PALYNOSTRATIGRAPHIC ZONATION OF THE UPPER CRETACEOUS-PALEOGENE SEQUENCE OF BENGAL BASIN

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ABSTRACT

Eight distinct palynological biostratigraphic zones in the subcrop Upper Cretaceous-Paleogene sequence of Bengal Basin have been recognised, all of which are assemblage zones. The main emphasis for the palynological breakdown has been laid on the data available from the deep test wells Jalangi-1, Bolpur-1 and Memari-1, which happen to occupy different basinal positions.

INTRODUCTION

The preliminary account on the palynological biostratigraphy of the subsurface Upper Cretaceous-Tertiary sedimentary sequence of Bengal Basin is published by BAKSI (1972). In continuation of the previous work, detailed palynological analysis has been attempted which has resulted in the refinement of the palynostratigraphy of the sequence referred. As a result, some of the palynological zones of BAKSI (1972) have been redefined and renamed and others have been further subdivided into two or more distinct zones (Fig. 1). These zones have been compared and correlated with the other known equivalent zones of India and pan-tropical areas.

Of the innumerable spores, pollen and other associated microfossils, only a few significant key taxa have been recognised to be useful in the working out of the palynological zones. The detailed taxonomy of the palynological elements here under discussion is being published elsewhere. A check list of the taxa used for the zonations is accompanied.

Of the several deep test wells drilled by the Indo-Stanvac Petroleum Project and one by the Oil and Natural Gas Commission, seven are located in the shelf part of the Bengal depositional basin. It is in these wells that the Upper Cretaceous-Paleogene interval of sediments could be penetrated (Fig. 1). The others being located in the deeper basin areas (SENGUPTA, 1966), this interval of sediments was beyond the reach of the drilling rig that dug these wells. Thus, the palynological biostratigraphic zones obviously refer to these wells, viz. Burdwan-1, Galsi-1, Jalangi-1 ; Bolpur-1, Ghatal-1, Debagram-1 and Memari-1. Of these seven wells, emphasis with respect to the palynological breakdown has been laid on Jalangi-1, Memari-1 and Bolpur-1 which happen to occupy different basinal positions (Fig. 2).

The sediments of the studied Upper Cretaceous-Paleogene sequence contain, as usual, diverse lithology and obviously the entire sequence is not promising for its palynological contents. The shale "break" and argillaceous partings in an otherwise arenaceous and limestone sequence respectively are only useful for this purpose, which mark as low as 20% of such kind of "unproductive" sequence. For example, the sediments of the Eocene *Paleocaesalpiniaceaepites eocenicus* Zone are mainly composed of foraminiferal and algal limestone, which is devoid of any spores or pollen grains. But the occasional pre-

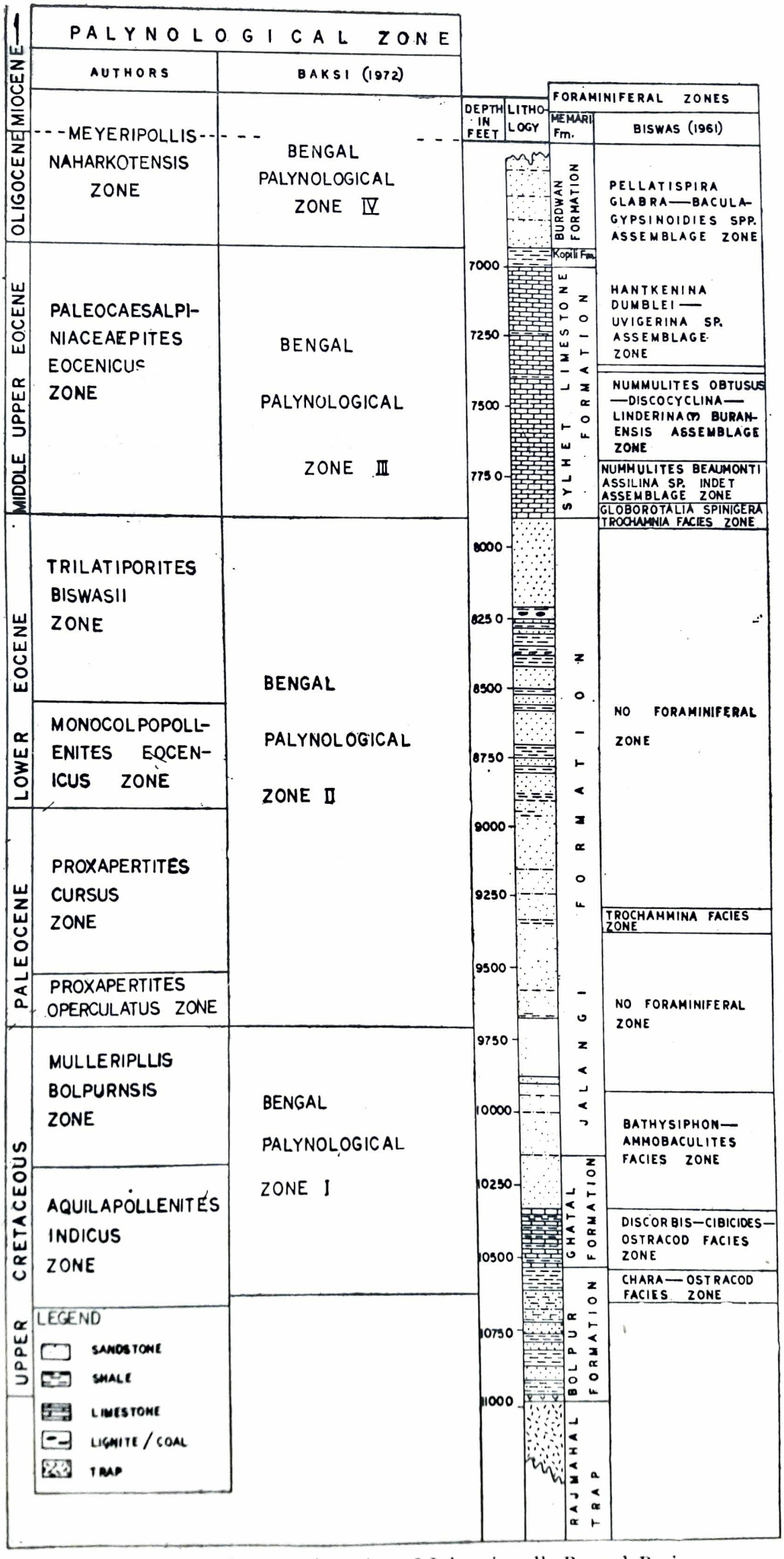

Fig. 1. Standard palynostratigraphy of Jalangi well, Bengal Basin.

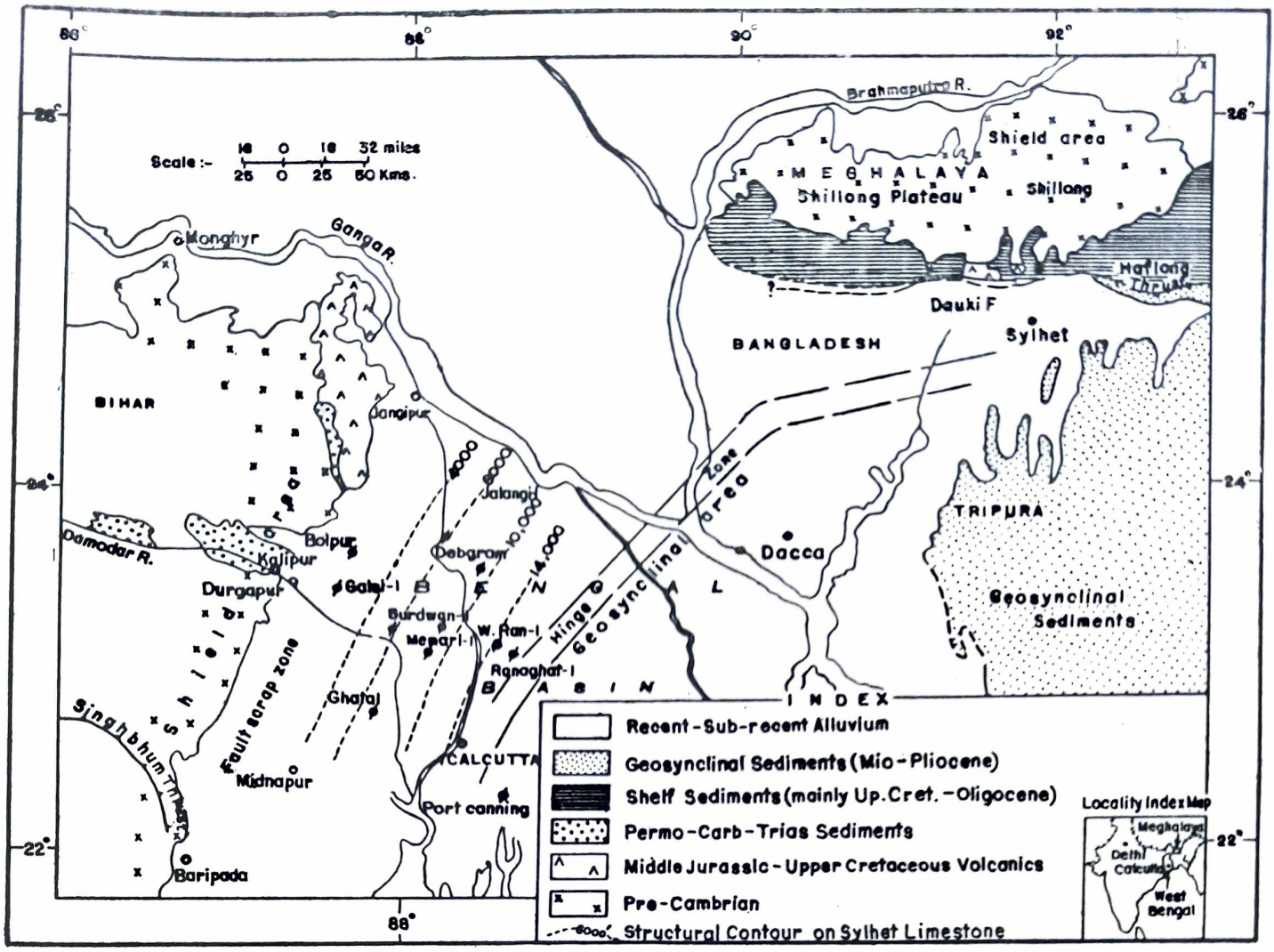

Fig. 2. Map showing the locations of the deep test wells in West Bengal. (After Sengupta, 1966 ; Baksi, 1972).

sence of thin dark marl and shale beds have been utilised for palynology, which have been proved palynologically to be very rich.

Even with the same kind of finer clastics, it is an experience that the microfloral percentage varies widely, which is probably inherent with the shedding and intrapment of pollen during that time. It is in this context that the boundaries of the palynological biostratigraphic zones have to be treated as flexible ones within certain limits governed by factors such as nonavailability of favourable lithology or nonavailability of samples or rarity of palynofossils in spite of the presence of finer clastics.

