala cutting on the eastern side of the village Kaiyari, Oligocene, Kachchh.

Occurrence — Nala cutting on the eastern side of the village Kaiyari.

Genus — *Triatriopollenites* (Pflug) Thomson & Pflug, 1953

Type Species — *Triatriopollenites rurensis* Thomson & Pflug, 1953.

Triatriopollenites sp.

Pl. 30, fig. 8

Description — Pollen grain triangular, 38 × 37 μm, triporate, anguloaperturate, pore distinct, circular, about 1 μm in diameter, exine 2-3 μm thick, sexine as thick as nexine, exine folded along margin, weakly intragranulose.

Comparison — The species is comparable to *Triatriopollenites rurensis* Thomson & Pflug (1953) in shape and pattern of thickening around margin but the latter is smaller in size and exine is less thickened in comparison to the present species.

Occurrence — Nala cutting on the eastern side of the village Kaiyari.

Genus — *Verrupolyporites* gen. nov.

Type Species — *Verrupolyporites globosus* sp. nov.

Diagnosis — Pollen grain subcircular-circular, polyporate, pores generally five, may be 4 or 6. Exine verrucose.

Description — Pollen grains more or less radially symmetrical, 18-42 × 17-41 μm, pores mostly distinct, situated at margin, outline elliptical, sometimes approximate colpi, apertures spaced at equal distance. Exine up to 2 μm thick, sexine as thick as nexine, verrucose, verrucae 1-2 μm high, closely placed, forming negative reticulum in surface view.

Comparison — There are number of polyporate genera which are comparable to *Verrupolyporites*. *Retistephanoporites* Guzmán (1967) has six pores but the exine is reticulate. *Verrustephanoporites* Leidelmeyer (1966) is verrucose but the shape is squarish and tetraporate and the margin of pores seems to be thickened. *Gemmastephanoporites* Guzmán (1967) is tetra-aperturate and possesses gemmae as sculptural elements. *Alexandriapollis* Krutzsch (1966) is finely reticulate and *Australopollis* Krutzsch (1966) is finely punctate. *Verrupolyporites* proposed here is distinguished from all the genera by the combination of characters like: subcircular shape, generally pentaporate, apertures situated at margin and verrucose sculptural elements.

Verrupolyporites globosus sp. nov.

Pl. 30, figs 9-12

Diagnosis — Pollen grains subcircular-circular, more or less radially symmetrical, 22-40 × 21-39 μm, generally pentaporate, may be 4 or 6. Exine 1-2 μm thick, sexine as thick as nexine, verrucose, verrucae 1-2 μm high, closely placed, providing pseudoreticulum in surface view.

Holotype — Pl. 30, fig. 9; size 33 × 31 μm; slide no. 8247/6.

Type Locality — Nala cutting on the eastern side of the village Kaiyari, Oligocene, Kachchh.

Occurrence — Nala cutting on the eastern side of the village Kaiyari.

Genus — *Polyporina* (Naumova) Potonié, 1960

Type Species — *Polyporina multistigmosa* (Potonié) Potonié, 1960.

Polyporina multiporosa sp. nov.

Pl. 30, fig. 13

Diagnosis — Pollen grains subcircular-circular, more or less radially symmetrical, 27-35 × 26-34 μm, polyporate, pores subcircular, 25-35 in number, 2-4 μm in diameter, 6-10 μm apart, evenly distributed. Exine 1-2 μm thick, sexine as thick as nexine, interporal space ± microreticulate.

Comparison — *Polyporina globosa* Sah (1967) compares well with the present species in size range and number of pores but the diameter of the pores are bigger (up to 5 μm) and the approximate distance between them is about 3 μm or less. *P. magna* Sah (1967) is much bigger in size range (68-74 μm) and the margin of pores is appreciably thickened.

Remarks — The genera *Polyporina* (Naumova) Potonié (1960), *Chenopodipollis* Krutzsch (1966) and *Poriporopollenites* Pflug (1952) generally accommodate fossil pollen of Amaranthaceae - Chenopodiaceae. The two families have been clubbed together because in the opinion of Erdtman (1952), Martin (1978) and Riollet and Bonnefille (1976) the pollen of these two families are difficult to differentiate. Potonié (1960) thinks that *Periporopollenites* is a synonym of *Liquidambarpollenites* Raatz (1937). Krutzsch (1966) also opines that the former genus is comparable to the latter. He also professes that *Polyporina multistigmosa*, the type species of *Polyporina*, happens to be a freshwater planktonic organism. If this is so then pollen grains assignable to Amaranthaceae-Chenopodiaceae should not be included in *Polyporina*.

Holotype — Pl. 30, fig. 13; size 32 × 31 μm; slide no. 8248/3.

Type Locality — Nala cutting on the eastern side of the village Kaiyari, Oligocene, Kachchh.

Occurrence — Nala cutting on the eastern side of the village Kaiyari, Mepasa gorge section.

Genus — *Palaeomalvaceaepollis* gen. nov.

Type Species — *Palaeomalvaceaepollis* (*Malvacearumpollis*) *rudis* (Kar) comb. nov.

Palaeomalvaceaepollis (*Malvacearumpollis*) *rudis* (Kar) comb. nov.

Pl. 30, fig. 14

1972 *Polyporites* Chandra & Chatterji, p. 32, pl. 7, fig. 4.

1979 *Malvacearumpollis rudis* Kar, p. 31, pl. 2, figs 46, 47.

Diagnosis — Pollen grains subcircular with undulated margin due to projection of spines, 52-76 × 50-74 μm. Panporate, pore margin thickened, pore circular-oval, 2-3 μm in size, 12-18 μm apart, number of pores 15-25. Exine 1.5-2.5 μm thick, spinose, spines situated on elevated part of sexine, only basal part of spines columellate, rest part solid, spines 6-9 μm long, base bulbous, 4-6 μm broad, 3-5 μm high, breadth of spines suddenly shortened from top of base to form curved, pointed tips. Spines on surface look like mammilate processes. Sexine columellate, interspinal sapce microreticulate-granulate.

Comparison — This species is distinguished from *Palaeomalvaceaepollis paucispinosus* and *P. mammilatus* by its nature of spines. In this species, columellate structure is restricted only to the basal part whereas in other two species the whole bulbous base is covered with pila. The appearance of spines is also more mammilate than others.

Holotype — Kar, 1979, pl. 2, fig. 46; size 57 × 55 μm; slide no. 5049/4.

Type Locality — Barkhana nala cutting near the village Sarangwara, Oligocene, Kachchh.

Occurrence — Barkhana nala cutting near the village Sarangwara, on the eastern side of the village Kaiyari.

PALYNOLOGICAL ZONATIONS

The palynological assemblages recovered from the Barkhana nala cutting near the village Sarangwara; cart-track junction of the villages Goela-Walasar and Fulai-Ramania, Mepasa gorge section, nala cutting on the eastern side of the village Kaiyari, Ber Mota exposures and Maniyara Fort consist of algal and fungal entities, pteridophytic spores, gymnospermic and angiospermic pollen grains. The assemblage consists of 46 genera and 55 species. Of them, 8 genera and 10 species belong to microplankton, 7 genera and 7 species to fungi, 13 genera and 17 species to pteridophytic spores, 1 genus and 1 species to gymnosperms and 17 genera and 20 species to angiosperms.

The samples from the Barkhana nala cutting, near the village Sarangwara, were most productive and most of the spores and pollen grains were recovered from these samples. The Mepasa gorge section and the nala cutting, on the eastern side of the village Kaiyari, also yielded some new types of spores and pollen grains though essentially they are rich in microplanktons. The samples from the cart-track junction of the villages Goela-Walasar and Fulai-Ramania are also rich in algal organisms. The samples from Ber Mota were not rich in microfossils content.

The microfossils recovered from the Barkhana nala cutting, near the village Sarangwara, is dominated by angiospermic pollen (50%) followed by pteridophytic spores (29%). The fungal elements occupy the third place by contributing 15% while microplankton and gymnospermic pollen contribute 4% and 2% respectively. Amongst the angiosperms, *Trisyncolpites* (37%) is most common and *Tricolpites* (9%) comes next. *Paleosantalaceaepites* shares only 2% while *Proxapertites* and *Stephanocolpites* contribute 1% each. *Striatriletes* (13%) is most common amongst pteridophytes and *Laevigatosporites* (3%) and *Polypodiaceaesporites* (3%) possess equal status. Similarly, *Leptolepidites* and *Polypodiisporites* each contribute 2%. Of the fungi, *Inapertusporites* (20%) is of common occurrence. Other genera occasionally found are *Dyadosporonites* (2%), *Lacrimasporonites* (2%) and *Phragmothyrites* (1%). Microplanktons are represented by *Operculodinium* (2%), *Tuberculodinium* (1%) and *Cordosphaeridium* (1%).

The palynological assemblage from Goela-Walasar and Fulai-Ramania cart-track junction is very much dominated by microplanktons (89%). Fungi (11%) come to next and gymnospermic-angiospermic pollen are hardly encountered. *Operculodinium* (72%) is most common amongst microplanktons; *Cleistosphaeridium* (9%), *Tuberculodinium* (5%) and *Cordosphaeridium* (3%) are also frequently encountered. *Inapertusporites* (10%) contributes mainly for fungi while *Phragmothyrites* (1%) is rarely met with.

Algal and fungal elements are most common in Ber Mota and Maniyara fort exposures. *Aplanosporites* (73%) is abundant and poorly followed by *Operculodinium* (17%), *Cleistosphaeridium* (4%), *Tuberculodinium* (1%) and *Cordosphaeridium* (1%) are also generally met with.

On the basis of above mentioned data, the assemblage is divisible into three cenozones as under:

1. *Operculodinium centrocarpum* Cenozone
2. *Trisyncolpites ramanujamii* Cenozone
3. *Aplanosporites robustus* Cenozone

Operculodinium centrocarpum Cenozone

Type Section — Near the cart-track junction of Ramania-Fulai and Goela-Walasar villages.

Lithology — This zone is characterized by limestone with thin shale partings.

Lower Contact — This zone lies conformably on a thin shale band full of invertebrate animal fossils.

Upper Contact — This is also a thin shale band within the limestone (Text-fig. 20).

Significant Species of Cenozone — *Operculodinium* sp., *Cleistosphaeridium heterocanthum, Tuberculodinium vancampoae, Cordosphaeridium* sp., *Inapertusporites kedvesii* and *Phragmothyrites eocaenicus.*

Remarks — This species is easily demarcated by its abundance of *Operculodinium centrocarpum.*

Trisyncolpites ramanujamii Cenozone

Type Section — The Barkhana nala cutting near the village Sarangwara.

Lithology — The lower and upper parts of this zone comprise shale with intercalation of sandstone.

Lower Contact — The carbonaceous shale at the base is the lower part of this cenozone.

Upper Contact — The sandy shale below the sandstone constitutes the upper contact.

Significant Species of Cenozone — *Leptolepidites chandrae, Striatriletes susannae, Laevigatosporites lakiensis, Polypodiaceaesporites chatterjii, Polypodiisporites constrictus, Podocarpidites cognatus, Proxapertites scabratus, Paleosantalaceaepites ellipticus, Dyadosporonites constrictus* and *Lacrimasporonites longus.*

Remarks — *Trisyncolpites ramanujamii* is the most common species and indicator of this cenozone. *Striatriletes susannae* is also frequently met with.

Aplanosporites robustus Cenozone

Type Section — The nala cutting near the village Ber Mota and Maniyara Fort.

Lithology — The shale bands between the limestones.

Lower Contact — The lower shale band forms the basal unit of this cenozone.

Upper Contact — The upper shale band is the topmost unit.

Significant Species of Cenozone — *Operculodinium centrocarpum, Operculodinium* sp., *Cleistosphaeridium heterocanthum, Cordosphaeridium* sp., *Inapertusporites kedvesii* and *Phragmothyrites eocaenicus.*

Remarks — The very high frequency of *Aplanosporites robustus* is sufficient to identify this cenozone.

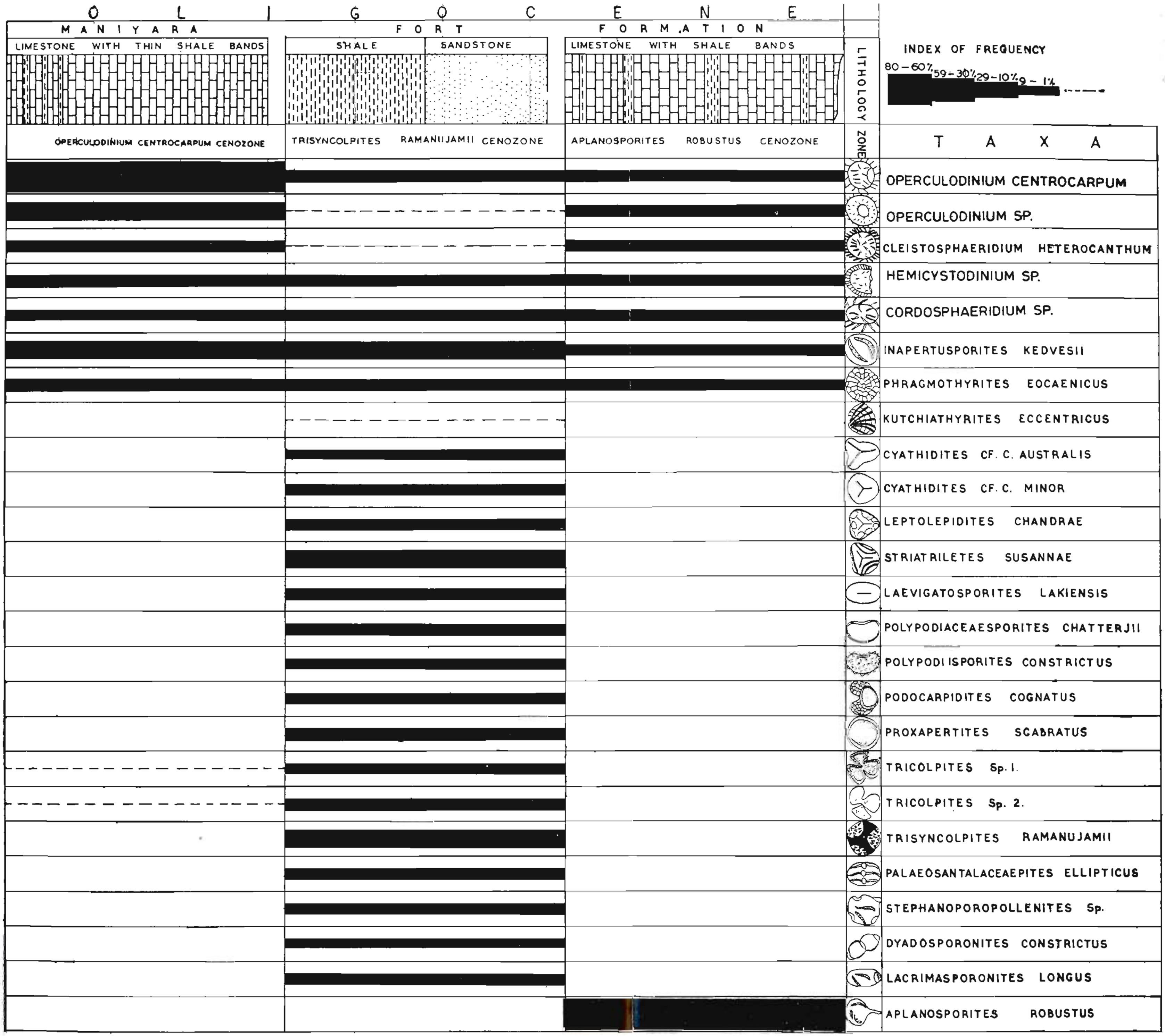
Spores and Pollen from Khari Nadi Formation (Miocene)

Genus — *Azolla*

Azolla aglochidia sp. nov.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Biretisporites convexus Sah & Kar, 1969



TEXT-FIG. 20 — Showing the palynological cenozones of the Oligocene sediments in Kachchh.

Genus — *Dictyophyllidites* (Couper) Dettmann, 1963

Dictyophyllidites laevigatus sp. nov.

Genus — *Striatriletes* van der Hammen emend. Kar, 1979

Striatriletes susannae van der Hammen emend. Kar, 1979

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

S. multicostatus Kar & Saxena, 1981

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

S. microverrucosus Kar & Saxena, 1981

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

S. aidaensis sp. nov.

S. paucicostatus sp. nov.

Genus — *Khariasporites* gen. nov.

Khariasporites densus sp. nov.

K. granulatus sp. nov.

Genus — *Lycopodiumsporites* Thiergart, 1938

Lycopodiumsporites globatus sp. nov.

Genus — *Cingulatisporites* Thomson emend. Potonié, 1956

Cingulatisporites sp.

Genus — *Pteridacidites* Sah, 1967

Pteridacidites sp.

Genus — *Laevigatosporites* Ibrahim, 1933

Laevigatosporites distinctus sp. nov.

Genus — *Psiloschizosporis* Jain, 1968

Psiloschizosporis psilata Kar & Saxena, 1981

Psiloschizosporis sp.

Genus — *Pinuspollenites* Raatz, 1937

Pinuspollenites crestus sp. nov.

Genus — *Abiespollenites* Thiergart, 1937

Abiespollenites cognatus sp. nov.

Genus — *Piceapollenites* Potonié, 1931

Piceapollenites excellensus sp. nov.

Genus — *Podocarpidites* Cookson emend. Potonié, 1958

Podocarpidites densicorpus sp. nov.

Podocarpidites sp.

Genus — *Magnamonocolpites* gen. nov.

Magnamonocolpites miocenicus sp. nov.

M. plicatus sp. nov.

M. baculatus sp. nov.

Genus — *Hibisceaepollenites* gen. nov.

Hibisceaepollenites splendus sp. nov.

Genus — *Palaeomalvaceaepollis* gen. nov.

Palaeomalvaceaepollis mammilatus sp. nov.

Genus — *Polyadopollenites* Thomson & Pflug, 1953

Polyadopollenites sp.

Genus — *Azolla*

Azolla aglochidia sp. nov.

Pl. 32, figs 7-10

Diagnosis — Megaspores with columella, rarely with floats. Columella distally continuous, projecting on both sides, one being much smaller than other, highly vacuolate. Megaspores without columella, 280-380 μm, generally with a perispore covering, endospore delicate, crumpled in most specimens. Exospore well-developed, 3-5 μm thick, laevigate and intramicrofoveolate, sometimes provide mud-crack like appearance in surface view.

Massulae subcircular-elliptical in shape with irregular margin, 78-250 μm, spongy, highly vacuolate, without any perceptible glochidia. Microspores found in groups within massulae, subcircular-circular, 8-14 μm, trilete rays extending almost up to margin in some specimens, more or less laevigate.

Description — Megaspores with attached floats and columella very rare. Only in one specimen (Pl. 32, fig. 7) floats with columella could be found. Floats subtriangular-subcircular, heavily vacuolate, spongy. Six floats seem to be present, this number, however, could not be definitely ascertained due to lack of specimens with distinct floats.

Columella very well-developed in all megaspores; of two columella, one far better developed than other, conical in shape, yellowish-brown in colour; smaller columella projects slightly, more or less blunt, also vacuolate like previous one.

Haptotypic mark rare, only in one specimen it could be detected; trilete rays narrow, ill-developed, extend less than half of radius.

Massulae greatly outnumber megaspores in samples. Their margin slightly undulated, no glochidia could be recognized on margin, as well as in dispersed condition on slides. Sometimes when margin of massulae lacerated, occasional outgrowth due to breaking could be observed. Massulae also found in attachment with megaspore.

Microspores almost always found embedded in spongy mass of massulae, they found in heterogenous groups, number of microspores though minute in size but generally with distinct trilete mark. Exine about 1 μm thick, sometimes folded parallel to margin, intrastructure not clearly discernible.

Comparison — The two fossil species of *Azolla*, viz., *A. intertrappea* Sahni & Rao (1934) and *A. indica* Trivedi & Verma (1971) so far known from India are from the Deccan Intertrappean beds (Eocene) of Madhya Pradesh. These two species are easily distinguished from *A. aglochidia* by the presence of well-developed glochidia in the former species. A massulae described as *Massulites coelatus* by Sahni and Rao (1943) and later transferred to *Salvinia intertrappea* by Mahabale (1950) is readily differentiated by its hollow massulae. *A. tuganensis* Dorofeev (1962) recorded from the Miocene of Sweden by Friis (1977) has irregular sculptural elements forming a coarse network on megaspore wall. *A. nikitinii* Dorofeev (1955), another species known from Miocene, has nine floats which are connected by dense mass of capilli arising from the edges. Besides, megaspore wall is ornamented with verrucae, rugulae and tubercles. *A. ventricosa* Nikitin (1965) has also irregular pila and tubercles on megaspore wall. *Azolla aglochidia* proposed here is distinguished from all the known species of fossil *Azolla* in the presence of columella on both sides, laevigate endospore and exospore and absence of glochidia on massulae.

Remarks — *Azolla aglochidia* resembles the extant species *A. nilotica* by the absence of glochidia in massulae (see Mahabale, 1961). According to Mahabale (1961) this is the most advanced species of *Azolla* and has the least geographical distribution. *A. pinnata* also comes somewhat closer by possessing delicate hair-like glochidia.

Holotype — Pl. 32, fig. 7; size 275 μm; slide no. 8255/7.

Type Locality — Khari River Section between Goyela and Chhasra, Miocene.

Occurrence — Khari River Section between Goyela and Chhasra.

Genus — *Biretisporites* (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Type Species — *Biretisporites potoniaei* Delcourt & Sprumont, 1955.

Biretisporites convexus Sah & Kar, 1969

Pl. 33, figs 1, 2

Remarks — The spores are subtriangular as originally described by Sah and Kar (1969) from the Lower Eocene of Kachchh. The size range is also similar but the trilete rays instead of two-thirds are extended almost up to three-fourths radius.

Occurrence — Khari River Section between Goyela and Chhasra.

Genus — *Dictyophyllidites* (Couper) Dettmann, 1963

Type Species — *Dictyophyllidites harrisii* Couper, 1958.

Remarks — *Dictyophyllidites* has nomenclatural priority over *Toroisporites* Krutzsch (1959). It may be mentioned here that Couper (1958) proposed this genus to accommodate the dispersed spore of *Dictyophyllum* a fern found in Jurassic. The spores of *Dictyophyllum muensteri* (Goeppert) Nathorst (1878) are about 65 μm in size while those of *D. nilssoni* (Brongniart) Goeppert (1846) are 40 μm in size. Both the species show well marked kyrtome along the haptotypic mark. Besides, spores of *Phlebopteris angustiloba* Pressl emend. Hirmer & Hoerhammer (1936) illustrated by Potonié (1962, pl. 11, fig. 296) have also thickening along the trilete rays.

Among the living ferns, the spores of *Cheiropleuria biscuspis*, *Trichopteris corcovadensis* and *Schizocaena moluccana* possess kyrtome. Devi (1977, fig. 119) illustrated the spores of *Hicriopteris glauca* of the family Gleicheniaceae from Assam which also seem to have thickening along the trilete rays.

Dictyophyllidites laevigatus sp. nov.

Pl. 33, figs 3, 4

Diagnosis — Spores triangular, 60-70 μm, apices rounded, interapical margins ± straight. Trilete, rays distinct, extending up to three-fourths radius, associated with exinal thickening. Exine 2-3.5 μm thick, thicker at apices, laevigate.

Comparison — *Dictyophyllidites* sp. A described by Sah and Kar (1969) has similar size range like the present species but has convex interapical margins and uniformly thick exine. *Dictyophyllidites* sp. B also described by Sah and Kar (1969) has very prominent kyrtome. *Dictyophyllidites* sp. described by Kar and Jain (1981) from the Neogene sediments of Kerala is smaller in size and the kyrtome is weakly intrastructured.

Holotype — Pl. 33, fig. 3; size 60 × 58 μm; slide no. 5985/10.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida.

Genus — *Striatriletes* van der Hammen emend. Kar, 1979a

Type Species — *Striatriletes susannae* van der Hammen emend. Kar, 1979a.

Striatriletes aidaensis sp. nov.

Pl. 33, figs 8, 9

Diagnosis — Spores subtriangular-subcircular, 90-110 × 85-105 μm. Apices very broadly rounded, trilete rays extending half of radius. Exine costate, costae 10-15 at each interapical margin, all originate at ray ends, extend on distal side to form three concentric rings. Costae very closely placed.

Comparison — *Striatriletes multicostatus* Kar & Saxena (1981) comes close to the present species in shape and presence of many costae. *S. aidaensis* is, however, distinguished by its bigger size and presence of more costae at each interapical margin.

Holotype — Pl. 33, fig. 8; size 100 × 94 μm; slide no. 5988/11.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Striatriletes paucicostatus sp. nov.

Pl. 33, fig. 10

Diagnosis — Spores triangular-subtriangular, 70-95 × 65-90 μm. Trilete, rays ill-developed. Exine costate, costae 5-8 at each interapical margin, quite apart from each other, ill-developed, may be branched, intercostate exine laevigate.

Comparison — *Striatriletes multicostatus* Kar & Saxena (1981) and *S. aidaensis* have many costae. *S. susannae* (van der Hammen) Kar (1979) compares well to the present species in the number of costae but they are very well-developed and strongly built.

Holotype — Pl. 33, fig. 10; size 90 × 77 μm; slide no. 8261/4.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Khariasporites* sp. nov.

Type Species — *Khariasporites densus* sp. nov.

Diagnosis — Spores subcircular-circular in shape, size range 190-265 × 170-250 μm. Trilete, rays half to three-fourths radius. Exine ± laevigate to granulose-spinose, incipient inner body may be present.

Description — Spores generally subcircular, sometimes due to irregular foldings they may be transformed to other shapes. Trilete, rays narrow, uniformly broad commissure well marked. Subcircular, incipient inner body observed in some spores, in others middle region thickened or semicircular-circular folds parallel to margin developed middle region of spores may be intrastructured. Exine 2-4 μm thick, perfectly psilate exine not found, instead sparsely placed, low set grana observed, in few spores grana intersperse with spines and sculptural elements clearly visible.

Comparison — *Calamospora* Schopf, Wilson & Bentall (1944) resembles the present genus in shape and in possessing incipient inner body but the former is distinguished by its laevigate exine. *Neocalamospora* Kar & Bose (1976) is also laevigate and having well developed haptotypic mark. *Callumispora* Bharadwaj & Srivastava (1969) is also devoid of any sculptural elements. *Todisporites* Couper (1958) approximates *Khariasporites* in subcircular shape but has no incipient inner body and granulose-spinose ornamentation. *Lygodiumsporites* (Potonié, Thomson & Thiergart) Potonié (1956) is generally triangular-subtriangular in shape. *Osmundacidites* Couper (1953) comes close to the present genus in having sparsely placed granulose exine but is much smaller in size and has no incipient inner body. *Verrutriletes* (van der Hammen) ex Potonié (1956) is subcircular in shape and ornamented with sparsely placed verrucae. *Biharisporites* Potonié (1956) has well marked curvature around trilete and inner body and is ornamented with coni.

Remarks — The spores are quite big in size and it seems quite likely that they are megaspores. Megaspores in the Tertiary sediments, it may be recalled here, are rare. Trivedi and Verma (1969) described a megaspore as *Calamospora* sp. from the Tertiary coal of Malaya which has been dated as Middle Eocene-Upper Eocene by Trivedi, Ambwani and Kar (1982). *Calamospora* sp. described by Trivedi and Verma (1969) is 1120 × 960 μm in size and has no haptotypic mark or inner body. *Calamospora* Schopf, Wilson and Bentall (1944) is essentially a Palaeozoic genus and it seems unlikely that the same genus prevailed in the Tertiary. The *Lycopsida* is either homosporous or heterosporous. The fossil microspores of *Lycopsida* are mostly trilete, sometimes monolete, azonate or zonate, cingulate or even monosaccate (Potonié, 1962). The megaspores have all trilete mark and may be azonate, zonate, cingulate or auriculate. The microspores of fossil Selaginellales are laevigate, reticulate or verrucose. A well marked cingulum is found almost in all of them. The megaspores are also variously ornamented and have a distinct cingulum, zona or corona. The various megaspores belonging to fossil *Lycopsida* and Selaginellales figured and described by Potonié (1962) do not show any close similarity to the genus instituted here.

Derivation of Name — After the Khari Nadi (river) which flows nearby the locality.

Khariasporites densus sp. nov.

Pl. 34, figs 2-4

Diagnosis — Spores generally subcircular, rarely circular, trilete distinct, rays uniformly broad, extending half to three-fourths radius. Incipient inner body present in few specimens, sometimes semicircular, folds parallel to margin also observed. Exine up to 3 μm thick, ± laevigate or ornamented with scantily placed low set grana.

Holotype — Pl. 34, fig. 2; size 270 × 250 μm; slide no. 5988/5.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Khariasporites granulatus sp. nov.

Pl. 34, fig. 5

Diagnosis — Spores originally subcircular, may be of various shapes due to irregular foldings, size range 180-425 × 160-401 μm. Trilete mostly not traceable, incipient inner body present in most specimens. Exine up to 3 μm thick, sparsely granulose, sometimes spines mix with grana.

Comparison — *Khariasporites densus* closely resembles the species described here in subcircular shape and presence of inner body; but the latter is distinguished by its well defined sculptural elements and absence of trilete mark in most cases.

Holotype — Pl. 34, fig. 5; size 230×223 μm; slide no. 5983/4.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River section between Goyela and Chhasra.

Genus — *Lycopodiumsporites* Thiergart, 1938

Type Species — *Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

Lycopodiumsporites globatus sp. nov.

Pl. 34, figs 6, 7

Diagnosis — Spores subcircular, 55-66 μm, trilete indistinct. Exine broadly reticulate, muri raised, meshes uniform, perisporial flange present in some specimens.

Comparison — *Lycopodiumsporites bellus* Sah & Kar (1969) described from the Eocene of Kachchh has triangular shape and very distinct trilete rays. *L. parvireticulatus* Sah & Dutta (1966) is also triangular with well defined trilete rays and smaller meshes. The other species described by Dutta and Sah (1970), viz., *L. speciosus*, *L. palaeocenicus* and *L. umstewensis* from the Tertiary sediments of South Shillong Plateau are also all triangular in shape, have distinct trilete rays and smaller meshes.

Holotype — Pl. 34, fig. 6; size 60 μm; slide no. 5987/7.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus—*Cingulatisporites* Thomson emend. Potonié, 1956

Type Species — *Cingulatisporites levispeciosus* Pflug, 1953.

Cingulatisporites sp.

Pl. 34, fig. 8

Description — Spore cingulate, subcircular, 56 μm. Trilete, rays uniformly broad, extending up to margin of central body, central body distinct, subcircular. Cingulum distinct. Exine about 1.5 μm thick, a few muri present.

Comparison — *Cingulatisporites* sp. described by Sah (1967) from the Upper Neogene of Rusizi Valley, Burundi is comparable to the present specimen in shape and size range; but in the latter the trilete rays are extending up to the margin of the central body and the cingulum is also comparatively broader. *Cingulatisporites levispeciosus* Pflug (1953) is only 36 μm in size and is triangular in shape.

Remarks — This genus is very rarely found in the assemblage.

Occurrence — Aida.

Genus — *Pteridacidites* Sah, 1967

Type Species — *Pteridacidites africanus* Sah, 1967.

Pteridacidites sp.

Pl. 34, fig. 9

Description — Spore subtriangular, cingulate, 60×56 μm. Central body ill-defined, subtriangular. Trilete rays indistinct, extending up to margin of central body. Cingulum thicker than central body, ± granulose, verrucae sparsely placed, perine present, hyaline.

Comparison — *Pteridacidites africanus* Sah (1967) has lobed cingulum and well-developed undulated perisporial flange. *P. rarus* Sah (1967) is also highly flanged, the central body is triangular and the verrucae are concentrated on the contact area. *P. vermiverrucatus* Sah (1967) is distinguished by its triangular shape. *P. rotundus* Sah (1967) is subcircular in shape but has prominent trilete rays and the inter-radial area on the proximal surface is covered by densely packed, low verrucae.

Occurrence — Aida.

Genus — *Laevigatosporites* Ibrahim, 1933

Type Species — *Laevigatosporites vulgaris* Ibrahim, 1932.

Laevigatosporites distinctus sp. nov.

Pl. 34, figs 10, 11

Diagnosis — Spore subcircular, 90-110 × 80-95 μm. Monolete mark distinct, straight or sinuous, extending more than half radius. Exine 1.5-2.5 μm thick, slightly scabrate, may be irregularly folded.

Comparison — *Laevigatosporites lakiensis* Sah & Kar (1969) and *L. cognatus* Sah & Kar (1969) from the Lower Eocene of Kachchh are much smaller in size than the present specimen. *Laevigatosporites arcotense* Ramanujam (1966-67) is bean-shaped. *L. ovalis* Wilson & Webster (1944) reported by Ramanujam (1972) from Miocene of Kerala is also bean-shaped. *L. copiosus* Salujha, Kindra & Rehman (1972) is bean-shaped and smaller in size than the present species.

Holotype — Pl. 34, fig. 10; size 100 × 84 μm; slide no. 5987/12.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Psiloschizosporis* Jain, 1968

Type Species — *Psiloschizosporis cacheutensis* Jain, 1968.

Psiloschizosporis psilata Kar & Saxena, 1981

Pl. 34, fig. 12

Remarks — Pollen grains are bigger in size (up to 120 μm) than those originally described by Kar and Saxena (1981) from the Eocene of Kachchh. Furrows in most of the specimens are distinct, sometimes appear as monolete. Exine is generally laevigate, in some cases it may be weakly intrastructured.

Occurrence — Aida.

Psiloschizosporis sp.

Pl. 35, fig. 1

Description — Solitary specimen, very big in size. Exine about 2 μm thick, laevigate. Furrows distinct, pollen grain splitting into two halves.

Comparison — The species described here resembles *Psiloschizosporis psilata* Kar & Saxena (1981) in shape and laevigate exine but the former is distinguished by its very big size.

Occurrence — Aida.

Genus — *Pinuspollenites* Raatz, 1937

Lectotype — *Pinuspollenites labdacus* (Potonié) Raatz, 1937.

Remarks — Recent Pinaceae has two types of pollen grains. One is exemplified by *Pinus* and the other by *Tsuga*. The former is bisaccate with coarsely intrareticulate sacci, the latter is monosaccate or pseudo-bisaccate. The two types, in the opinion of Staplin, Pocock and Jansonius (1967) are closely related. The pollen resembling the *Pinus* and the related genera has been found up to the Middle Triassic. Manum (1960) thinks that pollen assignable to *Pityosporites* (Seward) Potonié & Klaus (1954) is morphologically identical to modern *Pinus* pollen. *Schizosaccus* (Mädler) Mädler (1964) also seems to be similar to *Pinus* pollen.

Potonié (1958) placed *Pinuspollenites* Raatz (1937) under diploxylonoid forms. It may, however, be mentioned here that in *Pinus*, both diploxylonoid and haploxylonoid forms occur. The first type is generally found in *Pinus sylvestris*. So *Pinuspollenites* should accommodate only this type of pollen grains.

In the living pollen grains of *Pinus*, the cap of the central body is sharply distinguished from the body. The edge is generally undulated and it is more marked on the proximal side.

The *Pinus* is generally found in the temperate to subalpine regions of the northern hemisphere and also in the Saunda Islands. The following five species, however, also occur in India:

1. *Pinus wallichiana* Jackson — This species is found between 1800 and 3000 m height on the Himalayas except in Sikkim and major part of Kumaon.

2. *P. armandi* Franchet — This species is confined to the north-eastern part of India (Arunachal) and occur as a natural vegetation above the height of 1500 m.

3. *P. gaerdiana* Wall ex Lamb — In the dry interior valley of north western Himalayas at the height of 1800-3500 m this species is abundantly found.

4. *P. insularis* Endl. — It is only found in the north-eastern part of India and exhibits its maximum development between the height of 1000 and 2500 m.

5. *P. roxburghii* Sargent — This species grows well even at the height of 460 m but also found up to 2300 m along the foot hills of the Himalayas.

Besides, *P. markusii* Jungh & de Vr. which commonly occur between Burma and Philippines is also known to grow in Bangla Desh.

Pinuspollenites crestus sp. nov.

Pl. 35, figs 2, 3, 11

Diagnosis — Pollen grains, bisaccate, bilaterally symmetrical, 80-100×40-60 μm. Central body subcircular, cap distinct, prominent on proximal side, intrabaculate. Sacci hemispherical, intrareticulate. Proximal attachment of sacci to central body equatorial, distal attachment subequatorial, providing a wide sulcus.

Comparison — *Saccites* spp. illustrated by Banerjee (1964, pl. 2, figs 1-3) from Surma (Miocene) of Garo Hills resemble the species described here in size range, thickened cap on the central body and wide sulcus. *Pinus* spp. also described by Banerjee (1969, pl. 1, figs 5-8) from Siwalik (Miocene) of Punjab are much smaller in size range. *Pinus* sp. reported by Nandi (1972, pl. 3, figs 30, 33) from Siwalik shows similarity in size range, nature of the central body and the sacci.

Holotype — Pl. 35, fig. 2; size 96×42 μm; slide no. 8264/13.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Abiespollenites* Thiergart, 1937

Type Species — *Abiespollenites absolutus* Thiergart, 1937.

Remarks — The extant pollen grains of *Abies* are quite big in size (100-160 μm) and diploxylonoid. The central body is distinct, subcircular and with a thick and coarse cap. In optical section, the crest of the cap on the central body is narrow in the middle region but broad near the sacci. The reticulation is coarse on the sacci and somewhat radially oriented. The pollen grains have a tendency to fold along the central body revealing the distinct cap and the sacci are closely placed to one another.

In India, at present we have the following species of *Abies*:

1. *Abies spectabilis* (Don.) Spach. — This species occurs from Sikkim, Bhutan to western Himalayas and grows in between 2750 and 4000 m.

2. *A. pindrow* Royle — It is also widespread and found from Nepal to Afghanistan above 2200 m.

3. *A. densa* Griff. from Burma to Nepal and found above 2750 m.

4. *A. delewayi* (van Tiegh.) Franch. — It is found in Arunachal Pradesh and also above 2750 m.

Sahni (1931) described three petrified cones, viz., *Takiostrobus alatus*, *Indostrobus bifidolepsis*, and *Pityostrobus crassitesta* from the Deccan Intertrappean beds. According to Sahni (1931) both *Takiostrobus* and *Indostrobus* are abietinean.

Abiespollenites cognatus sp. nov.

Pl. 35, figs 4, 5

Diagnosis — Pollen grains bisaccate, diploxylonoid, bilaterally symmetrical, 100-150×80-130 μm. Central body distinct, subcircular cap on proximal side well marked, coarse, exine of central body laevigate-weakly intramicroreticulate. Proximal attachment of sacci to central body equatorial, distal attachment subequatorial, sulcus distinct.

Holotype — Pl. 35, fig. 4; size 140×100 μm; slide no. 5986/11.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Comparison — *Abiespollenites absolutus* Thiergart (1937) described from the Miocene of Europe is smaller in size range than the present species. *Abiespollenites* sp. described by Nandi (1972) are 84-100×44-104 μm in size, the sacci are smaller than the central body and the central body is infrareticulate. The specimens illustrated by her are badly preserved and so nothing could be deciphered about the cap on the central body.

Genus — *Piceapollenites* Potonié, 1931

Type Species — *Piceapollenites alatus* Potonié, 1931.

Remarks — In the living pollen grains of *Picea*, the sacci are not sharply distinguished from the contour of the central body. The line of attachment of the sacci to the central is equal to the diameter of sacci and the pollen grains are oval in shape. The central body is generally horizontally oval and the size of it is more than the sacci. The cap on the central body is distinct and the crest is thicker in the middle but thinning gradually towards the sacci. The exine of the central body is ± laevigate to intramicroreticulate and the sacci are broadly intrareticulate.

There are only two extant species of *Picea* in India. *Picea smithiana* (Wall.) Boiss is found from Afghanistan to Kumaon in between the height of 2130 and 3350 m. *P. spinulosa* (Griff.) Henery is found in Sikkim, Bhutan and Nepal Himalayas above 2400 m and below 2000 m.

Piceapollenites excellensus sp. nov.

Pl. 36, fig. 1

Diagnosis — Pollen grains bisaccate, haploxylonoid, bilaterally symmetrical, 108-138 ×61-88 μm. Central body well marked, horizontally oval, cap distinct, gradually thicker in middle region and thinner towards sacci, exine of central body ± laevigate — weakly intramicroreticulate. Proximal attachment subequatorial, sulcus wide, distinct, sacci intrareticulate.

Comparison — *Piceapollenites alatus* Potonié (1931) described from the Miocene of West Germany is comparable to the present species in haploxylonoid condition and general organisation but the species instituted here is easily distinguished by its much larger size range. *Piceapollenites* sp. described by Nandi (1972) from the Middle Siwaliks of India has also smaller size range (56-96 μm) and the central body is circular to subcircular in shape.

Holotype — Pl. 5, fig. 1; size 125×68 μm; slide no. 6187/10.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Infraturma — *Podocarpoiditi* Potonié, Thomson & Thiergart, 1950

Genus — *Podocarpidites* Cookson emend. Potonié, 1958

Type Species — *Podocarpidites ellipticus* Cookson, 1947.

Remarks — The sacci of the pollen grains of *Podocarpus* in equatorial position are distinctly separated from the central body. The line of attachment of the sacci to the body is smaller than the circle of the sacci. In the polar view, the pollen grains provide the appearance of three crossing circles. The pollen grains of Podocarpaceae are generally bisaccate but in *Dacrycarpus* they are trisaccate. Even amongst the genera producing disaccate pollen grains normally, few trisaccate pollen grains are also occasionally found. The central body is mostly thicker than the sacci and the cap is baculate. The cap is thicker on the proximal and thinner on the distal side.

The family Podocarpaceae is mainly restricted to southern hemisphere but the genus *Podocarpus* is also found in Japan, China and India. In India, we have only two species of Podocarpaceae, viz., *Podocarpus nerifolius* Don. and *P. wallichianus* Presl. The former species is found from the plains to the height of 900 m in the north-eastern India and is also reported to occur in Andamans, Burma and Bangla Desh. The second species is also found in the plains to the height of 1500 m in north-eastern India, in Western Ghats and Nilgiri Hills. The species is also found in Nicobar islands.

The megafossil record of Podocarpaceae in India is represented by vegetative shoots, petrified woods and strobili of both sexes. Sahni (1931), Suryanarayana (1953), Bhardwaj (1953) and Jain (1965) recorded various species of *Mesembrioxylon* from Mesozoic.

Rao (1946) and Vishnu-Mittre (1957) recorded sterile twigs as *Nipanioruha* from Rajmahal Hills which also belong to Podocarpaceae. *Elatocladus*, another sterile leaf genus of podocarpaceous affinity, is described by many authors from the Jurassic-Lower Cretaceous beds of India (Seward & Sahni, 1920; Sahni, 1928; Gopal & Jacob, 1955; Shah, Singh & Gururaja, 1973 and others). Rao (1943, 1949), Vishnu-Mittre (1957) and Rao and Bose (1972) recorded cones of Podocarpaceae, viz., *Nipaniostrobus*, *Mehtaia*, *Sitholeya* and *Podostrobus* from the Rajmahal Hills.

So far the Tertiary is concerned, Sahni (1931) described *Mesembrioxylon schmidianum* from the Cuddalore Series near Pondicherry Kräusel (1949) later transformed this species to *Podocarpoxylon*. Ramanujam (1953, 1954) described three species and Agashe (1969) one species of *Mesembrioxylon* from the same series. According to Lakhanpal, Guleria and Awasthi (1975) the affinity of these four woods are doubtful and they may either belong to *Podocarpoxylon*, *Phyllocladoxylon* or *Circoporoxylon*. Lakhanpal, Guleria and Awasthi (1975) reported *Podocarpoxylon kutchensis* from the Kankawati Series (Pliocene) of Kachchh. This is the solitary record of a gymnospermous fossil wood in the Tertiary of Kachchh.

Podocarpidites densicorpus sp. nov.

Pl. 35, figs 6, 7

Diagnosis — Pollen grains bisaccate, diploxylonoid, bilaterally symmetrical, 75-105 × 35-45 μm. Central body distinct, dense, horizontally oval, cap distinct, more prominent on proximal side, intrabaculate. Proximal attachment of sacci to central body equatorial, distal attachment subequatorial, sulcus wide; sacci hemispherical, intrareticulate.

Comparison — *Podocarpidites cognatus* Kar (1979) described from the Oligocene of Kachchh approximates the present species in oval shaped central body but the new species described here is comparatively larger in size range. *P. classicus* Salujha, Kindra & Rehman (1972) is also of smaller size and the central body is foveolate. *P. khasiensis* Dutta & Sah (1970) is separated by the presence of subcircular central body.

Holotype — Pl. 35, fig. 6; size 100 × 40 μm; slide no. 8264/2.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Tsugaepollenites* Potonié & Venitz, 1934

Type Species — *Tsugaepollenites igniculus* Potonié, 1931.

Remarks — The pollen grains of *Tsuga* are subcircular-circular in shape with undulated margin due to frilled nature of the saccus. The central body is generally denser or as dense as saccus. Exine on the proximal side of central body is thicker and coarser than the distal side.

In India, *Tsuga* is represented by one species, viz., *T. dumosa* (Don.) Eichler and is found from Kumaon to Arunachal Pradesh between the height of 1900 and 3050 m.

According to Staplin, Pocock and Jansonius (1967) pollen assignable to *Tsuga* is found only in the Tertiary where species almost identical to recent forms are common. They also think that the *Cerebropollenites* Nilsson (1958) which extends from the Rhaetian and possibly from the Upper Triassic to the top of the Cretaceous is the ancestral form of *Tsugaepollenites*. The former pollen has ruffled, finely intrapunctate saccus and subcircular, proximal leptomata with coarser rugulation and frilling of the saccus. Staplin, Pocock and Jansonius, (1967) also point out that in *Tsuga* the lateral frill developed from a bisaccate condition. Pollen of a few species still show bisaccate condition and individuals tending towards the bisaccate can be found in species which show a 'monosaccate' frill. Erdtman (1957) opines that the position of leptoma in *Tsuga* may be on the proximal side.

Tsugaepollenites velatus sp. nov.

Pl. 36, figs 3, 4

Diagnosis — Pollen grains monosaccate, 75-90 × 60-84 μm, subcircular-circular. Central body distinct, subcircular, rugose, sculptural elements more prominent on proximal side. Saccus distinct, frilled, granulose, attachment zone thickened.

Comparison — *Tsugaepollenites igniculus* Potonié (1931) described from the Miocene of West Germany is comparable to the present species in shape and rugose central body but is much smaller in size. *Tsugaepollenites* sp. recorded by Nandi (1972) is 26-47 μm in size and the central body is less ornamented than the saccus.

Holotype — Pl. 36, fig. 3; size 87 × 80 μm; slide no. 5985/6.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Magnamonocolpites* gen. nov.

Type Species — *Magnamonocolpites miocenicus* sp. nov.

Diagnosis — Pollen grains monocolpate, 210-295 × 57-127 μm, generally oval in shape. Colpus distinct extending end to end, sometimes associated with folds. Exine mostly laevigate, rarely baculate-pilate or intrabaculate.

Description — Pollen grains of unusually bigger size range with equally or unequally broad lateral ends. Colpus well-marked, open or slit-like, sometimes closed in middle region or one end broader than other, colpus may be associated with one longitudinal fold on either side. In one specimen, trilete mark observed, rays small, distinct, uniformly broad, situated in middle region. Exine 1.5-4 μm thick, mostly laevigate and weakly intrastructured; sometimes baculate-pilate, sculptural elements 2-3 μm long and up to 2 μm broad, closely placed, in some specimens intrabaculate structure also observed.

Comparison — *Cycadopites* (Wodehouse) ex-Wilson & Webster (1946) originally described from the Tertiary of Montana compares well with the present genus in shape and laevigate exine but is readily differentiated by its smaller size range (39-42 μm). *Ginkgocycadophytus* Samoilovich (1953) is generally known from the Upper Palaeozoic and is also much smaller in size than the present genus. *Magnamonocolpites* is also readily separated from *Cycadaceaelagella* Malawkina (1953) by its bigger size range. *Monosulcites* (Erdtman) ex Couper (1953), *Liliacidites* Couper (1953), *Palmidites* (Chitaley) ex Couper (1953), *Arecipites* Wodehouse (1933), *Palmaepollenites* Potonié (1951) and *Sabalpollenites* Thiergart (1937) are all angiospermic genera, much smaller in size range and hence are easily distinguished from the new genus proposed here.

Remarks — The monocolpate pollen grains described here are enormous in size. Dev (1961) described pollen grains comparable to the present ones as *Ginkgoretectina vastus* Dev (1961) from the Jabalpur Series (Jurassic) of Madhya Pradesh, India. The pollen grains described by him are 150-216 μm in size and the exine is either intragranulate or intrareticulate. Though he placed these pollen under *Ginkgoretectina*, he was in doubt about their affinity. Kar and Sah (1970) described *Ginkgocycadophytus srivastavae* from Vemavaram (Upper Jurassic) whose size range varies from 77-95 μm, the exine is laevigate and intrastructured.

The *in situ* pollen grains described from *Lunzia austriaca* Krasser (1917), *Androstrobus manis* Harris by Couper (1958) and *Androstrobus prisma* Thomas & Harris (1960) belonging to Cycadales are 27-35 μm in size. Similarly, *in situ* Cycadeoidales pollen of *Williamsonia lignieri* Nathorst (1909), *W. spectabilis* Nathorst (1909) and *Bennettistemon bursigerum* Harris (1932) are less than 60 μm in size. The pollen grains described by Harris (1948) of *Ginkgo huttoni* (Sternberg) Heer (1865) and *Sphenobaiera furcata* (Heer) Florin (1936) by Kräusel (1943) of Ginkgoales also do not exceed 50 μm in size. According to Coulter (1898), the extant Cycadales are represented by 9 genera and about 100 species. Wodehouse (1935) described the pollen grains of *Cycas*, *Zamia*, *Ceratozamia*, *Dioon* and *Microcycas*. The pollen grains of all these genera do not generally exceed more than 30 μm in length. The pollen grains of living *Magnolia*, which in the opinion of Wieland (1929) comes very close to *Williamsonia* and *Wielandiella* in shape and monocolpate nature, are 50-70 μm long and are more elongated than those of *Cycas*.

The rather abnormal size of *Magnamonocolpites* for this reason is not comparable to any of the known fossil and living genera. However, it seems that the pollen grains assignable to *Magnamonocolpites* are related to Cycadales. The genus *Cycas* has about 15 species distributed in Asia, Africa and Australia. Following species are found in India:

(1) *Cycas circinalis* Linn. is localized in Malabar coast, Andhra Pradesh, Tamil Nadu and Orissa.

(2) *C. pectinata* Griff. is found in Nepal, Sikkim and Khasi Hills.

(3) *C. rumphii* Miq. is reported from Andaman and Nicobar islands and also found in Ceylon.

(4) *C. beddomei* Dyer. occurs in Andhra Pradesh and Tamil Nadu.

Magnamonocolpites miocenicus sp. nov.

Pl. 36, fig. 5

Diagnosis — Pollen grains monocolpate, size range 210-295 × 57-127 μm, with equally or unequally broad lateral ends. Colpus distinct, extending from one end to other, open or slit-like, sometimes broader at one end. In some specimens a small but well marked trilete also observed. Exine up to 2.5 μm thick, laevigate or weakly intrastructured.

Holotype — Pl. 36, fig. 5; size 270 × 57 μm; slide no. 5987/3.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Magnamonocolpites plicatus sp. nov.

Pl. 36, figs 6, 7

Diagnosis — Monocolpate, oval pollen grains with more or less equally broad lateral end, size range 180-290 × 165-282. Colpus distinct, open or slit-like, associated with a longitudinal fold on each side. Exine 1.5-3 μm thick, laevigate, sometimes weakly intrastructured.

Comparison — *Magnamonocolpites miocenicus* is comparable to the present species in size range and laevigate exine, but the latter is easily distinguished by the presence of a longitudinal fold on each side of a colpus.

Holotype — Pl. 36, fig. 6; size 225 × 125 μm; slide no. 5988/14.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Magnamonocolpites baculatus sp. nov.

Pl. 36, figs 8, 9

Diagnosis — Pollen grains monocolpate, oval, size range 160-182 × 82-136 μm. Colpus distinct, extending end to end, one end generally much broader than other. Exine 2-4 μm long and 1-2 μm broad, sometimes intrabaculate.

Comparison — The species described here is differentiated from *Magnamonocolpites miocenicus* and *M. plicatus* by its baculate-pilate sculputural elements.

Holotype — Pl. 36, fig. 8; size 175 × 98 μm; slide no. 8264/9.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Hibisceaepollenites* gen. nov.

Type Species — *Hibisceaepollenites splendus* sp. nov.

Diagnosis — Pollen grains subcircular-circular, panporate, pores equally distributed on both sides, margin thickened. Exine spinose, spines with broad base and rather blunt tip, interspinal space pilate.

Description — Fully flattened specimens rare due to irregular foldings, size range 80-105 × 78-100 μm. Pores distinct, 4-8 μm in diameter, generally circular, sometimes slightly oval, pore margin 2-4 μm thick, denser than rest part, number of pores 25-35, in some specimens pores on proximal and distal sides placed opposite to each other. Exine 1-2.5 μm thick, spines well built, 8-12 μm long, 3-5 μm broad at base, 2.5 μm broad at tip, spines sparsely placed, 15-26 μm apart; tips generally blunt, sometimes curved.

Comparison — *Malvacearumpollis* Nagy (1962) is comparable to the present genus in subcircular shape and pilate exine but is distinguished by its nature of spines. The spines in *Malvacearumpollis* are projected from a bulging base, conical and tapering into acuminate tips. Besides, the pores in *M. bakonyensis*, the type species of the genus, according to Nagy (1962) are never more than four. *Echiperiporties* van der Hammen & Wijmstra (1964) resembles *Hibisceaepollenites* in panporate and echinate condition but the pores are generally not traceable and appear as inaperturate;

besides the base of spines is slightly thickened and somewhat intruding in the ectexine and the tip is pointed. The spine is only 1 μm long and the size range of the type species is 16-24 μm. It may be mentioned here that Frederiksen (1973) also included stephanoporate pollen in this genus. *Malvacipollis* Harris (1965) has only 4-5 pores and the ornamentation consists of spinules and or spines. The pilate structure is also very well developed. *Hibisceaepollenites* instituted here is distinguished from all the panporate genera by its sparsely placed spines with rather blunt tips, thickened pore margin and weakly developed pilate structure.

Remarks — Saad (1960) studied the sporoderm stratification in the family Malvaceae and also prepared a key to identify the pollen grains. Panporate pollen grains are dimorphic in *Malope*, *Kitaibelia*, *Lavatera* and *Althaea*. The spines are not dimorphic in *Sidalcea* and *Malva* but the diameter of the pores is only 2-3 μm. In *Urena*, *Pavonia* and *Malvaviscus* the spines are very long and the exine is considerably thick. In *Callirhoe*, the spines are cylindrical and rod-shaped but the exine is very thick (7 μm). Saad (1960) studied the pollen grains of seven species of *Hibiscus* and most of them have long, conical spines. In size, the mean diameter varies from 79 μm in *Hibiscus micranthus* to 149 μm in *H. rosasinensis*. The length of spines varies from 12 μm in *H. micranthus* to 21 μm in *H. sabdariffa*. The pore in *H. micranthus* is about 4 μm in diameter whereas in *H. esculentus* it is about 10 μm. The exine in *H. esculentus* is about 2.5 μm thick and in *H. trionum* it is 7 μm. The present genus does not very closely resemble in any of the above mentioned species but in general approximates the tribe Hibisceae. However, in size and other characters it shows more similarity to *H. micranthus* though branched spines were not observed in these specimens.

Hibisceaepollenites splendus sp. nov.

Pl. 36, fig. 11

Diagnosis — Pollen grains subcircular-circular, sometimes irregularly folded, 83-109×80-105 μm. Panporate, pores 25-35 in number, 6-10 μm in diameter with thickened margin, pores 8-15 μm apart. Exine up to 2 μm thick, spinose, spines 9-16 μm long, broader at base, tips rather blunt, spines sparsely placed, 10-16 μm apart, interspinal space pilate, pila 3-5 μm long, ill-developed.

Holotype — Pl. 36, fig. 11; size 90×78 μm; slide no. 8264/4.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari River Section between Goyela and Chhasra.

Genus — *Palaeomalvaceaepollis* gen. nov.

Type Species — *Palaeomalvaceaepollis (Malvacearumpollis) rudis* (Kar) comb. nov.

Palaeomalvaceaepollis mammilatus sp. nov.

Pl. 36, fig. 10

Diagnosis — Pollen grains subcircular with undulated margin due to sculptural elements, 51-72×49-70 μm. Panporate, pores distinct, sometimes indistinct due to strongly built spines, margin slightly thickened in most specimens, number of pores 15-25, placed 8-13 μm apart. Exine up to 2.5 μm thick, spinose, spines placed on elevated wart-like extension of sexine, 8-12 μm long, base bulbous, 4-7 μm broad at base, 4-7 μm long, abruptly tapers to form straight pointed tips, spines placed 6-10 μm apart. Due to bulbous base and sharply pointed tip spines appear as mammilate processes. Sexine columellate, pila covers base of spines completely, interspinal space ± granulate.

Comparison — *Palaeomalvaceaepollis paucispinosus* is distinguished from the present species by its comparatively sparsely placed, acuminate spines and non-thickening of the pore margin.

Holotype — Pl. 36, fig. 10; size 70×64 μm; slide no. 5985/5.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Bore-core no. 27 at Rataria and Aida.

Palynological Assemblage in Khari Nadi Formation — The yielding of miospores from this formation is rather poor. More than 100 samples were macerated but except about a dozen all were unproductive. Out of these, seven samples are rich in palynological taxa and the present observation is based on these samples only.

The lowermost black-grey unit of this formation is represented by two samples, viz., AB_1 and AB_2. These samples are overwhelmingly dominated by microplanktons and the spores and pollen grains are hardly encountered. *Operculodinium israelianum* is very much dominant and in the sample nos AB_1 and AB_2, it is found as high as 94% and 87% respectively. Needless to say, the other species are found in negligible percentage in the count and they are: *Operculodinium centrocarpum*, *Cordosphaeridium cantharellum*, *C. exilimurum*, *Millioudodinium unicornum*, *Spiniferites bulloideus* and *Tuberculodinium vancampoae*. The only pollen species found within the count is *Abiespollenites cognatus* (1%) in sample no. AB_2 (Text-fig. 21).

The middle siltstone unit yielded microfossils from the basal part. All the three samples (K_2, K_3 & K_5) are very rich in pteridophytic spores and poorly followed by gymnospermous pollen. The angiospermic pollen and microplankton are rare in these samples. The commonest genus is *Striatriletes* and *S. susannae* is the most common species in the assemblage and it almost contributes half of the total count. The other species of *Striatriletes* frequently encountered are: *S. multicostatus*, *S. microverrucosus*, *S. aidaensis* and *S. paucicostatus*. The massulae and megaspores of *Azolla aglochidia* are also quite common in these samples. *Khariasporites densus*, the other megaspore, is also occasionally encountered. The gymnospermous pollen are represented by *Abiespollenites cognatus*, *Piceapollenites excellensus*, *Podocarpidites densicorpus* and *Tsugaepollenites velatus*. The only microplankton species found here is *Operculodinium centrocarpum*. The angiospermic pollen finds its representation only in *Malvacearumpollis rudis*.

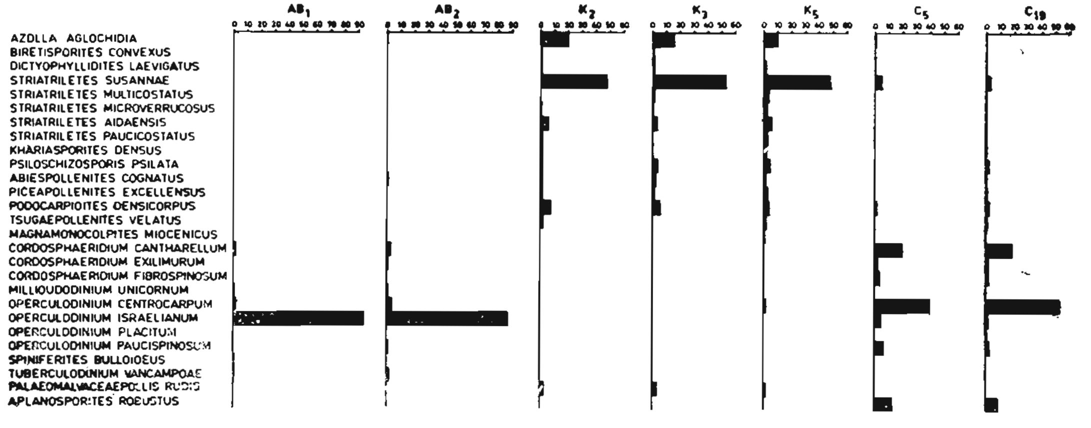
The upper clay and marl beds yielded two tolerably good samples (C5, C19). Both these samples are very rich in microplankton and the pteridophytic spores and gymnospermous pollen are found in negligible percentage. The angiospermic pollen are rare and do not figure within the counted specimens. The most common microplankton species is *Operculodinium centrocarpum* and is followed by *Cordosphaeridium cantharellum*. The other species frequently found are *Cordosphaeridium exilimurum*, *C. fibrospinosum*, *Operculodinium israelianum* and *O. paucispinosum*. Amongst the pteridophytes, *Striatriletes susannae* is common and *Psiloschizosporis psilata* is rare. *Piceapollenites excellensus*, *Podocarpidites densicorpus* and *Tsugaepollenites velatus* generally contribute for the gymnosperms. *Aplanosporites robustus*, a species of uncertain affinity is also found in good numbers.

