Palynological studies of the Barail Group (Oligocene) in the Type Area, Assam

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The surface samples from Disang (Eocene), Laisong (Lower Oligocene), Jenam (Middle Oligocene), Renji (Upper Oligocene) and Bhuban (Lower Miocene) formations exposed along Silchar-Halflong road in the type area in Assam were palynologically investigated. Six samples studied from Disang are placed into *Striatriletes microverrucosus* Cenozone. Laisong palynological assemblage comprises 30 genera and 28 identifiable species and the entire assemblage is placed into *Osmundacidites wellmanii* Cenozone. The Jenam assemblage has 49 genera and 42 identifiable species and the assemblage is divisible into: (i) *Malayaeaspora costata* Cenozone, and (ii) *Striatriletes susannae* Cenozone. The Renji assemblage constitutes *Cyathidites minor* Cenozone. The Bhuban assemblage is placed into *Pinuspollenites crestus* Cenozone. The Disang palynological assemblage is distinguished from Laisong by the high representation of *Phragmothyrites eocaenicus* and *Striatriletes susannae*. Laisong is differentiated from Jenam by the dominance of *Cyathidites minor, Lygodiumsporites lakiensis, Striatriletes susannae* and *Striatriletes multicostatus*. In Renji Formation, *Cyathidites minor* reappears in a good percentage but frequency of *Polypodiaceaesporites tertiarus, Striatriletes susannae, Striatriletes multicostatus* and *Osmundacidites wellmanii* is considerably reduced. The Bhuban assemblage is distinguished from Renji by the abundance of *Pinuspollenites crestus* and *Podocarpidites khasiensis*.

Key-words—Palynology, Barail Group, Oligocene (India).

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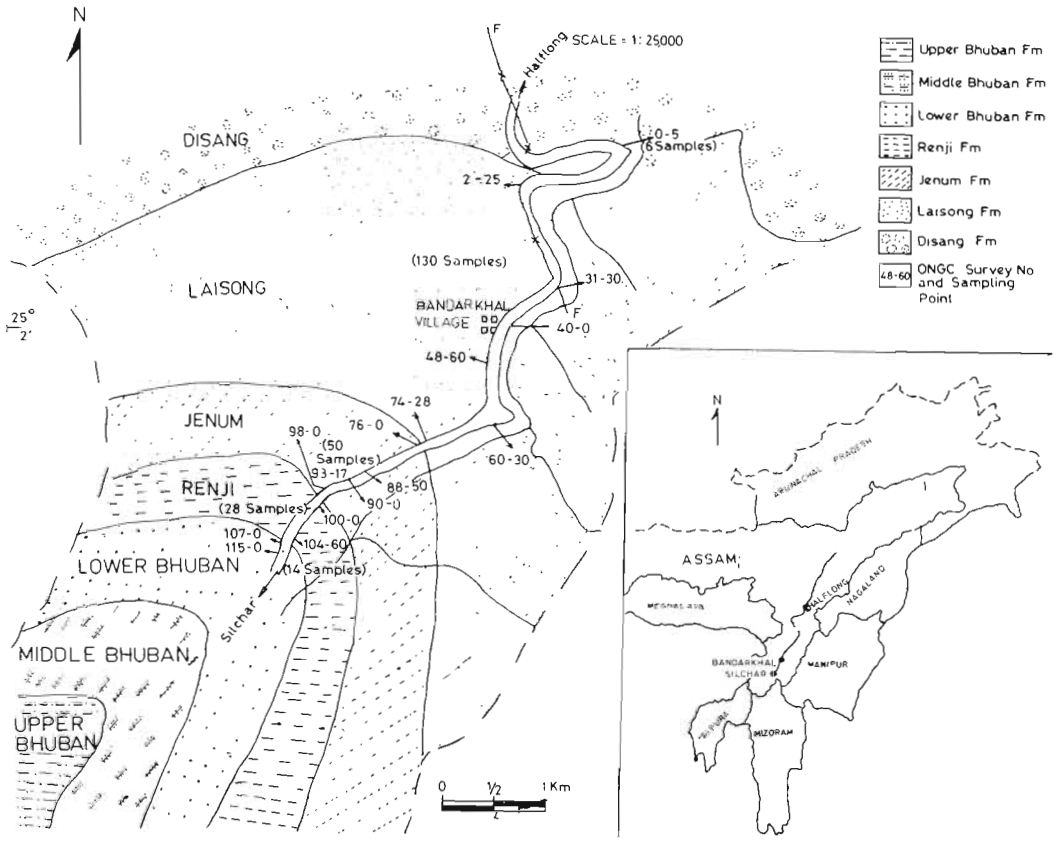
साराँश

असम में प्ररूप क्षेत्र में बैरेल समूह (पश्चनूतन) का परागाणविक अध्ययन

रंजीत कुमार कर

असम में प्ररूप क्षेत्र में सिल्चर हाफलौंग मार्ग के संग-संग विगोपित दिसाँग (आदिनूतन), लाइसोंग (अधरि पश्चनूतन), रेन्जी (उपरि पश्चनूतन) एवं भुबन (अधरि मध्यनूतन) शैल-समूहों का परागाणविक अन्वेषण किया गया है। दिसाँग से एकत्रित छः नमूनों को **स्ट्रिआट्रिलिटीज़ माइक्रोवेरुकोसस** नवमंडल में रखा गया है। लाइसोंग परागाणविक समुच्चय में 30 प्रजातियाँ एवं 28 जातियाँ विद्यमान हैं तथा यह पूरी समुच्चय **ओस्मुन्डेसिडाइटिस वैलमैन्नाई** नवमंडल में रखी गई है। जेनम समुच्चय में 49 प्रजातियाँ एवं 42 जातियाँ विद्यमान हैं तथा इसे (i) **मलायाइयास्पोरा कोस्टेटा** नवमंडल में रखा गया है। रेन्जी समुच्चय में **स्याथिडाइटिस माइनर** नवमंडल प्रेक्षित किया गया है। भुबन समुच्चय **पाइनसपोलिनाइटिस क्रेस्टस** नवमंडल में रखी गई है। दिसाँग समुच्चय **फ्रेग्मोथाइराइटिस ईओसेनिकस** एवं **स्ट्रिआट्रिलिटीस सुसान्न** की बाहुल्यता के कारण लाइसोंग समुच्चय से पृथक की जा सकती है। **स्याथिडाइटिस माइनर, लाइगोडियमस्पोराइटिस लाकीयेन्सिस, स्ट्रिआट्रीलिटीस सुसान्न** एवं **स्ट्रि० मल्टीकोस्टेटस** की प्रचुरता के कारण लाइसोंग को जेनम समुच्चय से पृथक किया जा सकता है। रेन्जी शैल-समूह में **स्याथिडाइटिस माइनर** पुनः अच्छी प्रतिशत मात्रा में मिलने लगता है परन्तु **पोलिपोडिएसिस्पोराइटिस टर्शियेरस, स्ट्रिआट्रिलिटीस सुसान्न, स्ट्रि० मल्टीकोस्टेटस** एवं **ओस्मुन्डेसिडाइटिस वैलमेनाई** पर्याप्त कम मात्रा में मिलते हैं। **पाइनसपोलिनाइटिस क्रेस्टस** एवं **पोडोकार्पिडाइटिस खासीयेन्सिस** की बाहुल्यता के आधार पर भुबन और रेन्जी समुच्चयों को एक दूसरे से पहचाना जा सकता है।

THE Barail Group is named after the Barail Range situated in Cachar and north Cachar Hill districts of Assam. The geosynclinal sediments of this group in Surma Valley are divided into Laisong, Jenam and Renji formations whereas in Upper Assam and Naga Hills, these are known as Naogaon, Baragolai and Tikak Parbat formations. To know the palynological assemblage of this group from the type locality, samples were collected from Silchar-Halflong road section (Lat. 25°2′ : Long. 92°45′) in collaboration with the Oil and Natural Gas Commission, Calcutta. In all, 228 samples were collected—6 samples from



Text-figure 1—Geological map of Silchar Halflong road showing the distribution of Disang, Laisong, Jenam, Renji and Bhuban formations

Disang, 130 samples from Laisong, 50 samples from Jenam, 28 samples from Renji and 14 samples from Bhuban (Text-fig. 1).

