Palaeobotanist 53(2004) : 113-121
0031-0174/2004/113-121 $2.00

Palynology of the Lakadong Sandstone (Late Palaeocene) exposed around Bhalukurung, North Cachar Hills, Assam

MADHABI CHAKRABORTY

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

(Received 17 June 1999; revised version accepted 10 February 2003)

ABSTRACT

Chakraborty M 2004. Palynology of Lakadong Sandstone (Late Palaeocene) exposed around Bhalukurung, North Cachar Hills, Assam. Palaeobotanist 53(1-3) : 113-121.

A rich palynoassemblage is recorded from the carbonaceous shale and coal beds in the Lakadong Sandstone exposed around Bhalukurung on the bank of Kopili River, near Umrongso (North Cachar Hills), Assam. The palynoassemblage comprises 40 genera and 60 species. The significant palynotaxa are *Dandotiaspora dilata*, *D. telonata*, *Lycopodiumsporites speciosus*, *Neocouperipollis kutchensis*, *Matanomadhiasulcites maximus*, *Spinizonocolpites echinatus*, *Proxapertites cursus*, *Lakiapollis ovatus*, *Tricolporopollis matanomadhensis* and *Proteacidites protrudus*. The present assemblage has been equated with that of *Lycopodiumsporites speciosus* Cenozone on the basis of palynofloral similarity. The assemblage has been compared with the known contemporaneous palynoassemblages from northeast India and Kutch to assess similarities and differences between them. The palynoflora indicates tropical, warm humid climate and coastal depositional environment with mangrove swamps. The assemblage indicates an Upper Palaeocene (Thanetion) age.

Key-words—Palynology, Lakadong Sandstone, Late Palaeocene, North Cachar Hills, Assam (India).

असम के उत्तर कछार पर्वत श्रेणियों के भालुकुरूंग के आस-पास अनावरित लाकाडाँग बालुकाश्म (पश्च पेलियोसीन) का परागाणु विज्ञान

माधबी चक्रवर्ती

सारांश

असम में उमराँग्सों (उत्तर कछार पर्वत श्रेणियों) के निकट कोपिली नदी के तट पर भालुकुरूंग के आस-पास अनावरित लाकाडाँग बालुकाश्म में कार्बनीकृत शेल तथा कोयला संस्तर से प्राप्त प्रचुर परागाणु समुच्चय अभिलिखित किया गया है। इस परागाणु समुच्चय में 40 वंश तथा 60 प्रजातियाँ शामिल हैं। इनमें से महत्वपूर्ण परागाणु वर्गक *डेन्डोटियास्पोरा डाइलेटा डी. टेलोनेटा, लाइकोपोडियमस्पोराइटीज़ स्पेसियोसस, नियोक्यूपरिपोलिस कच्छेन्सिस, मातानोमाढियासलकाइटीज़ मैक्सिमस, स्पीनीजोनोकॉलपाइटीज़ एकीनेटस, प्रोक्सापर्टाइटीज, क्यूर्सस, लेकियापोलिस ओवेटस, ट्राइकोलपोरोपोलिस मातानोमाढेन्सिस* एवं *प्रोटीएसीडाइटीज़ प्रोट्रूडस* हैं। वर्तमान समुच्चय को परागाणु वनस्पतिजात की समानता के आधार पर *लाइकोपोडियमस्पोराइटीज़ स्पेसियोसस* (सीनोजोन) के साथ बराबर माना गया है। इस समुच्चय की उत्तरी भारत तथा कच्छ से प्राप्त ज्ञात समकालीन परागाणु समुच्चयों के साथ उनके मध्य समानता तथा अन्तर निर्धारित करने हेतु तुलना की गई है। यह परागाणु वनस्पतिजात मैंग्रोव अनूप के साथ उष्णकटिबंधीय, उष्ण-आर्द्र जलवायु तथा तटीय निक्षेपण पर्यावरण का संकेत करता है। यह समुच्चय उपरि पेलियोसीन (थानेशियन) आयु का संकेत करता है।

संकेत-शब्द—परागाणुविज्ञान, लाकाडाँग बालुकाश्म, पश्च पेलियोसीन, उत्तरी कछार पर्वत श्रेणियाँ, असम।

INTRODUCTION

THE present study deals with the palynoassemblage recovered from the Lakadong Sandstone exposed at Bhalukurung (Long 92°37' E, Lat 30°31' N) in the North Cachar Hills District, Assam (Fig. 1).

Palynological studies on the Tertiary sediments of Jaintia Hills has been carried out by Mandal (1987, 1990), Saxena & Tripathi (1982), Tripathi & Singh (1985) and from Khasi Hills by Sah & Dutta (1966, 1968), Dutta & Sah (1970), Kar & Kumar (1986) and Kar (1992). Mehrotra (1981a, b, 1983), Mehrotra and Sah (1982) worked on the Mikir Hills while Kumar (1994) on Silchar Halflong Road section.

