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Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-VII. Discussion

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The palynofloral assemblages from the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Meghalaya and Assam have been discussed and interpreted. The total assemblage consists of 68 genera and 113 species. Qualitative analysis of the assemblage reveals that Lycopodiaceae, Polypodiaceae, Matoniaceae, Hymenophyllaceae, Ophioglossaceae, Schizaeaceae, Cyatheaceae, Osmundaceae, Gleicheniaceae, Parkeriaceae, Podocarpaceae, Pinaceae, Palmae, Potamogetonaceae, Araceae, Oleaceae, Bombacaceae, Labiatae, Mimosaceae and Malvaceae are represented in the assemblage. The present day distribution of these families indicates the prevalence of mainly tropical-subtropical climate during the deposition of Barail-Surma sediments. The environment of deposition has been interpreted as coastal marine. Quantitatively, the pteridophytic spores constitute a major part (62%) of the assemblage followed by gymnospermous pollen grains (23%), angiospermous pollen grains (5.5%), dinoflagellate cysts (5%) and fungal remains (4.5%). A comparison of this assemblage with similar Oligocene-Lower Miocene assemblages of India has been made. The age of the sediments has also been discussed.

Key-words—Palaeopalynology, Tropical-subtropical climate, Barail-Surma Groups, Oligocene-Lower Miocene (India).

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सारांश

जयन्तिया पहाड़ियों (मेघालय) एवं कछर (असम) में सोनपुर-बदरपुर मार्ग खंड के संग-संग विगोपित बैरेल (पश्चनूतन) एवं सूरमा (अधरि मध्यनूतन) अवसादों का परागाणविक अध्ययन. भाग 7—विवेचन

हरिपाल सिंह, मलागलापल्ली रामचन्द्र राव एवं रमेश कुमार सक्सेना

मेघालय एवं असम में सोनपुर-बदरपुर मार्ग खंड के संग-संग विगोपित बैरेल (पश्चनूतन) एवं सूरमा (अधरि मध्यनूतन) अवसादों से उपलब्ध परागाणुवनस्पतिजात की व्याख्या एवं विवेचन किया गया है। सम्पूर्ण समुच्चय में 68 प्रजातियाँ एवं 113 जातियाँ विद्यमान हैं। समुच्चय के गुणात्मक विश्लेषण से व्यक्त होता है कि इसमें लाइकोपोडिएसी, पोलिपोडिएसी, मेटोनिएसी, हाइमेनोफ़िल्लेसी, ओफिओग्लोसेसी, शाइजिएसी, स्याथिएसी, ओस्मुन्डेसी, ग्लाइकीनिएसी, पार्केरिएसी, पोडोकार्पेसी, पाइनेसी, पाल्मी, पोटेमोजिटोनेसी, अरेसी, ओलिएसी, बोम्बेकेसी, लेबिएटी, माइमोसेसी एवं माल्वेसी नामक कुल विद्यमान हैं। इन कुलों के वर्तमान वितरण से बैरेल-सूरमा अवसादों के निक्षेपण के समय मुख्यतया उष्णकटिबन्धीय-उपोष्णकटिबन्धीय जलवायु का होना इंगित होता है। निक्षेपण का वातावरण तटीय-समुद्री के रूप में प्रस्तावित किया गया है। टेरीडोफ़ाइटी बीजाणु भारात्मक दृष्टि से समुच्चय का प्रमुख भाग (62 प्रतिशत) हैं जिनके पश्चात् अनावृतबीजी परागकण (23 प्रतिशत), आवृतबीजी परागकण (5.5 प्रतिशत), घूर्णिकशाभ पुटीयाँ (5 प्रतिशत) तथा कवकीय अवशेष (4.5 प्रतिशत) क्रम में आते हैं। इस समुच्चय की तुलना भारत के सदृश पश्चनूतन-अधरि मध्यनूतन युगीन समुच्चयों से की गई है। इसके अतिरिक्त इन अवसादों की आयु भी विवेचित की गई है।

THE area under present study, i.e. Sonapur-Badarpur Road Section, is located in the southeast of Shillong, in Jaintia Hills (Meghalaya) and Cachar (Assam) districts and constitutes a part of the Shillong-Badarpur Highway (National Highway-44). Excellent sections of Barail (Oligocene) and Surma (Lower

Miocene) groups of geosynclinal facies are exposed along this section. The Barail Group of this area is divided into Laisong, Jenam and Renji formations. The Laisong Formation (1750 m thick) represents mainly arenaceous facies consisting of grey, very hard, thinly bedded, very fine to medium grained sandstones alternating with subordinate, hard, sandy shales. The Jenam Formation (850 m thick) is mainly argillaceous and consists of shales and sandy shales with fine to medium grained sandstones. The Renji Formation (800 m thick) is again arenaceous and is made up of thickly bedded or massive, fine to medium grained, hard, ferruginous sandstones alternated by thin shales. The Renji Formation is unconformably overlain by the Surma Group. This group is divided into Bhuban and Bokabil formations. The Bhuban Formation (1850 m thick) is further divided into Lubha, Umkiang and Dona members. The lower and upper members are mainly arenaceous whereas the middle member is argillaceous. The Bokabil Formation (150 m thick) is made up of thick sandy shales with alternations of very fine grained laminated sandstone. The lithostratigraphy of the section has been published by Saxena and Tripathi (1982).

Palynological study of the Barail and Surma sediments of this section has been carried out by Sein and Sah (1974), Rao (1983), Singh and Rao (1984), Saxena and Rao (1984), Rao *et al.* (1985), Singh *et al.* (1986), Rao (1986), Saxena *et al.* (1987) and Rao and Singh (1987). Based on the above work, the present paper deals with the qualitative and quantitative analyses of Barail-Surma palynoflora, its comparison with other similar palynoassemblages from India and interpretations regarding palaeoclimate, environment of deposition and age.

PALYNOFLORAL ASSEMBLAGE

Dinoflagellate Cysts

Polysphaeridium subtile Davey & Williams *in* Davey *et al.*, *Polysphaeridium* sp., *Impletosphaeridium insolitum* Eaton, *Adnatosphaeridium vittatum* Williams & Downie *in* Davey *et al.*, *Membranilarnacia donaensis* Saxena & Rao, *Cordosphaeridium inodes* (Klumpp) Eisenack emend. Morgenroth, *C. multispinosum* Davey & Williams in *Davey et al.*, *C. fibrospinosum* Davey & Williams in Davey *et al.*, *C. gracilis* (Eisenack) Davey & Williams in Davey *et al.*, *Operculodinium* sp. cf. *O. major* Jain & Dutta in Dutta & Jain, *Achomosphaera ramulifera* (Deflandre) Evitt, *A. sagena* Davey & Williams in Davey *et al.*, *Homotryblium floripes* (Deflandre & Cookson) Stover, *Homotryblium meghalayaensis* Saxena & Rao, *Tuberculodinium vancampoae* Rossignol) Wall emend. Wall & Dale, Dinocyst types 1, 2, 3, *Heliospermopsis* sp. (acritarch).