GENERAL GEOLOGY

Silchar-Halflong road exposes Disang, Laisong, Jenam, Renji, Bhuban and Bokabil formations. Disang consists generally of shale with minor sandstone/siltstone. The shales are mainly black to dark, steel-grey, weathering to reddish-brown in most of the places. This is laminated, highly fissile to splintery, rarely concretionary and with small clots of carbonaceous coaly material at places. Disang shales are fluvial, non-marine flood-plain deposits formed in a narrow trough bounded by Barisal-

→

PLATE 1

(All photomicrographs, unless otherwise mentioned, are × 500)

1,2,5. *Malayaeaspora costata* Trivedi, Ambwani & Kar, × 1000; slide no. BSIP 10032, U20 1, M32/1, M16.

3,7,11. *Polypodiaceaesporites chatterjii* Kar; slide nos. BSIP 10265, M36 2; 10266, R28; 10054, V21/1.

4,23. *Striatriletes multicostatus* Kar & Saxena; slide nos. BSIP 10264, F16 1; 10021, N39.

6. *Dictyophyllidites kyrtomatus* Kar & Kumar; slide no. BSIP 10021, R14/1.

8. *Cyathidites minor* Couper; slide no. BSIP 10057, J37 2.

9,10. *Osmundacidites wellmanii* Couper; slide nos. BSIP 10027, Z45 3; 10079, W21.

12. *Todisporites kulchensis* Sah & Kar; slide no. BSIP 10267, × 19.

13. *Phragmothyrites eocaenicus* Edwards emend. Kar & Saxena; slide no. 10037, O40/2.

14,15,20,21. *Klausipollenites sulcatus* Kar, Kieser & Jain; slide nos. BSIP 10045, P12; 10046, L26/3; 10047, L43; 10039, R32 4.

16. Spore mass; slide no. BSIP 10048, V43 2.

17. *Spinizonocolpites echinatus* Muller; slide no. BSIP 10269, V20 1.

18. *Laevigatosporites lakiensis* Sah & Kar; slide no. BSIP 10074, N25 4.

19. Tetracolporate pollen; slide no. BSIP 10023, D28/4.

22. *Platysaccus papilionis* Potonié & Klaus; slide no. BSIP 10079, M43.

24. *Abiespollenites cognatus* Kar; slide no. BSIP 10268, Z8/4.

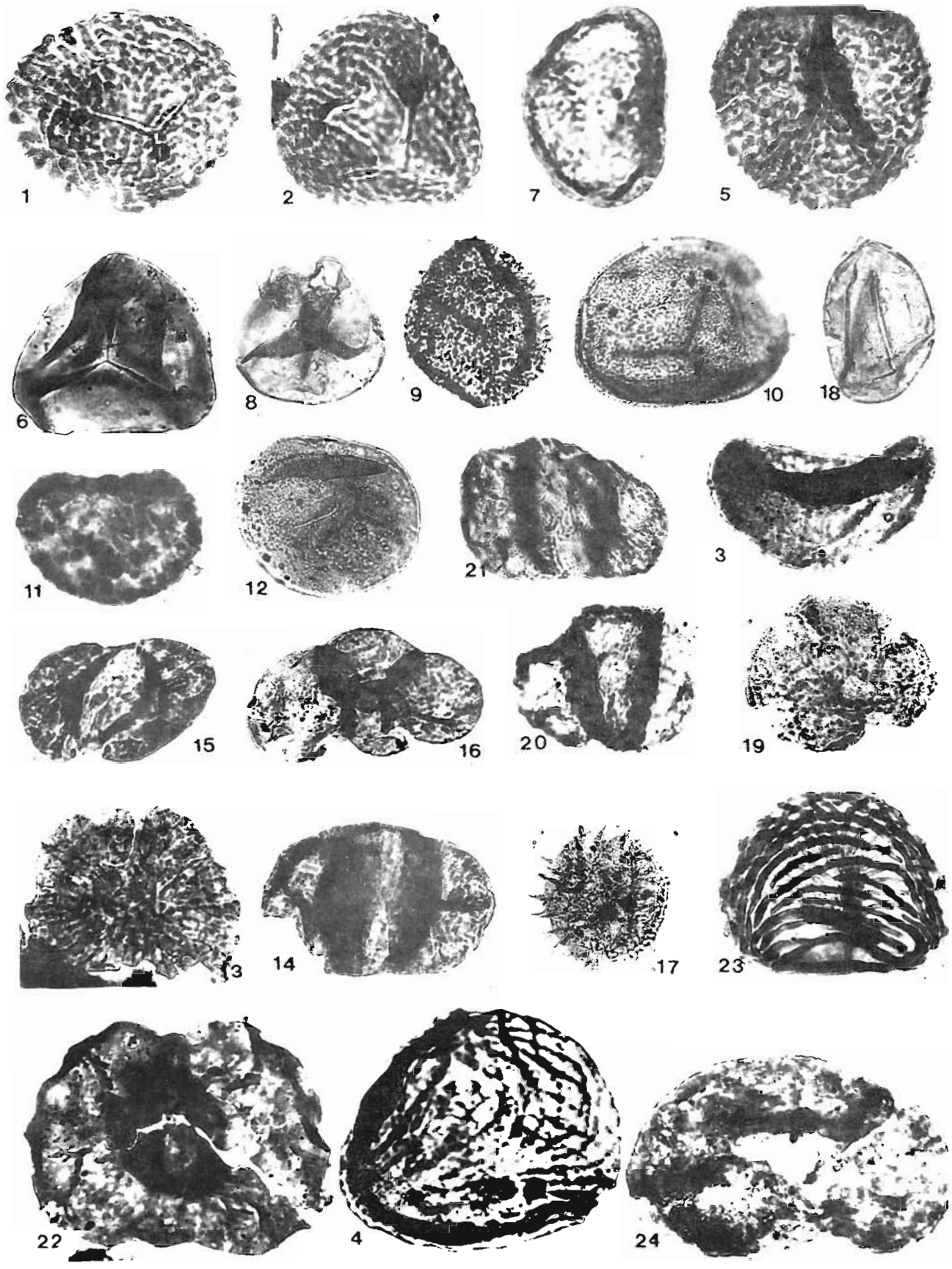


PLATE 1

Chandpur high in the west with ancestral Arakan-Yoma ridge in the east. Disang shales are not related to the shelf carbonate-clastic deposits of Khasi and Jaintia hills.

Disang is overlain by a conformable thick group of alternating hard sandstone and shale known as Barail Group. The Laisong is its basal formation and it generally consists of sandstones with occasional interbeds of shales and siltstones. The sandstones are grey to dark grey, weathering to reddish-brown, medium to coarse-grained, thick-bedded, hard and compact. Jenam, the middle unit of Barail Group, is essentially an argillaceous unit with shale and sandstone with minor alternation of fairly thick sandstone bands. In this section, the sandstones are more common and consist more or less equal proportion of sandstone and shale. The shales are dark grey to grey, laminated and carbonaceous at places. This formation shows conformable and gradational contact with the underlying Laisong Formation.

The topmost Renji Formation comprises entirely sandstone with occasional thin bands of highly fossile silty shale. The sandstones are dirty-grey to greenish-grey with tinge of violet, occasionally pinkish, weathering to yellowish-brown. The dicot leaf-impressions are mostly found in this formation. It is difficult to demarcate the contact of Jenam with overlying Bhuban, as the lower beds of Bhuban are highly arenaceous. However, the presence of frequent shales and conglomerate bands in Bhuban separates it with underlying Renji Formation.

DISANG ASSEMBLAGE

Out of 6 samples collected and macerated from Disang, 5 samples yielded palynofossils. The samples are poor in spores and pollen grains. The following species are recorded:

Cyathidites minor Couper 1953
Todisporites major Couper 1958
Dictyophyllidites dulcis Kar 1985
Intrapunctisporis intrapunctis Krutzsch 1959
Lygodiumsporites lakiensis Sah & Kar 1969
Striatriletes susannae van der Hammen emend. Kar 1979
S. paucicostatus Kar 1985
S. multicostatus Kar & Saxena 1981
S. microverrucosus Kar & Saxena 1981
Osmundacidites wellmanii Couper 1953
Polypodiaceaesporites chatterjii Kar 1979
P. tertiarus Dutta & Sah 1970
P. levis Sah 1967
Polypodiaceaesporites sp.
Polypodiisporites repandus Takahashi 1964
Psiloschizosporis psilata Kar & Saxena 1981
Podocarpidites khasiensis Dutta & Sah 1970
Pinuspollenites crestus Kar 1985
Piceapollenites excellensus Kar 1985
Klausipollenites sulcatus Kar, Kieser & Jain 1972
Taeniaesporites sp.
Hamiapollenites sp.
Neocouperipollis achinatus (Sah & Kar) Kar & Kumar 1986
Margocolporites tsukadai Ramanujam 1966
Pellicieroipollis langenheimii Sah & Kar 1970
Palaeomalvaceaepollis mammilatus Kar 1985
Phragmothyrites eocaenicus Edwards emend. Kar & Saxena 1976
Parmathyrites indicus Jain & Gupta 1970
Nototthyrites setiferus Cookson 1947
Inapertusporites kedvesii Elsik 1968
Inapertusporites sp.
Diporisporites anklesvarensus (Varma & Rawat) Elsik 1968
?*Sumatradinium* sp.