The detailed qualitative and quantitative palynological analysis of the Upper Cretaceous-Paleogene sedimentary sequence has led to the recognition of eight palynological zones in the Bengal Basin (Fig. 1). These biostratigraphic zones have been recognised in the sense of the American Commission on Stratigraphic Nomenclature (1961). All of these are given the status of assemblage zones and are represented by a rich micro-floral composition (Fig. 3).

The categories for the frequency of occurrence have been grouped as following : 0-1%—Rare, 1-5%—Frequent, 5-10%—Common, > 10%—Abundant.

Check list of significant pollen taxa used for palynostratigraphic zonations of Cretaceous-Paleogene sequences of Bengal Basin :

Aquilapollenites indicus Baksi & Deb 1976

A. bengalensis Baksi & Deb 1976
Arecipites (*Palmaepollenites*) *communis* (Sah & Dutta 1966) Baksi & Deb (MS B)
Araliaceoipollenites ramanujamii Deb 1972
Araucariacites australis (Cookson) Couper 1953
Azolla cretacea Stanley 1965
Bauhiniapollenites burdwanensis (Biswas 1962) Baksi 1971
Camarozonosporites eocenicus Baksi & Deb (MS B)
Couperipollis (*Monosulcites*) *rarispinosus* (Sah & Dutta 1966) Venkatachala & Kar 1969
Crotonipollis burdwanensis Baksi, Deb & Siddhanta 1979
Cyathidites australis Couper 1953
Cyacadopites sp.
Dandotiaspora dilata Sah, Kar & Singh 1975
Distaverrusporites simplex Muller 1968
Ephedripites multicostatus Brenner 1963
Erdtmanipites reticulatus Baksi & Deb (MS B)
Foldexina inaperturata Baksi 1962
Foveomonoletes cooksonii Ramanujam 1966
Hesperipollis pulcher Baksi & Deb (MS B)
Jalangia tuberosa Baksi & Deb (MS A)
Laevigatosporites gracilis Wilson & Webster 1946
Leiotriletes sinuosoides Krutzsch 1959b
Leptolepidites sp.
Longapertites vaneedenburgi Germeraad, Hopping & Muller 1968
Longapertites bolpurensis Baksi & Deb (MS B)
Lycopodiumsporites palaeocenicus Dutta & Sah 1970
Magnastriatites sp.
Marginipollis kutchensis (Venkatachala & Kar 1969) Rao & Ramanujam 1975
M. obscurus Baksi & Deb (MS B)
M. cribraria Baksi & Deb (MS B)
Margocolporites sahnii Ramanujam 1966
Meyeripollis naharkotensis Baksi & Venkatachala 1970
Monocolpopollenites bengalensis Baksi & Deb (MS A)
M. parvus Baksi & Deb (MS A)
M. (*Palmaepollenites*) *eocenicus* (Sah & Dutta 1966) Baksi & Deb (MS B)
Mulleripollis bopurensis Baksi & Deb 1976
Myricipites (*Triorites*) *harrissi* (Couper 1953) Dutta & Sah 1970
M. vulgaris Dutta & Sah 1970
Nyssapollenites incertus Dutta & Sah 1970
Paleocaesalpiniaceaepites eocenicus Biswas 1962
Paleosantalaceaepites primitiva Biswas 1962
Podocarpidites sp.
Polycolpites cooksonii Sah & Dutta 1966
P. multitrimatus Dutta & Sah 1970
Polygonaceaepites zonoides Baksi 1962
Plypodiidites delicatissmus Ramanujam 1966
Polypodiisporites mawkmaensis Dutta & Sah 1970
P. speciosus Sah & Dutta 1968
Proteacidites excertus Dutta & Sah 1970

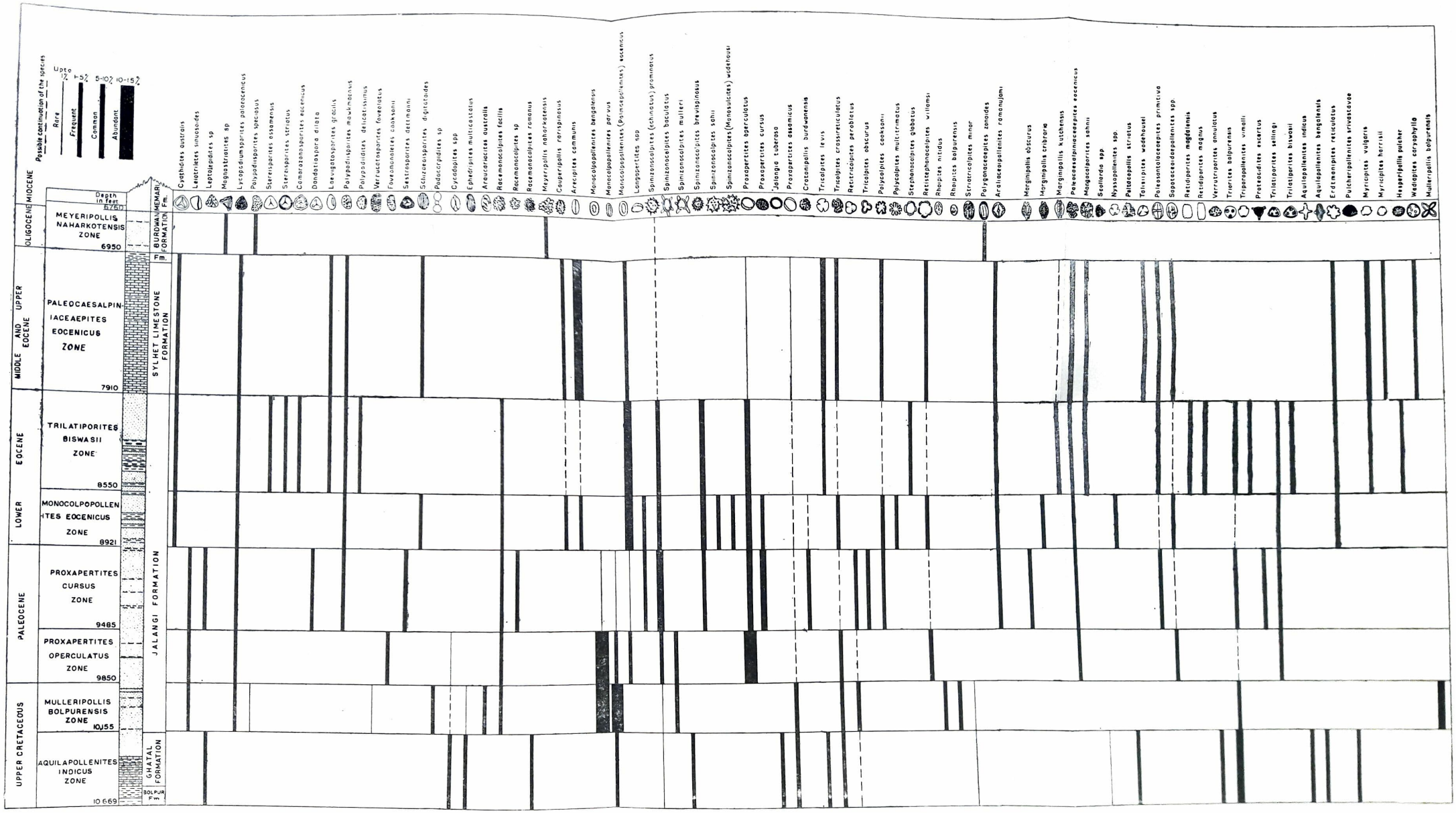

Fig. 3. Distribution of palynomorphs in the Bengal Palynostratigraphic Zones.

Proxapertites operculatus Van der Hammen 1956
P. cursus Van Hoeken-Klinkenberg 1966
P. assamica (Biswas 1962) Baksi, Deb & Muller
Psittacolpollis striatus Baksi & Deb (MS A)
Pulcheripollenites srivastavae Baksi & Deb (MS A)
Racemonocolpites romanus Gonzalez 1967
R. facilis Gonzalez 1967
R. sp.
Retistephanocolpites williamsii Germeraad, Hopping & Muller 1968
Retitricolpites peroblatus Muller 1968
Retitricolporites alangiensis Baksi & Deb (MS B)
Retidiporites magdalensis Van der Hammen & Garcia 1966
R. magnus Baksi & Deb (MS B)
Rhoipites psilatus Sah 1967
R. nitidus Sah & Dutta 1968
R. bolpurensis Baksi & Deb (MS A)
R. basilicus Baksi & Deb, (MS A)
R. ghatalensis Baksi & Deb (MS A)
Sapotaceoidaepollenites baksii Deb 1972.
Sestrosporites dettmanni Dutta &Sah 1970
Schizaeoisporites digitatoides (Cookson) Potonie' 1951
Scollardia sp. 1
Scollardia sp. 2
Simsangia trispinosa Baksi 1952
Spinizonocolpites baculatus Muller 1968
S. prominatus (Mc Intyre) Stover & Evans 1973
(=*S. echinatus* Muller 1968)
S. brevispinosus (Biswas 1962) Baksi & Deb (MS C)
S. sahii Baksi & Deb (MS C)
S. mulleri Baksi & Deb (MS A)
S. wodehousei (Sah & Dutta 1966) Baksi & Deb (MS C)
Stephanocolpites globatus Venkatachala &Kar 1969
Stereisporites assamensis Sah & Dutta 1967
S. striatus Baksi & Deb B
Striatricolporites minor Muller 1968
Tricolpites crassireticulatus Dutta & Sah 1970
Tricolpites levis Sah & Dutta 1966
T. spinosus (Baksi 1962) Baksi 1971
T. obscurus Baksi & Deb B
Tricolporopollenites anguloluminosus (Anderson 1960) Elsik 1968
Triorites bolpurensis Baksi & Deb (MS A)
Trilatiporites sellingi Ramanujam 1966
T. biswasii Baksi & Deb B
Triporopollenites vimalii Sah & Dutta 1966
Talisiipites wodehousei Dutta & Sah 1970
Verrutriporites annulatus Baksi & Deb (MS A)
Verrucatosporites foveolatus Baksi & Deb (MS A)
Wadiapites caryophylla Biswas 1962

Aquilapollenites indicus Zone

The basal palynological zone in the Upper Cretaceous-Paleogene sequence of Bengal is designated as *Aquilapollenites* Zone. This zone is of Upper Cretaceous age which has been established on Chara-Ostracod assemblage and *Discorbis Cibicides*-Ostracod assemblage of Biswas (1961) (Fig. 1). The zone is named after the well known Upper Cretaceous genus *Aquilapollenites* Rouse 1957, and particularly the species *A. indicus* Baksi & Deb 1976, which for all practical purposes, characterises this zone. The genus is restricted to this zone only. This zone is represented only in the Jalangi well and covers the top part of Bolpur Formation, and lower and middle part of Ghatal Formation (Fig. 3). The sediments of this zone overlie the Rajmahal trap and unfossiliferous trap-wash sediments and other clastics. Lithologically, the sediments of this zone are composed of unfossiliferous dull red shale and sandstone at the bottom, overlain by sand-shale alternations, shell limestone with thin streaks of dark shale and coaly shale and calcareous sandstone. Shales and thin streaks of dark shale and coaly shales constitute the lithology of the spore-pollen bearing samples.

