PALYNOSTRATIGRAPHY OF THE TERTIARY SEDIMENTARY FORMATIONS OF ASSAM: 2. STRATIGRAPHIC SIGNIFICANCE OF SPORES AND POLLEN IN THE TERTIARY SUCCESSION OF ASSAM*

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ABSTRACT

Inspite of extensive geological work, our knowledge of the Tertiary sequence of Assam remains incomplete, because of the limited range of rock types, rarity of marker beds, paucity of invertebrate fossils and absence of reliable plant megafossils. Bio-stratigraphic studies taken up by the authors have furnished definite evidence that Palynological assemblages of the different formations (stages) of the Tertiary sequence of Assam include taxa which can be potentially used in dating and correlation.

The distribution chart of the characteristic palynological taxa from the different sedimentary groups of the Tertiary sequence amply demonstrate the principles of stratigraphical palynology and the value of these guide fossils in dating, classifying and correlating the Tertiary formations in Assam.

INTRODUCTION

THE Tertiary system of Assam is lithologically divided into five major rock units: (1) Dihing Series (2) Tipam Series (3) Surma Series (4) Barail Series and (5) Disang Series. Although our knowledge of the Tertiary sedimentary rocks of Assam has considerably increased during the last few decades as a result of extensive geological mapping, geophysical surveys and exploratory drilling, their lithological classification for correlation problems still remains problematical. This is because of the extreme rarity of distinctive lithological types. The whole succession is made up of alternations of sandstones, shales, clays, siltstones and mudstones which makes difficult the determination of formation boundaries. With this limited range of rock types, the basis of stratigraphical division has been the general character of the rocks, e.g. coarseness, degree of cementing, characters of bedding, frequency of sandy laminae, etc. Apart from lithological similarity, several other factors have also combined to make correlation by normal stratigraphic methods, a difficult task.

In the first place reliable ' marker ' beds (with invertebrate fossils) are almost missing, except for the Nummulitic limestone of the Eocene and one occurrence of a rich Aquitanian fauna in the Upper Bhuban member of the Surma Valley and some Burdigalian forms in the Boka Bil Formation in the Garo Hills. The Nummulitic limestone bed may be regarded as a marker horizon, but the latter two cannot be of much use as they are solitary local occurrences and have not been exposed at other localities. In addition, subsurface data are scarce and there are very few exposures, except in the Khasi and Jaintia Hills, where they can be seen in escarpments or gorge sections. The Mikir, Garo and Naga Hills are thickly forested and the exposures are generally covered by thick soil. Lastly, the whole region is generally in a disturbed condition, being seismically unstable, with numerous thrust-faults, simple faults and displacements. The complexity in stratigraphy has further been increased by faults whose direction and displacement cannot be ascertained with any certainty.

In recent years it has been found that the distribution of heavy mineral suites have been of considerable importance for dating and zoning purposes. However, the marker suites seem to provide indices useful for local correlations only. Regional correlations by heavy minerals seem hazardous because the mineral suites are bound to be influenced by local conditions of deposition and differences in derivation from different source rocks.

In consequence of these difficulties in stratigraphic correlation, several attempts have been made in the past to study the spore-pollen distribution in the Tertiary succession of Assam, to explore the possibility of correlating the rocks with the help

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of palynological fossils. The first major effort in this direction was made, as early as 1943, under the guidance of Professor Sahni. Extensive investigations were carried out on core samples supplied by the then Burmah Oil Company (now Assam Oil Co.). However, except for a short report published in Palaeobotany in India VI (SAHNI, SITHOLEY & PURI, 1948, pp. 262-263; PLS. 14-17), the bulk of this work remains unpublished and unknown.

Lately the studies of Biswas (1962), Baksi (1962, 1965) and Ghosh and Banerjee (1963) have provided valuable palynological data. Inspite of these individual papers of considerable merit, our knowledge concerning stratigraphical palynology of Assam remains meagre. Bio-stratigraphic and Time-stratigraphic units of many mapped formations have not been even approximately determined. This is chiefly because the earlier investigations have been based on individual samples or deal only with locally related formations.

The present study is based on extensive collections made from several outcrop sections of Type Localities of all the different sedimentary units covering the Lower, Central and Upper Assam. The samples were selected to cover the maximum possible vertical and horizontal range of the succession, special care being directed towards making them as representative as possible.

LITHOSTRATIGRAPHY

The Tertiary sequence in Assam commences with the Eocene, having two facies — a shelf facies and a geosynclinal facies. The shelf facies, locally known as the Jaintia Series, is best developed on the southern slopes of the Shillong Plateau and is divided into 3 stages — (1) Kopili Stage (Upper Eocene) (ii) Sylhet Limestone Stage (Lower to Middle Eocene, but generally regarded as Lower Eocene) and the Therria Stage (including Tura and Cherra Formation; Lowermost Eocene). The basal Therria Stage (= Cherra Formation), composed of a thick series of sandstones, shales and coal seams is, in all probability, Palaeocene in age. The contact between the Cherra Formation and the underlying Langpar Stage on the one hand and with the overlying Sylhet Limestone Stage on the other, is generally conformable. A single but distinct angular unconformity between the Cherra Sandstone and the Langpar Stage has been observed at the gorge face of 1023′ falls (91° 43′30″: 25°19′0″).

The Langpar Stage, comprising limestone and Calcareous shale, is considered to be Danian in age because of the contained foraminifera, like *Globigerina pseudobulloides* and *Globigerina triloculinoides*, etc.

The Sylhet Limestone Stage consists of highly foraminiferal limestone containing forms like *Miscellanea*, *Ranikothalia*, *Discocyclina*, *Gypsina*, etc. which are typical of the Ranikot, Laki and the Kirthar's. The limestones of the Sylhet Stage have been found to pass laterally into arenaceous marginal facies. Similar change to the arenaceous sedimentation cycle is also a common occurrence in the overlying Kopili Stage and the basal Therria Stage, which has given rise to difficulties in mapping them. Higher up in the sequence is the Kopili Stage which is composed of alternations of limestones, sandstones and shales and is regarded as the youngest member of the Eocene.

The geosynclinal facies of the Eocene, known as the Disang Series, is made up of dark-grey shales with thin bands of sandstones. The sandstones become frequent at the top and pass gradually upwards and sometimes laterally into the Barail Series.

The Barail Series, best developed in the north-eastern part of Assam is essentially arenaceous, comprising alternation of ferruginous sandstones, clays, shales and thick coal seams. The lowermost part of Barail Series appears to pass laterally into the upper part of the underlying Disang Series and may possibly be uppermost Eocene in age, but the upper part is definitely considered to be Oligocene in age. The shelf facies beds of the Barail Series outcrop in North Cachar and Mikir Hills and are mainly formed of ferruginous sandstones associated with carbonaceous shales. The geosynclinal facies is best developed in the Surma Valley and Upper Assam, forming a 4000-6000 metres thick series. The lowermost beds (Naogoan-Laisong Stage) are mostly well bedded sandstones associated with small shale bands. The Naogaon Stage is overlain by the comparatively much thicker Baragolai (= Jenum) Stage, which consists of sandstones, carbonaceous sales and coal seams. The overlying Tikak Parbat (= Renji) Stage is lithologically similar but is marked by a thick coal seam at the base.

The Barail Series is usually unconformably overlain by the beds of the Surma Series. The post-Barail unconformity or the Oligocene-Miocene unconformity is a marked feature in Upper Assam and forms an important factor in regional correlation, as well as in the correlation of the Assam sequence with that found in Burma and other regions. The Surma Series is essentially an alternation of medium-grained sandstones, siltstones, shales and thin bands of conglomerate. There is a record of a rich Aquitanian fauna in the Upper Bhuban substage (Lower Surma) in the Surma Valley which ascribes a Lower Miocene age to the Surma Series.

The Tipam Series, best exposed in the Mikir Hills and in Upper Assam, comprises variable thickness of coarse, gritty, ferruginous sandstone, at places, blue, greenish or brownish in colour, generally followed by a group of mottled clays. The Boka Bil Stage in the Garo Hills, now regarded as the basal member of the Tipam Series, has a rich Burdigalian fauna. The age of the Tipam Series is considered to be Middle to Upper Miocene.

The second important unconformity occurs above the Tipam Series. The Tipams are unconformably overlain by the Dupi Tila (= Namsang) beds which are subsequently overlain by the Dihing Series characterized by the pebble-beds, thin clays and sands. The Dupi Tila Series and Dihing Series are correlated with Lower and Upper Bone Beds of the Irrawaddy Series which are regarded as ranging from Late Miocene or Early Pliocene to Late Pliocene.

PALYNOSTRATIGRAPHY

The qualitative and quantitative analyses of samples representing the different series of the Tertiary succession in Assam has clearly revealed that (i) the sedimentary rocks, especially carbonaceous shales, siltstones, clays and coals are fairly rich in microfossil contents and (ii) the palynological assemblages include spore and pollen taxa which are stratigraphically significant. In order to interpret the stratigraphical value of the palynological data, the composition of individual palynological assemblage was first critically apprised and the relative frequency of individual species carefully noted, followed by the selection of important types. Only those species or taxa have been selected or taken into consideration which possess some distinctive features or which show reliable significant difference, of potential value in facies or regional correlation, i.e. the fossils must have a restricted vertical range, and must have been recognized from a sufficiently large number of localities. The following account sums up the information available from the palynological data collected so far and the general conclusion that may be drawn from it.