Fungal Remains

Phragmothyrites eocaenica Edwards emend. Kar & Saxena, *Phragmothyrites* sp., *Paramicrothallites menonii* Jain & Gupta, *Notothyrites setiferus* Cookson, *N. amorphus* Kar & Saxena, *N. padappakarensis* Jain & Gupta, *Parmathyrites ramanujamii* Singh *et al.*, *Kutchiathyrites* sp., *Lirasporis intergranifer* Potonié & Sah emend. Jain & Kar, *Inapertisporites ovalis* Sheffy & Dilcher, *I. miocenicus* Singh *et al.*, *Inapertisporites* sp., *Inapertisporites* sp. cf. *I. kedvesii* Elsik, *Dicellaesporites fusiformis* Sheffy & Dilcher, *Dicellaesporites* spp. A, B, *Multicellaesporites* spp. A, B, C, D, *Lacrimasporonites* sp., *Monoporisporites* sp., *Dyadosporonites grandiporus* Singh *et al.*, *Dyadosporonites* sp., *Diporisporites* sp., *Pluricellaesporites verrucatus* Singh *et al.*, *Pluricellaesporites* spp. A, B, *Pluricellaesporites* sp. cf. *P. alleppeyensis*, Ramanujum & Rao, *Diporicellaesporites verrucatus* Singh *et al.*, *Diporicellaesporites* spp. A, B, *Fusiformisporites* sp., *Frasnacritetrus* sp.

Pteridophytic Spores

Cyathidites australis Couper, *C. minor* Couper, *Lygodiumsporites lakiensis* Sah & Kar emend. Rao & Singh, *L. eocenicus* Dutta & Sah, *L. donaensis* Rao & Singh, *Todisporites major* Couper, *T. minor* Couper, *Biretisporites meghalayaensis* Rao & Singh, *B. oligocenicus* Rao & Singh, *Surmaspora sinuosa* Singh & Rao, *Gleicheniidites senonicus* Ross, *Dictyophyllidites indicus* Rao & Singh, Garotriletes sp., *Corrugatisporites* sp., *Foveotriletes* spp. A, B, *Foveosporites triangulus* Dutta & Sah, *F. miocenicus* Ramanujam, *Foveosporites* sp., *Lycopodiumsporites abundans* Salujha *et al.*, *Striatriletes susannae* van der Hammen emend. Kar, *S. sinuosus* Rao & Singh, *S. pachyexinus* Rao & Singh, *Malayaeaspora costata* Trivedi *et al.*, *Cingutriletes* sp., *Polypodiaceaesporites tertiarus* Sah & Dutta, *P. chatterjii* Kar, *Monolites major* (Cookson) Potonié, *Polypodiisporites favus* Potonié, *P. speciosus* Sah, *P. formosus* Salujha *et al.*, *P. tuberculensis* (Baksi) Rao & Singh.

Gymnospermous Pollen

Laricoidites punctatus Saxena, *Podocarpidites classicus* Salujha *et al.*, *Podocarpidites meghalayaensis* Rao, *Podocarpidites* sp., *Pinuspollenites foveolatus* Rao, *Piceapollenites* sp., *Abiespollenites surmaensis* Rao.

Angiospermous Pollen

Retipilonapites delicatissimus Ramanujam, *Verrualetes assamicus* Singh & Saxena, *Verrualetes* sp., *Assamiapollenites* sp., *Spinainaperturites* spp. A, B,

Palmidites maximus Couper, *Couperipollis robustus* Saxena, *C. donaensis* Rao *et al.*, *C. ramanujamii* Rao *et al.*, *Couperipollis* sp. cf. *C. wodehousei* (Biswas) Venkatachala & Kar, *Proxapertites* sp., *Tricolpites* sp., *Verrutricolpites* sp., *Retitrescolpites* sp., *Trifossapollenites constatus* Dutta & Sah, *Bombacacidites inausus* Venkatachala & Rawat, *Echistephanocolpites meghalayaensis* Rao *et al.*, *Echistephanocolpites* sp. cf. *E. echinatus*, Wijmstra, *Gemmastephanocolpites* sp., *Triporopollenites* sp., *Stephanoporopollenites* sp., *Malvacearumpollis* sp., *Polyadopollenites sahii* Rao *et al.*

DISCUSSION

Pteridophytic spores and gymnospermous pollen are the dominant constituents of the Barail-Surma Assemblage while angiospermous pollen are comparatively poorly represented. Algal and fungal remains are also present. The qualitative and quantitative analyses of the palynofloral assemblage and its comparison with other known equivalent assemblages from India have been discussed.

Qualitative Analysis

THALLOPHYTA

The thallophytic remains are represented in the assemblage by dinoflagellate cysts (9 genera & 15 species), epiphyllous fungi and fungal spores (17 genera & 34 species).

PTERIDOPHYTA

Pteridophytic spores are richly represented in the Barail-Surma sediments of Sonapur-Badarpur Road Section. Their comparison with the extant flora indicates the presence of the following families :

Lycopodiaceae—Lycopodiumsporites abundans, Foveotriletes spp. A, B and *Foveosporites triangulus* are comparable to the spores found in some members of the family Lycopodiaceae. This family is represented in tropical to temperate regions and inhabits moist and shady places.

Polypodiaceae—This family is represented by *Monolites major, Polypodiaceaesporites tertiarus, P. chatterjii, Polypodiisporites favus, P. formosus, P. tuberculensis* and *P. speciosus.* The present day distribution of Polypodiaceae is cosmopolitan.

Matoniaceae—Dictyophyllidites indicus may be related to the fern family Matoniaceae.

Hymenophyllaceae—Biretisporites oligocenicus and *B. meghalayaensis* are doubtfully related to the family Hymenophyllaceae.

Ophioglossaceae—Foveosporites miocenicus is similar to the spores of some species of *Ophioglossum* of the family Ophioglossaceae.

Schizaeaceae—Lygodiumsporites lakiensis, L. eocenicus and *L. donaensis* compare with the spores of the family Schizaeaceae. It is chiefly distributed in tropical and subtropical regions.

Cyatheacéae—Cyathidites australis and *C. minor* are referable to this family. Plants of this family are mainly found in tropical and subtropical area.

Osmundaceae—Todisporites major and *T. minor* are referable to this family. Members of this family are found both in tropical and temperate regions, generally inhabiting damp woods and thickets.

Gleicheniaceae—Morphologically *Gleicheniidites senonicus* is comparable to the spores produced by some members of the family Gleicheniaceae. The members of this family chiefly grow in tropics.

Parkeriaceae—All the three species of *Striatriletes*, viz., *S. susannae, S. sinuosus* and *S. pachyexinus* seem to be related to *Ceratopteris* (Parkeriaceae). The genus *Ceratopteris* is a water fern of the tropical and subtropical regions.

GYMNOSPERMAE

Gymnospermous pollen grains are comparati vely less represented in the assemblage than pteridophytic spores. These are referable to the following families :

Podocarpaceae—Podocarpidites classicus, P. meghalayaensis, and *Podocarpidites* sp. have close affinity with this family. The family is distributed in subtropical as well as temperate regions.

Pinaceae—Pinuspollenites foveolatus, Abiespollenites surmaensis, Piceapollenites sp. and *Laricoidites punctatus* are referable to the members of Pinaceae which is a temperate taxon.