Aquilapollenites indicus zone is palynologically composed of a very rich assemblage. The assemblage is dominated by angiosperm elements. Gymnosperm pollen and pteridophytic spores comprise relatively a minor part.

The palynological elements that characterise the assemblage of *Aquilapollenites* zone are the following (Fig. 3 ; Pl. 1) :

1. Dominant and restricted occurrence of *Spinizonocolpites mulleri* (more than 5%) and *Jalangia tuberosa* (more than 10%).
2. Very characteristic and restricted occurrence of two species of the Upper Cretaceous genus *Aquilapollenites*, viz. *A. indicus* and *A. bengalensis*.
3. Restricted and frequent (1-5%) occurrence of *Pulcheripollenites srivastavae* and *Verrutriporites annulatus*.
4. Restricted and rare occurrence (up to 1%)of *Ephedripites multicostatus*, *Racemonocolpites romanus*, *Syncolpites* sp., *Scollardia* sp. 1 and *Scollardia* sp. 2.
5. Dominant occurrence of *Proxapertites assamicus* (more than 10%) and *Triorites bolpurensis* (more than 10%) which continue to younger zones.
6. Abundant occurrence of glochidia and massulae of *Azolla cretacea*.

In addition to the elements cited above, the following taxa are also recorded : *Leiotriletes* sp., *Leptolepidites* sp., *Inaperturopollenites* sp., *Cycadopites* sp., *Spinizonocolpites prominatus* (= *S. echinatus*), *Retitricolpites peroblatus*, *Tricolpites levis*, *Tricolpites crassireticulatus*, *Striatricolporites minor*, *Retitricolporites jalangiensis*, *Tricolporopollenites* sp., and a number of small tricolporate grains and a few fungal spores.

Mulleripollis bolpurensis Zone

The next palynological zone overlying *Aquilapollenites indicus* zone is designated as *Mulleripollis* Zone. The age of the sediments of this zone is also (Upper Senonian) Upper Cretaceous which has been established on the basis of foraminiferal zone of *Bathysiphon-Ammobaculites* assemblage (Biswas, 1961) (Fig. 1). This zone is named after the peculiar pollen tetrad *Mulleripollis bolpurensis* Baksi & Deb 1976, which is restricted to this zone. This zone is represented in the wells Jalangi-1, Bolpur-1, Burdwan-1 and Debagram-1 and covers the topmost sediments of Ghatal Formation and lower part of Jalangi Formation (Fig. 3) in West Bengal. Lithologically the sediments of this zone are composed of

medium grained sandstone with occasional shale, dark shale, carbonaceous shale and claystone laminae. The shale, dark shale, claystone laminae and finer clastics in glauconitic sandstone constitute the lithology of the spore-pollen bearing samples.

The palynoflora of *Mulleripollis bolpurensis* Zone is composed of very rich assemblage, dominated by angiosperm elements, particularly by two monosulcate species, viz. *Monocolpopollenites bengalensis* and *Monocolpopollenites parvus*. Pteridophytic spores and gymnosperm pollen constitute relatively lower percentage.

The composition of this palynological zone that characterises the assemblage of *Mulleripollis bolpurensis* Zone is given by the following (Fig. 3 ; Pl. 1) :

(1) Dominant occurrence of *Monocolpopollenites parvus* and *M. bengalensis*.
(2) Restricted and common occurrence of the very characteristic pollen tetrad *Mulleripollis bolpurensis* (more than 5%).
(3) Common occurrence of *Retitricolpites peroblatus* (9%).
(4) Restricted occurrence of a primitive angiosperm type, viz. *Victorisporis minimus*.
(5) Restricted and rare occurrence of a few pteridophytic spores such as *Leiotriletes sinuosoides*, *Distaverrusporites simplex*, and *Verrucatosporites foveolatus*.
(6) Restricted and frequent occurrence of *Inaperturopollenites bolpurensis*.
(7) Rare occurrence of *Podocarpidites* sp.
(8) Frequent occurrence of both *Spinizonocolpites prominatus* (=*S. echinatus*) which continues from *Aquilapollenites indicus* Zone and *S. baculatus* which makes its first appearance.
(9) *Proxapertites simplexus* continues from the underlying zone and occurs in much lesser frequency (1%).

In addition to the elements cited above, the following taxa are also recorded to accompany the assemblage : *Lycopodiumsporites palaeocenicus*, *Foldexina inaperturata*, *Racemonocolpites facilis*, *Ephederipites* sp., *Retitricolpites* sp., *Retibrevitricolpites* sp., *Rhoipites nitidus*, *Rhoipites bolpurensis*, *Rhoipites basilicus*, *Rhoipites ghatalensis*, *Triorites bolpurensis* and a few unidentified assorted angiosperm pollen.

The following taxa continue from the underlying zone—*Spinizonocolpites echinatus* (more or less same frequency), *Proxapertites simplexus* (much lower frequency), *Retitricolpites peroblatus* (much higher frequency), and *Triorites bolpurensis* (much lower frequency).

Proxapertites operculatus Zone

The palynological zone that succeeds the *Mulleripollis bolpurensis* Zone is designated as *Proxapertites operculatus* Zone. This zone is of Paleocene age.

The zone is named after the well known pantropically distributed Paleocene species *Proxapertites operculatus* Van der Hammen 1956, which makes its first appearance in this zone and is represented abundantly (more than 25%). This zone is represented only in the Jalangi well in Bengal and covers the lower part of Jalangi Formation (Fig. 3). Lithologically the sediments of this zone are composed of coarse to medium grained sandstone, with occasional thin laminae of shale, carbonaceous shale and carbonaceous matter. The samples for palynological study are the thin laminae of shale, carbonaceous shale and streaks and lentils of coal.

This zone is moderately rich in palynological elements and is again dominated by angiosperm elements as the underlying zones.

The palynological elements that characterise the assemblage of *Proxapertites operculatus* Zone are the following (Fig. 3 ; Pl. 3) :

(1) First appearance and dominant occurrence (more than 25%) of *Proxapertites operculatus*.
(2) Dominant occurrence (more than 25%) of *Monocolpopollenites bengalensis* which continues from *Mulleripollis bolpurensis* Zone.
(3) First appearance and frequent occurrence (more than 1.0%) of *Monocolpopollenites (Palmaepollenites) eocenicus*.
(4) First appearance and frequent occurrence (1-5%) of *Sapotaceoidaepollenites granulatus*, *Paleocaesalpiniaceaepites eocenicus*, *Trilatiporites sellingi* and *Retistephanocolpites williamsi* which become important Eocene element in the overlying zones.
(5) Rare and restricted occurrence of *Cycadopites* sp., *Liliacidites* sp., frequent occurrence of *Racemonocolpites facilis*.
(6) Rare to frequent occurrence of a few pteridophytic spores such as *Cyathidites minor*, *Leiotriletes sinuosoides*, *Lycopodiumsporites palaeocenicus* and *Foveomonoletes cooksonii*.
(7) Last appearance from bottom upwards of *Spinizonocolpites baculatus*, and *Monocolpopollenites parvus*.

In addition to the above mentioned taxa, the following species are also recorded : *Foldexina inaperturata*, *Spinizonocolpites prominatus (echinatus)* (=*S. echinatus*), *Tricolpites crassireticulatus*, *Rhoipites ghatalensis*, *R. bolpurensis*, *Marginipollis cribrania*, *Myricipites harrissii* and other assorted small tricolporates and fungal elements.

Proxapertites cursus Zone

Next in overlying succession to the *Proxapertites operculatus* Zone is *Proxapertites cursus* Zone. This is also of Paleocene age. The age has been established on the basis of *Trochammina* Facies Zone of Biswas (1961) (Fig. 1).

This zone is named after the well known pantropically distributed Paleocene species, *Proxapertites cursus* Van Hoeken-Klinkenberg 1966 which begins to appear in this zone and later occurs abundantly (more than 15%). This zone covers the lower part of Jalangi Formation (Fig. 3) and is present in the wells Debagram-1, Burdwan-1, Jalangi-1, Memari-1, Galsi-1, Bolpur-1 and Ghatal-1 in West Bengal (Fig. 2). Lithologically, the sediments of this zone are composed of coarse to medium grained sandstone with occasional thin laminae of shale and carbonaceous shale. The latter lithologies obviously constitute the samples for palynological investigation. This zone is palynologically very rich. *Proxapertites* and *Spinizonocolpites* pollen complex play a dominant role in the assemblage of this zone.

The following taxa characterise the assemblage of this zone (Fig. 3; Pl. 2) :
(1) Abundant occurrence of *Proxapertites cursus* (more than 15%), *P. operculatus* continues from the underlying zone in much lesser frequency (7%).
(2) Dominant occurrence of *Spinizonocolpites prominatus* (more than 12%) and first appearance and common occurrence of *S. brevispinosus* (5%).
(3) Restricted and frequent occurrence of *Crotonipollis burdwanensis*.
(4) First appearance and frequent occurrence of *Longapertites vaneedenburgi* and *L. bolpurensis*.
(5) First appearance of *Araliaceoipollenites ramanujamii*, *Paleosantalaceaepites primitiva* and *Polycolpites cooksonii*.
(6) First appearance of the genus *Marginipollis*.
(7) Restricted and frequent occurrence of *Proteacidites excertus*.
(8) Restricted and rare occurrence of *Dandotiaspora dilata*.

(9) *Retitricolpites peroblatus* and *Triorites bolpurensis* still continue from the underlying Upper Cretaceous zones ; their absence in the intermediary *Proxapertites operculatus* Zone is probably due to the fact that the said zone is comparatively poor in pollen content and the preservation of many pollen is still poorer.

In addition to the above mentioned taxa the following species are also recorded : *Lycopodiumsporites palaeocenicus*, *Leiotriletes sinuosoides*, *Polypodiisporites mawkmaensis*, *Monocolpopollenites* spp., *Paleocaesalpiniaceaepites eocenicus*, *Trilatiporites sellingi*, *Myricipites vulgaris*, *Marginipollis obscurus* and assorted small tricolporate grains and *Diporicelladesporites* sp. and other fungal spores.

Monocolpopollenites eocenicus Zone

Succeeding above the *Proxapertites cursus* Zone is the *Monocolpopollenites eocenicus* Zone of Lower Eocene age. The age for this zone and also for the succeeding one has been assigned on the basis of stratigraphic position of this interval of sediments which are bounded by dated lower and upper limits (Fig. 3) together with the considerations based on the comparative palynological assemblage of other known areas (e.g. Meghalaya, Cauvery, Kutch, etc.). This zone is named after *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* (Sah & Dutta 1966) Baksi & Deb (MS B), which occurs abundantly in this zone. The sediments of this zone cover the middle and upper part of Jalangi Formation (Text-fig. 3) and is represented in the wells Jalangi-1, Bolpur-1 and Memari-1 in West Bengal (Fig. 2).