Palynological Cenozones — The assemblage is clearly divisible into three palynological cenozones in the ascending order as follows:

(1) *Cordosphaeridium cantharellum* Cenozone

(2) *Striatriletes susannae* Cenozone

(3) *Operculodinium israelianum* Cenozone



TEXT-FIG. 21 — Showing the percentage of different palynological taxa in Khari Nadi Formation.

The first and third cenozones comprise mostly the microplanktons indicating marine influence. The second one on the otherhand, generally represents the terrestrial entities pointing there by fresh water influence. The presence of *Striatriletes* in considerable percentage leads to the supposition that it grew in a warm, humid, fresh water swampy area. The gymnospermous pollen grains which are also frequently encountered along with *Striatriletes* pose a problem to this contention. Perhaps, *Striatriletes* grew *in situ* or nearby areas whereas the bisaccate pollen due to their wind borne nature materialised from the long distance. They could even derive from the rising Himalayas because investigation reveals that they are being deposited even in Rajasthan desert at present (Text-fig. 22).

Operculodinium israelianum Cenozone

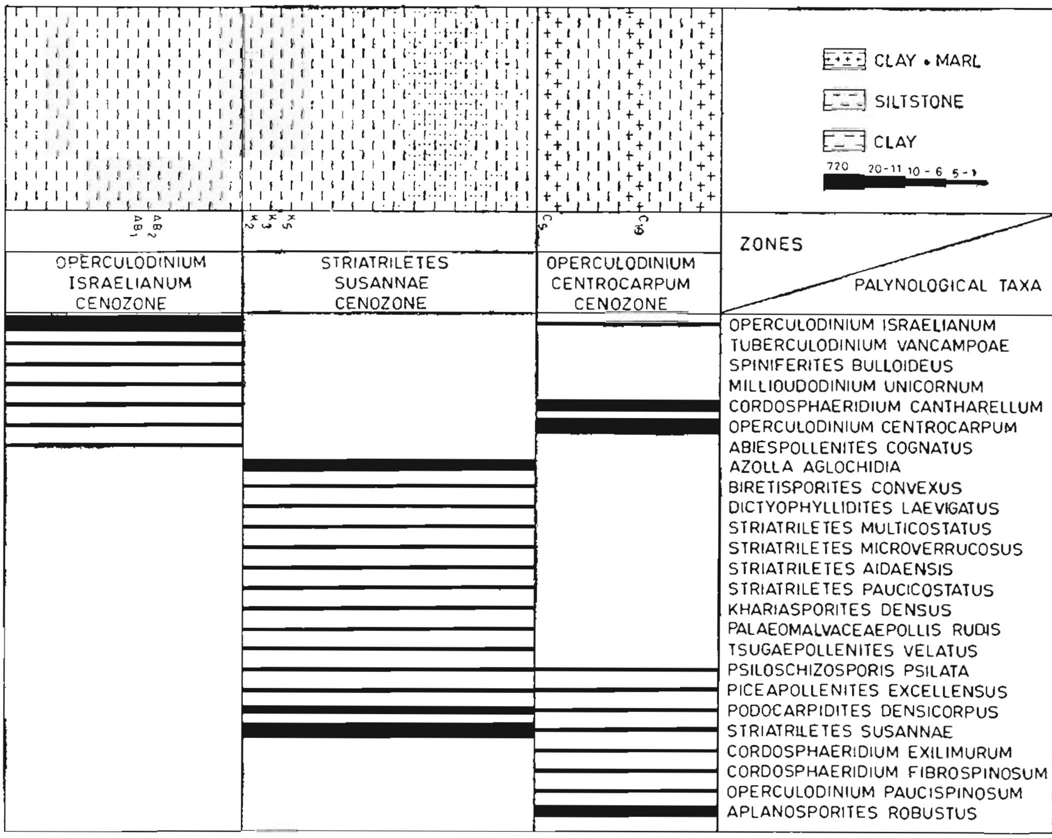
Type Section — Khari River Section near the village Aida, Kachchh, Gujarat.

Lithology — This cenozone consists of black-grey clay. The approximate thickness is 10 metres.

Lower Contact — The lower contact of this zone is clay.

Upper Contact — The upper contact is also the black-grey clay.

Significant Species of this Cenozone— *Cordosphaeridium cantharellum*, *Operculodinium centrocarpum*, *Tuberculodinium vancampoae*,



TEXT-FIG. 22 — Showing the palynological cenozones of the Miocene sediments in Kachchh. Please read *Cordosphaeridium cantharellum* instead of *Operculodinium centrocarpum* cenozone.

Spiniferites bulloideus, *Millioudodinium unicornum*, *Cordosphaeridium exilimurum* and *Abiespollenites cognatus*.

Remarks — Only two samples from the middle part of black-grey unit have yielded. It seems probable that the whole unit may belong to this cenozone.

Striatriletes susannae Cenozone

Type Section — Khari River Section near the village Aida, Kachchh, Gujarat.

Lithology — This cenozone is made up of siltstone with intercalation of clay.

Lower Contact — This rests conformably on black-grey clay bed.

Upper Contact — The upper contact of this zone comprises siltstone with alternation of clay.

Significant Species of this Cenozone — *Azolla aglochidia*, *Podocarpidites densicorpus*, *Psiloschizosporis psilata*, *Striatriletes aidaensis*, *Striatriletes paucicostatus*, *Khariasporites densus*, *Abiespollenites cognatus*, *Piceapollenites excellensus*, *Tsugaepollenites velatus*, *Operculodinium centrocarpum*, *Biretisporites convexus* and *Dictyophyllidites laevigatus*.

Cordosphaeridium cantharellum Cenozone

Type Section — Khari River Section near the village Aida, Kachchh, Gujarat.

Lithology — This cenozone consists of clay with alteration of marl.

Lower Contact — This rests conformably on siltstone and clay.

Significant Species of this Cenozone — *Operculodinium centrocarpum*, *Operculodinium paucispinosum*, *Striatriletes susannae*, *Operculodinium israelianum*, *Aplanosporites robustus*, *Cordosphaeridium exilimurum*, *Cordosphaeridium fibrospinosum*, *Psiloschizosporis psilata*, *Podocarpidites densicorpus* and *Piceapollenites excellensus*.

General Palynological Assemblage

In total, there are about 179 spore-pollen species in Palaeocene, Lower and Middle Eocene, Oligocene and Miocene. Of them, 42 species which are confined to Palaeocene are: *Lygodiumsporites eocaenicus*, *L. pachyexinus*, *Todisporites major*, *T. minor*, *Dandotiaspora dilata*, *D. telonata*, *D. pseudoreticulata*, *Osmundacidites microgranifer*, *O. minutus*, *O. cephalus*, *Leptolepidites major*, *Lycopodiumsporites umstewensis*, *Gleicheniidites senonicus*, *Polypodiaceaesporites levis*, *P. major*, *Polypodiisporites repandus*, *P. mawkmaensis*, *Retipilonapites cenozoicus*, *Couperipollis wodehousei*, *C. robustus*, *Matanomadhiasulcites maximus*, *M. kutchensis*, *Arecipites matanomadhensis*, *Palmidites maximus*, *Proxapertites assamicus*, *Tricolpites parvireticulatus*, *T. baculatus*, *T. matanomadhensis*, *Verrutricolpites perverrucatus*, *Psilastephanocolpites guaduensis*, *Retistephanocolpites kutchensis*, *Favitricolporites retiformis*, *Palaeocoprosmadites arcotense*, *Dermatobrevicolporites triangulus*, *Triangulorites triradiatus*, *Triporopollenites multiformis*, *Trilatiporites cooksonii*, *Sonneratioipollis bellus* and *Kielmeyerapollenites eocenicus*.

Thirtynine species are found only in Eocene, of these 17 and 9 species are restricted to Lower Eocene and Middle Eocene respectively. The rest 13 species which met with both in Lower and Middle Eocene are: *Osmundacidites kutchensis*, *Marginipollis kutchensis*, *Seniasporites verrucosus*, *Arecipites bellus*, *Umbelliferoipollenites ovatus*, *Araliaceoipollenites matanamadhensis*, *Cupuliferoipollenites ovatus*, *Symplocoipollenites kutchensis*, *Pellicieroipollis langenheimii*, *Retitetrabrevicolporites globatus*, *Polybrevicolporites nadhamunii*, *Paleosantalaceaepites primitiva* and *Dermatobrevicolporites dermatus*.

Seventeen species restricted only to Lower Eocene are: *Biretisporites bellus*, *Todisporites flavatus*, *Lakiasporites triangulus*, *Lycopodiumsporites parvireticulatus*, *Laevigatosporites cognatus*, *Seniasporites minutus*, *Retimonosulcites ellipticus*, *R. ovatus*, *Couperipollis perspinosus*, *Arengapollenites achinatus*, *Clavatipollenites cephalus*, *Tricolpites levis*, *Striacolporites striatus*, *Meliapollis raoi*, *Triangulorites minutus*, *Trilatiporites minutus* and *Pseudonothofagidites cerebrus*.

Stereisporites assamensis, *Verrudandotiaspora verrucata*, *Scantigranulites triangulus*, *S. sparsus*, *Lophotriletes tertiarus*, *Foveosporites splendus*, *Polypodiaceaesporites strictus*, *Arecipites intrapunctatus*, *Pilapanporites spinosus* and *Proxapertites reticulatus* occur only in the Middle Eocene.

The following 25 species found only in Oligocene are: *Punctatisporites sarangwarensis*, *Punctatisporites* sp., *Dictyophyllidites dulcis*, *Leptolepidites chandrae*, *Leptolepidites* sp., *Polypodiaceaesporites chatterjii*, *Polypodiisporites constrictus*, *Podocarpidites cognatus*, *Proxapertites scabratus*, *Tricolpites* sp. A, *Tricolpites* sp. B, *Retitricolpites delicatus*, *Trisyncolpites ramanujamii*, *Araliaceoipollenites* sp., *Monoporopollenites* sp., *Triporopollenites exactus*, *Triporopollenites* sp., *Stephanoporopollenites* sp., *Bombacacidites triangulatus*, *Compositoipollenites tricolporatus*, *Graminidites granulatus*, *Triatriopollenites* sp., *Verrupolyporites globosus*, *Polyporina multiporosa* and *Palaeomalvaceaepollis rudis*.

Twenty-one species are confined to the Miocene. They are *Azolla aglochidia*, *Dictyophyllidites laevigatus*, *Striatriletes aidaensis*, *S. paucicostatus*, *Khariasporites densus*, *K. granulatus*, *Lycopodiumsporites globatus* *Cingulatisporites* sp., *Pteridacidites* sp., *Laevigatosporites distinctus*, *Psiloschizosporis* sp., *Pinuspollenites crestus*, *Abiespollenites cognatus*, *Piceapollenites excellensus*, *Podocarpidites densicorpus*, *Podocarpidites* sp., *Tsugaepollenites velatus*, *Magnamonocolpites miocenicus*, *M. plicatus*, *M. baculatus* and *Hibisceaepollenites splendus*.

Thirty-three species are restricted to Palaeocene and Eocene, of which 15 are confined to Palaeocene and Lower Eocene and the rest are found in Palaeocene, Lower Eocene and Middle Eocene. The 15 species which are found in Palaeocene and Lower Eocene are: *Lycopodiumsporites bellus*, *Couperipollis rarispinosus*, *C. achinatus*, *Tricolpites minutus*, *Intrareticulites brevis*, *Ghoshiacolpites globatus*, *Retistephanocolpites granulatus*, *Paleosantalaceaepites ellipticus*, *Meliapollis ramanujamii*, *M. navalei*, *M. quadrangularis*, *M. meliodes*, *Triangulorites bellus*, *Proteacidites protrudus* and *Trilatiporites kutchensis*.

The 18 species which are observed both in Palaeocene and Eocene are: *Dandotiaspora plicata*, *Intrapunctisporis apunctis*, *Osmundacidites kutchensis*, *Couperipollis brevispinosus*, *C. kutchensis*, *Palmaepollenites kutchensis*, *P. nadhamunii*, *P. ovatus*, *P. plicatus*, *Dracaenoipollis circularis*, *Tricolpites reticulatus*, *Retistephanocolpites flavatus*, *Lakiapollis ovatus*, *Retibrevicolporites matanamadhensis*, *Verrucolporites verrucus*, *Striacolporites cephalus*, *S. ovatus* and *Pseudonothofagidites kutchensis*.

The three species which are noted in Palaeocene and Middle Eocene are *Spinizonocolpites echinatus*, *Tricolpites crassireticulatus and T. retibaculatus*. *Palaeomalvaceaepollis mammilatus* and *Cheilanthoidspora monoleta* are recorded from Middle Eocene and Oligocene. *Psiloschizosporis psilata*, *Striatriletes multicostatus* and *S. microverrucosus* are recorded both from Oligocene and Miocene. *Striatriletes susannae* is recovered from Middle Eocene, Oligocene and Miocene, while *Biretisporites convexus* is in record from the Lower Eocene, Middle Eocene, Oligocene and Miocene. Six species which are long ranging and observed from Palaeocene to Oligocene are: *Cyathidites minor*, *Lygodiumsporites lakiensis*, *Todisporites kutchensis*, *Laevigatosporites lakiensis*, *Proxaperites microreticulatus* and *Paleosantalaceaepites minutus*.

Spores and Pollen Grains from Pliocene

Mathur and Mathur (1969) for the first time described fungal and pteridophytic spores, angiospermic and gymnospermous pollen from Naera-Baraia area. Several attempts were made by me to recover palynological fossils from this area but it was never rewarding. Shri Y. K. Mathur was very kind to provide me the photographs illustrated by them and the description given below is also mainly according to them.

Genus — *Pluricellaesporites* (van der Hammen) Clarke, 1965

Type Species — *Pluricellaesporites typicus* van der Hammen, 1954.

Pluricellaesporites rectangulata Mathur & Mathur, 1969

Pl. 37, fig. 1

Diagnosis (*after Mathur & Mathur, 1969*) — Surface view. Spores horizontally septate, 45 × 8.5 μm in size, borne on short pedicel, 8-11 septa. Apical cell dome shaped. Others rectangular, faint germ pores present. Exine 1 μm thick, brown.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 1; size 45 × 8.5 μm; slide no. P1/1.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Pluricellaesporites ellipticus Mathur & Mathur, 1969

Pl. 37, fig. 2

Diagnosis (*after Mathur & Mathur, 1969*) — Surface view. Spores four-celled, stalked, broadly elliptical in shape, 39.5 × 19.6 μm, central cells bigger than end ones. Exine *ca.* 1 μm thick, brown.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 2; size 39.5 × 19.6 μm; slide no. P2/1.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera.

Genus — *Dyadosporonites* van der Hammen, 1954

Type Species — *Dyadosporonites umirensis* van der Hammen, 1954.

Dyadosporonites constrictus Mathur & Mathur, 1969

Pl. 37, fig. 3

Diagnosis (*after Mathur & Mathur, 1969*) — Surface view. Spores bilocular, horizontally septate, strongly constricted at the septa, individual cells 12 × 9.8 μm in size, two layered, psilate, brown.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 3; size 12 × 9.8 μm (individual cell); slide no. P3/8.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera.

Genus — *Marattisporites* Couper, 1958

Type Species — *Marattisporites scabratus* Couper, 1958.

Marattisporites longiletus Mathur & Mathur, 1969

Pl. 37, fig. 4

Diagnosis (*after Mathur & Mathur, 1969*) — Lateral view. Heteropolar, bilaterally symmetrical, reniform, 44 × 27 μm in size, monolete. Lete mark more than half of the length of the spores. Exine scabrate, 2.5 μm thick, sexine thinner than nexine, brownish yellow.

Remarks — This species exhibits close resemblance to *Polypodiaceaesporites* Thiergart (1938).

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 4; size 44 × 27 μm; slide no. P4/2.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera, Baraia.

Genus — *Verrucososporites* (Knox) Potonié & Kremp, 1954

Type Species — *Verrucososporites obscurus* (Kosanke) Potonié & Kremp, 1954.

Verrucososporites longiletus Mathur & Mathur, 1969

Pl. 37, fig. 5

Diagnosis (*Mathur & Mathur, 1969*) — Lateral view. Heteropolar, bilaterally symmetrical, reniform, 44 × 34.3 μm in size, monolete. Lete mark more than half of the length of the spore. Exine verrucate, thickness of the exine could not be measured due to the sculpture, brown.

Remarks — This species resembles *Polypodiisporites* Potonié (1934) in general characters.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 5; size 44 × 34.3 μm; slide no. P20/1.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Genus — *Naeratisporites* Mathur & Mathur, 1969

Type Species — *Naeratisporites psilatus* Mathur & Mathur, 1969.

Naeratisporites psilatus Mathur & Mathur, 1969

Pl. 37, fig. 6

Diagnosis (*after Mathur & Mathur, 1969*) — Oblique proximal view. Heteropolar, radiosymmetric, amb subtriangular, auriculate, 93×76 μm in size, trilete. Lete mark broad and extending more than half the length of the spore. Exine psilate, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 6; size 83×76 μm; slide no. P/5/1.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera.

Genus — *Todisporites* Couper, 1958

Type Species — *Todisporites major* Couper, 1958.

Todisporites subtriangulatus Mathur & Mathur, 1969

Pl. 37, fig. 7

Diagnosis (*after Mathur & Mathur, 1969*) — Proximal view. Heteropolar, radiosymmetric, amb subtriangular with rounded apices and convex sides, 98×85.7 μm in size, trilete. Trilete mark long, almost reaching the periphery, lips psilate. Exine psilate, 2.5 μm thick, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 7; size 98×85.7 μm; slide no. P5/1.

Type Locality — Baraia, Pliocene Kachchh.

Occurrence — Baraia.

Genus — *Verrucosisporites* (Ibrahim) Potonié & Kremp, 1954

Type Species — *Verrucosisporites verrucosus* (Ibrahim) Potonié & Kremp, 1955.

Verrucosisporites longiletus Mathur & Mathur, 1969

Pl. 37, fig. 8

Diagnosis (*after Mathur & Mathur, 1969*) — Proximal view. Heteropolar, radiosymmetric, amb subtriangular with rounded apices and convex sides, 33 μm in diameter, trilete. Lete mark clear, extending up to the periphery of the spore. Exine verrucate, 3 μm thick (including verrucae), yellowish brown.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 8; size 33 μm; slide no. P6/3.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera, Baraia.

Genus — *Lycopodiumsporites* Thiergart, 1938 ex Delcourt & Sprumont, 1955

Type Species — *Lycopodiumsporites agathoecus* (Potonié) Thiergart, 1938.

Lycopodiumsporites hyalinum Mathur & Mathur, 1969

Pl. 37, fig. 9

Diagnosis (*after Mathur & Mathur, 1969*) — Distal view. Heteropolar, radiosymmetric, amb spherical, 22.5 μm in diameter. Trilete mark not clear. Exine *ca.* 2 μm thick, reticulate, brown. Muri projecting *ca.* 5.5 μm into a hyaline layer.

Holotype — Mathur & Mathur, 1969, pl. 1, fig. 9; size 22.5 μm; slide no. P6/3.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera.

Genus — *Cicatricosisporites* Potonié & Gelletich, 1933

Type Species — *Cicatricosisporites dorogensis* Potonié & Gelletich, 1933.

Cicatricosisporites sp.

Pl. 38, fig. 1

Description (*after Mathur & Mathur, 1969*) — Heteropolar, radiosymmetric, amb subtriangular with rounded apices and convex sides, 115×103 μm in size, trilete. Trilete mark long. Exine striated, striations 3.5 μm apart and 2.5 μm in breadth, brown.

Remarks — The specimens seem to belong to *Striatriletes* van der Hammen emend. Kar, 1979a.

Occurrence — Baraia.

Genus — *Piceapollenites* Potonié, 1931

Type Species — *Piceapollenites alatus* Potonié, 1931.

Piceapollenites naeransus Mathur & Mathur, 1969

Pl. 38, fig. 2

Diagnosis (*after Mathur & Mathur, 1969*) — Lateral oblique view. Grains bilaterally symmetrical, two winged. Wings smaller than the body, 112×42 μm in size with microfoveoreticulate thickenings at the inner side of the exine, lumina medium-sized. Body 112×56 μm, microfoveolate. Exine 5 μm thick.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 11; size 112×42 μm; slide no. P8/2.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera.

Genus — *Palmaepollenites* Potonié, 1954

Type Species — *Palmaepollenites tranquillus* (Potonié) Potonié, 1951.

Palmaepollenites longicolpus Mathur & Mathur, 1969

Pl. 38, fig. 3

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, bilaterally symmetrical, 25 μm long and 20 μm broad, ellipsoidal, monocolpate. Colpus long, broad, tapering towards the ends. Exine thin, intragranulose, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 2; size 25×20 μm; slide no. P/2.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia and Naera.

Palmaepollenites medicolpus Mathur & Mathur, 1969

Pl. 38, fig. 5

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, bilaterally symmetrical, 29 μm long: 24 μm broad, oval, monocolpate. Colpus not extending from one margin to another, narrow. Exine thin, intragranulose, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 16; size 29×24 μm; slide no. P9/2.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia and Naera.

Genus — *Liliacidites* Couper, 1953

Type Species — *Liliacidites kaitangataensis* Couper, 1953.

Liliacidites minireticulatus Mathur & Mathur, 1969

Pl. 37, fig. 10

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, bilaterally symmetrical, ellipsoidal, 39×22 μm in size, monocolpate. Colpus long and thin. Exine thin with fine small reticulations.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 13; size 39×22 μm; slide no. P6/3.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Liliacidites medireticulatus Mathur & Mathur, 1969

Pl. 37, fig. 11

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, bilaterally symmetrical, 42 μm long and 22 μm broad, ellipsoidal, monocolpate. Colpus long, running from one end to the other end of the larger axis, broad, tapering towards the ends. Exine thin, reticulate, reticulations of medium size, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 14; size 42×22 μm; slide no. P11/2.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera and Baraia.

Genus — *Couperipollis* Venkatachala & Kar, 1969a

Type Species — *Couperipollis perspinosus* (Couper) Venkatachala & Kar, 1969a.

Couperipollis baculatus Venkatachala & Kar, 1969a

Pl. 38, fig. 4

Diagnosis (*after Mathur & Mathur, 1969a*) — Apolar, bilaterally symmetrical, 44 μm long, colpus long, running from one end of the larger axis. Exine, thick, baculate.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 15; size 44×26 μm; slide no. P6/3.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Genus — *Striamonocolpites* Mathur & Mathur, 1969

Type Species — *Striamonocolpites longicolpatus* Mathur & Mathur, 1969.

Striamonocolpites longicolpatus Mathur & Mathur, 1969

Pl. 37, fig. 12

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, bilaterally symmetrical, ellipsoidal, 46.5×24 μm in size, monocolpate. Colpus long and broad. Exine thin with thin striations.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 17; size 46.5×24 μm; slide no. P2/2.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Genus — *Cupuliferoipollenites* Potonié, 1951

Type Species — *Cupuliferoipollenites pusillus* Potonié, 1951.

Cupuliferoipollenites barainsus Mathur & Mathur, 1969

Pl. 38, fig. 6

Diagnosis (*after Mathur & Mathur, 1969*) — Equatorial view. Isopolar, radiosymmetric, amb oval, 17×12 μm, colpi three, long and thick, each with a germ pore, exine thin, psilate.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 18; size 17×12 μm; slide no. P/11/2.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

Genus — *Favitricolporites* Sah, 1967

Type Species — *Favitricolporites eminens* Sah, 1967.

Favitricolporites medireticulatus Mathur & Mathur, 1969

Pl. 38, fig. 7

Diagnosis (*after Mathur & Mathur, 1969*) — Isopolar, radiosymmetric, 41.6×36.7 μm in size, tricolporate. Colpi long and broad, provided with a pore. Exine about 2 μm thick with medium-sized reticulations.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 19; size 41.6×36.7 μm; slide no. P20/1.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia and Naera.

Genus — *Graminidites* Cookson, 1947

Type Species — *Graminidites media* Cookson, 1947.

Graminidites protrudus Mathur & Mathur, 1969

Pl. 38, fig. 8

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, radiosymmetric spherical, 38.5 μm in diameter, monoporate. Pore slightly protruding, psilate. Exine 1.5 μm thick, almost psilate with very faint reticulate texture, pale yellow.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 20; size 38.5 μm; slide no. P3/1.

Type Locality — Naera, Pliocene, Kachchh.

Occurrence — Naera and Baraia.

Genus — *Polyporina* (Naumova) Potonié, 1950

Type Species — *Polyporina multistigmosa* (Potonié) Potonié, 1960.

Polyporina mediporus Mathur & Mathur, 1969

Pl. 38, fig. 9

Diagnosis (*after Mathur & Mathur, 1969*) — Apolar, radiosymmetric, spherical, 22.5 μm in diameter, polyporate. Pores almost circular, medium sized, not equatorially distributed. Exine *ca.* 1.5 μm thick, tegillate, brownish yellow.

Holotype — Mathur & Mathur, 1969, pl. 2, fig. 21; size 22.5 μm; slide no. P10/2.

Type Locality — Baraia, Pliocene, Kachchh.

Occurrence — Baraia.

GENERAL REMARKS

The Lower Eocene deposit exhibits the maximum number of spore-pollen species. The total number of species of this period is 113, of them 83 species belong to angiosperms and the rest 30 to pteridophytes. The presence of thick lignite in Lower Eocene also corroborates that during this period there was luxuriant vegetation. Middle Eocene and Palaeocene have 89 and 87 species respectively. In Palaeocene, the total pteridophytic spore species are 30 but in Middle Eocene it is reduced to 21. On the contrary, angiospermic species are more in Middle Eocene (68) than in Palaeocene (57). Oligocene and Miocene witness the gradual decrease in plant population. In Oligocene, 40 species are found when in Miocene only 28 species are encountered. In Oligocene spore and pollen population is more or less balanced. Besides the angiosperms, one species of gymnosperm also appears in the scene. During Miocene, only 3 angiospermic pollen species are observed but 9 gymnospermic pollen are found. This is the highest representation of gymnosperms in the Tertiary sediments of Kachchh. Spore population is more or less steady and it is represented by 16 species, of which six belong to aquatic ferns (Text-fig. 23A, B).

The gradual decrease of spore-pollen species from Eocene onward probably points out that the condition was becoming inhospitable for the higher plants. This is evidenced by the presence of only 3 species of angiosperms in Miocene. The 9 species of gymnospermic pollen which have been recorded were perhaps not growing in Kachchh. The elimination of these species as outside elements from the assemblage makes it more poorer (Text-fig. 24).

COMPARISON OF PALYNOLOGICAL ASSEMBLAGES OF KACHCHH WITH OTHER ASSEMBLAGES

Matanomadh Formation — The end of the Mesozoic Era witnessed a general sinking of the major parts of eastern and western India where the oldest Tertiary rocks were deposited. The Lower Member of Matanomadh Formation was deposited on the trap and mostly consists of laterites, lithomargic clay and trap wash. This member did not yield any miospore and has been designated as Barren zone. This zone may perhaps be equated with *Proxapertites crassimurus* Cenozone of Cherra Formation by Dutta and Sah (1970), *Proxapertites* (*Assamialetes*) *emendatus* Cenozone of Tura Formation by Sah and Singh (1974), *Proxapertites crassimurus* Cenozone of Mikir-North Cachar hills by Sah and Mehrotra (manuscript) and *Proxapertites operculatus* Cenozone of Bengal Basin by Baksi (1972) and Deb (1976) and *Proxapertites hammenii* Cenozone of Cauvery Basin by Venkatachala and Rawat (1972, 1973).

Dandotiaspora dilata Cenozone broadly resembles *Araliaceoipollenites reticulatus* Cenozone of Cherra Formation by Dutta and Sah (1970), *Dandotiaspora telonata* Cenozone of Tura Formation by Sah and Singh (1974), *Dandotiaspora dilata* Cenozone of Mikir-North Cachar hills by Sah and Mehrotra (manuscript) and *Proxapertites cursus* Cenozone by Baksi (1972) and Deb (1976). The presence of *Dandotiaspora dilata* in good percentage in all the regions marks this cenozone. The other important species of the cenozone are, however, slightly different. In Cherra Sandstone, *Araliaceoipollenites reticulatus*, *A. psilatus*, *Droseridites parvus*, *Corrugatisporites formosus*, *Dandotiaspora telonata* and *Lycopodiumsporites palaeocenicus* are very common in this cenozone, while they are absent in Kachchh. In Tura Formation, *Dandotiaspora telonata*, *Proxapertites assamicus*, *Proxapertites* (*Assamialetes*) *emendatus* and *Foveotriletes palaeocenicus* are found in good percentage, whereas in the present zone they are not so common. In Bengal Basin, *Monocolpopollenites lipidus*, *Sapoteceoidaepollenites granulatus*, *Paleocaesalpiniaceaepollenites eocenicus* and *Trilatiporites sellingi* are also commonly found.

Couperipollis kutchensis Cenozone broadly resembles *Proxapertites* (*Assamialetes*) *dubius* Cenozone of Lakadong Sandstone by Dutta and Sah (1970), *Palmidites plicatus* Cenozone of Tura Formation by Sah and Singh (1974), *Monocolpopollenites* Zone of Baksi (1972) and Deb (1976), *Psiladiporites hammenii* Cenozone of Cauvery Basin by Venkatachala and Rawat (1972, 1973). In *Proxapertites* (*Assamialetes*) *dubius* Cenozone, besides the well representation of different species of *Couperipollis*, *Dandotiaspora dilata* and *D. telonata* are also found in good number. In *Palmidites plicatus* Cenozone, *Palmidites plicatus*, *P. maximus*, *Dandotiaspora dilata*, *Lycopodiumsporites palaeocenicus* and *Foveotriletes palaeocenicus* are also common. In *Monocolpopollenites* Zone, *Couperipollis* first appears and *Monocolpopollenites lepidus*, *Proxapertites operculatus* are abundant. In *Psiladiporites hammenii* Cenozone, *Psiladiporites hammenii* and *Cupanieidites cauveriensis* contribute in good percentage.

The Sponge spicule zone is not comparable to any of the known palynological assemblages as in others it is based on spores and pollen grains.

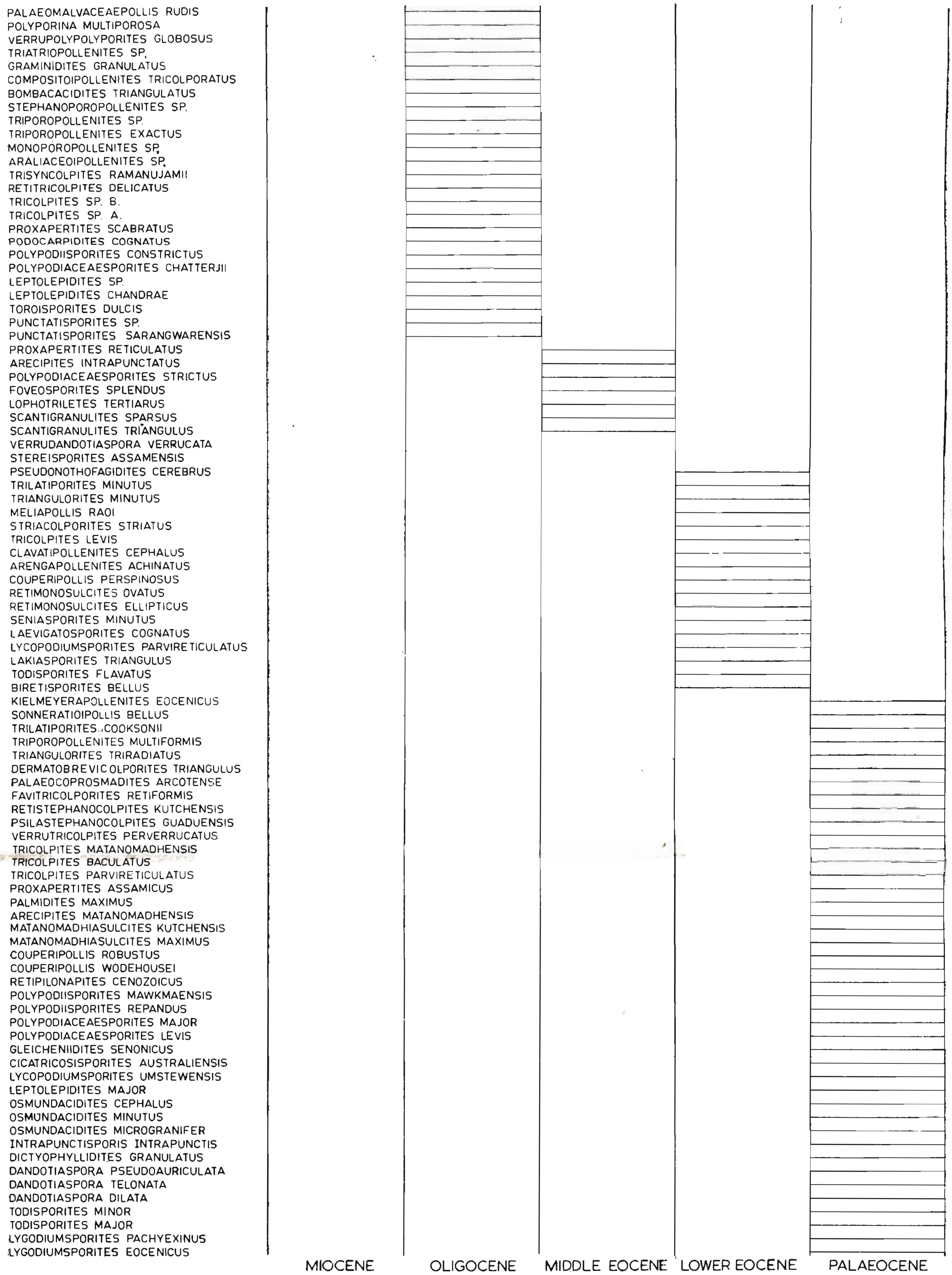
Naredi Formation — *Lakiapollis ovatus* Cenozone represents the lower part of this formation and is more or less comparable to *Proxapertites assamicus* Cenozone of Tura Formation by Sah and Singh (1974), *Palmaepollenites eocenicus* Cenozone of Mikir and North Cachar hills by Sah and Mehrotra (manuscript) and *Trilatiporites biswasii* Zone of Baksi (1972). It does not resemble much *Anacolosidites trilobatus* zone of Venkatachala and Rawat (1972, 1973). *Proxapertites assamicus* Cenozone like *Tricolpites reticulatus* subzone has good representation of *Proxapertites* but in Tura Formation, *Cicatricosisporites macrocostatus*, *Polypodiisporites oligocenicus*, *Foveotriletes palaeocenicus* and *Lycopodiumsporites palaeocenicus* are also commonly encountered. *Palmaepollenites eocenicus* Cenozone has many species of microplankton of the genera *Polysphaeridium* and *Oligosphaeridium*. *Palmaepollenites* is also well-represented in this cenozone. *Trilatiporites biswasii* zone is distinguished from this zone by the presence of *Monocolpopollenites lepidus*, *Cinnamomumipollis pulcher*, *Monoporites minutus*, *Retidiporites magnus* and *R. magdalensis*.

Lygodiumsporites lakiensis Cenozone of the upper part of Naredi Formation does not closely resemble any of the cenozones proposed by Dutta and Sah (1970), Sah and Singh (1974), Sah and Mehrotra (manuscript), Baksi (1972), Deb (1976) and Venkatachala and Rawat (1972, 1973).

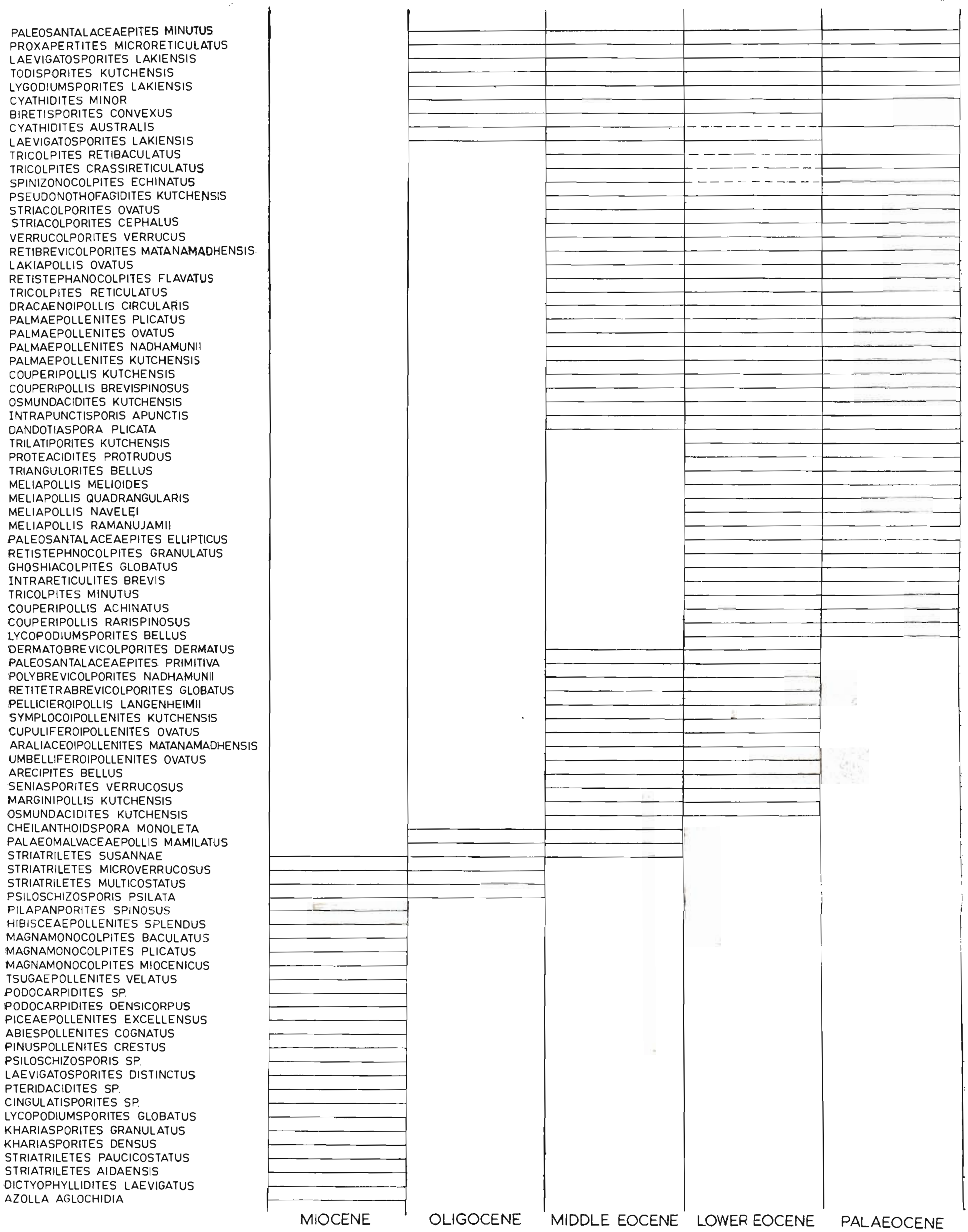
Harudi Formation — This formation exposed around Harudi is well represented by the *Proxapertites microreticulatus* Cenozone. This cenozone, however, does not closely resemble to those of Siju, Garampani and Sylhet Limestone formations. *Couperipollis* and *Cyathidites* though are found in good percentage in Harudi but the genera *Retipilonapites*, *Palmidites* and *Polycolpites* which are also found in good percentage in Siju are not at all found in this formation. The Garampani Limestone assemblage comprises microplanktons only whereas the present cenozone is devoid of this kind of fossil. Surprisingly, the Sylhet Limestone palynological assemblage recorded from the Bengal Basin does not exhibit any similarity with this cenozone.

Rataria Bore-core — The behaviour of the palynological species in the bore-core is rather inconsistent perhaps due to different depositional environment. The percentage of *Striatriletes susannae* is more than any of the species in the bore-core. However, the assemblage has been designated as *Cheilanthoidspora enigmata* Cenozone because in Miocene where the former species is more abundant, a cenozone has been proposed after it. This zone does not show close similarity to those known form the Rewak and Kopili formations of Meghalaya, Assam and Bengal basin. The presence of *Striatriletes* (*Cicatricosisporites*) both in Kopili Formation of Khasi and Jaintia Hills and in Rataria is, however, significant.

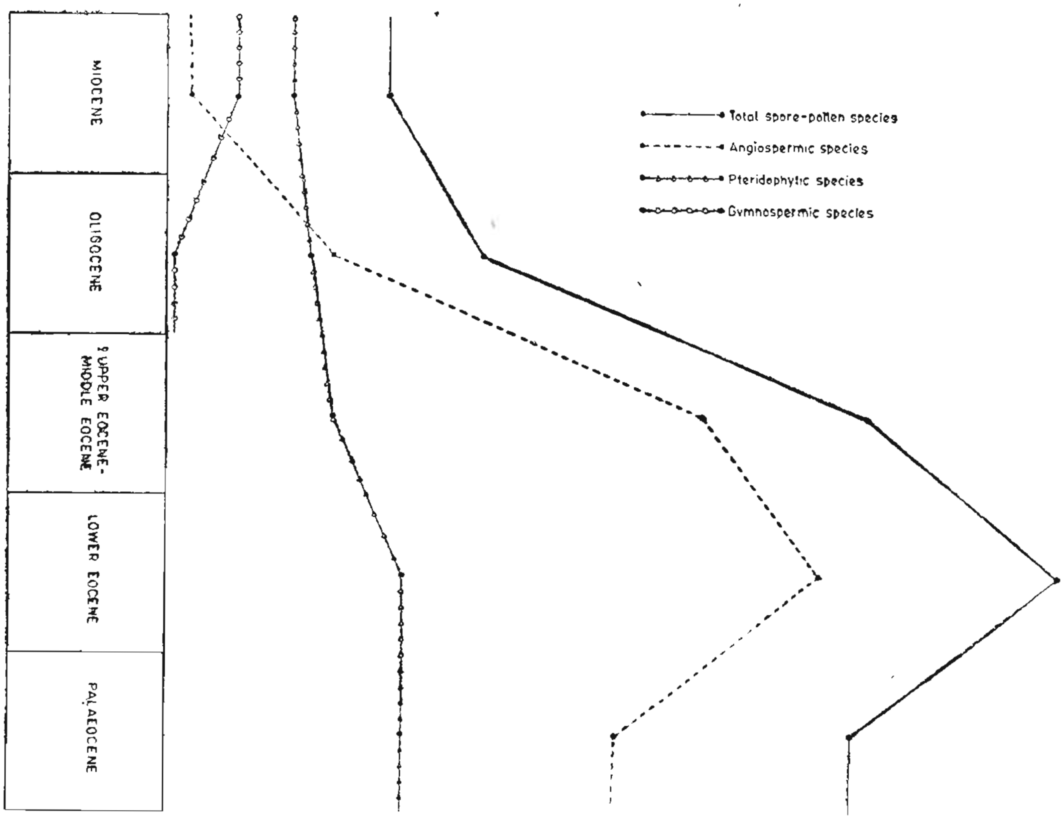
Maniyara Fort Formation—The assemblage is not much comparable to the Simsang Palynological Zone III of Baksi (1962, 1965) from the South Shillong Plateau except the occasional presence of Parkeriaceous spores. The other characteristic



TEXT-FIG. 23A — Showing the presence of different spore-pollen species from Palaeocene to Miocene in Kachchh.



TEXT-FIG. 23B — Showing the presence of different spore-pollen species from Palaeocene to Miocene in Kachchh.



TEXT-FIG. 24 — Showing the behaviour of different spore-pollen species from Palaeocene to Miocene sediments in Kachchh.

forms like abundance of *Meyeripollis*, first appearance of striate-tricolpate pollen, very frequent occurrence of smooth *Leiotriletes*, presence of some granular pollen tetrads and frequent occurrence of monocolpate spinose pollen are not generally encountered in the present one.

The Bengal Palynological Zone IV proposed by Baksi (1972) for the Oligocene sediments of Bengal Basin embracing Burdwan and a part of Memari formations also does not show much similarities with the Oligocene of Kachchh. Baksi (1972) thinks that three palynological zones found in Assam during Oligocene are condensed into one in the Oligocene sediments of Bengal.

The Bengal Palynological Zone V of Baksi (1972) is of Miocene in age and does not show much similarity to the present assemblage because of its abundance of small tricolporate and triporate pollen and its first appearance of a few diagnostic pollen species assignable to *Barringtonia*, Polygonaccae and *Bauhinia*. The microplanktons recorded by Baksi (1972) from this zone are also different from the present one.

Khari Nadi Formation — Of the three cenozones two are mainly based on microplanktons and one on spores and pollen grains. *Operculodinium israelianum* Cenozone is the oldest and does not show much similarity with the Bhuban Formation of the Khasi and Jaintia Hills as it has *Simsangia magna*, *Hystrichosphaeridium spectabilis*, *Ovoidites rarus* and *Eximispora tuberculata*. *Striatriletes susannae* Cenozone somewhat resembles the Bokabil palynological assemblages recorded from the Khasi and Jaintia Hills and Tripura by the presence of good numbers of *Striatri letes* (*Magnastriatites*). However, *Polypodiisporites speciosus*, *Triporopollenites trique-*

trus, *Foveosporites rariformis*, *Eximispora tuberculata*, *Monosulcites perforatus*, *Tricolpites gracilis*, *Meyeripollis laudabilis* and *Triporopollenites rotundus* are not at all found in the Khari Nadi Formation. The Tipam Sandstone assemblage from the Upper Assam closely resembles this cenozone by the abundance of *Striatriletes* (*Cicatricosisporites*) *macrocostatus* and the presence of *Podocarpidites*. The Tipam Sandstone assemblage of Tripura is, however, quite different as it has *Lacrimapollis subcircularis*, *Favitricolporites prolificus* and *Ericipites quadratus* in good percentage.

In *Operculodinium centrocarpum* Cenozone microplankton and spores-pollen are well represented. This cenozone comes close to Pandua (Malta) assemblage of Bengal Basin by the good representation of bisaccate pollen. This assemblage is, however, devoid of microplankton genera found in Kachchh. The Girujan Clay assemblage of Upper Assam is not much comparable to the present one as most of the species are absent in this cenozone.

Botanical Affinities

The dispersed spores and pollen species hitherto described under artificial genera are very difficult to tag with the living ones. Most of Palaeocene-Eocene genera have either become extinct long back or some of the allied forms have migrated to some other continents. Many angiosperm genera produce indiscreet pollen making the task more difficult to identify them in the dispersed state. Besides, the difference in some of them is very subtle and likely to be undetected in fossil condition. The rich pteridophytic and angiospermic flora of India also stand on the way as it is impossible to have pollen slides of all those species to compare with the fossil ones. The pollen which seems to be characteristic of some extant genera could have been produced by other unrelated forms in the bygone days turning the endeavour to correlate with the living genera more speculative than elucidative. Still the temptation to trace the botanical affinites of some of the forms which are bestowed with distinct morphological characters led us to deal with the following discussion. Perhaps, future investigation would further improve on those suppositions and would throw better light on this interesting topic.

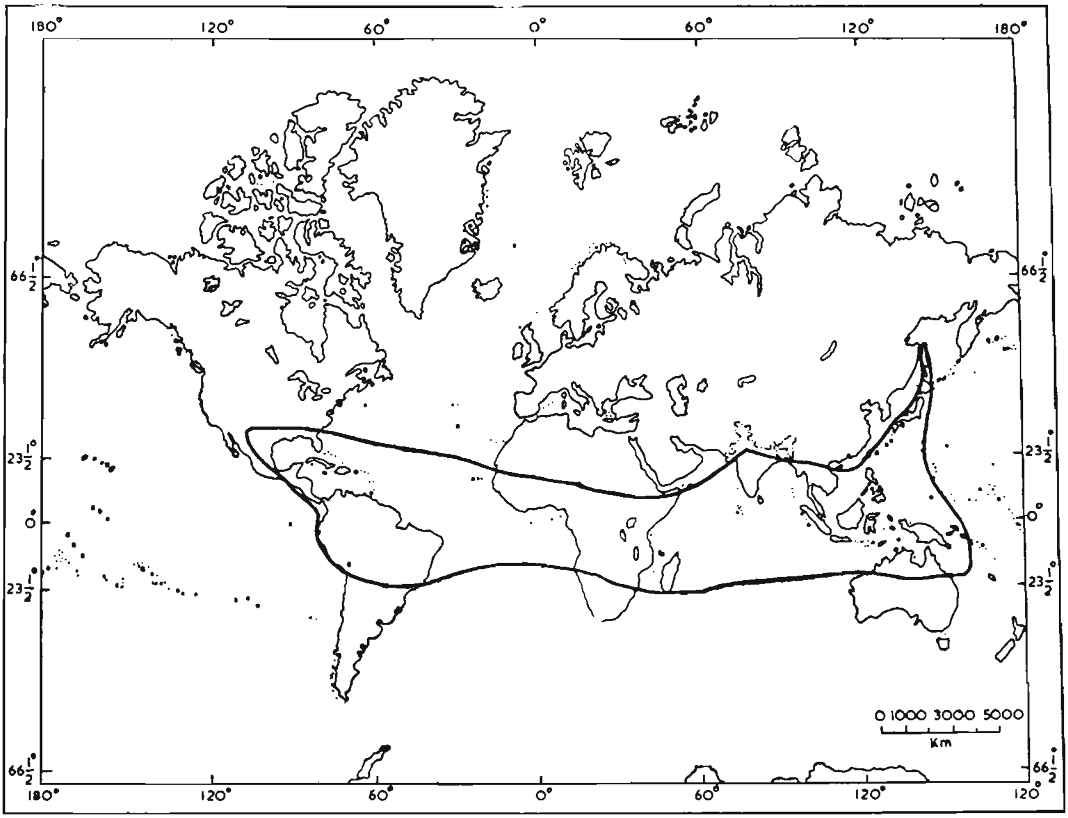
Parkeriaceae — *Ceratopteris* is the only genus of the family and its spores are so characteristic that it could be easily identified in the dispersed condition. Lloyd (1972) thinks that the genus constitutes 4 species, whereas Chowdhury (1973) thinks there are 7 species. The spores of all the species, however, exhibit more or less same morphological characters. This genus, in the opinion of Chowdhury (1972), is found in Dehradun and Haldwani in Uttar Pradesh, Gujarat except Kachchh, Maharashtra, Goa, Kerala, Tamil Nadu, Orissa, Bihar, West Bengal and Assam. Hooker and Baker (1868) reported its occurrence throughout the tropics in quiet water (Text-fig. 25).

The genus *Striatriletes* which accommodates the dispersed fossil spores of *Ceratopteris* is found from Middle-Upper Eocene in India. During Oligocene and Miocene it shows maximum development not only in Kachchh but also in Assam and Meghalaya. In Pliocene, its representation appreciably dwindles down and in some sediments it almost disappears.

Since *Ceratopteris* grows only in a limited habitat on alluvial plain, swamp and near the coast as an aquatic form in tropical region, the preponderance of *Ceratopteris* spores during Oligocene and Miocene in Kachchh might be explained in this light. From Pliocene onwards, Kachchh faced a dry climate resulting the extinction of *Ceratopteris* from this region.

Lycopsida — The paucity of *Lycopodium*-like spores in the Tertiary deposits of Kachchh is very striking. In Palaeocene and Eocene, *Lycopodiumsporites* is represented by two species and in Miocene, by one species only. In north-east India, on the other hand, *Lycopodiumsporites* is very well represented particularly in the Lower Tertiary deposits. This anomaly needs some explanation.

The lycopodiaceous plants in India are confined to 27 species comprising the genera *Huperzia*, *Phlegmariurus*, *Palhinhaea*, *Lycopodium* and *Diphasium*. Of them, the species belonging to the genera *Diphasium*, *Palhinhaea* and *Lycopodium* (*sensu stricto*) are generally restricted to the subalpine forest. *Lycopodium clavatum* and *Palhinhaea cernua* are, however, found from alpine to subtropical climatic zones.



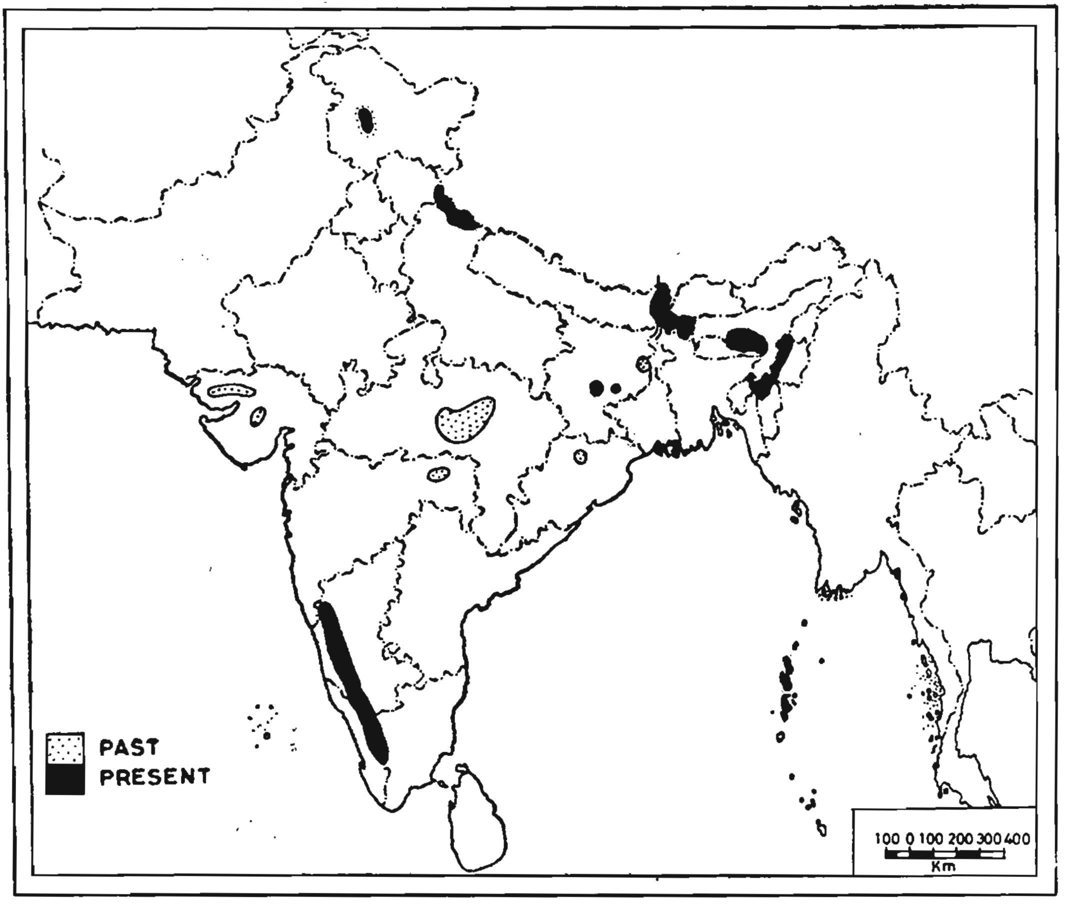
TEXT-FIG. 25 — Map showing the present day distribution of *Ceratopteris* Brong. (Parkeriaceae).

Perhaps from the beginning of Tertiary, Kachchh never enjoyed a subalpine climate and there by hindering the development of lycopodiaceous plants in the region. The scanty specimens assignable to *Lycopodiumsporites* in all likelihood came from a long distance (Text-fig. 26).

Lycopodiumsporites umstewensis Dutta & Sah (1970) recorded from Assam as well as Kachchh does not belong to *Lycopodium clavatum* as professed by Dutta and Sah (1970) because the spores of latter exhibit very broad reticulation and this character is absent in *L. umstewensis* (see Kar & Mandal, 1983).

Amaranthaceae-Chenopodiaceae — The pollen grains of these two families are hardly could be differentiated and so they would be dealt here together. The pollen grains of these two families have been provisionally kept in *Polyporina*. It is interesting to note that oldest Amaranthaceae-Chenopodiaceae pollen record is from the Maestrichtian of Canada by Srivastava (1962). Kedves (1971) also recorded it from the Maestrichitian of Egypt. Nichols and Traverse (1971) recorded this type of pollen from the Palaeocene of U.S.A., China and Onyike. Sowunmi (1978) reported the same type of pollen from the Eocene of Nigeria.

The occurrence of this type of pollen from Australia as well as from India is from Oligocene onwards. Martin (1978) noted several types of Amaranthaceae-Chenopodiaceae pollen from the Oligocene. This kind of behaviour, in the opinion of Muller (1981), is probably due to the desiccation of the continent. It may be stated here that the pollen of these two families even from the beginning are encountered in the transitional environment between the continental and marine facies.



TEXT-FIG. 26 — Map showing the past and present day distribution of *Lycopodium* in India.

Clusiaceae : *Kielmeyera* — *Kielmeyerapollenites* initially instituted by Sah & Kar (1974) from the Palana lignite of Rajasthan was also eventually recorded from the Palaeocene of Kachchh. *Kielmeyerapollenites* closely resembles the pollen grains of *Kielmeyera* in shape, size, tetrahedral tetrads and the position and number of apertures in the tetrads. The exine thickness and the nature of ornamentation is also matching each other.

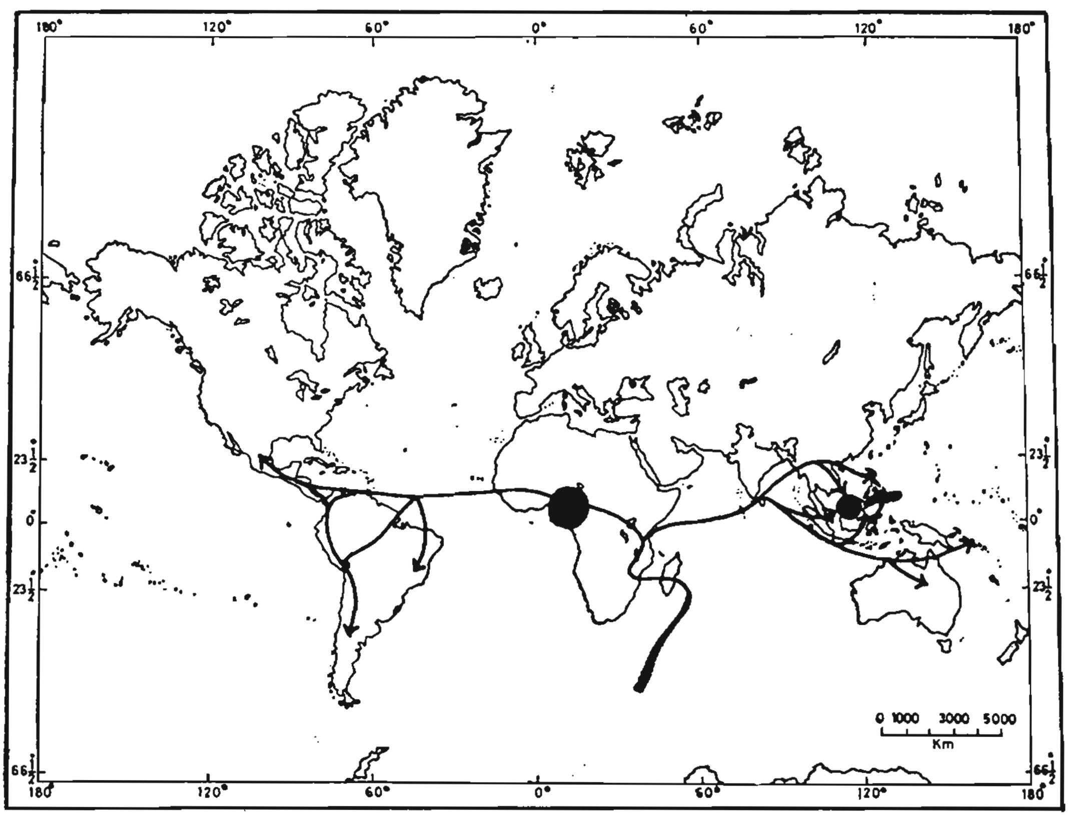
It is interesting to note that *Kielmeyera* is no more found in India though some other genera of the family, viz., *Calophyllum* and *Garcinia* are found in north-eastern parts and Western Ghats of India. The former is confined to the tropical forest of Brazil in the present day. *Calophyllumpollenites* Sah & Kar (1974) was originally instituted to accommodate disperse pollen of *Calophyllum*; but Muller (1981) kept the genus in pending.

The occurrence of *Kielmeyera* pollen in the Lower Tertiaries of India and its present day distribution in tropical Brazil poses many problems of plant migration and palaeogeography. It may be recalled here that Sahni (1931) described *Rodeites*— a water fern from the Deccan Intertrappean beds of Madhya Pradesh, which closely resembles the extant *Regnillidium* also found in Brazil at present. Perhaps from Africa, these plants migrated towards India and Brazil. They faced extinction subsequently in India due to inhospitable condition but thrived and flourished in Brazil in congenial environment.

Bombacaceae — The family Bombacaceae, in the opinion of Croizat (1952), is a forbidding group from the taxonomic and nomenclatural view point but a very interesting one from the dispersal point. It contains elements of the shore and the hinterland right behind the shore. They are also observed in open forest not liable to inundation, forest which is occasionally inundated, swampy soils with a substratum of humus and sand and arid coast indicating perhaps that the family originated at the marine shore (Text-fig. 27).

The bombacaceous pollen is easily recognizable in the fossil state. Wolfe (1975, 1976) recorded this type of pollen from the Maestrichtian of U.S.A. Elsik (1968) also recorded *Bombacacidites* from the Palaeocene of Texas. Germeraad, Hopping and Muller (1968) also recorded this genus from the Palaeocene/Eocene transition of Nigeria; Stover and Partridge (1973) from the Lower Eocene of Australia; and Couper (1960) from Oligocene-Miocene of New Zealand. In India, this genus starts appearing only from the Oligocene.