The reworked gymnospermous Mesozoic forms in the assemblage are: *Klausipollenites sulcatus* Kar, Kieser & Jain 1972, *Taeniaesporites* sp. and *Hamiapollenites* sp.

Palynological Zonation

The Disang palynological assemblage is assigned to one palynological zone, named as *Striatriletes microverrucosus* Cenozone.

Striatriletes microverrucosus Cenozone

Type section—Silchar-Halflong road section near Bandarkhal Village at the U-shape bend of the road (0-5, Text-fig. 1).

Lithology—Mostly highly fissile to splintery shales, generally with alternation of sandstone/siltstone.

Lower contact—Thin band of sandstone.

Upper contact—Hard sandstone.

Distinguishing characters of Cenozone—This zone is represented by the dominance of *Cyathidites minor, Striatriletes microverrucosus, Polypodiaceaesporites tertiarus, Pinuspollenites crestus* and *Phragmothyrites eocaenicus.*

Palaeoecology—The sediments were deposited mostly in fresh water condition.

Age—Late Eocene.

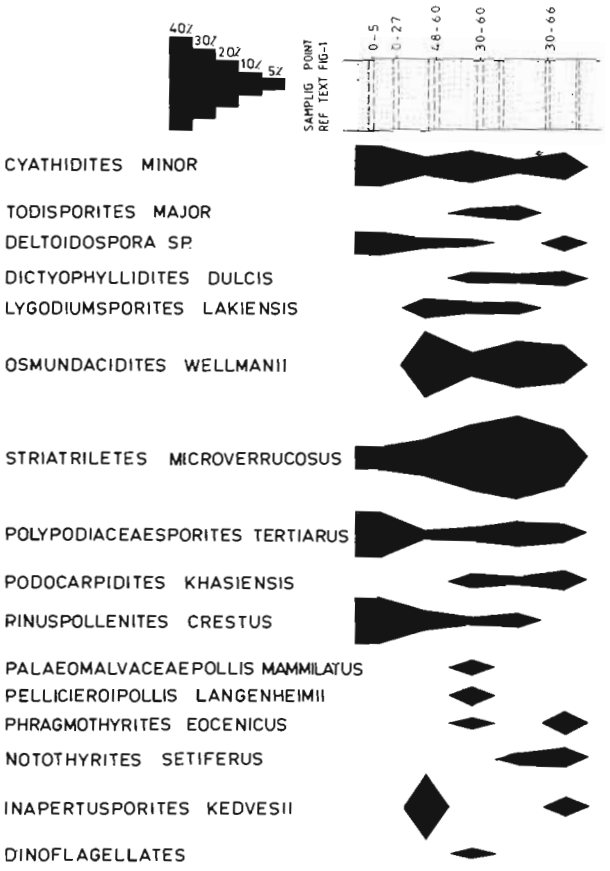
Correlation with other cenozones—This cenozone is not comparable to any of the known cenozones.

LAISONG ASSEMBLAGE

This formation is well exposed along Silchar-Halflong road section. One hundred and thirty samples were macerated, out of which 70 samples yielded microfossils. Palynotaxa recovered from this formation are listed below:

Cyathidites minor Couper 1953
Todisporites major Couper 1958
Dictyophyllidites dulcis Kar 1985
Lygodiumsporites lakiensis Sah & Kar 1969
Intrapunctisporis apunctis Krutzsch 1959
I. intrapunctis Krutzsch 1959
Lycopodiumsporites palaeocenicus Dutta & Sah 1970
L. globatus Kar 1985
Lycopodiumsporites sp.
Osmundacidites wellmanii Couper 1953
Striatriletes susannae van der Hammen emend. Kar 1979
S. paucicostatus Kar 1985
S. multicostatus Kar & Saxena 1981
S. microverrucosus Kar & Saxena 1981
Malayaeaspora costata Trivedi, Ambwani & Kar 1981
Deltoidospora sp.
Dandotiaspora telonata Sah, Kar & Singh 1971
Densoisporites sp.
Verrucosisporites sp.
Dulhuntyispora dulhuntyi Potonié 1956
Polypodiaceaesporites tertiarus Dutta & Sah 1970
P chatterjii Kar 1979
Polypodiisporites repandus Takahashi 1964
Podocarpidites khasiensis Dutta & Sah 1970
Pinuspollenites crestus Kar 1985
Klausipollenites sulcatus Kar, Kieser & Jain 1972
Neocouperipollis achinatus (Sah & Kar) Kar & Kumar 1986
Tetracolporites sp.
Monoporisporites sp.
Palaeomalvaceaepollis mammilatus Kar 1985
Inapertusporites kedvesii Elsik 1968
Phragmothyrites eocaenicus Edwards emend. Kar & Saxena 1976
Bicellaesporites sp.
Diporicellaesporites sp.
Spiniferites hypercanthus (Deflandre & Cookson) Cookson & Eisenack 1974
S. bulloideus (Deflandre & Cookson) Sarjeant 1970
Operculodinium sp. cf. *O. centrocarpum* (Deflandre & Cookson) Wall 1967

In addition, 6 genera and 4 species are reworked palynofossils, viz., *Dandotiaspora telonata, Densoisporites* sp., *Verrucosisporites* sp., *Dulhuntyispora dulhuntyi, Klausipollenites sulcatus* and *Neocouperipollis achinatus* (Text-fig. 2).



Text-figure 2—Percentage of different spore-pollen species in Laisong Formation.

Palynological zonation—The assemblage is assigned to the *Osmundacidites wellmanii* Cenozone.

Osmundacidites wellmanii Cenozone

Type section—Silchar-Halflong road section, opposite to Bandarkhal Village (40—0, Text-fig. 1).

Lithology—Hard sandstone with occasional layers of shale and siltstone.

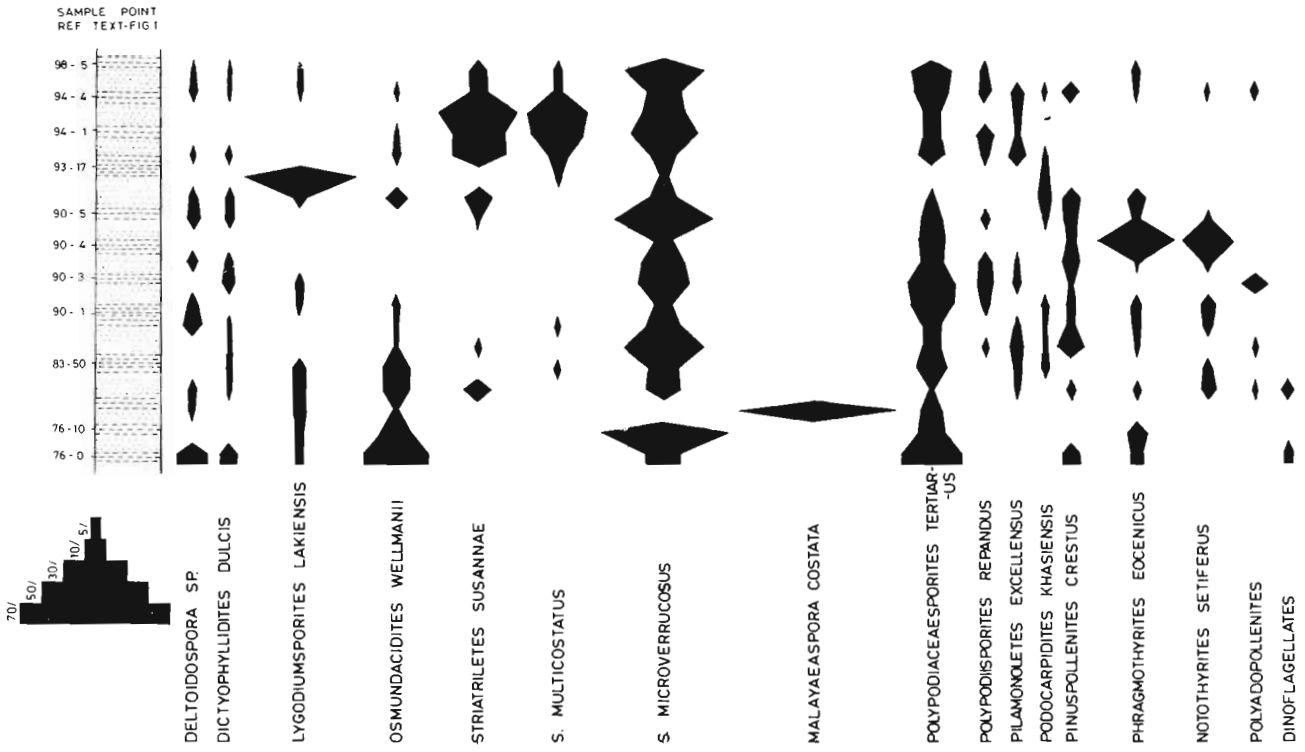
Lower contact—Hard sandstone.