GEOLOGY

Smith (1898), Evans (1932, 1964) and Bhandari *et al.* (1973) carried out the stratigraphic studies of the different coal bearing rocks of the Jaintia Hills, in North Cachar Hills and adjoining Mikir Hills (Karbianglong District). The generalised stratigraphy of the region following the above mentioned workers is as follows (after Raja Rao, 1981):

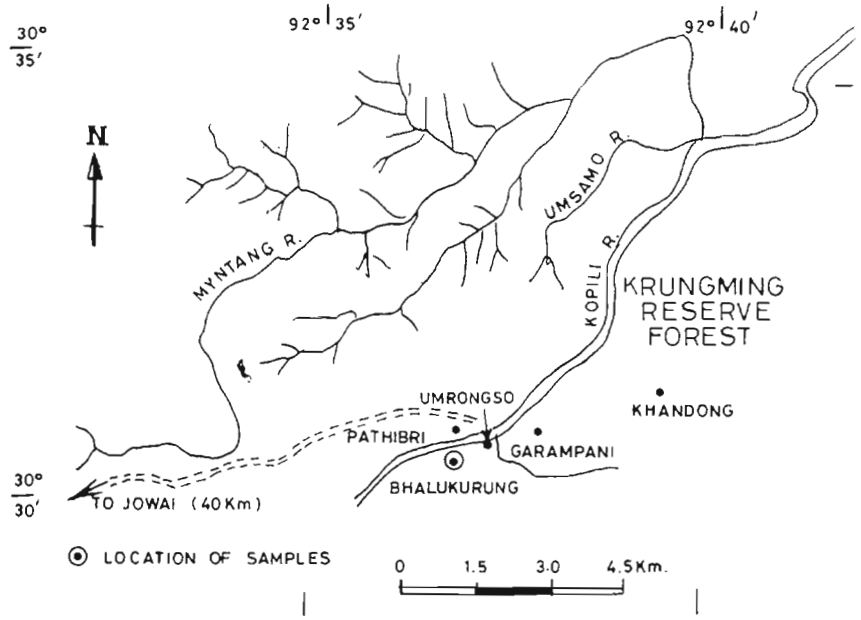

Fig. 1—Location map showing the studied area (Bhalukurung).

Age	Group	Formation	Member	Lithology
Late Eocene		Kopili		Alternation of shale and hard sandstone with a few limestone bands
Middle Eocene	J A		Prang Limestone	Fossiliferous, bluish massive to finely bedded limestone
Early Eocene	I N	Sylhet Limestone	Nurpuh Sandstone	Coarse to medium grained, ferruginous sandstone with bands of sandy limestone
Late Palaeocene	T I		Umlatadoh Limestone	Grey to pinkish grey foraminiferal lime-stone containing a few sandstone bands
Middle Palaeocene	A		Lakadong Sandstone	Predominantly buff coloured, medium grained arkosic carbonaceous shales and coal seams
			Lakadong Limestone	Grey to brownish fossiliferous limestone

MATERIAL AND METHODS

Section of Bhalukurung is investigated. The sequence of the rocks is given below-

LITHOUNITS	THICKNESS
Sandstone	4.4 m
Shale	0.2 m
Sandstone	1.5 m
Coal	0.6 m
Shale	0.2 m
Sandstone	4.5 m
Shale	0.5 m
Sandstone	3.0 m

Seven samples for palynological investigation were taken from shale and coal bands and were treated with concentrated Nitric acid followed by five percent KOH solution. The slides were prepared by smearing the macerals in Polyvinyl alcohol and mounted in Canada balsam. Slides and negatives of the figured specimens are stored in the Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow.

PALYNOLOGICAL ASSEMBLAGE

The palynofloral assemblage from Bhalukurung comprises 40 genera and 60 species. In this assemblage pteridophytic spores are represented by 10 genera and 20 species, the angiospermic pollen by 23 genera and 30 species and the fungal entities by 8 genera and 10 species. The gymnospermic pollen are not recorded.