Mahadek and Langpar Stages — There is no definite record of fossil spores and pollen grains from the Mahadek (Maestrichtian) or the Langpar (Danian) sediments of Assam, except for a few species recorded by Biswas (1962, PL. 2, p. 35) from the Langpar formation of Um Sohryngkew river section of the Shillong Plateau. The partial palynological assemblage figured by Biswas (1962, PL. 2) seems to be a very poor representation of the Upper Cretaceous palynological assemblage and although the descriptions accompanying his figures are inadequate, the Um Sohryngkew assemblage approaches very close to the basal Cherra assemblage. More than 40 samples, from Type Sections of the Mahadek and the Langpar Stages of South Shillong Plateau have been investigated, but we have, so far not been able to obtain any palynological assemblage from them.

Jaintia Series — The Eocene sediments of Assam have been extensively studied. Analysis of the palynological data clearly indicates that the microfossil assemblages of the Palaeocene, Lower-Middle Eocene are fairly distinct and can be used for regional or facies correlation.

The Palaeocene sediments (from Cherra and Tura Formation) are well developed in Khasi and Jaintia, Mikir and Garo Hills. The palynological assemblages from several sections reveal that they are, in all cases, characterized by the predominance of two genera of uncertain affinities: *Schizosporis* Cookson & Dettmann (1959) and *Retialetes* Sah & Dutta (1966), which constitute 50 to 60 per cent of the total assemblage. The other important families represented are—Lycopodiaceae (PL. 1, FIG. 5, 8%), Matoniaceae (PL. 1, FIG. 8, 4%) and Polypodiaceae

(PL. 1, FIG. 4, 8%). The Angiosperms also form an important group, being fairly well represented, both in variety and frequency. The important families are Rubiaceae (PL. 2, FIGS. 11 & 15, 6%); Myricaceae (PL. 2, FIG. 13; 5-6%); Palmae (PL. 1, FIGS. 16 & 19, 5%); Onagraceae (PL. 2, FIGS. 16 & 18, 4%); Polygalaceae (PL. 2, FIG. 4, 2%) and Sapindaceae (PL. 2, FIG. 6, 2%). The coniferous and cycadophytic pollen are practically absent.

Passing on to the palynological assemblage of the Sylhet Limestone Stage (Lower-Middle Eocene), it was noticed that the frequency of angiosperms have increased, becoming ± dominant, while the pteridophytic grains have notably declined. The assemblage is further characterized by the ± total disappearance of *Schizosporis* and the corresponding increase in the number of *Monosulcites* (PL. 1, FIGS. 24-26), constituting up to 30 per cent of the total assemblage. Although the grains of *Retialetes emendatus* Sah & Dutta (1966) are comparatively less frequent in the Lower-Middle Eocene, than during the Palaeocene, they still remain an important constituent of the assemblage. Another important species, *Retialetes dubius* sp. nov. which appears to make its first appearance during the Middle Eocene times and reaching its maximum during the Upper Eocene is unrepresented in the Lower Eocene and Palaeocene.

The Kopili Formation (Upper Eocene) is generally very poor in microfossils. This assemblage differs from that of the Sylhet Limestone Stage in the absence of *Lycopodiumsporites* and *Retialetes* and a slight increase in the frequency of *Biretisporites* and *Polypodiisporites*. Amongst the angiosperms, grains of *Monosulcites* are fairly common, followed by the Myricaceae — type of grains, referred here to the genus *Triporopollenites*. The polycolpate-type and the Onagraceae-type of pollen have almost disappeared.

Barail Series — The difference in composition between the palynological assemblages of the Jaintia Series (Eocene) and the Barail (Oligocene) is more distinct. The genera *Schizosporis*, *Retialetes* and *Lycopodiumsporites*, which were very prominent in the Cherra formation, dwindled markedly during the deposition of the Kopili Formation, and seem to disappear completely from the Barails. The Barail Series is characterized by the marked abundance of pteridophytic spores among which polypodiaceous spores constitute nearly 50 per cent of the total assemblage. The important species are *Polypodiisporites oligocenicus* (PL. 1, FIG. 11, 30%); *Polypodiaceaesporites tertiarus* (PL. 1, FIG. 12, 15%); *Biretisporites* (*Hymenophyllumsporites*) *deltoidus* (PL. 1, FIG. 4, 8%); *Stereisporites psilatus* (PL. 1, FIG. 3, 2-3%) and *Schizosporites digitatoides* (PL. 1, FIG. 15; 1-2%). The angiosperms constitute the next important group with the following important species — *Palmaepollenites communis* (PL. 1, FIG. 19; 10-12%); *Anacolosidites luteoides* (PL. 2, FIG. 17; 5%); *Tetracolporites longicolpus* (PL. 2, FIG. 7; 1-2%); *Tetracolporites onagraceoides* (PL. 2, FIG. 15; 2-3%); *Cupuliferoidaepollenites liblarensis* (PL. 2, FIGS. 3, 8; 4-6%); *Favitricolporites complex* (PL. 2, FIG. 15; 5%) and *Polyporina excellens* (PL. 2, FIG. 20; 1-2%). The 'Gammate-Syncolpate' type, (in BAKSHI, 1962, PL. 3, FIGS. 38-39, Distribution Chart) appears to be restricted to the Laisong Stage of Lower and Central Assam.

Surma Series — Only 2 core samples from the Surma Series could be investigated, and none of them yielded any palynological fossils.

Tipam Series — The palynological distinction between the Barail Series (Oligocene) and the Tipam Series (Miocene) is distinctly marked by the highest occurrence of *Cicatricosisporites* (*Ceratopteris*) *macrocostata* (PL. 1, FIGS. 6-7; 40%) and the ± absence of *Polypodiisporites oligocenicus* in the latter. In the Tipam Series a number of new forms make their appearance e.g., *Podocarpidites microreticuloidatus* (PL. 1, FIG. 23; 4%); *Bombacacidites assamicus* (PL. 2, FIG. 12; 3%); *Rhoipites nitidus* (PL. 2, FIG. 10; 2-3%); *Ilexpollenites ornus* (PL. 2, FIG. 5; 2%) and *Graminidites assamicus* (PL. 2, FIG. 21; 5%).

Dihing Series — Although a few samples from the Dhekiajuli beds have so far been examined, the miofloral break between the Miocene and the Pliocene seems more apparent than it is between the Oligocene and the Miocene. The Dhekiajuli beds (Pliocene) can be distinguished by the abundance of *Corrugatisporites terminalis* (PL. 1, FIG. 9; 35%) followed by *Polygonacidites frequens* (PL. 2, FIGS. 22-23; 30%); *Polypodiaceaesporites tertiarus* (PL. 1, FIG. 12; 8-10%); *Retipilonapites cenozoicus* (PL. 2, FIG. 1; 8-10%); and *Polyporina globosa* (PL. 2, FIG.

19; 5%). Many palynological species are common to both the Miocene and the Pliocene assemblages. Some important species, such as *Cicatricosisporites* (*Ceratopteris*) *macrocostata*, *Podocarpidites microreticuloidatus*, *Bombacacidites assamicus*, *Rhoipites nitidus*, which are present in the Miocene assemblage, have not been found in the Dhekiajuli assemblage.

CONCLUSION

The analyses of the palynological data given in the previous section confirm that the application of these studies to dating and correlation of the Tertiary strata in Assam is practical and may prove to be a useful tool to economic and petroleum geologists. This conclusion is also supported by the results obtained by Bakshi (1962, 1965). A large measure of success has been achieved in distinguishing the five larger groups (i.e. Jaintia, Barail, ?Surma, Tipam and the Dihing Series). Differentiation of the stages and the formations have so far been attempted only in the South Shillong Plateau and Namdang River Section, as extensive field-work and sampling are essential to cover this aspect. Detailed palynostratigraphic studies of the Jaintia and the Barail Series are in advanced stages and the results obtained so far on the three stages of the Jaintia Series (i.e. Kopili Stage, Sylhet Limestone Stage and the Therria Stage) clearly indicate that palynological zones can not only be recognized within the Series but also within the Stages.

The vertical ranges of the significant taxa, evaluated from the data collected so far, are given in the distribution chart. The geologic value of the range of these selected taxa have been confirmed, as far as possible, from comparative studies of test samples from other sedimentation units. The credibility of the range chart presented here, is further evidenced from the close similarity of the curves obtained by Bakshi (1962, TEXT-FIG. 1) from the Simsang River Section. Despite the large number of samples investigated, much more information is still required. For successful regional correlation it has also to be seen whether the same guide fossils will be sufficient or whether separate guide fossils or range zones would have to be established for strata representing other depositional environment. The characteristics of the Palaeocene, Lower-Upper Eocene, Oligocene, Miocene and Pliocene are fairly well established. Very little is known about the palynological assemblage of the Upper Cretaceous sediments of Assam and, therefore, the relationship between the Upper Cretaceous and the Palaeocene remains uncertain and consequently the downward extension of the Palaeocene taxa has yet to be determined.

There seems to be a gradual and consistent passage of forms from the Palaeocene onwards up to the Miocene. The Sylhet Limestone Stage assemblage, in part, shows a transitional change from that of the Cherra Formation and by the Upper Eocene times (Kopili Stage) this change becomes marked. Similarly the Tipam (Miocene) assemblage, although quite distinct in part, shows a transitional relationship with the Barail assemblage (Oligocene). This is evident from the extenson of a fairly large number of Barial taxa into the Tipams. The values of the characteristic Barail taxa, together with the introduction of new forms, dominate and characterize the Tipam assemblage. Similar characteristics, with perhaps a few changes in frequency values, should be found in the Surma Series, when an assemblage is obtained from them. The " Gammate-Syncolpate " type of Bakshi (1962, PL. 3, FIGS. 38-39; TEXT-FIG. 1) which he considers as an index type for the Lower Oligocene, is infact restricted to the Lower Oligocene of Lower-Central Assam (Laisong Stage). They have not been observed in the equivalent Naogoan Stage of Upper Assam, nor have they been found in any of the Barail samples, considerably away from the geosynclinal sediments.