Muller (1981) opines that the early distribution pattern of the genus seems to support Wolfe's hypothesis (1975) that the genus originated in the eastern part of North America and then to Africa. Croizat (1952), however, believes that *Bombax* has a centre of specialization in Nigeria and the bombacaceous *genorheitron* fared from the modern Indian Ocean to the New World over a classic line of migration which crossed Central Africa in the direction of the modern West Indies. He believes that this is the reason why



TEXT-FIG. 27 — Map showing the major dispersal trends in Bombacaceae (after Croizat, 1952).

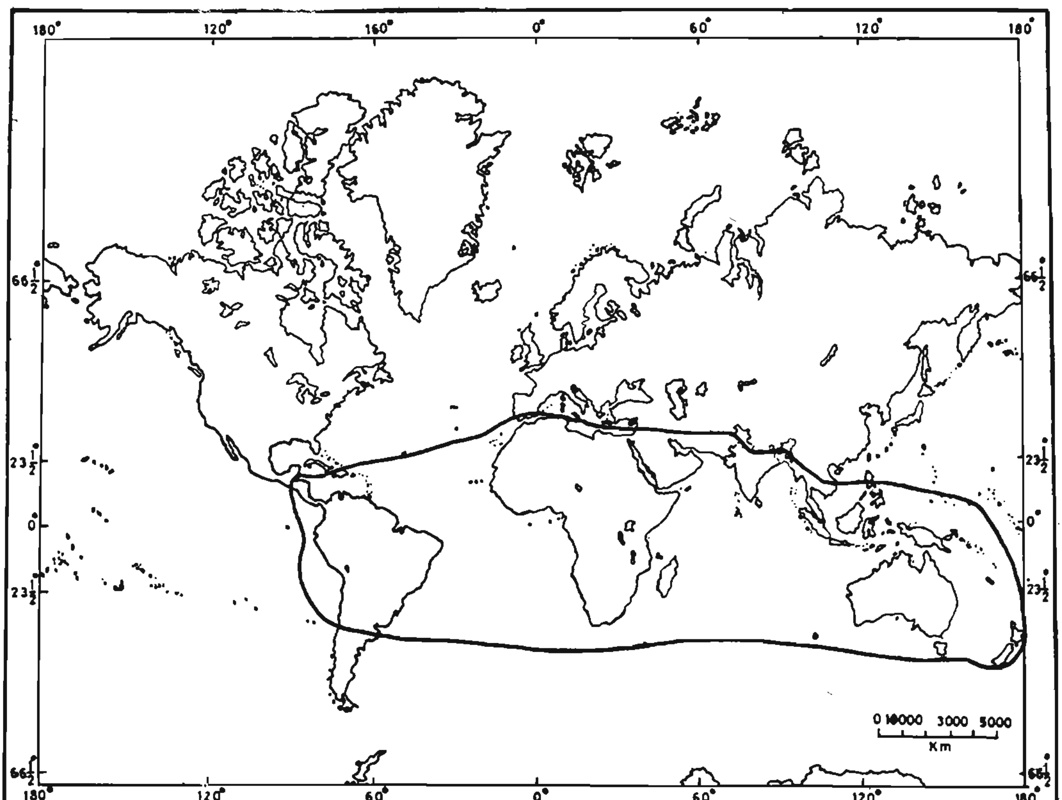
Nigeria shows so much speciation of *Bombax*.

Malvaceae — The family is represented here by 3 genera, viz., *Palaeomalvaceaepollis*, *Pilapanporites* and *Hibisceaepollenites*. Of these, *Palaeomalvaceaepollis* is found from Middle-Upper Eocene onwards while the other two are restricted to Oligocene and Miocene respectively. Croizat (1952) thought that Malvaceae originated in South America and the southern Atlantic and then migrated towards Europe.

Muller (1970) reported *Hibiscus* type of pollen from the Upper Eocene of Venezuela. He designated this as *Echiperiporites estelae*. Regali, Uesugue and Santos (1974a, 1974b) also reported the same type of pollen from the Upper Eocene of Brazil. Germeraad, Hopping and Muller (1968) reported Malvaceous pollen grains from the Oligocene of Africa while Hekel (1972) described it from Miocene of Australia.

Acaceae — Bentham (1875) revised the suborder Mimoseae and grouped *Acacia* into several divisions. Of them, *Vulgares* and *Gummiferae* types are generally encountered in the fossil state. Dhyansagar (1955) investigated the embryological features of Mimosaceae and placed *Acacia* below *Calliandra* and above *Pithecolobium* in the evolutionary ladder. Guinet (1969) studied in detail the pollen morphology of Mimosaceae and figured many extant *Acacia* pollen. He also tabulated the pollen characters of the polyads found in other families (Text-fig. 28).

The pollen assignable to *Acacia* has been referred as *Polyadopollenites* and found only in Oligocene and Miocene. Salard-Cheboldaeff (1978), however, recorded



TEXT-FIG. 28 — Map showing the major centres of distribution of *Acacia* in the present day.

Polyadopollenitesae vancampoae from the Upper Eocene of Cameron. Guinet and Salard-Cheboldaef (1975) also surveyed the fossil pollen referable to *Acacia*. The first record of *Acacia*-type of pollen encountered just below the boundary between Early and Middle Miocene in Australia is by Cookson (1954) and Martin (1978). Considering the present day concentration of *Acacia* in Australia this seems to be unusual. Croizat (1952) postulated that 'phyllodine' *Acacia* together with Proteaceae, Ericaceae, Euphorbiaceae and Asclepiadaceae evolved in Australia or adjacent region because they have often moulded them out in time in the shape of taxonomic groups wholly of their own.

Caesalpiniaceae — The pollen of *Caesalpinia* are tricolporate, occasionally margocolporate and abundantly found not only in Kachchh but also in Assam, Meghalaya and other parts of India from the Lower Eocene onwards (Baksi, 1972, 1973, 1974, Sah & Dutta, 1966, Dutta & Sah, 1973) etc. *Paleocaesalpiniaceaepites* and *Margocolporites* generally accommodate *Caesalpinia* pollen in fossil state in India.

In Kachchh, *Margocolporites* is well-represented in Lower Eocene by the presence of three species, viz., *Margocolporites tsukadai*, *M. sitholeyi* and *M. sahnii*. Besides, *Foveotricolporites* and *Pilatricolporites* may also belong to *Caesalpinia* type. *Margocolporites*, however, is poorly represented in Oligocene and Miocene sediments. *Trisyncolpites* reported from the Oligocene of Kachchh closely resembles the living pollen of *Poinciana pulcherrima* of Eucaesalpiniaceae. The pollen of this species are also trisyn-margocolporate, baculate and punctitegillate. Interestingly enough, this species even today grows in India.

Muller (1981) noted that the oldest fossil occurrence of *Caesalpinia* and at the same time its maximum development with greatest variability are found in the Lower Tertiaries of India. This led him to advocate that India might have been the cradle of that part of Caesalpiniaceae which ultimately gave rise to the highly distinctive *Caesalpinia*-type of pollen.

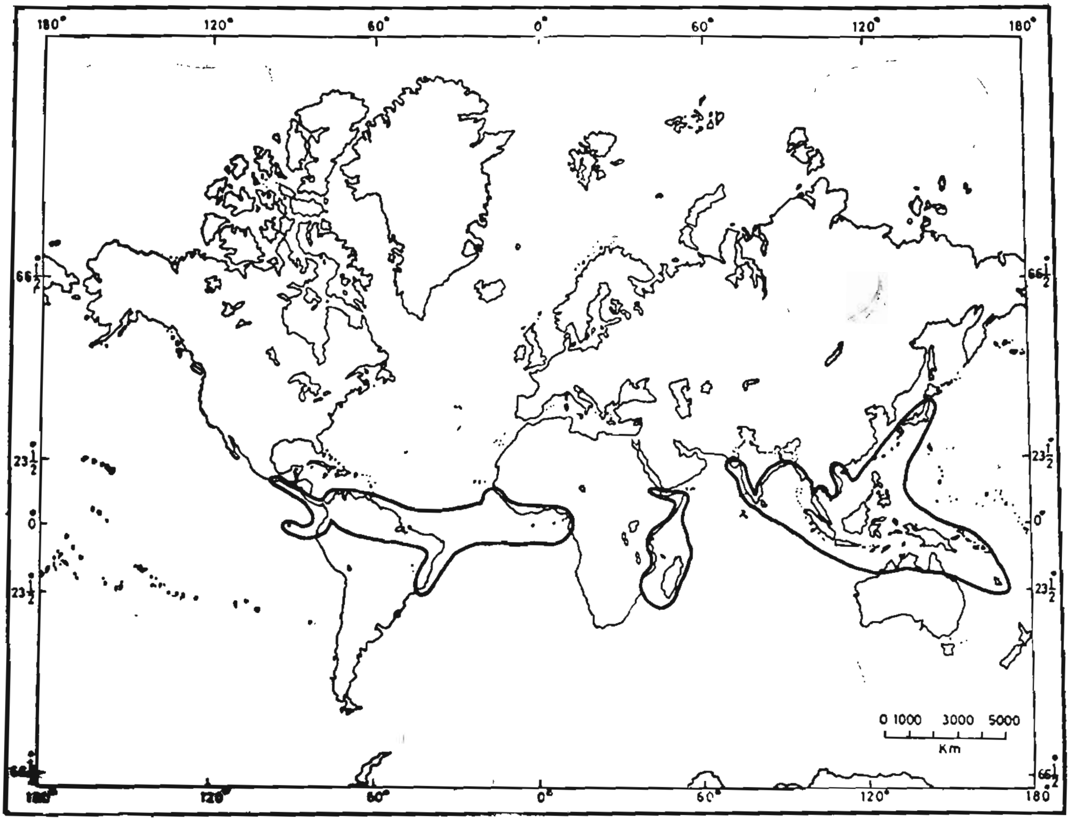
Rhizophoraceae — *Rhizophora* is the most important genus of this family and it also plays an important role as a pioneer to establish the mangrove vegetation. *Paleosantalaceaepites* Biswas emend. Dutta & Sah (1970) is supposed to be fossil pollen of *Rhizophora-Bruguiera* type. The genus *Paleosantalaceaepites* is frequently encountered in Palaeocene, Eocene and Oligocene sediments in Kachchh. According to Muller and Caratini (1977) an abundance of fossil *Rhizophora* pollen in sediments would indicate a humid, tropical, lowland climate because the genus thrives along river and estuary banks on unconsolidated clayey to sandy soils in a marine to brackish environment. The specific delimitation of *Rhizophora* on the basis of pollen character is very difficult to distinguish (Text-fig. 29).

Kuyl, Muller and Waterbolk (1955) noted the occurrence of *Rhizophora* pollen in great abundance from the Oligocene onwards in Venezuela, Nigeria and Malesian area. Wijmstra (1971) reported abundance of *Rhizophora* pollen from early Miocene in Guiana.

In India, the family Rhizophoraceae is mostly concentrated in Sunderban, Krishna and Godavari deltas, Pichavaram and in isolated patches on the western coast. Tissot (1980) recorded the disappearance or rapid extinction of some species of mangroves from the coastal plain of South India. In general this is true for all the mangroves vegetation in India.

Lecythidaceae-Barringtonia—The fossil *Barringtonia* pollen is easily distinguished by its characteristic reticulate border around the mesocolpia and polar thickenings of the colpate ridges. The fossil *Barringtonia* pollen assignable to *Marginipollis* is recorded from the Lower Eocene of Borneo (Muller, 1981). In India, it is also found from the Lower Eocene and continues up to the Oligocene. The occurrence of fossil *Barringtonia* pollen is, however, always rare in Kachchh sediments (Text-fig. 30).

Croizat (1952) designated Barringtoniaceae along with Bombacaceae, Dipterocarpaceae and Tiliaceae as 'near mangroves' because these plants of the hot tropical lowlands are competent to stand for long period of drought interrupted by torrential rains, and possibly also, times of active root - submersion. Barringtonieae, Combretodendreae and Foetidieae are common to Asia and Africa and extending even up to Polynesia and Hawaii. Craterantheae and Napoleoneae are, however, restricted to western Africa.



TEXT-FIG. 29 — Map showing the present day distribution of the genus *Rhizophora* (Rhizophoraceae) (after Muller & Caratini, 1977).

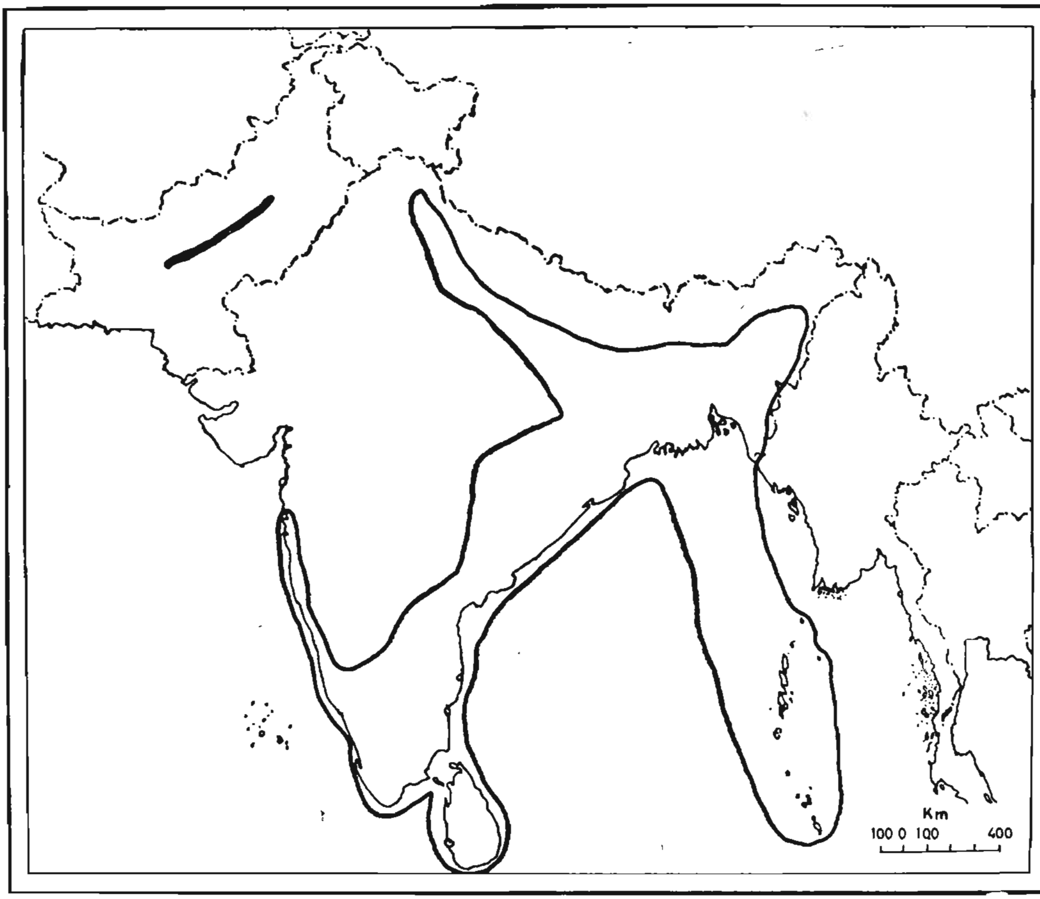
Barringtonia is a quite large genus with abundance of narrow ranging species or similar forms. In Indian subcontinent, *B. asiatica* is restricted to Andaman Islands; *B. racemosa* in Ceylon, South India, Andaman and Nicobar Islands; *B. actuangula* in Afghanistan, Ceylon, India, Bangla Desh and Burma. The latter is a deciduous tree occurring mostly in sub-Himalayan tract, Assam, West Bengal, Bihar, Central and Southern India and also in the Western Coast of India.

Meliaceae — Muller (1981) observed that due to lack of detailed study of Meliaceous pollen, it is rather difficult to distinguish different types of pollen in the family. This also makes the task difficult to recognize them in fossil condition. Muller (1970) thought that *Dysoxylum* described by Couper (1960) might be a Meliaceous pollen, this has, however, considered as doubtful by Mildenhall (1980).

Sah and Kar (1970) proposed *Meliapollis* to include the fossil pollen of Meliaceae and particularly of the genus *Melia*. The pollen assignable to *Meliapollis* are very common both in Palaeocene and Eocene in Kachchh. They are virtually absent in Oligocene and Miocene.

Ctenolophonaceae — *Ctenolophon* pollen for their characteristic exinal thickening can easily be recognized in the dispersed state. Germeraad, Hopping and Muller (1968) recognized *Ctenolophon engleri* type (*Ctenolophonidites costatus*), *Ctenolophon* type A (*Ctenolophonidites lismae*), *Ctenolophon parvifolius* type (*Retistephanocolpites williamsi*).

In Palaeocene-Lower Eocene of Kachchh, *Ghoshiacolpites* broadly resembles the



TEXT-FIG. 30 — Map showing the distribution of *Barringtonia acutangula* in Indian subcontinent.

Ctenolophon pattern of exinal thickening. Besides, *Ctenolophonidites costatus* and *Ctenolophonidites* sp. are present in Lower Eocene. Dr Thanikaimoni (personal communication) thinks that *Ctenolophonidites* is colporate and not colpate as envisaged by van Hoeken-Klinkenberg (1966). Muller (1981) thinks that the pollen described by Baksi (1962) as *Pentacolpites*, *Octacolpites* and *Polycolpites* from Assam belong to *Ctenolophonidites*. He also included the forms reported as *Stephanocolpites octacolpoides*, *Retistephanocolpites coromandelensis* and *Polycolpites pedaliaceoides* by Venkatachala and Rawat (1972) to this genus. Muller (1981) also opines that from India *Ctenolophon* type of pollen disappears in the post-Eocene. However, Kar and Jain (1981) recorded *Ctenolophonidites* from the Miocene sediments around Quilon and Varkala, Kerala Coast, South India.

Germeraad, Hopping and Muller (1968) think that *Ctenolophon* probably originated in Africa during Upper Cretaceous, followed by an early differentiation into an *engleri* and *parvifolius* pollen types, the *engleri* type remained almost throughout the Tertiary and Quaternary in Africa. This type migrated to South America in Palaeocene and faced extinction within a short time. The *parvifolius* type reached Malesia through India in Eocene but could not survive in Africa.

Polygalaceae — The pollen grains of Polygalaceae are colporate and the apertures are generally more than four, the pores are lalongate and sometimes fused to form synorate condition. This provides a peculiar appearance by which the pollen of this family in dispersed condition can be easily distinguished.

Sah and Dutta (1966) first recorded *Polygalacidites clarus* from the South Shillong Plateau, Palaeocene, Meghalaya. *Polygalacidites* is rare in Kachchh and *P. gujaratensis* occurs only in the Lower Eocene. Doubinger and Chotin (1975) described *Psilastephanocolporites fissilis* from the Palaeocene of Chile which according to Muller (1981) appears to be the oldest record of Polygalaceae. This species is very much similar to the pollen of *Monnina angustifolia* described by Heusser (1971). Leopold and Macginitie (1972) described Polygalaceous pollen from the Middle Eocene of U.S.A. resembling the *Securidaca bombacopsis* type (see Muller, 1981).

Alangiaceae — Muller (1981) already commented that the pollen assigned to *Pellicieroipollis* Sah & Kar (1970) could be the pollen of *Alangium*. Morley (1982) made an intensive study of the pollen grains attributable to *Alangium* from the Tertiary of Malaysia. He observed that the characters considered as advanced by Reitsma (1970) were already present in Middle-Upper Eocene sediments of Malaysia. Analysing the past and present distribution of *Alangium*, Morley (1982) came to the tentative conclusion that to begin with *Alangium* was solely a tropical megatherm genus, evolving in South East Asia at a fairly early stage and then dividing into two separate evolutionary lines—one tropical characterized by section *Conostigma* and the other subtropical to temperate, comprising section *Marlea*. This would explain the fact why *Marlea* is scantily represented in South East Asian Tertiary. Eyde, Bartlett and Barghoorn (1969) opined that since all *Alangium* fossil record from outside South East Asia belong to the section *Marlea* it is indicative of the probability that sections other than *Marlea* never extended far beyond their present ranges (Text-fig. 31).

In Kachchh, fossil pollen closely comparable to *Alangium* is frequently found in Lower-Middle Eocene. At present the genus is confined to East Africa including the northern part of Madagascar, major part of India, Ceylon, Burma, Thailand, south-eastern part of China and Malaysia.

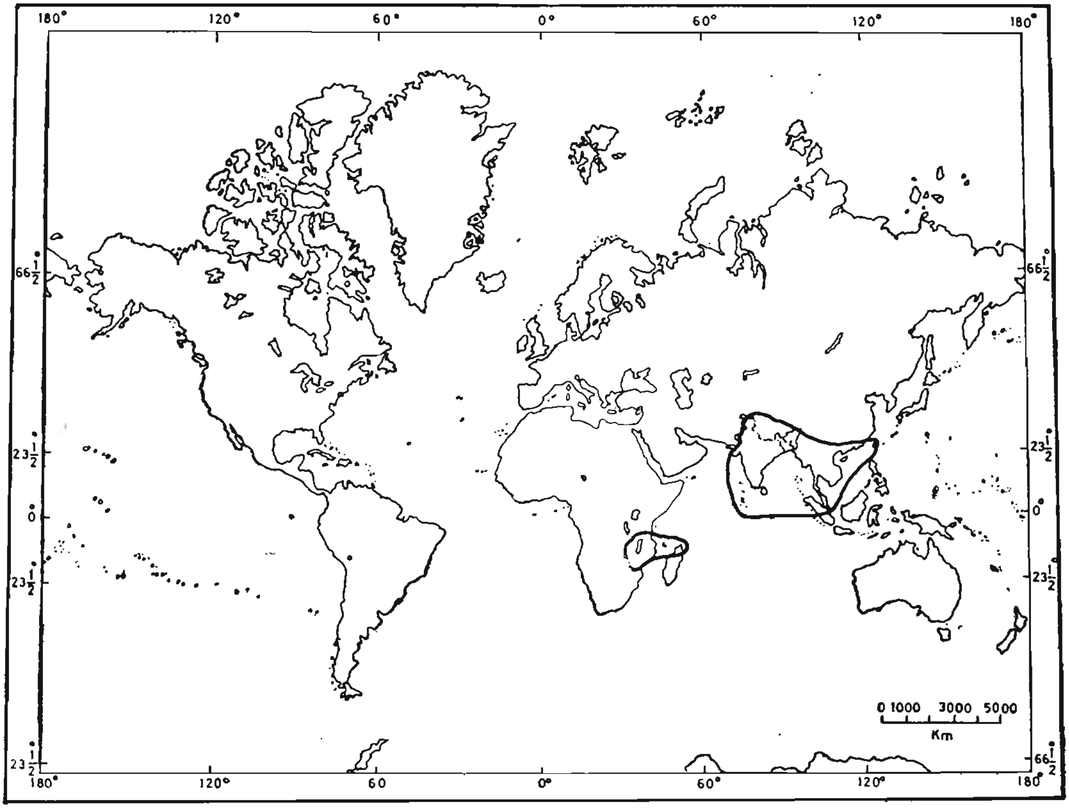
Apiaceae (*Umbelliferae*) — Cerceau-Larrival (1962) distinguished five main groups in Apiaceae on the basis of pollen morphology. These are *Hydrocotyle* type, *Bupleurum* type, *Sanicula* type, *Echinophora* type and *Selinum* type. Of these, only *Selinum* is recorded from Pliocene and the rest are from Eocene onwards.

Apiaceae is represented here by *Umbelliferoipollenites ovatus* and *U. constrictus*. According to Muller (1981) these two species belong to *Echinophora* type and compare most closely with the pollen of *Echinophora* (Endressioideae). Gruas-Cavagnetto (1978) recorded Apiaceous pollen assignable to *Hydrocotyle* type from the Paris Basin. He also recorded *Sanicula* type of pollen from the Upper Eocene of England. Van Campo (1976) also reported this type of pollen from the Upper Miocene of Spain and Diniz (1969) from the Pliocene of Portugal.

Umbelliferoipollenites is quite common in the Eocene of Kachchh but is almost absent in lower and upper horizon. *Parumbelliferoipollis* which is also assignable to Apiaceae is restricted to Middle Eocene. In the Lower Tertiary sediments of Assam and other region, Apiaceous pollen is not well represented.

Asteraceae (*Compositae*) — Germeraad, Hopping and Muller (1968) grouped the dispersed pollen of this family into *Tubuliflorae*, *Liguliflorae* and *Ambrosia* types. Skvarla, Turner, Patel and Tomb (1977) studied the pollen morphology of this family in detail and commented that on the basis of columellate structure *Tubuliflorae* and *Liguliflorae* can further be subdivided. According to Germeraad, Hopping and Muller (1968) the *Tubuliflorae* type seems to be the oldest and the most widespread of the three Asteraceae pollen types.

In Kachchh, Asteraceous pollen grains assignable to *Liguliflorae* type and named as *Liguliflorаedites* have been recorded from the Lower Eocene. The other type has been kept in *Compositoipollenites* and recovered from the Oligocene. Both the types are, however, very rare. Kuyl, Muller and Waterbolk (1955) opined that on the basis of palynological record, Asteraceae emerges as one of the youngest developments within the angiosperms. But the presence of *Liguliflorae* type of pollen from the Lower Eocene indicates that it is not so young as they postulated.



TEXT-FIG. 31 — Map showing the distribution of the genus *Alangium* at present.

Germeraad, Hopping and Muller (1968) observed that Asteraceae though widespread in the present day tropical countries are more common in open vegetation types, such as savannah or higher montane vegetation than in the closed lowland rain forest. That perhaps explains the reason for the scanty representation of Asteraceae in Kachchh.

Poaceae (*Gramineae*) — The Poaceae pollen in the fossil state has been designated as *Monoporopollenites*, *Graminidites*, *Sparganiaceaepollenites*, etc. The pollen referable to this family has been recorded here as *Monoporopollenites* from the Lower Eocene and Oligocene. *Graminidites granulatus*, another grass pollen, has also been described here from Oligocene. The grass pollen in Kachchh is very rare and it seems that at least up to Miocene they were not habitating this region in large numbers.

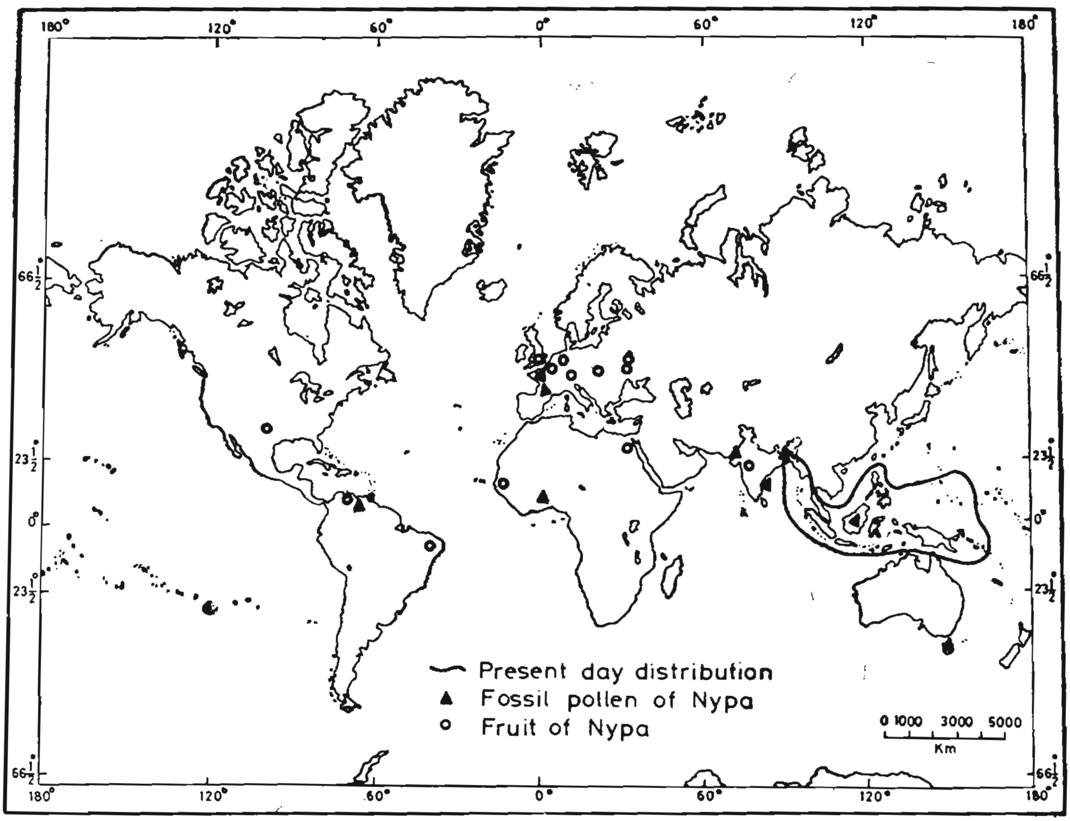
It may be mentioned here that Mathur and Mathur (1973) recorded *Monoporopollenites* sp. from the Middle Cretaceous subsurface samples of Rajasthan. Muller (1981) kept it pending due to inadequate documentation. He also kept pending *Graminidites* sp. reported by Takahashi (1974) from the Aptian of Japan. Regali, Uesugui and Santos (1974a, 1974b) recorded unmistaken grass pollen from the Palaeocene of Brazil. Salard-Cheboldaeff (1978), Adegoke, Chéne and Agumanu (1978) and Harris (1965) also noted Poaceous pollen from Africa and Australia respectively. In the Lower Eocene according to Muller (1981) this type becomes more frequent particularly in Africa and also encountered in other regions.

Arecaceae — *Nypa* belongs to the Nypoid group of palms and *Nypa fruticans* is the sole representative of this genus. This species grows in Sunderban, Andaman and Nicobar Islands eastwards to Malayasia and the northern tip of Australia. The stem of this plant mostly remains underground in muddy water nurturing huge leaves. In Andamans, it always grows along narrow channels.

The fossil pollen of *Nypa* is known as *Spinizonocolpites* Muller (1968) and is easily distinguished from other palm pollen by its zonisulcate aperture, nature of the spines and the finely reticulate exine. Jardine and Magloire (1963) recorded *Nypa* pollen from the Senonian of West Africa. Muller (1968) also recorded this type of pollen from the undifferentiated Senonian of Borneo. In Kachchh, *Spinizonocolpites echinatns* Muller (1968) is found from Palaeocene-Oligocene sediments. Kulkarni and Phadtare (1981) reported it from the Miocene of Maharashtra (Text-fig. 32).

The fossil pollen of *Nypa* is helpful in deciphering the palaeoecology of the sediment as it could grow only in a limited ecological condition. Tralau (1964) and Moore (1973) studied the present and past distribution of the genus and it is interesting to note that fossil *Nypa* fruits are also recorded from South as well as North America. The disparity in past and present day distribution of *Nypa* is baffling. Muller (1979) thinks that the present day habitat of *Nypa* is a later innovation and so originally *Nypa* might not be a constituent of mangrove vegetation.

Amongst 12 species of *Arenga*, *Arenga pinnata* is the most common and best known. *Arenga* has a solitary, straight and unarmed stem growing up to 10 m tall in Indonesia. The leaves are also proportionately large and may be up to 9 m long bearing dark green 150-250 pinnate

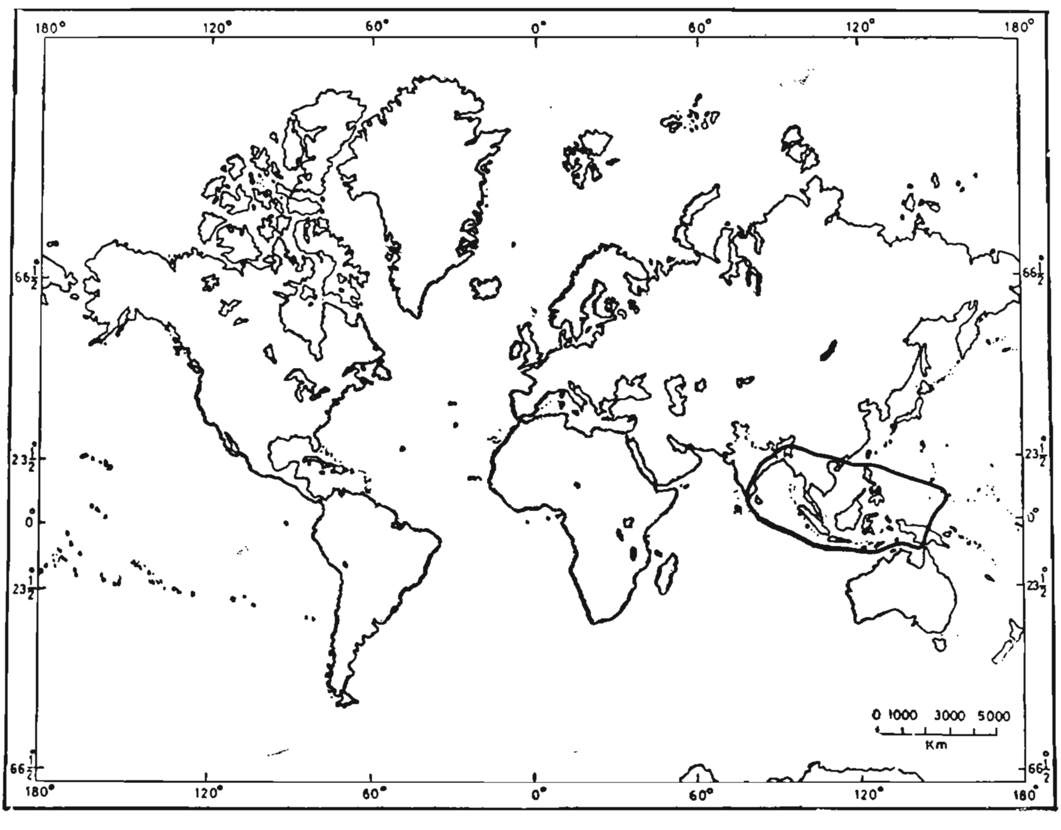


TEXT-FIG. 32 — Present and past distribution of *Nypa* (after Muller, 1979).

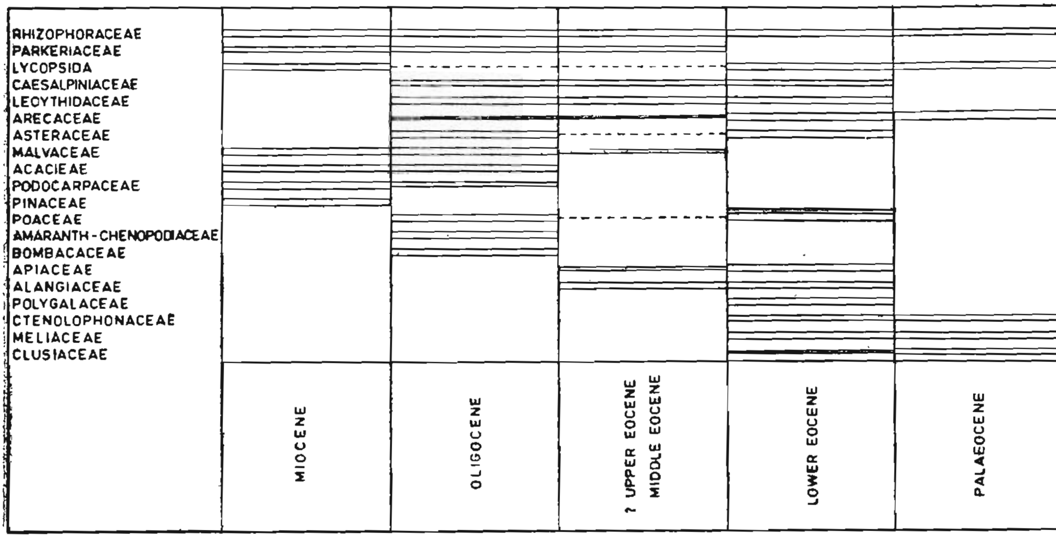
leaflets. *Arenga* belongs to the *Caryotoid* group of palms and at present it is concentrated on the Australasian tropics. Muller (1979) thinks that it is yet difficult to trace the origin of this group of palms and so far *Arenga* is concerned there is no evidence for a former wide extension outside its present day range (Text-fig. 33).

The recovery of *Arenga* type of pollen (*Arengapollenites*) from the Lower Eocene of Kachchh extends its past history up to the western coast of India. Soekarjoto and Mangindaan (1981) think that *Arenga* is indigenous to Indo-Malaysian archipelago with Indonesia as its main centre of distribution. Muller (1979), however, thinks that overall picture of palm evolution which emerges from the fossil pollen data is one of the vigorous evolution in the Senonian of the American-African tropics which markedly contrast with the different development in south-east Asia. Moore (1973) also did not think that palm originated in Malayasia because of its absence of a rich and diversified palm pollen flora from Middle Cretaceous onwards. Same perhaps holds good for *Arenga*.

Amongst the families enumerated above, Rhizophoraceae is most common throughout the Tertiary sediments. It is found from Palaeocene to Miocene though in the latter it becomes rare. Perhaps, it indicates that during Tertiary, Kachchh was in proximity of the sea as in the present day and harboured the mangroves in the coastal region. *Lycopsida* spores are never found in abundance but they are present in Palaeocene, Lower Eocene and Miocene. Arecaceae is dominant in Palaeocene and Lower Eocene, it becomes rare in Middle Eocene and Oligocene and disappears completely in Miocene. Caesalpiniaceae is restricted to Lower Eocene, Middle Eocene and Oligocene. The behaviour of Caesalpinia-



TEXT-FIG. 33 — Map showing the present day distribution of the genus *Arenga*.



TEXT-FIG. 34 — Showing the behaviour of different known families from Palaeocene to Miocene in Kachchh.

ceae is same that of Arecaceae. It is also found up to Oligocene. Parkeriaceae enters in the scene in Middle-Upper Eocene, gradually establishes in Oligocene and is overwhelmingly dominated in Miocene. Asteraceae appears sparsely in Eocene and occurs again in Miocene. Middle Eocene witnesses the emergence of Malvaceae and it develops as one of the common constituents in Oligocene and Miocene. Acaciaceae is frequently found only in Oligocene and Miocene. Podocarpaceae starts occurring in Oligocene and exhibits its maximum development in Miocene. Pinaceae is generally confined to Miocene. With the present state of knowledge, it seems that during Miocene, the families Pinaceae, Podocarpaceae, Acaciaceae, Malvaceae, Rhizophoraceae, Parkeriaceae and *Lycopsida* were growing in the vicinity of Kachchh. Of them, Pinaceae and Podocarpaceae seem to be deposited from the far distant land (Text-fig. 34).

Bombacaceae and Amaranthaceae-Chenopodiaceae are restricted to Oligocene. Besides, Acacieae, Asteraceae, Malvaceae, Parkeriaceae and Lecythidaceae are also found as common elements. Middle Eocene — ?Upper Eocene lacks any marker family. However, Alangiaceae, Apiaceae, Malvaceae, Arecaceae, Lecythidaceae and Parkeriaceae are common constituents. Polygalaceae is the only family which is restricted to Lower Eocene and Alangiaceae and Apiaceae are found only in Lower and Middle Eocene. Other common families of the Lower Eocene are: Meliaceae, Ctenolophonaceae, Arecaceae and Caesalpiniaceae.

The three families which are restricted to Palaeocene and Lower Eocene are: Clusiaceae, Meliaceae and Ctenolophonaceae. Arecaceae is also found as a common element in these two periods.

LOWER EOCENE DINOFLAGELLATES

Genus — *Areoligera* Lejeune-Carpentier emend. Williams & Downie, 1966

Type Species — *Areoligera senonensis* Lejeune-Carpentier, 1938.

Areoligera digitata sp. nov.

Pl. 41, figs 2, 3; Pl. 40, fig. 3

Diagnosis — Subcircular chorate cysts with convex dorsal side and flat ventral side. Processes arranged in circular fashion distally, intratabular. Size of body 42-54 × 36-52 μm, processes 38-55 μm, branched, finger-like from middle, body as well as processes granulose, processes on ventral side generally not highly branched. Archaeopyle apical.

Comparison — *Areoligera senonensis* Lejeune-Carpentier (1938) has very well-developed processes on the distal surface but they do not branch in the digitate fashion. *Areoligera* cf. *senonensis* described and illustrated by Williams and Downie (1966) possesses closely placed processes. *A. coronata* (Wetzel) Lejeune-Carpentier (1938) is characterized by broad processes which are branched only at upper part. *Areoligera* cf. *medusettiformis* (Wetzel) Lejeune-Carpentier (1938) reported by Williams and Downie (1966) has also closely placed, broad distal processes.

Holotype—Pl. 41, fig. 2; size 50×48 μm; slide no. 8286/2.

Type Locality — Lakhpat bore-core no. 1, depth 10.5 m, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 1, depth 10.5 m, Lakhpat.

Genus — *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams, 1966

Type Species — *Cleistosphaeridium diversispinosum* Davey, Downie, Sarjeant & Williams, 1966.

Cleistosphaeridium diversispinosum Davey, Downie, Sarjeant & Williams, 1966

Pl. 40, figs 4, 5

Diagnosis (*after Davey, Downie, Sarjeant & Williams, 1966*) — *Cleistosphaeridium* with granular wall and polygonal archaeopyle. Processes solid, taeniate or tabular, usually slender and proximally expanded. Distal end forked or expanded.

Remarks — The specimens studied here have bigger size range (42-58 μm).

Holotype — Davey, Downie, Sarjeant & Williams, 1966, pl. 10, fig. 7.

Type Locality — White cliff, London Clay, Eocene.

Occurrence — Bore-core no. 1, 12 m and 48 m, Lakhpat.

Cleistosphaeridium cephalum sp. nov.

Pl. 40, figs 1, 2; Pl. 41, fig. 1

Diagnosis — Subspherical, chorate, dinoflagellate cysts, 62-83×60×80 μm in size without processes. Processes numerous, 8-12 μm in length with pin headed tips. Cyst body granulose, archaeopyle apical.

Comparison — *Cleistosphaeridium diversispinosum* Davey, Downie, Sarjeant & Williams (1966) resembles the present species in shape, but is distinguished by its smaller size range (38-43 μm) and longer processes (7-23 μm). *C. ancoriferum* Cookson & Eisenack (1960) has anchor-shaped appendages, the stalks of which narrow distally and divide into two slender, recurved branches with transparent tips.

Holotype — Pl. 40, fig. 1; size 80×76 μm; slide no. 8274/1.

Type Locality — Lakhpat bore-core no. 1, depth 15 m, Lower Eocene, Kachchh.

Occurrence — Bore-core no. 1, 10.5 m and 15 m, Lakhpat.

Genus — *Cordosphaeridium* Eisenack emend. Davey, 1969

Type Species — *Cordosphaeridium inodes* (Klumpp) Eisenack, 1963.

Cordosphaeridium gracilis (Eisenack) Davey & Williams, 1966

Pl. 40, fig. 6

Diagnosis (*after Davey & Williams, 1966*) — Spherical to subspherical, fibrous central body bearing small number of fibrous processes. Processes cylindrical, solid, erect, simple or branched and distinctly digitate; intratabular, one per plate area, number never less than 19 or greater than 20. Archaeopyle apical, haplotabular, and reflected tabulation that of the genus *Cordosphaeridium*.

Holotype — Eisenack, 1954, pl. 10, fig. 5.

Type Locality — Nordstrand des Samlandes, Bursterot, Lower Oligocene.

Occurrence — Bore-core no. 1, 48 m, Lakhpat.

Cordosphaeridium exilimurum Davey & Williams, 1966

Pl. 41, figs 4, 5

Diagnosis (*after Davey & Williams, 1966*) — Ovoidal central body, composed of thin, smooth of slightly granular endophragm with fine fibrils of periphragm running over surface. Processes tubiform or buccinate, or variable width, and rarely latispinous, distally open with serrate or undulose margin. Wall of processes thin and often fenestrate.

Holotype — Davey & Williams, 1966, pl. 11, fig. 2.

Type Locality — Whitecliff Bay, Isle of Wight, London Clay, Eocene.

Occurrence — Bore-core no. 1, depth 10.5 m, 13 m and 15 m, Lakhpat.

Genus — *Glaphyrocysta* Stover & Evitt, 1978

Type Species — *Glaphyrocysta retiintexta* (Cookson) Stover & Evitt, 1978.

Remarks — Many species hitherto described under *Cyclonephelium* Deflandre & Cookson (1955) by Cookson (1955), Deflandre and Cookson (1955), Williams and Downie (1966), Morgenroth (1966), Gerlach (1961), Bujak (1976) and others have been transferred by Stover and Evitt to a new genus, viz., *Glaphyrocysta*. In their opinion this genus differs from *Cyclonephelium* in possessing longer and fewer projection, which are always connected distally by a trabecular ectophragm. It is distinguished from *Adnatosphaeridium* Williams & Downie (1966) in having a lenticular rather than a subspherical body and generally more complicated processes.

Glaphyrocysta pastielsii (Deflandre & Cookson) Stover & Evitt, 1978

Pl. 40, figs 7, 8

Diagnosis (*after Sarjeant, 1966*) — Archaeopyle apical in position with zigzag margin. Prominent sulcal notch lies to the right of the mid-ventral line. Numerous, solid taeniate processes complexly united along their length and distally. Proximally processes arise singly or in groups of twos or threes. Distally interconnecting trabeculae may be perforated up to 5-6 μm in width. Unconnected short, slender, acuminate or bifid spines often arise from the trabeculae. Occasional simple acuminate processes occur on central body.

Remarks — Sarjeant (1966) commented that the specimens assignable to this species can have two antapical protuberances, one more strongly developed than the other. When these are present, the outline of the central body comes close to that of *Areoligera* Lejeune-Carpentier (1938).

Lectotype — Pastiels, 1948, fig. 15.

Type Locality — Quenast, Belgium, Eocene.

Occurrence — Bore-core no. 1, depth 10.5 m and 13 m, Lakhpat.

Genus — *Heterosphaeridium* Cookson & Eisenack, 1968

Type Species — *Heterosphaeridium conjunctum* Cookson & Eisenack, 1968.

Remarks — Stover and Evitt (1978) opined that in contradiction to the statement of Cookson and Eisenack (1968) that the opening of the archaeopyle is along a straight line, the principal archaeopyle suture appears to be slightly zig-zag. Besides, the position of the sulcal notch is not determinable from the illustrations, hence whether the body is subspherical or lenticular can not be ascertained. They also suspect that the type species of the genus is probably a species of *Systematophora* Klement (1960).

Heterosphaeridium heteracanthum (Deflandre & Cookson) Eisenack & Kjellstrom, 1971

Pl. 41, fig. 6

Diagnosis (*after Deflandre & Cookson, 1955*) — Shell large, approximately circular in outline, with numerous appendages of variable shape, size and form. Appendages solid, usually elongated, frequently filiform, sometimes as broad as long, the apices either pointed, everted, or irregularly branched. Surface of shell punctate.

Remarks — Stover and Evitt (1978) placed this species as provisionally accepted one under the genus *Heterosphaeridium*. The stratigraphic range of this species varies from ?Upper Cretaceous to Lower Eocene.

Holotype — Deflandre & Cookson, 1955, pl. 2, fig. 5.

Type Locality — Nelson bore-core, depth 6065 ft, Victoria, ?Upper Cretaceous.

Occurrence — Bore-core no. 1, depth 13 m and 48 m, Lakhpat.

Heterosphaeridium heteracanthum subsp. *sparsiprocessum* (Varma & Dangwal) Eisenack, 1971

Pl. 40, fig. 9

Diagnosis (*after Varma & Dangwal, 1964*) — Body spherical to hemispherical, brown and densely granulate. Body wall thin but clearly observed. Processes occurring singly and sparsely studded all over the body. Each process is stiff, usually unbranched, hollow, with tip ending abruptly. Tip part not observed in most cases, probably due to secondary breakage. Sometimes two or more processes appear to coalesce at the base but dissociate near the tip, giving a falsely furcate appearance.

Holotype — Varma & Dangwal, 1964, pl. 1, fig. 7.

Type Locality — Bore-core C.D.W. no. 2, depth 1,523-1,526 m, Cambay Basin, Eocene-Oligocene.

Occurrence — Bore-core no. 1, depth 10.5 m and 48 m, Lakhpat.

Genus — *Homotryblium* Davey & Williams, 1966

Type Species — *Homotryblium tenuispinosum* Davey & Williams, 1966.

Remarks — This genus is very peculiar in having an epitractal archaeopyle which has a compound operculum comprising the apical and precingular plate series. The genera *Hemicystodinium* Wall (1967) and *Eocladopyxis* Morgenroth (1966) also possess the same type of archaeopyle, but are distinguished from *Homotryblium* in the presence of nontabular processes. Stover and Evitt (1978) have provided a modified description for the genus.

Homotryblium tenuispinosum Davey & Williams, 1966

Pl. 41, fig. 7

Diagnosis (*after Davey & Williams, 1966*)—Spherical central body with wall composed of thin layers— smooth inner endophragm, outer strongly granular periphragm. Processes erect or curved, tubiform, simple open distally with serrate or aculeate margin, rarely perforate. Width of processes variable.

Remarks — The diameter of the central body of holotype is 48×41 μm, whereas in the present specimen it is 58×50 μm. The length of processes is, however, same (20-25 μm). Davey and Williams (1966) assumed that the processes are restricted to one per plate area and indicated a reflected tabulation of 3′, 6″, 6C, 5‴, 1P, 1⁗ and 1-5S. The margin of the archaeopyle is interrupted on the epitract by a short projection, i.e. the sulcal tongue. This has a corresponding sulcal notch on the hypotract.

Holotype — Davey & Williams, 1966, pl. 12, fig. 5.

Type Locality — Enborne, Berkshire, Metropolitan Water Board bore-core no. 11, London Clay, Eocene.

Occurrence — Bore-core no. 1, depth 15 m, Lakhpat.

Homotryblium pallidum Davey & Williams, 1966

Pl. 41, figs 8-10

Diagnosis (*after Davey & Williams, 1966*) — Subspherical to ovoidal central body composed of thin inner endophragm and granular periphragm. Processes of variable width, simple tubiform forming a circular where they arise from central body. Archaeopyle epitractal and processes reflecting generic tabulation.

Remarks — According to Davey and Williams (1966), *H. pallidum* differs from the type species of the genus in possessing a thinner wall, generally broader processes with more variable distal margins and well marked proximal circle where they arise from the central body. In addition to broader processes, it has also got some very slender acuminate processes.

Holotype — Davey & Williams, 1966, pl. 12, fig. 6.

Type Locality — Enborne, Berkshire, Metropolitan Water Board bore-core no. 11, London Clay, Eocene.

Occurrence — Bore-core no. 1, depth 10.5 m and 48 m, Lakhpat.

Genus — *Hystrichosphaeridium* Deflandre emend. Davey & Williams, 1966

Type Species — *Hystrichosphaeridium tubiferum* (Ehrenberg) Deflandre emend. Davey & Williams, 1966.

Hystrichosphaeridium salpiugophorum (Deflandre) Davey & Williams, 1966

Pl. 41, figs 11, 12

Diagnosis (*after Davey & Williams, 1966*) — Central body spherical to ovoidal with characteristic reflected tabulation of 4′, 6″, 6C, 5‴, 1P, 1⁗ with variable number of sulcal processes. Processes well-developed, tubiform with sub-quadrate distal openings. Distal margins entire or denticulate. Number of processes present 25 to 30. Apical tetratabular archaeopyle practically always present.

Occurrence — Bore-core no. 1, depth 15 m and 48 m, Lakhpat.

Genus — *Litosphaeridium* Davey & Williams, 1966

Type Species — *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams, 1966.

Remarks — This genus possesses robustly built subcylindrical to dome-shaped intratabular processes. These are usually longer than wide and the tips are generally narrower than the bases. Davey and Verdier (1973) extended the circumscription of the genus to include specimens with paracingular processes and those with more than one process per plate in the genus. Stover and Evitt (1978) expressed dissatisfaction to this treatment and recommended to accommodate those species in the genus in accordance with the diagnosis of Davey and Williams (1966).

Litosphaeridium siphoniphorum (Cookson & Eisenack) Davey & Williams, 1966

Pl. 40, fig. 10

Diagnosis (*after Davey & Williams, 1966*) — Spherical to subspherical, central body composed of thin endophragm and thick reticulate periphragm. Processes composed of smooth periphragm, varying considerably in shape and size but commonly cylindrical or sub-conical and always hollow. Distal margin of processes entire or serrate. Hexagonal apical archaeopyle usually present. Number of processes 13, rarely 14 or 15 in specimens possessing an archaeopyle. Inferred tabulation 3′, 5″, 1P, 1⁗ and 0-2S.

Remarks — This is a long ranging species and according to Wilson and Clowes (1980) this is found from Albian to Eocene.

Holotype — Cookson & Eisenack, 1958, pl. 11, fig. 8.

Type Locality — Seismic shot-hole B_2, Ginging area, West Australia, Albian.

Occurrence — Bore-core no. 2, depth 12 m, Lakhpat.

Genus — *Nematosphaeropsis* Deflandre & Cookson emend. Williams & Downie, 1966

Type Species — *Nematosphaeropsis balcombiana* Deflandre & Cookson, 1955.

Remarks — *Cannosphaeropsis* Wetzel emend. Williams & Downie (1966) comes close to *Nematosphaeropsis* by its presence of a network of parasutural trabeculae supported by varying number of processes. However, in *Nematosphaeropsis* ectophragmal trabeculae, in the opinion of Stover and Evitt (1978), represent extensions of the triradiate tips of the gonal processes so that at least two trabeculae connect adjacent processes. This feature also differentiates this genus from *Achomosphaera* Evitt (1963) and *Spiniferites* Mantell emend. Sarjeant (1970).

Nematosphaeropsis densiradiata (Cookson & Eisenack) Stover & Evitt, 1978

Pl. 40, figs 11, 12

Diagnosis (*after Cookson & Eisenack, 1962*) — Shell spherical, thin-walled with numerous stiff radial appendages of nearly equal size, the secondary or tertiary bifurcations of which form the enclosing network. In the type, the subdivisions of the radial appendages may form by their union, small polygonal or irregularly shaped meshes to the walls of which at their angles, the threads of the enclosing network are attached.

Holotype — Cookson & Eisenack, 1962, pl. 4, fig. 5.

Type Locality — Brickhouse bore 1210 ft, Carnarvon Basin, probably Cenomanian.

Occurrence — Bore-core no. 1, depth 48 m, Lakhpat.

Middle Eocene Dinoflagellates

Genus — *Achomosphaera* Evitt, 1963

Type Species — *Achomospharera ramulifera* (Deflandre) Evitt, 1963.

Achomosphaera ramulifera (Deflandre) Evitt, 1963

Description (after Evitt, 1963) — Test consists of a spherical to ellipsoidal central body with precingular archaeopyle and furcate, spine-like processes like those of *Hystrichosphaera* in both structure and distribution, but without sutural ridges or septa connecting their bases as in that genus. Tips of processes not interconnected. Wall two-layered; layers typically in close contact between bases of processes.

Remarks — According to Jain and Tandon (1981) the specimens from Kachchh attributed to the present species differ from London Clay forms in the presence of shorter processes.

The transfer of this species to *Spiniferites* by Reid (1974) and May (1980) was rejected by Letin and Williams (1977, 1981).

Holotype — Deflandre, 1937, pl. 14, fig. 5.

Type Locality — Silex Senonien(?), galet (Erratikum), Paris.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Achomosphaera multifurcata Jain & Tandon, 1981

Diagnosis (after Jain & Tandon, 1981) — Cyst body subspherical, moderately thick, smooth; processes variable in width, paracingular processes usually cylindrical, trifurcate, tips bifid; usually processes proximally broad, branched 2-3 times, last branching followed with thread-like extensions. Paratabulation that of genus with precingular archaeopyle.

Measurements:

	Holotype	Range
Cyst body size	40 μm	40-50 μm
Overall size	80 μm	80-100 μm
Process length up to	26 μm	30 μm

Comparison — Multifurcate nature of processes with thread-like last branching separates the present species from the other species of the genus.

Holotype — Jain & Tandon, 1981, pl. 1, fig. 10.

Type Locality — Baranda, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Adnatosphaeridium* Williams & Downie, 1966

Type Species — *Andatosphaeridium vittatum* Williams & Downie, 1966.

Adnatosphaeridium vittatum Williams & Downie, 1966

Description (after Williams & Downie, 1966) — Chorate cysts bearing tubular or solid intratabular processes varying in number on a single plate. Processes united distally by interconnecting trabeculae. Archaeopyle apical.

Remarks — The specimens from Kachchh possess distinct, densely coarse granulate periphragm having both distally free and united processes, and regular serrate terminations on the outer margin of the distal branches of the processes. They have also 3-4 apical processes which are not known in the genotype. The reflected tabulation of the genus in the opinion of Jain and Tandon (1981) is thus 3-4′, 6″ m 5‴ 1P and 1⁗.

Holotype — Williams & Downie, 1966, pl. 24, fig. 7.

Type Locality — Sheppey, Kent, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Araneosphaera* Eaton, 1976

Type Species — *Araneosphaera araneosa* Eaton, 1976.

Araneosphaera consociata Jain & Tandon, 1981

Pl. 44, figs 7, 8

Diagnosis (*after Jain & Tandon, 1981*) — Cyst body spherical, surface fibroreticulate; paracingulum raised, equally divided cyst body. Periphragm gives rise to fibrous apical, precingular, postcingular and antapical processes only. Cingular processes absent. Apical and precingular processes usually short, distally united by fenestrate membrane. Paratabulation that of genus; archaeopyle broader than long, precingular (3″).

Measurements:

	Holotype	Range
Cyst size	150 × 100 μm	100-180 × 90-120 μm
Diameter of cyst body	86 μm	60-90 μm
Length of processes up to	50 μm	60 μm

Remarks — The processes on both apical and antapical sides are irregularly branched, fibrous and thin, at times their identification as separate process becomes difficult.

Holotype — Jain & Tandon, 1981, pl. 3, fig. 47.

Type Locality — Baranda, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Areoligera* Lejeune-Carpentier emend. Downie & Carpentier, 1938

Type Species — *Areoligera senonensis* Lejeune-Carpentier, 1938.

Areoligera coronata (Wetzel) Lejeune-Carpentier, 1938

1966 *Areoligera* cf. *coronata* (Wetzel) Williams & Downie, p. 288, pl. 25, fig. 5.

Remarks — The specimens from Kachchh have process complexes on both ventral and distal sides. The surface is coarsely granulate.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Areoligera sp.

Description (*after Jain & Tandon, 1981*) — Cyst lenticular, 54 × 48 μm in size, two layered, endophragm granular, periphragm smooth, gives rise to soleate complexes and single processes, up to 30 μm in length, soleate complexes variable, proximal membrane fenestrate to nonfenestrate, processes arise from distal margin of the membrane, distally united by trabeculae, in some cases processes distally serrate. Reflected tabulation 4″, 6″, 1-3C, 5‴, 1 P, 1″″. Cingular processes single, distally fenestrate, only a few (? 1-3) could be located, others usually in soleate complexes. Archaeopyle apical, operculum detached.

Remarks — Jain and Tandon (1981) could recover only one specimen. Soleate complexes having proximal fenestration and distal connection by trabeculae in the present form suggest its closeness to *Areoligera coronata* (Wetzel) Lejeune-Carpentier (1938) but is distinguished in the presence of granular endophragm.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Areosphaeridium* Eaton, 1971

Type Species — *Areosphaeridium dictyoplokus* (Klumpp) Eaton, 1971.

Areosphaeridium arcuatum Eaton, 1971

Description (*after Eaton, 1971*) — Dinoflagellate cyst having a central body which is subcircular to subquadrate in outline, with a finely granular surface, bearing solid, fibrous, intratabular processes. The process stems may be simple or branched and frequently show fenestration. Distally the process stems are expanded and they terminate either as distal bifurcation or a broad distal platform. Processes are invariably present on the apical, pre- and postcingular, and antapical zones. Processes may or may not be present on the cingular zone. One process per plate, although some plates may be devoid of processes. Reflected tabulation 4′, 5-6‴, 0-1 p, 1⁗. Archaeopyle apical, tetratabular.

Holotype — Klumpp, 1953, pl. 18, figs 3, 4.

Type Locality — Holstein, Bohrung Wohrden, Upper Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Chiropteridium* Gocht, 1960

Type Species — *Chiropteridium lobospinosum* (Gocht) Gocht, 1960.

Chiropteridium sp. A

Description — Cyst 66 × 50 μm in size, lenticular, flattened, consisting of two layers, periphragm thin, reticulate, forming processes along margin, antapical lobation distinct. Archaeopyle apical, parasulcal notch deep.

Remarks — Jain and Tandon (1981) could recover only one specimen.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams, 1966

Type Species — *Cleistosphaeridium diversispinosum* Downie, Sarjeant & Williams, 1966.

Cleistosphaeridium sp. A

Pl. 44, fig. 3

Description — Cyst spherical, double-walled, endophragm smooth, periphragm reticulate, covered with numerous processes; processes broader at base, simple or branched, distally bifid or recurved, closed; stem fibrous, striated with fenestration. Archaeopyle apical, margin zigzag.

Measurements — Size of cyst body 54 μm. Length of processes up to 15 μm.

Remarks — The reticulate periphragm of the specimen distinguishes it from the rest of the *Cleistosphaeridium* species.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Cordosphaeridium* Eisenack, 1963 emend. Davey, 1969

Type Species — *Cordosphaeridium inodes* (Klumpp) Eisenack, 1963.

Cordosphaeridium fibrospinosum Davey & Williams, 1966

Pl. 43, fig. 8; Pl. 44, fig. 9

Description (*after Davey & Williams, 1966*) — Ovoidal central body with wall up to 0.5 μm thick, composed of smooth endophragm and fibrous periphragm. Processes fibrous, often very broad and ovoidal in cross section, walls perforate. Processes open distally with entire or undulose margin. One process per plate reflecting a tabulation typical of genus. Archeopyle apical, haplotabular.