Upper contact—Hard sandstone.

Distinguishing characters of Cenozone—It is recognized by good representation of *Cyathidites minor, Osmundacidites wellmanii, Striatriletes microverrucosus, Polypodiaceaesporites tertiarus, Pinuspollenites crestus* and *Inapertusporites kedvesii*.

Palaeoecology—The sediments were deposited in fluviatile conditions.

Age—Early Oligocene.



Text-figure 3—Percentage of different palynotaxa in Jenam Formation.

Correlation with other cenozones—This zone resembles *Striatriletes microverrucosus* Cenozone in the common presence of several forms but is distinguished by its high representation of *Osmundacidites wellmanii*.

JENAM ASSEMBLAGE

Fifty samples from this formation was macerated and 38 samples yielded spores and pollen grains belonging to following 49 genera and 42 identifiable species (Text-fig. 3).

Cyathidites minor Couper 1953
Todisporites major Couper 1958
Dictyophyllidites dulcis Kar 1985
Lygodiumsporites lakiensis Sah & Kar 1969
Deltoidospora sp.
Intrapunctisporis apunctis Krutzsch 1959
Alsophilidites sp.
Dandotiaspora plicata (Sah & Kar) Sah, Kar & Singh 1971

PLATE 2 →

(All photomicrographs, unless otherwise mentioned, are × 500)

1. *Polypodiaceaesporites levis* Sah; slide no. BSIP 10082, H26/4.
2,4. *Polypodiaceaesporites chatterjii* Kar; slide nos. BSIP 10083, R15 1, 10084, P34/1.
3,18,21 *Cyathidites minor* Couper; slide nos. BSIP 10021, T30; 10088, Z34; 10078, U22.
5,26. *Osmundacidites wellmanii* Couper; slide nos. BSIP 10083, P26/3; 10089, 026/3.
6. *Nototyrites setiferus* Cookson; slide no. BSIP 10036, H41
7,11. *Phragmothyrites eocaenicus* Edwards emend. Kar· slide nos. BSIP 10028, S36; 10037, O40 2
8. *Podocarpidites khasiensis* Sah & Kar; slide no. BSIP 10026; T30.
9. *Todisporites kutchensis* Sah & Kar; slide no. BSIP 10070, L22.
10. *Indotriradites sparsus* Tiwari; slide no. BSIP 10092, W45/3.
12. *Klausipollenites sulcatus* Kar, Kieser & Jain; slide no. BSIP 10029, R48.
13,14,15. *Polypodiaceaesporites haardti* Thiergart; slide nos. BSIP 10086, Q42/4; 10092, U12/4; 10093, G26.
16. *Biretisporites convexus* Sah & Kar; slide no. BSIP 10079, R34/2.
17,22,24. *Lygodiumsporites lakiensis* Sah & Kar; slide nos. BSIP 10021, R34; X23; 10094, R13/4.
19. *Parmathyrites indicus* Jain & Gupta; slide no. BSIP 10037, U44.
20. *Tsugaepollenites velatus* Kar; slide no. BSIP 10091, O7
23. *Lycopodiumsporites globatus* Kar; Slide no. BSIP 10096, H15/4.
25. *Triporoletes* sp; slide no. BSIP 10067, Y28.