ANGIOSPERMAE

The angiospermous pollen are not richly represented in the Barail-Surma assemblage, however, they form a significant group at certain levels. These are represented by the following families :

Palmae—Palmidites maximus, Couperipollis robustus, C. donaensis and *C. ramanujamii* are comparable to the pollen of Palmae. The distribution of this family is restricted to tropical and subtropical regions.

Potamogetonaceae—Retipilonapites delicatissimus is comparable to the pollen grains of Potamogetonaceae. This aquatic family is cosmopolitan.

Araceae—Proxapertites sp. resembles the pollen of Araceae. The family is chiefly tropical.

Oleaceae—This family appears to be represented by the pollen of *Retitrescolpites.* The family is

restricted to tropical and warm temperate regions of the world.

Bombacaceae—Bombacacidites inausus is comparable to the pollen of Bombacaceae.

Labiatae—Trifossapollenites constatus, Echistephanocolpites meghalayaensis and *Gemmastephanocolpites* sp. are probably related to family Labiatae. The present day distribution of this family is ubiquitous.

Mimosaceae—The pollen grains of *Polyadopollenites sahii* show definite affinity with this family. At present, the members of this family are found mainly in tropical-subtropical regions of the world.

Malvaceae—Malvacearumpollis sp. resembles the pollen grains of Malvaceae. The family is mainly tropical in distribution.

Quantitative Analysis

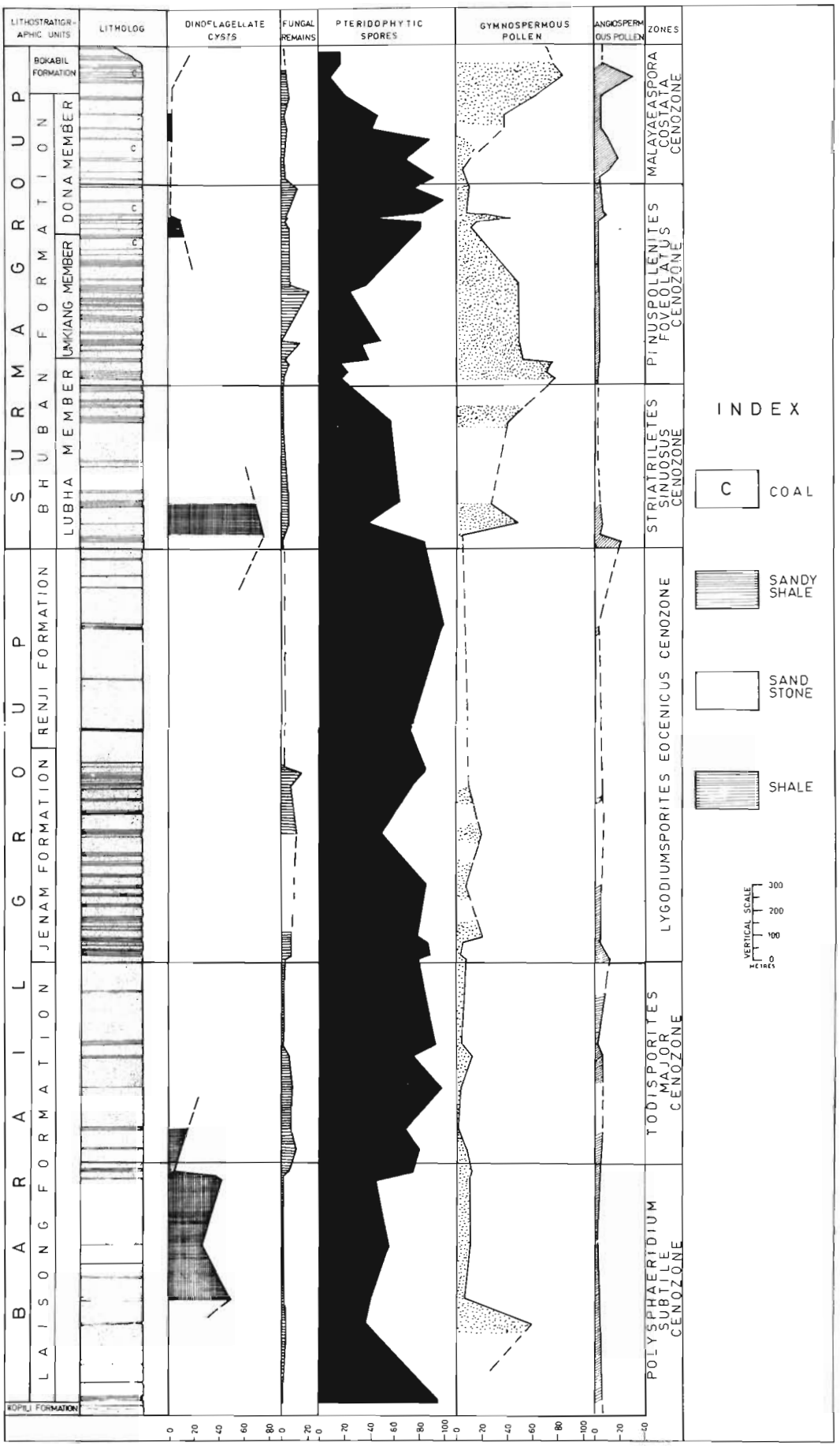
The present palynoassemblage is populated by 68 genera and 112 species of dinoflagellate cysts, fungal remains, pteridophytic spores and gymnospermous and angiospermous pollen grains. Quantitatively, the pteridophytic spores constitute a major part (62%) of the assemblage, followed by gymnospermous pollen grains (23%), angiospermous pollen grains (5.5%), dinoflagellate cysts (5%) and fungal remains (4.5%). The botanical allocation of the various genera and species is given below: dinoflagellate cysts-9 genera and 15 species; fungal remains 17 genera and 33 species; pteridophytic spores 18 genera and 32 species; gymnospermous pollen grains 5 genera and 7 species; angiospermous pollen grains 18 genera and 24 species; *incertae sedis* 1 genus and 1 species. The quantitative analysis of the assemblage has been done on the basis of the frequency of various species in a count of 200 specimens per sample but in some cases where the yield was poor only 100 to 150 palyno-fossils were counted. The percentage of each group in each sample has been calculated and plotted to show its distribution in the Barail-Surma Sequence of the Sonapur-Badarpur Section (Text-fig. 1).

The quantitative analysis of the palynoflora recorded from each formation is discussed below:

Laisong Formation—The palynotaxa of the Laisong assemblage (Lower Oligocene) are represented by the following percentages: dinoflagellate cysts (14.3%), fungal remains (4.5%); pteridophytic spores (62.5%), gymnospermous pollen grains (16%) and angiospermous pollen grains (2.7%). The dinoflagellate cysts are dominant in the lower part of the Laisong Formation (*Polysphaeridium subtile* Cenozone) but they decrease in frequency in the upper part (*Todisporites major* Cenozone). *Polysphaeridium subtile* constitutes 30 per cent of the dinoflagellate cysts in the lower part of the formation. In some samples its frequency reaches up to 45 per cent. *Adnatosphaeridium vittatum* is restricted to this formation only. *Cordosphaeridium inodes, C. fibrospinosum, C. multispinosum* and *Homotryblium floripes* are among the other species of dinoflagellate cysts recorded from this formation. The fungal remains are better represented in the upper part (up to 12%) than in the lower part (1-4%) and consist of *Notothyrites setiferus* and *Phragmothyrites eocaenica*. Among the pteridophytic spores, trilete spores form the dominant element while the monolete spores remain insignificant. *Striatriletes* is the most dominant genus throughout the formation and in some samples its frequency reaches up to 60%. Other pteridophytic genera in the order of their relative abundance are *Todisporites* and *Lygodiumsporites*. Gymnospermous pollen, mainly represented by *Pinuspollenites foveolatus* are insignificant in the lower part of the formation while in the upper part their frequency is comparatively low. *Podocarpidites* is another important gymnospermous pollen genus in this formation. The angiospermous pollen grains constitute 2.7 per cent of the assemblage, being represented by *Polyadopollenites sahii* and *Echistephanocolpites meghalayaensis*.