Holotype — Davey & Williams, 1966, pl. 5, fig. 5.

Type Locality — Enborne, Berkshire, Metropolitan waterboard bore-core no. 11, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Cordosphaeridium latispinosum Davey & Williams, 1966

Description (*after Davey & Williams, 1966*) — Ellipsoidal central body having a finely striate periphragm from which two types of processes: broad ovoidal to quadrate ones, closed or with restricted distal opening and slender oblate processes. Larger processes reflecting a tabulation of 1′, 6″, 6‴, 1⁗; smaller ones restricted to sulcal and cingulum regions.

Holotype — Davey & Williams, 1966, pl. 5, fig. 8.

Type Locality — Sheppey, Kent, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Diphyes* Cookson emend. Davey & Williams, 1966

Type Species — *Diphyes colligerum* (Deflandre & Cookson) Cookson, 1965.

Diphyes colligerum (Deflandre & Cookson) Cookson, 1965

Description (*after Cookson, 1965*) — Shell composed of two parts, more or less unequal in size. The anterior part circular in outline with or without appendage. Archaeopyle apical. The posterior part roughly bell shaped to spherical with a small circular antapical opening and without typical appendages.

Holotype — Deflandre & Cookson, 1955, pl. 7, fig. 3.

Type Locality — Point Ronald, Victoria, Lower Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Eatonicysta* Stover & Evitt, 1978

Type Species — *Eatonicysta ursulae* (Morgenroth) Stover & Evitt, 1978.

Eatonicysta ursulae (Morgenroth) Stover & Evitt, 1978

Description (*after Stover & Evitt, 1978*) — Cysts proximate; body subspherical with 16 to 21 (typically 17) solid, normally, fibrous intratabular processes; processes support ectophragm, which may be thin, smooth, and continuous or reduced by perforations to an open reticulum; paratabulation gonyaulacacean, indicted by intratabular processes and archaeopyle, latter apical.

Dimensions:

Diameter of central body	60 μm
Length of processes up to	26 μm

Holotype — Morgenroth, 1966, pl. 3, figs 11, 12.

Type Locality — Insel Fehmarn, Katharinenhof, Lower Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Eocladopyxis* Morgenroth emend. Stover & Evitt, 1978

Type Species — *Eocladopyxis peniculatum* Morgenroth, 1966.

Eocladopyxis sp. A

Pl. 43, fig. 3

Description (*after Jain & Tandon, 1981*) — Cyst oblong in shape, 70 × 64 μm in size, double layered, periphragm reticulate and covered with sparsely placed processes having semicircular bulbous base, distally pointed, closed, proximally touching the wall only at a point. Archaeopyle? apical. Paracingulum indistinct, broken area marks paracingulum position; paratabulation are suggestive.

Remarks — Jain and Tandon (1981) were able to recover only a single specimen. According to them presence of bulbous processes on the proximal side and indication of paracingulum and archaeopyle suggest its placement under the genus *Eocladopyxis*. *E. peniculata* described by Williams and Brideaux (1975) comes very close to the present specimen.

This genus is so far known only from the Eocene sediments (Morgenroth, 1966; Williams and Brideaux, 1975).

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Glaphyrocysta* Stover & Evitt, 1978

Type Species — *Glaphyrocysta retiintexta* (Cookson) Stover & Evitt, 1978.

Glaphyrocysta kachchhensis Jain & Tandon, 1981

Pl. 44, fig. 5

Diagnosis (*after Jain & Tandon, 1981*) — Cysts dorsoventrally flattened, double layered, periphragm coarsely granulate having two types of processes along peripheral zone; on one side short, stout broad, variously branched proximal fenestration distinct, some distally not united with each other, arcuate process complexes distinct. Archaeopyle apical with zig-zag margin.

Measurements:

	Holotype	Range
Cyst size	50 × 32 μm	40-60 × 25-30 μm
Length of short process up to	18 μm	32 μm
Length of long process up to	30 μm	30 μm

Comparison — *Glaphyrocysta kachchhensis* Jain & Tandon (1981) differs from the known species of the genus in its thin variable type of processes and coarsely granulate periphragm.

Holotype — Jain & Tandon, 1981, pl. 1, figs 17, 18.

Type Locality — Baranda, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Glaphyrocysta exuberans (Deflandre & Cookson) Stover & Evitt, 1978

Pl. 42, fig. 2

Description (*after Williams & Downie, 1969*) — Chorate cysts with central body flattened, dorso-ventrally and apparently concavo-convex, outline circular to slightly oval. Diameter of central body 56-85 μm, length of processes up to 46 μm. Prominent sulcal notch lies to the right of the mid-ventral line. Surface of central body commonly granular. Archaeopyle apical, tetratabular. Wall layers not distinguished.

Remarks — The specimens assignable to this species from Kachchh have coarsely granulate outer membrane.

Lectotype — Pastiels, 1948, pl. 5, figs 11, 13.

Type Locality — Quenast, Belgium, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Glaphyrocysta intricata (Eaton) Stover & Evitt, 1978

Pl. 42, fig. 11

Description (*after Stover & Evitt, 1978*) — Cysts skolochorate, body lenticular with several annulate to arcuate pentabular process complexes; most complexes joined to one another distally by a simple to intricate system of trabeculae; midventral and mid-dorsal areas typically process-free or with reduced processes; archaeopyle apical, parasulcal notch offset.

Remarks — In the opinion of Jain and Tandon (1981), Kachchh specimens possess a coarsely granulate outer surface having broad processes along the peripheral zone. Processes proximally connected or free, when connected forming semicircular ridges, distally expanded and mostly bifurcate, bifurcation varies from recurved to patulate, in recurved condition the marginal extensions united together by trabeculae which are distally dentate.

Holotype — Eaton, 1971, pl. 4, figs 8-10.

Type Locality — Bracklesham bed, Isle of Wight, Middle Eocene, England.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Glaphyrocysta ordinata (Williams & Downie) Stover & Evitt, 1978

Description (*after Williams & Downie, 1966*) — Thin-walled central body with granular surface. Processes formed from periphragm and restricted to linear complexes regularly distributed on central body. Reflected tabulation deduced from linear complexes of 4′, 6″, 5‴, 1P 1⁗. Processes slender, solid, taeniate, united half to two-thirds along their length by membranes or trabeculae. Processes distally unconnected and unequally bifurcate.

Measurements:

Overall size	80-84 μm
Diameter of central body	58 μm
Length of processes up to	30 μm

Holotype — Williams & Downie, 1966, pl. 25, fig. 3.

Type Locality — Enborne, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Glaphyrocysta pastielsii (Deflandre & Cookson) Stover & Evitt, 1978

Description — (*after Williams & Downie, 1969*) — Archaeopyle apical with zig-zag margin. Prominent sulcal notch lies to right of midventral line. Numerous, solid, taeniate processes complexly united along their length and distally. Proximally processes arise singly or in groups of two and threes. Distally interconnecting trabeculae may be perforate, up to 5-6 μm in width. Unconnected short, slender, acuminate or bifid spines often arise from trabeculae. Acuminate processes often occur on central body.

Lectotype — Pastiels, 1948, fig. 15.

Type Locality — Quenast, Belgium, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Glaphyrocysta sp. A

Pl. 42, fig. 10

Description (after Jain & Tandon, 1981) — Cyst body subcircular, surface granular, processes restricted to peripheral zone only, stem narrow, distally united by fenestrate membrane, meshes with thick wall. Archaeopyle apical, tetratabular.

Measurements:

Central body diameter	62×46 μm
Length of processes up to	25 μm

Remarks — The specimen closely resembles *Glaphyrocysta exuberans* and *G. pastielsii* in having fenestrate membrane on the distal side but the former is distinguished in the presence of mesh walls and short stem.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Hemicystodinium* Wall, 1967

Type Species — *Hemicystodinium zoharyi* (Rossignol) Wall, 1967.

Hemicystodinium zoharyi (Rossignol) Wall, 1967

Description (after Wall, 1967) — Test hemispherical, midventral point marked by a small subrectangular projection and displacement of rim. Test smooth to microreticulate, spine bases weakly striate. Spines numerous, length variable, all but a few simple and capitate, others bifurcate. Parallel alignment of spines in equatorial region reflect the position of a girdle and midventral projection or sulcal notch probably indicates the former position of the anterior limit of the longitudinal furrow.

Measurements:

Cyst diameter	46 μm
Length of processes up to	6 μm

Holotype — Rossignol, 1964, pl. 2, fig. 4.

Type Locality — Kustenebenen Israels, Pleistocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Homotryblium* Davey & Williams, 1966

Type Species — *Homotryblium tenuispinosum* Davey & Williams, 1966.

Homotryblium plectilum Drugg & Loeblich, 1967

Pl. 42, figs 3-5

Description (after Drugg & Loeblich, 1967) — Spherical chorate cyst with thin endophragm and periphragm, the latter giving rise to processes. The wall is about 1 μm thick with the periphragm slightly thinner than the endophragm. Wall smooth to faintly and delicately granulate. The processes are intratabular, buccinate, entire to secate, opening distally but not opening into the central cavity. The walls of the processes are striate and may faintly fibrous. The striations are formed by three or four nerve-like delicate thickenings which extend from the distal terminations to the basal areas where they radiate outwardly for a short distance. The distal ends of the processes are entire or else may be secate with from two to six lobes. The archaeopyle is epitractal with the line of separation just above the cingular processes.

Holotype — Drugg & Loeblich, 1967, pl. 2, fig. 1.

Type Locality — Hinds Country, Mississipi, Oligocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Homotryblium pallidum Dave & Williams, 1966

Description (*after Davey & Williams, 1966*) — Subspherical to ovoidal central body composed of thin inner endophragm and granular periphragm. Processes of variable width, simple tubiform forming a circle where they arise from central body. Archaeopyle epitractal and processes reflecting generic tabulation.

Remarks — Jain and Tandon (1981) remarked that the elongate shape of central body with indistinct granular surface ornamentation goes against for the placement of the present specimens under *H. pallidum*. However, it comes to the Palaeocene forms described by Schumacker and Chateauneuf (1976) as *Homotryblium* cf. *pallidum*.

Holotype — Davey & Williams, 1966, pl. 12, fig. 6.

Type Locality — Enborne, Berkshire, Metropolitan water board no. 11, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Hystrichokolpoma* Klumpp emend. Williams & Downie, 1966

Type Species — *Hystrichokolpoma cincta* Klumpp, 1953.

Hystrichokolpoma cincta Klumpp, 1953

Pl. 43, fig. 1

Description (*after Jain & Tandon, 1981*) — Central body ovoidal, both endophragm and periphragm layers smooth and thin. Processes of two types formed from periphragm, broad tapering, slightly branched along distal margin corners. Antapical process longer than broad. Archaeopyle apical.

Measurements:

Size of central body	32×40 μm
Length of broad processes up to	14 μm
Width of broad processes up to	16 μm

Holotype — Klumpp, 1953, pl. 17, fig. 3.

Type Locality — Vossbrook bei Kiel, Upper Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Hystrichokolpoma unispinum Williams & Downie, 1966

Description (*after Williams & Downie, 1966*) — Central body subspherical with thin smooth endophragm, continuous beneath processes, and thin smooth periphragm. Processes formed from periphragm and of two types, broad tapering lagenate, and buccinate more slender processes. Reflected tabulation of 4′, 6″, 6g, 5‴, a p, 1⁗ and at least 5s. Each cingular plate possessing only one process.

Holotype — Williams & Downie, 1966, pl. 17, fig. 7.

Type Locality — Whitecliff, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Hystrichokolpoma sp. cf. *granulata* Eaton, 1976

Pl. 43, fig. 2

Description (*after Jain & Tandon, 1981*) — Central body of cyst spherical, two layered, both appressed; endophragm smooth to finely granulate, periphragm coarsely granulate, gives rise to two types of processes with granular surface, broad processed distally closed with small distally open tabules, base quadrate, longitudinal folds over broad processes frequent, slender processes simple or sometimes distally branched, open, tubiform. Antapical processes considerably large than other processes, tapering, closed. Archaeopyle apical, tetratabular, paratabulation like the genotype.

Measurements:

Diameter of central body	38 μm
Length of apical processes up to	25 μm
Size of antapical processes	24×20 μm
Size of other processes up to	26×30 μm

Remarks — The four specimens described here resembles *Hystrichokolpoma* by the presence of broad, antapical process, apical archaeopyle and same paratabulation. It, however, differs from rest of the known species in possessing fenestrate antapical process with distally expanded, bifurcate, apical processes.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Impagidinium* Stover & Evitt, 1978

Type Species — *Impagidinium dispertitum* (Cookson & Eisenack) Stover & Evitt, 1978.

Impagidinium sp.

Description — Cyst oval, 70×60 μm in size, without horn, plates coarsely granular bordered by high ledges. Paratabulation indistinct. Archaeopyle precingular, operculum intact.

Remarks — According to Jain and Tandon (1981) the present form closely resembles *Impagidinium dispertitum* (Cookson & Eisenack) Stover & Evitt (1978) described from the Middle Eocene of Australia. However, indistinct paratabulation precludes further comparison.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Impletosphaeridium* Morgenroth, 1966

Type Species — *Impletosphaeridium transfodum* Morgenroth, 1966.

Impletosphaeridium granulosum Jain & Tandon, 1981

Pl. 42, fig. 9; Pl. 43, fig. 4

Diagnosis (after Jain & Tandon, 1981) — Cyst body spherical, surface granular, covered with numerous erect, simple or branched solid processes, process stem striate, fenestrate, distal termination recurved or serrate or bifid. Archaeopyle precingular, triangular.

Measurements:

	Holotype	Range
Diameter of central body	72 μm	66-72 μm
Length of processes up to	14 μm	12-16 μm

Comparison — *Impletosphaeridium granulosum* proposed by Jain and Tandon (1981) differs from the known species of the genus by its large size and granular surface.

Holotype — Jain & Tandon, 1981, pl. 2, fig. 30.

Type Locality — Baranda, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Impletosphaeridium insolitum Eaton, 1976

Diagnosis (after Eaton, 1976) — Cyst body spherical or subspherical, with smooth or finely granular surface. Processes numerous, slender and solid. They are simple or bifurcate, with small bulbous spherical or subspherical distal terminations and may be thickened by development or proximal membrane, membrane may also be present in angle of bifurcation.

Remarks — Jain and Tandon (1981) remarked that except for capitate distal termination of the processes rest of the features are similar to *I. insolitum* Eaton (1976). This species has been kept under ?*Cleistosphaeridium* by Lentin and Williams (1981). Stover and Evitt (1978) also placed this species to *Cleistosphaeridium*.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Lingulodinium* Wall emend. Wall & Dale in Wall, Dale & Harada, 1973

Type Species — *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall, 1967.

Lingulodinium machaeriphorum (Deflandre & Cookson) Wall, 1967

Pl. 42, fig. 7

Description (after Wall, 1967) — The test is spherical but rarely found whole. Upon dehiscence it develops a large compound precingular archaeopyle, so all that remains of the epitheca are narrow, elongated, angular projection attached to the hypotheca ventrally. The archaeopyle, its most form, represents the loss of five precingular plate areas (1″ to 5″) but it may represent only four plates (2″ to 5″) or very rarely only the dorsal precingular plate 3″. The test is microgranular and bears numerous (15 to 20 in optical section) flexuous, hollow spines of variable length. Their bases are circular and minutely striated; their distal extremities are flexuous, closed and bear spinules. There is a tendency towards flattening of spines.

Remarks — Jain and Tandon (1981) could not ascertain the occurrence of archaeopyle in the specimens studied by them. However, in general morphological features these are almost identical to *L. machaerophorum* (Deflandre & Cookson) Wall, 1967.

Measurements:

Diameter of cyst body	46-52 μm
Length of processes up to	20 μm

Holotype — Deflandre & Cookson, 1955, pl. 9, fig. 4.

Type Locality — Birregurra, Victoria, bore-core no. 1, depth 514-516 ft, Balcombe Bay, Middle Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Lingulodinium solarum (Drugg) Wall & Dale in Wall, Dale & Harada, 1973

Pl. 44, fig. 4

Description (*after Wall, Dale & Harada, 1973*) — Spherical to ovoid spinose dinoflagellate, cysts with complex precingular archaeopyle. Spines numerous, intratabular, often flattened, blade-like and pointed with striate bases and irregular distal spinules or granules.

Measurements:

Central body diameter	50 μm
Length of processes up to	16 μm

Holotype — Drugg, 1970, fig. 16 A-C.

Type Locality — Hinds Country, Oligocene. Glendon Limestone, Mississipi.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Muratodinium* Drugg, 1970

Type Species — *Muratodinium fimbriatum* (Cookson & Eisenack) Drugg, 1970.

Muratodinium sp. A

Pl. 44, fig. 6

Description (*after Jain & Tandon, 1981*) — Cyst ovoidal, double-layered endophragm smooth to finely granulate, gives rise to apical and antapical horns, periphragm fibrous in nature, appears to form veil-like fringes which mark plate areas; paratabulation? 4′ 1 a, 2.6″, 5‴, 1⁗. Archaeopyle precingular (3″).

Measurements:

Overall cyst size	106×90 μm
Size of central body including horns	86×60 μm
Length of apical horn	8 μm
Length of antapical horn	10 μm

Remarks — Jain and Tandon (1981) thought that the present specimen shows features common to both *Muratodinium* Drugg (1970) and *Kenleyia* Cookson & Eisenack (1965) but the occurrence of tabulation precludes its placement under *Kenleyia*. The veil-like outer extension similar to *Thalassiphora pelagica* is due to the distortion of the specimens.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Muratodinium sp. B

Description (*after Jain & Tandon, 1981*) — Cyst oblong, double-layered, distorted, antapical projection present, apical not observed, endophragm smooth to finely granulose, periphragm extends beyond central body, fenestrate. Archaeopyle present but position remains doubtful.

Measurements:

Overall size	100×90 μm
Central body size	66×50 μm

Remarks — Presence of an antapical horn with slight indication of paratabulation suggests its provisional placement under the genus *Muratodinium*.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Operculodinium* Wall, 1967

Type Species — *Operculodinium centrocarpum* (Deflandre & Cookson) Wall, 1967.

Operculodinium centrocarpum (Deflandre & Cookson) Wall, 1967

Pl. 42, fig. 12

Description (*after Deflandre & Cookson, 1955*) — Shell globular, more or less ellipsoidal (probably by deformation) covered with numerous straight, slender processes placed irregularly or with a certain alignment. Processes solid, showing radiating fibrils at their point of insertion on the shell, which is clearly ornamented with a fine reticulum. The slightly widened apices of the processes are fringed with 10 or more small curved spines.

Remarks — Archaeopyle position in the present forms is not distinctly marked.

Holotype — Deflandre & Cookson, 1955, pl. 8, figs 3, 4.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Peridictyocysta* Cookson & Eisenack, 1974

Type Species — *Peridictyocysta mirabilis* (Cookson & Eisenack) Cookson & Eisenack, 1974.

Peridictyocysta sp. A

Description (*after Jain & Tandon, 1981*) — Cyst elongate, ellipsoidal periphragm thin, scabrate, covered with slendrical, narrow, branched processes, arranged in distinct longitudinal rows distally united by trabeculae forming a sort of network around apical and antapical sides. Archaeopyle apical (EA).

Measurements:

Size of central body	50×28 μm
Length of processes up to	30 μm

Remarks — Jain and Tandon (1981) could recover only one specimen.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Polysphaeridium* Davey & Williams, 1966

Type Species — *Polysphaeridium parvispinum* (Deflandre) Davey & Williams, 1966.

Polysphaeridium ornamentum Jain & Tandon, 1981

1975 *Cordosphaeridium* sp. A in Williams & Brideaux, p. 15, fig. 8.

Diagnosis (*after Jain & Tandon, 1981*) — Cyst ovoidal, periphragm thick, surface coarsely granulate to verrucate, processes numerous, more than 60, long, simple or sometimes branched, spongy at point of origin, distally open, recurved. Archaeopyle not clearly marked, probably apical.

Measurements:

Overall cyst size	140-170 μm
Central body size	66×50 μm
Length of processes up to	55 μm

Comparison — *Polysphaeridium ornamentum* compares best with *P. giganteum* Caro (1973) in having large size but differs in its prominent periphragm, ornamentation and recurved distal end of the processes.

Holotype — Jain & Tandon, 1981, pl. 2, fig. 35.

Type Locality — Jhadwa, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Polysphaeridium pastielsii Davey & Williams, 1966

Description (after Davey & Williams, 1966) — Ovoidal central body with smooth or granular surface. Apical archaeopyle with zig-zag margin. Processes numerous, all of one type; simple open, tapering distally to narrow neck before spreading slightly to an opening with entire or serrate margin, processes sometimes united proximally, slightly fibrous.

Holotype — Davey & Williams, 1966, pl. 4, fig. 10.

Type Locality — Sheppey, Kent, London Clay, Eocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Samlandia* Eisenack, 1954

Type Species — *Samlandia chlamydophora* Eisenack, 1954.

Samlandia chlamydophora Eisenack, 1954

Pl. 42, fig. 13

Description (after Eisenack, 1954) — Central body elliptical, thick-walled, laevigate, surrounded by a thin second membrane which is connected to inner shell by supports, whose cross sections form irregularly curved lines. Pylome apical.

Measurements:

Cyst size	95 × 80-105 × 75 μm
Cyst body size	55 × 65 μm
Apical horn length	22 μm
Height of pillars up to	18 μm
Archaeopyle size	21 × 24 μm

Remarks — Wilson (1967) described the specimen as *Samlandia* aff. *auqustivela* having an apical archaeopyle. However, Jain and Tandon (1981) think that the position of the archaeopyle appears to be doubtful.

Holotype — Eisenack, 1954, pl. 11, fig. 12.

Type Locality — Samland, Lower Oligocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Spiniferites* Mantell emend. Sarjeant, 1970

Type Species — *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich, 1966.

Spiniferites ramosus subsp. *granomemobraneceus* (Davey & Williams) Lentin & Williams, 1973

Pl. 42, fig. 8

Diagnosis (after Davey & Williams, 1969) — A variety of *Spiniferites ramosus* possessing a central body with a granular surface. Membranes well-developed on plate boundaries particularly in cingular and polar regions.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Systematophora* Klement, 1960

Type Species — *Systematophora areolata* Klement, 1960.

Systematophora placacantha (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams, 1966

Description (after Jain & Tandon, 1981) — Cyst body spherical, outer surface coarsely granulate, processes arranged in soleate manner, five precingular plates distinct but sixth obscure, fields separated from each other by an area of no process. Processes in each field equally developed, branched, spongy in nature along the point of origin, distally united by trabeculae. Archaeopyle apical.

Measurements:

Central body size	35 × 50 μm
Length of processes up to	25 μm

Holotype — Deflandre & Cookson, 1955, pl. 9, figs 1, 2.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Thalassiphora* Eisenack & Gocht emend. Gocht, 1968

Type Species — Thalassiphora pelagica (Eisenack) Eisenack & Gocht, 1960.

Thalassiphora pelagica (Eisenack) Eisenack & Gocht emend. Gocht, 1968

Description (after Eisenack & Gocht, 1960) — Central body spherical to ellipsoidal, hollow, firm-walled, surrounded by an equatorially placed helmet to bowl-shaped, wide, flexible membranous wing that nevertheless is double walled. The central body commonly has a circular to horse shoe-shaped pylome.

Measurements:

Overall cyst size	120 × 100 μm
Central body size	60 × 50 μm

Holotype — Eisenack, 1954, pl. 12, fig. 17.

Type Locality — Samland, Lower Oligocene.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Turbiosphaera* Archangelsky, 1968

Type Species — Turbiosphaera filosa (Wilson) Archangelsky, 1968.

Remarks — Stover and Evitt (1878) opined that *Turbiosphaera* is distinguished from *Fibrocysta* Stover & Evitt (1978) in possessing wider and flatter processes, particularly in apical and antapical areas, by the presentation of paracingulum by shelf-like structure rather than tubular processes and in the presence of smaller processes and spines scattered among the larger precingular and postcingular processes.

Turbiosphaera sp.

Pl. 43, figs 5, 6

Description — Cyst body subcircular to oval, rounded at apex, slightly drawn out into a short extension at antapical pole, periphragm fibrous, apical, precingular, cingular, post-cingular and antapical zones marked. Processes fibrous, broad, distally free, flared. Paratabulation distinct, 1′, 6″, 6C, 6‴ 1 p, 1⁗. Antapical process largest. Epithecal processes comparatively much smaller than hypothecal. Archaeopyle broadly triangular, pre-cingular, formed by the detachment of plate 3″.

Measurements:

Overall cyst size	130 × 80 μm
Cyst body size	90 × 80 μm
Length of processes up to	40 μm

Remarks — Jain and Tandon (1981) placed the specimens under *Turbiosphaera* due to the distinct paratabulation having single apical and antapical, six precingular, six paracingular and six post-cingular plates. In the elliptical shape of the cyst body, distribution of free processes, single apical plate and antapical extension, it approaches nearest to the Danian species *Palmnickia californica* Drugg (1967) but differs in having distinct paratabulation with greater number of plates.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Wilsonidium* Lentin & Williams, 1976

Type Species — Wilsonidium glaessneri (Cookson & Eisenack) Loeblich & Loeblich, 1968.

Wilsonidium lineidentatum (Deflandre & Cookson) Lentin & Williams, 1976

Pl. 43, fig. 7

Description (after Deflandre & Cookson, 1955) — Cell encysted, compressed, nearly quadrangular with a toothed margin. Epitheca imperfectly preserved, probably triangular, opening apparently quadrangular, hypotheca with 2 short unequal horns. Membranes of cyst thick, roughened. Cell membranes with numerous short lines, blunt teeth, in surface view relatively widely spaced both equatorially and so as to delimit roughly polygonal areas analogous to the plates characterising the Peridiniales.

Holotype — Deflandre & Cookson, 1955, pl. 5, fig. 5.

Type Locality — Near Denmark, W.A., ?Lower Tertiary.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Wetzeliella* Eisenack emend. Lentin & Williams, 1976

Type Species — *Wetzeliella ariculata* Eisenack, 1938.

Wetzeliella sp.

Pl. 43, fig. 9

Description (after Jain & Tandon, 1981) — Cyst broadly pentagonal, horns reduced, central body ovoidal, surface vermiculate; pericoel totally enclosing endocoel. Periphragm gives rise to tubular processes arranged in rows, distally united by thin perforate membrane. Apical horn short, formed from periphragm extension; antapical horn two, unequal in length; lateral horns much reduced (seen only on one side). Archaeopyle intercalary, hexagonal. Tabulation indistinct.

Remarks — Jain and Tandon (1981) could recover only a single badly preserved specimen. According to them it compares well with *?Kisselovia clathrata* (Eisenack) Lentin & Williams (1977) in having reduced horns and similar arrangement of processes, but differs in the absence of processes arranged in simulate complexes.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Cylopsiella* Drugg & Loeblich, 1967

Type Species — *Cyclopsiella elliptica* Drugg & Loeblich, 1967.

Cyclopsiella coniata Jain & Tandon, 1981

Pl. 44, figs 1, 2

Diagnosis (after Jain & Tandon, 1981) — Cyst ovoidal, double layered, endophragm thick ornamented with regular coni on one side and smooth on other; periphragm thin, delicate, loose, spongy, extending beyond endophragm margin from all over. Aperture circular, apical, margin thickened forming a ring. Operculum free.

Comparison — The present species closely compares with *Cyclopsiella elliptica* Drugg & Loeblich (1967) but differs mainly in having only one side of the endophragm ornamented with coni and loose widely separated periphragm. *C. vieta* Drugg & Loeblich (1967) has also loose periphragm but differs in endophragm ornamentation.

Holotype — Jain & Tandon, 1981, pl. 2, fig. 33; slide no. 6435.

Type Locality — Near Baranda, Harudi Formation, Middle Eocene, Kachchh.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

Genus — *Pterospermopsis* Wetzel, 1952

Pterospermopsis sp.

Description — Cyst circular, 68 μm in diameter, central body round, 46 μm in diameter, flange 12 μm, broad, folded. Central body characterised by a ring of small pores arranged along the peripheral margin.

Occurrence — About 3.2 km south of Baranda between Ratchelo and Jhadwa.

MICROPLANKTON FROM RATARIA

Genus — *Hystrichosphaeridium* Deflandre emend. Davey & Williams, 1966

Type Species — *Hystrichosphaeridium tubiferum* (Ehrenberg) Deflandre emend. Davey & Williams, 1966.

Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre emend. Davey & Williams, 1966

Pl. 45, fig. 1

Diagnosis (after Davey & Williams, 1966) — Central body spherical to subspherical, smooth or slightly granular, wall composed of two layers. Processes well-developed, tubiform, open distally with entire or serrate circular margin. Processes give a reflected tabulation of 4-5′, 6″, 6C, 5-6‴, 1p, 1⁗ and a variable number of sulcal plates, commonly 4-5. Apical archaeopyle usually present.

Holotype — Davey and Williams, 1966, pl. 6, figs 1, 2.

Type Locality — Feuerstein, Ceschiebe, Senon.

Occurrence — Bore-core no. 27 at Rataria.

Genus—*Oligosphaeridium* Davey & Williams, 1966

Type Species — *Oligosphaeridium complex* (White) Davey & Williams, 1966.

Oligosphaeridium complex (White) Davey & Williams, 1966

Pl. 45, figs 9, 10

Diagnosis (*after Davey & Williams, 1966*)—Central body subspherical to ovoidal. Wall composed of thin endophragm and periphragm, the latter giving rise to processes. Processes simple or branched, cylindrical for most of their length, open and expanded distally with aculeate or secate margin. Reflected tabulation inferred 4′, 6″, 5-6‴, 1p, 1⁗. Apical archaeopyle usually present having zig-zag margin. Processes in complete specimens not exceeding 18.

Holotype — White, 1942, pl. 4, fig. 11.

Type Locality — Surrey, Fetcham Mill, Geological Survey bore-hole, depth 750 ft, Cenomanian, Lower Chalk.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Perisselasphaeridium* Davey & Williams, 1966

Type Species — *Perisselasphaeridium pannosum* Davey & Williams, 1966.

cf. *Perisselasphaeridium pannosum* Davey & Williams, 1966

Pl. 45, fig. 2

Remarks — Only a single specimen could be recovered. The central body is subcircular, 50×48 μm, made up of two layers — the inner endophragm and the outer periphragm, the latter bears the processes. The processes are of two kinds — one is broad open and tabulation is not distinct and the apical archaeopyle not detectable.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Cordosphaeridium* Eisenack emend. Davey & Williams, 1966

Type Species — *Cordosphaeridium inodes* (Klumpp) Eisenack, 1963.

Cordosphaeridium gracilis Eisenack emend. Davey & Williams, 1966

Pl. 45, fig. 12

Diagnosis (*after Davey & Williams, 1966*) — Spherical to subspherical fibrous central body bearing small number of fibrous processes. Processes cylindrical solid, erect, simple or branched and distinctly digitate; intratabular, one per plate area, number never less than 19 or greater than 20. Archaeopyle apical, haplotabular and reflected tabulation that of the genus *Cordosphaeridium.*

Holotype — Eisenack, 1954, pl. 10, fig. 5.

Type Locality — Nordstrand des Samlandes, Hubnicken, Lower Oligocene.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Cleistosphaeridium* (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams, 1966

Type Species — *Cleistosphaeridium diversispinosum* Davey, Downie, Sarjeant & Williams, 1966.

Cleistosphaeridium heteracanthum (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams, 1966

Pl. 45, figs 3, 4

Remarks — Davey *et al.* (1966) thought that the large, broadly rectangular process is apical in position and the archaeopyle when developed is also apical in position. By the nature of the processes, it seems that there are more than one process per plate.

Holotype — Deflandre & Cookson, 1955, pl. 2, fig. 5.

Type Locality — Victoria, Nelson bore core, depth 6065 ft, ?Upper Cretaceous.

Occurrence — Bore-core no. 27 at Rataria.

Genus — *Hystrichokolpoma* Klumpp emend. Williams & Downie, 1966

Type Species — *Hystrichokolpoma cinctum* Klumpp, 1953.

Hystrichokolpoma eisenacki Williams & Downie, 1966

Pl. 45, fig. 8

Diagnosis (*after Williams & Downie, 1966*) — Central body ovoidal, slightly granular, bearing processes of two types, broad subconical or bulbose, with wide restricted distal opening and slender, simple or bifurcate processes open or closed distally.

Holotype — Williams & Downie, 1966, pl. 17, fig. 5.

Type Locality — Enborne, London Clay, Eocene.

Occurrence — Bore-core no. 27 at Rataria.

MICROPLANKTON FROM OLIGOCENE

Genus — *Operculodinium* Wall, 1967

Type Species — *Operculodinium centrocarpum* (Deflandre & Cookson) Wall, 1967.

Operculodinium centrocarpum (Deflandre & Cookson) Wall, 1967

Pl. 47, figs 9, 10

1979a *Polysphaeridium* (*Hystrichosphaeridium*) *microtriainum* (Klumpp) Kar, p. 33, Pl. 4, fig. 70.

Description (*after Jain, 1980*) — Cyst body subspherical, 51×44 μm in size, endophragm and periphragm appressed. No parasutural features, surface covered with nontabular processes measuring 6.2-7.8 μm in length, capitate, distally closed, tips bear hooklets, base conical with minute striations; areas between processes granulate. Archaeopyle broadly triangular, precingular.

Holotype — Deflandre & Cookson, 1955, pl. 8, figs 3, 4.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — Barkhana nala cutting, near the village Sarangwara; near the junction of Ramania-Fulai and Goela-Walasar cart-tracks; in the nala cutting near the village Ber Mota.

Operculodinium sp.

Pl. 47, fig. 16

1979a *Polysphaeridium cephalum* Kar, p. 34, pl. 4, fig. 67.

Description — Cyst subspherical, 50 μm in diameter, distorted, periphragm covered with short, 4-5 μm long processes, distally capitate, base circular, distance between processes coaresly granulate. Archaeopyle precingular.

Occurrence — Barkhana nala cutting near the village Sarangwara; near the junction of Ramania-Fulai and Goela-Walasar cart-tracks.

Genus — *Tuberculodinium* Wall, 1967

Type Species — *Tuberculodinium vancampoae* (Rossignol) Wall emend. Wall & Dale, 1971.

Tuberculodinium vancampoae (Rossignol) Wall emend. Wall & Dale, 1971

Pl. 46, fig. 7

1979a *Membranilarnacia* sp. Kar, p. 35, pl. 4, fig. 72.

Diagnosis (*after Wall, 1967*) — Test discoidal with two cell wall layers, the outer supported above the inner by numerous short, stout, tuberculate projections. Dorsal surface with a large compound archaeopyle which probably corresponds to a combination of precingular and intercalary plates.

Remarks (*after Jain, 1980*) — The specimen is characterized by the presence of numercus short, stout, tuberculate projections all over the body in apical-antapical view. Archaeopyle is antapical and polygonal. Paratabulation is indistinct.

Holotype — Rossignol, 1962, pl. 2, figs 17, 18.

Type Locality — Kuste von Israel, Bohrung Ashdod, Pleistocene.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Hemicystodinium* Wall, 1967

Type Species — Hemicystodinium zoharyi (Rossignol) Wall, 1967.

Hemicystodinium sp. cf. *H. congregatum* Stover, 1977

1979a *Polysphaeridium* (*Hystrichosphaeridium*) *microtriainum* (Klumpp) Kar, p. 33, pl. 4, fig. 65.

Description (*after Jain, 1980*) — Cyst spherical, endophragm and periphragm appressed, latter bears processes arranged in poorly delimited groups. Processes hollow, tapered, distally open. Archaeopyle not distinctly marked.

Occurrence — Barkhana nala cutting near the village Sarangwara; near the junction of Ramania-Fulai and Goela-Walasar cart-tracks; in the nala cutting near the village Ber Mota.

Hemicystodinium sp.

1979a *Membranilarnacia delicata* Kar, p. 35, pl. 4, fig. 71.

Remarks (*after Jain, 1980*) — The cyst is broken along the periphery and is characterized by the presence of hemispherical shape with numerous spines having weakly striated base. Archaeopyle is not seen. Parallel alignment of spines in the equatorial region reflects the position of paracingulum.

Occurrence — Near the junction of Ramania-Fulai and Goela-Walasar cart-tracks; Barkhana nala cutting near the village Sarangwara.

Genus — *Sumatradinium* Lentin & Williams, 1976

Type Species — Sumatradinium hispidum (Drugg) Lentin & Williams, 1976.

?*Sumatradinium* sp.

Pl. 46, fig. 8; Pl. 47, figs 4-6, 8

1979a *Polysphaeridium cephalum* Kar, p. 34, pl. 4, fig. 66a-b.

Description (*after Jain, 1980*) — Cyst subcircular, 62×56 μm in size, surface finely granulate and covered with numerous short (4-6 μm long), nontabular processes; processes pointed distally. Archaeopyle? intercalary, angular, broadly triangular, probably six sided, operculum free.

Occurrence — Barkhana nala cutting near the village Sarangwara; near the junction of Ramania-Fulai and Goela-Walasar cart-tracks.

Genus — *Cordosphaeridium* Eisenack emend. Davey, 1969

Type Species — Cordosphaeridium inodes (Klumpp) Eisenack, 1963.

Cordosphaeridium sp.

Pl. 46, figs 9-11

Description (*after Jain, 1980*) — Cyst subspherical, endophragm and periphragm appressed between processes. Processes intratabular, about 30 or more in number, cord-like, loosely fibrous, solid, some branched, broader at base, distally gradually narrow and open, at the tip fibres diverge in paint brush-like fashion. Paratabulation indeterminable. Archaeopyle shape and position not distinctly observed due to bad preservation (broken specimen) but appears to be large and triangular.

Occurrence — Near the junction of Ramania-Fulai and Goela-Walasar cart-tracks; Barkhana nala cutting near the village Sarangwara.

Genus — *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams, 1969

Type Species — Cleistosphaeridium diversispinosum Davey, Downie, Sarjeant & Williams, 1969.

Cleistosphaeridium heteracanthum (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams, 1969

Description (*after Davey, Downie, Sarjeant & Williams, 1969*) — Central body may be smooth or reticulate. Processes extremely variable in shape but do not vary markedly in length. A distinctive apical process may be present, archaeopyle apical. Alignment of processes on surface of central body not observed.

Remarks — Lentin and Williams (1981) thought that this species may now be placed in *?Heterosphaeridium* Cookson & Eisenack (1968). Stover and Evitt (1978) also treated this species more or less in the same manner.

Holotype — Deflandre & Cookson, 1955, pl. 2, fig. 5.

Type Locality — Victoria, Nelson borecore, depth 6065 ft, ?Upper Cretaceous.

Occurrence — Near the junction of Ramania-Fulai and Goela-Walasar cart-tracks; Barkhana nala cutting near the village Sarangwara; in the nala cutting near the village Ber Mota.

Genus — *Spiniferites* (Mantell) Sarjeant, 1970

Type Species — *Spiniferites ramosus* (Ehrenberg) Mantell, 1950.

Spiniferites ramosus subsp. *granosus* (Davey & Williams) Lentin & Williams, 1973

Pl. 47, figs 1-3

Description (*after Davey & Williams, 1969*) — Central body thin-walled, granular. Gonal ± sutural processes always extending beyond confines of sutural crests, solid or hollow, the latter closed distally. Typical gonal processes trifurcate, sutural processes bifurcate, both commonly terminating distally in a small bifurcation.

Occurrence — Barkhana nala cutting near the village Sarangwara.

Genus — *Aplanosporites* Kar, 1979a

Type Species — *Aplanosporites robustus* Kar, 1979a.

Aplanosporites robustus Kar, 1979a

Pl. 46, figs 1-5

Diagnosis (*after Kar*, 1979a) — Spores originally subcircular but due to irregular folds take various shapes, 68-127 μm. Spore coat up to 2 μm thick, laevigate. A tail-like appendage which seems to be remnant of hyphae present in most specimens.

Holotype — Kar, 1979a, pl. 3, fig. 58; size 98 μm; slide no. 5112/3.

Type Locality — Nala cutting near the village Ber Mota, Oligocene, Kachchh.

Occurrence — Nala cutting near the village Ber Mota.

MICROPLANKTONS FROM KHARI NADI FORMATION (MIOCENE)

ALGAE

Family — Hydrodictyaceae

Genus — *Pediastrum*

Pediastrum simplex var. *duodenarium* (Bailey) Rabenhorst

Description — Colonies circular to oval, 4-8-16-32 or more cells with large intercellular spaces. Inner face of marginal cells more or less concave while the outer face tapered to form a single process. Interior cells also somewhat similar to marginal cells but the processes are short in comparison to the outer ones. Cell wall laevigate, individual cells 8-24 μm broad and 10-45 μm long.

Remarks — This variety is cosmopolitan in distribution and in India it occurs as a planktonic organism in the standing water of ponds, tanks and rivers. Bruhl and Biswas (1962) described this species as *P. clathratum* var. *baileyanum* Lemm. and Singh (1939) as *P. clathratum* var. *duodenarium* (Bailey), Lemm. Kamat (1962), Patel (1970) and Patel and George (1977) reported its presence in Gujarat.

Wilson and Hoffmeister (1953) instituted four new species of *Pediastrum* from the Lower Formation (Palaeogene) of southern Sumatra. Amongst them, *P. kajaites* very closely resembles the present species in the presence of single layered coenobia with large intercellular spaces and a tapering process from each outer cell which may be slightly dichotomising at ends. Wilson and Hoffmeister (1953) also commented that this species seems to be most closely related to *P. clathratum* (Schroeter) Lemmermann and to *P. simplex* var. *duodenarium* (Bailey) Rabenhorst. In fact, from the latter species *P. kajaites* could not be differentiated. *Pediastrum* sp. illustrated by Elsik (1969, pl. 1, fig. 8) from the Late Neogene of northern gulf of Mexico also seems to belong to this species.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Pediastrum boryanum var. *longicorne* Reinsch

Pl. 32, fig. 3

Description — Coenobia subcircular, internal cells closely spaced, generally without or with very few perforations in between. Outer face of marginal cells with deep emargination to form two projected, tapering spine-like projections, individual cells sometimes granulose, 6-18 µm long.

Remarks — Philipose (1967) reported its occurrence from Bihar and Orissa while Patel and George (1977) reported it from Gujarat. *Pediastrum angulatus* Singh & Khanna (1978, pl. 1, figs 8, 9), *P. magnus* Singh & Khanna (1978, pl. 1, fig. 11) and *P. indicus* Singh & Khanna (1978, pl. 1, fig. 12) closely resemble *P. boryanum* var. *longicorne* Reinsch in the presence of emargination on the outer marginal cells to form two long, tapering, spine-like projections on each cell. *P. bifidites* Wilson & Hoffmeister (1953, pl. 1, figs 9, 12) is also very much similar to the species described here. *Pediastrum* figured by Evitt (1963, figs 1, 4) from the Lower Cretaceous of Pakistan and Upper Cretaceous of California also seems to belong to this species. Similar specimen has also been illustrated by Elsik (1969, pl. 1, fig. 9) from the Late Neogene of Mexico gulf.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Pediastrum boryanum var. *undulatum* Will

Pl. 32, figs 1, 2

Description — Colonies subcircular, 4-8-16-32 cells. Internal cells more or less compact, generally without any internal space, in some colonies a few perforations, however, observed. Cells more or less hexagonal. Each outer cell has two blunt processes.

Remarks — The present specimens are very much similar to *P. boryanum* var. *longicorne* except the latter has long, tapering processes. Patel and George (1977) reported its occurrence from Gujarat.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Achomosphaera* Evitt, 1963

Type Species — *Achomosphaera ramulifera* (Deflandre) Evitt, 1963.

Remarks — The diagnostic characters of this genus in the opinion of Evitt (1963) are the precingular archaeopyle and *Hystrichosphaera*-like processes, combined with an absence of sutural ridges or septa between process bases and an absence of trabeculae between process tips.

Achomosphaera ramulifera (Deflandre) Evitt, 1963

Pl. 48, fig. 1

Diagnosis (after Evitt, 1963) — Test consists of a spherical to ellipsoidal central body with precingular archaeopyle and furcate, spine-like processes like those in *Hystrichosphaera* in both structure and distribution, but without sutural ridges or septa connecting their bases as in that genus. Tips of processes not interconnected. Wall two-layered; layers typically in close contact between bases of processes.

Holotype — Deflandre, 1937, pl. 14, fig. 5.

Type Locality — Silex Senonien(?), galet (Erratikum), Paris.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Cordosphaeridium* Eisenack emend. Davey, 1969

Type Species — *Cordosphaeridium inodes* (Klump) Eisenack, 1963.

Cordosphaeridium Eisenack emend. Davey (1969) comes close to *Kleithriasphaeridium* Davey (1974), *Amphorosphaeridium* Davey (1969), *Fibrocysta* Stover & Evitt (1978) and other allied genera in the presence of fibrous faintly striated processes and precingular archaeopyle. According to Stover and Evitt (1978) *Cordosphaeridium* is distinguished from *Kleithriasphaeridium* in possessing fibrous rather than smooth or faintly striated processes. The other genera have generally rontabular processes and intratabular processes are rare. Sah, Kar and Singh (1970) proposed *Achomosphaera valianta* from the Langpar Formation (Palaeocene) of north-east India. This species has been transferred to *Cordosphaeridium* by Stover and Evitt (1978).

Cordosphaeridium gracilis Eisenack emend. Davey & Williams, 1966

Pl. 49, fig. 5

Diagnosis (after Davey & Williams, 1966) — Spherical fibrous central body bearing small number of fibrous processes. Processes cylindrical, solid, erect, simple or branched and distinctly digitate; intratabular, one per plate area, number never less than 19 or greater than 20. Archaeopyle apical, haplotabular and reflected tabulation that of the genus *Cordosphaeridium.*

Holotype — Brosius, 1963, pl. 6, fig. 1.

Type Locality — Nordstrand des Samlandes, Hubnicken, Lower Oligocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Cordosphaeridium cantharellum (Brosius) Gocht, 1969

Pl. 48, figs 2, 3

Diagnosis (after Brosius, 1963) — Central body circular, smooth, processes 15-20, broadly cylindrical, slightly narrow in middle and broad at tip, processes closely placed.

Holotype — Brosius, 1963, pl. 6, fig. 1.

Type Locality — Bohrung, Vollmashausen, Kasseler Meeressand, Upper Oligocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Cordosphaeridium exilimurum Davey & Williams, 1966

Pl. 48, fig. 4

Diagnosis (after Davey & Williams, 1966) — Ovoidal central body, composed of thin, smooth or slightly granular endophargm with fine fibrills of periphragm running over surface. Processes tubiform or buccinate, of variable width, and rarely latispinosus, distally open with serrate or undulose margin. Wall of processes thin and often fenestrate.

Holotype — Davey & Williams, 1966, pl. 11, fig. 2.

Type Locality — Whitecliff Bay, Isle of Wight, London Clay, Eocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Cordosphaeridium fibrospinosum Davey & Williams, 1966

Pl. 49, fig. 6

Diagnosis (after Davey & Williams, 1966) — Ovoidal central body with wall up to 0.5 μm thick, composed of smooth endophragm and fibrous periphragm. Processes fibrous, often very broad and ovoidal in cross section, walls perforate. Processes open distally with entire or undulose margin. One process per plate reflecting a tabulation typical of genus. Archaeopyle apical, haplotabular.

Holotype — Davey & Williams, 1966, pl. 5, fig. 5.

Type Locality — Enborne, Berkshire, bore-core no. 11, London Clay, Eocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Cordosphaeridium cracenospinosum Davey & Williams, 1966

Pl. 48, figs 5, 6

Diagnosis (after Davey & Williams, 1966) — Subspherical to polygonal central body with wall composed of endophragm and periphragm, up to 1.5 μm in thickness. Endophragm very thin. Archaeopyle apical, haplotabular, processes slender, buccinate, erect or curved, solid or with fine central tubule or hollow, the last two types open distally. Distal margins foliate, bifurcate or digitate. Processes one per plate area.

Remarks — Stover and Evitt (1978) remarked that processes of this species are unusually slender and seem to be nonfibrous. They have placed this species under *Cordosphaeridium* as an provisional one.

Holotype — Davey & Williams, 1966, pl. 3, fig. 4.

Type Locality — Enborne, Berkshire, bore-core no. 39, London Clay, Eocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Cordosphaeridium sp.

Pl. 49, fig. 7

Description — Subcircular, chorate cysts possessing a two-layered wall, outer one covered with more or less homogeneous regularly distributed processes. Processes slender, cylindrical forming net-work at tips. Approximately 30 appendages observed. Nature of archaeophle not discernible.

Comparison — *Cordosphaeridium craceno-spinosum* Davey & Williams (1966) comes close to this species in the presence of slender processes but the species described here is distinguished by its smaller size of the cyst and more slender processes.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Hystrichokolpoma* Klumpp emend. Williams & Downie, 1966

Type Species — *Hystrichokolpoma cinctum* Klumpp, 1953.

Remarks — Klumpp (1953) instituted *Hystrichokolpoma* from the Eocene sediments to include rounded shell with a girdle-like zone separating the shell into two halves. The lower half consists of six while the upper one has four plates. Williams and Downie (1966) emended this genus to accommodate two types of intratabular processes, the slender ones delimiting the well marked cingulum and sulcal zone. Stover and Evitt (1978) further elaborated the circumscription of the genus.

Hystrichokolpoma rigaudae Deflandre & Cookson, 1955

Pl. 48, figs 7, 8

Diagnosis (after Deflandre & Cookson, 1955) — Shell globular, more or less ellipsoidal with approximately axial symmetry and processes of two kinds not communicating with the interior, disposed in parallel series starting from 1 pole considered as apical. Antapical pole with a large aperture having a straight or angular margin. Bases of the large processes marked by lines forming quadrangular areas that give the impression of plates. Large processes always closed at their distal extremities, generally widened and provided with more or less numerous and sometimes relatively long horns. The large process situated at the apical pole is often longer than the others and is sometimes shaped into a hollow horn. The narrow tubular processes are slightly widened or divided at the extremities, which are either open or closed. Certain filliform processes seem to be solid throughout.

The narrow processes forming the equatorial series are about 10 in number, of which some may be paired. Between the equatorial series and the apex there is a circle of 4 large appendages and a space occupied by a large number (3-5) of narrow processes similar to those of the equatorial belt.

Below the equator there is a circle of 6 large processes, or in certain specimens 1 of these processes may, perhaps, be duplicated or replaced by several thinner appendages. Membrane of the shell smooth or indistinctly granular.

Remarks — This species is long ranging and is found from Palaeocene to Pleistocene. Maier (1959), Gerlach (1961), Rossignol (1962), Brosius (1963), Williams and Downie (1966), Morgenroth (1966), Cookson and Eisenack (1967) and others have recorded this species in various horizons.

Holotype — Deflandre & Cookson, 1955, pl. 6, fig. 6.

Type Locality — Bore-core no. 1, Victoria, Miocene or older.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Hystrichokolpoma poculum Maier, 1959

Pl. 49, fig. 1

Diagnosis (after Maier, 1959) — This is a characteristic species of the genus with all cylindrical broader processes while the small ones are in rows. The average size is 55 μm.

Holotype — Maier, 1959, pl. 31, fig. 3.

Type Locality — Holstein, Rehden, Middle Miocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Hystrichokolpoma unispinum Williams & Downie, 1966

Pl. 49, fig. 2

Diagnosis (after Williams & Downie, 1966) — Central body subspherical with thin smooth periphragm. Processes formed from periphragm and of two types, broad, tapering laginate, and buccinate more slender processes. Reflected tabulation of 4′, 6″, 6g, 5‴ 1 p, 1⁗ and at least 5s. Each cingular plate possessing only one process.

Remarks — Williams and Downie (1966) opined that the species has four apical plates, 1′ being smaller than the other three. Five of the precingular plates and processes are equal in size, the other, plate 6″, is smaller, more closely approaching the anterior sulcal plate.

Holotype — Williams & Downie, 1966, pl. 17, fig. 7.

Type Locality — Whitecliff, London Clay, Eocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Lingulodinium* Wall emend. Dale & Harada, 1973

Type Species — *Lingulodinium machaerophorum* Deflandre & Cookson) Wall, 1967.

Remarks — Deflandre and Cookson (1955) recorded *Hystrichosphaeridium machaerophorum* from the Middle Miocene of Victoria, Australia. Wall (1967) instituted the genus *Lingulodinium* and transferred *H. machaerophorum* as the type species of the genus. Wall and Dale (1973) also placed *L. pugiatum* (Drugg, 1970), *L. siculum* (Drugg, 1970) and *L. solarum* (Drugg, 1970) into this genus. Gerlach (1961) reported this species from Middle Oligocene-Middle Miocene of north-west Germany. Wall and Dale (1966, 1967) showed its existence in the recent sediments.

Stover and Evitt (1978) remarked that in contrast to most other dinoflagellate cyst genera, the multiple archaeopyle types shown by *Lingulodinium* are exceptional. The hollow, distally closed, blade-like non-tabular processes are characteristic of *Lingulodinium*. By this character alone, the similar appearing skolochorate cysts like *Operculodinium* Wall (1967) and *Exochosphaeridium* Davey (1966) are separated from *Lingulodinium*.

Lingulodinium machaerophorum (Deflandre & Cookson) Wall, 1967

Pl. 49, figs 3,4

Diagnosis and Description (after Wall, 1967) — The test is spherical but rarely found whole. Upon dehiscence it develops a large compound precingular archaeopyle, so all that remains of the epitheca is a narrow, elongated, angular projection, attached to the hypotheca ventrally. The archaeopyle, its most entire form, represents the loss of five precingular plate-areas (1″ to 5″) or but it may represent only four plates (2″ to 5″) or very rarely only the dorsal precingular plate 3″. The test is microgranular and bears numerous (15 to 20 in optical section), flexuous, hollow spines of variable length. Their bases are circular and minutely striated; their distal extremities are flexuous, closed and bear spinules. There is a tendency towards flattening of the spines.

Holotype — Deflandre & Cookson, 1955, pl. 9, fig. 4.

Type Locality — Birregurra, Victoria, bore-core no. 1, Balcombe Bay, Middle Miocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Genus — *Millioudodinium* Stover & Evitt, 1978

Type Species — *Millioudodinium fetchamense* Sarjeant, 1966.

Remarks — Stover and Evitt (1978) instituted this genus to accommodate proximate cysts with subspherical to ellipsoidal autocyst decorated generally with a prominent apical horn. The paratabulation is typically gonyaulacean which is indicated usually with low parasutural ridges. The paraplates are without any accessory ridges, septa or other rectilinear markings. The archaeopyle is distinctly precingular.

This genus closely resembles *Apteodinium* Eisenack (1958) in possessing more or less same shape and precingular archaeopyle. However, *Millioudodinium* is distinguished from *Apteodinium* in the presence of parasutural ridges. It also differs from *Cribroperidinium* Neale & Sarjeant (1962) in the absence of accessory ridges or septa on the paraplates.

Millioudodinium unicornum sp. nov.

Pl. 49, fig. 8

Diagnosis — Proximate cysts, subspherical to ellipsoidal, 51-72×48-70 µm, apical horn distinct. Wall conied, sometimes interspersed with grana, archaeopyle precingular, paracingulum generally indicated by parallel transverse equatorial ridges.

Comparison — *Millioudodinium apionis* (Cookson & Eisenack) Stover & Evitt (1978) resembles the present species in possessing a distinct apical horn but is separated by its smooth wall, a shell twice as long as broad and its bigger size (105×57 µm). *M. tenuitabulatum* (Gerlach) Stover & Evitt (1978) has a small apical horn and granulate wall.

Holotype — Pl. 49, fig. 8; size 60×59 µm; slide no. 8267/12.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Operculodinium* Wall, 1967

Type Species — *Operculodinium centrocurpum* (Deflandre & Cookson) Wall, 1967.

Remarks — Morgenroth (1966) transferred *Operculodinium centrocarpum* (Deflandre & Cookson) Wall (1967) to *Cordosphaeridium tiara* (Klumpp) Morgenroth (1966). With this treatment the genus *Operculodinium* becomes invalid. Lentin and Williams (1973), however, did not agree with this approach and they transferred the type species again to *Operculodinium*. Stover and Evitt (1978) also maintained the same status of this species.

Operculodinium centrocarpum (Deflandre & Cookson) Wall, 1967

Pl. 50, fig. 5

Diagnosis (*after Wall, 1967*) — The test is almost spherical and densely ornamented with slender radiating spines whose length (8-16 µm) varies between approximately one-fifth and one-quarter of the cell diameter, the dorsal precingular archaeopyle is large and subtrapezoidal. The outer cell wall is microgranular and the immediate spine bases are conical with minute striations. The spine tips bear small hooklets which are visible only at high magnifications. The spines are aligned in the girdle region but there is no distinct ventral sulcus. The spine arrangement is intratabular, most spines lying alongside the sutural lines.

Holotype — Deflandre & Cookson, 1955, pl. 8, fig. 3.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Operculodinium israelianum (Rossignol) Wall, 1967

Diagnosis (*after Wall, 1967*) — Their spines vary from three to six microns and are equivalent to approximately one-tenth or less of the test diameter which ranges from 40 to 65 µm. A narrow girdle and small mid-ventral depression are visible sometimes. The dorsal archaeopyle is trapezoidal and precingular. Carribbean and Mediterranean specimens examined consistently have very short spines with weakly capitate tips and in these respects differ from the description given by Rossignol. *O. israelianum* is fundamentally similar to *O. centrocarpum* according to these observations and only distinguishable by its smaller spines relative to the test size but this is a consistent feature.

Holotype — Rossignol, 1964, pl. 2, fig. 2.

Type Locality — Ashdod yam, Israel, Pleistocene.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Operculodinium placitum Drugg & Loeblich, 1967

Pl. 48, fig. 10

Diagnosis (after Drugg & Loeblich, 1967) — Tract small, elliptical in outline. The precingular archaeopyle is more or less elliptical in outline at the top with a squared-off lower edge. It is located on the upper face of the tract and extends from near the apex to the equator. The wall is about 1-1.5 μm thick, endophragm thinner than periphragm. The latter is finely granulate and ornamented with short, more or less blunt spines of about 1 μm in length. These spines are spaced approximately 1-2 μm apart and do not reflect any apparent tabulation.

Remarks — Drugg and Loeblich (1967) placed this species in the genus *Operculodinium* because of its precingular archaeopyle and spinose ornamentation. It does not, however, show any spine arrangements suggestive of plate patterns, and there is no indication of a cingulum or sulcus. The present species comes close to *Pyxidiella pandora* Cookson & Eisenack (1958), *P. scrobiculata* (Deflandre & Cookson) Cookson & Eisenack (1958). According to Drugg and Loeblich (1967), it differs from *P. scrobiculata* in the smaller size and thinner nonpunctate wall. From both species it differs in possessing a precingular archaeopyle instead of an intercalary archaeopyle.

Holotype — Drugg & Loeblich, 1967, pl. 1, fig. 11.

Type Locality — Hinds Country, Missisipi, Oligocene Glendon Limestone.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Operculodinium paucispinosum sp. nov.

Pl. 50, fig. 6

Diagnosis — Body ellipsoidal, two layered, endophragm and periphragm appressed between projections, body granular, processes 22-35 μm long, tapering at ends, strongly built, about one-third of body diameter, sparsely placed, tips divide more than three times (generally five times). Archaeopyle seems to be precingular, paratabulation not clear.

Comparison — *Operculodinium centrocarpum* (Deflandre & Cookson) Wall (1967) is densely ornamented with slender radiating spines whose length varies between 8 and 26 μm. *O. israelianum* (Rossignol) Wall (1967) has only 3-6 μm long spines and they are about one-tenth of the body diameter. The periphragm of *O. placitum* Drugg & Loeblich (1967) is finely granulate and ornamented with short, more or less blunt spines of about 1 μm in length.

Holotype — Pl. 50, fig. 6; size 90 μm (without processes); slide no. 8269/3.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Operculodinium delicatum sp. nov.

Pl. 50, fig. 7

Diagnosis — Body subcircular, wall two-layered, endophragm and periphragm appressed between projections, body conied, processes 8-15 μm long, about one-sixth of body diameter, processes conied, particularly at basal part; divided at tips. Archaeopyle probably precingular in position, paratabulation not discernible.

Comparison — *Operculodinium paucispinosum* has strongly built long processes. *O. centrocarpum* (Deflandre & Cookson) Wall (1967) has same size of spines as in the present species; but the body is microgranular and the immediate spine bases are conical with minute striations.

Holotype — Pl. 50, fig. 7; size 70 μm (without processes); slide no. 8270/2.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Operculodinium robustum sp. nov.

Pl. 50, fig. 8

Diagnosis — Body subcircular, wall two-layered, endophragm and periphragm appressed between projections. Processes long, 20-35 μm, approximately one-third diameter of body, generally with pointed tips dividing at ends. Archaeopyle precingular, paratabulation and paracingulum not distinct.

Comparison — *Operculodinium paucispinosum* comes close to the present species in the presence of long, robustly built processes; however, the tips of the processes in *O. paucispinosum* are divided more than three times. *O. delicatum* has conied processes which are also divided at tips. In *O. centrocarpum* (Deflandre & Cookson) Wall (1967), the processes are slender and comparatively smaller (8-16 μm) in size. *O. robustum* is distinguished from all the known species of *Operculodinium* by its long processes which are not generally divided at tips.

Holotype — Pl. 50, fig. 8; size 58 μm (without processes); slide no. 8271/2.

Type Locality — Aida, Khari Nadi Formation, Miocene, Kachchh.

Occurrence — Aida, Chasara, Laiyari, Khari Nadi Formation, Kachchh.

Operculodinium sp.

Pl. 50, fig. 9

Description — Body subcircular, 80 μm (without processes), about 2 μm thick, two-layered, endophragm and periphragm appressed between projections, wall granulate, grana about 1 μm high, evenly distributed. Processes 35-45 μm long, very strongly built, striated and granulose at base, closely placed, sometimes dichotomising in middle region, looking like bacula, tips generally divided into 5 parts.