Pteridophytes

Cyathidites minor Couper, 1953

Dandotiaspora dilata (Mathur) Sah *et al.*, 1971

D. plicata (Sah & Kar) Sah *et al.*, 1971

D. telonata Sah *et al.*, 1971

Dictyophyllidites kyrtomatus Kar & Kumar, 1986

Intrapunctisporis apunctis Krutzsch, 1959

Lycopodiumsporites compartmentus Kar & Kumar, 1986

L. concavus Kar & Kumar, 1986

L. duttae Kar & Kumar, 1986

L. palaeocenicus Dutta & Sah, 1970

L. parvireticulatus Sah & Dutta, 1966

L. speciosus Dutta & Sah, 1970

L. umstewensis Dutta & Sah, 1970

Lygodiumsporites lakiensis Sah & Kar, 1969

Polypodiaceaesporites major Saxena, 1978

Polypodiisporites mawkmaensis Dutta & Sah, 1970

P. repandus Takahashi, 1964

P. umstewensis Kar & Kumar, 1986

Pteridacidites meghalayaensis Kar & Kumar, 1986

Seniasporites verrucosus Sah & Kar, 1969

Angiosperms

Arecipites bellus Sah & Kar, 1970

Arengapollenites achinatus Kar, 1985

Kielmeyerapollenites eocenicus Sah & Kar, 1974

Lakiapollis ovatus Venkatachala & Kar, 1969

Margocolporites sahnii Ramanujam, 1966

Matanomadhiasulcites maximus (Saxena) Kar, 1985

Neocouperipollis achinatus (Sah & Kar) Kar & Kumar, 1986

N. kutchensis (Venkatachala & Kar) Kar & Kumar, 1986

N. magnus (Dutta & Sah) Kar & Kumar, 1986

Palmaepollenites ovatus Sah & Kar, 1970

Palmidites aplicatus Kar & Kumar, 1986

Proteacidites protrudus Sah & Kar, 1970

Proxapertites cursus van der Hammen, 1956

P. emendatus (Sah & Dutta) Kar & Kumar, 1986

P. operculatus van der Hammen, 1956

Psilastephanocolpites psilatus Kar & Kumar, 1986

Retimonosulcites ellipticus (Venkatachala & Kar) Kar, 1985

R. ovatus (Sah & Kar) Kar, 1985

Retistephanocolpites multirimatus (Dutta & Sah 1970) Saxena, 1982

R. flavatus (Sah & Kar 1970) Saxena, 1979

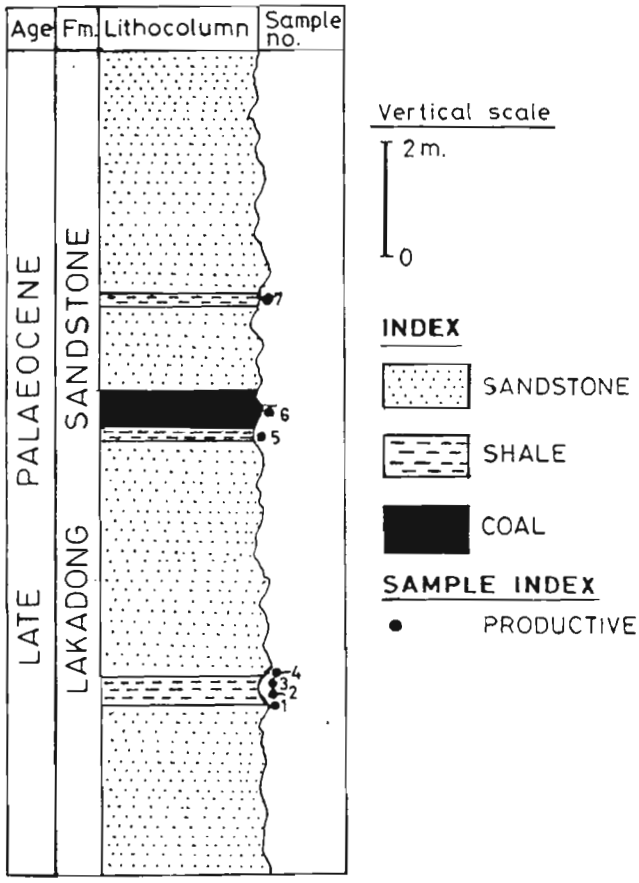

Fig. 2—Litholog of the outcrop of the studied coal seam section at the Bhalukurung.

Retistephanocolporites granulatus (Sah & Kar) Kar, 1985

Retitrescolpites typicus Sah, 1967

Retitribrevicolporites matanomadhensis (Venkatachala & Kar) Kar, 1985

Spinizonocolpites echinatus Muller, 1959

Striacolporites striatus Sah & Kar, 1970

Triangulorites inferius (Dutta & Sah) Kar & Kumar, 1986

Triangulotricolporites triangulus Kar, 1985

T. bellus (Sah & Kar) Kar, 1985

Tricolpites reticulatus Cookson ex Couper, 1953

Tripilaorites triangulus (Sah & Kar) Kar, 1985

Fungi

Cucurbitacidites bellus Kar *et al.*, 1972

Diporicellaesporites pluricellus Kar & Saxena, 1976

Fusiformisporites sp.

Inapertisporites kedvesii Elsik, 1968

Monosporisporites stoverii Elsik, 1968

Phragmothyrites eocenicus Edwards emend. Kar & Saxena, 1976

Pluricellaesporites hillsei Elsik, 1968

P. meghalayensis Elsik, 1968

P. planus Trivedi & Verma, 1969

Trichothyrites setiferus (Cookson) Saxena & Misra, 1990

PLATE 1

(All photographs are enlarged (*ca.* x 1000)