Jenam Formation—The Jenam Formation consists of fungal remains (12.2%), pteridophytic spores (77%), gymnospermous pollen grains (7.5%) and angiospermous pollen grains (3.3%) while dinoflagellate cysts are completely absent. The frequency of the fungal remains increases (12%) in this formation. The species recorded are: *Notothyrites setiferus, Phragmothyrites eocaenica* and *Paramicrothallites menonii*. Like Laisong Formation, this formation too is rich in trilete spores while the monolete spores occur in lesser frequency. The monolete spores recovered from this formation are represented by *Polypodiaceaesporites tertiarus* only. Among the trilete spores, *Striatriletes* spp. occur at all levels of this formation. *Striatriletes pachyexinus* (49%) has been recovered only from one sample and is restricted to this formation. The frequency of *Striatriletes susannae* is 60 per cent and at some levels it increases even up to 78 per cent. *Lygodiumsporites* spp. and *Todisporites major* are among the other significant forms. The gymnospermous pollen grains are poorly represented in this formation, being only 7.5 per cent. *Polyadopollenites sahii* and *Malvacearumpollis* sp. are among the important species of angiospermous pollen grains. Angiospermous pollen are not represented in the upper part of this formation.

Renji Formation—In this formation the yield of palynomorphs was comparatively poor. The pteridophytic spores (99.4%) form the most dominant element in this formation while angiospermous pollen grains are rare (0.6%). Algal and fungal



Text-figure 1—Group-wise distribution of palynofossils in Barail-Surma Sequence of Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam).

remains and gymnospermous pollen grains are absent. *Dictyophyllidites indicus* (46%), a trilete pteridophytic spore, is restricted to this formation. *Striatriletes susannae* (40%), *Lygodiumsporites lakiensis* (7%) and *Todisporites major* (6%) are the other important taxa. The angiospermous pollen grains are represented by *Malvacearumpollis* sp. only.

Bhuban Formation—The palynoflora recovered from this formation is represented by dinoflagellate cysts (4.3%), fungal remains (5%), pteridophytic spores (50%), gymnospermous pollen grains (37%) and angiospermous pollen grains (3.7%). The dinoflagellate cysts reappear in the lower part of the Bhuban Formation. *Cordosphaeridium inodes* and *Homotryblium floripes* are the important species. The fungal remains consist of *Notothyrites setiferus, N. padappakarensis, Parmathyrites ramanujamii, Phragmothyrites eocaenica, Inapertisporites miocenicus, Dicellaesporites* spp., *Dyadosporonites grandiporus, Pluricellaesporites* spp. and *Multicellaesporites* spp. The pteridophytic spores are dominant in the lower (57%) and upper (66%) members of this formation whereas in the middle member their frequency is comparatively less (29%). The genus *Striatriletes* occurs in all the samples. *Striatriletes sinuosus* is restricted to the lower part (Lubha Member) only whereas the *Surmaspora sinuosa, Malayaeaspora costata, Biretisporites meghalayaensis* and *Lygodiumsporites donaensis* are restricted to the upper part (Dona Member). In addition, the frequency of *Lygodiumsporites eocenicus* decreases in the lower part, being completely absent in the middle and finally reappearing in the upper part. *Cyathidites australis, C. minor, Foveosporites triangulus, Todisporites major, T. minor, Polypodiaceaesporites tertiarus, P. chatterjii, Polypodiisporites speciosus* and *P. formosus* are some of the other important species of pteridophytic spores. The gymnospermous pollen are comparatively better represented (64%) in the middle levels than in the lower (23%) and upper (20%) levels of this formation. *Pinuspollenites foveolatus* constitutes the major part (60%) of gymnospermous pollen grains in the middle levels (Umkiang Member). *Abiespollenites surmaensis* is an important taxon in the Lower Bhuban Formation but its frequency decreases in the middle and upper parts of the Bhuban Formation. *Podocarpidites meghalayaensis, Piceapollenites* sp. and *Laricoidites punctatus* are the other important forms. The angiospermous pollen grains show comparatively higher frequency in the Upper Bhuban Formation than those in the lower and middle levels. *Couperipollis* spp. constitute the major part of the assemblage. The frequencies of *Malva-cearumpollis* sp. and *Echistephanocolpites megha-layaensis* increase in this formation. The other important taxa are: *Verrualetes assamicus, Retipilonapites delicatissimus* and *Polyadopollenites sahii.*

Bokabil Formation—The Bokabil palynoflora consists of fungal remains (3%), pteridophytic spores (15.8%), gymnospermous pollen grains (60%) and angiospermous pollen grains (21.2%). Dinoflagellate cysts are completely absent. *Monoporisporites* sp. is the only fungal species recorded from this formation. The pteridophytic spores are represented by *Striatriletes susannae, Lygodiumsporites lakiensis* and *Polypodiaceaesporites tertiarus.* Among the gymnospermous pollen grains, *Pinuspollenites foveolatus* is an important taxon being represented by (50%). Other gymnospermous pollen species present are: *Abiespollenites surmaensis* (8%) and *Piceapollenites* sp. (3%). *Assamiapollenites* sp., *Couperipollis* spp., and *Malvacearumpollis* sp. are the angiospermous pollen genera recorded from this formation.

Palynofloral Comparison

During the last twentyfive years significant contributions to the Tertiary palynostratigraphy of Kutch, Meghalaya, Assam, Bengal, Himachal Pradesh and South India have been made. A comparison of the present assemblages with those known from the above areas has been attempted below.

KUTCH

Kar (1979) reported a rich palynoflora consisting of 39 genera and 33 identifiable species, from the Maniyara Fort Formation (Oligocene) of Kutch, Gujarat. The palynotaxa common to the Maniyara Fort assemblage and present Barail assemblage are: *Cyathidites, Lygodiumsporites lakiensis, Todisporites, Biretisporites, Striatriletes susannae, Polypodiaceaesporites chatterjii, Polypodiisporites, Podocarpidites, Couperipollis, Tricolpites, Triporopollenites, Stephanoporopollenites, Malvacearumpollis, Phragmothyrites eocaenica, Notothyrites, Kutchiathyrites, Inapertisporites, Dyadosporonites, Polysphaeridium* and *Homotryblium.* The palynotaxa present in the Maniyara Fort assemblage but absent from the present assemblage are: *Punctatisporites, Intrapunctisporis, Toroisporis, Leptolepidites, Laevigatosporites, Cheilanthoidspora, Retitricolpites, Trisyncolpites, Araliaceoipollenites, Retibrevitricolpites, Paleosantalaceaepites, Monoporopollenites, Cleistosphaeridium, Spiniferites, Membranilarnacia, Fromea* and *Aplanosporites.* The palynotaxa present in the Barail assemblage but absent from the Maniyara Fort assemblage are: *Garotriletes, Gleicheniidites, Corrugatisporites, Foveotriletes, Pinuspollenites, Piceapollenites, Abiespollenites, Laricoidites, Verrutricolpites, Bombacacidites inausus, Echistephanocolpites meghalayaensis, Polyado-*

pollenites sahii, Dicellaesporites, Multicellaesporites, Fusiformisporites, Adnatosphaeridium, Cordosphaeridium, Impletosphaeridium and *Frasnacritetrus*. A comparative study reveals that the Maniyara Fort Assemblage of Kutch and the present Barail Assemblage are mostly comparable qualitatively.