Lithologically, the sediments of this zone are composed of coarse to medium grained sandstone with alternations of shale, carbonaceous and coaly shales. The shale, carbonaceous and coaly shales alternations constitute the samples for palynological study.

Palynologically, this zone is composed of very rich assemblage. In the following are the elements that characterise the assemblage of this zone (Fig. 3 : Pl. 3) :

(1) Abundant occurrence of *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* (20%).

(2) Abundant occurrence of *Proxapertites operculatus* (more than 15%), and a low percentage of *P. cursus* (2%). This is almost the reverse in the situation in the occurrence of these two species obtained in the underlying zone, where almost an opposite frequency of occurrence can be observed.

(3) *Spinizonocolpites prominatus* (=*S. echinatus*) (5%) and *S. brevispinosus* (more than 6%) continue from the underlying zone. First appearance, restricted and frequent occurrence of *S. wodehousei* and *S. sahii*.

(4) First appearance and frequent occurrence of *Couperipollis rarispinosus*.

(5) Frequent occurrence of *Marginipollis*.

(6) First appearance and rare occurrence of *Schizaeoisporites digitatoides* and *Erdtmanipites reticulatus*.

(7) *Lycopodiumsporites palaeocenicus*, *Polypodiisporites mawkmaensis*, *Foldexina inaperturata*, *Longapertites vaneedenburgi*, *L. bolpurensis*, *Paleocaesalpiriaceaepites eocenicus*, *Araliaceoipollenites ramanujamii* and *Polycolpites cooksonii* continue from the underlying zone.

In addition to the taxa cited above, the following species are also noted. *Cyathidites australis*, *Retibrevitricolpites* sp., *Tricolpites* sp., *Tricolpopollenites angululuminosus*, *Nyssapollenites incertus*, *Rhoipites psilatus*, *Sapotaceoidaepollenites* sp., *Trilatiporites sellingi*, *Polycolpites multitrimatus*, *Retistephanocolpites williamsi*, assorted small tricolporates and abundant occurrence of *Phragmothyrites* sp.

Trilatiporites biswasii Zone

The next overlying zone to the *Monocolpopollenites lepidus* Zone is *Trilatiporites biswasii* Zone of Lower Eocene age.

This zone is named after the species *Trilatiporites biswasii* Baksi & Deb (MS B) which makes its first appearance in this zone and occurs as a common element. This is a distinct zone by its constituent elements but is of restricted distribution within the basin being so far only confined to the Bolpur Well. Palynologically this is given for the time being the status of a zone, but its viability as an operational biostratigraphic unit is obviously dependent on its wide occurrence like other zones. It might prove as well in future a local biofacies development.

The sediments of this zone cover the Upper part of Jalangi Formation in West Bengal (Fig. 2).

Lithologically, the sediments of this zone are composed of coarse, medium grained and fine grained sandstone, shale and siltstone with lignitic and coaly lentils, lignitic shale and coaly shale. The lignite and coaly shales, thin lentils of lignite and coal, shale and siltstone constitute the spore-pollen bearing samples.

Palynologically this is a very rich zone, dominated by angiosperm elements. However, pteridophytic spores are represented in relatively more number of species in comparison to other zones.

The elements that characterise the assemblage of this zone are the following (Fig. 3 ; Pl. 3) :

(1) First appearance and common occurrence of *Trilatiporites biswasii*. *T. sellingi* continues from the *Proxapertites operculatus* Zone
(2) Occurrence of a number of spore species viz. *Cyathidites australis*, *Lycopodiumsporites palaeocenicus*, *Stereisporites assamensis*, *Camarozonosporites eocenicus*, *Laevigatosporites gracilis*, *Polypodiisporites mawkmaensis* and *Polypodiidites delicatissimus*.
(3) Abundant occurrence of *Proxapertites operculatus* (more than 15%) and *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* (more than 15%).
(4) Constant presence of *Spinizonocolpites prominatus* (=*S. echinatus*) (2%) and *S. brevispinosus* (6%).
(5) Rare and restricted occurrence of *Hespenipollis pulcher*.
(6) First appearance and frequent occurrence of *Marginipollis kutchensis*.
(7) Frequent occurrence of *Tricolpites levis*.
(8) First appearance and frequent occurrence of *Margocolporites sahnii*.
(9) *Paleocaesalpiniaceaepites eocenicus*, *Araliaceoipollenites ramanujamii*, *Paleosantalaceaepites primitiva* and *Erdtmanipollis reticulatus* continue from the underlying zones.
(10) Restricted and rare occurrence of *Retidiporites magnus* and *R. magdalensis*.
(11) Occurrence of three triporate species *Triporopollenites vimalii* (2%), *Triorites bolpurensis* (6%) and *Myricipites vulgaris* (2%).

In addition to the elements cited above the following taxa also accompany the assemblage : *Foldexina inaperturata*, *Racemonocolpites facilis*, *Retibrevitricolpites* sp., *Tricolpites* sp., *Rhoipites* sp., *Stephanocolpites globatus* and *Stereisporites stimatus*. Different types of fungal spores occur abundantly.

Paleocaesalpiniaceaepites eocenicus Zone

This zone is of Middle-Upper Eocene age, which has been established on the basis of foraminiferal zones established by Biswas (1961).

This zone is named after the species *Paleocaesalpiniaceaepites eocenicus* Biswas 1962, which occurs commonly in this zone. This zone covers the sediments of Sylhet Limestone Formation at the bottom and Kopili Formation at the top (Fig. 3) and is present in the Wells Jalangi-1, Bolpur-1, Memari-1 (Fig. 2).

Lithologically this zone is composed of foraminiferal and algal limestone, strongly glauconitic limestone at the bottom part with occasional thin laminae of shale and dark coloured marl. The thin laminae of shale and marl within the limestone constitute the samples for palynological study.

Palynologically, this zone is composed of a very rich assemblage. In the following are the elements that characterise the assemblage of this zone (Fig. 3 ; Pl. 4) :

(1) Common occurrence of *Paleocaesalpiniaceaepites eocenicus ;* frequent occurrence of *Margocolporites sahnii.*

(2) Abundant occurrence of *Arecipites communis* (20%), frequent occurrence of *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* and common occurrence of *Monocolpopollenites* spp.

(3) Rare occurrence of *Proxapertites operculatus* and *P. assamicus.*

(4) Frequent occurrence of *Couperipollis rarispinosus.*

(5) Common occurrence of *Tricolpites levis* (9%).

(6) Frequent occurrence of *Araliaceoipollenites ramanujamii, Palaeosantalaceaepites primitiva* and *Sapotaceoidaepollenites baksii.*

(7) Rare but restricted occurrence of *Wadiapites caryophylla.*

(8) Common occurrence of *Myricipites vulgaris* and frequent occurrence of *M. harrissii.*

(9) Rare to frequent occurrence of *Retistephanocolpites williamsi, Polycolpites cocksonii* and *Erdtmanipites reticulatus.*

(10) Frequent occurrence of *Cyathidites australis, Laevigatosporites gracilis, Schizaeoisporites digitatoides* and *Polypodiisporites mawkmaensis.*

(11) Rare and restricted occurrence of *Talisiipites wodehousei.*

Meyeripollis naharkotensis Zone

This zone of Oligocene age overlies the *Palaeocaesalpiniaceapites eocenicus* Zone and is found to be the topmost palynological zone in the Upper Cretaceous-Paleogene succession of Bengal basin (Fig. 3). The contact between this zone and the underlying zone is well defined and sharp. Many characteristic elements of the underlying zone completely disappear and are replaced by a number of new types. The age has been established on the basis of foraminiferal zones established by Biswas (1961) (Fig. 1).

This zone is named after the well known Oligocene pollen species *Meyeripollis naharkotensis* Baksi & Venkatachala 1970, after which the *Meyeripollis naharkotensis* Peak Zone has been established earlier in Assam-Meghalaya region (Baksi, 1974a,b). In Bengal Basin, this species makes its first appearance in this zone and is represented by its restricted, and persistent occurrence. This significant taxon is not so abundant here as that in the Laisongs (Lr. Barails) of Sonai River, Lubha River etc. of Upper Assam (Baksi, 1962). This zone covers the sediments of Burdwan Formation and lower part of Memari Formation (Fig. 3) and is represented in all the wells of the shelf area except Ghatal-1 and Galsi-1. In Memari-1, the upper part of the zone is enriched with hystrichosphaerid, dinoflagellate and microforaminifera which shows a sharp contact with the overlying zone unlike in other wells.

Lithologically, this zone is composed of coarse to medium grained sandstone with

alterations of shale and carbonaceous shales which constitute the samples for palynological study.

Palynologically, this is a rich zone. The following are the elements that characterise the assemblage of this zone (Fig. 3, Pl. 4) :

(1) Restricted, common and persistent occurrence of *Meyeripollis naharkotensis.*
(2) First appearance and frequent occurrence of *Polygonaceaepites zonoides.*
(3) Frequent occurrence of *Polypodiisporites speciosus.*
(4) First appearances and frequent occurrence of *Magnastriatites* sp.
(5) Frequent occurrence of *Cyathidites minor.*
(6) First appearance of *Simsangia trispinosa.*
(7) Frequent occurrence of *Spinizonocolpites prominatus* (*S. echinatus*).

In addition to the above taxa, the following elements also accompany the assemblage : *Bauhiniapollenites burdwanensis*, *Graminidites* sp., *Paleosantalaceaepites primitiva*, a number of small tricolporate pollen grains, *Phragmothyrites*, etc.

CORRELATION OF THE PALYNOLOGICAL BIOSTRATIGRAPHIC ZONES

The palynological biostratigraphic zones or palynostratigraphic zones established in the present paper have been compared and correlated with the similar zones occurring in different Cretaceous-Tertiary sedimentary sequence within and outside the study area. The correlation has been attempted in three steps—

I. correlation of Bengal and Meghalaya palynostratigraphic zones,
II. correlation of Bengal palynostratigraphic zones with the equivalent or comparable zones or assemblages from other basins within India and
III. The examination of equivalency of these assemblages or zones with respect to extra-Indian occurrences.

These biostratigraphic zones are obviously not meant to carry precise temporal value with them, but, within the basin, these zones are highly dependable units in the stratigraphic analysis and contemporaneity. The delimiting boundaries of these zones, however generally meet with limitations when they are carried over long distances ;—i.e., they may not be contemporaneous. In this study, it is revealed, that the Paleocene palynostratigraphic zone, viz. *Proxapertites cursus* Zone in particular appears to hold out its temporal significance ever when it is correlated on inter-continental scale.