1. *Palmaepollenites ovatus* Sah & Kar, 1970, Slide No. BSIP 12278, S 40/4.
2. *Proxapertites cursus* van der Hammen, 1956, Slide No. BSIP 12281, P33/3.
3. *Retistephanocolpites flavatus* (Sah & Kar) Saxena, 1979, Slide No. BSIP 12281, R 24/2.
4. *Polypodiisporites umstewensis* Kar & Kumar, 1986, Slide No. BSIP 12281, P/9.
5. *Lycopodiumsporites speciosus* Dutta & Sah, 1970, Slide No. BSIP 12284, N19.
6. *Lycopodiumsporites speciosus* Dutta & Sah, 1970, Slide No. BSIP 12283, T19/4.
7. *Proteacidites protrudus* Sah & Kar,1970, Slide No. BSIP 12282, U22.
8. *Triangulorites inferious* (Dutta & Sah) Kar & Kumar, 1986, Slide No. BSIP, 12278, M 40.
9. *Retitrescolpites typicus* Sah, 1967, Slide No. BSIP 12282, G 14.
10. *Racemonocolpites thanjinathensis* Mandal,1990, Slide No. BSIP, 12282,T26/3.
11. *Triangulotricolporites triangulus* Kar, 1985, Slide No. BSIP, 12278, N41/3.
12. *Dandotiaspora dilata* (Mathur) Sah *et al.*, 1971, Slide No. BSIP 12279, M13/1
13. *Fusiformisporites* sp., Slide No. BSIP 12278, Q26/3.
14. *Dictyophilidites kyrtomatus* Kar & Kumar, 1986, Slide No. BSIP 12278, F12.
15. *Proxapertites emendatus* (Sah & Dutta) Kar & Kumar, 1966, Slide No. BSIP 12284, N51/4.
16. *Pteridacidites meghalayaensis* Kar & Kumar, 1986, Slide No. BSIP 12284A, O37/4.
17. *Pluricellaesporites meghalayensis* Elsik, 1968, Slide No. BSIP 12284B, R 35/4.
18. *Seniasporites verrucosus* Sah & Kar, 1969, Slide No. BSIP 12281, O23/1.
19. *Striacolporites striatus* Sah & Kar, 1970, Slide No. BSIP 12284, M36.
20. *Kielmeyerapollenites eocenicus* Sah & Kar, 1974, Slide No. BSIP, 12284, O48.