The Tipam and Dihing (Dhekiajuli beds) assemblages appear to show a slightly discordant relationship. This is seen in the simultaneous termination of several Miocene taxa. Although the Dhekiajuli assemblage is very rich, our studies on the Dihing Series are not detailed enough to establish the reasons for this noticeable inconsistency. It could be due to the omission of some sequence of geologic-time (?Namsang Stage) or it could be due to some major environmental shift.

SYSTEMATIC PALYNOLOGY

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch, 1881) Potonié & Kremp, 1954

19; 5%). Many palynological species are common to both the Miocene and the Pliocene assemblages. Some important species, such as *Cicatricosisporites* (*Ceratopteris*) *macrocostata*, *Podocarpidites microreticuloidatus*, *Bombacacidites assamicus*, *Rhoipites nitidus*, which are present in the Miocene assemblage, have not been found in the Dhekiajuli assemblage.

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SYSTEMATIC PALYNOLOGY

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch, 1881) Potonié & Kremp, 1954

Subturma — *Azonotriletes* Luber, 1935
Infraturma — *Laevigati* (Bennie & Kidson) Potonié, 1956

Genus *Cyathidites* Couper, 1953

Cyathidites minor Couper, 1953

Pl. 1, Fig. 1

1948 — In Sahni, Sitholey and Puri, pl. 16, fig. 35.
1952 — *Trilites* spm. 9, in Vimal, p. 138; pl. 5, fig. 13.
1962 — *Leiotriletes garoensis*, Baksi, p. 18; pl. 3, fig. 36.

Affinity — Cyatheaceae. Couper has noted the resemblance of his spores to those of *Coniopteris hymenophylloides*. The Assam grains compare closely to the spores of *Thyrsopteris elegans* Kunze.

Distribution — Tertiary sediments of Assam; Eocene of Dandot (Pakistan). Jurassic and Cretaceous of Australia.

Genus *Stereisporites* Pflug, 1953

Stereisporites psilatus (Ross) Pflug, 1953

Pl. 1, Fig. 3

1952 — In Pratap Singh, p. 418; fig. 9.

Remarks — The Assam spores cannot be distinguished from spores figured by Ross (1953) under *Trilites psilatus* and under *S.* (*Trilites*) *psilatus* by Pflug, (In THOMSON & PFLUG 1953, p. 53). The trilete mark in the Assam spores appears to have comparatively shorter rays and thinner lips.

Affinity — Ross (*l.c.*, p. 32) has described the spore from Scania as *Sphagnum*-like. The Assam spores, however, show closer affinity to spores found in the Cyatheaceae (*Cyathea dregei* Kunz) and to those met with in the family Dennstaedtiaceae (*Microlepia*).

Distribution — Cretaceous of Scania; Tertiary of Middle Europe; Palaeogene of Assam.

Stereisporites assamensis sp. nov.

Holotype — Pl. 1, Fig. 2; Size 44 μ; Sample No. 32942, Slide No. 6/4.

Type Locality — Assam, Umstew, South Shillong Plateau, India.

Horizon — Cherra Formation (Palaeocene).

Diagnosis — Size range 40-48 μ; amb deltoid; trilete distinct, laesura length 1/2 to 3/4 of the spore radius, lips elevated; exine up to 2 μ thick, ornamentation psilate.

Description — Miospores biconvex, amb roundly triangular to sub-spheroidal, generally deltoid in polar view. Trilete distinct, rays straight, with faint thickenings. Exine uniformly thick, usually having small folds.

Comparison — *Stereisporites assamensis* differs from *S. antiquasporites* (Wilson & Webster) Dettmann 1963, in having a more triangular form and also in the larger size of the grains. *S. stereoides* (Potonié & Venitz) Pflug (in Thomson and Pflug, 1953) also differs from the present species in its comparatively much smaller size and in having longer laesura. *S. psilatus* (Ross) Pflug also differs in its comparatively much smaller size and a thick exospore. *Stereisporites* (*Sphangnites*) *australis* Cookson 1954, can be distinguished by its smaller size and much thicker wall of the exine.

Distribution — Tertiary of Assam.

Genus *Biretisporites* (Delcourt & Sprumont) Dettmann & Hughes, 1965

Biretisporites (*Hymenophyllumsporites*) *deltoidus* (Rouse, 1957) Dettmann, 1963

Pl. 1, Fig. 4

1964 — *Scabratriletes* sp. Banarjee, p. 8; pl. 1, fig. 8, 10.

Distribution — Upper Cretaceous of Western Canada and Tertiary of Assam.

Biretisporites triglobosus Sah & Dutta, 1966

Pl. 1, Fig. 8

Distribution — Eocene of Assam, and Dandot.

Infraturma — *Murornati* Potonié & Kremp, 1954

Genus *Corrugatisporites* (Thomson & Pflug; Ibrahim) ex Weyland & Greifeld, 1953

Corrugatisporites terminalis sp. nov.

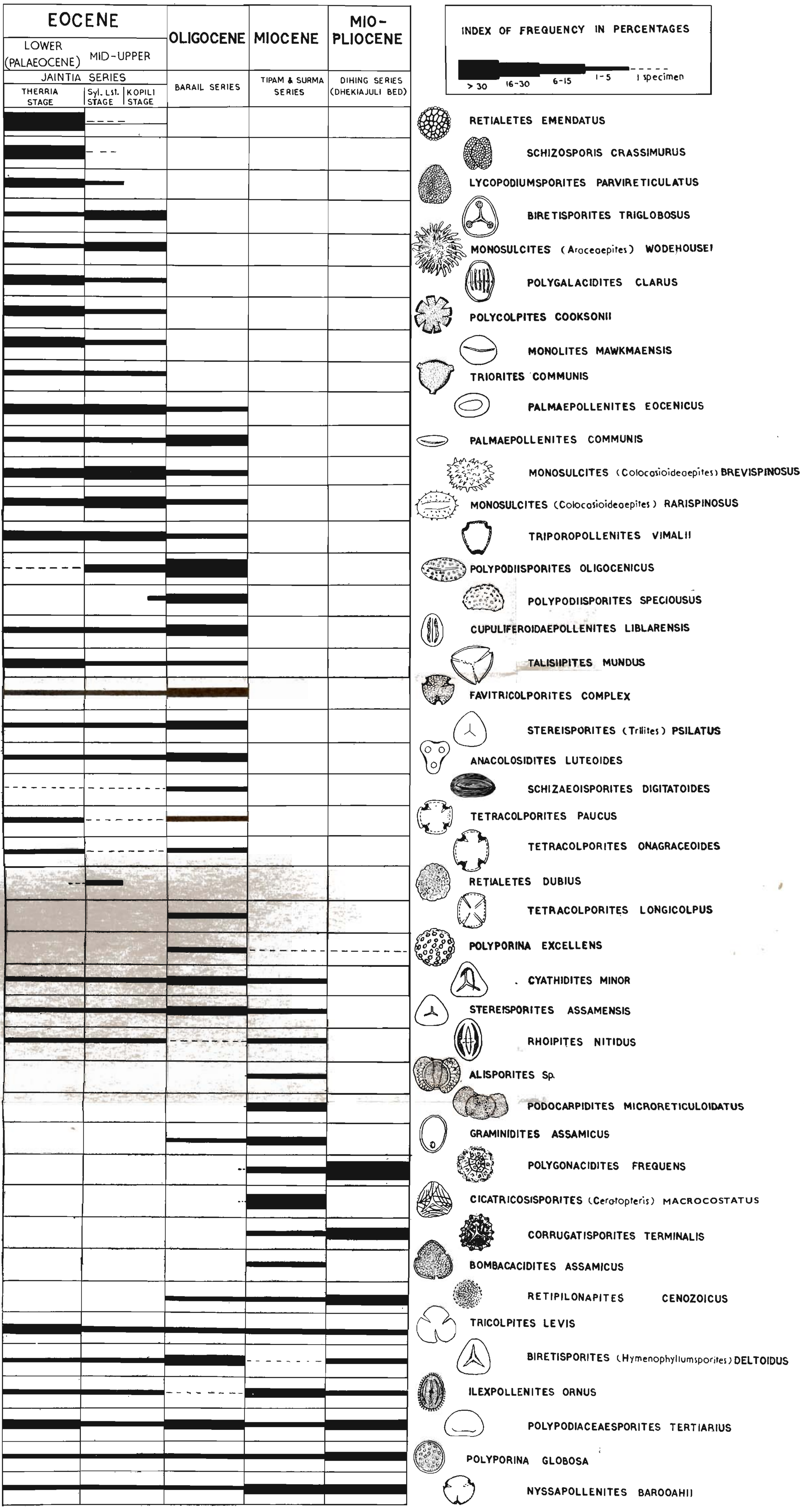
Holotype — Pl. 1, Fig. 9; Sample No. 2792, Slide No. 2/25.

Type Loctity — Upper Assam, Digboi field, India.

Horizon — Dhekiajuli Beds, Dihing Series (Mio-Pliocene).

Specific Diagnosis — Size range 45-56 μ; amb roundly triangular to convexly triangular; trilete present, laesura straight, more than 3/4 the spore radius; exine thick, ornamented both proximally and distally, proximal face having rugulae forming

STRATIGRAPHIC RANGE OF THE SIGNIFICANT TAXA IN THE TERTIARY SUCCESSION OF ASSAM



variously shaped channels, distal surface reticulate.