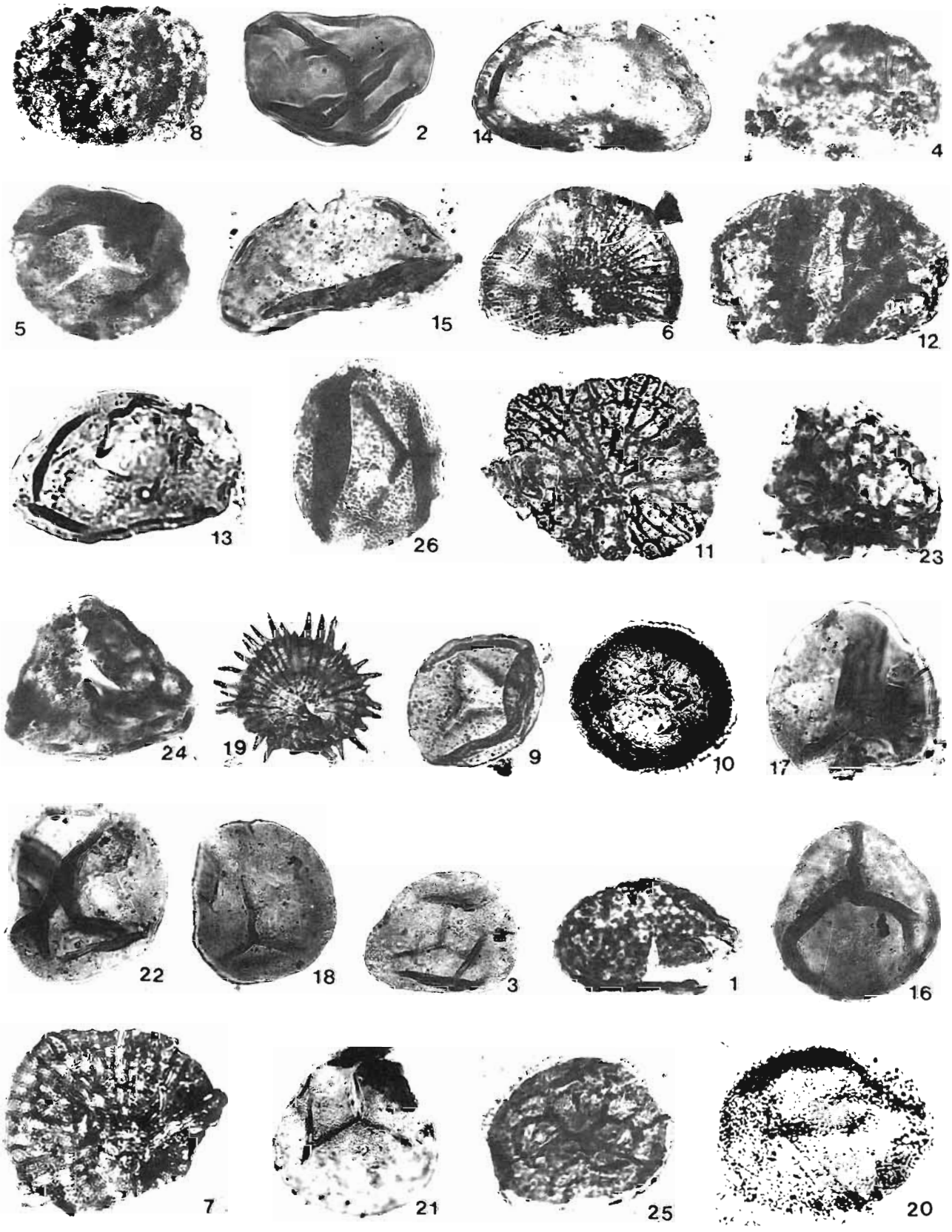


PLATE 2

Neocalamospora sp.
Azolla aglochidia Kar 1985
Osmundacidites wellmanii Couper 1953
Lycopodiacidites sp.
Lycopodiumsporites globatus Kar 1985
Striatriletes susannae van der Hammen emend. Kar 1979
S. paucicostatus Kar 1985
S. multicostatus Kar & Saxena 1981
S. microverrucosus Kar & Saxena 1981
Cheilanthoidspora monoleta Sah & Kar 1974
Verrucosisporites sp.
Polypodiaceaesporites levis Sah 1967
P. tertiarus Dutta & Sah 1970
P. chatterjii Kar 1979
P haardti Thiergart 1940
Polypodiisporites repandus Takahashi 1964
P. ornatus Sah 1967
Tiwariasporis sp.
Pilamonoletes excellensus Kar (MS.)
Psiloschizosporis psilata Kar & Saxena 1981
Psiloschizosporis sp.
Podocarpidites khasiensis Dutta & Sah 1970
Abiespollenites cognatus Kar 1985
Pinuspollenites crestus Kar 1985
Piceapollenites excellensus Kar 1985
Klausipollenites sulcatus Kar, Kieser & Jain 1972
K. decipiens Jansonius 1962
Platysaccus sp.
Rhizomaspora radiata Wilson 1962
Tsugaepollenites velatus Kar 1985
Neocouperipollis kutchensis (Venkatachala & Kar) Kar & Kumar 1986
N. achinatus (Sah & Kar) Kar & Kumar 1986
Spinizonocolpites echinatus Muller 1968
Magnamonocolpites miocenicus Kar 1985
Tricolpites reticulatus Cookson 1947
Retitrescolpites sp.
Acanthotricolpites brevicolpus Kar (MS.)
Platoniapollenites iratus Sah & Kar 1974
Retistephanocolpites sp.
Tetracolporites sp.
Polyadopollenites sp.
Pellicieroipollis langenheimii Sah & Kar 1970
Palaeomalvaceaepollis mammilatus Kar 1985
Inapertusporites kedvesii Elsik 1968
Phragmothyrites eocaenicus Edwards emend. Kar & Saxena 1981
Notothyrites setiferus Cookson 1947
Monoporisporites spp.
Lacrimasporonites sp.
Bicellaesporites sp.
Pluricellaesporites sp.
Multicellaesporites sp.

There are also few dinoflagellates in the assemblage. The above list includes reworked Palaeozoic, Mesozoic and older Tertiary forms, too. These are: *Neocalamospora* sp., *Klausipollenites sulcatus, Klausipollenites decipiens, Platysaccus* sp., *Rhizomaspora radiata, Neocouperipollis kutchensis, Neocouperipollis achinatus, Spinizonocolpites echinatus, Platoniapollenites iratus* and *Pellicieroipollis langenheimii.*

The assemblage is divisible into (i) *Malayaeaspora costata* Cenozone, (ii) *Polypodiaceaesporites tertiarus* Cenozone, and (iii) *Striatriletes susannae* Cenozone in ascending order.

Malayaeaspora costata Cenozone

Type section—Silchar-Halflong road section between 76-0-88-50 points (Text-fig. 1).

Lithology—Mainly sandstone with occasional thin layers of carbonaceous shale.

Lower contact—Thick sandstone.

Upper contact—Thick sandstone.

Distinguishing characters of Cenozone—This has the dominance of *Malayaeaspora costata, Striatriletes microverrucosus, Osmundacidites wellmanii* and *Polypodiaceaesporites tertiarus.*

Palaeoecology—The deposition took place in fluviatile condition.

Age—Middle Oligocene.

Correlation with other cenozones—This cenozone compares well with the *Osmundacidites wellmanii* Cenozone of Laisong Formation in the representation of *Osmundacidites wellmanii, Striatriletes microverrucosus* and *Polypodiaceaesporites tertiarus.* However, insignificant contribution by *Cyathidites minor* and *Pinuspollenites crestus* and prominent representation of *Malayaeaspora costata* differentiate this cenozone.

Polypodiaceaesporites tertiarus Cenozone

Type section—Silchar-Halflong road section between 90-0 to 90-20-5 points (Text-fig. 1).

Lithology—Hard, compact sandstone with alternation of shale.

Lower contact—A sandstone band.

Upper contact—A sandstone band.

Distinguishing characters of Cenozone—Abundance of *Polypodiaceaesporites tertiarus, Striatriletes microverrucosus, Phragmothyrites eocaenicus* and *Notothyrites setiferus.*

Palaeoecology—The sediments were deposited in fluviatile condition.

Age—Middle Oligocene.

Correlation with other cenozones—

Malayaeaspora costata Cenozone resembles this zone in the presence of *Striatriletes microverrucosus, Osmundacidites wellmanii* and *Polypodiaceaesporites tertiarus*. However, substantial contribution of *Phragmothyrites eocaenicus* and *Notothyrites setiferus* in this cenozone distinguishes it from the preceding one.

Striatriletes susannae Cenozone

Type section—Silchar-Halflong road section between 93-17 to 98-0-5 points (Text-fig. 1)

Lithology—Mostly sandstone with thin partings of carbonaceous shale.

Lower contact—Thick sandstone.

Upper contact—A hard sandstone band.

Distinguishing characters of Cenozone—Fair presence of *Striatriletes susannae, Striatriletes multicostatus, Striatriletes microverrucosus, Lygodiumsporites lakiensis* and *Polypodiaceaesporites tertiarus*.

Palaeoecology—The sediments were deposited in fluviatile condition.

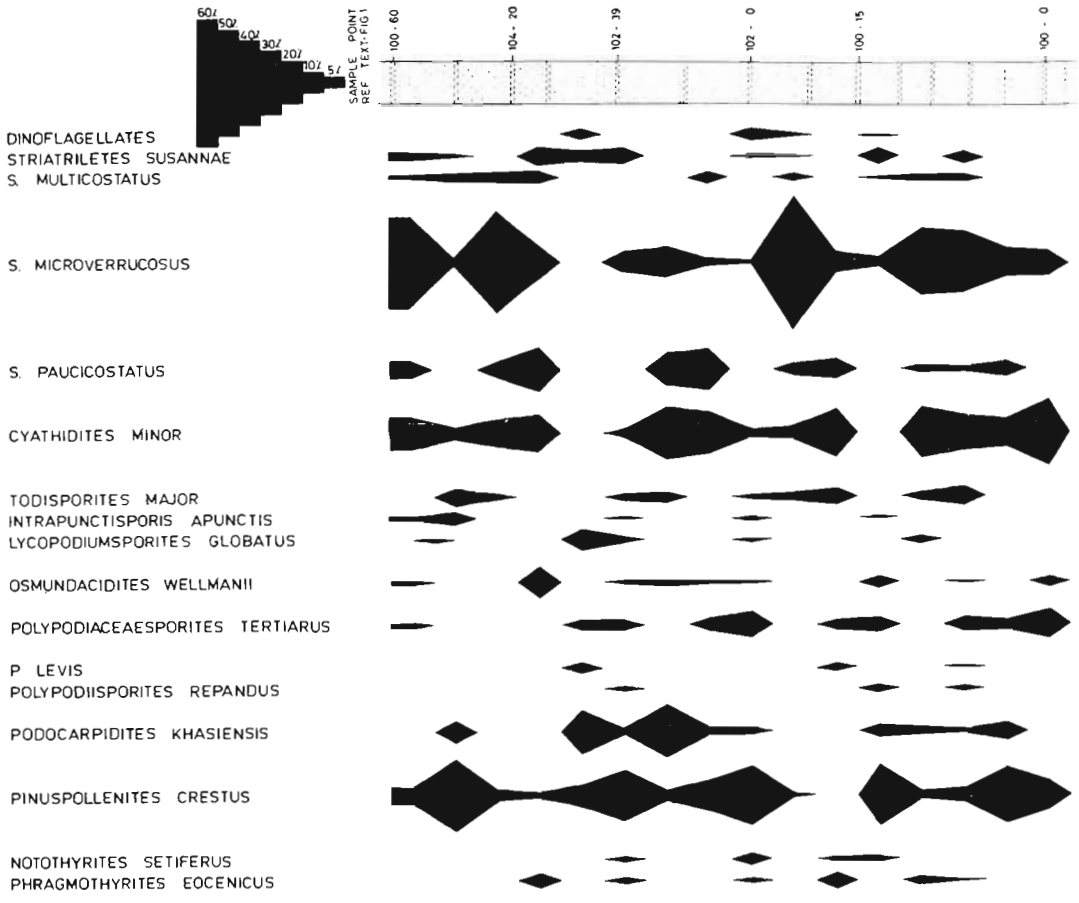
Age—Middle Oligocene.