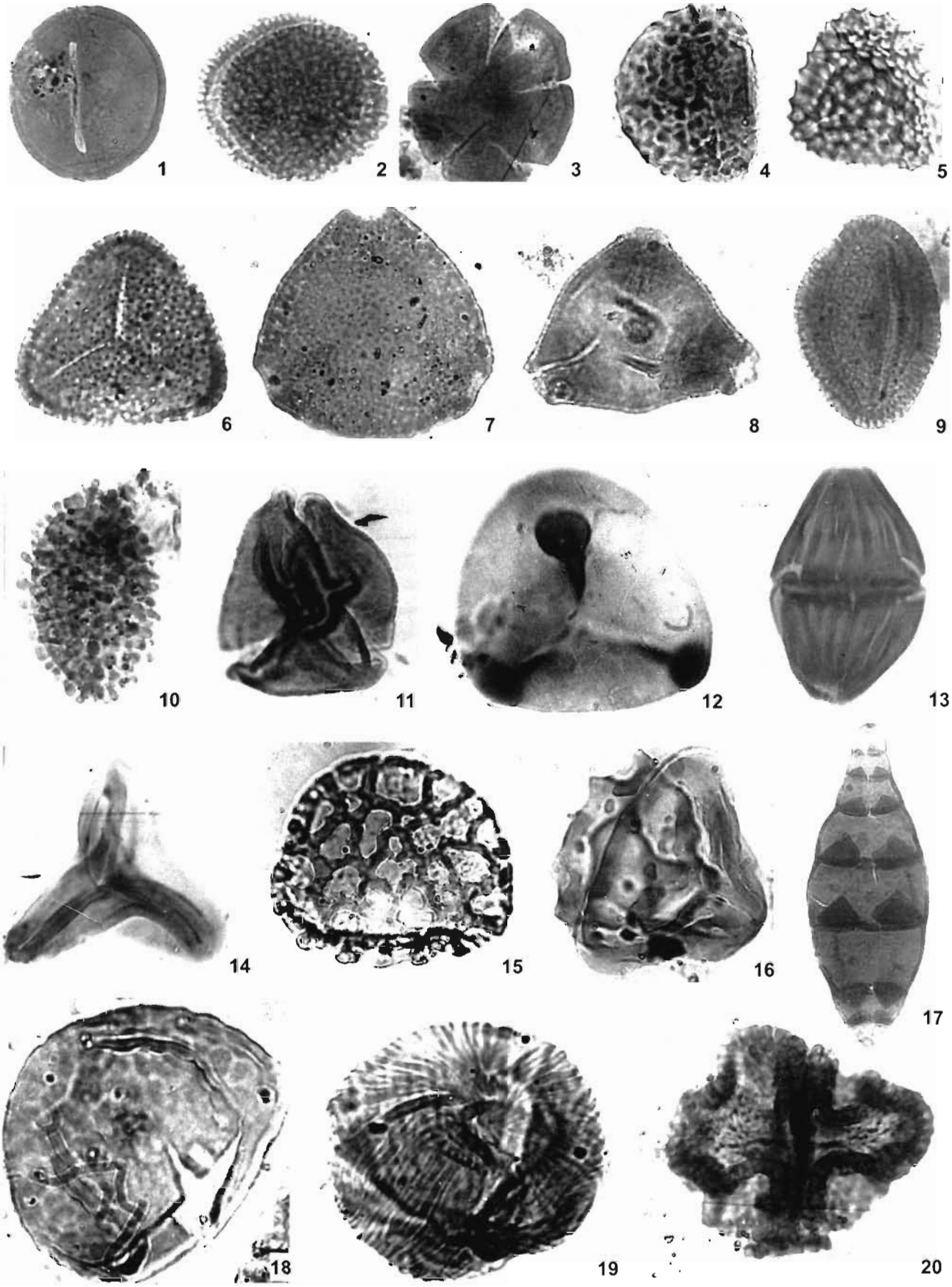

PLATE 1

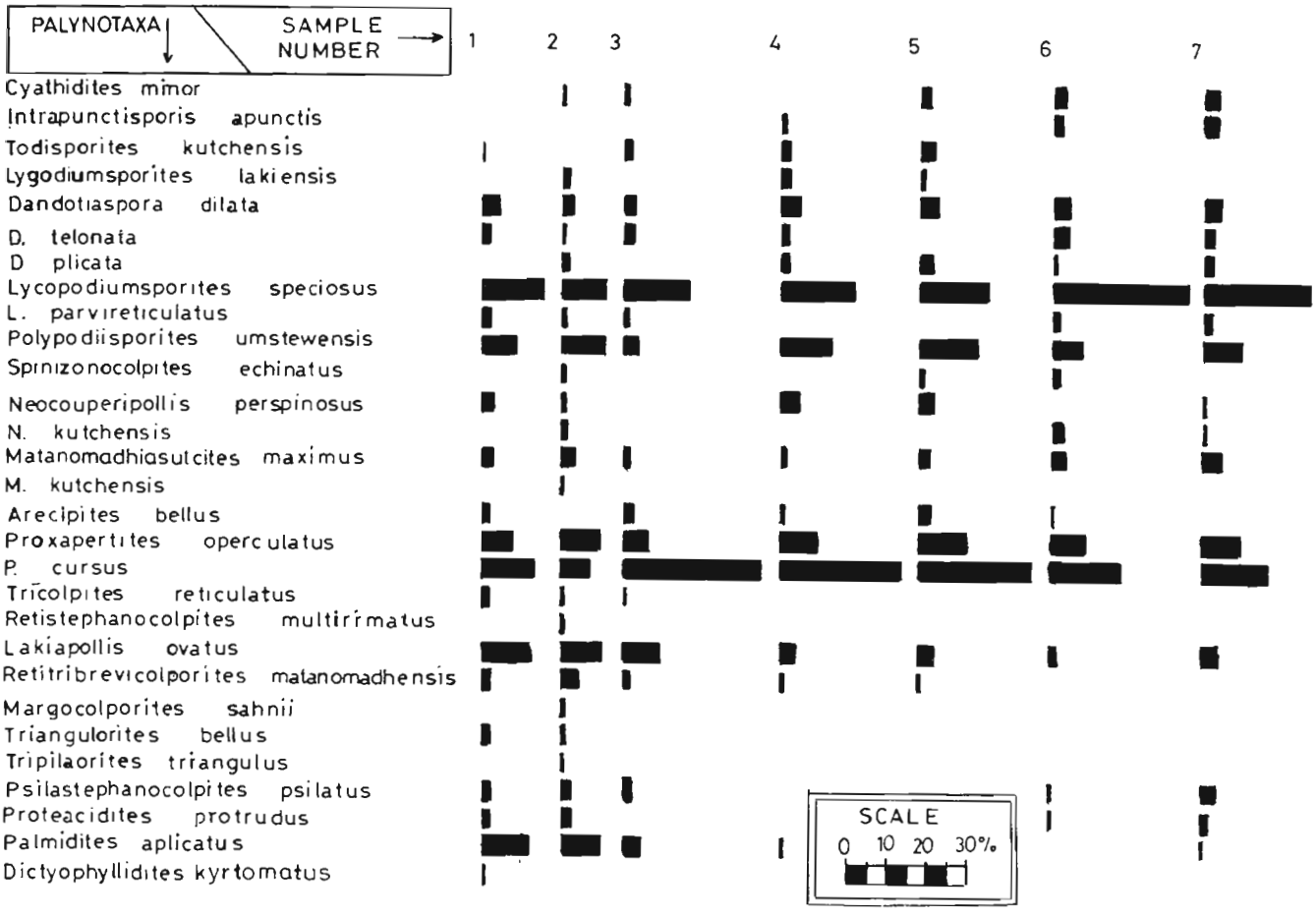

Fig. 3—Distribution of selected palynomorphs (in percentage) in the studied samples.

QUANTITATIVE ANALYSIS

The quantitative analysis of the assemblages was done on the basis of frequency count of 100 specimens per sample. The vertical distribution of some species is shown in Fig. 3.