MEGHALAYA—ASSAM

The palynological studies on the Tertiary sediments of Meghalaya and Assam have been carried out by Biswas (1962), Baksi (1962, 1965), Sah and Dutta (1966, 1968, 1974), Dutta and Sah (1970), Sah *et al.* (1970), Salujha *et al.* (1972, 1973, 1974), Singh (1977a, 1977b), Singh and Singh (1978), Mehrotra (1981, 1983) and Dutta and Jain (1982). There are few reports from Upper Assam by Banerjee *et al.* (1973), Srivastava *et al.* (1974), Singh and Tewari (1979), Sah *et al.* (1980) and Singh and Saxena (1984). The palynofloras reported by the above mentioned authors are largely from the Palaeocene-Eocene sediments whereas the reports from the Oligocene-Miocene sediments are very scanty. A comparative study of the distributional patterns of the known Oligocene-Miocene palynofloras from the Assam Basin is given below:

Banerjee (1964) published some palynotaxa from the Surma sediments (Miocene) of Garo Hills, Meghalaya. To make a comparative study of this palynoflora with the present one, it was thought essential to transcribe various genera described therein to the equivalent forms in the present assemblage. To accomplish this objective, the names of the genera used by Banerjee are given in parentheses. The palynotaxa in common with the Surma Group of Garo Hills and that of the present section are: *Polypodiaceaesporites* = (*Psilamonoletes*, in Banerjee, pl. 1, fig. 3), *Lygodiumsporites* = (*Retitriletes*, in Banerjee, pl. 1, fig. 4), *Todisporites* = (*Scabratriletes*, in Banerjee, pl 1, figs 8, 10), *Pinuspollenites* and *Podocarpidites* = (*Saccites*, in Banerjee, pl. 2, figs 1-6), *Palmidites maximus* (=*Monocolpites*, in Banerjee, pl. 2, fig. 7), *Echistephanocolpites* =(*Stephanocolpites*, in Banerjee, pl. 2, fig. 29), *Striatriletes* and *Tricolpites*. A comparative study reveals that the present Surma assemblage is closely comparable with that of Garo Hills.

Baksi (1962) described palynomorphs from the Simsang River Section, South Shillong Front, Meghalaya and recognized four palynozones. Of these, the third and fourth palynozones were assigned to Oligocene and Miocene ages respectively. The present assemblage and the assemblage of third and fourth zones of Simsang River Section have the following genera in common: *Striatriletes, Malayaeaspora* ± = *Schizaeaceaesporites, Parkeriaceaesporites*, in Baksi, pl. 3, fig. 41; pl. 5, fig. 54), *Cyathidites/Lygodiumsporites/Todisporites* ± = (smooth trilete spores of *Leiotriletes garoensis*, in Baksi pl. 3, fig. 36), *Polypodiisporites tuberculensis* = (*Polypodiaceaesporites tuberculensis*, in Baksi, pl. 3, fig. 40), *Couperipollis* ± = (spinose monocolpate pollen in Baksi, pl. 2, fig. 18) and *Triporopollenites* ± = (triporate pollen, in Baksi, pl. 3, fig. 33). Besides, conifer pollen grains and dinoflagellate cysts are also common to the two assemblages. The palynotaxa present in the Simsang River Section but absent from the present assemblage are: gemmate syncolpate pollen, *Meyeripollis, Bau-hinia burdwanensis, Tetradopites, Tricolpopites, Polygonaceaepites* and *Densexinosporites*. The palynotaxa present in the present assemblage but absent from the third and fourth zones of Simsang River Section are: *Biretisporites, Surmaspora, Gleichenii-dites, Dictyophyllidites, Garotriletes, Foveosporites, Foveotriletes, Corrugatisporites, Lycopodiumsporites, Monolites, Laricoidites, Retipilonapites, Verrualetes, Palmidites, Proxapertites, Bombacacidites, Verrutri-colpites, Retitrescolpites, Trifossapollenites, Echistephanocolpites, Gemmastephanocolpites, Malvaceaerumpollis* and *Polyadopollenites*. The present authors have established 3 palynozones in the Barail Group (Oligocene), viz., (i) *Polysphaeridium subtile* Cenozone, (ii) *Todisporites major* Cenozone, and (iii) *Lygo-diumsporites eocenicus* Cenozone which are broadly comparable to the third palynozone of Baksi (1962) from the Simsang River Section.

Likewise, the Surma Group (Miocene) strata of the present investigation is also divided into three palynozones, viz., (i) *Striatriletes sinuosus* Cenozone, (ii) *Pinuspollenites foveolatus* Cenozone, and (iii) *Malayaeaspora costata* Cenozone. In the fourth zone of Simsang River Section, the abundant occurrence of two-winged coniferous pollen grains and the frequent occurrence of ribbed spores (*Ceratopteris* type) have been recorded by Baksi (1962). A comparative study reveals that the *Pinuspollenites* = (coniferous pollen, Baksi, pl. 4, fig. 49; pl. 5, fig. 60) and *Striatriletes* = (*Ceratopteris* Baksi, pl. 4, fig. 53) are present in both the assemblages. So the fourth zone of Simsang River Section is comparable to the fourth, fifth and sixth cenozones of the Surma Group of Sonapur-Badarpur Road Section.

Besides the above, the present assemblage was also compared with those recorded by Salujha *et al.* (1972, 1974 Palaeogene assemblage from Garo Hills and Jaintia Hills respectively), Salujha *et al.* (1973, Surma assemblage from the southern edge of Shillong Plateau), Sein and Sah (1974, Eocene-Oligocene assemblage from Jaintia Hills), Banerjee *et al.* (1973, Oligocene-Miocene assemblage from the subcrops of Upper Assam) and Singh and Saxena (1984, Neogene assemblage from Jorajan Well-3, Upper Assam) but none of them was found to be closely comparable.

BENGAL BASIN

Deb (1970) studied the palynology of the Cenozoic sediments of Bengal Basin, south of Calcutta. She instituted three palynozones for the Miocene, Pliocene and Quaternary sediments respectively. The palynozone III (Miocene) contains *Striatriletes* = (*Ceratopteris*, in Deb, pl. 2, fig. 9) and pollen grains of Coniferae and Palmae which are also present in the present assemblage.