I. Correlation of Bengal and Meghalaya Palynostratigraphic Zones

Aquilapollenites indicus Zone and Mulleripollis bolpurensis Zone

These two Upper Cretaceous zones of Bengal can not be identified in Meghalaya as such. The only Upper Cretaceous section of the shelf sediments in Meghalaya is exposed in the Khasi Trough and the only microfloral record from the Upper Cretaceous sediments of Meghalaya is from Dawki and Cherrapunji areas (Jain, Sah & Singh, 1973 and Sah & Singh, 1977). The recent records of the palynological assemblages recovered from the Gumaghat and Mahadek Formations of Meghalaya (Sah & Singh, 1977), however do not show any correspondence with the Upper Cretaceous assemblage of Bengal Basin. The Upper Cretaceous microflora recovered from the *Aquilapollenites indicus* Zone and *Mulleripollis bolpurensis* Zone of Bengal represented by the significant occurrence of *Aquilapollenites*, *Spinizonocolpites mulleri*, *Mulleripollis*, *Retitricolpites peroblatus*, *Monocolpopollenites bengalensis*, *M. parvus* and a number of tricolpate and tricolporate species is an angiosperm dominant one. On the other hand the ? Capmpanian microflora of Gumaghat

TABLE-1—Correlation of palynostratigraphic zones of the Paleogene sequences of Bengal and Meghalaya

	1	2	3	4	5
	Bengal	Meghalaya			
Age		Tura Formation	Cherra Formation		Simsang River Section.
	Authors	Sah & Singh, 1974.	Sah & Dutta, 1974 (Dutta & Sah, 1970).	Baksi, 1974	Baksi, 1962.
Oligocene	*Meyeripollis naharkotensis* Zone				Simsang Palynological Zone III.
		Dandotiaspora telonata Cenozone.	*Araliaceoipollenites reticulatus* Cenozone (Middle zone of Cherra Formation).	*Polycolpites-Monosulcites* (*Colocasioideaepites*) Assemblage Zone.	
	Monocolpopollenites eocenicus Zone	*Palmidites plicatus* Cenozone.	*Tricolpites reticulatus* Cenozone (Upper Zone of Cherra Formation).		No II Palynological Zone.
Eocene	*Nymphaeoipollis assamicus* Cenozone	Lakadong Palynological zone.			
	Trilatiporites biswasii Zone.				Simsang Palynological Zone I.
	Paleocaesalpiniaceaeopites eocenicus Zone.				
				Monocolpites broadcolpusi-Simsangia Assemblage Zone.	
Paleocene	*Proxapertites cursus* Zone	*Relikaletes emendatus* Cenozone.	*Nymphaeoipollis crassimurus* Cenozone (Lower Zone of Cherra Formation).	*Proxapertites* Assemblage Zone.	Case of Simsang Palynological Zone I.

Formation and Maestrichtian microflora of Mahadek Formation (SAH & SINGH, 1977) are pteridophyte and gymnosperm dominant. The Gumaghat flora contains also a few angiosperm elements such as *Verrutricolporites assamicus* and *Spinatriporites mesozoicus*. Otherwise, the Gumaghat assemblage is represented by *Clavinaperturites ornatus*, *Microfoveolatosporites scottsbergii*, *Callialasporites punctatus*, *Jadukatasporites assamicus*, etc. The Mahadek microflora is characterised by *Ariadnaesporites intermedicus*, *Contignisporites cooksonii*, *Klukisporites suspinicus*, *Coptospora mesozoica*, *Rouseisporites reticulatus*, *Araucariacites australis* and *Callialasporites punctatus*. None of the Upper Cretaceous marker elements of Bengal is found in the Upper Cretaceous Gumaghat and Mahadek microflora of Meghalaya.

Proxopertites operculatus Zone and Proxapertites cursus Zone :

The basal Paleocene zone, the *Proxapertites operculatus* Zone, is not traceable in the equivalent stratigraphic position in the Meghalaya outcropping sediments. The next succeeding Paleocene zone encountered in Bengal is the *Proxapertites cursus* Zone, the assemblage of which can confidently be correlated with that of the equivalent horizon in Meghalaya. This zone can be identified besides other characteristic elements by the prominent occurence of *Proxapertites cursus* complex. The pollen grains previously described by different authors under several generic and specific names from Meghalaya Region, such as *Retialetes emendatus*, *Nymphaeoipollis crassimurus*, *Microreticulatipites intecta*, etc. are considered to be identical to *Proxapertites cursus* (BAKSI, DEB & MULLER, 1979). Thus, in the following discussion all the above mentioned species are treated as synonyms of *P. cursus* and on that basis, this zone from Bengal is correlated with the equivalent zones of Meghalaya as follows :

(1) There is a possibility of finding an identical assemblage agreeing with that of *P. cursus* Zone at the base of Simsang River section underlying the Simsang Palynological Zone I (BAKSI, 1962). By the restricted occurrence of *Microreticulatipites intecta* this assemblage can confidently be correlated with *P. cursus* Zone (Table-1).

(2) The works of DUTTA AND SAH (1970), SAH AND DUTTA (1966, 1968 and 1974) and BAKSI (1974) deal with palynological zonation of Cherra Formation of Meghalaya. The basal zone, *Proxapertites* assemblage Zone (BAKSI, 1974) (— *Nymphaeoipollis crassimurus* Cenozone of SAH AND DUTTA 1974 ; Lower Zone of DUTTA & SAH (1970) is represented by a bulk assemblage, of which most of the significant taxa are represented in the *P. cursus* Zone of Bengal (Table-1). The striking similarity lies in the predominant occurrence of *P. cursus* complex. The other common elements to both the zones are *Proxapertites operculatus*, *Polypodiisporites mawkmaensis*, *Polycolpites cooksonii*, *Spinizonocolpites brevispinosus* (*Couperipollis brevispinosus*), *Couperipollis rarispinosus*, *Dandotiaspora dilata*, *Lycopodiumsporites palaeocenicus*, *Monocolpopollenites* (*Palmaepollenites*) *eocenicus*, *Proteacidites excertus*, *Arecipites* (*Palmaepollenites*) *communis* and *Sestrosporites dettamanii*.

It is worth mentioning that, the *Dandotiaspora* group, which is represented by 6-9% comprising several species in the *Nymphaeoipollis crassimurus* Zone (SAH & DUTTA, 1974) in Meghalaya is represented only by one species, viz. *D. dilata* and that too, is confined to the *P. cursus* Zone in Bengal.

The absence of the other spore species from Bengal such as *Corrugatisporites formosus*, and *Foraminisporis medius* may also be mentioned.

Lakiapollis matanamadhensis, *Triorites inferius*, *T. communis* and *Trifossapollenites con-*

status, which are significantly present in the *Nymphaeoipollis crassimurus* Zone (Table 1) are absent in *P. cursus* Zone in Bengal.

The following significant taxa which are present in *P. cursus* Zone of Bengal are not represented in the above mentioned zone of Meghalaya : *Crotonipollis burdwanensis*, *Disulcites vaneedenburgi*, *D. bolpurensis*, *Marginipollis kutchensis*, *Retitricolpites peroblatus*, *Triorites bolpurensis*, *Trilatiporites sellingi* and *Paleocaesalpiniaceaepites eocenicus*. The absence of the Eocene genera starting from the Paleocene *P. cursus* Zone of Bengal in the above mentioned zone of Meghalaya such as *Trilatiporites*, *Paleocaesalpiniaceaepites* and *Marginipollis* is quite remarkable.

(3) It is worthmentioning here that a number of pollen grains and spores reported under different specific names from the Tura Formation of Tura-Dalu Road section as well as from the second clastic interbed of Sylhet Limestone Formation of Meghalaya (Biswas, 1962) remarkably match a few significant taxa of the *Proxapertites cursus* Zone of Bengal, for example *Polypodiisporites mawkmaensis* (=*Polypodiaceaesporites stoliczkana*), *Proxapertites cursus* (=*Nonaperturipites chandleri*), *Crotonipollis burdwanensis* Baksi, Deb & Siddhanta 1979 (=*Nonaperturipites berryi*), *Racemonocolpites facilis* (=*Nonaperturipites thiergarti*) etc. As the systematic palynology demands, the bracketed names have been replaced by valid generic and specific names by the present authors, which will be published elsewhere.

(4) Sah and Singh (1974) have presented palynological zonation of Tura Formation from Meghalaya (Table-1). The basal zone has been recognised as *Retialetes emendatus* Cenozone. The bulk assemblage of this zone again matches the bulk assemblage of *Proxapertites cursus* Zone. The *Retialetes emendatus* Cenozone is represented by high percentage of *Proxapertites cursus* complex (more than 70%), which can alone be taken as a single reliable character for distinguisting this zone (Sah & Singh, 1974). This zone can therefore be confidently correlated with *P. cursus* Zone of Bengal.

The common elements for both the zones are the following : *Dandotiaspora dilata*, *Proxapertites cursus* (=*Retialetes emendatus*, *Nymphaeoipollis crassimurus*), *Proxapertites* (=*Nymphaeoipollis assamicus*), *Monocolpopollenites* (=*Palmaepollenites*) *eocenicus*, *Lycopodiumsporites palaeocenicus*, *Spinizonocolpites brevispinosus* (=*Couperipollis brevispinosus*) and *Arecipites* (*Palmaepollenites*) *communis*.

The following characterstic species of the Sah and Singh's (1974) *Retialetes emendatus* Cenozone are absent in the *Proxapertites cursus* Zone of Bengal : *Polycolpites speciosus*, *Meliapollis ramanujamii*, *Liliacidites major*, *Leiotriletes punctatus*, *Lycopodiumsporites speciosus*, *Lakiapollis matanamadhensis*, *Cyathidites minor*, *Triporopollenites vimalii*, *Polypodiisporites oligocenicus*, *Stereisporites psilauts*, *Nyssapollenites barooahii*, *Tricolpites levis*, *Couperipollis rarispinosus*, *Triorites communis* and *Droseridites parvus*.

It is worth mentioning that the genera *Crotonipollis*, *Disulcites*, *Trilatiporites*, *Paleocaesalpiniaceaepites* and the species *Retitricolpites peroblatus*, *Proteacidites excertus*, *Araliaceoipollenites ramanujamii*, *Triorites bolpurensis* occurring in the *Proxapertites cursus* Zone of Bengal are absent in the *Retialetes emendatus* Cenozone of Meghalaya.

Monocolpopollenites eocenicus Zone :

This zone is well correlatable to the zones of equivalent horizons of Meghalaya. As may be recalled, this zone is marked by (1) a sudden change in frequency of *Proxapertites cursus* complex which is represented by a much lower percentage, (2) increased percentage of *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* and *Proxapertites operculatus*.

1. The first two features match with the assemblage of *Araliaceoipollenites reticulatus* Cenozone, *Tricolpites reticulatus* Cenozone and Lakadong Zone (Dutta & Sah 1974) (=*Polycolpites-Monosulcites*) (*Colocaceoideaepites*) Assemblage Zone of Baksi. (1974) (Table-1).