The present palynoassemblage comprises 40 genera and 60 species of pteridophytic spores, angiospermic pollen and fungal remains. The important palynotaxa of the assemblage are *Polypodiisporites umstewensis, Dandotiaspora dilata, Neocouperipollis perspinosus, Matanomadhiasulcites maximus, Arecipites bellus, Lakiapollis ovatus* and *Psilastephanocolpites psilatus.*

The palynoassemblage is dominated by *Lycopodiumsporites speciosus*, and is placed in *Lycopodiumsporites speciosus* Cenozone of Kar & Kumar (1986). The other taxa representing the Cenozone are *Lycopodiumsporites parvireticulatus, Dandotiaspora dilata, D. telonata, D. plicata, Cyathidites minor, Intrapunctisporis apunctis, Neocouperipollis kutchensis, Lakiapollis ovatus, Psilastephanocolpites psilatus, Proteacidites protrudus, Matanomadhiasulcites maximus, Proxapertites cursus* and *P. operculatus.*

Remarks—The upper *Kielmeyerapollenites syncolporatus* Cenozone of Kar and Kumar (1986) from the Lakadong Sandstone, Khasi Hills, Meghalaya is not recognisable in the present assemblage. It seems that the coal and shale of Bhalukurung locality constitute only the lower part of the Lakadong Sandstone. However, present assemblage differs from *Lycopodiumsporites speciosus* Cenozone by the abundance of *Proxapertites* spp., palm pollen and pteridophytic spores.

CORRELATION

KHASI HILLS

The Bhalukurung palynoassemblage shows similarity with the palynoassemblage of various coal seams of Lakadong Sandstone of Meghalaya (Dutta & Sah, 1970; Kar & Kumar, 1986) Both the assemblages have *Dandotiaspora dilata, D. telonata, Lycopodiumsporites speciosus, L. umstewensis, Polypodiisporites repandus, Neocouperipollis kutchensis, Matanomadhiasulcites maximus, Spinizonocolpites echinatus, Proxapertites cursus, Lakiapollis ovatus* and *Kielmeyerapollenites eocenicus*. The palynotaxa of *Proxapertites cursus* (= *Nymphaeoipollis crassimurus*) Cenozone proposed by Dutta and Sah, 1970 is also found to be common here.

Jaintia Hills

Mandal (1990) studied Palaeocene sediments of Thanjinath and Kumar (1994) of Jarain and Laitrymbai coal seams in Jaintia Hills. The palynoassemblage of these coal seams are also dominated by *Lycopodiumsporites* spp. The palynotaxa found to be common here are : *Lycopodiumsporites speciosus, L. palaeocenicus, Dandotiaspora dilata, D. telonata, Lygodiumsporites lakiensis, Matanomadhiasulcites maximus, Retimonosulcites ellipticus, Neocouperipollis kutchensis, N. echinatus, Palmidites aplicatus,* etc.

Garo Hills

The spores-pollen of Bhalukurung closely resembles with the palynotaxa reported from Garo Hills, Meghalaya (Singh, 1977; Sah & Singh, 1974). The palynotaxa found to be common are : *Lycopodiumsporites speciosus, L. palaeocenicus, Cyathidites minor, Dandotiaspora dilata, D. telonata, D. plicata, Polypodiisporites umstewensis, Neocouperipollis kutchensis, Proxapertites cursus, P. operculatus, Matanomadhiasulcites maximus, Lakiapollis ovatus, Retitribrevicolporites matanomadhensis* and *Proteacidites protrudus.*

Matanomadh Formation, Kutch

Palynofossils recorded by Kar & Saxena (1976), Saxena (1978, 1979, 1980) and Kar (1985) from Matanomadh Formation of Kutch are also comparable to the present palynoassemblage. On the basis of relative frequency of palynotaxa, Kar (1985) proposed five cenozones for the Matanomadh Formation. These are : (i) Barren Zone (ii) *Dandotiaspora dilata* Cenozone (iii) *Tricolpites minutus* Cenozone (iv) *Neocouperipollis kutchensis* Cenozone and (v) Sponge spicules Zone.

The *Dandotiaspora dilata* Cenozone (Kar, 1985) exhibits close similarity to the present assemblage by the good percentage of *Dandotiaspora plicata, Lygodiumsporites lakiensis, Proxapertites operculatus, P. cursus, Matanomadhiasulcites maximus, Neocouperipollis kutchensis, N. perspinosus, Proteacidites protrudus, Tricolpites reticulatus, Lakiapollis ovatus, Retitribrevicolporites matanomadhensis* and *Psilastephanocolpites psilatus.*