Comparison — The specimen described here is differentiated from *Operculodinium paucispinosum*, *O. delicatum* and *O. robustum* by its very long, bacula-like processes which are sometimes dichotomising in middle part.

Occurrence — Chasara, Aida, Khari Nadi Formation, Kachchh.

Genus — *Spiniferites* Mantell emend. Sarjeant, 1970

Type Species — *Spiniferites ramosus* (Ehrenberg) Loeblich & Loeblich, 1966.

Remarks — Stover and Evitt (1978) included the genera *Achomosphaera* Evitt (1963), *Cannosphaeropsis* Wetzel (1933), *Hystrichostrogylon* Agelopoulos (1964), *Nematosphaeropsis* Deflandre & Cookson (1955), *Rottnestia* Cookson & Eisenack (1961) and *Spiniferites* Mantell emend. Sarjeant (1970) in the *Spiniferites* complex. According to them, the essential characteristic of these genera is the presence of gonal structure with trifurcate tips with or without the intergonal features having bifurcate tips. Other features which are more or less common to these genera are:

(1) Cysts are subspherical to ellipsoidal.
(2) Ends of the paracingulum are strongly offset and the parasulcus is somewhat sinuous.
(3) The archaeopyle is precingular and belongs to the type 3″ only.
(4) Parasutural features, viz., processes, ridges or trabeculae are prominent.
(5) Processes are gonal or gonal and intergonal, solid or hollow, distinctively branched. Primary branching of gonal processes is trifurcate, of intergonal processes, bifurcate. In some cases processes are represented only by their distal portions.
(6) Paraplates 1′ and 4′ tend to be elongate, more or less equal and parallel, and mostly on the ventral surface.
(7) Paraplates 6″ tends to be subtriangular and its contact with paraplate 4′ is very short.

Spiniferites and *Achomosphaera* both are devoid of trabeculae or only locally. In *Spiniferites* parastructural ridges or septa are distinct, whereas in *Achomosphaera* these ridges are absent or faint. This generic distinction between the two genera in the opinion of Stover and Evitt (1978) is also an open question because the distinction depends solely on the prominence of the parasutural ridges. Effective arguments can be put forwarded both for and against the use of this criterion for distinguishing the two genera. The specimens assignable to *Achomosphaera ramulifera* (Deflandre) Evitt (1963) show no apparent intergradation between those lacking well-developed parasutural ridges and those possessing such features. However, in some other species of the genus, individuals that are associated in a single sample may appear to be essentially identical.

Stover and Evitt (1978) modified the generic circumscription and redefined the paratabulation as indicated by parasutural ridges or septa combined with processes.

The paratabulation is basically gonyaulacacean and the formula is 3-4′, 5-6″, 6c, 5-6‴, 1p, 1″″. They also concurred with Morgenroth's (1968) interpretation that *Areoligera birma* Maier (1959) and *A. dermatica* Maier (1959) are conspecific with *Hystrichosphaera furcata* (*Spiniferites ramosus*), the type species of the genus *Spiniferites*.

Spiniferites bulloideus (Deflandre & Cookson) Sarjeant, 1970

Pl. 50, figs 1, 2

Diagnosis (*after Deflandre & Cookson, 1955*) — Shell small, spherical or nearly so, having the general appearance of *Hystrichosphaera furcata* and *H. ramosa*. Outline circular in well preserved specimens, elliptical or oval when broken. Membrane rather thin and delicate, easily broken and crumpled when owing to their unnaturally close proximity, the processes seem more numerous than in fully expanded examples. Processes always trifurcate, the 3 branches being widely separated and shortly bifurcate.

Holotype — Deflandre & Cookson, 1955, pl. 5, fig. 3.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Spiniferites hypercanthus (Deflandre & Cookson) Cookson & Eisenack, 1974

Pl. 49, fig. 9

Diagnosis (*after Deflandre & Cookson, 1955*) — Shell globular, spherical or almost spherical, polygonal fields, characteristic of the genus with fine, sometimes almost indistinguishable outlines, the equatorial series recognizable by the alignment of the processes. Stalks of processes long, stiff, often slender, divided into 3 distinct branches with simple or bifurcate apices, inserted both at the angles of the fields and along their sides, the usual arrangement being 1 process to each angle of the field and 2 along each side.

Holotype — Deflandre & Cookson, 1955, pl. 6, fig. 7.

Type Locality — Victoria, Balcombe Bay, Middle Miocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Spiniferites mirabilis Rossignol

Pl. 48, fig. 9; Pl. 50, figs 3, 4

Diagnosis (*after Rossignol, 1962*) — A large, membraneous antapical process present processes trifurcate but bifurcate in intercalaried position, paratabulation is like that of *Hystrichosphaera furcata* and *H. bentori*.

Holotype — Rossignol, 1964, pl. 2, fig. 1.

Type Locality — Kuste von Israel, Bohrung Ashdol Yam, Pleistocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

Genus — *Thalassiphora* Eisenack & Gocht, 1968

Type Species — *Thalassiphora pelagica* (Eisenack) Eisenack & Gocht, 1960.

Thalassiphora pelagica (Eisenack) Eisenack & Gocht, 1960

Pl. 50, fig. 10

Diagnosis (*after Eisenack & Gocht, 1960*) — Central body spherical to ellipsoidal, hollow, firm-walled, surrounded by an equatorially placed helmet to bowl-shaped, wide, flexible membraneous wing that never the less is double walled. The central body commonly has a circular to horse shoe-shaped pylome.

Holotype — Eisenack, 1954, pl. 12, fig. 17.

Type Locality — Phosphorites, Oligocene, Germany.

Occurrence — Aida, Khari Nadi Formation, Kachchh.

Genus — *Tuberculodinium* Wall emend. Wall & Dale, 1967

Type Species — *Tuberculodinium vancampoae* (Rossignol) Wall & Dale, 1971.

Remarks — Wall and Dale (1971) demonstrated that the type species *Tuberculodinium vancampoae* (Rossignol) Wall & Dale (1971) is the cyst of living *Pyrophacus* Stein. Stover and Evitt (1978) opined that such treatment has far reaching ramifications involving many living and fossil genera. Until an intensive investigation of the problem is made and a procedure adopted they preferred to assign the fossil forms in the cyst genera. The same practice has also been followed here.

Tuberculodinium vancampoae (Rossignol) Wall & Dale, 1971

Pl. 49, figs 10, 11

Description — Subspherical, autophragm and ectophragm separated with intervening ectocoel occupied by intratabular features. Intratabular features pillar-like, barrel to dumb bell shaped, and arranged in latitudinal rows; ectophragm and autophragm generally smooth or faintly ornamented the latter perhaps coarsely granulate antapically. Paratabulation formula as indicated by intratabular features and by archaeopyle is 5-(7)-8′, 8-(10)-13″, 6-(10)-13‴, 3-(8)-11⁗. Archaeopyle antapical, compound, outline polygonal with one long and two short straight margins and a zigzag fourth margin; operculum free, composed of two or three paraplates which are smooth or coarsely granulate. Paracingulum indicated by the absence of intratabular features.

Holotype — Rossignol, 1964, pl. 2, fig. 17.

Type Locality — Kuste von Israel, Pleistocene.

Occurrence — Aida, Laiyari, Khari Nadi Formation, Kachchh.

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EXPLANATION OF PLATES

(All the photomicrographs are magnified *ca.* ×500, unless otherwise mentioned)

Plate 1

1. *Cyathidites australis* Couper, slide no. 4936/14.
2. *Cyathidites minor* Couper, slide no. 4937/14.
3. *Lygodiumsporites lakiensis* Sah & Kar, slide no. 4938/8.
4, 5, 16. *Lygodiumsporites pachyexinus* Saxena, slide nos. 4766/12, 4766/11 and 4791/7.
6. *Todisporites major* Couper, slide no. 4939/20.
7, 17. *Todisporites minor* Couper, slide nos. 4733/1 and 4944/2.
8. *Dandotiaspora dilata* (Mathur) Sah, Kar & Singh, slide no. 4940/6.
9. *Dandotiaspora telonata* Sah, Kar & Singh, slide no. 4942/1.
10. *Dictyophyllidites granulatus* Saxena, slide no. 4777/10.
11, 12. *Osmundacidites cephalus* Saxena, slide nos. 4945/8 and 4940/7.
13. *Leptolepidites major* Couper, slide no. 4767/3.
14. *Lycopodiumsporites bellus* Sah & Kar, slide no. 4766/2.
15. *Polypodiisporites repandus* Takahashi, slide no. 4773/2.

Plate 2

1. *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh, slide no. 4941/14.
2. *Dictyophyllidites* sp., slide no. 8301/1.
3, 4. *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, slide nos. 4796/7 and 4767/30.
5. *Retipilonapites cenozoicus* Sah, slide no. 4780/9.
6. *Proxapertites microreticulatus* Jain, Kar & Sah, slide no. 4780/7.
7. *Proxapertites assamicus* (Sah & Dutta) Singh, slide no. 4939/22.
8. *Palmaepollenites kutchensis* Venkatachala & Kar, slide no. 4957/2.
9. *Palmaepollenites nadhamunii* Venkatachala & Kar, slide no. 4940/19.
10. *Psilastephanocolpites guaduensis* (van der Hammen) Saxena, slide no. 4957/14.
11. *Platoniapollenites* sp., slide no. 4962/1.
12. *Tricolpites reticulatus* Cookson, slide no. 4767/12.
13. *Intrareticulites* (*Tricolpites*) *brevis* (Sah & Kar) comb. nov., slide no. 4788/7.
14. *Palaeocoprosmadites arcotense* Ramanujam, slide no. 4788/9.
15. *Triporopollenites minutiformis* (Ramanujam) Saxena, slide no. 4971/7.
16. *Paleosantalaceaepites ellipticus* Sah & Kar, slide no. 4964/4.
17. *Paleosantalaceaepites minutus* Sah & Kar, slide no. 4965/4.
18. *Sonneratioipollis bellus* Venkatachala & Kar, slide no. 4791/1.
19. *Ghoshiacolpites globatus* Sah & Kar, slide no. 4794/20.
20. *Meliapollis melioides* (Ramanujam) Sah & Kar, slide no. 4970/2.
21. *Retistephanocolpites kutchensis* Saxena, slide no. 4772/2.
22. *Granustephanocolpites sahii* Saxena, slide no. 4779/8.
23. *Pseudonothofagidites kutchensis* Venkatachala & Kar, slide no. 4962/11.
24. *Retistephanocolpites flavatus* (Sah & Kar) Saxena, slide no. 4775/3.
25. *Retistephanocolpites kutchensis* Saxena, slide no. 4772/2.
26, 27. *Couperipollis robustus* Saxena, slide nos. 4766/3 and 4772/1.
28. *Striacolporites ovatus* Sah & Kar, slide no. 4968/8.
29. *Lakiapollis spinosus* Saxena, slide no. 4769/14.
30. Sponge spicule, slide no. 4973/1.

Plate 3

1, 2. *Matanomadhiasulcites* (*Liliacidites*) *maximus* (Saxena) comb. nov., slide nos. 4955/5 and 4800/9.
3. *Matanomadhiasulcites* (*Liliacidites*) *kutchensis* (Saxena) comb. nov., slide no. 4956/1.
4. Pollen-type 1, slide no. 4972/1.
5. *Retitribrevicolporites* (*Lakiapollis*) *matanamadhensis* (Venkatachala & Kar) comb. nov., slide no. 4963/5.
6. *Meliapollis ramanujamii* Sah & Kar, slide no. 4769/22.
7. *Tricolpites retibaculatus* Saxena, slide no. 4774/4.
8. *Kielmeyerapollenites eocenicus* Sah & Kar, slide no. 4950/12.

Plate 4

1. *Liliacidites matanomadhensis* Saxena, slide no. 4956/1.
2, 3. *Polypodiisporites* sp., slide nos. 4949/25 and 4936/8.
4. *Palmidites maximus* Couper, slide no. 4796/10.
5. *Tricolpites matanomadhensis* Saxena, slide no. 4953/33.
6. *Tricolpites crassireticulatus* Dutta & Sah, slide no. 4960/26.
7. *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov., slide no. 4780/10.
8. *Triangulorites* (*Triorites*) *triradiatus* (Saxena) comb. nov., slide no. 4959/1.
9. *Meliapollis ramanujamii* Sah & Kar, slide no. 4771/2.
10. *Dermatobrevicolporites* (*Meliapollis*) *triangulus* (Saxena) comb. nov., slide no. 4767/15.
11. *Meliapollis quadrangularis* (Ramanujam) Sah & Kar, slide no. 4969/8.
12. *Striacolporites cephalus* Sah & Kar, slide no. 4967/10.
13. *Cicatricosisporites australiensis* (Cookson) Potonié, slide no. 4771/19.

Plate 5

1. *Biretisporites bellus* Sah & Kar, slide no. 3372/3.
2. *Biretisporites convexus* Sah & Kar, slide no. 3351/10.
3, 11. *Todisporites kutchensis* Sah & Kar, slide nos. 3347/1 and 4777/2.

4, 5. *Todisporites plicatus* Sah & Kar, slide nos. 3364/8 and 3363/10.
6. *Todisporites* sp., slide no. 3379/11.
7, 8. *Lygodiumsporites lakiensis* Sah & Kar, slide nos. 3371/12 and 3372/7.
9. Spore-type 1, slide no. 3351/15.
10. *Gleicheniidites* sp., slide no. 3352/15.
12. cf. *Laevigatosporites* sp., slide no. 3365/2.
13. *Laevigatosporites cognatus* Sah & Kar, slide no. 3357/2.
14. *Laevigatosporites lakiensis* Sah & Kar, slide no. 3374/9.
15. *Polypodiisporites repandus* Takahashi, slide no. 4773/2.

PLATE 6

1. *Cyathidites minor* Couper, slide no. 3371/4.
2. *Leptolepidites* sp. A, slide no. 3374/5.
3, 4. *Leptolepidites* sp. B, slide nos. 3372/28 and 3368/10.
5-7. *Lakiasporites triangulus* Sah & Kar, slide nos. 3376/1, 3354/9 and 3364/6.
8. *Lycopodiumsporites umstewensis* Dutta & Sah, slide no. 4948/11.
9. *Lycopodiumsporites parvireticulatus* Sah & Dutta, slide no. 3357/16.
10-13. *Lycopodiumsporites bellus* Sah & Kar, slide nos. 3353/23 and 3359/18.
14, 15, 24, 25. *Laevigatosporites lakiensis* Sah & Kar, slide nos. 3373/3, 3371/16, 3362/3 and 3362/5.
16. *Laevigatosporites* sp. B, slide no. 3374/10.
17. *Monolites* sp., slide no. 3372/24.
18. *Polypodiaceaesporites* sp., slide no. 3366/6.
19-21. *Seniasporites verrucosus* Sah & Kar, slide nos. 3353/17, 3367/4 and 3376/11.
22, 23. *Seniasporites minutus* Sah & Kar, slide nos. 3349/4 and 3350/17.

PLATE 7

1. *Laevigatosporites* sp., slide no. 3362/3.
2. *Laevigatosporites* sp., slide no. 3362/4.
3. *Schizaeoisporites* sp., slide no. 3372/12.
4. A partially degraded trilete spore, slide no. 3368/6.
5. *Spinozonocolpites echinatus* Muller, slide no. 8233/4.
6-8. Algal phytoplankton, slide nos. 8234/4 and 8235/7.
9-12. *Arengapollenites achinatus* gen. et sp. nov., slide nos. 8236/2, 8237/1, 8237/1 and 8238/7.
13. Same as above *ca.* × 1000.
14-16. *Intrareticulites* (*Tricolpites*) *brevis* (Sah & Kar) comb. nov., slide nos. 3348/4 and 3350/5.
17. *Cheilanthoidspora monoleta* Sah & Kar, slide no. 8239/3.
18. *Ligulifloraedites pilatus* gen. et sp. nov., slide no. 8240/3.
19. Same magnified *ca.* × 1000 to show the characters, slide no. 8240/3.

PLATE 8

1, 2. *Symplocoipollenites constrictus* Sah & Kar, slide nos. Holotype — 3370/4 and 3371/2.
3. *Dracaenoipollis circularis* Sah & Kar, slide no. 3360/14.
4. *Trilatiporites minutus* Sah & Kar, slide no. 3370/3.
5. *Paleosantalaceaepites primitiva* Biswas, slide no. 3375/1.
6. *Paleosantalaceaepites ellipticus* Sah & Kar, slide no. 3363/2.
7. *Tricolpites minutus* Sah & Kar, slide no. 3376/17.
8. *Tricolpites* sp., slide no. 3376/15.
9. *Verrutricolpites triangulus* Sah & Kar, slide no. 3371/17.
10. *Dermatobrevicolporites* (*Triorites*) *dermatus* (Sah & Kar) comb. nov., slide no. 3372/8.
11. *Meliapollis ramanujamii* Sah & Kar, slide no. 3363/7.
12. *Meliapollis navalei* Sah & Kar, slide no. 3379/1.
13, 14. *Pellicieroipollis langenheimii* Sah & Kar, slide nos. 3376/11 and 3372/17.
15. *Striacolporites striatus* Sah & Kar, slide no. 3362/2.
16, 17. *Striacolporites ovatus* Sah & Kar, slide nos. 3376/13 and 3376/6.
18. *Arecipites bellus* Sah & Kar, slide no. 8241/10.
19. *Thymelaepollis crotonoidis* Sah & Kar, slide no. 3372/12.
20. Pollen type-1, slide no. 3376/2.
21. *Retistephanocolpites* (*Polycolpites*) *granulatus* (Sah & Kar) comb. nov., slide no. 3372/32.
22-24. *Retistephanocolpites* (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov., slide nos. 3363/13, 3363/3 and 3363/4.
25. *Ghoshiacolpites globatus* Sah & Kar, slide no. 3362/3.
26. *Ctenolophonidites* sp., slide no. 3371/10.

PLATE 9

1-6. *Tribrevicolporites eocenicus* gen. et sp. nov., slide nos. 3372/7, 3363/9, 3371/4, 3372/1 and 3362/2, 8240/4.
7. *Retitribrevicolporites* (*Lakiapollis*) *matanomadhensis* (Venkatachala & Kar) comb. nov., slide no. 3376/18.
8. *Ligulifloraedites pilatus* gen. et sp. nov. *ca.* × 700, slideno. 8230/3.
9. *Proxapertites assamicus* (Sah & Dutta) Singh, slide no. 3368/6.
10. *Thymelaepollis crotonoides* Sah & Kar, slide no. 8230/1.
11. cf. *Thymelaepollis* sp., slide no. 8237/2.
12. *Sastriipollenites trilobatus* Venkatachala & Kar, 1969a, slide no. 3376/12.
13. *Meliapollis* sp., slide no. 3379/3.
14. Tricolpate spinose pollen, slide no. 8231/1.
15. Tetracolporate pollen, slide no. 3376/9.
16. cf. *Tribrevicolporites* sp., slide no. 3363/11.
17. Tricolporate pollen, slide no. 3363/8.
18, 19. *Tricolpites reticulatus* Cookson, 1947, slide nos. 3363/14 and 3370/2.

PLATE 10

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Retimonosulcites* (*Liliacidites*) *ellipticus* (Venkatachala & Kar) comb. nov., slide no. 3319/3.
2. *Retimonosulcites* (*Monosulcites*) *ovatus* (Sah & Kar) comb. nov., slide no. 3353/6.
3. *Matanomadhiasulcites* (*Liliacidites*) *maximus* (Saxena) comb. nov., slide no. 3560/19. Note the pila-bacula forming negative reticulum in surface view.

4. Same as above, showing the sculptural elements on margin.
5. *Matanomadhiasulcites* (*Liliacidites*) *kutchensis* (Saxena) comb. nov., slide no. 3353/20.
6. *Meliapollis quadrangularis* Sah & Kar, slide no. 3361/7.
7. *Paleosantalaceaepites primitiva* Biswas, slide no. 3375/1.
8. *Marginipollis* (*Rostripollenites*) *kutchensis* (Venkatachala & Kar) Kar, slide no. 3317/9. Note the beak-shaped appearance of colpi at ends.
9. Same as above, showing the areolate exine.
10. *Umbelliferoipollenites ovatus* Venkatachala & Kar, slide no. 3352/3.

PLATE 11

(All the photomicrographs are enlarged *ca.*× 1000)

1-3. *Palmaepollenites kutchensis* Venkatachala & Kar, slide nos. 3317/2, 3346/3 and 3353/6.
4. *Acanthotricolpites bulbospinosus* gen. et sp. nov. slide no. 3357/1. Note one of the colpi and the spines.
5. Same as above, showing the bulbous base and pointed tip of spines.
6. Same as above, showing the three colpi.
7. *Polybrevicolporites cephalus* Venkatachala & Kar, slide no. 3322/16.
8. *Polybrevicolporites* (*Stephanocolpites*) *nadhamunii* (Venkatachala & Kar) comb. nov., slide no. 3311/7.
9. *Retitetrabrevicolporites* (*Stephanocolpites* cf. *arcotense*) sp. (Venkatachala & Kar) comb. nov., slide no. 3314/9.
10. *Retitetrabrevicolporites* (*Stephanocolpites*) *globatus* (Venkatachala & Kar) comb. nov., slide no. 3314/10. Note the rounded margin in some of the apertures indicating the presence of pores.
11. Same as above, showing the extension of colpi.
12. *Ctenolophonidites costatus* van Hoeken-Klinkenberg, slide no. 3353/26. Note the nature of exine in deep focus.
13. Same as above, showing the thickening of exine.
14. *Retistephanocolpites* (*Polycolpites*) *flavatus* (Sah & Kar) comb. nov., slide no. 3353/1.
15. *Retistephanocolpites* (*Polycolpites*) *granulatus* (Sah & Kar) comb. nov., slide no. 3372/32.

PLATE 12

(All the photomicrographs are enlarged *ca.*× 1000)

1. *Dracaenoipollis circularis* Sah & Kar, slide no. 3346/2.
2. *Palmaepollenites ovatus* Venkatachala & Kar, slide no. 3364/15.
3. *Spinozonocolpites echinatus* Muller, slide no. 3353/26. Note the microreticulate ornamentation.
4. Same as above, showing the zone from where the pollen splitted into two slightly unequal halves.
5. *Pilatricolporites eocenicus* gen. et sp. nov., slide no. 3353/17. Note the colpi and pila heads.
6. Same as above, showing tricolporate nature.
7. *Triangulotricolporites triangulus* gen. et sp. nov. slide no. 3367/2. Note the configuration of pollen grain in deep focus and thickened margin of pores.
8. Same as above, showing the extension of colpi.
9. Same as above, showing the sculptural elements.
10. *Clavatipollenites cephalus* Sah & Kar, slide no. 3352/13.
11. *Ctenolophonidites* sp., slide no. 3365/8.
12. *Pellicieroipollis langenheimii* Sah & Kar, slide no. 3372/17.

PLATE 13

(All the photomicrographs are enlarged *ca.*× 1000)

1. *Retitribrevicolporites* (*Lakiapollis*) *matanamadhensis* (Venkatachala & Kar) comb. nov., slide no. 3353/2. Note one of the pores in deep focus.
2. Same as above, showing colporate condition and ornamentational pattern.
3. *Pellicieroipollis langenheimii* Sah & Kar, slide no. 3377/3. Note the tricolporate condition, thickened margin of pores and ornamentational pattern.
4. Same as above, showing the extension of colpi in deep focus.
5. *Minutitricolporites* (*Tricolpites*) *minutus* (Sah & Kar) comb. nov., slide no. 3350/10. Note the extension of colpi and ornamentational pattern.
6. Same as above, showing the pore in deep focus.
7. *Minutitricolporites* (*Tricolpites*) *minutus* (Sah & Kar) comb. nov., slide no. 3348/2. Note the colporate nature in one of the apertures.
8. *Minutitricolporites* (*Tricolpites*) *minutus* (Sah & Kar) comb. nov., slide no. 3350/17. Note the extension of colpi and ornamentational pattern in deep focus.
9. *Tribrevicolporites eocenicus* gen. et sp. nov., slide no. 3362/2.
10. Same as above, showing the brevicolpate nature.

PLATE 14

(All the photomicrographs are enlarged *ca.*× 1000)

1. *Intrareticulitis* (*Tricolpites*) *brevis* (Sah & Kar) comb. nov., slide no. 3350/18. Note the nature of colpi and their extension.
2. Same as above, showing the reticulation pattern.
3. *Retitetrabrevicolporites delicatus* gen. et sp. nov., slide no. 3350/1. Note the extension of the colpi and ornamentational pattern.
4. Same as above, focusing the margin and one at the apertures.
5. *Paleosantalaceaepites minutus* Sah & Kar, slide no. 3357/4.
6. *Umbelliferoipollenites constrictus* Venkatachala & Kar, slide no. 3320/3.
7. *Verrucolporites verrucus* Sah & Kar, slide no. 3351/8. Note the sculptural elements.
8. Same as above, showing one of the apertures.
9. *Striacolporites striatus* Sah & Kar, slide no. 3362/2.
10. *Striacolporites cephalus* Sah & Kar, slide no. 3367/11.
11. *Thymelaepollis crotonoides* Sah & Kar, slide no. 3372/12.
12. Same as above, showing the pores.
13. *Meliapollis navalei* Sah & Kar, slide no. 3379/1.

PLATE 15

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Pilatricolporites eocenicus* gen. et sp. nov., slide no. 3357/2. Note the nature of the colpi and thickened margin of one of the pores.
2. Same as above, showing the negative reticulum formed by the pila.
3. Same as above, showing the head of pila.
4. *Dermatobrevicolporites* (*Triorites*) *dermatus* (Sah & Kar) comb. nov., slide no. 3365/20. Note the thickened margin of pores.
5. Same as above, showing the extension of one of colpi and laevigate exine.
6. *Foveotricolporites reticuloidus* gen. et sp. nov., slide no. 3364/13. Note the extension of one of the colpi.
7. Same as above, showing the colporate nature of the apertures.
8. Same as above, showing the sculptural elements forming reticuloid pattern.
9. *Polygalacidites gujaratensis* sp. nov., slide no. 3353/19.
10. *Couperipollis achinatus* Sah & Kar, slide no. 3353/26.
11. *Dermatobrevicolporites exaltus* sp. nov., slide no. 3377/2. Note the thickening of exine around pores.
12. Same as above, showing the extension of one of the colpi.

PLATE 16

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Sastripollenites trilobatus* Venkatachala & Kar, slide no. 3320/18. Note the extension of colpi and grana-coni on margin.
2. Same as above, showing the thickened margin of colpi.
3. *Angulocolporites microreticulatus* gen. et sp. nov., slide no. 3353/24. Note the colporate condition and microreticulate ornamentation.
4. *Pseudonyssapollenites* (*Nyssapollenites*) *kutchensis* (Venkatachala & Kar) comb. nov., slide no. 3317/7. Note the thickened margin of pores and laevigate exine.
5. Same as above, showing the extension of colpi.
6. *Pseudonyssapollenites* (*Nyssapollenites*) *kutchensis* (Venkatachala & Kar), comb. nov., slide no. 3318/25. Note the extension of the colpi.
7. Same as above, showing the pollen grain in deep focus.
8. *Angulocolporites microreticulatus* gen. et sp. nov., slide no. 3353/6, showing the pollen grain in deep focus.
9. Same as above, note the microreticulate ornamentation.
10. *Spinulotetradites juxtatus* gen. et sp. nov., slide no. 3353/16, showing the orientation of tetrad.
11. Same as above, showing the sculptural elements.
12. Same as above, showing the extension of colpi.

PLATE 17

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Couperipollis achinatus* Sah & Kar, slide no. 3353/22.
2. Tetrads of *C. achinatus* Sah & Kar, slide no. 3365/13.
3. *Umbelliferoipollenites constrictus* Venkatachala & Kar, slide no. 3320/2.
4. Tricolporate pollen grain, slide no. 3350/4. Note the lalongate pore and ornamentational pattern.
5. Same as above in deep focus.
6. *Cheilanthoidspora enigmata* Sah & Kar, slide no. 4354/4.
7. *Lakiapollis ovatus* Venkatachala & Kar, slide no. 3377/3. Note the tricolporate nature.
8, 9. Same as above showing the thickened margin of pores.

PLATE 18

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Arecipites bellus* Sah & Kar, slide no. 3367/8.
2. *Umbelliferoipollenites constrictus* Venkatachala & Kar, slide no. 3320/6.
3. *Meliapollis ramanujamii* Sah & Kar, slide no. 3378/1.
4. *Striacolporites ovatus* Sah & Kar, slide no. 3360/5. Note the striate reticulation.
5. *Striacolporites ovatus* Sah & Kar, slide no. 3376/6. Note one of the apertures in equatorial view.
6. *Polybrevicolporites cephalus* Venkatachala & Kar, slide no. 3322/16.
7. *Ctenolophonidites costatus* van Hoeken-Klinkenberg, slide no. 3373/7. Note the thickenings of exine.
8. Same as above, showing the colpi.
9. *Ghoshiacolpites globatus* Sah & Kar, slide no. 3365/14. Note the shield-like plate in central region.
10. Same as above, showing the colpi.

PLATE 19

(All the photomicrographs are enlarged *ca.* × 1000)

1. *Tripilaorites* (*Triorites*) *triangulus* (Sah & Kar) comb. nov., slide no. 3358/4. Note the big ora and negative reticulate pattern.
2. Same as above, showing the pila.
3. *Polygalacidites gujaratensis* sp. nov., slide no. 3353/19.
4. *Pseudonothofagidites cerebrus* Venkatachala & Kar, slide no. 3364/8.
5. *Palmaepollenites nadhamunii* Venkatachala & Kar, slide no. 3313/3.
6. *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov., slide no. 3372/4. Note three distinct and 1 indistinct ora in folded condition.
7. *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov., slide no. 3352/10. Note the protruding arms and folded indistinct ora.
8. Same as above, in deep focus.

PLATE 20

1-2. *Verrudandotiaspora* (*Dandotiaspora*) *verrucata* (Kar & Saxena) comb. nov., slide nos. 6360/11 and 6364/1.
3. *Foveosporites splendus* Kar & Saxena, slide no. 6351/7.

4. *Todisporites kutchensis* Sah & Kar, slide no. 6351/4.
5, 6. *Striatriletes susannae* van der Hammen emend. Kar, slide nos. 6356/2 and 6352/5.
7-9. *Striatriletes multicostatus* Kar & Saxena, slide nos. 6358/6, 6357/11 and 6356/9.
10, 11. *Striatriletes microverrucosus* Kar & Saxena, slide nos. 6352/11 and 6351/11.
12. *Striatriletes* sp., slide no. 6357/11.

PLATE 21

1, 2. *Lophotriletes tertiarus* Kar & Saxena, slide no. 6370/5.
3. *Stereisporites assamensis* Dutta & Sah, slide no. 6371/7.
4. *Lygodiumsporites lakiensis* Sah & Kar, slide no. 6352/4.
5, 6. *Intrapunctisporis apunctis* Krutzsch, slide nos. 6365/5 and 6371/9.
7. *Biretisporites convexus* Sah & Kar, slide no. 6361/5.
8. *Lygodiumsporites lakiensis* Sah & Kar, slide no. 6364/15.
9. *Foveosporites splendus* Kar & Saxena, slide no. 6370/3.
10. *Dandotiaspora plicata* (Sah & Kar) Sah, Kar & Singh, slide no. 6368/10.
11. *Laevigatosporites lakiensis* Sah & Kar, slide no. 6368/22.
12, 13. *Polypodiaceaesporites strictus* Kar & Saxena, slide nos. 6368/8 and 6370/8.
14-16. *Biswasiaspora baculata* Kar & Saxena, slide nos. 6363/12, 6364/17 and 6368/21.
17-18. *Biswasiaspora pseudoreticulata* Kar & Saxena, slide nos. 6363/12 and 6364/1.
19. cf. *Osmundacidites* sp., slide no. 6364/6.

PLATE 22

1. *Cheilanthoidspora monoleta* Sah & Kar, slide no. 6366/3.
2. *Cheilanthoidspora enigmata* Sah & Kar, slide no. 6367/7.
3. *Foveosporites* sp., slide no. 6365/1.
4, 5. *Polypodiaceaesporites strictus* Kar & Saxena, slide nos. 6366/14 and 6359/11.
6. *Polypodiisporites* sp., slide no. 6364/10.
7. *Arecipites intrapunctatus* Kar & Saxena, slide no. 6361/6.
8. *Arecipites bellus* Sah & Kar, slide no. 6364/19.
9. *Longapertites retipilatus* sp. nov., slide no. 6365/4.
10. Dicolpate pollen type-1, slide no. 6368/4.
11. *Polypodiaceaesporites* sp., slide no. 6364/5.
12. *Cyathidites australis* Couper, slide no. 6351/13.
13. *Callialasporites trilobatus* (Balme) Dev, slide no. 6371/2.
14, 15. *Palmidites naviculus* Kar & Saxena, slide nos. 6366/9 and 6358/11.
16. *Parasaccites* sp., slide no. 6368/18.

PLATE 23

1-3. *Tricolporopilites* (*Retitrescolpites*) *robustus* (Kar & Saxena) comb. nov., slide nos. 6364/17, 6364/12 and 6366/8.
4, 5. *Tricolporocolumellites pilatus* gen. et sp. nov., slide nos. 6359 and 6372/5.
6. *Pellicieroipollis langenheimii* Sah & Kar, slide no. 6372/3.
7. *Dermatobrevicolporites* (*Myricipites*) *globatus* (Kar & Saxena) comb. nov., slide no. 6368/2.
8, 9. *Palaeomalvaceaepollis paucispinosus* sp. nov., slide nos. 6351/10 and 6351/8.
10. *Palaeomalvaceaepollis mammilatus* sp. nov., slide no. 6351/17.
11. *Spinizonocolpites echinatus* Muller, slide no. 6367/8.
12. *Spinizonocolpites* sp., slide no. 6352/1.

PLATE 24

1. *Pilapanporites spinosus* gen. et sp. nov., slide no. 6358/12.
2, 3. *Tricolporopilites pseudoreticulatus* sp. nov., slide nos. 6359/1 and 6362/10.
4. *Podocarpidites khasiensis* Dutta & Sah, slide no. 6368/16.
5. *Arecipites* sp., slide no. 6367/15.
6-8. *Psiloschizosporis psilata* Kar & Saxena, slide nos. 6370/2, 6369/6 and 6355/1.
9, 10. *Psiloschizosporis punctata* Kar & Saxena, slide nos. 6355/2 and 6363/9.
11. *Dermatobrevicolporites* (*Myricipites*) *globatus* (Kar & Saxena) comb. nov., slide no. 6370/11.
12. *Striacolporites cephalus* Sah & Kar, slide no. 6366/2.

PLATE 25

1. *Dermatobrevicolporites dermatus* (Sah & Kar) comb. nov., slide no. 6360/5.
2. *Spinulotriradites juxtatus* sp. nov., slide no. 6366/10.
3. cf. *Triangulorites* (*Triorites*) *bellus* (Sah & Kar) comb. nov., slide no. 6373/2.
4. Dicolpate pollen type-1, slide no. 6367/3.
5. *Ratariacolporites foveolatus* sp. nov., slide no. 6359/10.
6, 7. *Ratariacolporites plicatus* gen. et sp. nov., slide nos. 6368/19 and 6367/9.
8-10. *Varispinitriporites ratariensis* gen. et sp. nov., slide nos. 6352/8, 6353/8 and 6352/9.
11. *Spinizonocolpites echinatus* Muller, slide no. 6367/19.
12, 13. *Proxapertites* (*Assamialetes*) *reticulatus* (Kar & Saxena) comb. nov., slide nos. 6364/13 and 6364/16.
14, 15. *Plicatiaperturites retipilatus* gen. et sp. nov., slide nos. 6373/4 and 6373/5.
16. cf. *Plicatiaperturites* sp., slide no. 6361/3.
17. *Echitricolporites* sp., slide no. 6353/4.
18. *Trisyncolpites* sp., slide no. 6370/7.
19. *Marginipollis kutchensis* (Venkatachala & Kar) Kar, slide no. 6372/9.
20. *Palmaepollenites kutchensis* Venkatachala & Kar, slide no. 3317/2.
21. *Umbelliferoipollenites ovatus* Venkatachala & Kar, slide no. 6370/2.
22. *Cupuliferoipollenites ovatus* Venkatachala & Kar, slide no 6372/2.
23. *Paleosantalaceaepites primitiva* Biswas, slide no. 6362/9.

PLATE 26

1-3. *Phragmothyrites eocaenica* emend. Kar & Saxena, slide nos. 6358/7, (*ca.*×250), 6355/1 and 6362/1.

4, 5. *Notothyrites setiferus* Cookson, slide nos. 6357/10 (*ca.*×250) and 6357/10.
6. *Notothyrites amorphus* Kar & Saxena, slide no. 6361/13.
7-9. *Inapertusporites kedvesii* Elsik, slide nos. 6369/11, 6367/21 and 6363/1.
10. *Lacrimasporonites longus* Kar, slide no. 6358/5.
11. *Kutchiathyrites eccentricus* Kar, slide no. 6357/4.
12. *Dicellaesporites minutus* Kar, slide no. 6362/7 *ca.*×250.
13. *Parmathyrites robustus* Jain & Kar, slide no. 6359/9.
14. *Dyadosporonites schwabii* Elsik, slide no. 6356/7.

PLATE 27

1. *Intrapunctisporis* sp., slide no. 5074/2.
2. *Biretisporites convexus* Sah & Kar, slide no. 5078/2.
3. *Cyathidites* cf. *C. australis* Couper, slide no. 5095/5.
4, 5. *Polypodiaceaesporites chatterjii* Kar, slide nos. 5079/1 and 5080/9.
6. *Polypodiaceaesporites* sp., slide no. 5099/4.
7, 8. *Polypodiisporites constrictus* Kar, slide nos. 5087/4 and 5088/8.
9. *Cyathidites* sp., slide no. 5098/5.
10. *Laevigatosporites* sp., slide no. 5107/4.
11, 12. *Proxapertites scabratus* Jain, Kar & Sah, slide nos. 5115/2 and 5092/5.
13. *Cheilanthoidspora monoleta* Sah & Kar, slide no. 5089/2.
14, 16. *Podocarpidites cognatus* Kar, slide nos. 5091/2 and 5087/3.
17. *Spinizonocolpites echinatus* Muller, slide no. 5093/1.
18. *Paleosantalaceaepites minutus* Sah & Kar, slide no. 5123/5.
19. *Tricolpites* sp., slide no. 5081/3.
20. Spore type-1, slide no. 5090/5.
21. *Polyadopollenites* sp., slide no. 5123/4.

PLATE 28

1. *Cyathidites* cf. *C. australis* Couper, slide no. 5072/2.
2. *Cyathidites* cf. *C. minor* Couper, slide no. 5053/1.
3, 4. *Punctatisporites sarangwaraensis* Kar, slide nos. 5075/2 and 5075/6.
5. *Punctatisporites* sp., slide no. 5076/3.
6. *Biretisporites convexus* Sah & Kar, slide no. 5076/3.
7, 8. *Dictyophyllidites* (*Toroisporis*) *dulcis* (Kar) comb. nov., slide nos. 5077/4 and 5078/3.
9. *Dictyophyllidites*, slide no. 5098/3.
10, 11. *Leptolepidites chandrae* Kar, slide nos. 5080/8 and 5081/5.
12, 13. *Leptolepidites* sp., slide nos. 5078/3 and 5080/7.
14. cf. *Striatriletes* sp., slide no. 5078/8.
15, 16. *Striatriletes susannae* van der Hammen emend. Kar, slide no. 5082/6.
17, 18. *Striatriletes microverrucosus* Kar & Saxena, slide nos. 5085/1 and 5086/3.

PLATE 29

1. *Trisyncolpites ramanujamii* Kar. Note the sculptural elements and ill-defined pores, slide no. 5099/6.
2. Same as in above showing the distinct trisyncolpate condition.
3. *Trisyncolpites ramanujamii* Kar, showing one of the pores and sculptural elements, slide no. 5094/2.
4. *Palaeomalvaceaepollis mammilatus* sp. nov. Note the mammilate processes and the circular pore, slide no. 5094/4.
5. Same as in above, showing the bacula at the base of spines.
6. Same as in above, showing the microreticulate structure.
7. *Paleosantalaceaepites minutus* Sah & Kar, slide no. 5123/5.
8. *Araliaceoipollenites* sp., slide no. 5080/3.
9. *Triporopollenites exactus* Salujha, Kindra & Rehman, slide no. 5076/2.

PLATE 30

1, 2. *Bombacacidites triangulatus* sp. nov., slide nos. 8242/2 and 8250/3.
3, 4. *Compositoipollenites tricolporatus* sp. nov., slide nos. 8243/10 and 8246/9.
5-7. *Graminidites granulatus*, slide nos. 8245/1, 8246/4 and 8249/3.
8. *Triatriopollenites* sp., slide no. 8248/4.
9-12. *Verrupolyporites globosus* gen. et sp. nov., slide nos. 8247/6, 8247/4, 8249/2 and 8298/4.
13. *Polyporina multiporosa* sp. nov., slide no. 8248/3.
14. *Palaeomalvaceaepollis* (*Malvacearumpollis*) *rudis* (Kar) comb. nov., slide no. 8298/3.
15. Tricolporate pollen type-1, slide no. 8299/4.
16. Tetraporate pollen type-1, slide no. 8250/2.
17. *Polypodiaceaesporites* sp. 1, slide no. 8250/4.
18. *Polyadopollenites* sp., slide no. 8242/4.
19. *Tricolpites* sp., slide no. 8300/9.
20. *Podocarpidites* sp., slide no. 8245/3.

PLATE 31

1. *Monoporopollenites* sp., slide no. 5102/3.
2. *Stephanoporopollenites* sp., slide no. 5080/4.
3. *Proxapertites* sp., slide no. 5110/4.
4-7. *Kutchiathyrites eccentricus* Kar, slide nos. 5106/6, 5106/1, 5107/5 and 5108/2.
8. *Phragmothyrites eocenicus* (Edwards) Kar & Saxena, slide no. 5116/4.
9. *Notothyrites* sp., slide no. 5105/1.
10, 11, 17. *Inapertusporites kedvesii*. Elsik, slide nos. 5111/2, 5109/3 and 5107/4.
12. *Lacrimasporonites* sp., slide no. 5072/5.
13. *Pluricellaesporites planus* Trivedi & Verma, slide no. 5106/7.
14, 15. *Dyadosporonites constrictus* Kar, slide nos. 5109/2 and 5110/3.
16. *Lacrimasporonites longus* Kar, slide no. 5111/1.

PLATE 32

1, 2. *Pediastrum boryanum* var. *undulatum* Willie, slide no. 6632/16.
3. *Pediastrum boryanum* var. *longicorne* Reinsch, slide no. 6633/17.
4. Reworked Permian monosaccate pollen (*Cahenia-saccites ovatus* Bose & Kar, slide no. 6187/4).
5. Reworked Permian bisaccate pollen (*Platysaccus* sp., slide no. 5988/6).
6. Reworked Permian monosaccate pollen (*Potonieisporites* sp. B, slide no. 5984/21).

7-8. *Azolla aglochidia* Kar (Ms.) megaspores *ca.* ×100, slide nos. 5985/7 and 8261/11.
9. *Azolla aglochidia* Kar (Ms.), massulae with microspores, *ca.*×200, slide no. 8264/15.
10. *Azolla aglochidia* Kar (Ms.), microspores embedded in massula *ca.*×200, slide no. 8264/15.

PLATE 33

1, 2. *Biretisporites convexus* Sah & Kar, slide nos. 5982/11 and 5982/7.
3, 4. *Dictyophyllidites laevigatus* sp. nov., slide nos. 5985/10 and 5983/5.
5. *Striatriletes susannae* (van der Hammen) Kar, slide no. 5986/4.
6. *Striatriletes multicostatus* Kar & Saxena, slide no. 8261/14.
7. *Striatriletes microverrucosus* Kar & Saxena, slide no. 5985/8.
8, 9. *Striatriletes aidaensis* sp. nov., slide nos. 5988/11 and 5987/6.
10. *Striatriletes paucicostatus* sp. nov., slide no. 8261/4.

PLATE 34

1. *Striatriletes paucicostatus* sp. nov., slide no. 6183/12.
2. *Khariasporites densus* gen. et sp. nov., slide no. 5988/5 *ca.*×200.
3, 4. *Khariasporites densus* gen. et sp. nov., slide nos. 5987/5, 5988/13, *ca.*×100.
5. *Khariasporites granulatus* sp. nov., slide no. 5983/4.
6, 7. *Lycopodiumsporites globatus* sp. nov., slide nos. 5987/7 and 6187/8.
8. *Cingulatisporites* sp., slide no. 8261/18.
9. *Pteridacidites* sp., slide no. 5984/16.
10, 11. *Laevigatosporites distinctus* sp. nov., slide nos. 5987/12 and 5988/10.
12. *Psiloschizosporis psilata*, slide no. 5985/9.

PLATE 35

1. *Psiloschizosporis* sp., slide no. 5983/8, *ca.*×100.
2, 3, 11. *Pinuspollenites crestus* sp. nov., slide nos. 8264/13 and 5984/14.
4, 5. *Abiespollenites cognatus* sp. nov., slide nos. 5986/11 and 5984/7.
6, 7. *Podocarpidites densicorpus* sp. nov., slide nos. 8264/2 and 8264/24.
8, 9. Extant pollen of *Podocarpus latifolius*.
10. Modern pollen of *Abies webbiana*.

PLATE 36

1. *Piceapollenites excellensus* sp. nov., slide no. 6187/10.
2. *Podocarpidites* sp., slide no. 5987/4.
3, 4. *Tsugaepollenites velatus* sp. nov., slide nos. 5987/6 and 5987/14.
5. *Magnamonocolpites miocenicus* sp. nov., slide no. 5987/3, *ca.*×100.
6. *Magnamonocolpites plicatus* sp. nov., slide no. 8259/14, *ca.*×100.
7. *Magnamonocolpites plicatus* sp. nov., slide no. 5986/7, *ca.*×100.
8, 9. *Magnamonocolpites baculatus* sp. nov., slide nos. 8264/9 and 5984/18, *ca.*×100.

10. *Palaeomalvaceaepollis* (*Malvacearumpollis*) *mammilatus* sp. nov., slide no. 5985/5.
11. *Hibisceaepollenites splendus* sp. nov., slide no. 8264/4.
12. *Polyadopollenites* sp., slide no. 8261/17.

PLATE 37

(All the photomicrographs are magnified *ca.*×1000)

1. *Pluricellaesporites rectangulata* Mathur & Mathur, slide no. Pl/1.
2. *Pluricellaesporites ellipticus* Mathur & Mathur, slide no. P2/1.
3. *Dyadosporonites constrictus* Mathur & Mathur, slide no. P3/8.
4. *Marattisporites longiletus* Mathur & Mathur, slide no. P4/2.
5. *Verrucososporites longiletus* Mathur & Mathur, slide no. P20/1.
6. *Naeratisporites psilatus* Mathur & Mathur, slide no. P5/1.
7. *Todisporites subtriangulatus* Mathur & Mathur, slide no. P5/1.
8. *Verrucosisporites longiletus* Mathur & Mathur, slide no. P6/3.
9. *Lycopodiumsporites hyalinum* Mathur & Mathur, slide no. P6/3.
10. *Liliacidites minireticulatus* Mathur & Mathur, slide no. P6/3.
11. *Liliacidites medireticulatus* Mathur & Mathur, slide no. P11/2.
12. *Striamonocolpites longicolpatus* Mathur & Mathur, slide no. P2/2.

PLATE 38

(All the photomicrographs are magnified *ca.*×1000)

1. *Cicatricosisporites* sp., slide no. P6/2.
2. *Piceapollenites naeransus* Mathur & Mathur, slide no. P8/2.
3. *Palmaepollenites longicolpus* Mathur & Mathur, slide no. P/2.
4. *Couperipollis baculatus* Mathur & Mathur, slide no. P6/3.
5. *Palmaepollenites medicolpus* Mathur & Mathur, slide no. P9/2.
6. *Cupuliferoipollenites barainsus* Mathur & Mathur, slide no. P11/2.
7. *Favitricolporites medireticulatus* Mathur & Mathur, slide no. P20/1.
8. *Graminidites protrudus* Mathur & Mathur, slide no. P3/1.
9. *Polyporina mediporus* Mathur & Mathur, slide no. P10/2.

PLATE 39

1. *Cyathidites australis* Couper, slide no. 3252/1.
2. *Intrapunctisporis harudiensis* Kar, slide nos. 3254/7, 3255/9 and 3256/3.
6, 7. *Scantigranulites triangulus* Kar, slide nos. 3260/3 and 3261/4.
8-11. *Scantigranulites sparsus* Kar, slide nos. 3262/2, 3263/1, 3261/9 and 3264/11.
12. *Laevigatosporites* sp., slide no. 3257/17.
13. *Polypodiisporites constrictus* Kar, slide no. 3253/12.
14. *Schizaeoisporites* sp., slide no. 3264/13.

15, 16. *Proxapertites microreticulatus* Jain, Kar & Sah, slide nos. 3263/3 and 3265/2.
17. *Couperipollis brevispinosus* (Biswas) Venkatachala & Kar, slide no. 3257/10.
18. *Tricolpites* sp. cf. *T. matauraensis* Couper, slide no. 3255/6.
19. *Tricolpites* sp., slide no. 3266/1.
20-24. *Parumbelliferoipollis dulcis* Kar, slide nos. 3254/13, 3256/9, 3258/1, 3258/4 and 3253/11.
25. *Diporites* sp., Slide no. 3255/5.
26. *Marginipollis kutchensis* (Venkatachala & Kar) Kar, slide no. 3259/6.
27. Pollen polyad type-1, slide no. 3261/5.

PLATE 40

1, 2. *Cleistosphaeridium cephalum* sp. nov., slide nos. 8274/1 and 8275/2.
3. *Areoligera digitata* sp. nov., slide no. 8276/6.
4, 5. *Cleistosphaeridium diversispinosum* Davey, Downie, Sarjeant & Williams, slide nos. 8277/3 and 8278/4.
6. *Cordosphaeridium gracilis* (Eisenack) Davey & Williams, slide no. 8279/15.
7,8. *Glaphyrocysta pastielsii* (Deflandre & Cookson) Stover & Evitt, slide nos. 8280/1 and 8281/2.
9. *Heterosphaeridium heteracanthum* sub sp. *sparsiprocessum* (Varma & Dangwal) Eisenack, slide no. 8282/1.
10. *Litosphaeridium siphoniphorum* (Cookson & Eisenack) Davey & Williams, slide no. 8283/2.
11, 12. *Nematosphaeropsis densiradiata* (Cookson & Eisenack) Stover & Evitt, slide nos. 8282/2 and 8283/1.

PLATE 41

1. *Cleistosphaeridium cephalum* sp. nov., slide no. 8286/2.
2, 3. *Areoligera digitata* sp. nov., slide nos. 8286/2 and 8276/7.
4, 5. *Cordosphaeridium exilimurum* Davey & Williams, slide nos. 8288/1 and 8289/1.
6. *Heterosphaeridium heteracanthum* (Deflandre & Cookson) Eisenack & Kjellstrom, slide no. 8290/1.
7. *Homotryblium tenuispinosum* Davey & Williams, slide no. 8291/1.
8-10. *Homotryblium pallidum* Davey & Williams, slide nos. 8277/5, 8293/1 and 8289/3.
11, 12. *Hystrichosphaeridium salpiugophorum* (Deflandre) Davey & Williams, slide nos. 8276/4 and 8296/3.

PLATE 42

1. *Hystrichokolpoma rigaudae* Deflandre & Cookson, slide no. 6426; coordinates: 109.9 × 20.3.
2. *Glaphyrocysta exuberans* (Deflandre & Cookson) Stover & Evitt, slide no. 6429; coordinates: 140.4 × 11.5.
3-5. *Homotryblium plectilum* Drugg & Loeblich. *ca.* × 1000, slide no. 6430; coordinates: 123.5 × 23.4 and 105.5 × 6.5 respectively.
6. *Hystrichokolpoma* sp., slide no. 6453; coordinates: 109.8 × 8.8.
7. *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall, slide no. 6424; coordinates: 127.7 × 22.5.

8. *Spiniferites ramosus* subsp. *granomembranaceous* (Davey & Williams) Lentin & Williams, slide no. 6443; coordinates: 118.0 × 18.4.
9. *Impletosphaeridium granulosum* Jain & Tandon, slide no. 6436; coordinates: 135.1 × 13.8.
10. *Glaphyrocysta* sp. A, slide no. 6426; coordinates: 97.5 × 12.7.
11. *Glaphyrocysta intricata* (Eaton) Stover & Evitt, slide no. 6431; coordinates: 102.9 × 22.6.
12. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall, slide no. 6426; coordinates: 114.2 × 22.7.
13. *Samlandia chlamydophora* Eisenack, slide no. 6442; coordinates: 107.7 × 16.7.

PLATE 43

1. *Hystrichokolpoma cincta* Klumpp, slide no. 6431; coordinates: 120.4 × 22.6.
2. *Hystrichokolpoma* sp. cf. *granulata* Eaton, slide no. 6431; coordinates: 117.6 × 19.2.
3. *Eocladopyxis* sp. A, slide no. 6425; coordinates: 118.7 × 7.0.
4. *Impletosphaeridium granulosum* Jain & Tandon, slide no. 6430; coordinates: 120.0 × 13.9.
5, 6. *Turbiosphaera* sp., slide nos. 6424 and 6443; coordinates: 103.3 × 19.1 and 116.5 × 19.3 respectively.
7. *Wilsonidinium lineidentata* (Deflandre & Cookson) Lentin & Williams, slide no. 6440; coordinates: 120.0 × 14.0.
8. *Cordosphaeridium fibrospinosum* Davey & Williams, slide no. 6424; coordinates: 125.2 × 22.7.
9. *Wetzeliella* sp., slide no. 6430; coordinates: 126.8 × 11.2.

PLATE 44

1, 2. *Cyclopsiella coniata* Jain & Tandon, slide nos. 6427 and 6435; coordinates: 138.9 × 13.8 and 119.1 × 7.0 respectively.
3. *Cleistosphaeridium* sp. A, slide no. 6434; coordinates: 106.3 × 12.0.
4. *Lingulodinium solarum* (Drugg) Wall & Dale, slide no. 6437; coordinates: 113.7 × 16.4.
5. *Glaphyrocysta kachchhensis* Jain & Tandon, slide no. 6439; coordinates: 129.0 × 14.2.
6. *Muratodinium* sp. A, slide no. 6425; coordinates: 95 × 9.6.
7, 8. *Araneosphaera consociata* Jain & Tandon, slide nos. 6424 and 6442; coordinates: 96.3 × 6.9 and 129.9 × 14.8 respectively.
9. *Cordosphaeridium fibrospinosum* Davey & Williams, slide no. 6424; coordinates 125.2 × 22.7.

PLATE 45

1. *Hystrichosphaeridium tubiferum* (Ehrenberg) Davey & Williams, slide no. 6357/2.
2. cf. *Perisselasphaeridium pannosum* Davey & Williams, slide no. 6351/14.
3, 4. *Cleistosphaeridium heteracanthum* (Deflandre & Cookson) Davey, Downie, Sarjeant & Williams, slide nos. 8302/2 and 6370/6.
5. *Cryptosphaera valvata* Sah & Kar, slide no. 6359/5.
6. *Cornplanktona unicorna* Sah & Kar, slide no. 6361/12.
7. *Tetraporina* sp., slide no. 6359/12.

8. *Hystrichokolpoma eisenacki* Williams & Davey, slide no. 6356/6.
9, 10. *Oligosphaeridium complex* (White) Davey & Williams, slide no. 6369/8 and 6357/5.
11. *Cordosphaeridium* sp., slide no. 6363/4.
12. *Cordosphaeridium gracilis* (Eisenack) Davey & Williams, slide no. 6357/6.

PLATE 46

1-5. *Aplanosporites robustus* Kar, slide nos. 5112/3, 5113/1, 5114/3, 5115/4, and 5112/2.
6. Broken trilete spore, slide no. 5077/3.
7. *Tuberculodinium vancampoae* (Rossignol) Wall emend. Wall & Dale, slide no. 5087/2.
8. ?*Sumatradinium* sp., slide no. 5118/1.
9-11. *Cordosphaeridium* sp., slide nos. Gw/2/6, 5087/6 and Gw/7/1.

PLATE 47

1-3. *Spiniferites ramosus* subsp. *granosus* (Davey & Williams) Lentin & Williams, slide nos. 5086/8, S3/4/2 and 8273/2.
4-6. ?*Sumatradinium* sp., slide nos. 5119/2, 5083/1 and S2/1/4.
7. ?Epitractal archaeopyle of *Homotryblium*, slide no. 5075/1.
8. ?*Sumatradinium* sp., slide no. S2/2/9.
9, 10. *Operculodlnium centrocarpum* (Deflandre & Cookson) Wall, slide no. Gw/1/2.
11-15. *Operculodinium* sp. cf. *centrocarpum* (Deflandre & Cookson) Wall, slide nos. Gw/6/4, Gw/6/1, 5116/1, 5116/5 and 5120/3.
16. *Operculodinium* sp., slide no. 5123/2.

PLATE 48

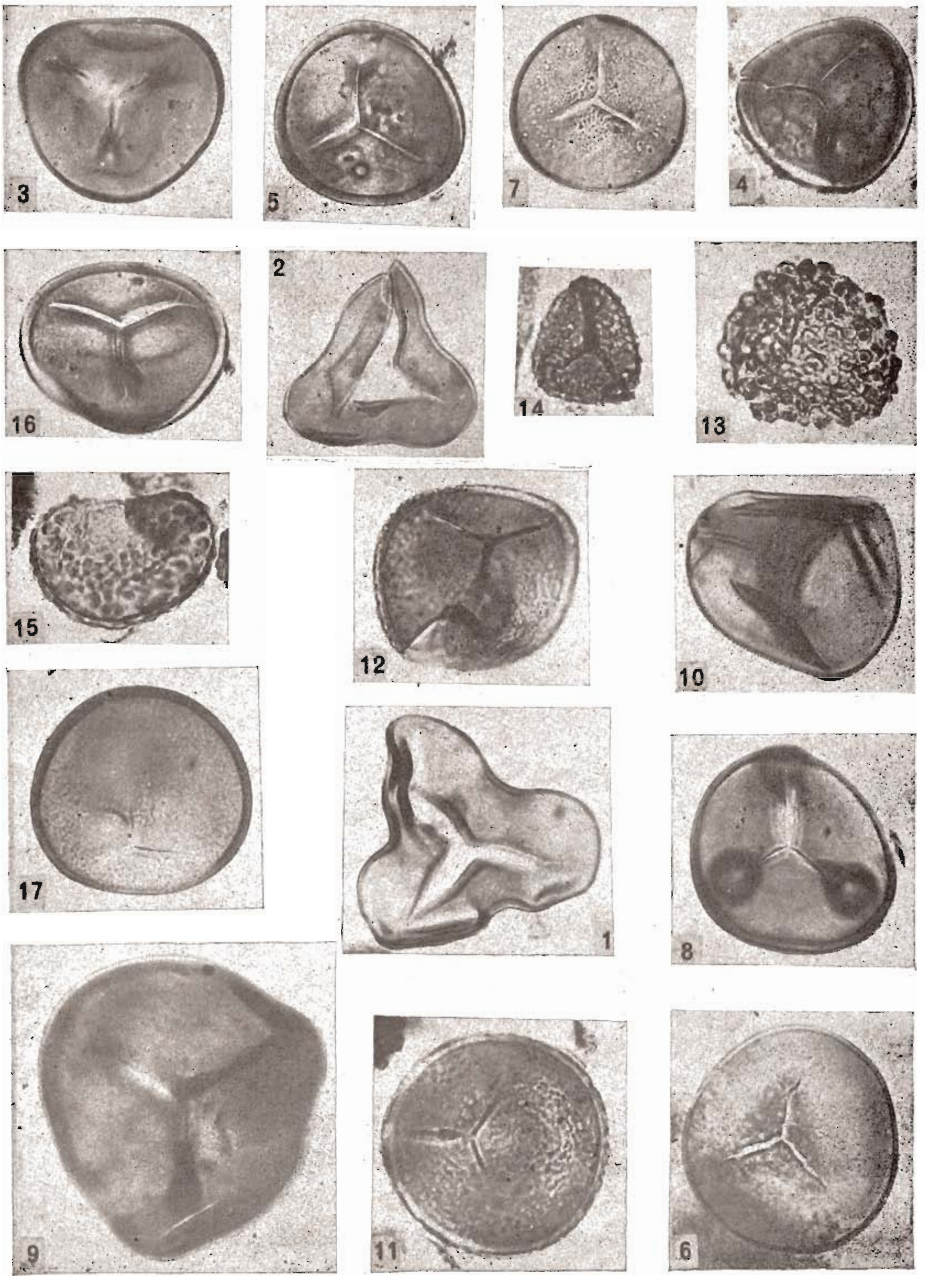
1. *Achomosphaera ramulifera* (Deflandre) Evitt, slide no. 6634/17.
2, 3. *Cordosphaeridium cantharellum* (Brosius) Gocht, slide nos. 8268/9 and 6634/20.
4. *Cordosphaeridium exilimurum* Davey & Williams, slide no. 8268/10.
5. 6. *Cordosphaeridium cracenospinosum* Davey & Williams, slide nos. 6632/4 and 6632/15.
7, 8. *Hystrichokolpoma rigaudae* Deflandre & Cookson, slide nos. 8269/5 and 6634/8.
9. *Spiniferites mirabilis* (Rossignol), slide no. 6633/10.
10. *Operculodinium placitum* Drugg & Loeblich, slide no. 6633/9.