2. The almost similar case is noted in the three polynological zones of Tura Formation (Sah & Singh, 1974), viz. *Dandotiaspora telonata* Cenozone, *Palmidites plicatus* Cenozone and *Nymphaeoipollis assamicus* Cenozone (Table-1). The dominant occurrence of *Dandotiaspora* spp., in Tura Formation may be considered as a local feature and the nature of occurrence of *P. cursus* complex and *M. eocenicus* should be given more weightage for correlation purposes. Based on these criteria, these above mentioned six zones of Cherra and Tura Formations are correlated with *M. eocenicus* Zone of Bengal.

1. (*a*) The common elements of *Araliaceoipollenites reticulatus* Cenozone of Meghalaya and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Spinizonocolpites brevispinosus* (=*Couperipollis brevispinosus*), *Lycopodiumsporites palaeocenicus*, *Proxapertites cursus* (=*Retialetes emendatus*, in much lower frequency), *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* and *Polycolpites cooksonii*. *Araliaceoipollenites reticulatus* comes very close to *A. ramanujamii* occurring in *M. eocenicus* Zone.

   (*b*) The common elements of *Tricolpites reticulatus* Cenozone of Meghalaya and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Polycolpites cooksonii*, *Spinizonocolpites brevispinosus* (=*Couperipollis brevispinosus*), *Couperipollis rarispinosus*, *Monocolpopollenites* (*Palmaepollenites*) *eocenicus*, *Proxapertites cursus* and *Arecipites* (*Palmaepollenites*) *communis*.

   (*c*) The common elements of Lakadong Zone of Meghalaya and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Dandotiaspora dilata*, *Spinizonocolpites brevispinosus*, *Couperipollis rarispinosus*, *Monocolpopollenites* (*Palmaepollenites*) *eocenicus*, *Polycolpites cooksonii* and *Arecipites* (*Palmaepollenites*) *communis*.

In addition to the diagnostic elements characterising the Cherra zones (Dutta & Sah, 1970 and Sah & Dutta, 1974) a few types are also found to be common with the *Monocolpopollenites eocenicus* Zone assemblage. Although these taxa have been mentioned as non-diagnostic by the above mentioned authors, the present authors think that these are characteristic elements for biostratigraphic zonation and correlation.

While describing the zones there is no mention about the occurrence of *Retitrescolpites* which is most probably the same as *Paleocaesalpiniaceaepites*. *Spinizonocolpites* (*Monosulcites*) *wodehousei* is another form confined to the *M. eocenicus* Zone occurring in the equivalent zones of Cherra Formation. *Tricolpites crassireticulatus* is another species common to both the Bengal zone and the Meghalaya zones of Dutta and Sah (1970). Other common forms are *Polycolpites multitrimatus* and *Cyathidites australis*.

2. (*a*) The common elements of *Dandotiaspora telonata* Cenozone of Meghalaya and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Polycolpites cooksonii*, *Proxapertites cursus*, *Lycopodiumsporites palaeocenicus*, *Couperipollis rarispinosus*, *Spinizonocolpites brevispinosus*, *Monocolpopollenites* (*Palmaepollenites*) *eocenicus*, *Proxapertites* (*Nymphaeoipollis*) *assamicus* and *Arecipites* (*Palmaepollenites*) *communis*.

   (*b*) The common species of *Palmidites plicatus* Cenozone of Meghalaya (Sah & Singh, 1974) and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Monocolpopollenites* (*Palmaepollenites*) *eocenicus*, *Polycolpites cooksonii*, *Lycopodiumsporites palaeocenicus*, *Spinizonocolpites brevispinosus* and *Couperipollis rarispinosus*.

(*c*) The common elements of *Nymphaeoipollis assamicus* Cenozone of Meghalaya (*op. cit.*) and *Monocolpopollenites eocenicus* Zone of Bengal are the following : *Monocolpopollenites eocenicus*, *Arecipites* (*Palmaepollenites*) *communis*, *Polycolpites cooksonii*, *Lycopodiumsporites palaeocenicus*, *Couperipollis rarispinosus* and *Spinizonocolpites prominatus*(=*S. echinatus*).

The abundant occurrence of *P. operculatus* in the *Nymphaeoipollis assamicus* Cenozone is the same as in *Monocolpopollenites eocenicus* Zone.

The following significant genera and species of *M. eocenicus* Zone are absent in the above mentioned six zones of Meghalaya : *Racemonocolpites facilis*, *Disulcites vaneedenburgi*, *D. bolpurensis*, *Paleocaesalpiniaceaepites eocenicus*, *Marginipollis kutchensis*, *Trilatiporites sellingi*, *Retistephanocolpites williamsi* and *Erdtmanipites reticulatus*.

Monocolpopollenites eocenicus Zone can not be recognised in the Simsang River section (Baksi, 1962). The characteristic elements of this zone do not constitute a distinct assemblage to be recognised as a separate zone in the Simsang River section.

Trilatiporites biswasii Zone :

The assemblage of this zone of Bengal basin is not represented in Meghalaya as such. However, a few diagnostic taxa of this zone, viz. *Trilatiporites biswasii* (=*Dorreenipites platydesma* Biswas 1962), *Monocolpopollenites* (*Palmaepollenites*) *eocenicus* (=*Palmaepites eocenica* Biswas 1962), *Proxapertites operculatus* (=*Potamogetonaceaepites pramathi* Biswas (1962), *Polypodiisporites mawkmaensis* (=*Polypodiceaesporites stoliczkana* Biswas 1962), *Spinizonocolpites* group, are common to the assemblage recorded by Biswas (1962) from the Tura Formation from the Tura-Dalu Road section, Meghalaya.

It is interesting to note that the genus *Trilatiporites* has been recorded only by Biswas (1962) from Tura Formation from Tura-Dalu Road section of Meghalaya. It has not been recorded yet from any other sections east of this section.

Paleocaesalpiniaceaepites eocenicus Zone :

The typical Middle-Upper Eocene assemblage of Bengal is not represented in the Cherra and Tura assemblages of Dutta and Sah (1970), Sah and Dutta (1974) and Sah and Singh (1974), respectively. A few diagnostic types marking the Middle-Upper Eocene assemblage of Bengal, start to appear in these two above mentioned assemblages. These are *Paleocaesalpiniaceaepites* (=*Retitrescolpites*), *Margocolporites*, *Tricolpites crassireticulatus* complex with the affinity of the *Caesalpiniaceae*, *Talisiipites*, *Paleosantalaceaepites* group, *Araliaceoipollenites* group, *Polycolpites* group, *Schizaeoisporites* and *Triporopollenites vimalii*.

The bulk assemblage of this zone of Bengal can confidently be correlated with the Simsang Palynological Zone I of Simsang River section of Garo Hills, Meghalaya (Table 1) covering Tura Formation and a part of Siju Formation (Bakshi, 1962). The Simsang Palynological Zone II covering Rewak Formation can not be correlated with the zones of Bengal. Due to the ill representation of the microfloral assemblage it is not possible to recognise this zone in Bengal. The *Monocolpites broadcolpusi* - *Simsangia* Assemblage Zone of Baksi (1974b) from the Kopili Formation of Meghalaya is also poorly represented and thus can not be correlated with the zones from the equivalent horizon of Bengal.

The palynological assemblage recovered from the Daranggiri and Rongrenggiri coalfields of Meghalaya by Ghosh (1969) is identical to that of the Simsang Palynological Zone I of Baksi (1962) and hence is well comparable to the above mentioned zone of Bengal.

The rich assemblage recovered from Tura Formation from the Tura-Dalu Road section and the second clastic bed of the Sylhet Limestone Formation from Umsohryngkew

river section of Khasi Hills of Meghalaya of Biswas (1962) shows almost identical assemblage to the above mentioned zone of Bengal.

The following significant taxa are common to *Palaeocaesalpiniaceaepites eocenicus* Zone of Bengal and Simsang Palynological Zone I (Baksi, 1962) of Meghalaya ; (1) Common occurrence of *Palaeocaesalpiniaceaepites eocenicus-Margocolporites sahnii-Tricolpites crassireticulatus* complex related to Caesalpiniaceae, (2) abundant occurrence of *Arecipites communis* (=*Palmaepites slimsliti*), a few other *Monocolpopollenites* sp., (3) frequent presence of *Foldexina inaperturata* Baksi 1962, (4) frequent presence of *Retistephanocolpites williamsii*, *Polycolpites cooksonii*, *Stephanocolpites globatus* and (5) frequent presence of *Araliaceoipollenites*, *Schizaeoisporites digitatoides* (=*Monocolpopites striaei* Baksi 1962).

Meyeripollis naharkotensis Zone :

The Oligocene assemblage of this zone of Bengal basin is almost identical to Simsang Palynological Zone III (Baksi, 1962) reported from the outcropping shelf sediments at Simsang River Section, Garo Hills, Meghalaya (Table-1).

Correlation of Bengal Palynostratigraphic Zone with the equivalent or comparable assemblages from other basins in India :

The *Aquilapollenites indicus* zone and *Mulleripollis bolpurensis* Zone can not be directly correlated as such with any other microfloral assemblages in India. The Upper Cretacious assemblages described from Cauvery basin (Venkatachala, 1974a, Venkatachala & Sharma, 1974) are not comparable to that of Bengal. However, the *Scollardia conferta* Zone of the former of Maestrichtian age has a few comparable elements to the two Upper Cretaceous zones of Bengal. *Monosulcites foveolatus* Venkatachala & Sharma, 1974 (comparable to *Monocolpopollenites bengalensis*), *Striatriporites cauveriana* Venkatachala & Sharma 1974, (comparable to *Pulcheripollenites strivastavae*), *Triporopollenites minimus* Venkatachala & Sharma, 1974 (comparable to *Triorites bolpurensis*) and *Azolla cretacea* are the comparable forms from the *Scollardia conferta* Zone of Cauvery basin.

Although the lower zone of Paleocene age, viz. *Proxapertites operculatus* Zone can not be identified in other parts of India, the characteristic assemblage of the succeeding *Proxapertites cursus* Zone is identified in several parts of India. The scanty information on the microflora of the Madh Series (Paleocene) of Western Kutch (Mathur, 1966) may suggest its correlation with *P. cursus* Zone. However, there is no mention of the occurrence of *P. cursus* from the Madh Series. The palynological assemblage from the Barmer Sandstone (Paleocene) of Rajasthan, dominated by *Proxapertites* complex (Sah & Kar, 1972) is more closely comparable to that of *P. cursus* zone.

The *Proxapertites hammenii* Zone (Paleocene) of Cauvery basin (Venkatachala & Rawat, 1972) may be correlated with the *P. cursus* Zone. Although there is no mention about the presence of *P. cursus* as such in this zone, the gross assemblage of *Proxapertites hammenii* Zone (Paleocene) and the overlying *Psilodiporites hammenii* Zone (Lower Eocene) of Cauvery basin (Venkatachala & Rawat, 1972) together compare closely that of the *Monocolpopollenites eocenicus* Zone of Bengal.