Correlation with other cenozones—*Polypodiaceaesporites tertiarus* Cenozone is not correlatable with the present one. *Striatriletes susannae* Cenozone of Rokhia bore hole core no. 1, Gajalia 1 and Baramura 2 closely resemble this cenozone as the assemblage is dominated by *Striatriletes*. *Phragmothyrites eocaenicus* Cenozone of Lakwa bore hole core no. 22 resembles this cenozone in the representation of *Striatriletes susannae* but is differentiated by its ill-representation of *Phragmothyrites eocaenicus*. *Striatriletes susannae* Cenozone of Lakwa bore-hole core no. 22 compares well with this assemblage in the dominance of *Striatriletes susannae* but other constituents, e.g., *Inapertusporites kedvesii, Phragmothyrites eocaenicus* and *Tricolpites reticulatus* are not found in good percentage in the present cenozone.

RENJI ASSEMBLAGE

Twenty-eight samples from this formation were macerated, out of which 17 samples yielded palynofossils.The following 47 genera and 52 species were recovered:

Cyathidites minor Couper 1953
Deltoidospora sp.
Alsophilidites sp.
Todisporites kutchensis Sah & Kar 1969
T. major Couper 1958
Lygodiumsporites lakiensis Sah & Kar 1969
Lygodiumsporites sp.
Biretisporites convexus Sah & Kar 1969
Intrapunctisporis intrapunctis Krutzsch 1959
I. apunctis Krutzsch 1959
Dictyophyllidites dulcis Kar 1985
D. kyrtomatus Kar & Kumar 1987
Lycopodiumsporites globatus Kar 1985
Lycopodiacidites sp.
Osmundacidites wellmanii Couper 1953
Striatriletes susannae van der Hammen emend. Kar 1979
S. paucicostatus Kar 1985
S. multicostatus Kar & Saxena 1981
S. microverrucosus Kar & Saxena 1981
S. aidaensis Kar 1985
Neocalamospora rotunda Bose & Kar 1976
Densoisporites velatus Weyland & Krieger 1953
Microbaculispora gondwanensis Bharadwaj 1962
Verrucosisporites sp.
Dulhuntyispora dulhuntyi Potonié 1956
Laevigatosporites lakiensis Sah & Kar 1969
Polypodiaceaesporites levis Sah 1967
P. tertiarus Dutta & Sah 1970
P. chatterjii Kar 1979
Polypodiisporites repandus Takahashi 1964
Seniasporites sp.
Pilamonoletes moderatus Kar (MS.)
Psiloschizosporis psilata Kar & Saxena 1981
P. scabratus Kar 1985
Podocarpidites classicus Salujha, Kindra & Rehman 1972
Pinuspollenites crestus Kar 1985
Piceapollenites excellensus Kar 1985
Abiespollenites cognatus Kar 1985
Tsugaepollenites velatus Kar 1985
Cuneatisporites radialis Leschik 1955
C. reticulatus Kar, Kiesser & Jain 1972
Platysaccus papilionis Potonié & Klaus 1954
Klausipollenites sulcatus Kar, Kieser & Jain 1972
Labirites raniganjensis Bharadwaj 1962
Striatopodocarpites diffusus Bharadwaj & Salujha 1964
Verticipollenites secretus Bharadwaj 1962
Rhizomaspora costa Venkatachala & Kar 1968
Palmaepollenites kutchensis Venkatachala & Kar 1969
Neocouperipollis kutchensis (Venkatachala & Kar) Kar & Kumar 1986
Neocouperipollis sp.
Retitrescolpites sp.
Minutitricolporites minutus (Sah & Kar) Kar 1985
Tetracolporites sp.
Pellicieroipollis langenheimii Sah & Kar 1970
Palaeomalvaceaepollis mammilatus Kar 1985



Text-figure 4—Percentage of different species in Renji Formation.

P. rudis Kar 1985

Polyadopollenites sp.

Phragmothyrites eocaenicus Edwards emend. Kar & Saxena 1976

Kutchiathyrites eccentricus Kar 1977

Inapertusporites kedvesii Elsik 1968

Pluricellaesporites sp.

Dinoflagellates

The reworked Palaeozoic forms found in this assemblage are: *Neocalamospora rotunda, Microbaculispora gondwanensis, Verrucosisporites* sp., *Dulhuntyispora dulhuntyi, Platysaccus papilionis, Labirites raniganjensis, Striatopodocarpidites diffusus, Verticipollenites secretus* and *Rhizomaspora costa.* Mesozoic reworked forms are not many; they are represented by *Densoisporites velatus, Cuneatisporites reticulatus* and *Klausipollenites sulcatus.* The older Tertiary species encountered in the assemblage are: *Palmaepollenites kutchensis, Neocouperipollis kutchensis, Neocouperipollis* sp., *Minutitricolporites minutus* and *Pellicieroipollis langenheimii* (Text-fig. 4).

Palynological Zonation

This palynological cenozone is named as *Cyathidites minor* Cenozone.

Cyathidites minor Cenozone

Type section—Silchar-Halflong road section between 100-0 to 104-60 points (Text-fig. 1).

Lithology—Sandstone with occasional thin bands of highly fissile silty shale.

Lower contact—A hard sandstone.

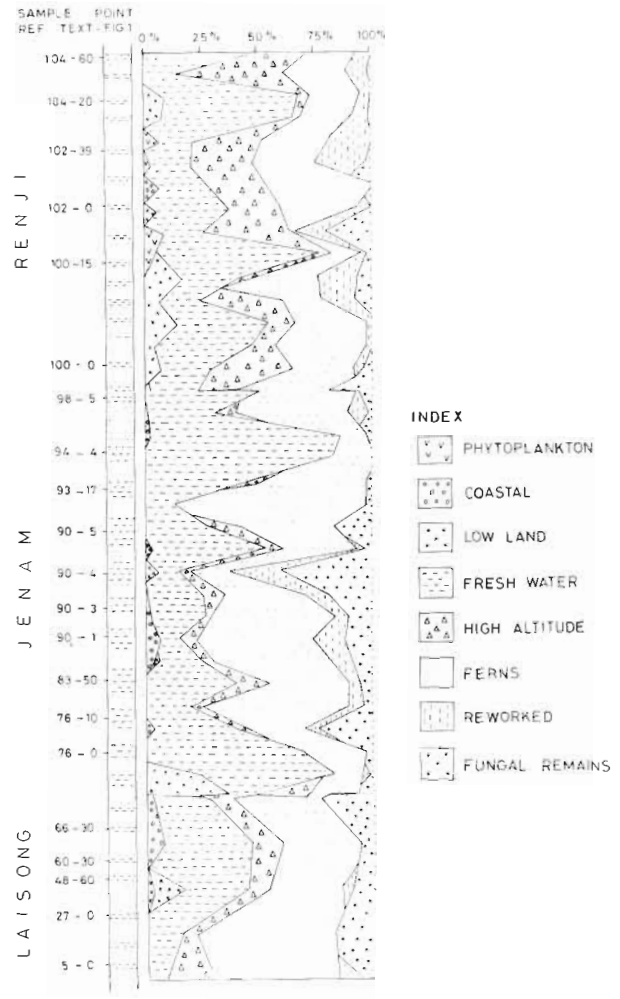
Upper contact—Sandstone.

Distinguishing characters of Cenozone—This shows the presence of *Cyathidites minor, striatriletes microverrucosus, Striatriletes paucicostatus, Pinuspollenites crestus* and *Podocarpidites khasiensis.*

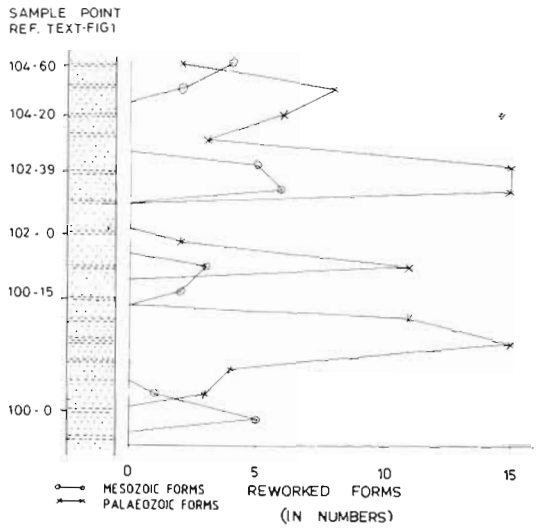
Palaeoecology—The sediments were deposited in fluviatile environment.

Age—Late Oligocene.

Correlation with other cenozones—*Striatriletes susannae* Cenozone—the topmost cenozone of



Text-figure 5—Summary diagram showing the representation of different ecological groups in Laisong, Jenam and Renji formations.



Text-figure 6—Percentage of reworked Palaeozoic and Mesozoic spore-pollen in Renji Formation.