PLATE 49

1. *Hystrichokolpoma poculum* Maier, slide no. 6632/8.
2. *Hystrichokolpoma unispinum* Williams & Downie, slide no. 6632/14.
3. 4 *Lingulodinium machaeophorum* (Deflandre & Cookson) Wall, slide nos. 6634/1 and 6633/4.
5. *Cordosphaeridium gracilis* Eisenack emend. Davey & Williams, slide no. 8268/12.
6. *Cordosphaeridium fibrospinosum* Davey & Williams, slide no. 8268/15.
7. *Cordosphaeridium* sp., slide no. 8270/1.
8. *Millioudodinium unicornum* sp. nov., slide no. 6634/12.
9. *Spiniferites hypercanthus* (Deflandre & Cookson) Cookson & Eisenack, slide no. 8270/1.
10, 11. *Tuberculodinium vancampoae* (Rossignol) Wall & Dale, slide nos. 6633/13 and 6632/16.

PLATE 50

1, 2. *Spiniferites bulloideus* (Deflandre & Cookson) Sarjeant, slide nos. 6633/9 and 6634/29.
3, 4. *Spiniferites mirabilis* Rossignol, slide nos. 6633/12 and 6634/23.
5. *Operculodinium centrocarpum* (Deflandre & Cookson) Wall, slide no. 8268/7.
6. *Operculodinium paucispinosum* sp. nov., slide no. 8269/3.
7. *Operculodinium delicatum* sp. nov., slide no. 8270/2.
8. *Operculodinium robustum* sp. nov., slide no. 8271/2.
9. *Operculodinium* sp., slide no. 8268/12.
10. *Thalassiphora pelagica* (Eisenack) Eisenack & Gocht, slide no. 8272/2.



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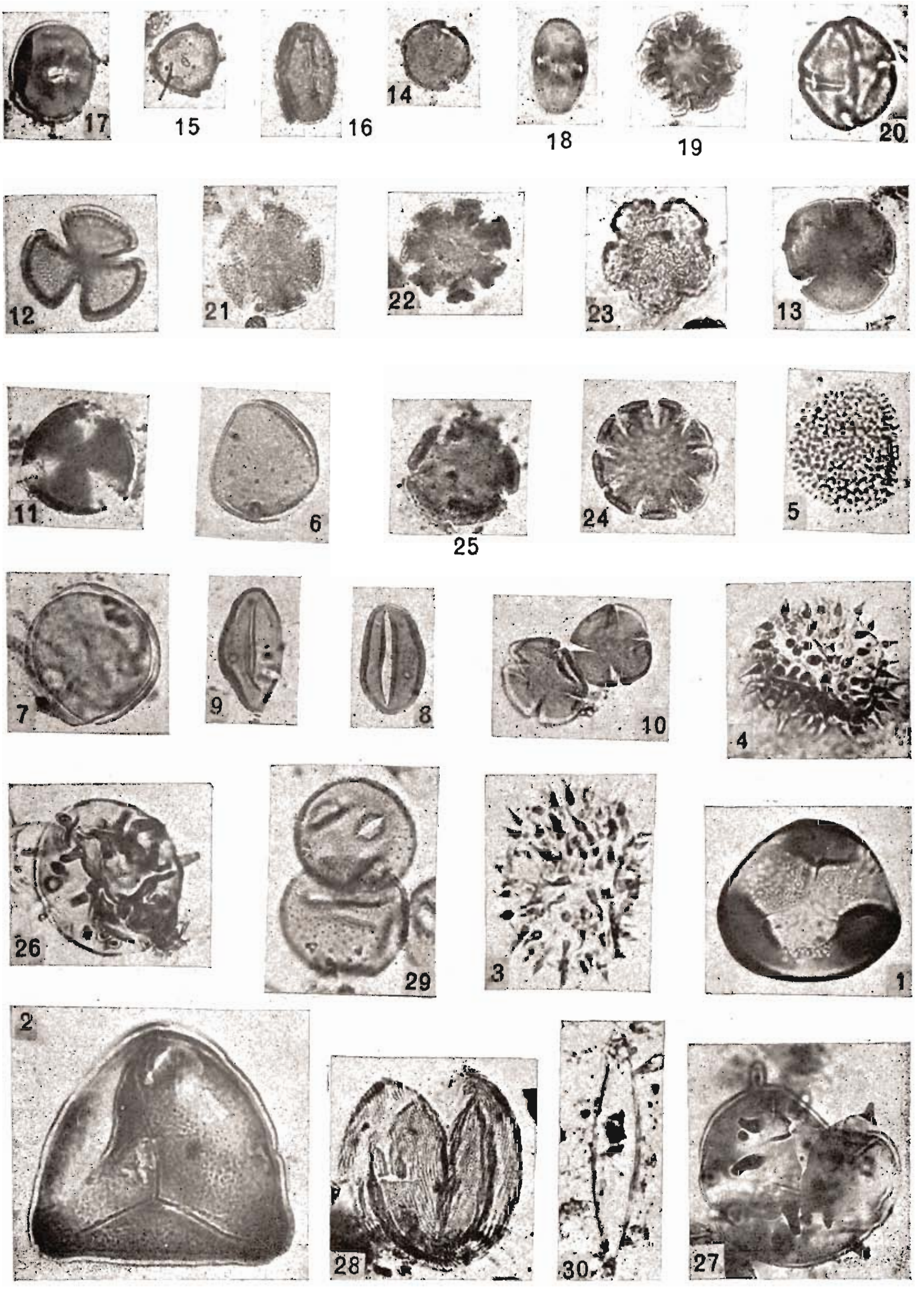
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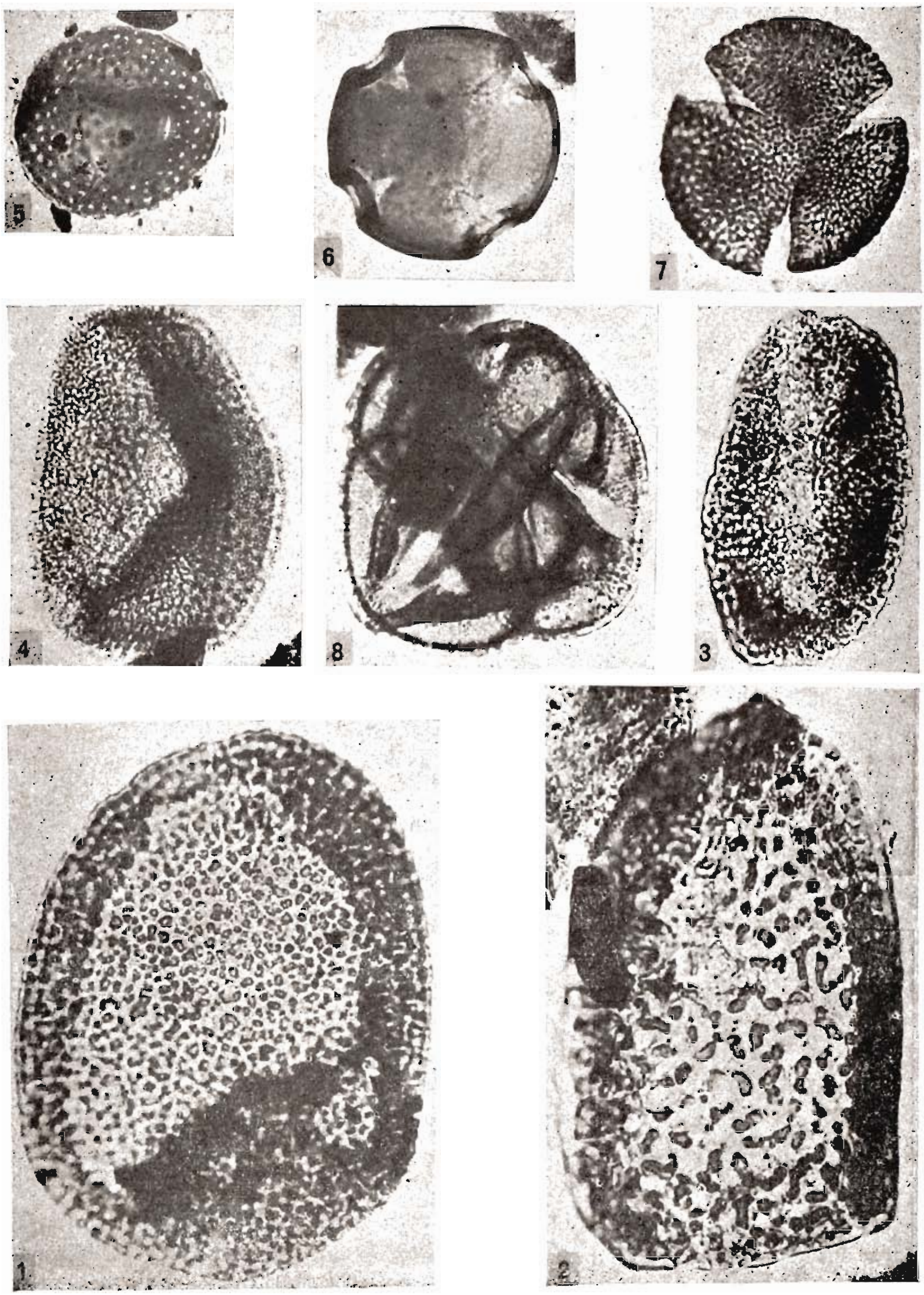

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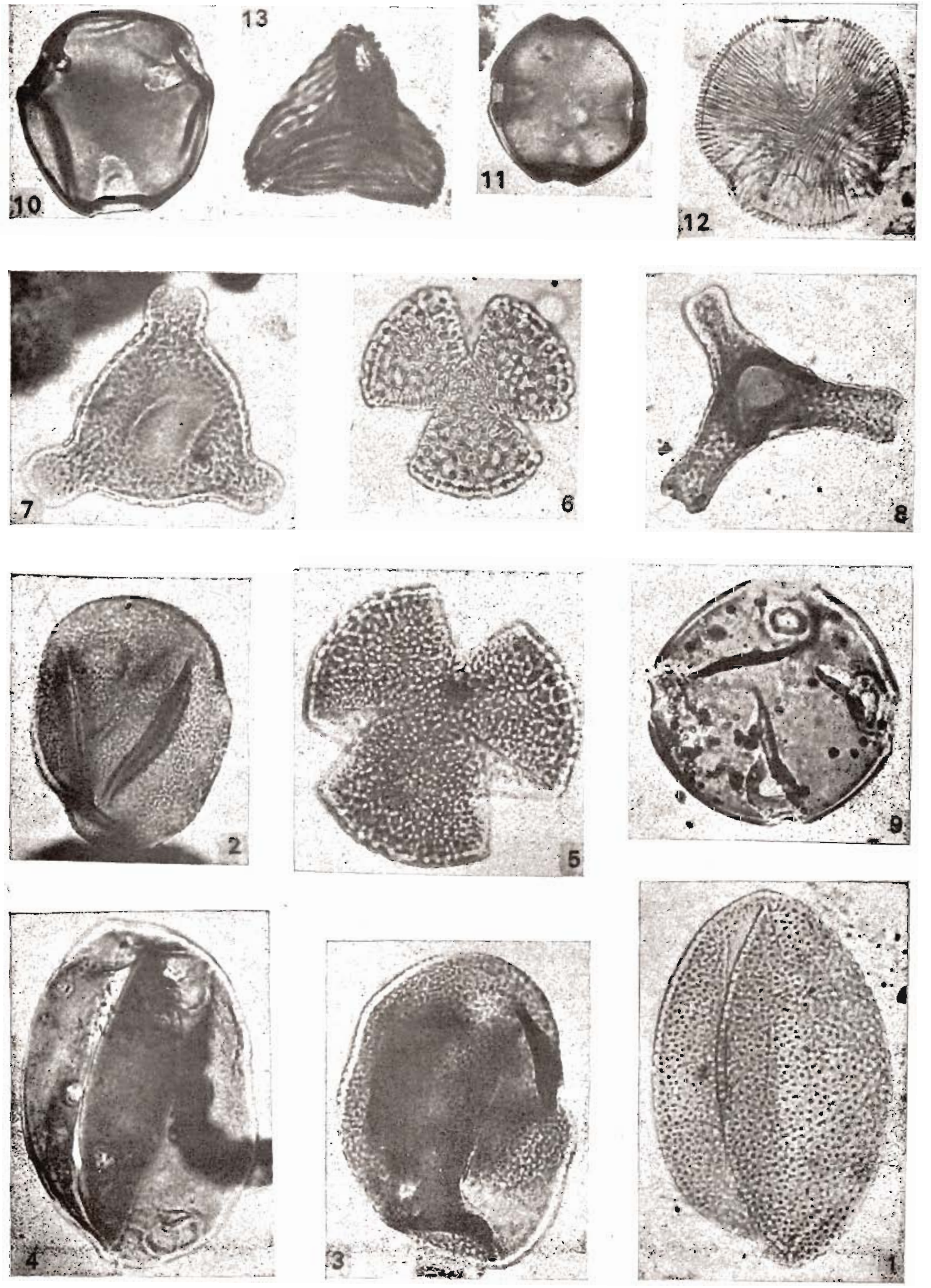

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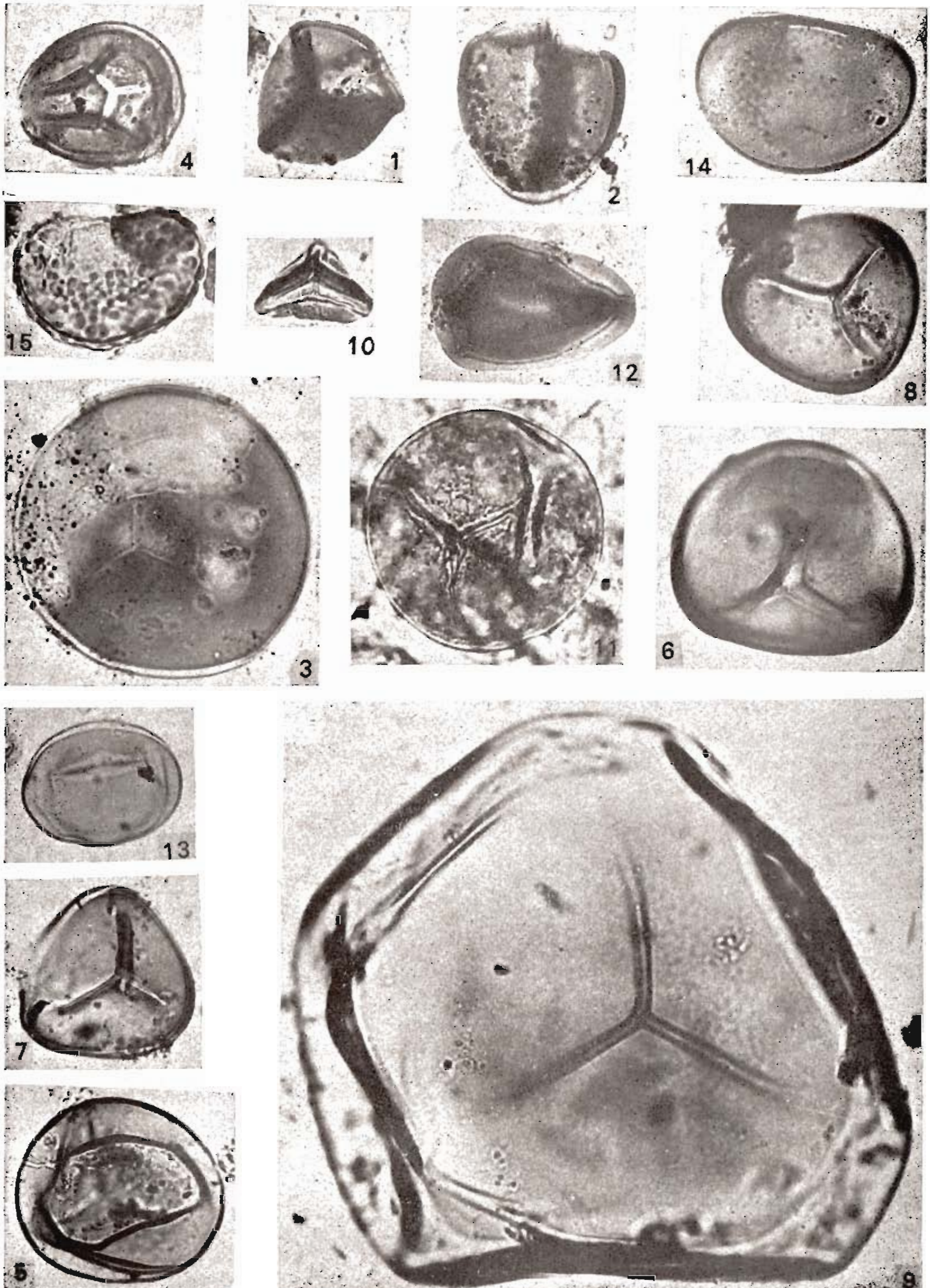

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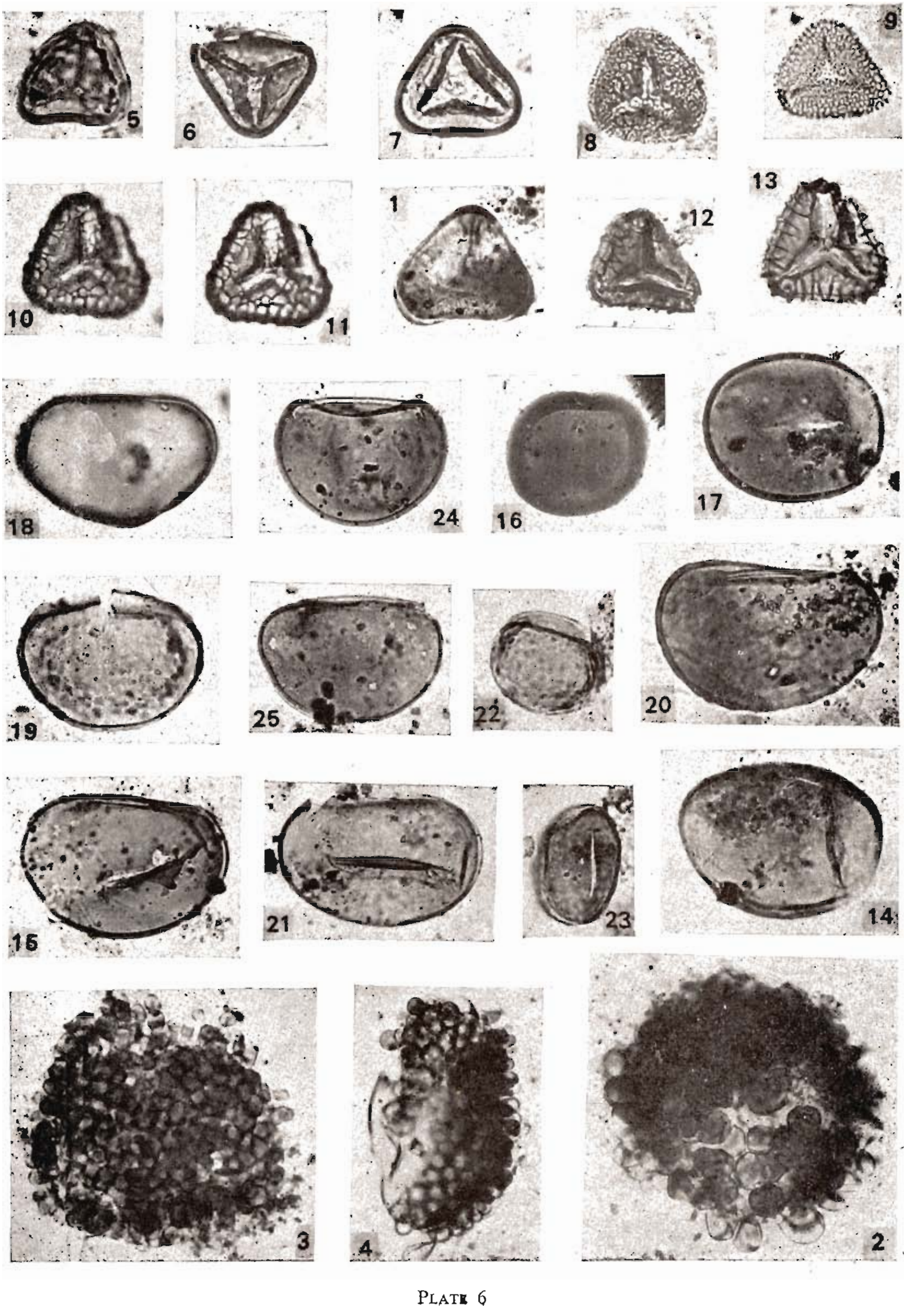

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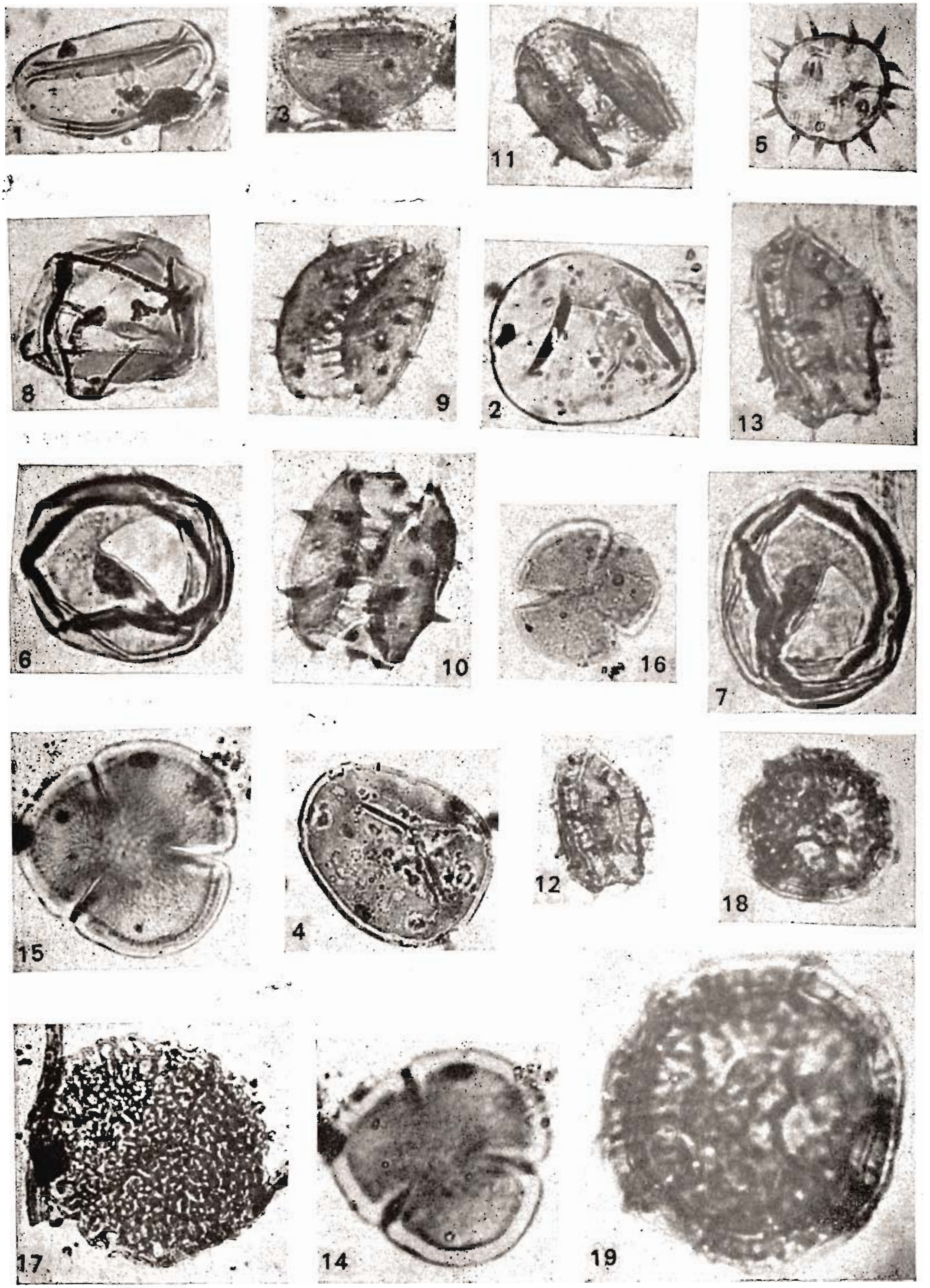

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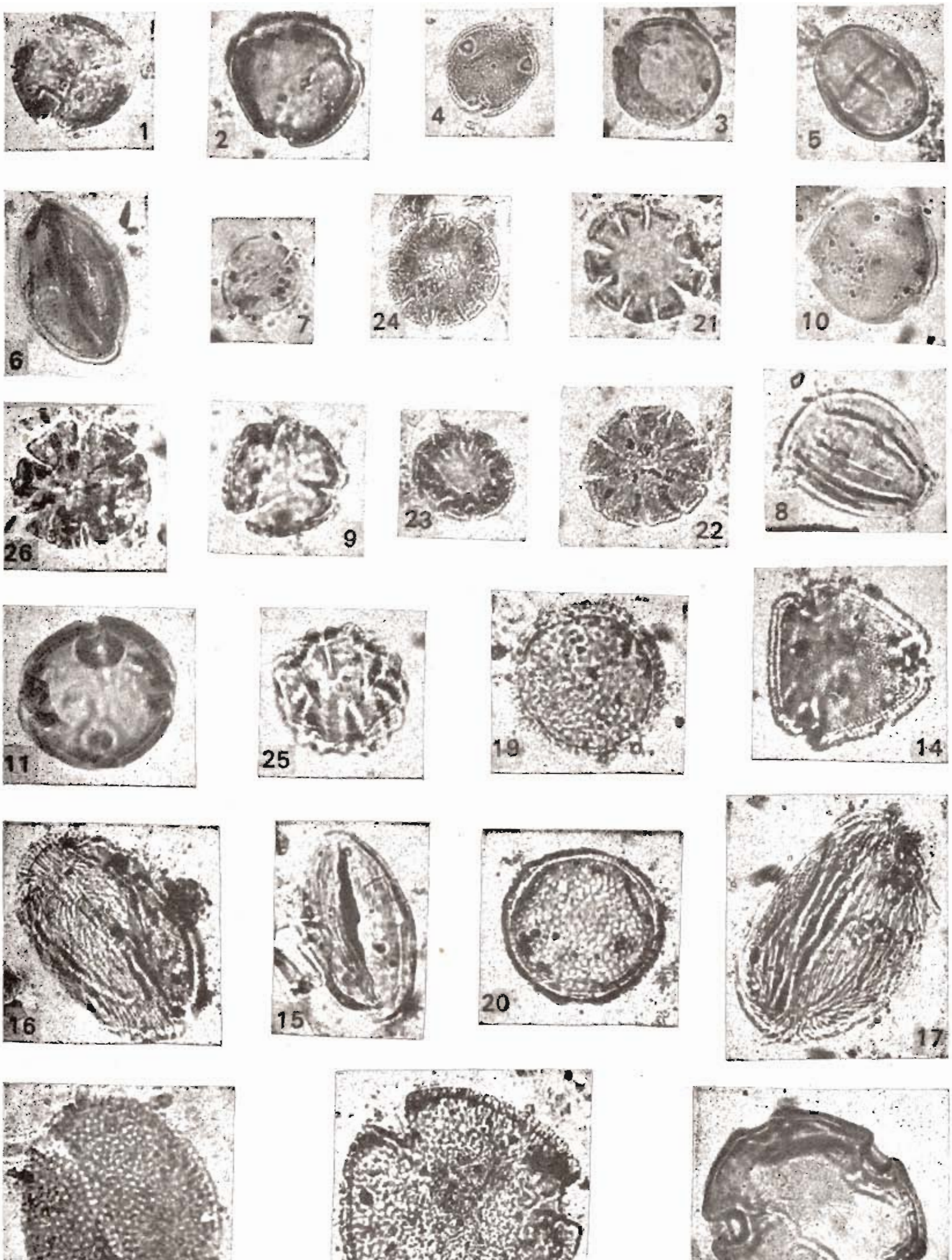

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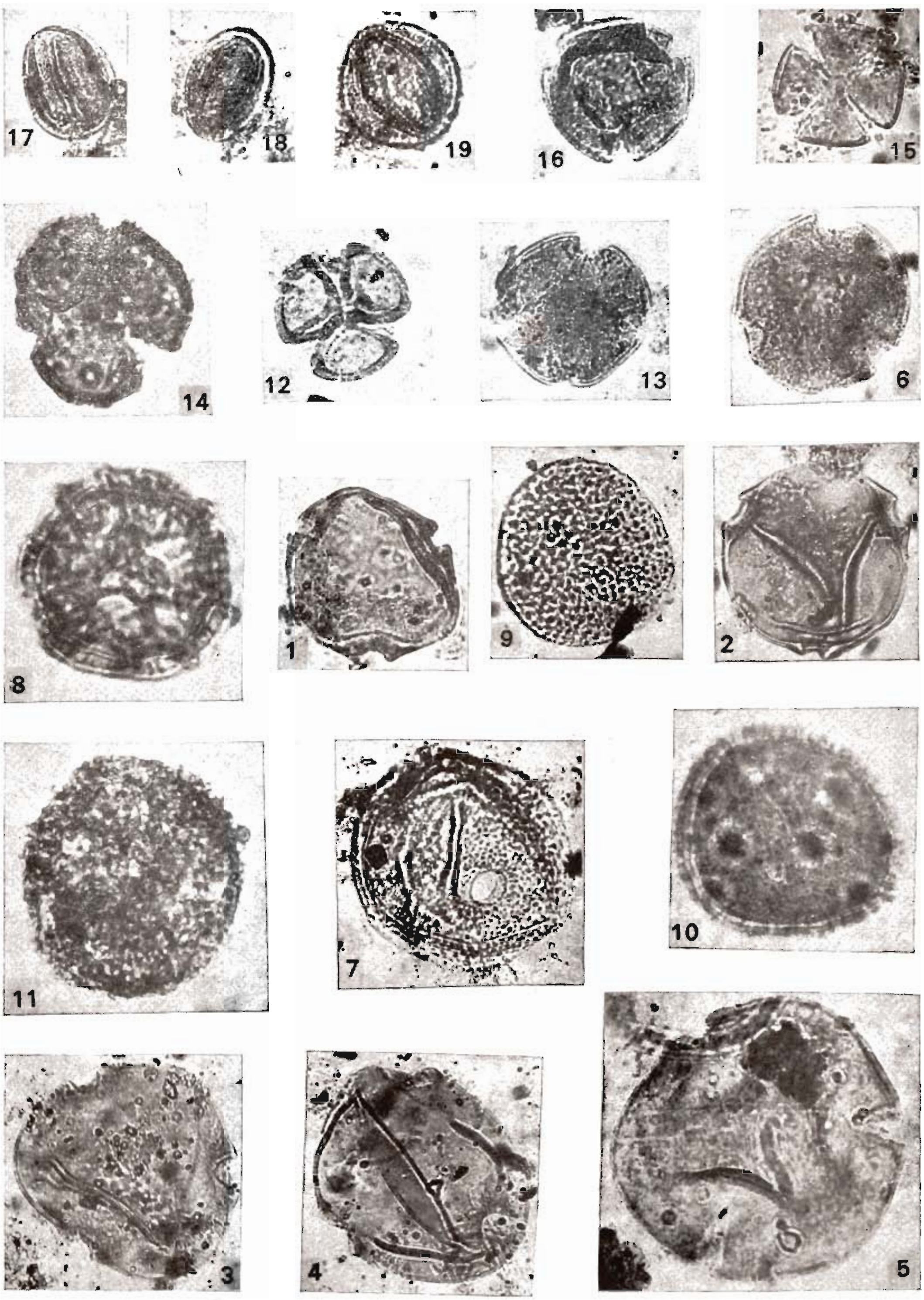

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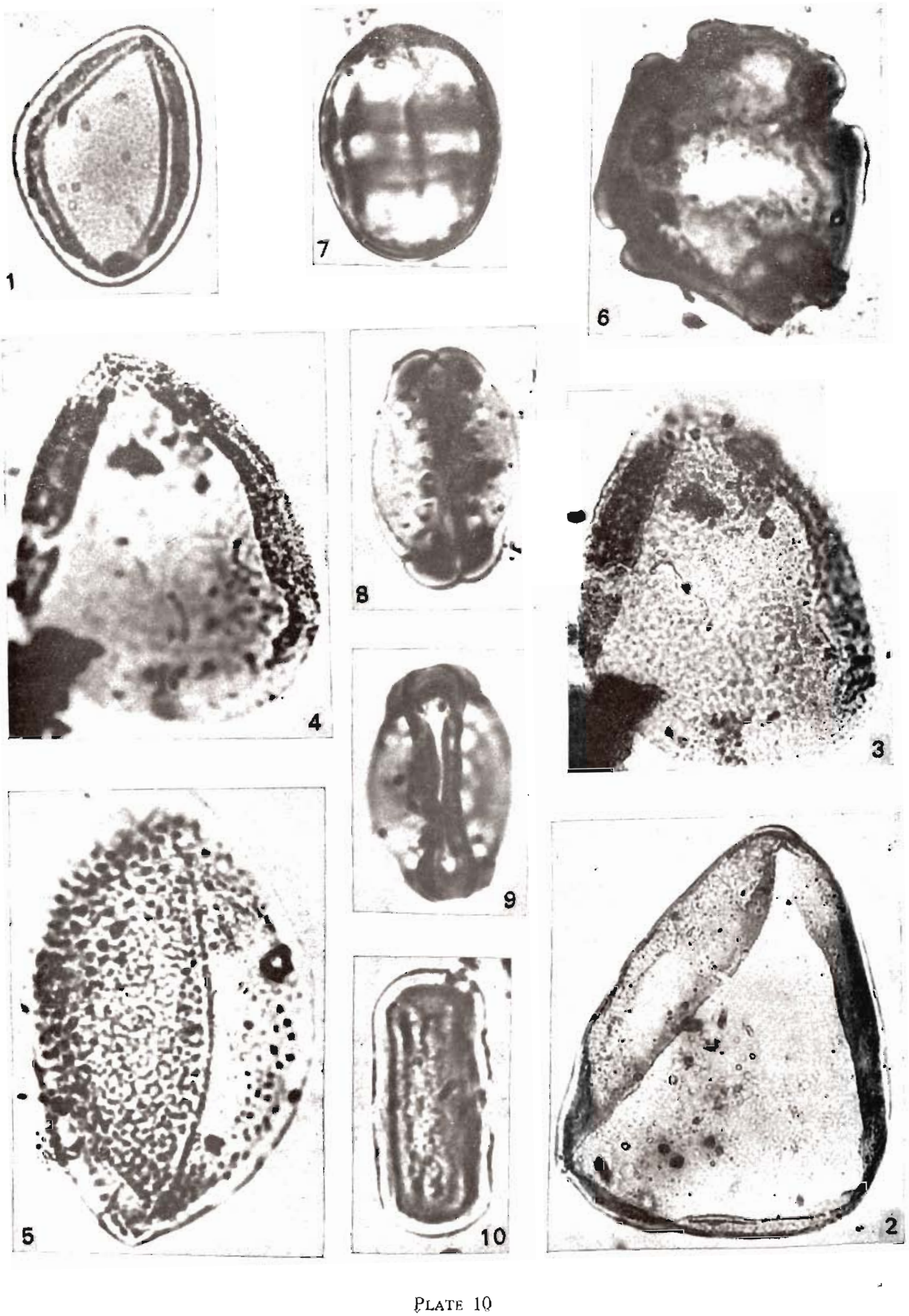

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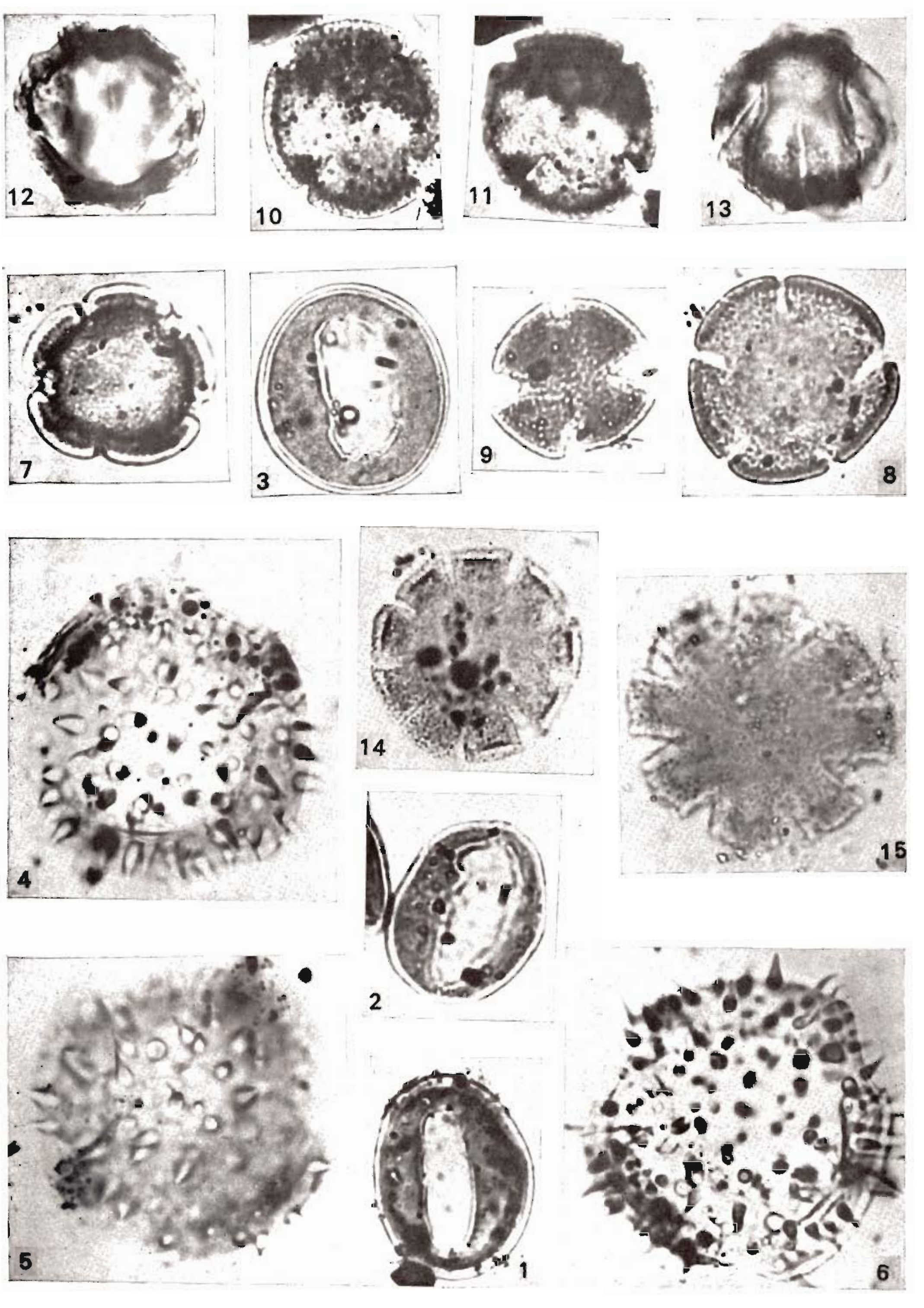

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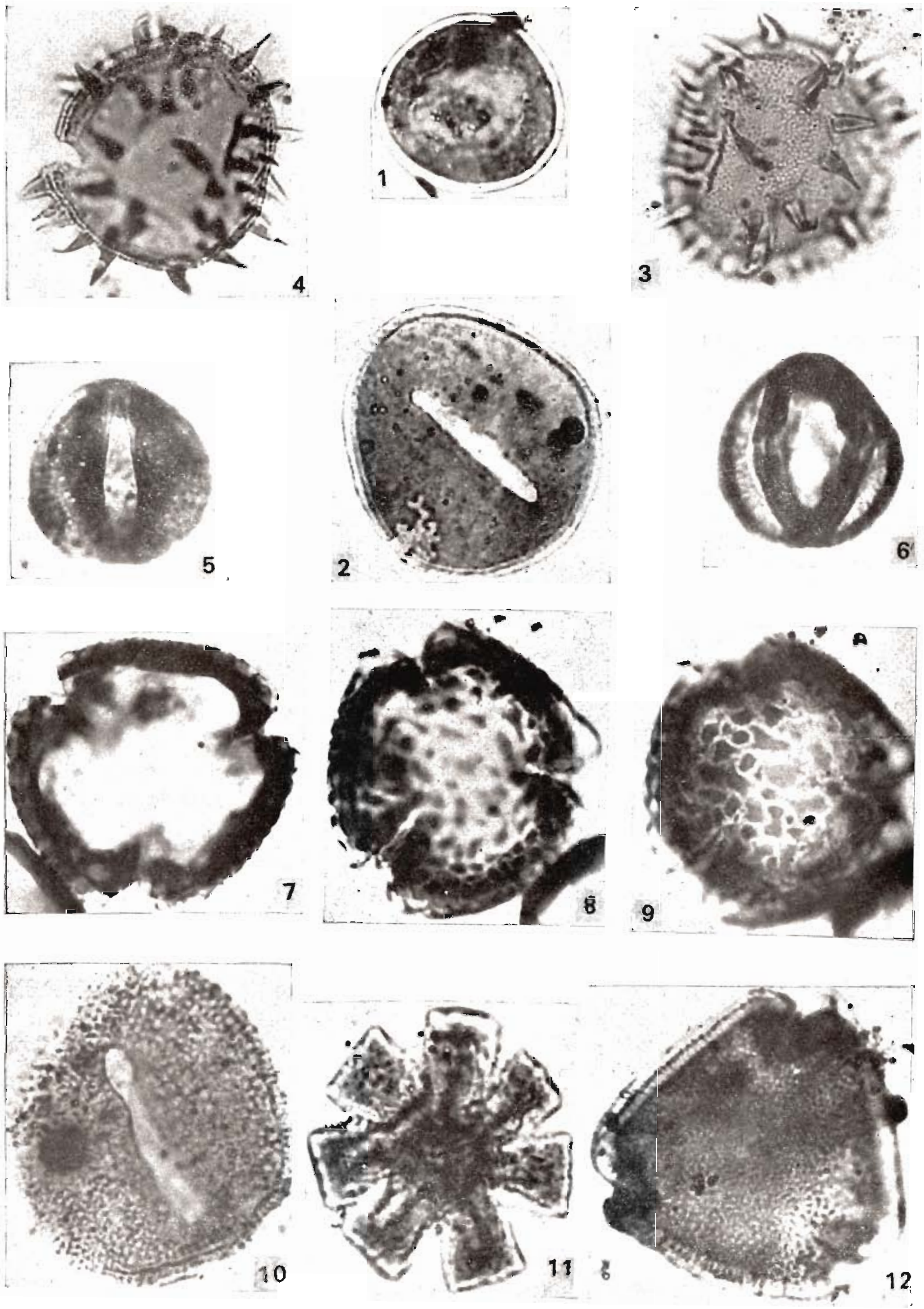

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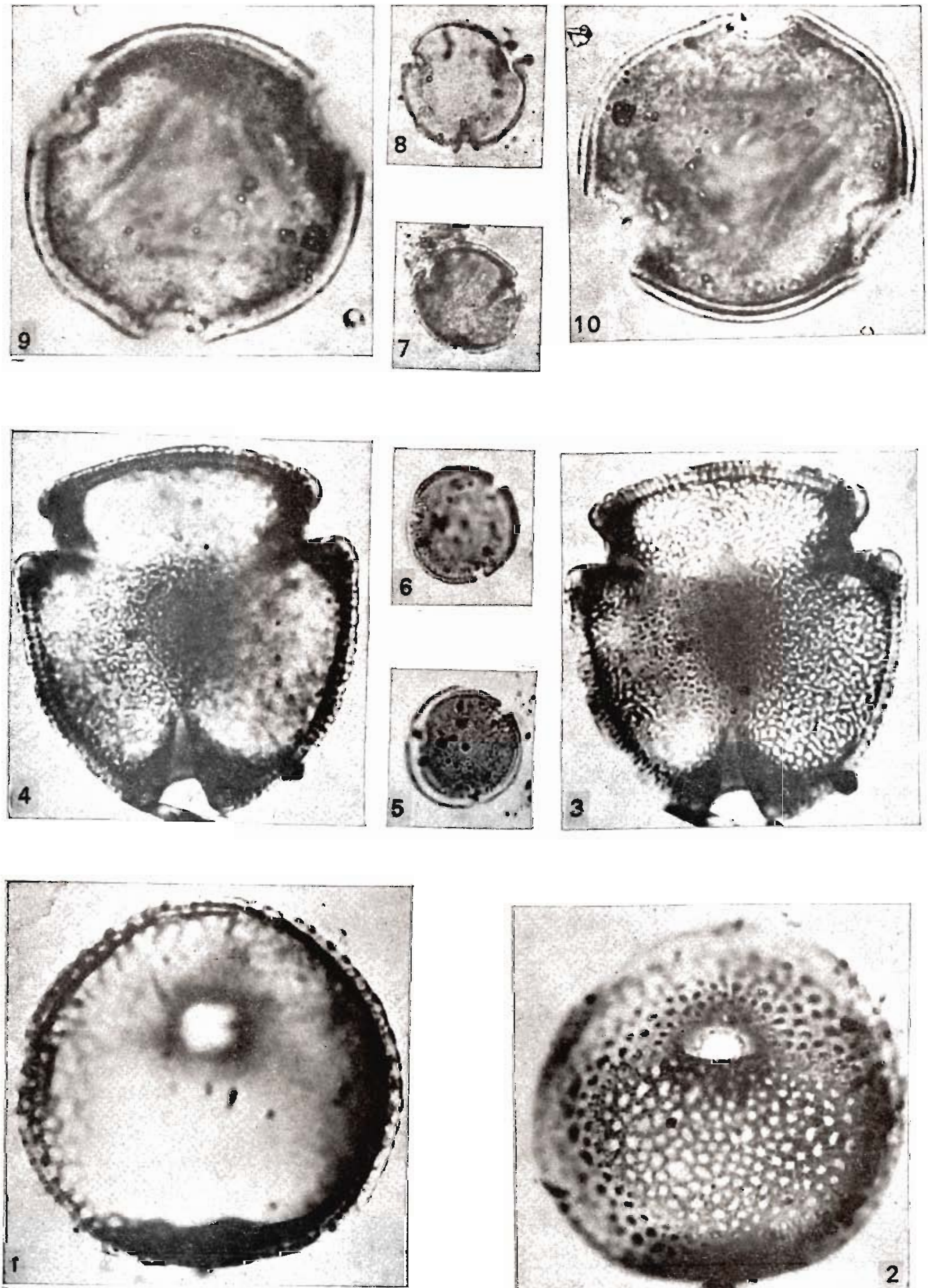

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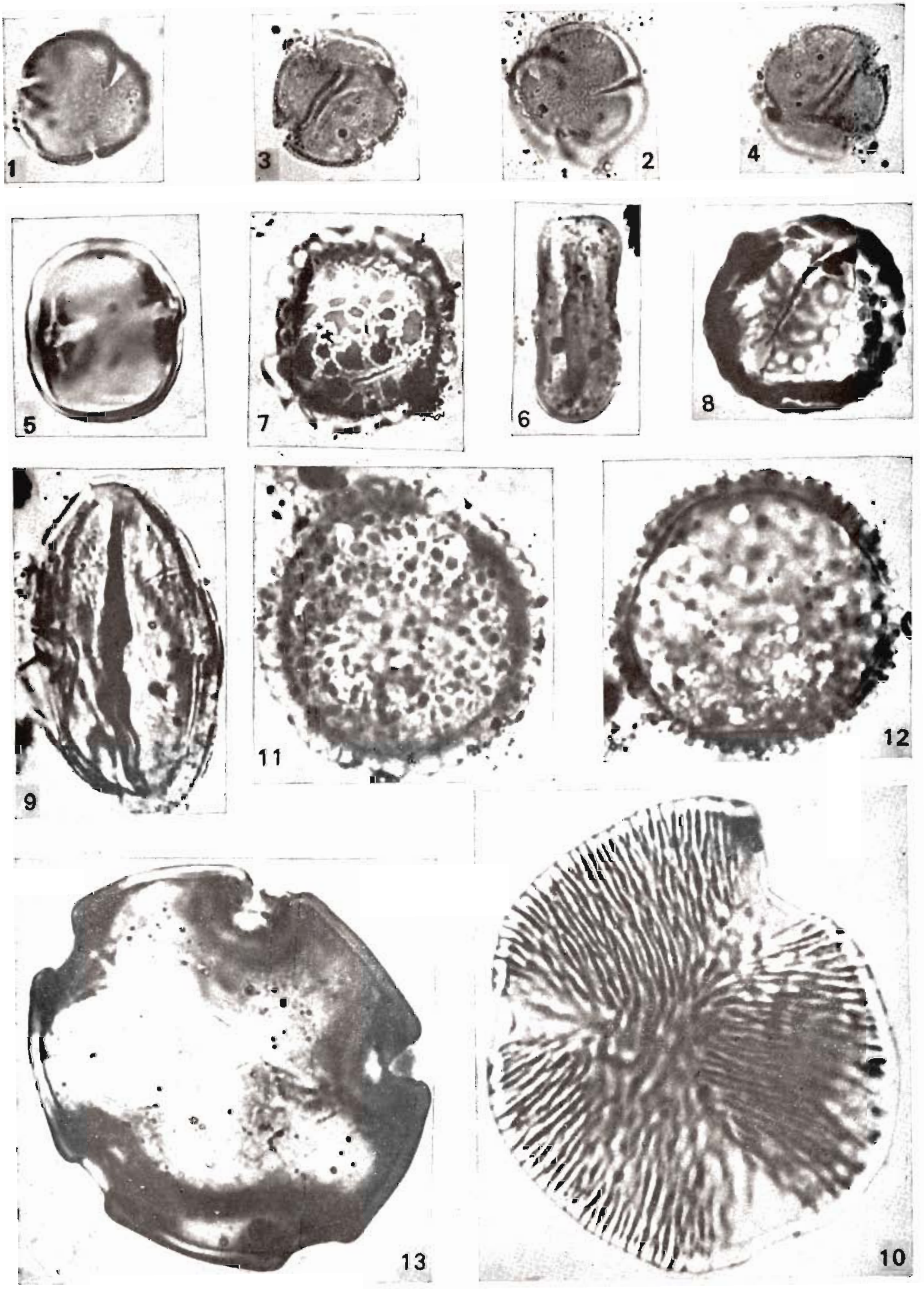

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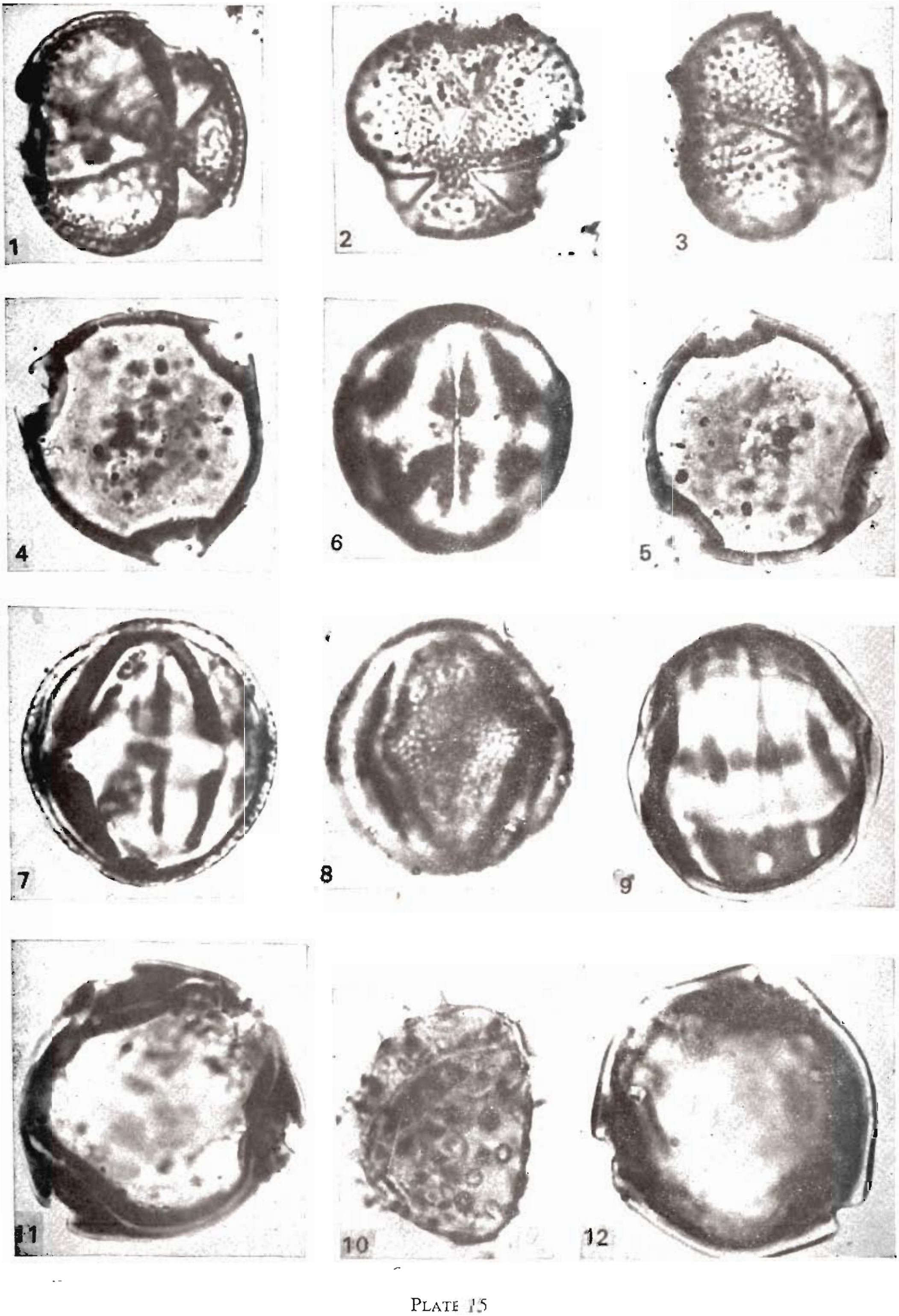

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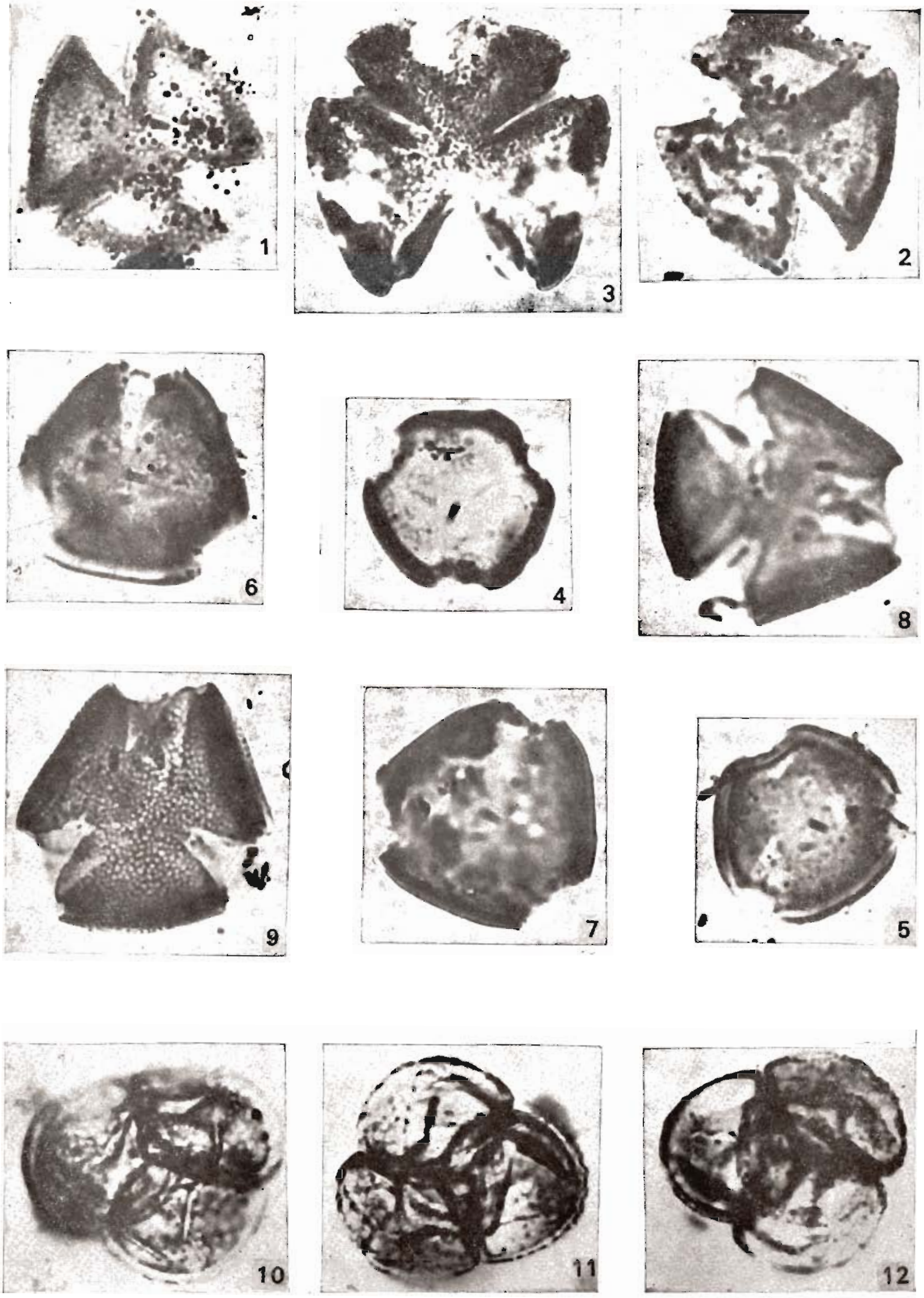

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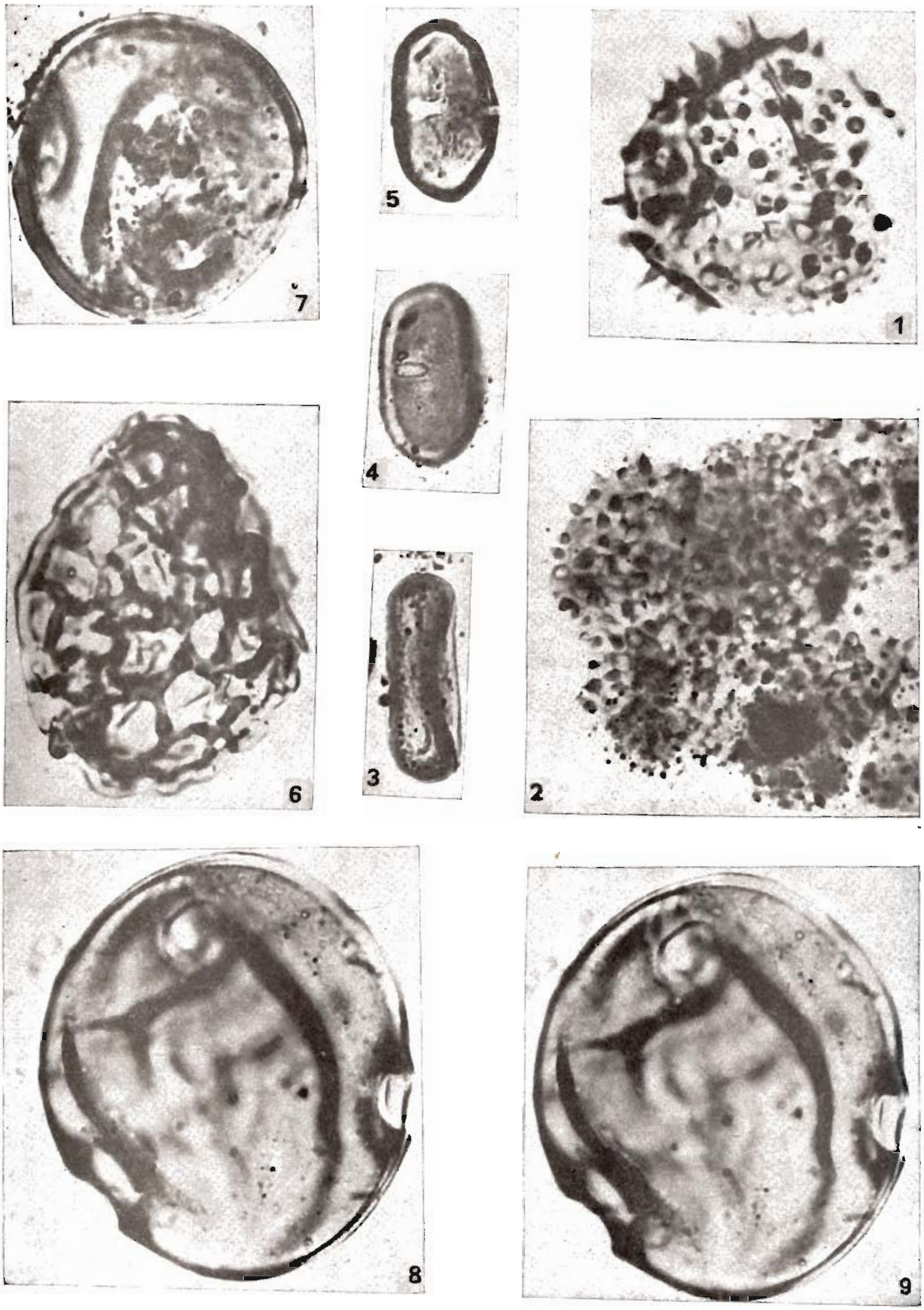