Baksi (1972) made a detailed palynostratigraphic study of the Upper Mesozoic and Tertiary succession of Bengal Basin, subdividing it into 7 palynological zones. Of these, zones IV and V are of Oligocene and Miocene ages respectively. These zones possess some palynomorphs which also occur in the present assemblage, viz., *Cyathidites/Lygodiumsporites/Todisporites* ± = (*Leiotriletes garoensis/Cyathidites minor*), *Polypodiisporites tuberculensis* ± = (*Polypodiaceaesporites tuberculensis/Polypodiisporites speciosus/P. oligocenicus*), *Malayaeaspora/Striatriletes* ± = (*Schizaeaceaesporites*), *Couperipollis* = (spinose monocolpate pollen) and *Tricolpites*. In addition to these, some dinoflagellate cysts, fungal spores/discs and conifer pollen are also shared by the two assemblages. The association of some important elements like *Meyeripollis*, abundant occurrence of small tricolpate pollen and first appearance of *Bauhinia burdwanensis* and *Barringtonia* in the Zone IV and V of Bengal Basin have not been detected in the Oligocene and Miocene sediments of the present study. Other palynotaxa like *Biretisporites, Dictyophyllidites, Polyadopollenites, Echistephanocolpites* and *Malvacearumpollis* which are present in Barail and Surma groups of the present section are absent from the zones IV and V of the Bengal Basin. Thus, the two assemblages are broadly comparable.

The present assemblage was also compared with Lower Siwalik assemblages from Himachal Pradesh, Uttar Pradesh and Nepal recorded by Banerjee (1968), Mathur (1973), Nandi (1975, 1980) and Saxena *et al.* (1984); Port Blair Formation (Palaeogene) of Andaman Islands recorded by Banerjee (1966); and Neogene assemblages of Tamil Nadu and Kerala recorded by Ramanujam (1960, 1966), Navale (1962), Jain and Gupta (1970), Deb (1972), Ramanujam and Rao (1973, 1977), Venkatachala and Rawat (1973), Rao and Ramanujam (1978, 1982), Navale and Misra (1979), Jain and Kar (1979), Kar and Saxena (1981), Ambwani *et al.* (1981) and Srisailam *et al.* (1981). It has been observed that these assemblages are not comparable with the present ones, hence their detailed account has not been given.

Palaeoclimate and Environment of Deposition

The Barail-Surma palynoflora from the Sonapur-Badarpur Road Section, Meghalaya and Assam consists of dinoflagellate cysts, fungal remains, pteridophytic spores, gymnospermous and angiospermous pollen grains. Based on the palynofloral evidence, an attempt is made here to interpret the palaeoclimate and environment of deposition prevalent during the sedimentation of this sequence.

PALAEOCLIMATE

The present day distribution of the various families represented in the Barail-Surma palynoflora is as follows :

Tropical	Tropical-subtropical	Temperate	Cosmopolitan
Matoniaceae	—	—	—
Gleicheniaceae	—	—	—
—	Ophioglossaceae	—	—
—	Cyatheaceae	—	—
—	Schizaeaceae	—	—
—	Parkeriaceae	—	—
—	Palmae	—	—
—	Mimosaceae	—	—
—	—	Pinaceae	—
—	—	—	Polypodiaceae
—	—	—	Osmundaceae
—	—	—	Podocarpaceae
—	—	—	Labiatae
—	—	—	Potamogetonaceae
—	—	—	Lycopodiaceae
—	—	—	Malvaceae
—	Oleaceae (Tropical-warm temperate)	—	—
—	Araceae	—	—
—	Bombacaceae	—	—

Parkeriaceae, Schizaeaceae, Ophioglossaceae, Cyatheaceae, Matoniaceae, Gleicheniaceae, Palmae and Mimosaceae are tropical to subtropical in distribution. The family Gleicheniaceae has been recorded only from the Barail Group while other families, viz., Cyatheaceae, Schizaeaceae, Osmundaceae, Matoniaceae and Mimosaceae are better represented in the Barail Group than in the Surma Group. The spores of Parkeriaceae occur predominantly throughout the Barail-Surma Sequence. Oleaceae which is subtropical to warm temperate in distribution, is poorly represented in and restricted to the lower Bhuban Formation. The tropical-subtropical elements are thus well represented throughout the Barail-Surma Sequence. The only temperate family, viz., Pinaceae, which is represented by *Pinuspollenites, Piceapollenites* and *Abiespollenites*,

occurs sporadically in the Barail Group (Oligocene) and attains predominance throughout the Surma Group.

Lakhanpal (1970), on the basis of palaeobotanical evidences, envisaged that the Palaeogene and Neogene floras in the Indian subcontinent were predominantly tropical. The occurrence of *Pinus* pollen grains (a temperate genus) in the latter may be interpreted as coming in from higher altitudes of temperate climate. The above observation is amply supported by the present palynofloral data too.

The present assemblage, as a whole, is dominated by pteridophytic spores (62%) indicating warm humid condition. This is also supported by the occurrence of epiphyllous microthyriaceous fungi, viz., *Phragmothyrites, Notothyrites* and *Parmathyrites.*

It may, therefore, be concluded that the area of present study enjoyed a mainly tropical-subtropical climate during the Oligocene-Lower Miocene time. The rich representation of pinaceous pollen grains in the Surma Group may be due to their derivation from the nearby upland region. A gradual cooling of the climate in the Miocene epoch may also be partly responsible for their occurrence. It appears likely that the Himalayan chain in the north of present area would have been sufficiently high during the Miocene to support the pinaceous elements.

ENVIRONMENT OF DEPOSITION

The oldest sediments of the present sequence, i.e. lower Laisong Formation (*Polysphaeridium subtile* Cenozone) consist of pteridophytic spores, gymnospermous pollen and dinoflagellate cysts. The dinoflagellate cysts are dominant in the lower part of the Barail Group, decrease in its middle and upper parts and again become important in the lower Bhuban Formation. The pteridophytic spores, mainly represented by *Striatriletes* are dominant throughout the sequence. The gymnospermous pollen exhibit low frequency in Barail Group while in the younger sediments, viz., Bhuban and Bokabil formations, they are encountered in very high frequency.

The dinoflagellate cysts are dominant in the lower part of the Barail Group and continue to be represented in the present sequence up to Lower Bhuban Formation indicating the prevalence of coastal marine environment of deposition. *Palmidites maximus, Couperipollis ramanujamii* and *C. donaensis* show proximity to the shore line. These as well as the fresh water elements, viz., *Retipilonapites* (Potamogetonaceae), *Proxapertites* and *Assamiapollenites* appear to have been transported to the site of deposition.

Age of the sediments

Limited efforts have so far been made on the palynological studies of the Barail and Surma groups (Baksi, 1962, 1965; Banerjee, 1964; Salujha, Kindra & Rehman, 1972, 1974; Salujha, Rehman & Kindra, 1973; Singh & Tewari, 1979). These papers have mainly concentrated on the systematic description of the palynoflora and its stratigraphic and palaeoecological significance. The interpretation regarding age of these sediments, on the basis of palynofossils has not so far been attempted. An attempt is therefore made here to assess the age of these sediments on palynological evidence.