Description — Miospores trilete, probably biconvex. Trilete mark usually inconspicuous, partly obscured by the sculptural elements. Proximal surface convex, with mostly elongate projections, rugulae irregular in shape, fairly thick and do not join to form a lumina; distal surface possessing a distinct and coarsely meshed reticulum, with 4 to 5 μ thick muri, lumina comparatively shallow and irregular in shape.

Comparison — Although *Corrugatisporites terminalis* compares superficially to the Type species *C. toratus* Weyland & Greifeld (1953, p. 42, PL. 11, FIG. 57), the former can be distinguished in possessing a perfect reticulum on the distal face and also in having much coarser sculptural elements. *C. terminalis* is also distinct from *C. solidus* Potonié (1934, p. 32), which has a distinct trilete and which also lacks rugulate sculpture on the proximal face. *C. multivallatus* Pflug (1953, p. 56; PL. 2, FIGS. 37-40) and *C. paucivallatus* Pflug (*l.c.*, p. 56; PL. 2, FIGS. 41-43) can be distinguished in having a distinct trilete and comparatively finer sculptural elements. The differentiation in the ornamentation of the proximal and distal faces has not been clearly defined by Pflug, nor is it clear from his photographs, hence it is difficult to compare the differences in the ornamentation pattern.

Affinity — Pflug (in THOMSON & PFLUG, p. 56, 1953) mentions that his species closely resemble to those of *Lygodium* (Schizaeaceae). The present species is not comparable to any of the two species of *Lygodium* found in Assam. The general morphological characters are, however, strongly suggestive of their relationship to *Lygodium*. Spores similar in shape, size, and ornamentation are also met with in the Lycopodiaceae.

Distribution — Mio-Pliocene of Assam.

Genus *Lycopodiumsporites* Thiergart, 1938

Lycopodiumsporites parvireticulatus Sah & Dutta, 1966

Pl. 1, Fig. 5

Distribution — Eocene of Assam.

Genus Cicatricosisporites Potonié & Gelletich, 1933

Cicatricosisporites (*Ceratopteris*) *macrocostatus* (Bakshi, 1962) comb. nov.

Pl. 1, Figs. 6-7

1962 — *Ceratopteris macrocostata* Bakshi, p. 20, pl. 4, fig. 53.

1962 — ? *Schizaeaceaesporites*/*Parkeriaceaesporites*, in Bakshi, p. 20; pl. 5, fig. 54.

1962 — ? *Cicatricosisporites* sp., in Biswas, p. 35; pl. 2, fig. 2.

1964 — *Steriatriletes* sp. A-B, in Banerjee, pp. 3-4; pl. 1, figs. 11, 16-18.

Lectotype — In Biswas, 1962, pl. 4, fig. 53, Size 72 μ, Sample No. VD301.

Type Locality — Assam, Simsang River Section, South Shillong, India.

Horizon — Simsang Palynological Zone IV (Miocene).

Restated Diagnosis — Size range 50-100 μ; amb roundly triangular, apices broadly rounded, sides concave, sometimes straight; trilete distinct, laesura straight, 1/2-3/4 of the spore radius, lips thin; exospore ornamented with fairly thick, parallel ridges, a number of which bifurcate and appear as two sets of intersecting ridges.

Comparison — The grains figured by Bakshi (1962, p. 20; PL. 4, FIG. 53) under *Ceratopteris macrocostata* and under *Schizaeaceaesporites*/*Parkeriaceaesporites* (PL. 5, FIG. 54) seem identical. Bakshi's placement of this spore under separate taxa does not seem justified. The minor variations between the two are seen in some of our specimens as mixed characters. The grain figured by Biswas (1962, PL. 2, FIG. 2) is very badly preserved. It is quite likely that it might belong to a different species. The grains figured by Banerjee (1964, PL. 1, FIGS. 11, 16-18) seem identical.

Affinity — Bakshi (1962, p. 20) has noted the resemblance of these spores to those of Parkeriaceae (*Ceratopteris*). From the large size and the disposition of the ridges on the exospore, they seem to compare more closely to Parkeriaceae than Schizaeaceae.

Distribution — Abundant in Miocene.

Turma — *Monoletes* Ibrahim, 1933
Subturma — *Azonomonoletes* Luber, 1935
Infraturma — *Laevigatomonoleti* Dybova & & Jachowicz, 1957

Genus *Polypodiaceaesporites* Thiergart, 1940

Polypodiaceaesporites tertiarus sp. nov.

Holotype — Pl. 1, Fig. 12, Size 46 μ; Sample No. 31702, Slide No. 4/1.

Type Locality — Upper Assam, Namdang River Section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Specific Diagnosis — Size range 40-51 μ; amb bean-shaped, extremities broadly rounded; monolete, laesura appearing as a narrow ridge, slightly more than 1/2 the longer axis, exine up to 2 μ thick, ornamentation scabrate, sometimes with a faintly discernible verrucoid pattern.

Description — Miospore monolete, bilateral; profile concavo-convex, proximal side slightly concave, distal side distinctly convex. Monolete mark bordered by a narrow, up to 2 μ high ridge. Wall of the exine firm, sculpture not clear but appears to be scabrate at some places and indistinctly verrucoid at others.

Comparison — *P. tertiarus* differs from the Genotype species *P. haardti* (Potonié & Venitz) Thiergart (1938, PL. 22, FIG. 17) in general form, thickness and ornamentation of the exine. *P.* (*Monolites*) *major* (Cookson, p. 135) comb. nov., differs in its larger size, simple laesura and in having a psilate exine. *P.* (*Monolites*) *minor* (Cookson) Potonié (1956, p. 76) also differs in the same characters.

Affinity — Polypodiaceae; the spores are closely comparable to those of *Microsorium* Link.

Distribution — Found throughout the Tertiary succession of Assam.

Genus *Monolites* (Erdtman) Potonié, 1956

Monolites mawkmaensis Sah & Dutta, 1966

Pl. 1, Fig. 18

Distribution — Eocene of Assam.

Infraturma — *Sculptatomonoleti* Dybova & Jachowicz, 1957

Genus *Polypodiisporites* Potonié, 1934

Polypodiisporites speciosus Sah, 1967

Pl. 1, Figs. 13 & 14

Affinity — Polypodiaceae.

Distribution — Upper Neogene of Rusizi Valley, Burundi; Oligocene of Upper Assam.

Polypodiisporites oligocenicus sp. nov.

Holotype — Pl. 1, Fig. 11; Sample No. 31702, Slide No. 3/5.

Type Locality — Upper Assam, Namdang River section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Specific Diagnosis — Size range 28-36 μ × 40-51 μ; amb elliptical in polar view; monolete, laesura appearing as a narrow prominent ridge, 1/2 to 3/4 the longer axis; exine up to 1 μ thick, verrucate, verrucae very low, with flat tops; *extrema lineamenta* more or less smooth.

Description — Miospores monolete, bilateral, profile plano-convex, proximal face ± straight, distal face convex. Exine ornamentation characterized by very low wart-like cusions which are not really verrucae. They are not very high and do not appear to project out.

Comparison — *Polypodiisporites oligocenicus* can be distinguished by its low wart-like cushions, which in the other species are in the form of coni or rounded verrucae or papillate outgrowths.

Affinity — Polypodiaceae. The present species is closely comparable to *Gomiophlebium amoenum*, which is a common species in the Khasi hills.

Distribution — Palaeogene of Assam.

Genus *Schizaeoisporites* Potonié, 1960

Schizaeoisporites digitatoides (Cookson, 1957) Potonié, 1960

Pl. 1, Fig. 15

1961 — *Schizaea digitata* Bolkhovitina, p. 23, pl. 3, fig. 9A-C.

1962 — *Monocolpopites striaei* Bakshi, p. 17, pl. 2, fig. 19.

Affinity — Schizaeaceae. The spores are closely comparable to the spores of *Schizaea digitata* (L) SW.

Distribution — Kalewa beds (Eocene) of Burma; Paleogene of Assam.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Disaccites* Cookson, 1947
Infraturma — *Pinosacciti* (Erdtman, 1945) Potonié, 1958

Genus *Alisporites* Daugherty, 1941

Alisporites sp.

Pl. 1, Fig. 10

Description — Pollen grains bisaccate, measuring 55-69 μ (including sacci). Body elongate, measuring 36 × 46 μ, with a 2-3 μ thick rim, and a vertical fusiform furrow. Bladders kidney-shaped, fairly large, measuring 36 × 59 μ. Ornamentation in both body and bladders not distinct but at places appears to be reticulate.

Comparison — A few grains have been recovered only from the Miocene strata. None of them are preserved well enough for specific comparisons.

Distribution — Tipam sandstone, Tipam Series (Miocene).

Infraturma — *Podocarpoiditi* Potonié, Thomson & Thiergart, 1950

Genus *Podocarpidites* (Cookson, 1947) Couper, 1953

Podocarpidites microreticuloidatus Cookson, 1947

Pl. 1, Fig. 23

1962 — *Coniferipites garoensis* Bakshi, p. 20; pl. 4, fig. 49.

1962 — ? *Coniferipites abiesimilis* Bakshi, p. 20; pl. 4, fig. 52.

Remarks — Pollen grains from Assam cannot be distinguished from the holotype species, *Podocarpidites microreticuloidatus* Cookson (*l.c.*). Although the grain figured by Bakshi (*l.c.*, PL. 4, FIG. 49) as *Coniferipites garoensis* is not well preserved, the general characters suggest that it is closely comparable to *P. microreticuloidatus*. Similarly the grain figured by him (*l.c.*, PL. 4, FIG. 52), though compressed and deformed, seem to be identical.

Affinity — Podocarpaceae.

Distribution — Tertiary of Kerguelen Archipelago; Miocene of Assam.