Jenam Formation, broadly resembles this cenozone in the abundance of *Striatriletes microverrucosus*. However, other dominant species of Jenam Formation, viz., *Striatriletes susannae, Striatriletes multicostatus* and *Polypodiaceaesporites tertiarus* though present in Renji Formation do not contribute much to the assemblage. Similarly, *Striatriletes susannae* Cenozone of Rokhia 1, Gajalia 1 and Baramura 2 proposed by Kar (MS) is only broadly comparable (Text-fig. 5).

Cyathidites minor Cenozone proposed for Lakwa bore-hole core no. 22 by Kar (MS) between the depth 3855-3390 m resembles this cenozone in the presence of *Cyathidites minor* in good numbers but the other dominant elements like *Polypodiisporites repandus, Polypodiaceaesporites* sp., *Striatriletes susannae* and *Phragmothyrites eocaenicus* are not found in appreciable percentage in this cenozone (Text-fig. 6).

BHUBAN ASSEMBLAGE

To distinguish the Upper Renji Formation from the Lower Bhuban at Silchar-Halflong road section, 14 samples were collected and macerated out of which 9 samples yielded the following palynological taxa:

Cyathidites minor Couper 1953
Todisporites major Couper 1958
Deltoidospora sp.
Dictyophyllidites dulcis Kar 1985
Lygodiumsporites lakiensis Sah & Kar 1969
Intrapunctisporis apunctis Krutzsch 1959
Pteridacidites fistulosus Sah 1967
Azolla aglochidia Kar 1984
Osmundacidites wellmanii Couper 1953
Lycopodiumsporites globatus Kar 1984
Lycopodiacidites sp.
Striatriletes susannae van der Hammen emend. Kar 1979
S. paucicostatus Kar 1985
S. multicostatus Kar & Saxena 1981
S. microverrucosus Kar & Saxena 1981
S. aidaensis Kar 1985
Malayaeaspora costata Trivedi, Ambwani & Kar 1981
Indotriradities sparsus Tiwari 1964
Indotriradites korbaensis Tiwari 1964
Indotriradites sp.
Neocalamospora rotunda Bose & Kar 1976
Psilaplicates triangulus Bose & Kar 1976
Laevigatosporites lakiensis Sah & Kar 1969
Polypodiaceaesporites levis Sah 1967
P. chatterjii Kar 1979

P haardti Thiergart 1940
Polypodiisporites repandus Takahashi 1964
P ornatus Sah 1967
Psiloschizosporis psilata Kar & Saxena 1981
Pilamonoletes moderatus Kar (MS)
Podocarpidites khasiensis Dutta & Sah 1970
Pinuspollenites crestus Kar 1985
Abiespollenites cognatus Kar 1985
Tsugaepollenites velatus Kar 1985
Klausipollenites sulcatus Kar, Kieser & Jain 1972
K. decipiens Jansonius 1962
Callialasporites monoalasporus Dev 1961
C. segmentatus (Balme) de Jersey 1962
Cuneatisporites reticulatus Kar, Kieser & Jain 1972
C. radialis Leschik 1955
Platysaccus papilionis Potonié & Klaus 1954
P queenslandi de Jersey 1962
Corisaccites alutas Venkatachala & Kar 1969
Lunatisporites sp.
Striatopodocarpites diffusus Bharadwaj & Salujha 1964
S. venustus Bharadwaj 1962
Rhizomaspora costa Venkatachala & Kar 1969
Faunipollenites varius Bharadwaj 1962
Limitisporites plicatus Bose & Kar 1966
Hindipollenites sp.
Elilasaccites elilaensis Bose & Kar 1966
Parasaccites korbaensis Bharadwaj & Tiwari 1964
Potonieisporites sp.
Plicatipollenites gondwanensis Lele 1964
Divarisaccus lelei Venkatachala & Kar 1966
Palaeomalvaceaepollis mammilatus Kar 1985
Polyadopollenites sp.
Notothyrites setiferus Cookson 1947
Phragmothyrites eocaenicus Edwards emend. Kar & Saxena 1976
Cordosphaeridium exilimurum Davey & Williams 1966

The assemblage has a large number of reworked Palaeozoic and Mesozoic palynofossils. The Palaeozoic spores and pollen grains recovered are: *Indotriradites korbaensis, Indotriradites sparsus, Indotriradites* sp., *Neocalamospora rotunda, Psilaplicates triangulus, Cuneatisporites radialis, Platysaccus papilionis, Corisaccites alutas, Lunatisporites* sp., *Striatopodocarpites diffusus, Striatopodocarpites venustus, Faunipollenites varius, Limitisporites plicatus, Hindipollenites* sp., *Elilasaccites elilaensis, Parasaccites korbaensis, Potonieisporites* sp., *Plicatipollenites gondwanensis* and *Divarisaccus lelei.*

The Mesozoic forms found in the assemblage are: *Klausipollenites sulcatus, Klausipollenites decipiens, Callialasporites monoalasporus, Callialasporites segmentatus, Cuneatisporites reticulatus* and *Platysaccus queenslandii.*

It is to note here that no Palaeocene-Eocene palynofossils are met within the samples studied here. Such abundance of reworked Palaeozoic and Mesozoic forms in the assemblage is nowhere found in the section. This feature may be considered to distinguish it from the older formations. Perhaps the Himalayan upliftment continued to influence the deposition. The angiosperms are represented only by two genera and their contribution is also insignificant. However, the gymnosperms and the pteridophytes are well represented.

Palynological zonation—Fifteen species are well represented in the samples. The distribution pattern of these species are more or less same, therefore, only one cenozone, viz., *Pinuspollenites crestus* Cenozone is proposed for this formation.

Pinuspollenites crestus Cenozone

Type section—Silchar-Halflong road section between 107 to 115·0 points (Text-fig. 1).

Lithology—Mainly sandy shale and sandstone.

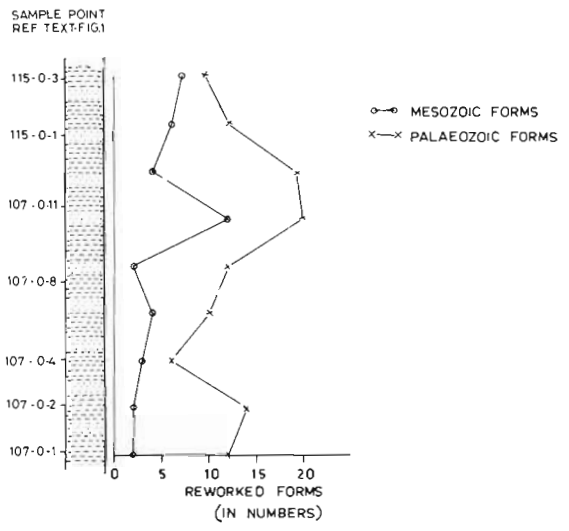
Lower contact—A hard sandstone band.

Upper contact—Sandstone.