PALAEOECOLOGY AND ENVIRONMENT OF DEPOSITION

A rich composition of palynoflora indicates terrestrial dominated vegetation with a moderate fraction of mangrove palynofossils influenced with swamp condition. The palynotaxa at basal shale and coal seam of the section representing dominance of the taxa belonging to swamp vegetation and palms. After a little fluctuations in their frequency this is followed upwards by dominance of pteridophytes which suggests prevalence of swamp with influence of fresh water conditions. This occurrence followed upward by pteridophytic dominance which also suggest above phenomenon. The occurrence of *Spinizonocolpites echinatus* (= *Nypa fruticans*) is less and gradual. The other taxa e.g., *Palmidites aplicatus, Neocouperipollis perspinosus* (Arecaceae), *Lakiapollis ovatus* (*Durio*, Bombacaceae) *Matanomadhiasulcites maximus* (Annonaceae), *Tricolpites reticulatus* (Gunneraceae) and *Proteacidites protrudus* (Proteaceae) suggest tropical climate. This may reflect the retreat of the arborescent vegetation with rich palms and then replaced by herbaceous pteridophytic dominated communities in an open swampy area under transgressive phase. The rich pteridophytic spores and microthyraceous fungi indicate prevailing of warm and humid condition.

DISCUSSION

The stratigraphic distribution of some characteristic taxa recovered from the studied outcrop section are shown in Fig. 3. Floral resemblance between Lakadong Sandstone and Bhalukurung indicates transitional environment and palaeoecological condition at the time of deposition. The palynotaxa showing similarity with Kutch (= Matanomadh Formation) is because of the position of both the regions at similar latitude which resulted to prevail similar climate and growth of some similar plants during the deposition. The occurrence of *Striacolporites striatus, Racemonocolpites*

thanjinathensis and *Kielmeyerapollenites eocenicus* is common. These taxa also occur in early Tertiary sediments of Meghalaya, Assam and Kutch. *Striacolporites striatus* (Ceaesalpiniaceae), *Kielmeyerapollenites eocenicus* (Clusiaceae), *Proteacidites protrudus* (Proteaceae), *Tricolpites reticulatus* (Gunneraceae), *Neocouperipollis perspinosus* (Arecaceae) and some polycolporate taxa which are found in the assemblage grow now in the tropical region in the other parts of the world. However, there are some differences between two assemblages, Kar (1992) noted that in north-east India, pteridophytic spores are found in abundance in Palaeocene and Eocene whereas, in western India these spores are rare. *Lycopodiumsporites specious* which contributes generously in Late Palaeocene rocks of north-east India is not present in good percentage. Kar (1992) also remarked that this disparity in palynofossils may perhaps be due to different physiographic features of the two regions.

Acknowledgements—*I am thankful to Professor Anshu K Sinha, Director, Birbal Sahni Institute of Palaeobotany, Lucknow for encouragement and infrastructural facilities.*

REFERENCES

Bhandari LL, Fuloria RC & Sastri VV 1973. Stratigraphy of Assam Valley, India. Bulletin of the American Association of Petroleum Geologist 57 : 642-654.

Couper RA 1953. Distribution of Proteaceae, Fagaceae and Podocarpaceae in some southern hemisphere Cretaceous and Tertiary beds. New Zealand Journal of Science and Technology, Section B 35 : 247-250.

Dutta SK & Sah SCD 1970. Palynostratigraphy of the Tertiary sedimentary formations of Assam 5. Stratigraphy and Palynology of South Shillong Plateau. Palaeontographica 131 B : 1-72.

Elsik WC 1968. Palynology of a Palaeocene Rockdale lignite, Milam County, Texas, 1. Morphology and Taxonomy. Pollen et Spores 10 : 263-314.

Evans P 1932. Tertiary succession of Assam. Transactions of the Mining and Geological Institute of India 27 : 155-260.

Evans P 1964. The tectonic framework of Assam. Journal of the Geological Society of India 5 : 80-96.

Kar RK 1985. The fossil floras of Kutch IV. Tertiary palynostratigraphy. Palaeobotanist 34: 1-280.

Kar RK 1992. Stratigraphical implications of Tertiary palynological succession in north-eastern and western India. Palaeobotanist 40 : 336-344.

Kar RK & Kumar M 1986a. Palaeocene palynostratigraphy of Meghalaya. Pollen et Spores 28 : 177-217.

Kar RK & Kumar M 1986b. *Neocouperipollis*—a new name for *Cuperipollis* Venkatachala & Kar. Palaeobotanist 35 : 171-174.

Kar RK & Saxena RK 1976. Algal and fungal microfossils from Matanomadh Formation (Palaeocene), Kutch, India. Palaeobotanist 23 : 1-15.

Kar RK, Singh RY & Sah SCD 1972. On some algal and fungal remains from Tura Formation of Garo Hills, Assam. Palaeobotanist 19 : 146-154.

Krutzsch W 1959. Einige neue Formgattungen und-Arten von Sporen und Pollen aus der Mittel europaischen Oberkreide und dem Tertiar. Palaeontographica B105 : 125-137 (German).

Kumar A 1994. Palynology of the Tertiary sediments exposed along the Silchar Halflong Road Section, Southern Assam. Palaeontographica Indica : 1-241.

Kumar M 1994. Palynological and palaeoecological studies of Palaeocene coal seams in Jarain and Laitrymbai areas, Jaintia Hills, Meghalaya, India. Geophytology 23 : 203-207.