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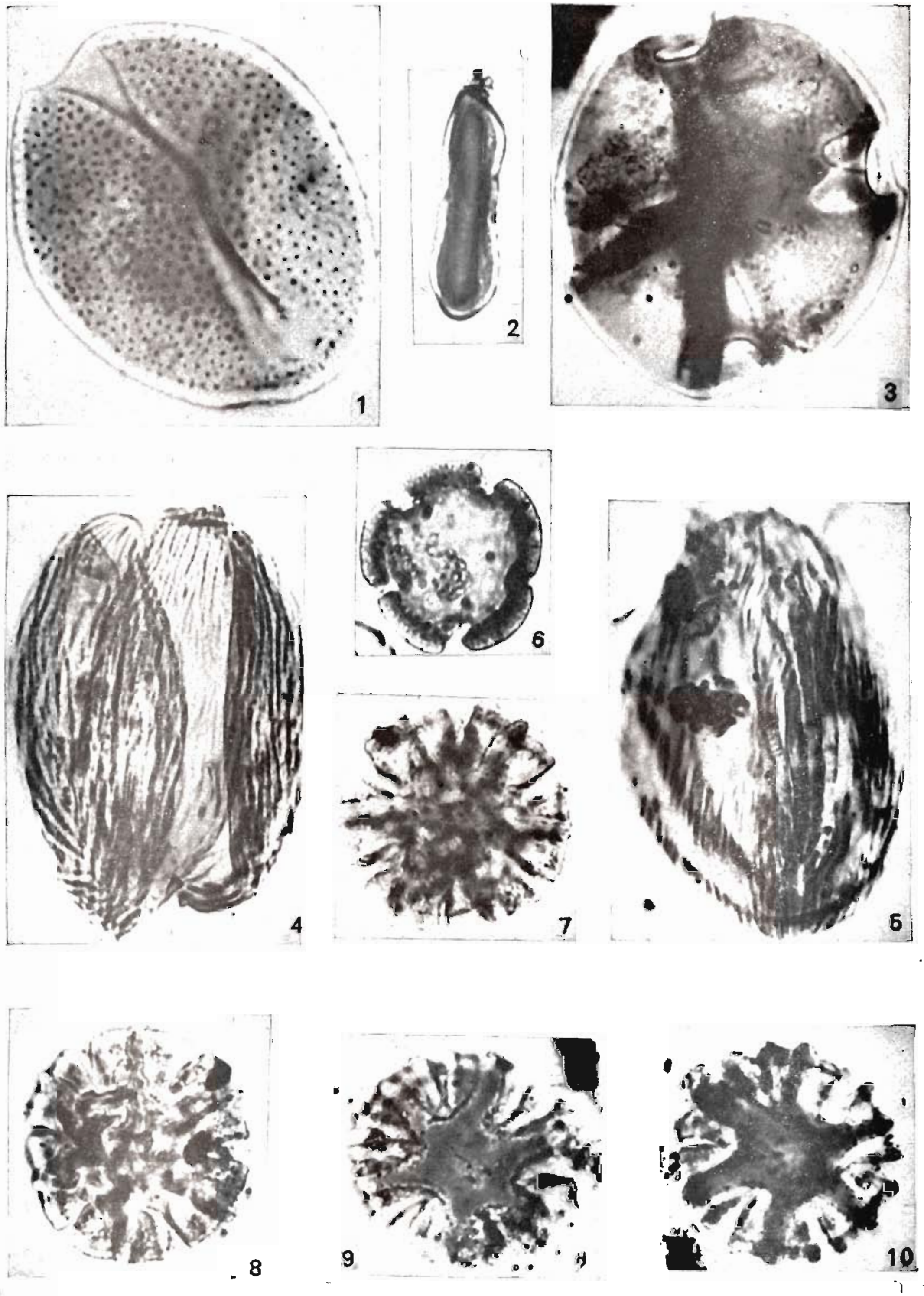

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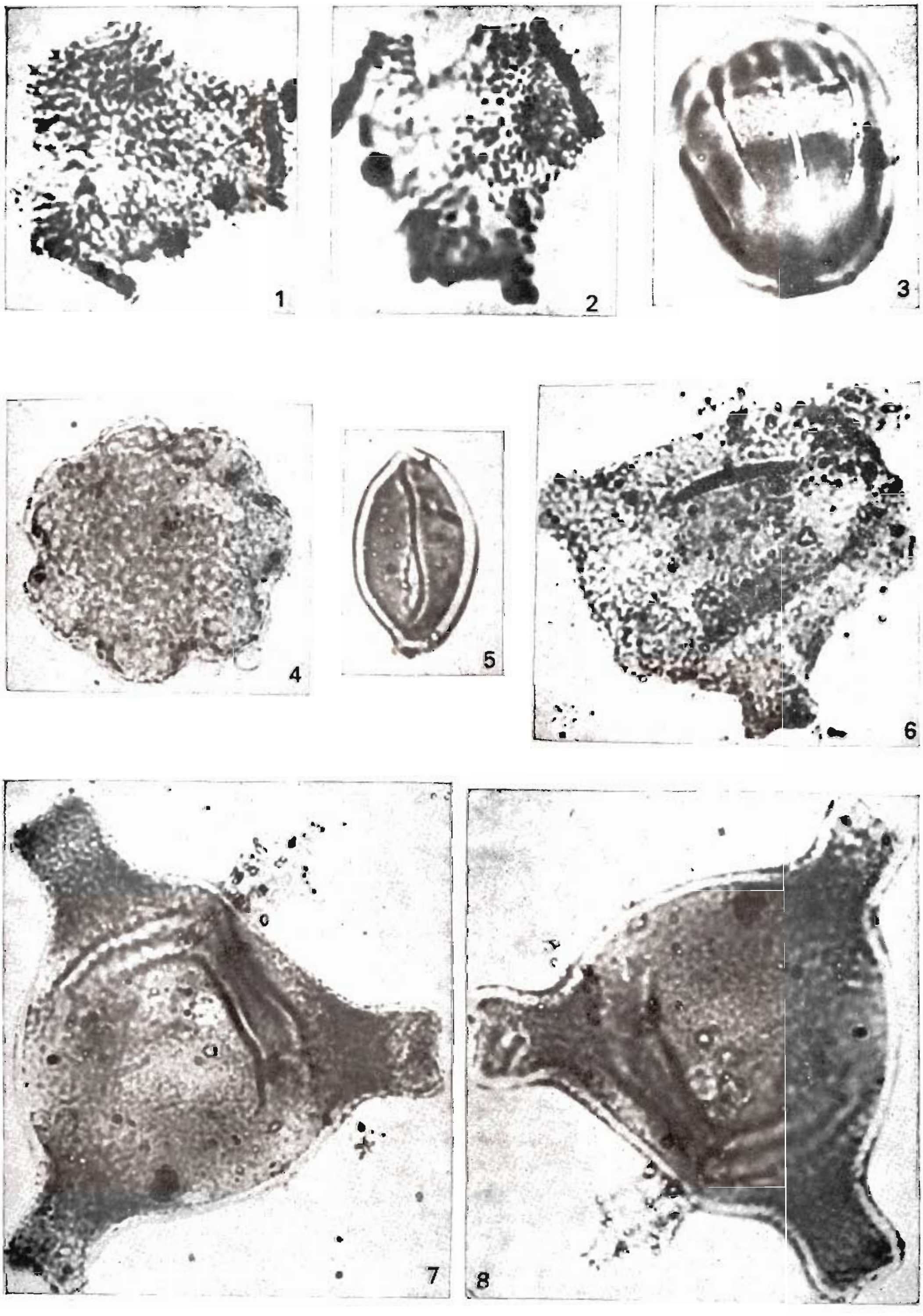

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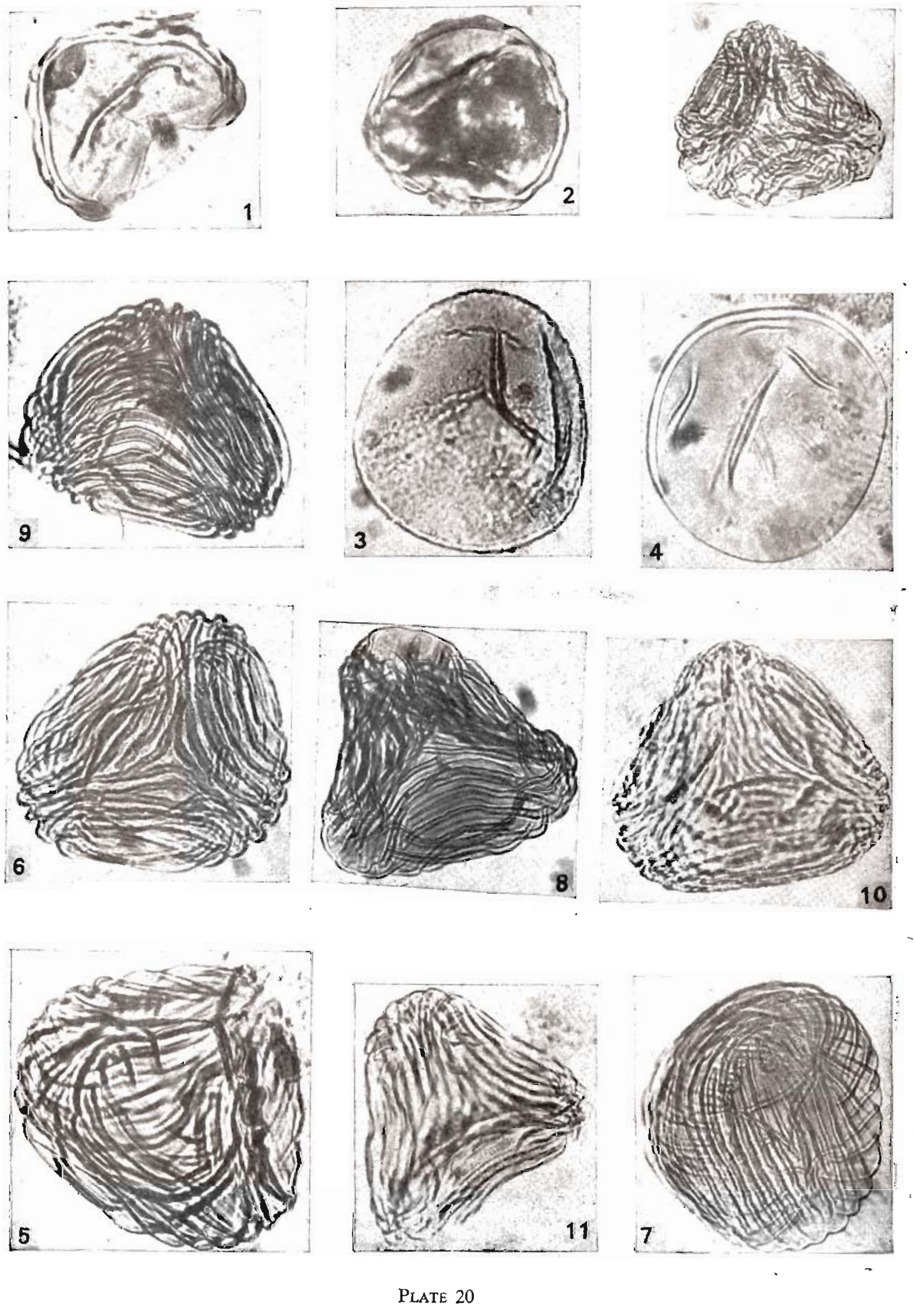

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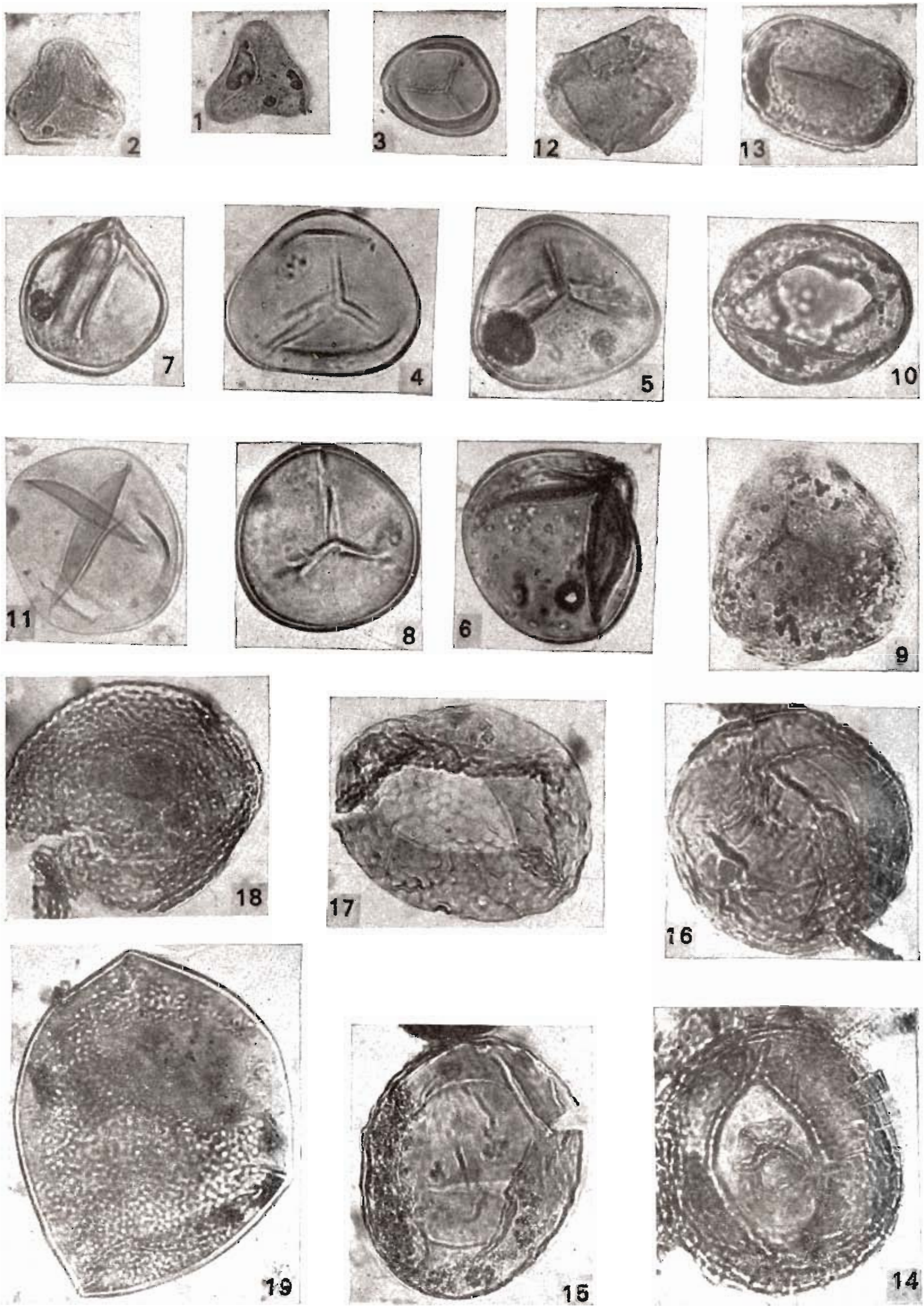

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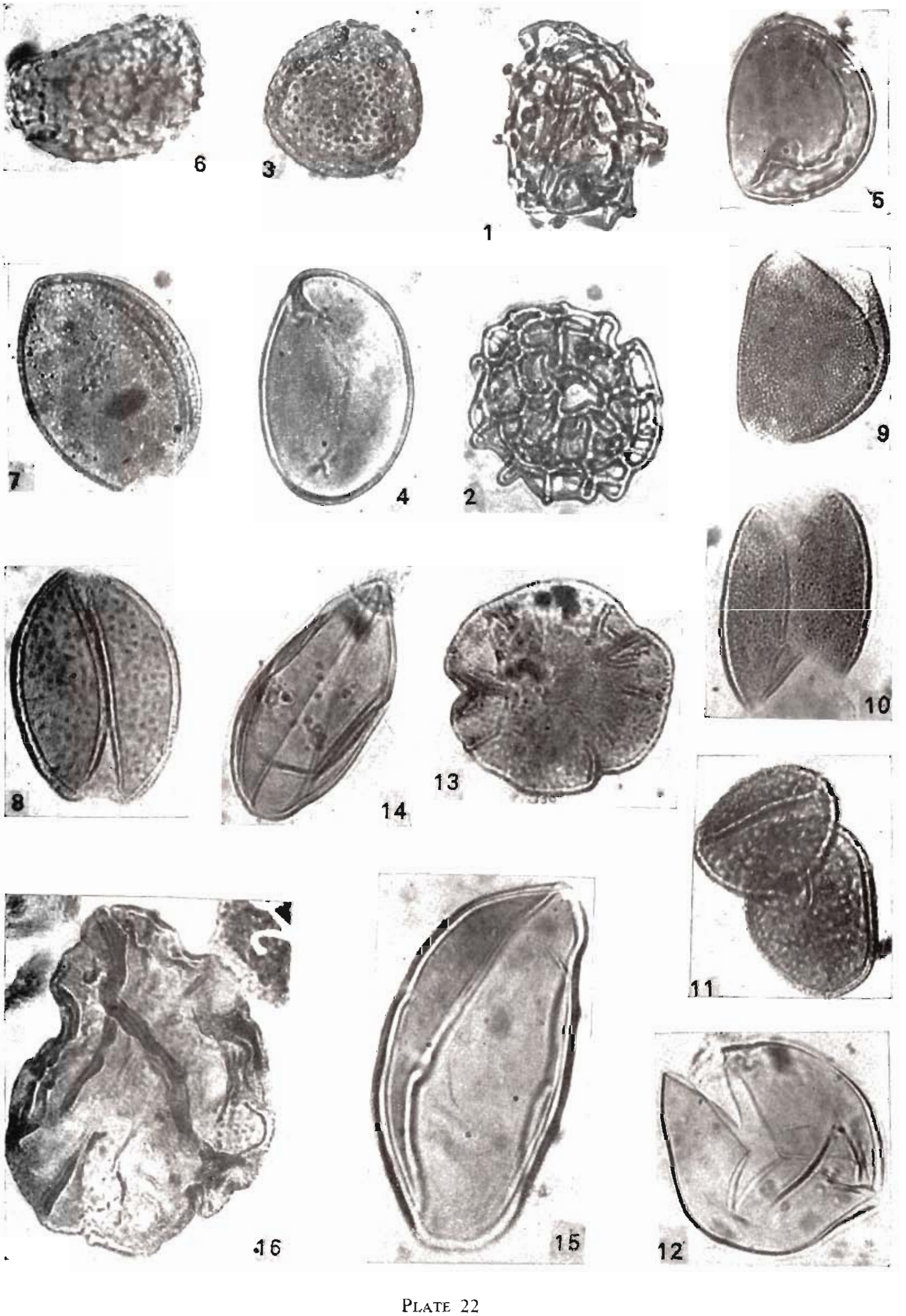

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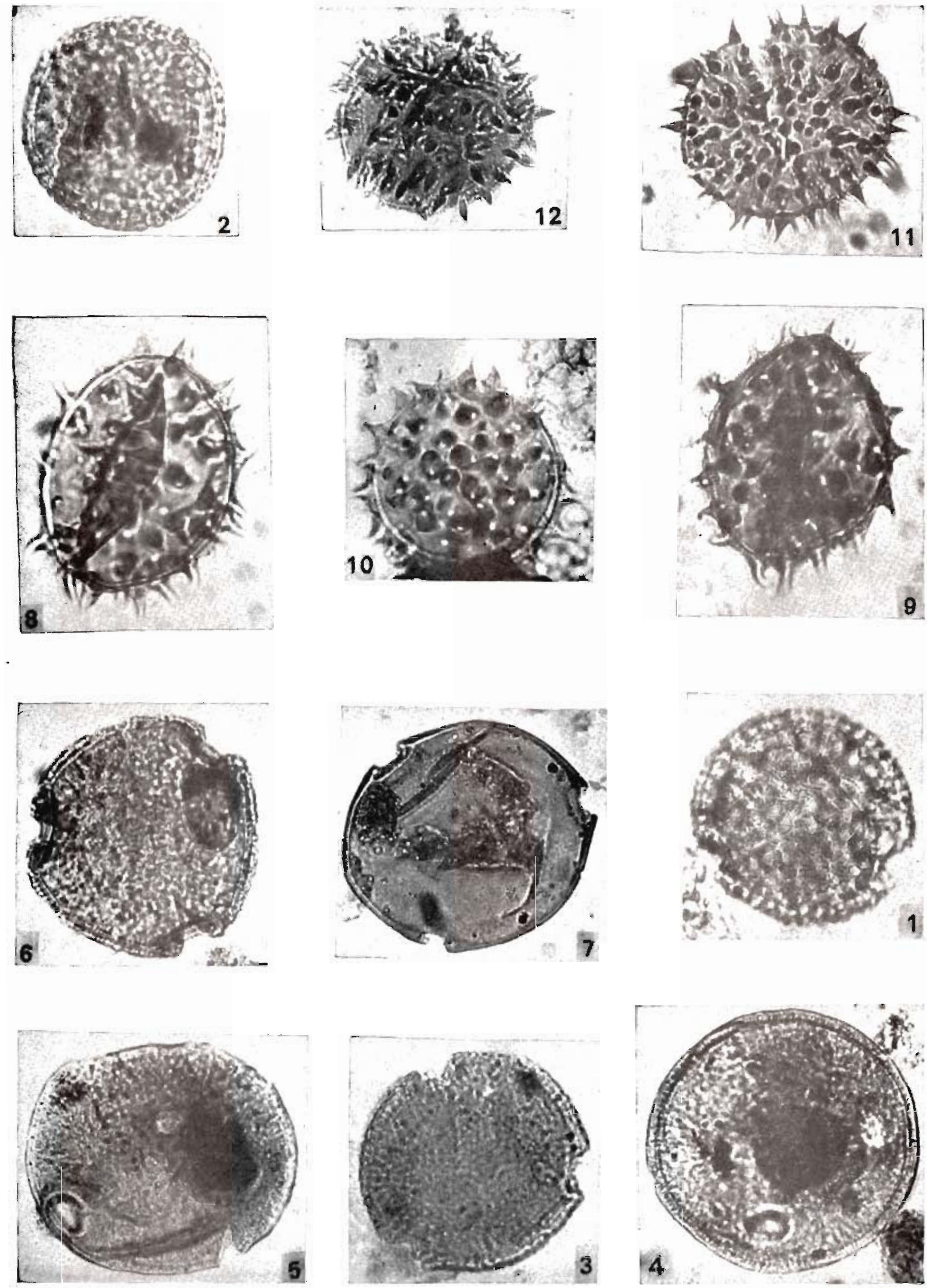

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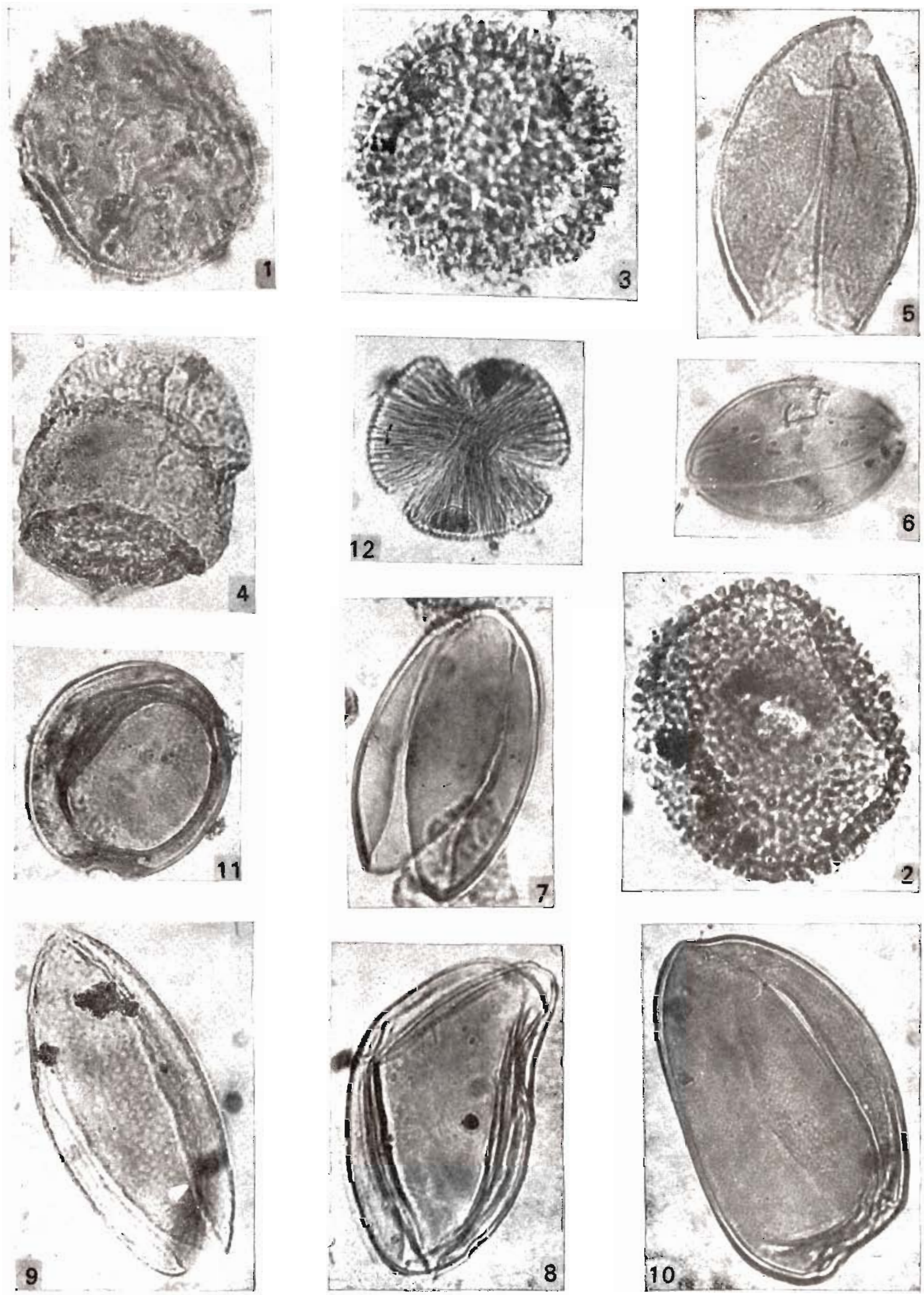

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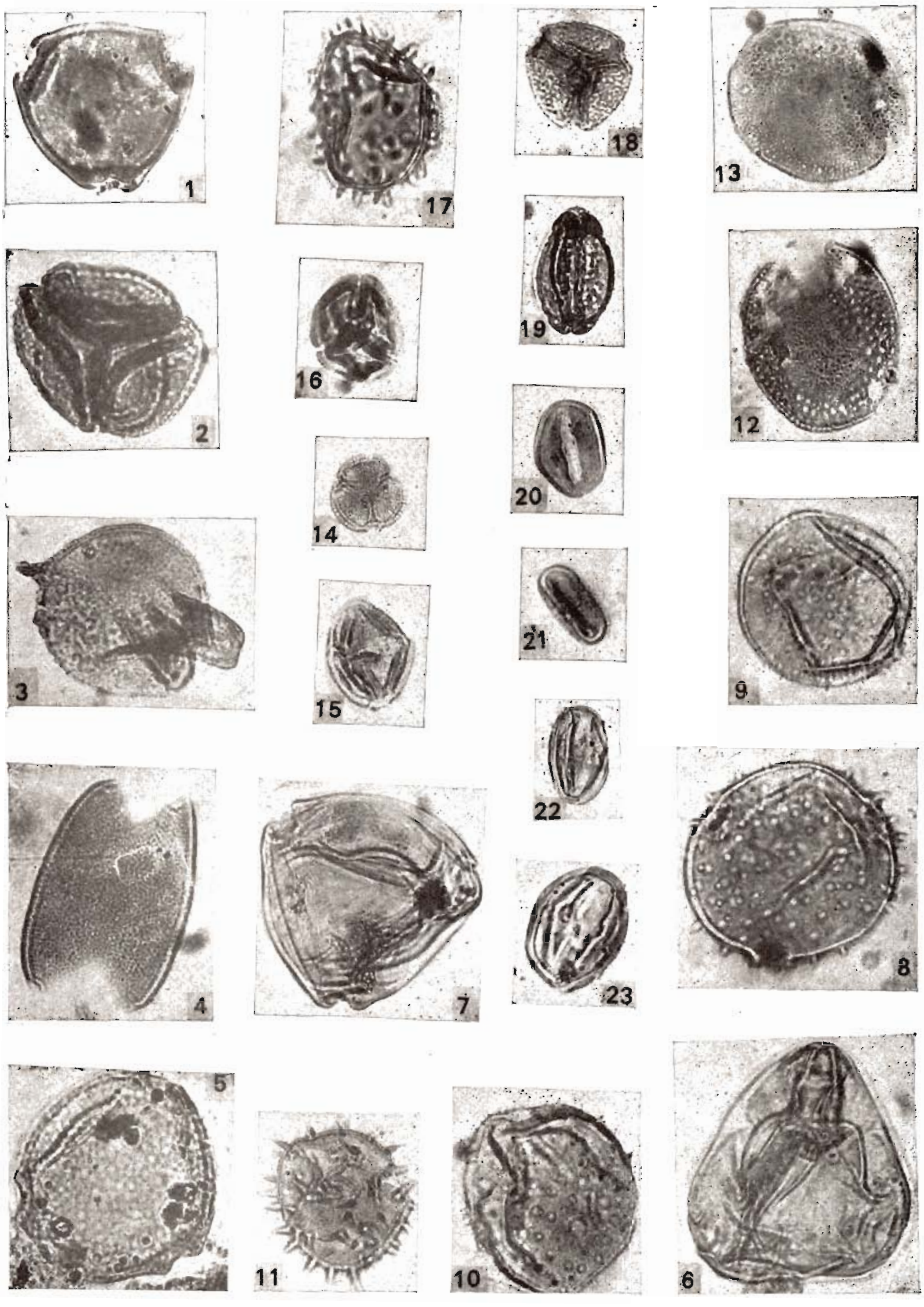

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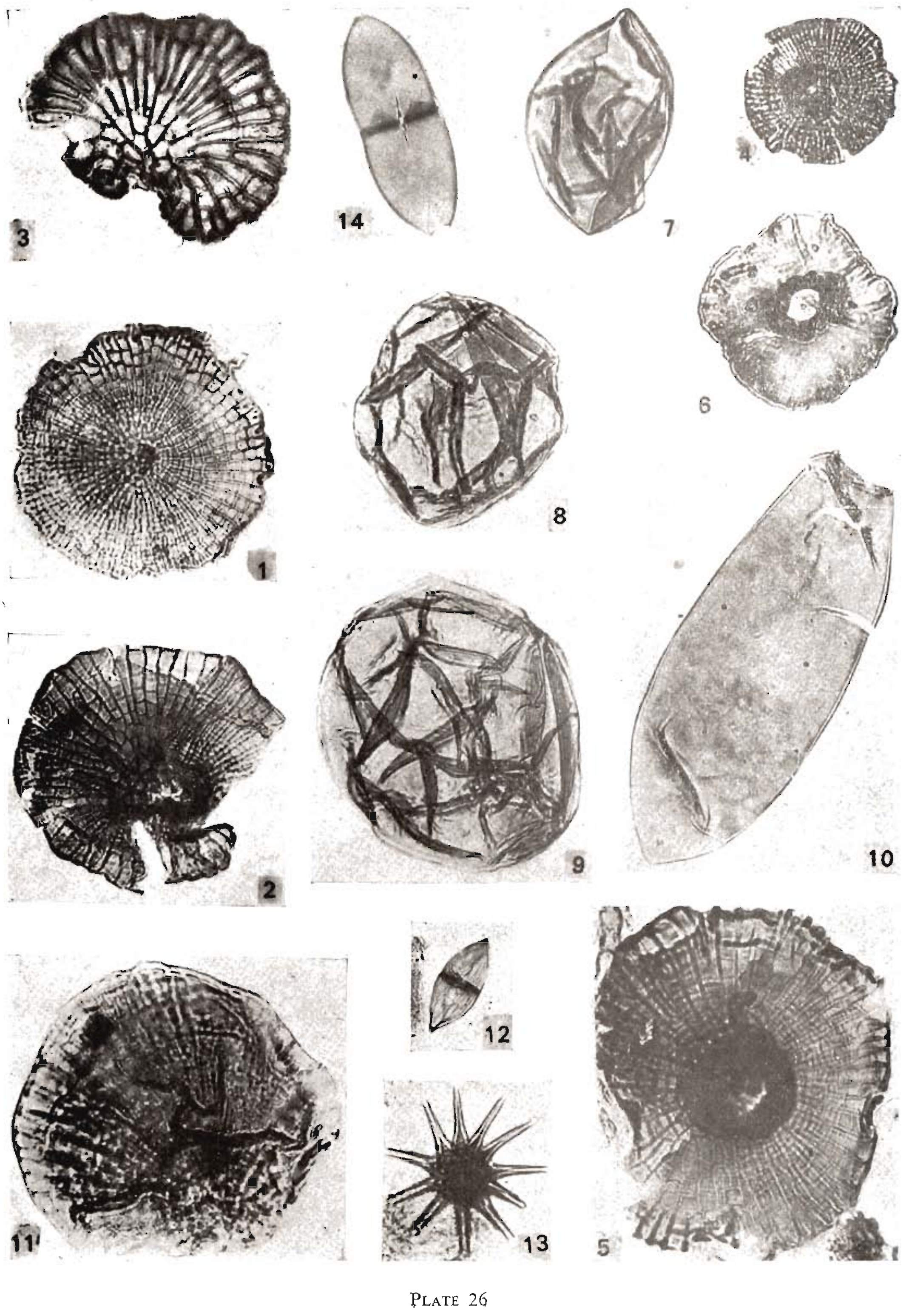

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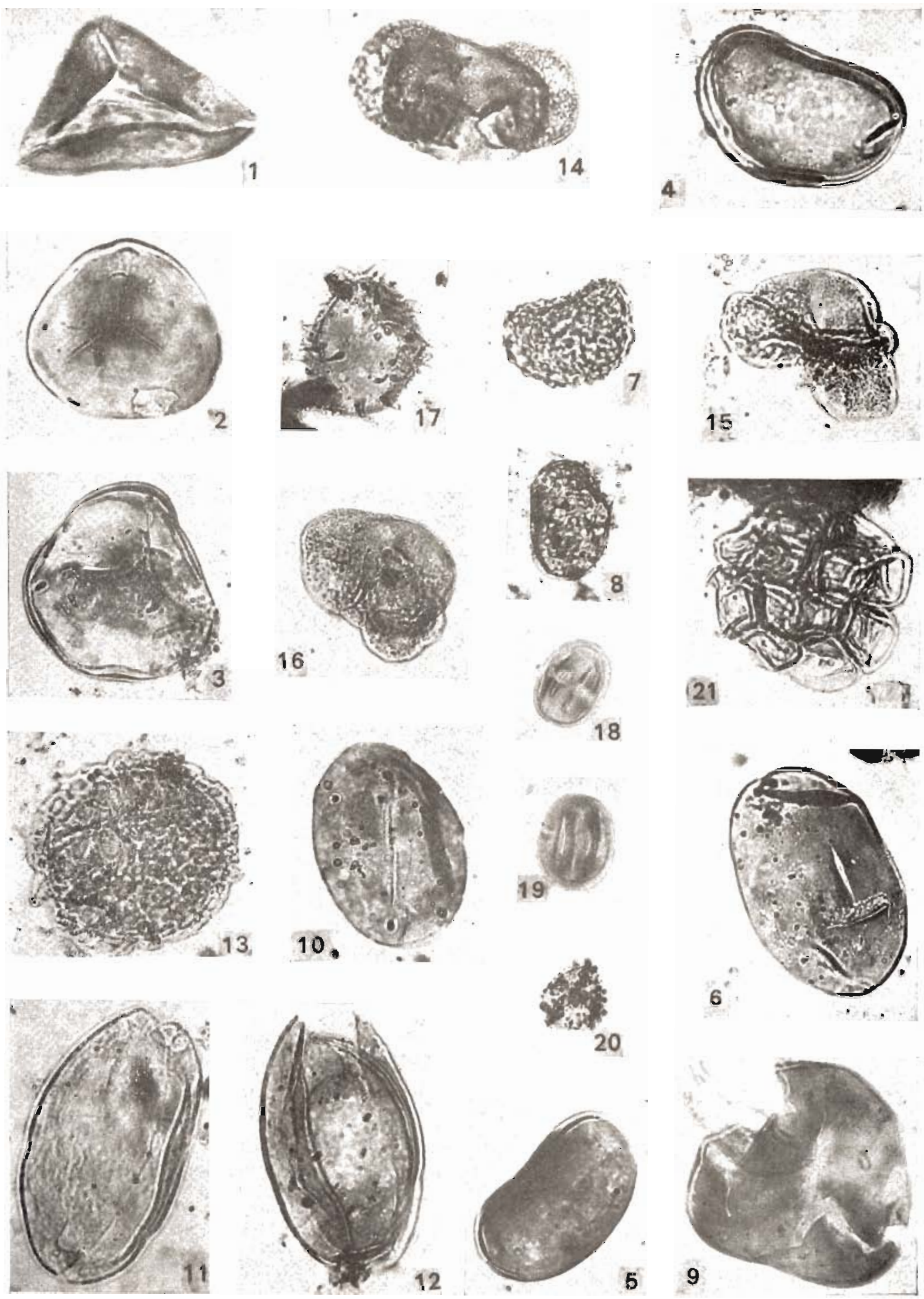

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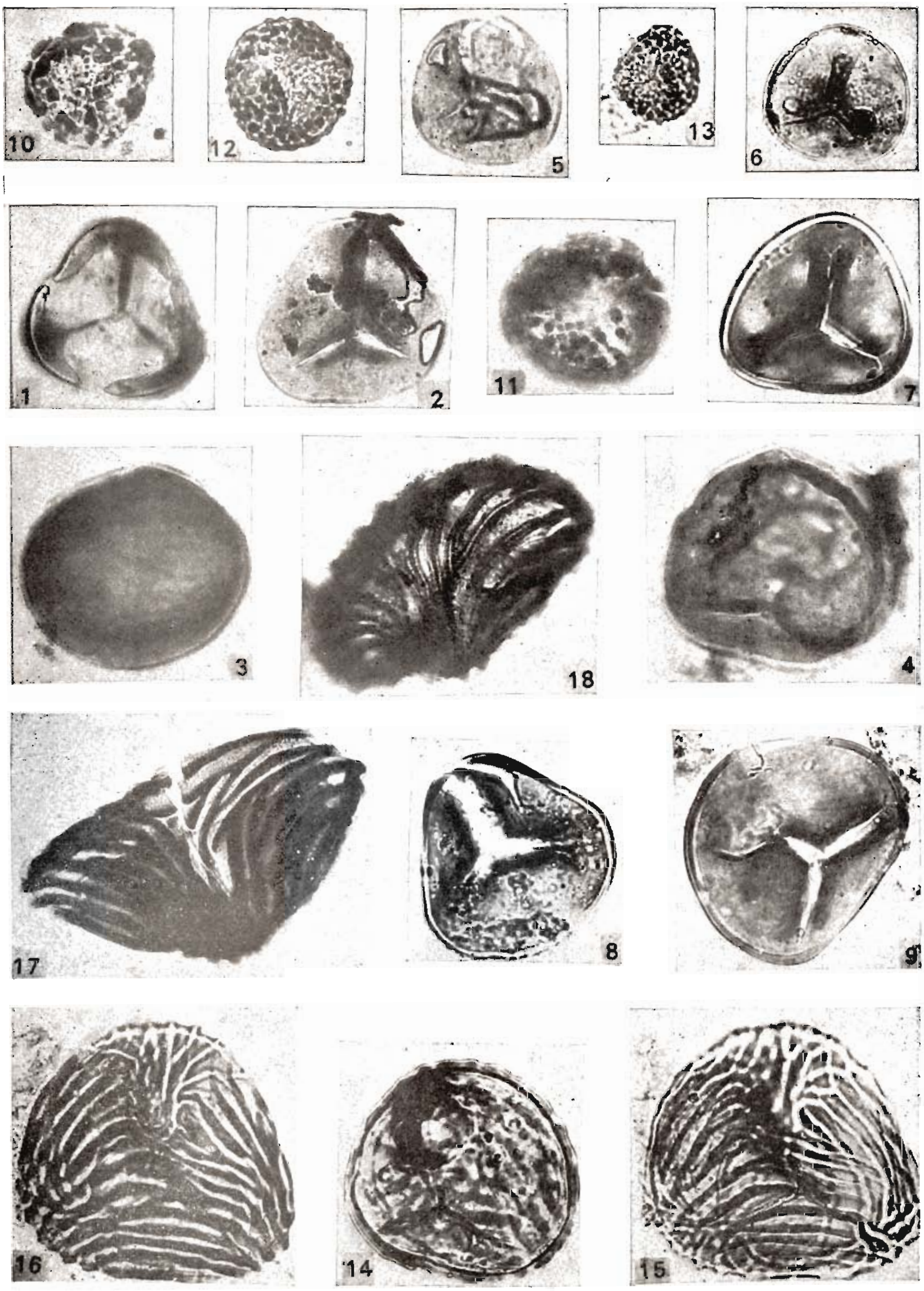

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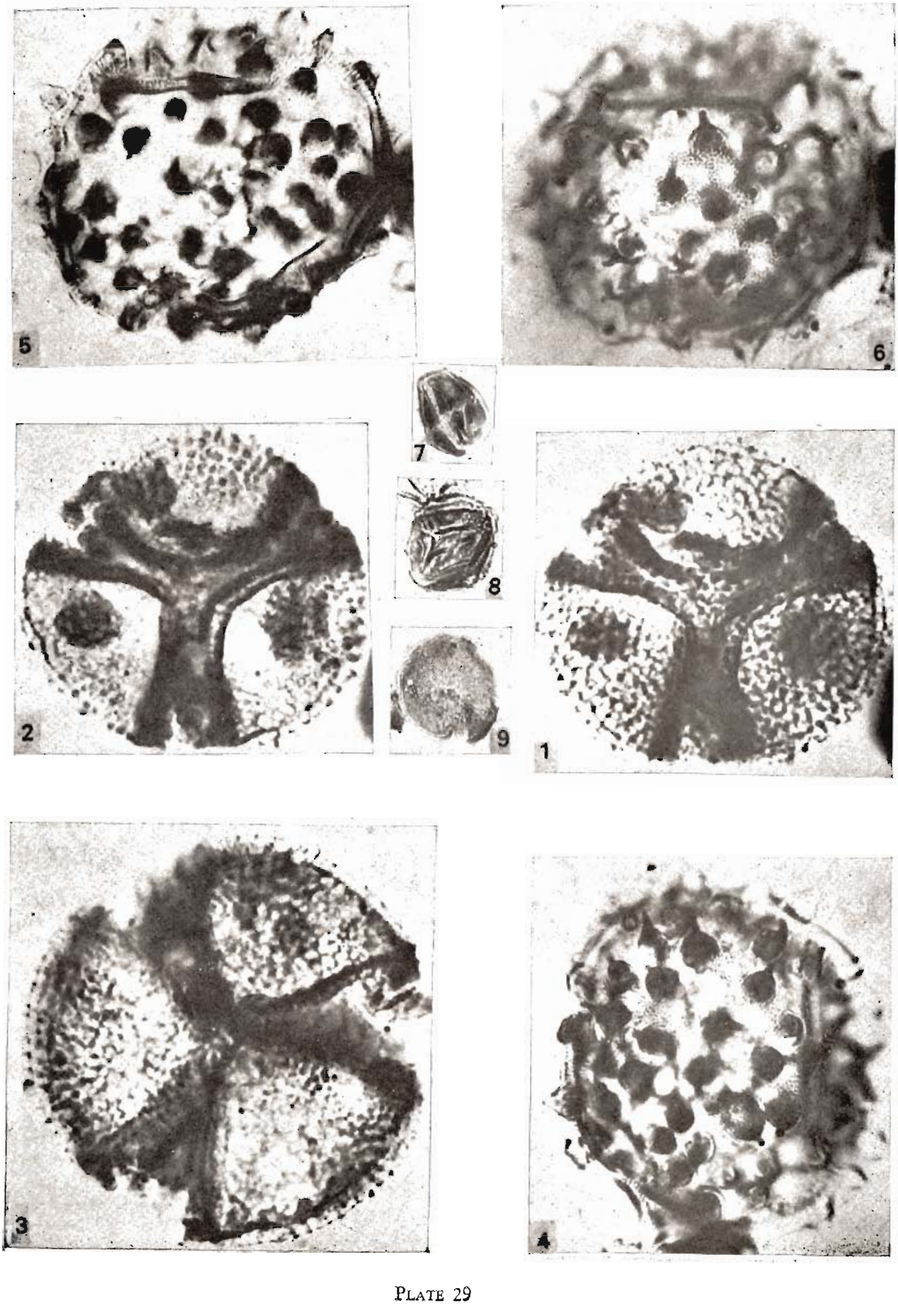

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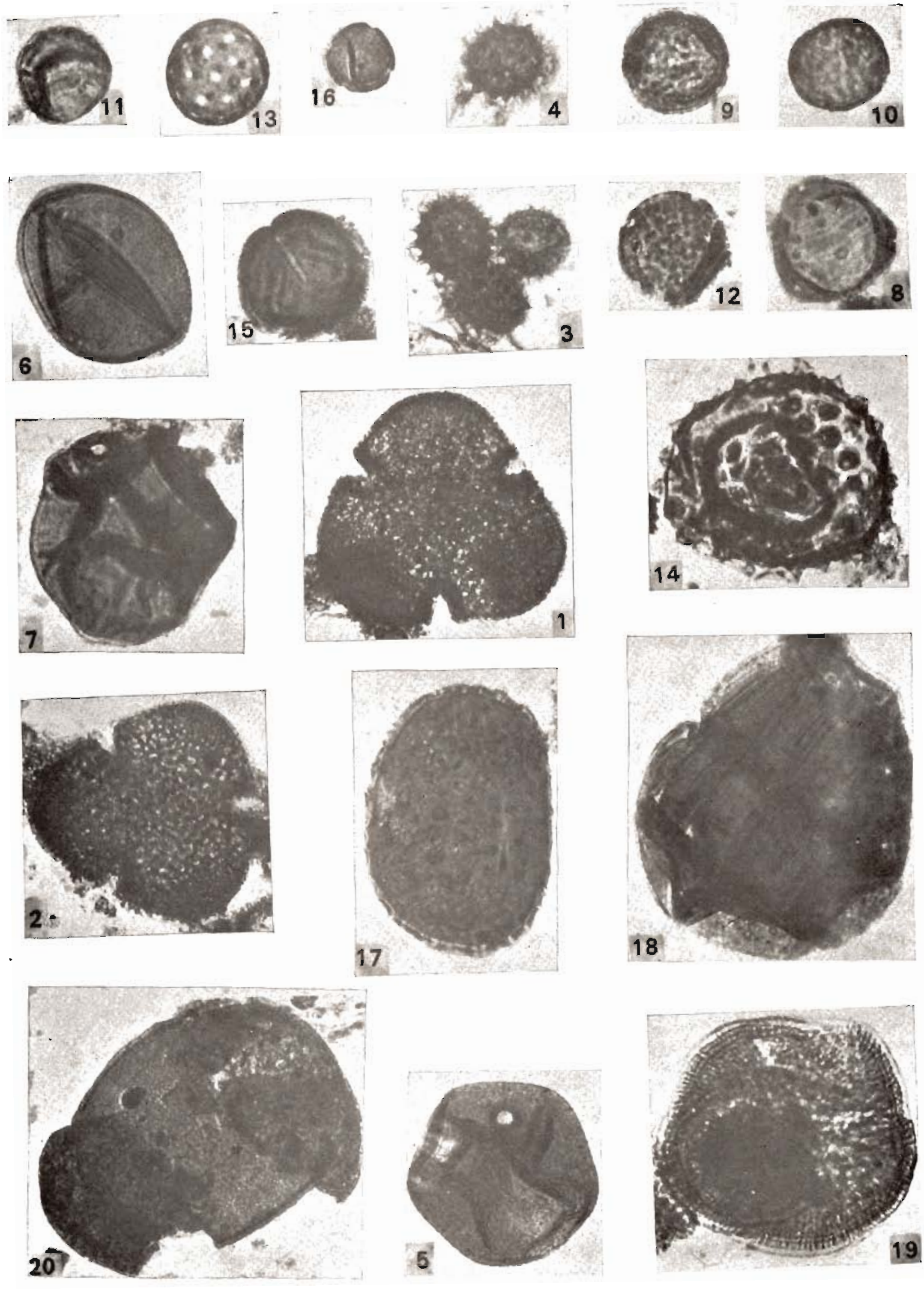

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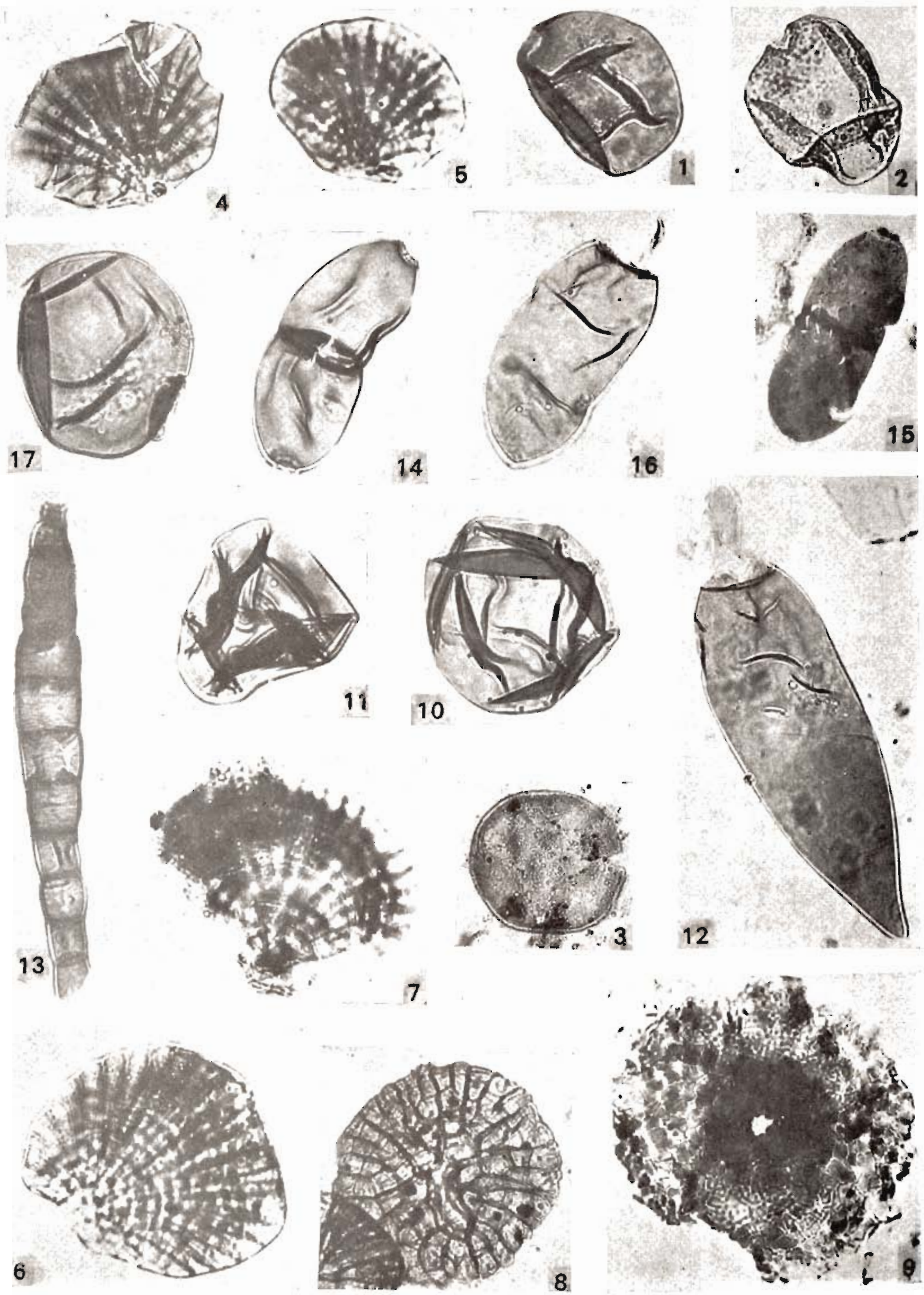

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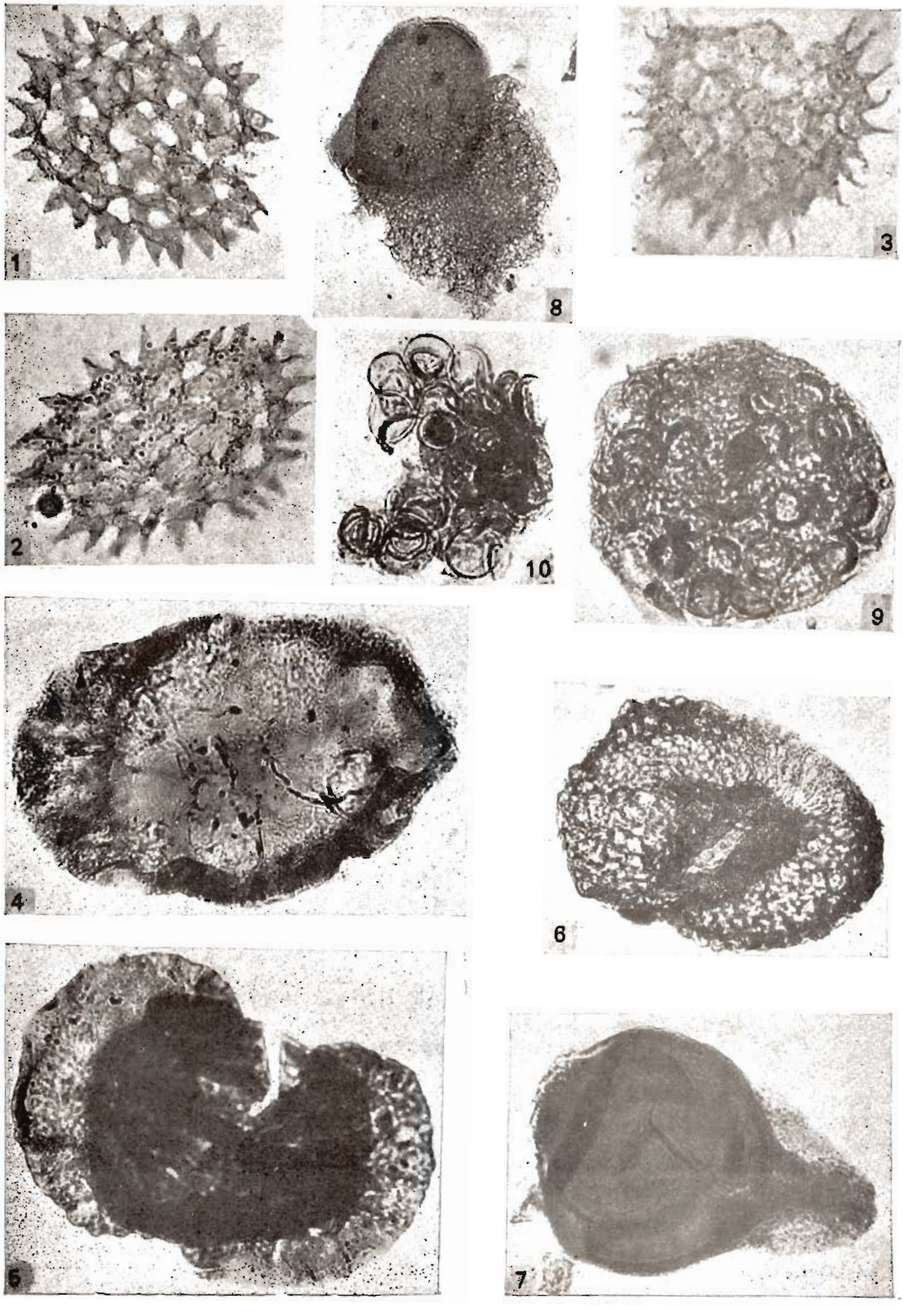

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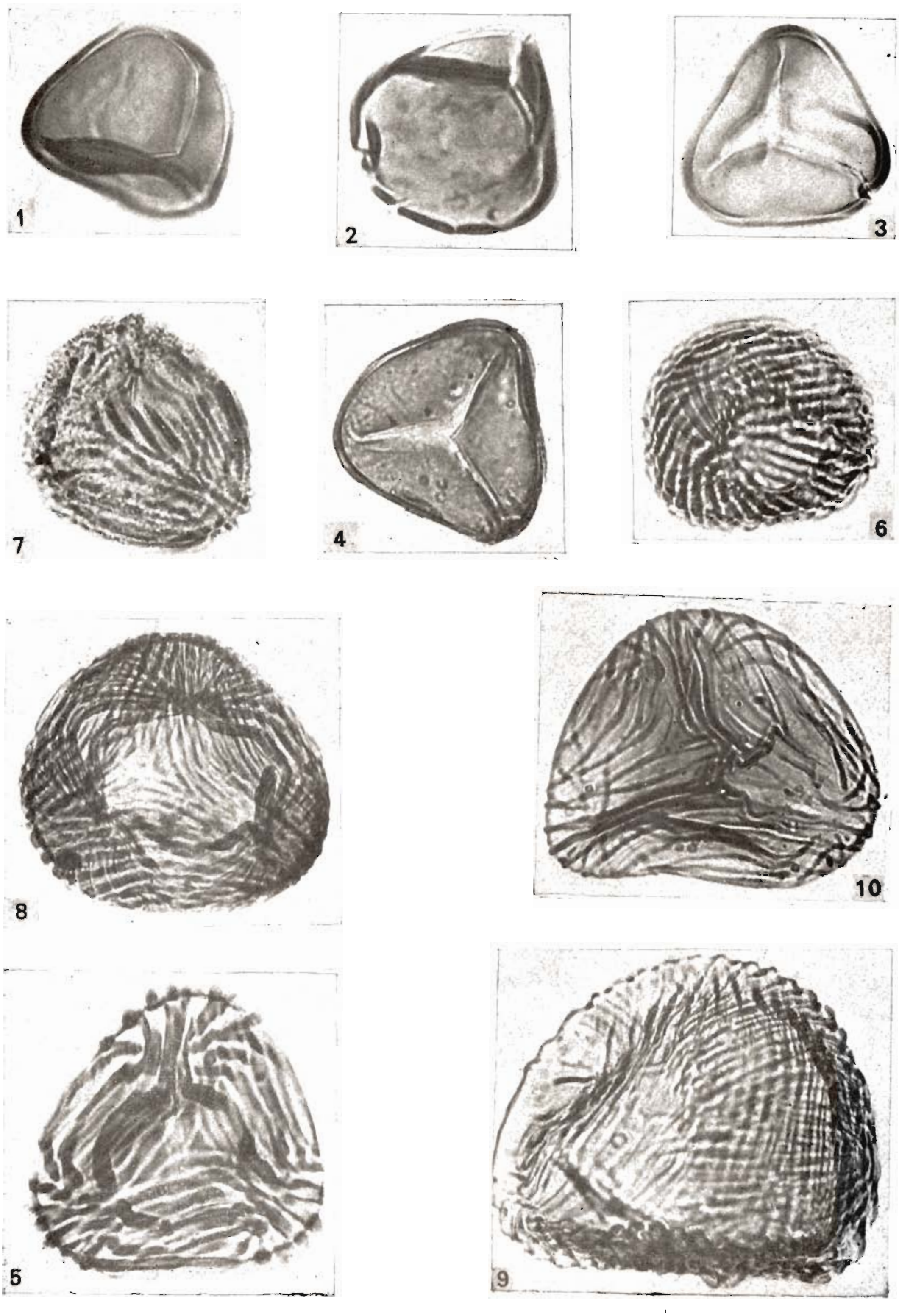

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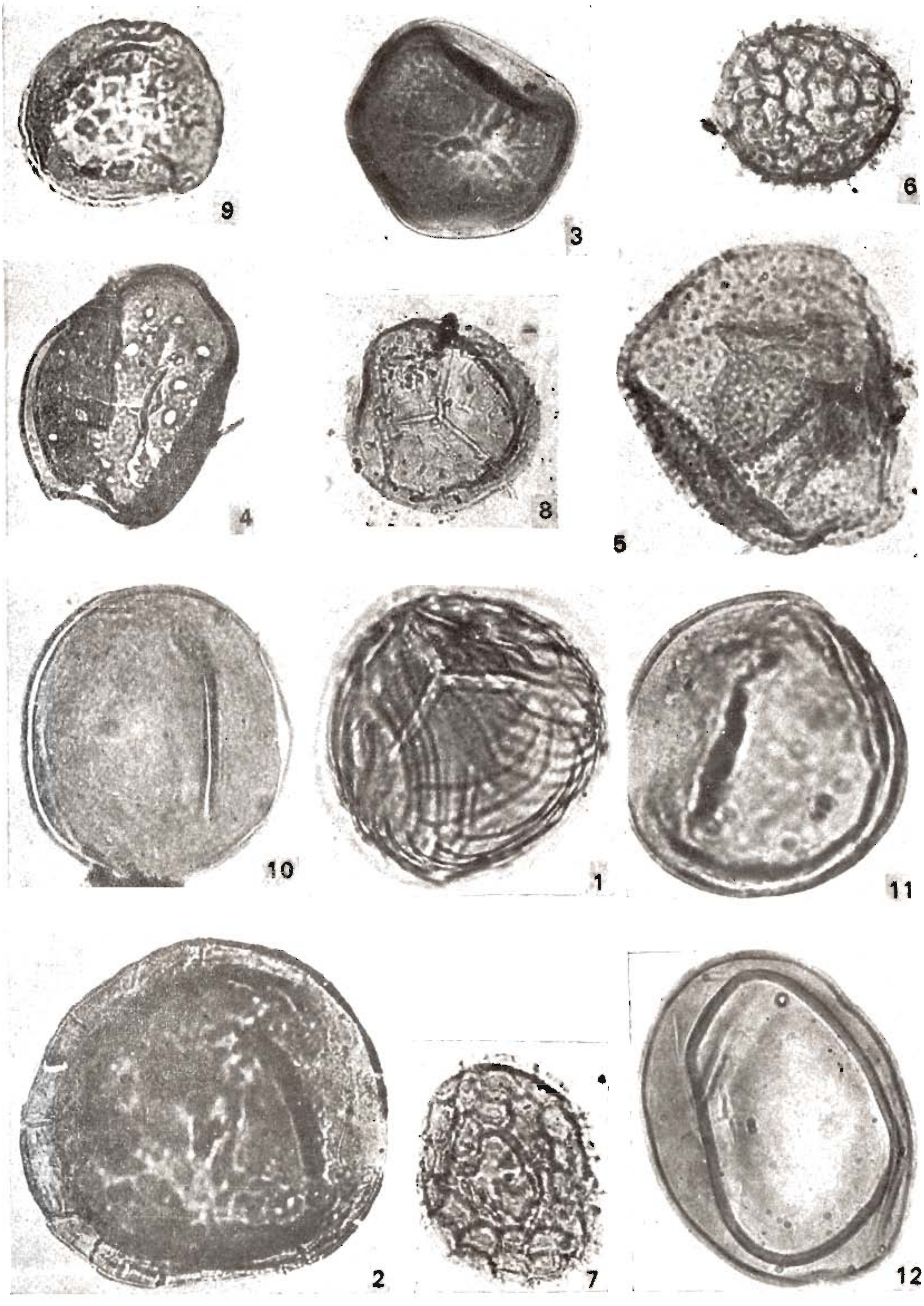