Barail Group—The palynoflora recorded here from the Barail Group is characterized by *Adnatosphaeridium vittatum, Polysphaeridium subtile, Biretisporites oligocenicus, Dictyophyllidites indicus* and *Striatriletes pachyexinus.* These forms do not extend to the Surma Group. The present assemblage has been compared with the Oligocene assemblages described from Kutch (Kar, 1979) and Bengal Basin (Baksi, 1972). Out of 39 palynomorph genera recorded from the Maniyara Fort Formation (Oligocene) of Kutch, 19 genera are also found in the present assemblage. Similarly, most of the important taxa from the palynological zone IV (Oligocene) of Bengal Basin (Baksi, 1972) are also encountered herein. Thus, the present Barail assemblage is also assignable to Oligocene age.

Surma Group—The palynoassemblage recorded from the Surma Group of the present section is characterized by *Lygodiumsporites donaensis, Surmaspora sinuosa, Biretisporites meghalayaensis, Striatriletes sinuosus, Malayaeaspora costata, Polypodiaceaesporites chatterjii, Polypodiisporites formosus, Couperipollis donaensis, C. ramanujamii, Assamiapollenites* sp. and *Malvacearumpollis* sp. The Surma Assemblage also shows the predominance of *Pinuspollenites, Abiespollenites* and *Piceapollenites.*

Among the other known Miocene palynofloras from Bengal (Deb, 1970; Baksi, 1972), Meghalaya (Banerjee, 1964; Salujha *et al.*, 1973), Tamil Nadu (Navale, 1962; Ramanujam, 1966; Venkatachala & Rawat, 1973; Navale & Misra, 1979) and Kerala (Ramanujam, 1960; Jain & Gupta, 1970; Ramanujam & Rao, 1973, 1977, 1978; Rao & Ramanujam, 1976, 1978, 1982; Jain & Kar, 1979; Kar & Jain, 1981; Ramanujam *et al.*, 1981), the palynofloras from Meghalaya are favourably comparable with the present Surma mioflora. The rich representation of the bisaccate pinaceous pollen in these floras is particularly significant in this connection. Hence the present Surma mioflora is assignable to Miocene age.

REFERENCES

Ambwani, K., Bande, M. B. & Prakash, U. 1981 Pollen grains of *Ctenolophonidites* from the Neyveli Lignite of South India, *Palaeobotanist* **27**(1) : 100-106.

Baksi, S. K. 1962. Palynological investigation of Simsang River Tertiaries, South Shillong Front, Assam. *Bull. geol. min. metall. Soc. India.* **26** : 1-22.

Baksi, S. K. 1965. Stratigraphy of Barail Series in southern part of Shillong Plateau, Assam, India. *Bull. Amer. Assoc. Petrol. Geol.* **49**(12) : 2282-2288.

Baksi, S. K. 1972. On the palynological biostratigraphy of Bengal Basin. *Proc. Sem. Paleopalynol. Indian Stratigr. Calcutta* : 188-206.

Banerjee, D. 1964. A note on the microflora from Surma (Miocene) of Garo Hills, Assam. *Bull. geol. min. metall. Soc. India* **29** : 1-8.

Banerjee, D. 1966. A note on Tertiary microflora from Andaman Islands, India. *Pollen Spores* **8**(1) : 205-212.

Banerjee, D. 1968. Siwalik microflora from Punjab (India). *Rev. Palaeobot. Palynol.* **6** 171-176.

Banerjee, D., Misra, C. M. & Koshal, V. N. 1973. Palynology of the Tertiary subcrops of Upper Assam. *Palaeobotanist* **20**(1) : 1-6.

Biswas, B. 1962. Stratigraphy of the Mahadeo, Langpar, Cherra and Tura formations, Assam, India. *Bull. geol. min. metall. Soc. India* **25** : 1-48.

Deb, U. 1970. Palynological investigation of Tertiary sediments of Bengal Basin, south of Calcutta. *Q. Jl geol. min. metall. Soc. India* **42**(3) : 127-140.

Deb, U. 1972. Some pollen grains from the Neyveli Lignite. *Proc. Sem. 'Paleopalynol. Indian Stratigr., Calcutta* : 220-228.

Dutta, S. K. & Jain, K. P. 1980. Geology and palynology of the area around Lumshnong, Jaintia Hills, Meghalaya, India. *Biol. Mem.* **5**(1) : 56-81.

Dutta, S. K. & Sah, S. C. D. 1970. Palynostratigraphy of the Tertiary sedimentary formations of Assam-5. Stratigraphy and palynology of South Shillong Plateau. *Palaeontographica* **131**B (1-4) : 1-72.

Jain, K. P. & Gupta, R. C. 1970. Some fungal remains from the Tertiaries of Kerala Coast. *Palaeobotanist* **18**(2) : 177-182.

Jain, K. P. & Kar, R. K. 1979. Palynology of Neogene sediments around Quilon and Varkala, Kerala Coast, South India-1. Fungal remains. *Palaeobotanist* **26**(2) : 105-118.

Kar, R. K. 1979. Palynological fossils from the Oligocene sediments and their biostratigraphy in the district of Kutch, western India. *Palaeobotanist* **26**(1) : 16-49.

Kar, R. K. & Jain, K. P. 1981. Palynology of Neogene sediments around Quilon and Varkala, Kerala Coast, South India-2. Spores and pollen grains. *Palaeobotanist* **27**(2) : 113-131

Lakhanpal, R. N. 1970. Tertiary floras of India and their bearing on the historical geology of the region. *Taxon* **19**(5) : 675-694.

Mathur, K. 1973. Studies in the palaeoflora of the Himalayan foothills-2. On the palynoflora in the Lower Siwalik sediments of Nepal. *J. Palynol.* **8** : 54-62.

Mehrotra, N. C. 1981. Palynological correlation of Mikir Formation with Lower Palaeogene sediments of Shillong Plateau. *Geophytology* **11**(2) : 133-142.

Mehrotra, N. C. 1983. Palynology of Mikir Formation in the type area. *Geosci. Jour.* **4**(1) : 1-34.

Nandi, B. 1975. Palynostratigraphy of the Siwalik Group of Punjab. *Him. Geol.* **5** : 411-423.

Nandi, B. 1980. Further contribution on the palynostratigraphy of the Siwalik Group. *IV int. palynol. Conf., Lucknow (1976-77)* **2** : 727-734. Birbal Sahni Institute of Palaeobotany, Lucknow.

Navale, G. K. B. 1962. Pollen grains and spores from Neyveli Lignite, South India. *Palaeobotanist* **10** : 87-90.

Navale, G. K. B. & Misra, B. K. 1979. Some new pollen grains from Neyveli Lignite, Tamil Nadu, India. *Geophytology* **8**(2) : 226-239.

Ramanujam, C. G. K. 1960. Some pteridophytic spores from the Warkalli Lignite in South India with reference to those of Schizaeaceae. *J. Indian bot. Soc.* **39** : 46-55.

Ramanujam, C. G. K. 1966. Palynology of the Miocene lignite from South Arcot District, Madras, India. *Pollen spores* **8**(1) : 149-203.

Ramanujam, C. G. K. & Rao, K. P. 1973. A study of the pollen grains of *Ctenolophonidites* from the Warkalli deposits of South India with a note on the geological history of *Ctenolophon. Palaeobotanist* **20**(2) : 210-215.