Turma — *Aletes* Ibrahim, 1933
Subturma — *Azonaletes* (Luber 1935) Potonié & Kremp, 1954
Infraturma — *Reticulonapiti* (Erdtman) Vimal, 1952

Genus *Retialetes* Sah & Dutta, 1966

Retialetes emendatus Sah & Dutta, 1966

Pl. 1, Fig. 22

Distribution — Eocene, abundant in Palaeocene-Lower Eocene.

Retialetes dubius sp. nov.

Holotype — Pl. 1, Fig. 20; Sample No. 2791; Slide No. 3/1.

Type Locality — Lower Cherrapunji, Assam, India.

Horizon — Lakadong sandstone, Jaintia Series (Lower-Middle Eocene).

Specific Diagnosis — Size range 36-42 μ, amb spheroidal to generally spherical; non-aperturate; exine up to 2 μ thick, surface sculpture reticulate, with irregular hexagonal meshes; *extrema lineamenta* smooth.

Description — Grains non-aperturate, radio-symmetrical. Exine two layered, distinctly reticulate, muri low, less than 1 μ high, lumina up to 10 μ in width.

Comparison — The grains do not compare with any of the known fossil or living taxa. The grain figured by Vimal (1953, FIG. 4, PHOTO 2), from the Warkalli lignites, is not well preserved, but from his figure (FIG. 4) and description (p. 302) it appears that the spore figured by him is closely comparable to the Assam species.

Affinity — Uncertain.

Distribution — Lower-Middle Eocene of Assam.

Infraturma — *Subpilonapiti* (Erdtman) Vimal, 1952

Genus *Retipilonapites* Ramanujam, 1966

Retipilonapites cenozoicus Sah, 1967

Pl. 2, Fig. 1

Affinity — Potamogetonaceae.

Distribution — Upper Neogene of Rusizi Valley, Congo; Oligocene to Mio-Pliocene of Assam.

Turma — *Plicates* (Naumova) Potonié, 1960
Subturma — *Monocolpates* Iverson & Troels-Smith, 1950
Infraturma — *Retectines* (Malwakina) Potonié, 1960

Genus *Monosulcites* (Cookson) Couper, 1953

Monosulcites rarispinosus Sah & Dutta, 1966

Pl. 1, Fig. 26

1948—In Sahni, Sitholey & Puri, pl. 4, fig. 18.

Distribution — Palaeogene of Assam.

Monosulcites (*Araceaepites*) *wodehousei* (Biswas, 1962) Sah & Dutta, 1966

Pl. 1, Fig. 24

1948 — In Sahni, Sitholey & Puri, pl. 15. fig. 21.

Distribution — Eocene of Assam.

Monosulcites (*Colocasioideaepites*) *brevispinosus* (Biswas, 1962) Sah & Dutta, 1966

Pl. 1, Fig. 25

1948 — In Sahni, Sitholey & Puri, pl. 16, fig. 44.

Distribution — Palaeogene of Assam.

Subturma — *Monoptyches* (Naumova 1937) Potonié, 1958

Genus *Palmaepollenites* Potonié, 1951

Palmaepollenites communis Sah & Dutta, 1966

Pl. 1, Fig. 19

Distribution — Palaeogene of Assam.

Palmaepollenites eocenicus (Biswas, 1962) Sah & Dutta, 1966

Pl. 1, Figs. 16-17

Distribution — Palaeogene of Assam.

Subturma — *Dicolpates* Erdtman, 1947

Genus *Schizosporis* Cookson & Dettman, 1959

Schizosporis crassimurus Sah & Dutta, 1966

Pl. 1, Fig. 21

Distribution — Palaeocene- Lower Eocene of Assam.

Subturma — *Triptyches* (Naumova) Potonié, 1960

Genus *Cupiliferoidaepollenites* Potonié, Thomson & Thiergart, 1950

Cupiliferoidaepollenites liblarensis Thomson (in Pot., Thoms. & Thierg., 1950)

Pl. 2, Figs. 3, 8

1962 — *Tricolpopites prolati* Baksi, p. 19; pl. 4, fig. 44.

Comparison — The Assam grains seem to compare closely to the Type species *Cupiliferoidaepollenites liblarensis* Potonié, Thomson & Thiergart (1950, FIG. 26; POTONIÉ, 1960, PL. 6, FIG. 94).

Affinity — ? Fagaceae. In their general form, shape and size the Assam grains compare closely to the pollen met with in the sub-family Castaneoideae.

Distribution — Palaeogene of Assam

Genus *Tricolpites* (Erdtman, Cookson, Ross) Couper, 1953

Tricolpites levis Sah & Dutta, 1966

Pl. 2, Fig. 2

Affinity — ? Polygonaceae. The grains closely compare with those of *Rumex* L.

Distribution — Tertiary of Assam.

Subturma — *Polyptyches* (Naumova) Potonié, 1960

Genus *Polycolpites* Couper, 1953

Polycolpites cooksonii Sah & Dutta, 1966

Pl. 2, Fig. 11

1948 — In Sahni, Sitholey & Puri, p. 15, fig. 27.

Distribution — Eocene of Assam.

Genus *Polygalacidites* Sah & Dutta, 1966

Polygalacidites clarus Sah & Dutta, 1966

Pl. 2, Fig. 4

Diagnosis — See Sah & Dutta, 1966, p. 81.

Distribution — Eocene of Assam.

Subturma — *Ptychotriporines* (Naumova) Potonié, 1960

Infraturma — *Prolati* Erdtman, 1943

Genus *Ilexpollenites* Thiergart, 1937

Ilexpollenites ornus sp. nov.

1962 — *Tricolpopites aquifoliaceaeformis* Biswas, p. 38; pl. 5, fig. 18.

1962 — In Biswas, pp. 40 and 44; pl. 10, fig. 3; pl. 6, fig. 29.

Holotype — Pl. 2, Fig. 5; Sample No. 2790, Slide No. 5/1.

Type Locality — Upper Assam, Tipam sandstone, Digboi field, India.

Horizon — Tipam sandstone, Tipam Series (Miocene).

Diagnosis — Size range 34-36 μ, amb rhomboid to elliptical in equatorial view; ? tricolporate, pores indistinct, colpi deep; exine two layered, ? retipilate, sexine composed of small piloid rodlets.

Description — Grains usually preserved in equatorial view. Pores generally indistinct (but discernible in some), colpi broad and long, but not reaching the poles. Exine relatively thin, less than 1·5 μ, surface beset with small rods.

Comparison — *Ilexpollenites ornus* agrees with *I. novae-angliae* Traverse (1955, FIG. 11, No. 76) in form and size but differs in the ornamentation of the exine, which in the latter is composed of baculae. The Assam species also differs from the other species in having ratipilate condition.

Affinity — Uncertain. The characters of the pollen grains are not conclusive and so it is difficult to suggest their natural affinity. The characters of the exine excludes the possibility of their having an affinity with the family Aquifoliaceae.

Distribution — Tertiary of Assam.

Genus *Rhoipites* Wodehouse, 1933

Rhoipites nitidus sp. nov.

1964 — *Psilatricolporites* spp., in Banerjee, p. 8; pl. 2, figs. 18 & 22.

Holotype — Pl. 2, Fig. 10; Sample No. 2790, Slide No. 3/6.

Type Locality — Upper Assam, Tipam sandstone, Digboi field, India.

Horizon — Tipam sandstone, Tipam Series (Miocene).

Specific Diagnosis — Size range 21-25 μ; amb oblate-spheroidal in polar view, subprolate in equatorial; 3-zonaperturate, distinctly colporate, os lalongate; exine thin, two-layered, ornamentation finely sculptured.

Description — Nearly spheroidal in polar view, divided into three lobes by fairly deep furrows. Grains usually preserved in equatorial view, oval-elongate in outline. Distinctly tricolporate, pores transversely elongate. Exine less than 1 μ wide, usually undifferentiated, ornamentation very faint, at places appearing to be finely striate.

Comparison — *Rhoipites bradleyi* Wodehouse (1933, p. 513; FIG. 45) differs in having a reticulate-pitted exine. *R. pseudocingulum* Potonié (1931, PL. 1, FIG. 3; 1934, PL. 3, FIGS. 20, 27-32, 34, 36-38; pp. 74-75) agrees in shape and somewhat size, but differs in the exine character. *R. dolium* Potonié (1931) agrees in size but differs in having circular pores and also in the ornamentation of the exine.

Affinity — Anacardiaceae. This distinctive species from Assam possess characters closely comparable with the pollen grains of *Rhus* and it is quite likely that they might represent that genus.

Distribution — Eocene and Miocene of Assam.

Genus *Bombacacidites* Couper, 1960

Bombacacidites assamicus sp. nov.

Holotype — Pl. 2, Fig. 12; Sample No. 2790, Slide No. 1/4.

Type Locality — Upper Assam, Tipam sandstone, Digboi field, India.

Horizon — Tipam sandstone, Tipam Series (Miocene).

Specific Diagnosis — Size range 30-36 μ; amb roundly triangular; planaperturate, 3-colporate, longicolpate; exine finely reticulate.

Description — Pollen grains small, distinctly triangular in outline, apex rounded, sides convex. Pores midway between the sides; colpi long almost reaching the poles. Exine two layered, sexine retipilate; surface pattern finely reticulate.

Comparison — *B. assamicus* compares with *B. bombaxoides* Couper (1960, p. 53; PL. 7, FIGS. 13-14) in shape, size and ornamentation but differs in having much longer colpi. The grain figured by Kuyl, Muller and Waterbolk (1955, PL. 2, FIG. 11) differs in having a coarser exine. *B. africanus* Sah and *B. clarus* Sah (1967) from the Neogene of Burundi, differ in possessing short colpi and a comparatively much coarser exine.