The rich palynological assemblage recovered from the Akli lignite of Kapurdi Formation, Barmer District of Rajasthan is closely comparable to that of the *Monocolpopollenites eocenicus* Zone of Bengal (Naskar & Baksi, 1976).

The palynological assemblages from the *Trilatiporites biswasii* Zone and *Paleocaesalpiniaceaepites eocenicus* Zone together are very important for the regional correlation of the equivalent horizons of India. The microfloras from the Laki Series of Kutch (Venkata-

CHALA & KAR 1968, 1969a, 1969b ; SAH & KAR 1969, 1970), Neyveli Lignite of Tamil Nadu and Warkalli Lignite and Quilon beds of Kerala, (RAMANUJAM, 1966, 1966-1967, 1972 ; DEB, 1972 ; RAO & RAMANUJAM, 1975), Palana Lignite of Rajasthan (Rao & VIMAL, 1950, 1952) are closely comparable to those of the two above mentioned zones of Bengal. A critical comparison of these assemblages has been presented in the paper by DEB, BAKSI AND GHOSH (1973).

The palynological assemblage from the *Margocolporites sahnii* Zone (Upper Eocene) of Cauvery basin (VENKATACHALA & RAWAT, 1972) is closely comparable to the combined assemblage of *Trilatiporites biswasii* Zone and *Paleocaesalpiniaceaepites eocenicus* Zone of Bengal and needs special mention. A few common features of these zones from Bengal basin and Cauvery basin may be mentioned here. The first appearance of *Margocolporites sahnii* in *Margocolporites sahnii* Zone is comparable to the first appearance of this species in the *Trilatiporites biswasii* Zone of Bengal. The absence of *Spinizonocolpites echinatus* in *Margocolporites* Zone is also recorded in the *Paleocaesalpiniaceaepites eocenicus* Zone of Bengal. The common characters are the presence of *Paleocaesalpiniaceaepites*, *Palmaepollenites*, *Schizaeoisporites*, *Proxapertites operculatus*, etc.

Examination of equivalency of Bengal polynostratigraphic Zones or assemblages with respect to extra Indian occurrances :

For intercontinental correlation of the biostratigraphic zones, the zones as much by names may not be collatable but examination of first appearances, relative frequency and percentage of occurrences of certain selected taxa from comparable regions leads to interesting correlation. The most noteworthy correlation which can even be traced by zonal name in the *Proxapertites* bearing zone occurring in India and other pantropical areas such as Borneo, Venezuela and Nigeria (Table-2). The oldest pantropical zone, as established

Table-2

	Age	Pantropical	Atlantic zones	Caribbean zones
Eocene	Upper	*Verrucatosporites usmensis*		
	Middle	*Monoporites annulatus*		*Retitricolporites guianensis*
				Psilatricolporites operculatus
				Psilatricolporites crassus
	Lower	*Retibrevitricolpites triangulatus*		
Paleocene		*Proxapertites operculatus*	*Retidiporites magdalensis*	*Foveotricolpites perforatus*
				Ctenolophonidites lisamae
	Danian			*Foveotriletes margaritae*
Senonian	Maestrichtian		*Proteacidites dehaani*	

After Germeraad, Hopping and Muller, 1968.

by the palynological study of the Tertiary sediments from tropical areas of GERMERAAD, HOPPING AND MULLER (1968) is the *Proxapertites* bearing zone, namely *Proxapertites operculatus* Zone. This zone is well developed in the Hubio-road section in Venezela, well Egoli-1, in Nigeria and in the Lundu-Kayan section of Borneo (GERMERAAD, HOPPING & MULLER, 1968).

Of these areas, the more closely comparable characters for correlation can be noticed between India and Borneo.

BORNEO

MULLER (1968) worked on the palynology of the Pedawan and Plateau Sandstone Formations (Cretaceous-Eocene) in Sarawak, North-Western Borneo, Malaysia. He has erected six distinct palynological zones ranging in age from Cenomanian to Eocene. Of these zones, the *Proxapertites* Zone of Paleocene age shows striking similarities in the features characterising *Proxapertites cursus* Zone of Bengal. The typical characters of the sudden and marked increase of frequency of *Proxapertites* complex, and *Disulcites* (described under *Dicolpopollis* by MULLER, 1968) and high percentage of *Proxapertites* complex, *Disulcites*, *Spinizonocolpites*, and *Psilatricolpites kayanensis* Muller 1968 (may be comparable to *Tricolpites obscurus* which occurs in high frequency in *Proxapertites cursus* Zone of Bengal) of the *Proxapertites* zone of the Sarawak appear to be simply duplicated in the *Proxapertites cursus* Zone of Bengal-Meghalaya region.

The combined assemblages of *Aquilapolllenites indicus* Zone and *Mulleripollis bolpurensis* Zone of Bengal of Upper Cretaceous age show a few collatable features with that of the *Rugubivesiculites* Zone of Senonian age from Sarawak, Borneo (Muller, 1968) such as :

1. The base of the *Rugubivesiculites* Zone of Sarawak is defined by the increase of *Triorites minutipori* and *Verrutriporites lunduensis*. *Triorites bolpurensis*, the closely comparable species to *T. minutipori* Muller 1968, occurs in high frequency in the *Aquilapollenites indicus* Zone and continues to *Mulleripollis bolpurensis* Zone of Bengal in lower frequency. *Verrutriporites annulatus* which is closely comparable to *Verrutriporites lunduensis* Muller 1968 occurs frequently and is restricted to *Aquilapollenites indicus* Zone.
2. *Spinizonocolpites baculatus* and *S. prominatus* (=*S. echinatus*) make their first appearance both in *Rugubivesiculites* Zone of Sarawak, Borneo and *Mulleripollis bolpurensis* Zone of Bengal.
3. Definite presence of a few identical species, viz. *Retitricolpites peroblatus* Muller 1968, *Striatricolporites minor* Muller 1968 and *Distaverrusporites simplex* Muller 1968 in both the above mentioned zones of Bengal and the *Rugubivesiculites* Zone of Sarawak. *Retitricolpites peroblatus* starts to occur rarely in *Aquilapollenites indicus* Zone and becomes a common element of the assemblage of *Mulleripollis bolpurensis* Zone. However, it occurs in rare frequency in the Sarawak Zone. *Distaverrusporites simplex* occurs rarely in *Mulleripollis bolpurensis* Zone, but it occurs in high frequency in *Rugubivesiculties* Zone of Sarawak.

Proxpertites operculatus is confined only to Paleocene *Proxapertites operculatus* Zone in Borneo except for a few grains found in the uppermost part of the underlying *Rugubivesiculites* Zone (Senonian) (GERMERAAD, HOPPING & MULLER, 1968). This species occurs in significant frequencies up to Lower Eocene both in Bengal and Meghalaya Regions. It is interesting to note that, *P. operculatus* also continues up to the Upper Eocene in Nigeria (*op. cit.*). The stratigraphic range of *P. cursus* in Borneo is the same as in Bengal-Meghalaya Region. In both the areas this species is confined to the Paleocene, *Proxapertites*

operculatus Zone of Borneo (*op. cit.*) and *Proxapertites cursus* Zone of Bengal. In Nigeria, however, it continues from Paleocene up to the Upper Eocene.

It is also worth mentioning that the species *Retistephanocolpites williamsi* Germeraad, Hopping & Muller 1968 occurring from the Paleocene to Upper Eocene of Bengal, occurs in the same horizons in Nigeria (*op. cit.*). However, in Borneo it is known only from the Neogene, where the base is not exactly known (*op. cit.*). The well distributed genus *Margocolporites* of Indian Eocene sediments starts to occur in the Upper Eocene of Nigeria and continues up to Oligocene and occurs in Borneo from Upper Eocene to Pleistocene (*op. cit*).

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EXPLANATION OF PLATES

PLATE 1

Fig. 1-6. *Aquilapollenites indicus Zone.*
Fig. 7-11. *Mulleripollis bengalensis Zone.*
Fig. 1. *Aquilapollenites indicus*
Fig. 2. *A. bengalensis*
Fig. 3. *Spinizonocolpites mulleri.*
Fig. 4. *Pulcheripollenites srivastavae*
Fig. 5. *Jalangia tuberosa*
Fig. 6. *Striatricolporites minor*
Fig. 7. *Mulleripollis bolpurensis*
Fig. 8. *Retitricolpites peroblauts*
Fig. 9. *Triorites bolpurensis*
Fig. 10. *Monocolpollenites parvus*
Fig. 11. *M. bengalensis*

PLATE 2

Fig. 12. *Proxapertites operculatus*
Fig. 13. *P. cursus*
Fig. 14. *Spinizonocolpites prominatus*
Fig. 15. *Disulcites vaneedenburgi*
Fig. 16. *Dandotiaspora dilata*
Fig. 17. *Retistephanocolpites williamsi*
Fig. 18. *Crotonipollis burdwanesis*