Ramanujam, C. G. K. & Rao, K. P. 1977. A palynological approach to the study of Warkalli deposits of Kerala in South India. *Geophytology* **7**(2) : 160-164.

Ramanujam, C. G. K. & Rao, K. P. 1978. Fungal spores from the Neogene strata of Kerala in South India. *IV int. palynol. Conf., Lucknow (1976-77)* **1** : 291-304. Birbal Sahni Institute of Palaeobotany, Lucknow.

Ramanujam, C. G. K., Srisailam, K. & Reddy, P. R. 1981. The genus *Crassoretitriletes* Germeraad, Hopping & Muller, 1968 from the South Indian Tertiary deposits and its stratigraphic importance. *Geosci. Jour.* **2**(1) : 1-6.

Rao, K. P. & Ramanujam, C. G. K. 1976. A further record of microthyriaceous fungi from the Neogene deposits of Kerala in South India. *Geophytology* **6** : 98-104.

Rao, K. P. & Ramanujam, C. G. K. 1978. Palynology of the Neogene Quilon beds of Kerala State in South India 1—Spores of pteridophytes and pollen of monocotyledons. *Palaeobotanist* **25** : 397-427

Rao, K. P. & Ramanujam, C. G. K. 1982. Palynology of the Quilon beds of Kerala State in South India II—Pollen of dicotyledons and discussion. *Palaeobotanist* **30**(1) : 68-100.

Rao, M. R. 1983. A new record of *Malayaeaspora costata* Trivedi, Ambwani & Kar from the Tertiary sediments of Meghalaya and Assam. *Geophytology* **13**(2) : 241-242.

Rao, M. R. 1986. Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-IV Gymnospermous pollen grains. *Geophytology* **16**(1) : 65-72.

Rao, M. R., Saxena, R. K. & Singh, H. P. 1985. Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-V Angiospermous pollen grains. *Geophytology* **15**(1) : 7-23.

Rao, M. R. & Singh, H. P. 1987 Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-III. Pteridophytic spores. *Palaeobotanist* **35**(3) :

Sah, S. C. D. & Dutta, S. K. 1966. Palynostratigraphy of the sedimentary formations of Assam. 1. Stratigraphical position of the Cherra Formation. *Palaeobotanist* **15**(1-2) : 72-86.

Sah, S. C. D. & Dutta, S. K. 1968. Palynostratigraphy of the Tertiary sedimentary formations of Assam-2. Stratigraphic significance of spores and pollen in the Tertiary succession of Assam. *Palaeobotanist* **16**(2) : 177-195.

Sah, S. C. D. & Dutta, S. K. 1974. Palynostratigraphy of the sedimentary formations of Assam-3. Biostratigraphic zonation of the Cherra Formation of South Shillong Plateau. *Palaeobotanist* **21**(1) : 42-47.

Sah, S. C. D., Kar, R. K. & Singh, R. Y. 1970. Fossil microplankton from the Langpar Formation of Therriaghat, South Shillong Plateau, Assam, India. *Palaeobotanist* **18**(2) : 143-150.

Sah, S. C. D., Singh, R. Y. & Singh, H. P. 1980. Palynological zonation of the Tipam Group in Nahorkatiya area of Upper Assam. *IV int. palynol. Conf. Lucknow (1976-77)* **2** : 635-642.

Birbal Sahni Institute of Palaeobotany, Lucknow.

Salujha, S. K., Kindra, G. S. & Rehman, K. 1972. Palynology of the South Shillong Front part-1. The Palaeogene of Garo Hills. *Proc. Sem. Paleopalynol. Indian Stratigr., Calcutta* : 265-291.

Salujha, S. K., Kindra, G. S. & Rehman, K. 1974. Palynology of the South Shillong Front, Part II. The Palaeogenes of Khasi and Jaintia Hills. *Palaeobotanist* **21**(3) : 267-284.

Salujha, S. K., Rehman, K. & Kindra, G. S. 1973. Distinction between the Bhuban and Bokabil sediments of the southern edge of Shillong Plateau based on palynofossil assemblages. *Bull. Oil Nat. Gas Commn.* **10**(1-2) : 109-117

Saxena, R. K. & Rao, M. R. 1984. Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-I. Dinoflagellate cysts. *Jour. Palaeont. Soc. India* **29** : 52-62.

Saxena, R. K., Rao, M. R. & Singh, H. P. 1987 Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-VI. Palynostratigraphic zonation. *Palaeobotanist* **35**(2) : 150-158.

Saxena, R. K., Sarkar, S. & Singh, H. P. 1984. Palynological investigation of Siwalik sediments of Bhakra-Nangal area, Himachal Pradesh. *Geophytology* **14**(2) : 178-198.

Saxena, R. K. & Tripathi, S. K. M. 1982. Lithostratigraphy of the Tertiary sediments exposed along Jowai-Badarpur Road in Jaintia Hills (Meghalaya) and Cachar (Assam). *Palaeobotanist* **30**(1) : 34-42.

Sein, M. K. & Sah, S. C. D. 1974. Palynological demarcation of Eocene-Oligocene sediments in the Jowai-Badarpur Road Section, Assam. *Symp. Stratigr. Palynol. Spl. Publs.* : 99-105. Birbal Sahni Institute of Palaeobotany, Lucknow.

Shrivastava, P. K., Ganeshan, S. & Ray, D. 1974. Tipam Group in the subsurface of Upper Assam Valley, South of Brahmaputra. *J. geol Soc. India* **15**(2) : 165-181

Singh, H. P. & Rao, M. R. 1984. *Surmaspora*, a new pteridophytic spore genus recovered from the Tertiary sediments of Meghalaya and Assam. *Curr. Sci.* **53**(15) : 803-805.

Singh, H. P. & Saxena, R. K. 1984. Palynology of the Neogene sediments of Jorajan well-3, Upper Assam. *Proc. Symp. Evolutionary Botany & Biostratigraphy, Prof. A. K. Ghosh Commem. Vol.* : 613-631

Singh, H. P., Saxena, R. K. & Rao, M. R. 1986. Palynology of the Barail (Oligocene) and Surma (Lower Miocene) sediments exposed along Sonapur-Badarpur Road Section, Jaintia Hills (Meghalaya) and Cachar (Assam). Part-II. Fungal remains. *Palaeobotanist* **35**(1) : 93-105.

Singh, R. Y. 1977a. Stratigraphy and palynology of the Tura Formation in the type area. part II (Descriptive palynology). *Palaeobotanist* **23**(3) : 189-205.

Singh, R. Y. 1977b. Stratigraphy and palynology of the Tura Formation in the type area (Part III) : Discussion. *Palaeobotanist* **24**(1) : 1-12.

Singh, R. Y. & Singh, H. P. 1978. Morphological observations on some spores and pollen grains from the Palaeocene subsurface assemblages of Garo Hills, Meghalaya. *Palaeobotanist* **25** : 475-480.

Singh, R. Y. & Tewari, B. S. 1979. A note on the palynostratigraphy of the Tertiary sediments of Upper Assam. *Bull. Indian Geol. Assoc.* **12**(2) : 151-159.

Venkatachala, B. S. & Rawat, M. S. 1973. Palynology of the Tertiary sediments in the Cauvery Basin-2. Oligocene-Miocene palynoflora from the subsurface. *Palaeobotanist* **20**(2) : 238-263.