Affinity — Bombacaceae.

Distribution — Miocene of Assam.

Subturma — *Ptychotriporines* (Naum.) Potonié, 1960

Genus *Nyssapollenites* Thiergart, 1937

Nyssapollenites barooahii sp. nov.

Holotype — Pl. 2, Fig. 9; 23 μ; Sample No. 2790, Slide No. 5/2.

Type Locality — Upper Assam, Tipam sandstone, Digboi field, India.

Horizon — Tipam sandstone, Tipam Series (Miocene).

Diagnosis — Size range 21-26 μ; amb roundly triangular in polar view, ovoid in equatorial; 3-zonaperturate, colporate, pores round, colpi wide at the equator, narrow towards the pole; exine two layered, sexine thickened at the aperture region, ornamentation psilate to scabrate.

Description — Pollen grains nearly circular in outline, but retaining its triangular shape, sides convex; distinctly three furrowed Pores slightly lalongate, colpi extending up to less than 1/2 the distance to the poles. Exine less than 1 μ in width, much thicker at the aperture regions, ornamentation obscure but at places appears to be infrastructured.

Comparison — *Nyssapollenites barooahii* can be distinguished from the other species of *Nyssapollenites* in having a more rounded amb and in the characteristically thickened exine at the aperture regions.

Affinity — Uncertain. Although the grains compare very closely to the pollen met with in the family Nyssaceae, a thickened exine at the aperture region has not been observed in any of the species of *Nyssa*. The thickened sexine at pore regions suggests affinity with the family Rutaceae or with the family Euphorbiaceae. Some of the indistinct characters, however, make an indication of their natural affinity difficult. Both the families are fairly common in the present day vegetation of the region.

Derivation of Name — The species is named after Sri S. K. Barooah, former Director, Geology and Mining, Government of Assam, who has extensively contributed towards the geology of Assam and for his constant help.

Distribution — Tertiary of Assam.

Genus *Favitricolporites* Sah, 1967

Genotype — *Favitricolporites eminens* sp. nov.; Pl. 6, Fig. 17, diameter 40 μ.

Type Locality — Burundi, Rusizi Valley, Kundava; Bore Hole Ru. 231; Neogene.

Favitricolporites complex sp. nov.

1962 — *Tricolporipites*, In Biswas, p. 37; pl. 5, fig. 3.

Holotype — Pl. 2, Fig. 15; Size 55 μ; Sample No. 31702; Slide No. 1/13.

Type Locality — Upper Assam, Namdang River Section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Diagnosis — Size range 53 to 59 μ; amb triangular; 3-zonaperturate, colporate, brevicolpate, grandorate, crassimarginate; exine thick, undifferentiated, ornamentation finely reticulate.

Description — Pollen grain medium-sized, distinctly triangular in polar view, aperture regions characterized with distinct thickenings, colpi short, widely gaping at the angles, pores ± rounded to slightly lalongate. Exine up to 3 μ thick, distinctly pitted-reticulate in surface view.

Comparison — *F. complex* compares closely to *F. magnus* Sah (1967) in general form, character of the apertures and the ornamentation of the exine, but differs in having a comparatively small size range and shorter colpi. In *F. magnus* the colpi are comparatively deep.

Affinity — Rubiaceae. The pollen grains of *F. complex* compare closely to the pollen grains of *Coffea*.

Distribution — Palaeogene of Assam.

Genus *Talisiipites* Wodehouse, 1933

Talisiites mundus sp. nov.

Holotype — Pl. 2, Fig. 6; Sample No. 31702, Slide No. 6/1.

Type Locality — Upper Assam, Namdang River Section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Diagnosis — Size range 20-28 μ; amb triangular in polar view; 3-zonaperturate, distinctly colporate, usually syncolpate, ora circular to slightly lalongate; exine undifferentiated; very faintly microreticulate.

Description — Pollen grains small, probably isopolar, with slightly convex sides. Angulaperturate, colpi usually uniting at the poles but none of the Assam specimens show a parasyncolpate condition, sometimes colpi not reaching the poles. Exine less than 1 μ thick, surface sculpturing very faint, but appears to be composed of a very fine and shallow reticulum.

Comparison — *Talisiipites mundus* sp. nov. compares closely to *T. fiocheri* Wodehouse (1933, pp. 513-514; FIG. 46) in shape and size but differs in having a faintly microreticulate sculpture, which in the latter is finely granular.

Affinity — Wodehouse (*l.c.* p. 513) has remarked that the type species matches perfectly with pollen of *Talisia depressa*. The morphological characters of the Assam species, especially aperture characters, strongly suggest affinity to the family Sapindaceae.

Distribution — Palaeogene of Assam.

Subturma — *Ptychopolyporines* (Naumova) Potonié, 1960

Genus *Tetracolporites* Couper, 1953

Tetracolporites paucus sp. nov.

Holotype — Pl. 2, Fig. 14; Sample No. 31702; Slide No. 3/2.

Type Locality — Upper Assam, Namdang River Section, Digboi field, India.

Horizon — Baragolai stage, Barail Series, (Oligocene).

Specific Diagnois — Size range 47-56 μ; amb quadrangular; 4-zonaperturate, colporate, os lalongate, crassimarginate; exine fairly thick, undifferented, ornamentation pitted-reticulate, polybrochate, simplibaculate.

Description — Pollen grains medium-sized, as a rule quadrangular in shape, sides convex, giving it a ± rounded appearance. Grains distinctly tetracolporate, ora rounded to slightly lalongate, with characteristically thickened rim; colpi distinct, very short, wide at the angles, pointed towards the poles. Exine up to 3 μ thick, sexine and nexine undifferentiated, surface ornamentation coarsely reticulate, reticulum composed of a large number of very small meshes.

Comparison — *Tetracolporites paucus* differs from *T. omarunsis* Couper (1954, p. 64; PL. 8, FIG. 106; 1960, p. 63; PL. 10, FIGS. 8-9), in general form and ornamentation of the exine. *T. ixerboides* Couper (1960, p. 63; PL. 10, FIGS. 12 & 13) compares in general form, size and aperture characters but differs in having a scabrate exine. *T. sphericus* Couper (1960, p. 64; PL. 10, FIGS. 10-11) differs in having a spherical shape and also in the ornamentation of the exine. The other species of *Tetracolporites* described by Sah from the Neogene of Congo (1967) also differ in shape and ornamentation of the exine.

Affinity — ? Rubiaceae; ? Onagraceae.

Distribution — Palaeogene of Assam.

Tetracolporites onagraceoides sp. nov.

1964 — *Stephanoporines*, in Banerjee, p.6, pl. 2, fig. 25.

Holotype — Pl. 2, Fig. 16; Sample No. 31702, Slide No. 3/4

Type Locality — Uppar Assam, Namdang River section, Digboi field India.

Horizon — Baragolai stage, Barail Series (Oligocene)

Specific Diagnosis — Size range 58 to 66 μ; amb quadrangular; 4-zonaperturate, colporate, brevicolpate, os lalongate, crassimarginate; sexine as thick as nexine, ornamentation obscure, at places appears to be scabrate.

Description — Pollen grains fairly large, quadrangular in outline, sides convex. Angulaperturate, with bulge-like apertures; colpi short, widely gaping at the angles, pointed towards the poles. Pores large, transversely elongate and rimmed with characteristic thickenings. Exine up to 4 μ thick, generally undifferentiated, surface sculpturing indistinct, in some specimens appears to be faintly sculptured.

Comparison — *Tetracolporites onagraceoides* can be distinguished from *T. paucus* in not having a pitted-reticulate sculpture. From the other species of the genus *Tetracolporites* the present species differs in having characteristic bulge-like apertural parts and also in the ornamentation of the exine.

Affinity — Onagraceae. Pollen grains of *T. onagraceoides* compare well with pollen grains of *Jussieua* L.

Distribution — Palaeogene of Assam.

Tetracolporites longicolpus sp. nov.

Holotype — Pl. 2, Fig. 7; Sample No. 31702, Slide No. 1/9.

Type Locality — Upper Assam, Namdang River section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Specific Diagnosis — Size range 27-34 μ; amb quadrangular; 4-zonaperturate, distinctly colporate, os slightly lalongate, colpi long, almost extending up to the poles; exine thick, undifferentiated, ornamentation obscure.

Description — Pollen grains medium-sized, prolate spheroidal in outline, sides convex. Angulaperturate, aperture regions appear to be thickened. Exine up to 4 μ thick, ornamentation indistinct.

Comparison — *Tetracolporites longicolpus* differs from all the three Australian species in having comparatively much longer colpi and also in the ornamentation of the exine. It differs from the other species of the genus *Tetracolporites* in the same characters.

Affinity — Meliaceae; the pollen grains of *T. longicolpus* compare very closely to the pollen grains of *Melia* L.

Distribution — Oligocene of Assam.

Turma — *Poroses* (Naumova) Potonié, 1960

Subturma — *Monoporines* (Naumova) Potonié, 1960

Genus *Graminidites* Cookson, 1947

Graminidites assamicus sp. nov.

Holotype — Pl. 2, Fig. 21; Sample No. 31702, Slide No. 2/2.

Type Locality — Upper Assam, Namdang River section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Specific Diagnosis — Size range 43-47 μ; amb oval-elliptical; monoporate, pore ulcerate; exine well differentiated, sexine as thick as nexine, ornamentation psilate.

Description — Pollen grains medium-sized, almost globular in outline. Monoporate, pore up to about 2·5-3 μ across. Surface ornamentation psilate to faintly structured.

Comparison — The two Australian species, *G. media* and *G. subreticulata* described by Cookson (1947, p. 134, PL. 15, FIGS. 41-43) differ in having a distinctly reticulate sculpture.