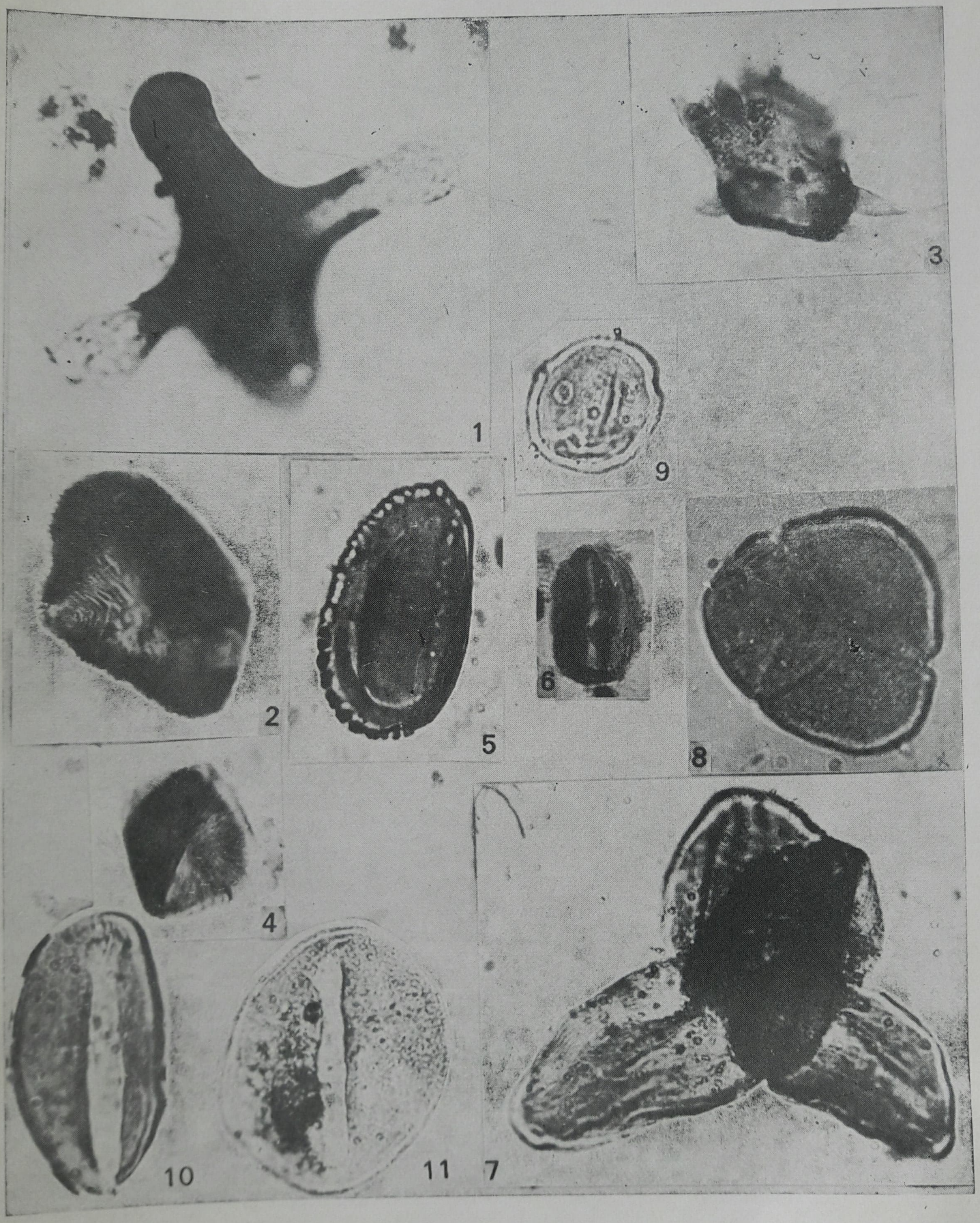
PLATE 3

Fig. 19-24. *Monocolpopollenites eocenicus Zone.*
Fig. 24-29. *Trilatiporites biswasii Zone.*
Fig. 19. *Monocolpopollenites (Palmaepollenites) eocenicus*
Fig. 20. *Couperipollis (Monosulcites) rarispinosus*
Fig. 21. *Spinizonocolpites sahii*
Fig. 22. *S. brevispinosus*
Fig. 23. *S. wodehousei*
Fig. 24. *Marginipollis kutchensis*
Fig. 25. *Retidiporites magnus*
Fig. 26. *Foveomonoletes cooksonii*
Fig. 27. *Trilatiporites biswasii*
Fig. 28. *T. sellingi*
Fig. 29. *Hesperipollis pulcher*

PLATE 4

Fig. 30-37. *Palaeocaesalpiniaceaepites eocenicus Zone.*
Fig. 38-42. *Meyeripollis naharkotensis Zone.*
Fig. 30. *Paleocaesalpiniaceaepites eocenicus*
Fig. 31. *Wadiapites caryophylla*
Fig. 32. *Arecipites (Palmaepollenites) communis*

Fig. 33. *Erdtmanipites reticulatus*
Fig. 34. *Schizaeoisporites digitatoides*
Fig. 35. *Retistephanocolpites williamsii*
Fig. 36. *Tricolpites levis*
Fig. 37. *Sapotaceoideaepollenites baksii*
Fig. 38. *Meyeripollis naharkotensis*
Fig. 39. *Polygonaceaepites zonoides*
Fig. 40. *Spinizonocolpites prominatus*
Fig. 41. *Magnastriatites* sp.
Fig. 42. *Simsangia trispinosa*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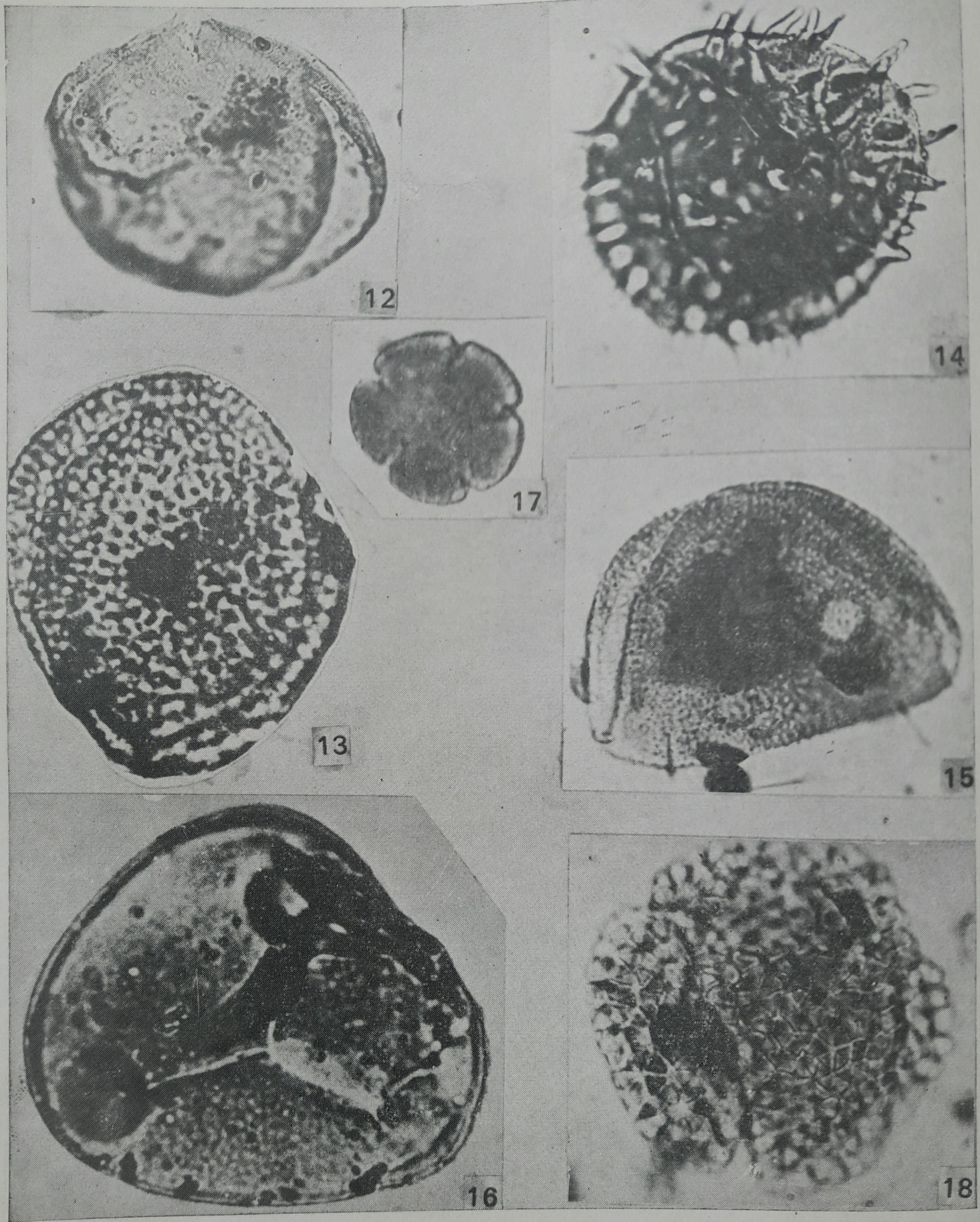
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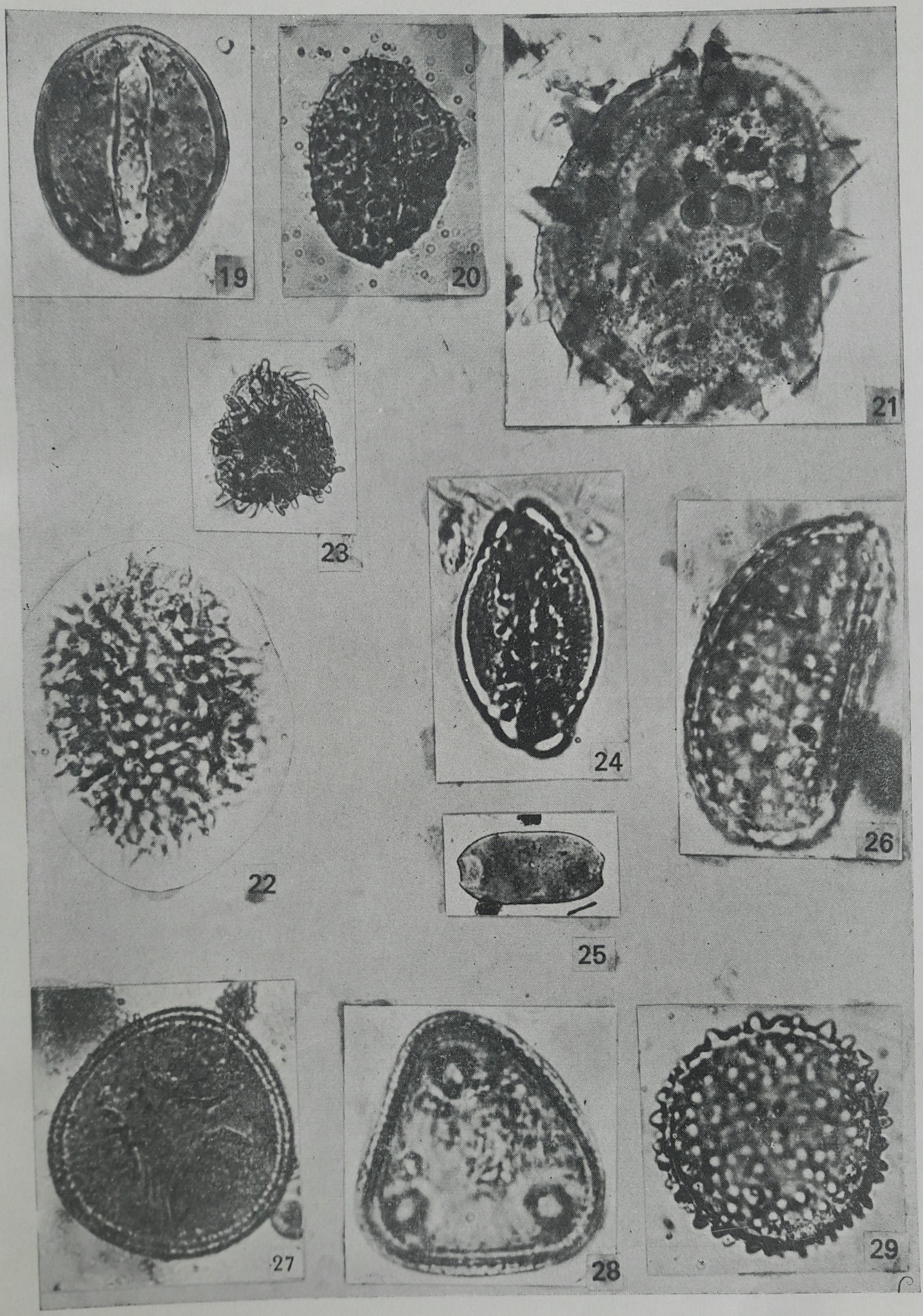
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