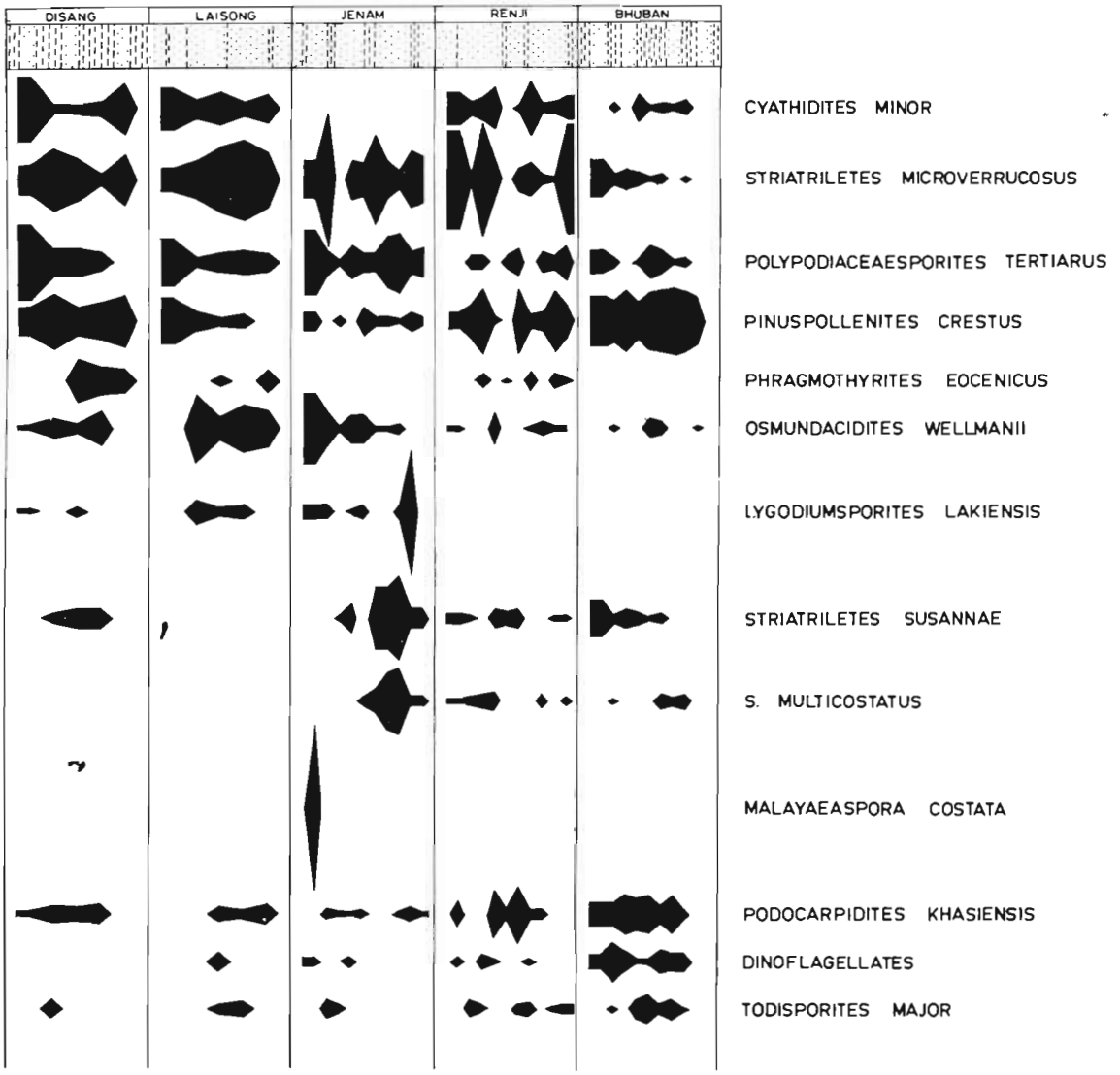
Distinguishing characters of Cenozone—Dominance of gymnospermous pollen grains represented by *Pinuspollenites crestus* and *Podocarpidites khasiensis* and presence of Palaeozoic and Mesozoic forms (Text-fig. 7).

Palaeoecology—The sediments were deposited in a flood plain.

Age—Miocene.



Text-figure 7—Distribution of reworked Palaeozoic and Mesozoic species in Bhuban Formation.



Text-figure 8—Distribution of stratigraphically important spore-pollen species in Disang, Laisong, Jenam, Renji and Bhuban formations.

Correlation with other known Cenozones—This cenozone resembles *Pinuspollenites crestus* Cenozone of Rokhia bore-hole core no. 1, Gajalia bore-hole core no. 1 and Baramura bore-hole core no. 2 by Kar (MS) The present one, however, slightly differs in the better representation of *Podocarpidites khasiensis* and in the absence of *Operculosculptites globatus*.

DISCUSSION

Samples from Disang, Laisong, Jenam, Renji and Bhuban formations were investigated to distinguish the Disang (Upper Eocene) and Laisong (Early Oligocene) and to find out the finer differentiation of Barails and Renji (Late Oligocene) and Bhuban (Miocene) palynological boundary.

It has been observed that Disang and Laisong can be separated on the basis of palynofossils. In Disang *Phragmothyrites eocaenicus* and *Striatriletes susannae* are found in good percentage. In Laisong, these two species are hardly found and instead *Osmundacidites wellmanii* are very well represented. The contribution of *Polypodiaceae-sporites tertiarus* is also comparatively reduced in the Laisong assemblage whereas that of *Striatriletes microverrucosus* is considerably increased (Text-fig. 8).

Laisong and Jenam formations are distinguished on the basis of the distribution of *Cyathidites minor, Lygodiumsporites lakiensis, Striatriletes susannae, Striatriletes multicostatus* and *Malayaeaspora costata*. In Laisong, *Cyathidites minor* is prominent but it is almost absent in Jenam Formation.

Lygodiumsporites lakiensis, Striatriletes susannae, Striatriletes multicostatus and *Malayaeaspora costata* are the dominant elements in Jenam, but are either ill-represented or totally absent in Laisong Formation.

Jenam and Renji formations, on the other hand, are distinguished on the basis of *Cyathidites minor, Polypodiaceaesporites tertiarus, Pinuspollenites crestus, Osmundacidites wellmanii, Malayaeaspora costata* and *Lygodiumsporites lakiensis*. *Cyathidites minor* reappears in Renji Formation in substantial percentage but the representation of *Polypodiaceaesporites tertiarus, Striatriletes susannae, Striatriletes multicostatus* and *Osmundacidites wellmanii* is reduced *Lygodiumsporites lakiensis* and *Malayaeaspora costata* are almost absent in Renji Formation.

Renji and Bhuban formations are easily demarcated by the proportionate occurrence of gymnospermous pollen grains. *Pinuspollenites crestus* and *Podocarpidites khasiensis* are present in both the formations, but in Bhuban their representation is maximum. Beside contribution of *Striatriletes microverrucosus, Cyathidites minor* also considerably dwindles but the percentage of dinoflagellates increases in Bhuban Formation. The reworked Palaeozoic and Mesozoic forms are also maximum in this formation.

Salujha and Kindra (1986) also worked out the Palynostratigraphy of the Silchar-Halflong road traverse and proposed 5 palynological zones for the Barail sediments. Of these, only the lower most and the third zones are moderately fossiliferous; others are poor in spores and pollen grains. All these zones are not comparable to the present ones as *Stephanoporopollenites validus, Tricolpites ovatus* and *Polyporina globosa* found in most of those zones as dominant forms are absent here. The assemblage recorded here is dominated by pteridophytic spores and the angiospermic pollen.

Comparison with other cenozones of Barail Group

Saxena *et al.* (1987) proposed *Polysphaeridium subtile* and *Todisporites major* cenozones for Lower and Upper Laisong Formation exposed along Sonarpur-Badarpur road section, Jaintia Hills, Meghalaya. *Polysphaeridium subtile* Cenozone has abundance of phytoplanktons. *Osmundacidites wellmanii* Cenozone proposed here for Laisong does not exhibit resemblance as the Sonarpur-Badarpur assemblage is dominated by dinoflagellates. However, *Cyathidites minor* and *Lygodiumsporites lakiensis* are found as dominant species in both.

Todisporites major Cenozone has *Cordosphaeridium multispinosum, Cordosphaeridium fibrospinosum, Polysphaeridium subtile, Striatriletes susannae, Biretisporites oligocenicus, Todisporites major, Lygodiumsporites lakiensis, Lygodiumsporites eocenicus, Polyadopollenites sahnii* and *Echistephanocolpites meghalayaensis* as dominant elements. This cenozone resembles the present one by the dominance of pteridophytic spores and some of the dominant forms, like *Lygodiumsporites lakiensis* and *Todisporites major*, are also common.

Saxena *et al.* (1987) also proposed *Lygodiumsporites eocenicus* Cenozone for Jenam and Renji formations. This cenozone is characterized by the high frequency of pteridophytic spores mostly represented by *Striatriletes susannae, Striatriletes pachyexinus, Lygodiumsporites eocenicus, Lygodiumsporites lakiensis, Todisporites major, Polypodiaceaesporites tertiarus, Podocarpidites meghalayaensis, Laricoidites punctatus* and *Polyadopollenites sahnii*. Out of these, *Striatriletes susannae, Lygodiumsporites eocenicus, Lygodiumsporites lakiensis, Todisporites major* and *Polypodiaceaesporites tertiarus* are also found in Jenam and Renji, but the present assemblage is more diversified.

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REFERENCES

Cookson, I. C. 1947. Plant microfossils from the lignites of Kerguelen Archipelago. *Rep. B.A.N.Z. antarct. Res. Exped.* Ser. A **2** : 127-142.

Kar, R. K. (MS). Palynological studies of Miocene and Mio-Pliocene of north-east India. *Palaeontographica*.

Miner, E. L. 1935. Palaeobotanical examinations of Cretaceous and Tertiary coals. *Amer. Midl. Nat.* **16** : 585-621.

Salujha, S. K. & Kindra, G. S. 1986. Palynostratigraphy of the Silchar-Halflong road traverse, district Cachar. *Bull. geol. Min. metall. Soc. India* **54** : 238-249.

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