Affinity — Gramineae.

Distribution — Oligocene and Miocene of Assam.

Subturma — *Triporines* (Naumova) Potonié 1960

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

Triporopollenites vimalii Sah & Dutta, 1966

Pl. 2, Fig. 13

1948 — In Sahni, Sitholey & Puri, pl. 14, fig. 19.

Distribution — Palaeogene of Assam.

Genus *Anacolosidites* Cookson & Pike, 1954

Anacolosidites luteoides Cookson & Pike, 1954

Pl. 2, Fig. 17

1955 — In Kuyl, Müller and Waterbolk, p. 64; pl. 2, fig. 8.

Remarks — Except for their slightly larger size, the Assam grains cannot be distinguished from *Anacolosidites luteoides* Cookson & Pike (1954) from the Eocene sediments of Australia. The grains figured by Kuyl, Müller and Waterbolk (1955) seem identical.

Affinity — Olacaceae. Morphologically the Assam grains are closely comparable to the pollen of *Anacolosia densiflora* and *A. arborea*.

Distribution — Cainozoic of Australia, Upper Tertiary of N. Guinea, Palaeogene of Assam.

Genus *Triorites* (Erdtman, Cookson) Couper, 1953

Triorites communis Sah & Dutta, 1966

Pl. 2, Fig. 18

1964 — *Verrutricolporites*, in Banerjee, p. 3; pl. 1, fig. 11.

Affinity — Onagraceae (*Epilobium*).

Distribution — Eocene of Assam.

Subturma — Polyporines (Naumova) Potonié, 1960

Infraturma — Periporiti (Van der Hammen) Potonié, 1960

Genus Polyporina (Naumova) Potonié, 1960

Polyporina globosa Sah, 1967

Pl. 2, Fig. 19

1964 — Polyforate grain, in Bose & Sah, p. 222; pl. 1, fig. 22.

Distribution — Tertiary of Assam; Neogene of Rusizi Valley, Burundi.

Polyporina excellens sp. nov.

Holotype — Pl. 2, Fig. 20; Sample No. 31702, Slide No. 2/1.

Type Locality — Upper Assam, Namdang River Section, Digboi field, India.

Horizon — Baragolai stage, Barail Series (Oligocene).

Specific Diagnosis — Size range 28-34 μ; amb globular; panaperturate, polyporate, pores about 50 in number; exine fairly thick, sexine thicker than nexine, ornamentation finely punctulate.

Description — Pollen grains small, regularly uniform in size, nearly or quite spherical in outline. Distinctly panporate, pores nearly circular in outline, up to 2·5 μ across and about 6 μ apart; exine up to 2·5 μ thick, well-differentiated, sculpturing very fine and distinctly punctulate.

Comparison — *Polyporina excellens* differs from *P. multistigmosa* Potonié (1934, FIGS. 11, 12, p. 68) in having larger number of pores and in the ornamentation of the exine. The grains of *Chenopodium oahuense* (Meyen) Allen, figured by Selling (1947, pp. 89-90; PL. 1, FIGS. 21-24) from Hawaii appear to be identical. *P. globosa* Sah (1967) from the Neogene of Burundi differs from *P. excellens* in having lesser number of pores and a comparatively coarser exine pattern.

Affinity — Chenopodiaceae — Amaranthaceae-type.

Distribution — Oligocene of Assam.

Genus Polygonacidites gen. nov.

Genotype — *Polygonacidites frequens* sp. nov., Pl. 2, Fig. 22; Diameter 41 μ.

Type Locality — Dhekiajuli beds, Digboi oilfield, Upper Assam, India.

Generic Diagnosis — Pollen grains usually ± spheroidal; panporate; apertures distinct or indistinct, usually not well defined;exine ornamentation variable, usually reticulate.

Comparison and *Affinity* — Pollen grains described under this genus are not comparable to any of the fossil genera known so far. Morphologically these grains cannot be distinguished from the pollen grains met with in the genus *Polygonum* L. and there can be no doubt that they are the fossil representative of the family Polygonaceae.

Polygonacidites frequens sp. nov.

Holotype — Pl. 2, Fig. 22; Size 41 μ; Sample No. 2792, Slide No. 3/6.

Isotype — Pl. 2, Fig. 23; Size 61 μ; Sample No. 2792, Slide No. 1/30.

Type Locality — Dhekiajuli beds, Digboi Oilfield, Upper Assam, India.

Horizon — Dhekiajuli beds, Dihing Series (Mio-Pliocene).

Specific Diagnosis — Size range 41-61 μ; amb globular, polyforate, apertures very small, inconspicuous; exine thick, sexine slightly thicker than nexine, ornamentation reticulate, duplibaculate, tegillate.

Description — Pollen grains large, spheroidal in outline. Exine up to 4·5 μ thick, surface characterized by a rather coarse reticulum formed of about 2 μ wide ridges and angular to irregular hexagonal lumina. Lumina floor having radially elongate elements. Some of the lumina distinctly showing ± irregular pores. The tops of the rod-like sexinous elements are fused, forming a thin transulcent tegillum.

Comparison — These grains do not compare with any of the known fossil taxa. Amongst the pollen grains of recent plants *Polygonacidites frequens* compares closely in size, shape and somehat ornamentation of the exine, with pollen grains of *Polygonum glabrum* Willd, described by Selling (1947, pp. 88-89, PL. 1, FIG. 20), from Hawaii. The Assam grains also closely compare with the pollen of *Polygonum strigosum* (HEDBERG 1946, pp. 384; 379, FIG. 46) in general form and exine character but appears to differ in its slightly larger size.

Affinity — Polygonaceae (*Polygonum*)

Distribution — Neogene of Assam.

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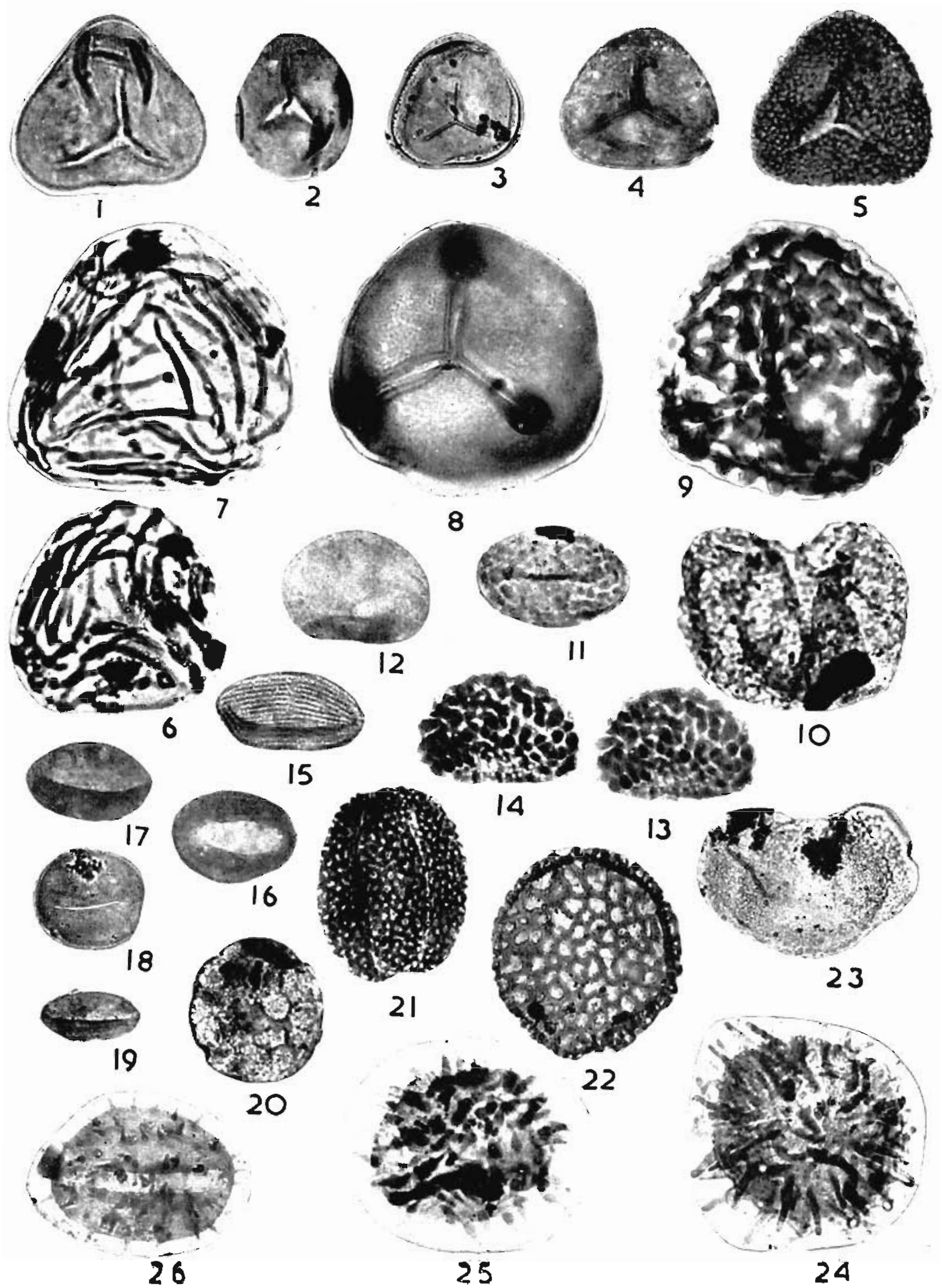
EXPLANATION OF PLATES

PLATE 1

(All microphotographs × 500)