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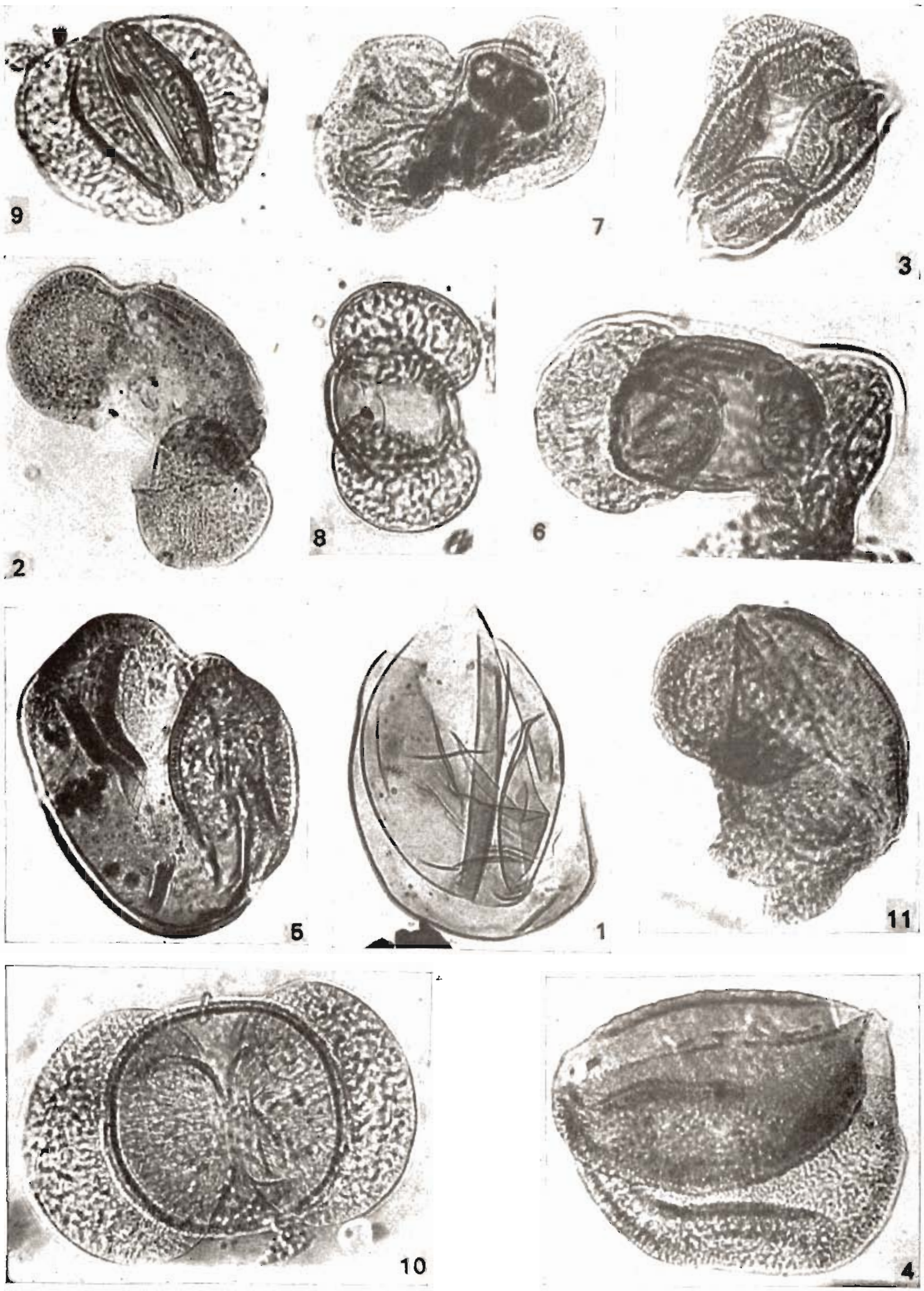

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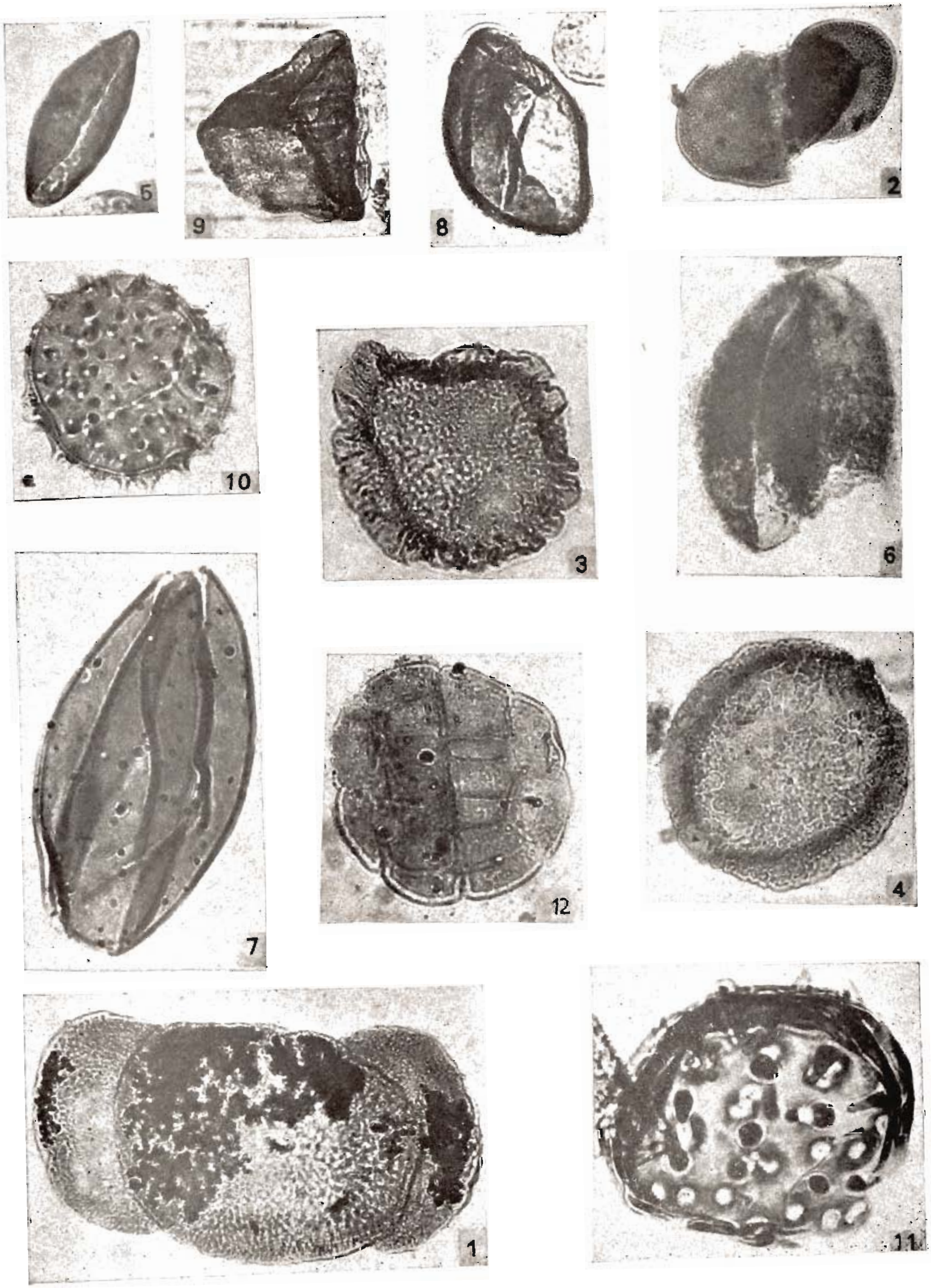

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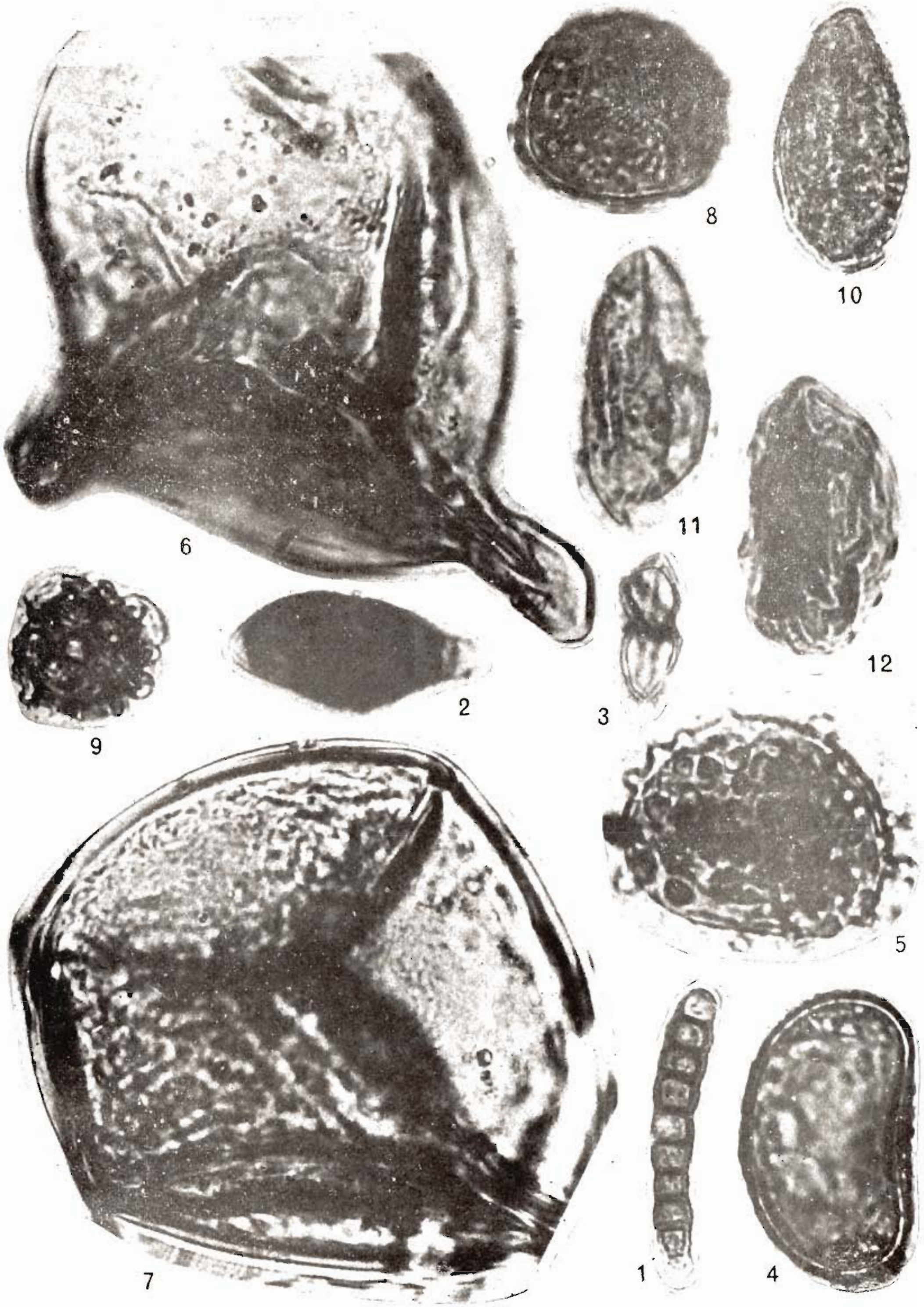

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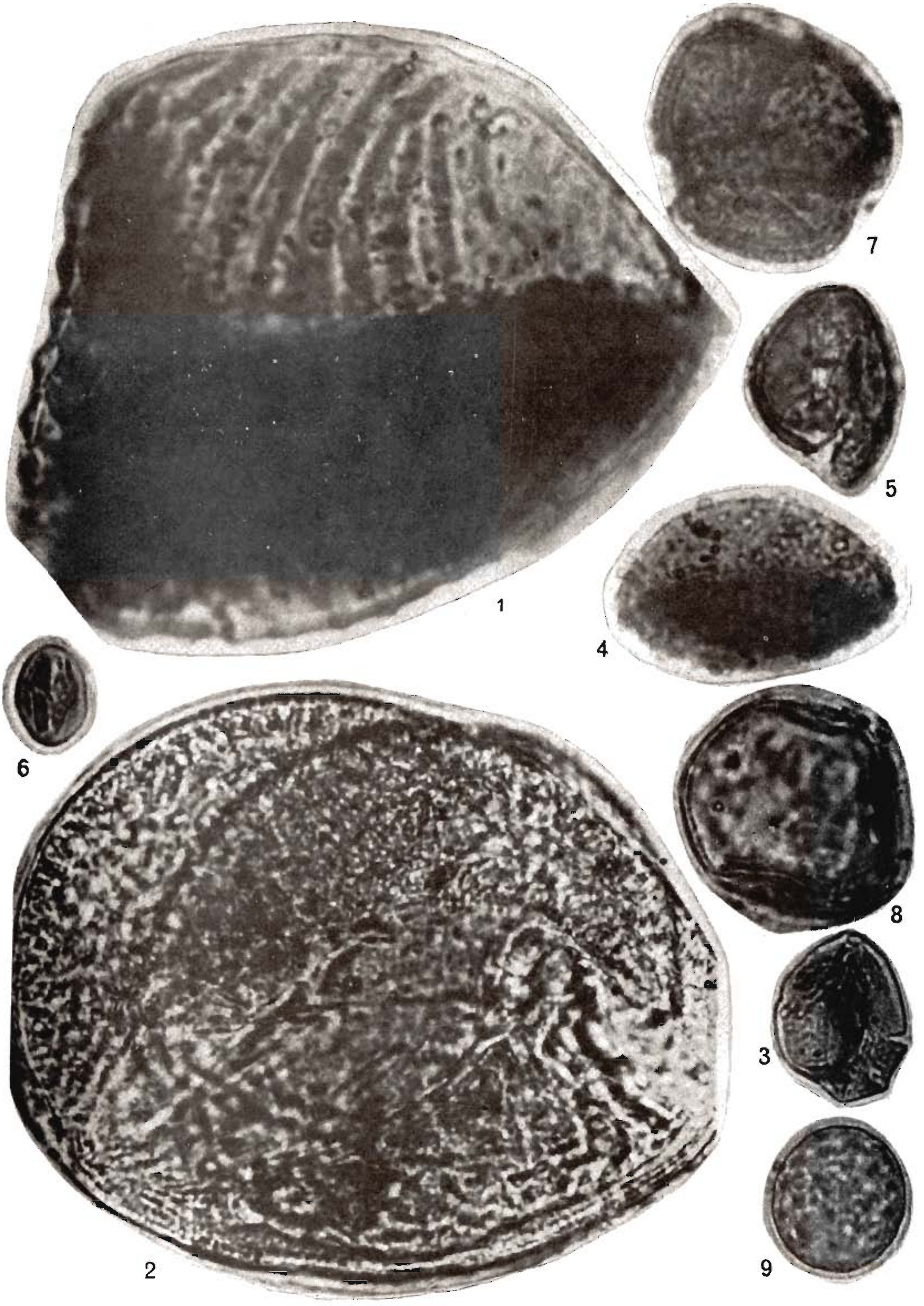

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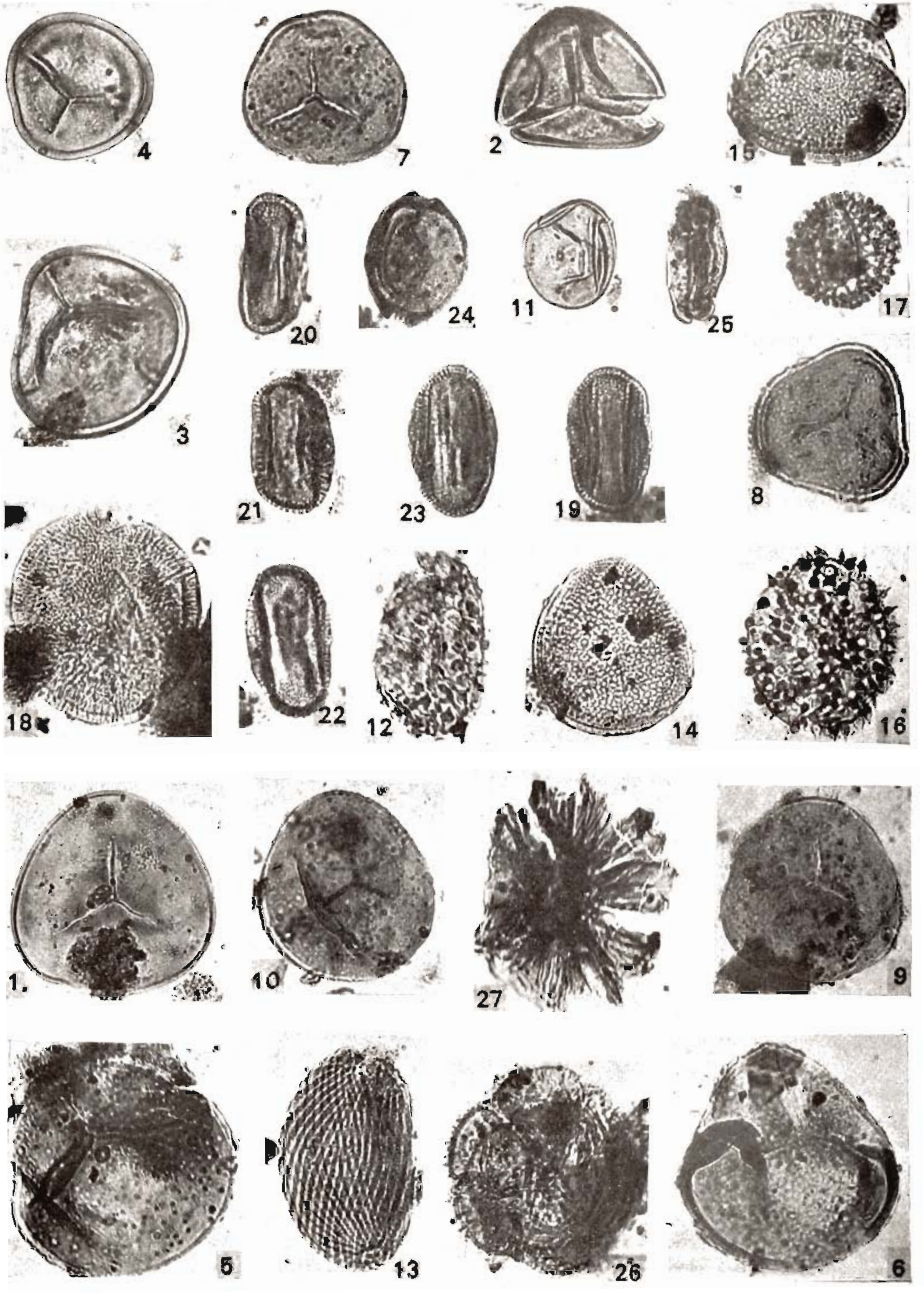

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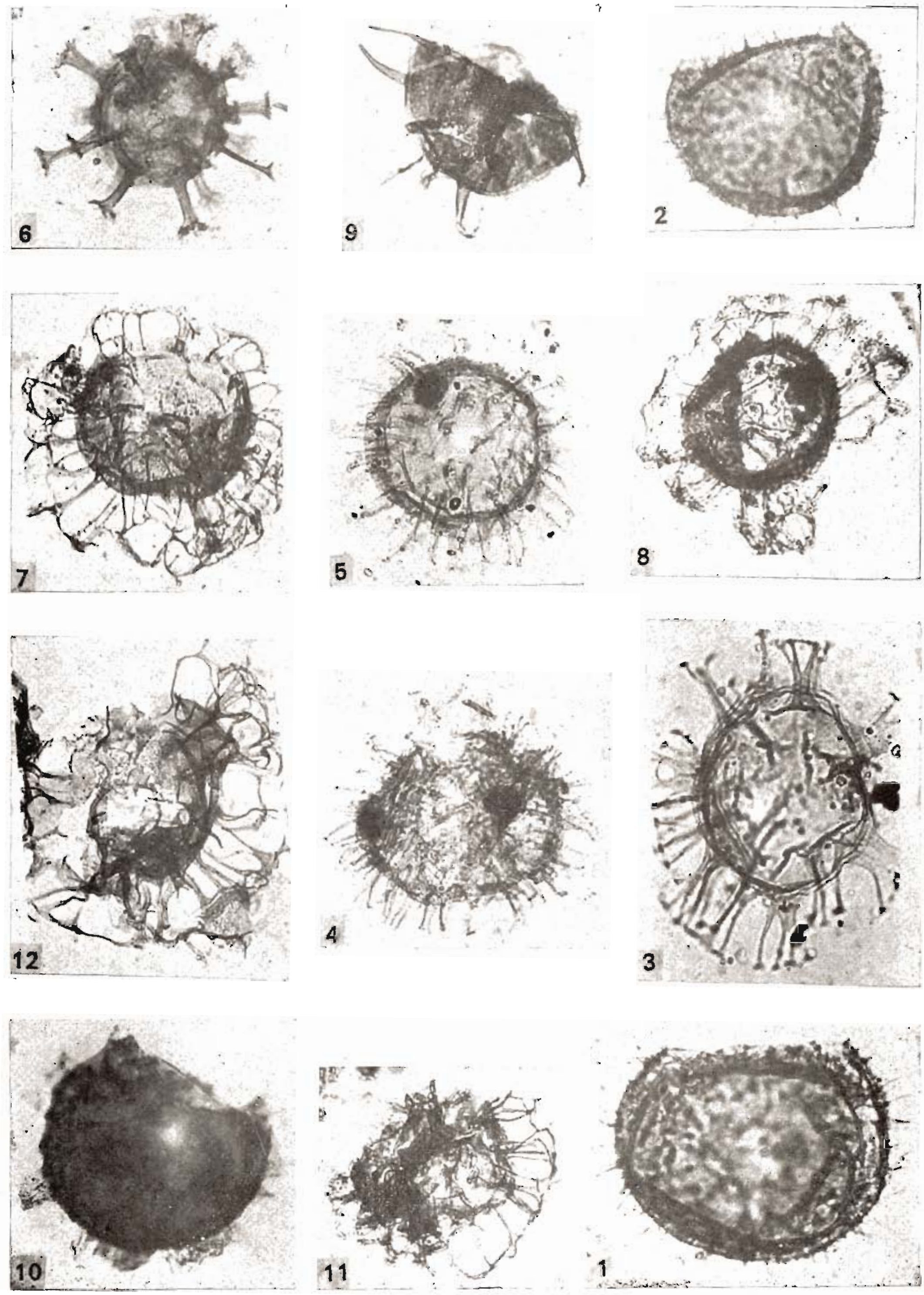

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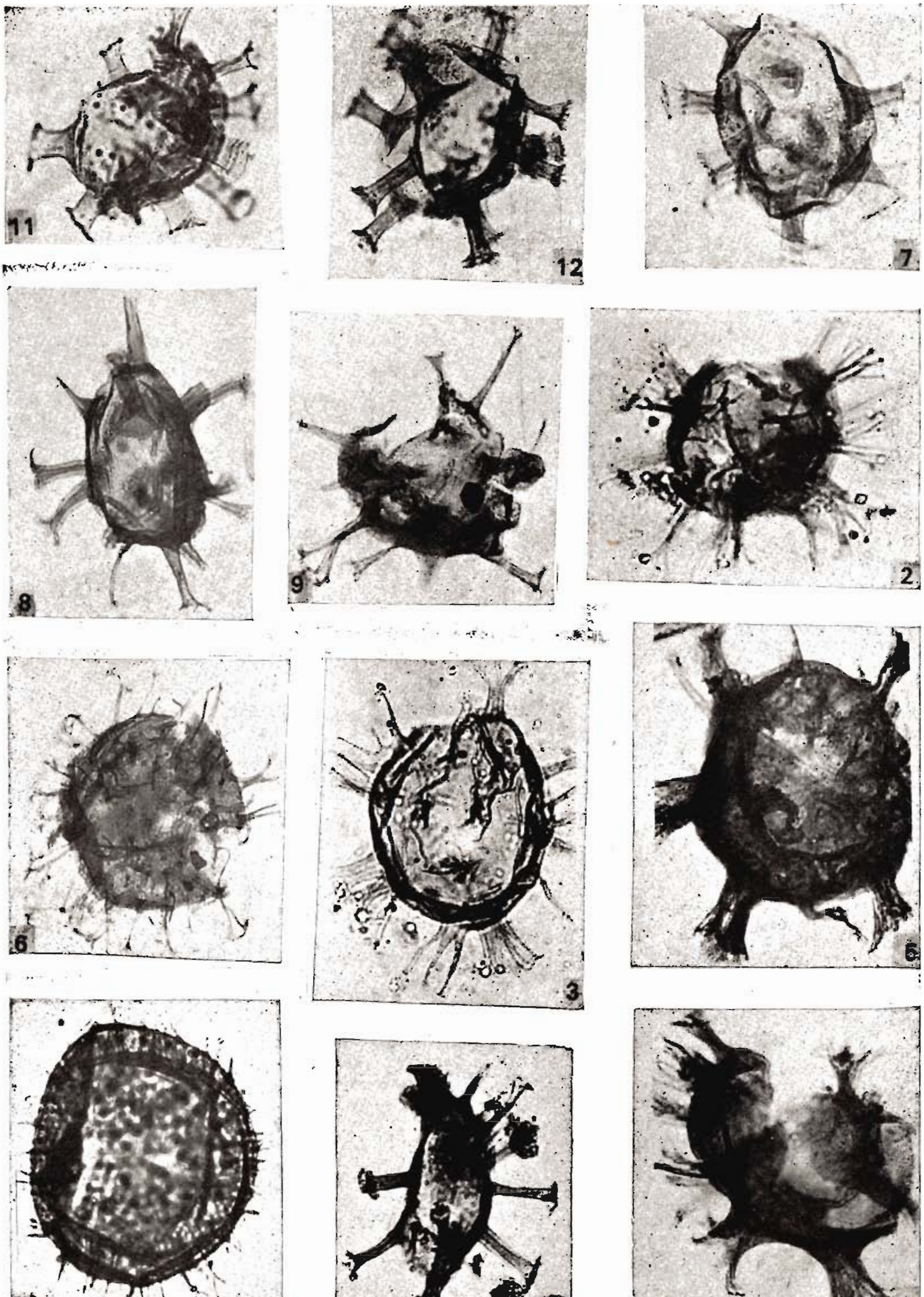

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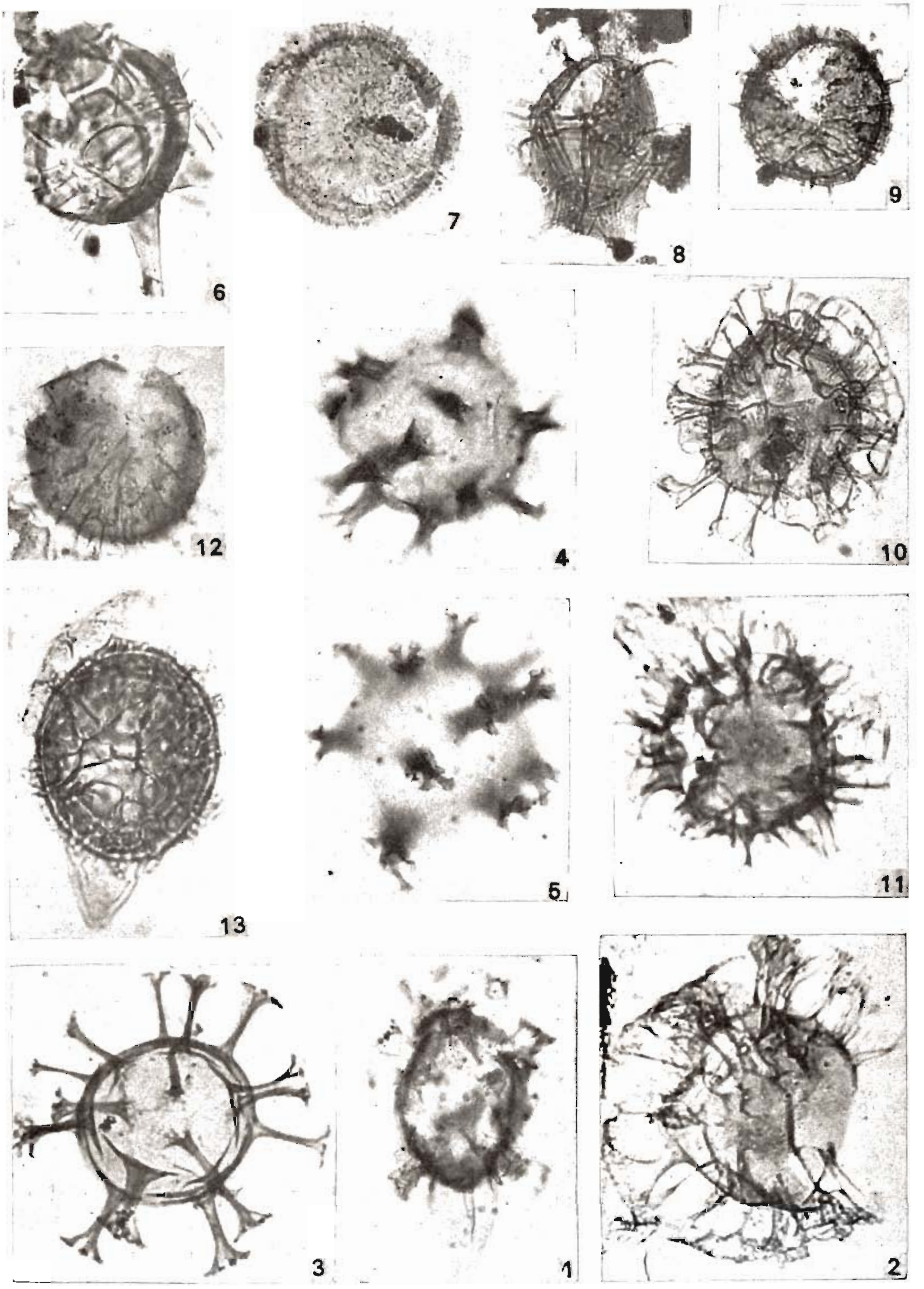

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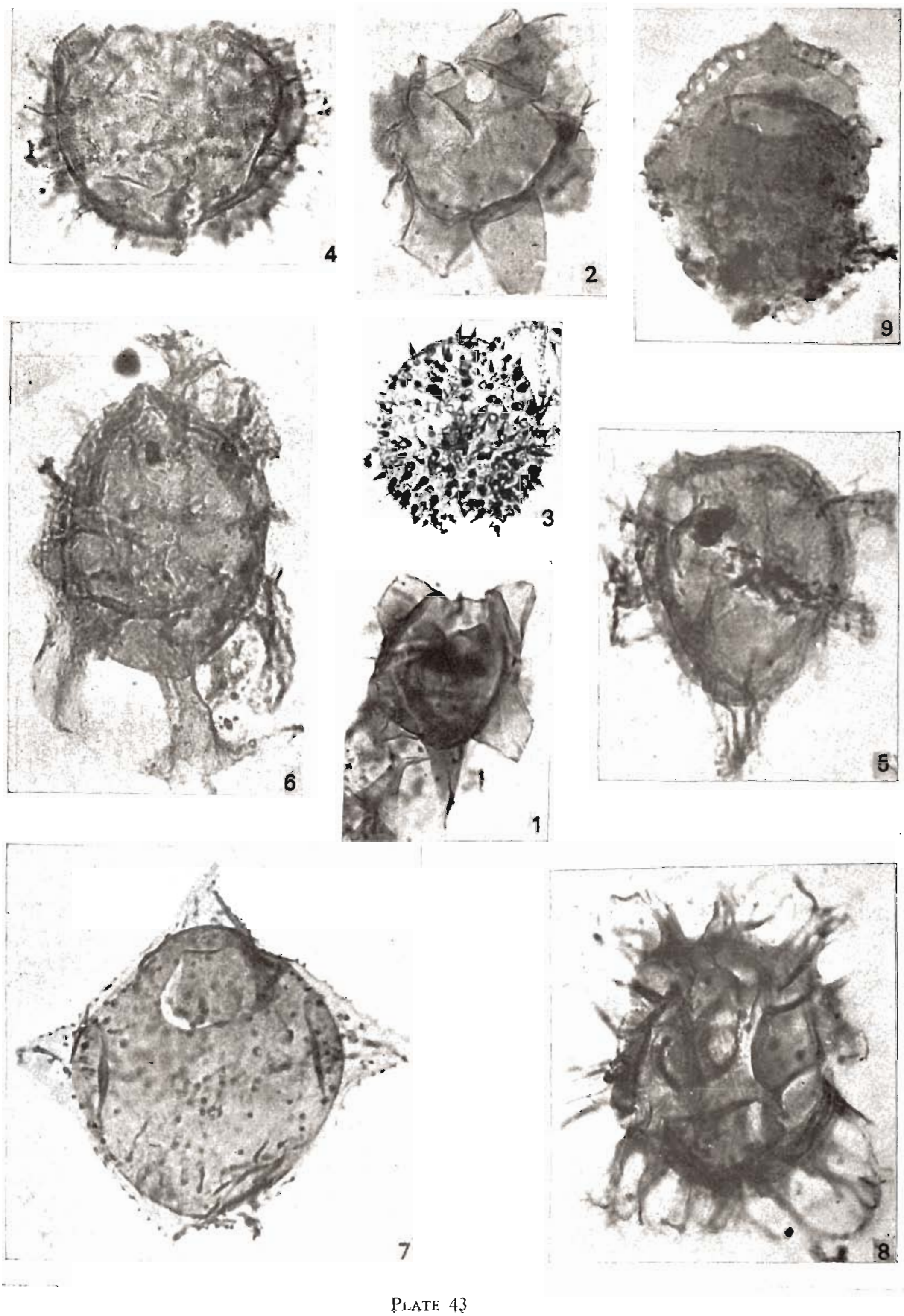

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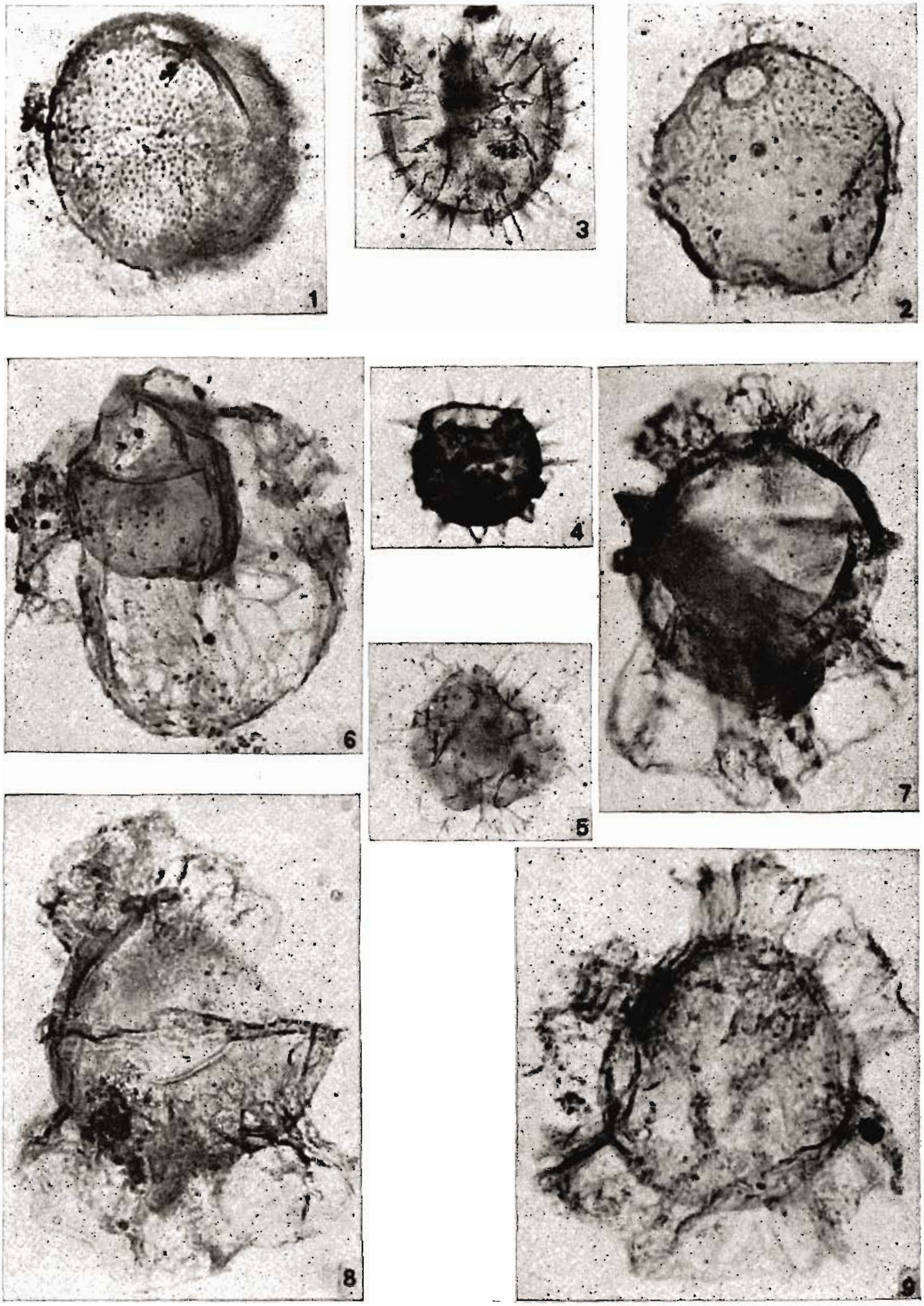

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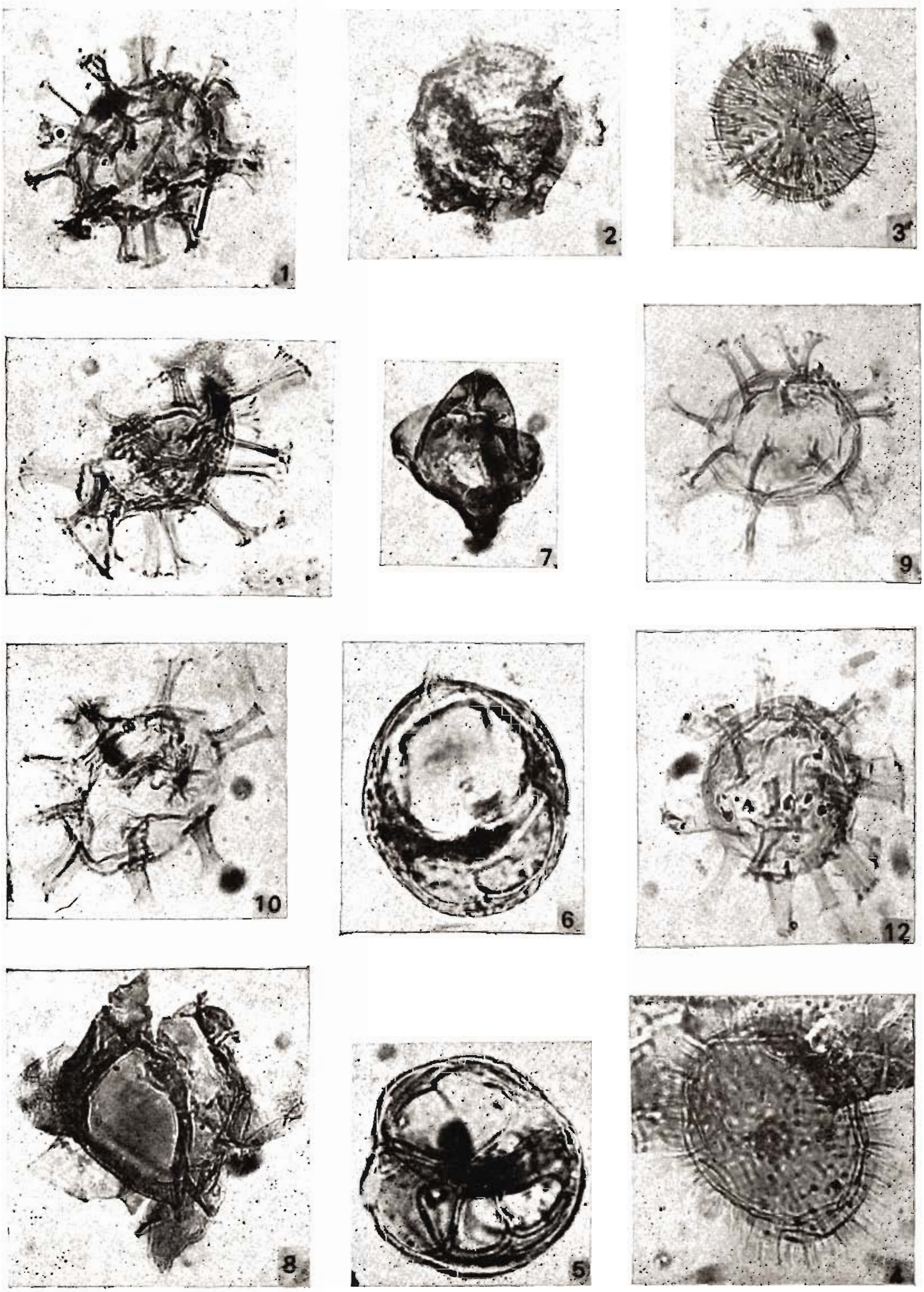

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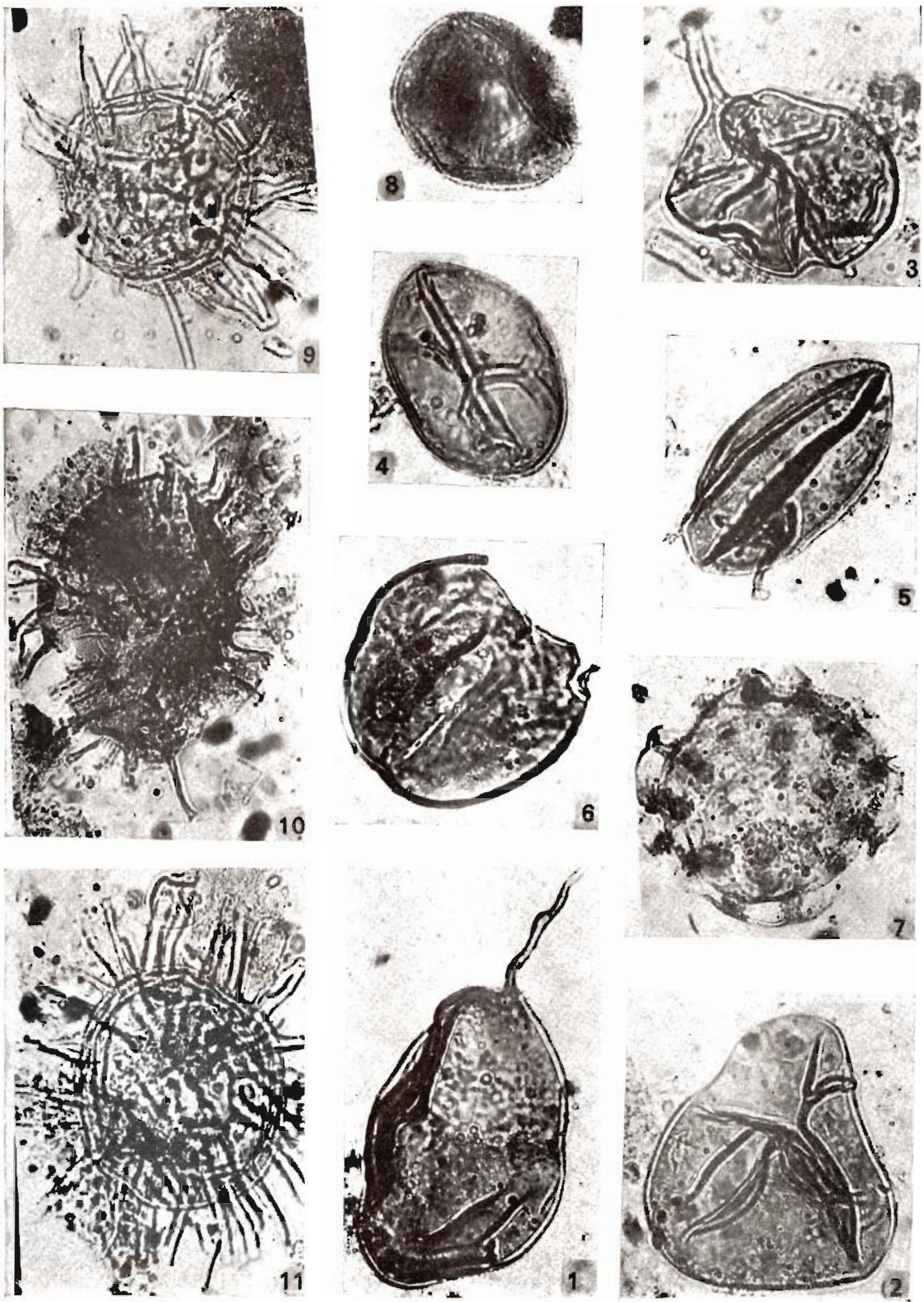

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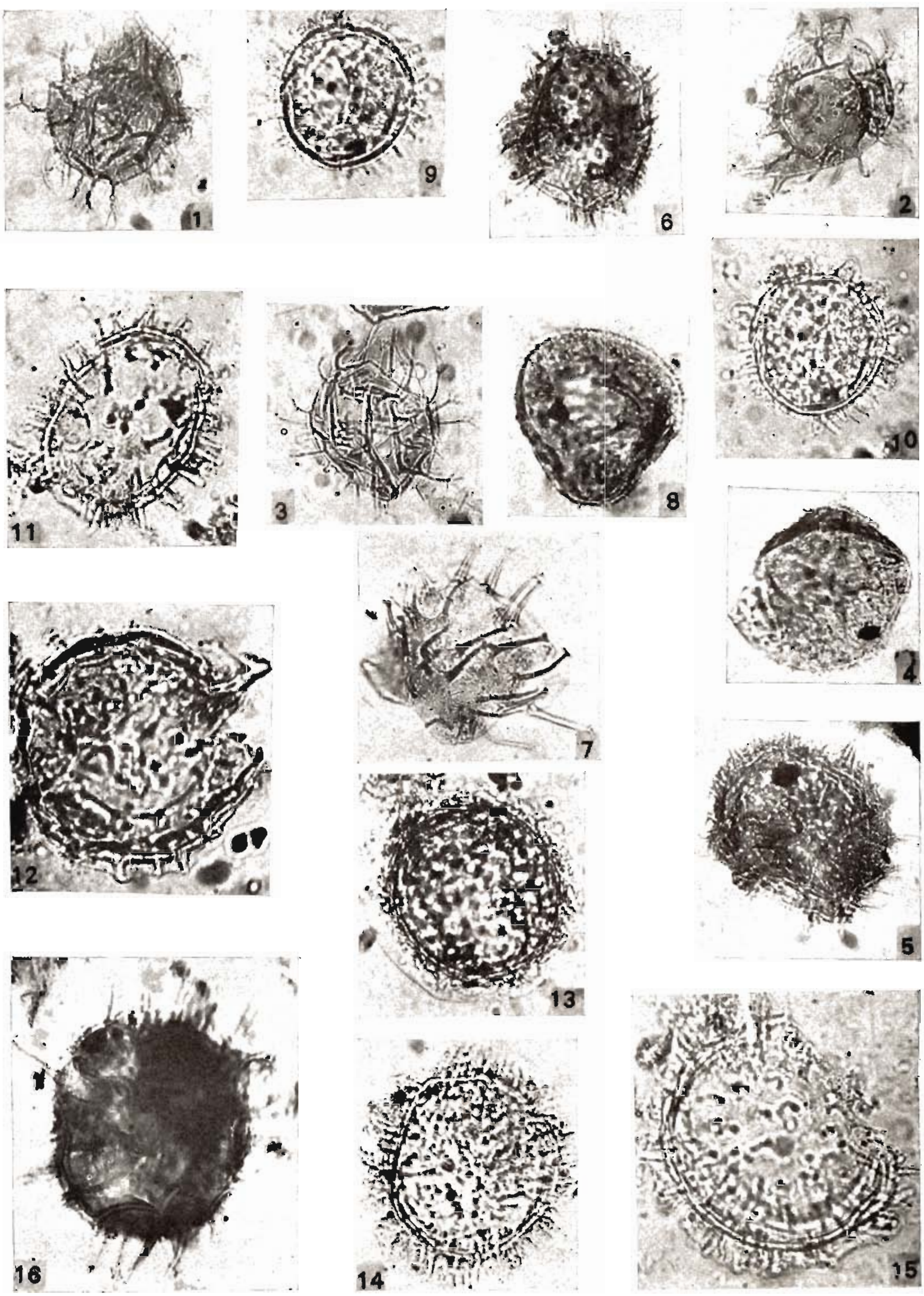

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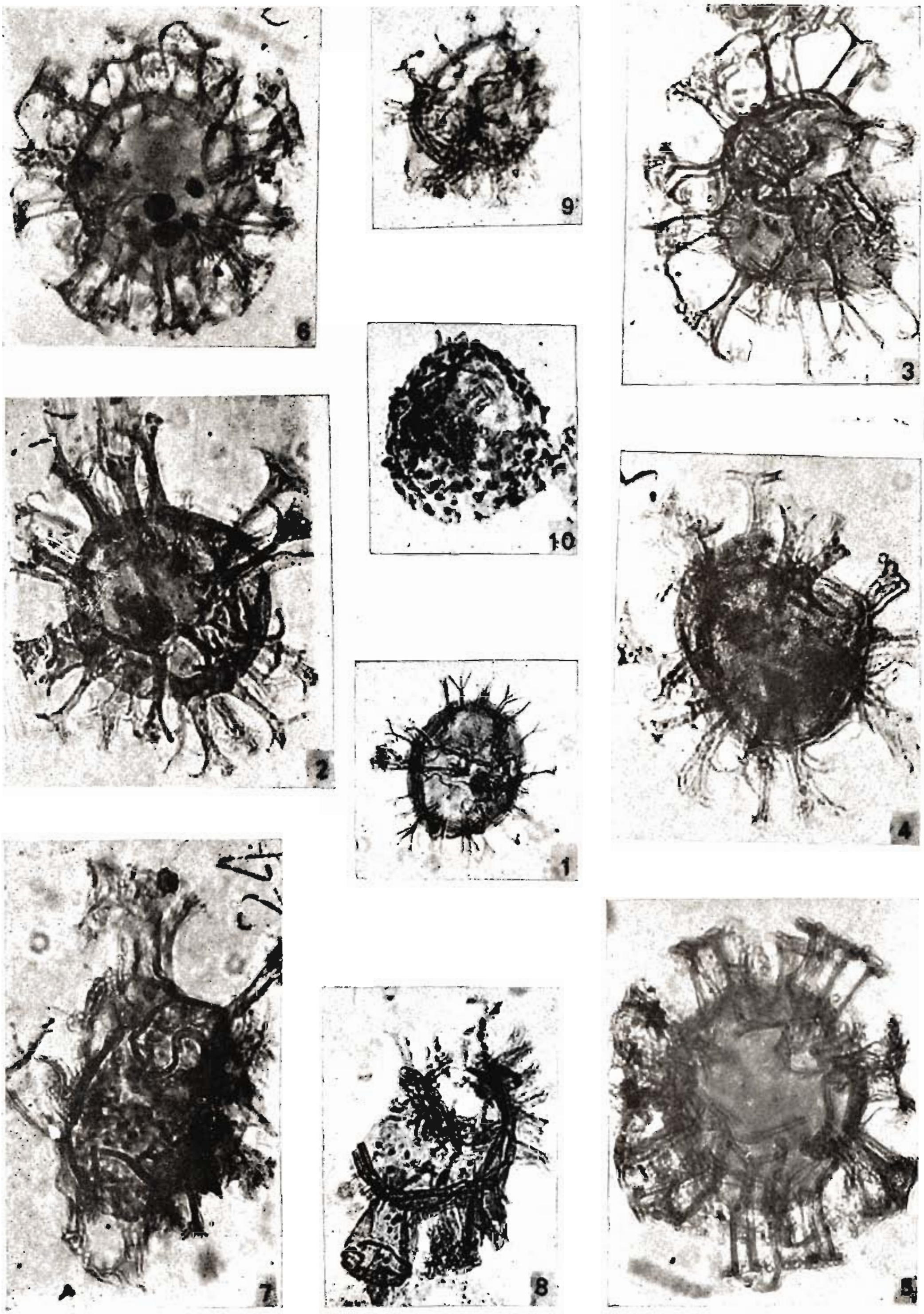

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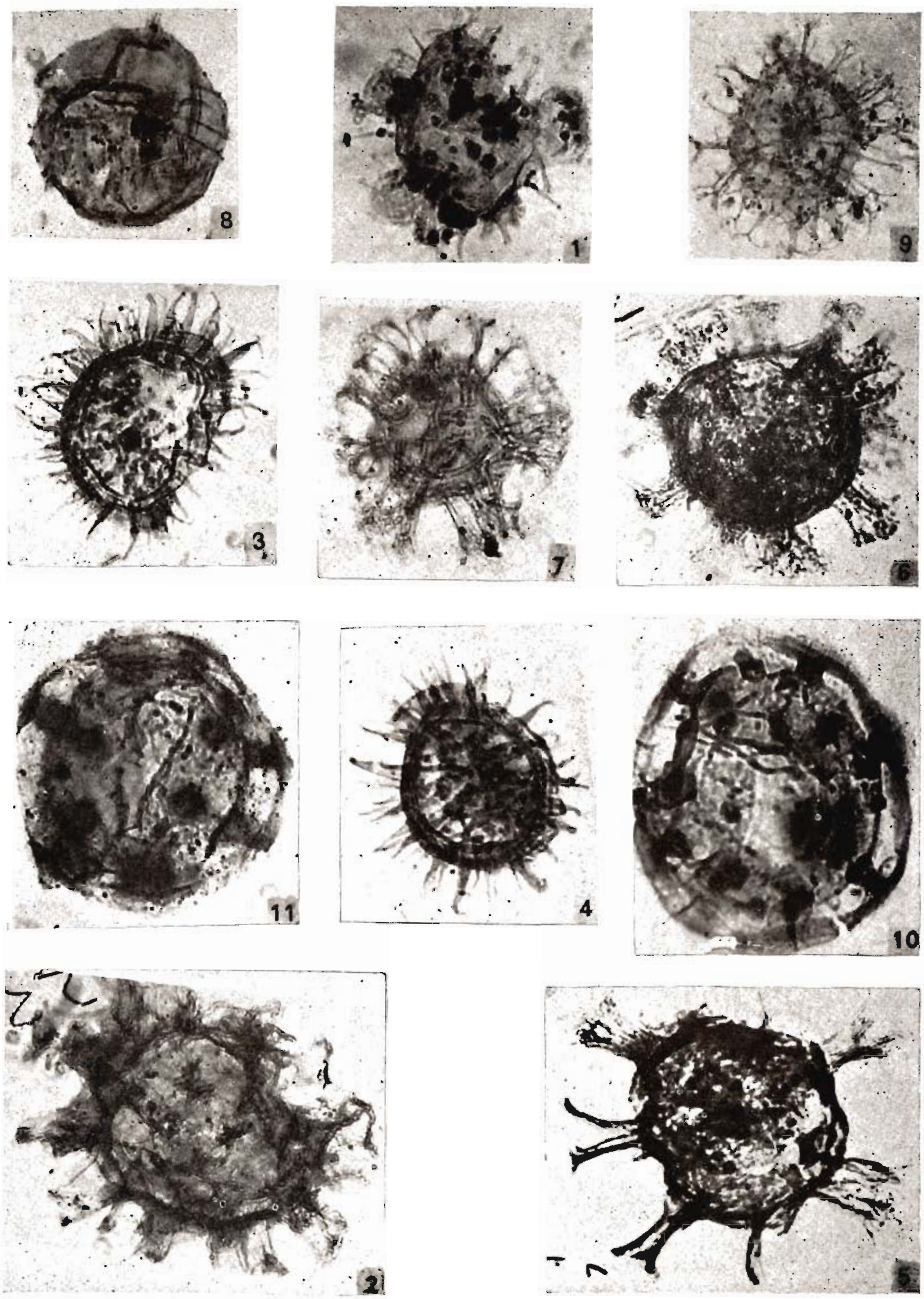

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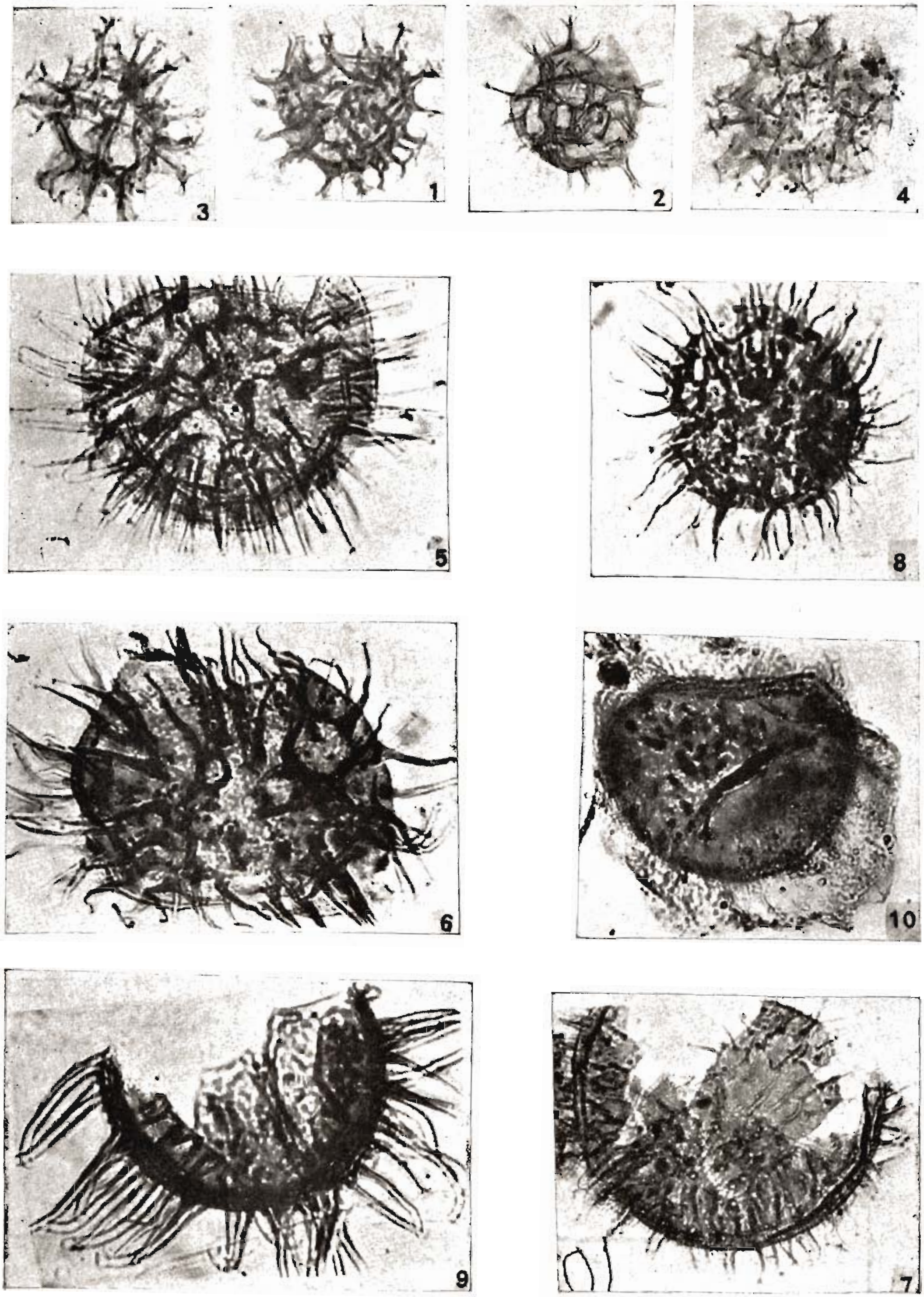

PLATE 50