Mandal J 1987. Palynological study of Sutunga coal seam, Jaintia Hills, Meghalaya. Palaeobotanist 35 : 196-199.

Mandal J 1990. Palynological investigation of Palaeocene sediments from Thanjinath, Meghalaya. Palaeobotanist 37 324-330.

Mehrotra NC 1981a. A palynological correlation of Mikir Formation with Lower Palaeogene sediments of Shillong Plateau Geophytology 11 : 133-142.

Mehrotra NC 1981b. Fossil dinoflagellates from subcrop Garampani Limestone sediments of Garampani area in North Cachar Hills, Assam. Geoscience Journal 2 : 13-22.

Mehrotra NC 1983. Palynology of the Mikir Formation in the type area. Geoscience Journal 4 . 1-34.

Muller J 1959. Palynology of recent Orinoco delta and shelf sediments: reports of the Orinoco shelf expedition. Micropalaeontology 5 : 1-32.

Raja Rao CS 1981. Coalfields of India 1. Coalfields of North Eastern India. Bulletin Geological Survey of India 45, Series A : 1-76.

Ramanujam CGK 1966. Palynology of the Miocene lignite from South Arcot District, Madras, India. Pollen et Spores 8 : 149-203.

Sah SCD 1967. Palynology of an Upper Neogene profile from Rusizi (Burundi). Musee Royal de L'Afrique Centrale—Tervuren, Belgique Annals—Serie in 8°—Sciences Geologiques 57 : 1-173.

Sah SCD & Dutta SK 1966. Palynostratigraphy of the sedimentary formations of Assam 1. Stratigraphical position of the Cherra Formation. Palaeobotanist 15 : 72-86.

Sah SCD & Dutta SK 1968. Palynostratigraphy of the Tertiary sedimentary formations of Assam 2. Stratigraphic significance of spore and pollen in the Tertiary succession of Assam. Palaeobotanist 16 : 177-195.

Sah SCD & Kar RK 1969. Pteridophytic spores from the Laki Series of Kutch, Gujarat, India. J Sen Memorial Volume : 109-121.

Sah SCD & Kar RK 1970. Palynology of the Laki sediments in Kutch 3. Pollen from the bore-holes around Jhulrai, Baranda and Panandhro. Palaeobotanist 18 : 127-142.

Sah SCD & Kar RK 1974. Palynology of Tertiary sediments of Palana, Rajasthan. Palaeobotanist 21 : 163-188.

Sah SCD, Kar RK & Singh RY 1971. Stratigraphic range of *Dandotiaspora* gen. nov. in the Lower Eocene sediments of India. Geophytology 1 : 54-63.

Sah SCD & Singh RY 1974. Palynological biostratigraphy of the Tura Formation in the type area. Symposium on Stratigraphy and Palynology, Special Publication, Birbal Sahni Institute of Palaeobotany 3 : 76-98.

Saxena RK 1978. Palynology of the Matanomadh Formation in the type area, north-western Kutch, India, (Part 1). Systematic description of pteridophytic spores. Palaeobotanist 25 : 448-456.

Saxena RK 1979. Palynology of the Matanomadh Formation in type area, north-western Kutch, India (Part 2). Systematic description of gymnosperm and angiosperm pollen grains. Palaeobotanist 26 : 130-143.

Saxena RK 1980. Palynology of the Matanomadh Formation in the type area, north western Kutch, India (Part 2). Systematic description of gymnospermous and angiospermic pollen grains. Palaeobotanist 26 : 130-143.

Saxena RK & Misra NK 1990. Palynological investigation of the Ratnagiri beds of Sindhu Durg District, Maharashtra. Palaeobotanist 38 : 263-276.

Saxena RK & Tripathi SKM 1982. Lithostratigraphy of the Tertiary sediments exposed along Jowai-Badarpur Road in Jaintia Hills (Meghalaya) and Cachar (Assam). Palaeobotanist 30 : 34-42.

Singh RY 1977. Stratigraphy and palynology of the Tura Formation in the type area, Part-II (Descriptive Palynology). Palaeobotanist 23 : 189-205.

Smith FH 1898. Geology of the Mikir Hills in Assam. Memoirs of the Geological Survey of India 28 71-95.

Takahashi K 1964. Sporen und Pollen der oberkretazeischen Hakobouchi-Schichtengruppe, Hokkaido. Memoir Faculty of Science, Kyushu University. Series D, Geology 14 159-271 (German).

Tripathi SKM & Singh HP 1985. Palynology of the Jaintia Group (Palaeocene-Eocene) exposed along Jowai-Badarpur Road Section, Meghalaya Part 1 (Systematic Palynology). Geophytology 15 164-187.

Trivedi BS & Verma CL 1969. A note on mega & microspore remains from the Tertiary coal of Malaya. Current Science 38 . 546-547.

van der Hammen T 1956. A palynological systematic nomenclature. Boletin Geologics Bogata 4 : 63-101.

Venkatachala BS & Kar RK 1969. Palynology of the Tertiary sediments of Kutch-1. Spores and pollen from bore hole no. 14. Palaeobotanist 17 : 157-178.