1. *Cyathidites minor* Couper; Reg. No. 32942, Slide No. 5/8.
2. *Stereisporites assamensis* sp. nov., Holotype; Reg. No. 32942, Slide No. 6/4.
3. *Stereisporites psilatus* Pflug, Reg. No. 2790, Slide No. 1/4.
4. *Biretisporites* (*Hymenophyllumsporites*) *deltoidus* Dettmann, Reg. No. 31702, Slide No. 2/8.
5. *Lycopodiumsporites parvireticulatus* Sah & Dutta; Reg. No. 32991, Slide No. 23/2.
6. *Cicatricosisporites* (*Ceratopteris*) *macrocostatus* (Bakshi) comb. nov. Isotype, Reg. No. 2794, Slide No. 1/3.
7. *C* (*Ceratopteris*) *macrocostatus* (Bakshi) Comb. nov., Reg. No. 2794, Slide No. 2/1.
8. *Biretisporites triglobosus* Sah & Dutta; Reg. No. 32951, Slide No. 12/1.
9. *Corrugatisporites terminalis* sp. nov., Holotype; Reg. No. 2792, Slide No. 2/25.
10. *Alisporites* sp., Reg. No. 2790, Slide No. 5/6.
11. *Polypodiisporites oligocenicus* sp. nov., Holotype, Reg. No. 31702, Slide No. 3/5.
12. *Polypodiaceaesporites tertiarus* sp. nov., Holotype; Reg. No. 31702, Slide No. 4/1.
13. *Polypodiisporites speciosus* Sah; Reg. No. 31702, Slide No. 1/9.
14. *P. speciosus* Sah; Reg. No. 31702, Slide No. 1/5.
15. *Schizaeoisporites digitatoides* Potonié; Reg. No. 31702, Slide No. 5/3.
16. *Palmaepollenites eocenicus* (Biswas) Sah and Dutta; Reg. No. 32936A, Slide No. 9/6.
17. *P. eocenicus* (Biswas) Sah & Dutta; Reg. No. 31702, Slide No. 3/1.
18. *Monolites mawkmaensis* Sah & Dutta; Reg. No. 32955, Slide No. 1/3.
19. *Palmaepollenites communis* Sah & Dutta; Reg. No. 32991, Slide No. 1/11.
20. *Retialetes dubius* sp. nov., Holotype; Reg. No. 2791, Slide No. 3/1.
21. *Schizosporis crassimurus* Sah & Dutta; Reg. No. 32951, Slide No. 21/1.
22. *Retialetes emendatus* Sah & Dutta, Reg. No. 32991, Slide No. 2/2.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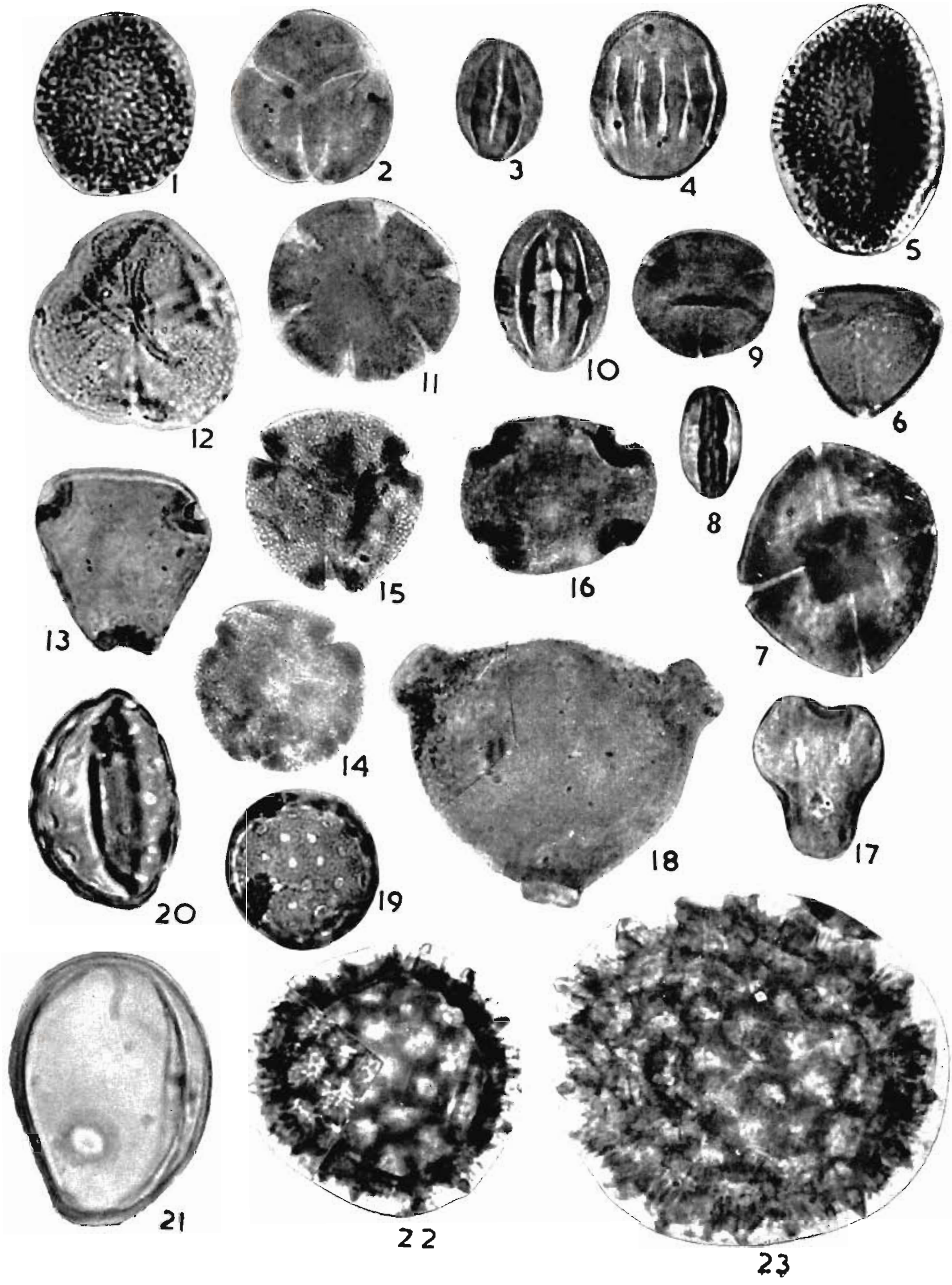
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23. *Podocarpidites microreticuloidatus* Cookson; Reg. No. 2790, Slide No. 2/2.
24. *Monosulcites* (*Araceaepites*) *wodehousei* (Biswas) Sah & Dutta; Reg. No. 32951, Slide No. 1/3.
25. *M.* (*Colocasioideaepites*) *brevispinosus* (Biswas) Sah & Dutta, Reg. No. 32942, Slide No. 3/13.
26. *M.* (*Colocasioideaepites*) *rarispinosus* Sah & Dutta, Reg. No. 32942, Slide No. 3/3.

PLATE 2

(All microphotographs × 1000 except where stated otherwise)

1. *Retipilonapites cenozoicus* Sah; Reg. No. 2792, Slide No. 1/1.
2. *Tricolpites levis* Sah & Dutta; Reg. No. 32951, Slide No. 9/1.
3. *Cupiliferoidaepollenites liblarensis* Thomson; Reg. No. 31702, Slide No. 3/1.
4. *Polygalacidites clarus* Sah & Dutta; Reg. No. 32951, Slide No. 10/2.
5. *Ilexpollenites ornus* sp. nov., Holotype; Reg. No. 2790, Slide No. 5/1.
6. *Talisiipites mundus* sp. nov. Holotype; Reg. No. 31702, Slide No. 6/1.
7. *Tetracolporites longicolpus* sp. nov., Holotype; Reg. No. 31702, Slide No. 1/9.
8. *Cupiliferoidaepollenites liblarensis* Thomson; Reg. No. 31702, Slide No. 2/3.
9. *Nyassapollenites barooahii* sp. nov., Holotype; Reg. No. 2790, Slide No. 5/2.
10. *Rhoipilites nitidus* sp. nov., Holotype; Reg. No. 2790, Slide No. 3/6.
11. *Polycolpites cooksonii* Sah & Dutta, Reg. No. 32951, Slide No. 4/1.
12. *Bombacacidites assamicus* sp. nov., Holotype, Reg. No. 2790, Slide No. 1/4.
13. *Triporopollenites vimalii* Sah & Dutta, Reg. No. 32937, Slide No. 4/13, × 500.
14. *Tetracolporites paucus* sp. nov., Holotype; Reg. No. 31702, Slide No. 3/2; × 500.
15. *Favitricolporites complex* sp. nov., Holotype; Reg. No. 31702, Slide No. 1/13; × 500.
16. *Tetracolporites onagraceoides* sp. nov., Holotype, Reg. No. 31702, Slide No. 3/4; × 500.
17. *Anacolosidites luteoides* Cookson & Pike Reg. No. 31702, Slide No. 2/6.
18. *Triorites communis* Sah & Dutta, Reg. No. 32991, Slide No. 20/1.
19. *Polyporina globosa* Sah; Reg. No. 32940, Slide No. 2/5.
20. *Polyporina excellens* sp. nov., Holotype; Reg. No. 31702, Slide No. 2/1.
21. *Graminidites assamicus* sp. nov., Holotype; Reg. No. 31702, Slide No. 2/2.
22. *Polygonaciditics frequens* gen et sp. nov., Holotype; Reg. No. 2792, Slide No. 3/6.
23. *P. frequens* sp. nov., Isotype; Reg. No. 2792, Slide No. 1/30.