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# Stratigraphic significance of some angiosperm pollen from the Tinali Oilfield, Upper Assam, India

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## ABSTRACT

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Twelve fossil pollen taxa *Polygonacidites frequens, Perfotricolpites neyvelii, Lanagiopollis eocaenicus, Tiliaepollenites* cf. *rotundus, Tiliaepollenites* sp. A, *Durgaipollenites galsii, Strobilanthidites* cf. *africanus, Retitrescolpites africanus, Retitricolporites* cf. *guianensis, Corsinipollenites jussiaeensis, Discoidites borneensis* and *Tinalipollenites duttae* gen. *et* sp. nov. are described from the Barail Group to Dhekiajuli Formation (mid Tertiary to Quaternary) of the subsurface Tinali area, Upper Assam. The fossil pollen are compared with similar pollen types from extant dicotyledonous species. The geological record and stratigraphic and palaeoecologic significance of the fossil forms are considered in relation to the geographic distribution and habitat of modern taxa with similar pollen.

**Key-words**—Angiosperm pollen, palaeoecology, morphology, mid Tertiary-Quaternary, Upper Assam.

## भारत के ऊपरी असम स्थित तिनाली तेल क्षेत्र से प्राप्त कुछ आवृतबीजी परागकणों का स्तरिकीय महत्त्व

जगन्नाथ प्रसाद मण्डल एवं माधव कुमार

## सारांश

ऊपरी असम के उपपृष्ठीय तिनाली क्षेत्र के बराइल समूह से ढेकियाजुली शैलसमूह तक के बीच (मध्य टर्शियरी से क्वार्टरनरी तक) से *पॉलीगोनेसिडाइटीज़ फ्रीक्वेन्स, परफोट्राईकोलपाईटीज़ नयवेलियाइ, लैनेजिओपोलिस इओकेनिकस्, टिलिएइपोलेनाइटीज़* तुलनीय रूप *रोटण्डस, टिलिएइपोलेनाइटीज़* प्रजाति 'ए', *दुर्गाइपॉलेनाइटीज़ गालसाई, स्ट्राबिलैन्थाइडाइटीज़* तुलनीय रूप *एफ्रीकैनस, रेटिट्रेसकोलपाइटीज़ एफ़्रीकैनस, रेटिट्राइकोलपोराइटीज़* तुलनीय रूप *गिएनेन्सिस, कोर्सीइनीपॉलेनाइटीज़, जूसियाइएन्सिस, डिसकॉयडायटीज़, वॉर्निएन्सिस* एवं *तिनालीपोलेनाईटीज़ दत्ताइ* नव वंश एवं नव प्रजातियों के बारह पाश्पाश्म परागकण वर्गक अभिलक्षणित किये गये हैं. पादपाश्म रूपों के भूगर्भीय अभिलेखों एवं स्तरकीय तथा परिस्थितिकीय महत्व का ध्यान रखते हुए आधुनिक समरूप परागकणों के भूमण्डलीय वितरण तथा अधिवास को आधार माना गया. परागाणु पादपाश्मों की तुलना विद्यमान द्विबीजपत्री प्रजातियों से प्राप्त समरूप परागकण प्ररूपों से की गई है.

**संकेत शब्द**—आवृतबीजी परागकण, पुरापारिस्थितिकी, संरचना विज्ञान, मध्य टर्शियरी-क्वाटरनरी, ऊपरी असम.

## INTRODUCTION

A palynological study of the Tinali well-7 from the Tinali Oilfield (27° 12' 08"-27° 15' 21" N : 95° 09' 32"-95° 13' 12" E), Upper Assam (Fig. 1) revealed a rich diversity of angiosperm pollen. The well penetrated through the Pleistocene to Oligocene (Dhekiajuli Formation to Naogaon Formation of Barail Group) sediments. The palynomorph assemblage is marked by numerous small pollen grains and some pollen types with distinct morphological features which were not known previously from this region.

In the present study, twelve fossil pollen taxa have been investigated to establish their distribution patterns and to assess their suitability as marker taxa. Modern pollen floras have been used to find morphological affinities for the fossil pollen types. Such affinities were found for some fossil taxa. The investigation on Tertiary pollen by Thanikaimoni *et al.* (1984) and Venkatachala *et al.* (1989) has contributed significantly in determining botanical affinities of some described taxa.

## MATERIAL AND METHODS

One hundred thirty samples from Tinali well-7 at depth interval between 3800 m and 1200 m (Fig. 2), Upper Assam provided by Oil India Limited, Duliajan, Assam were chemically processed. An usual maceration procedure was followed using HCl, HF, $HNO_3$ and 5% KOH. The slides were prepared in polyvinyl alcohol and mounted in Canada Balsam. All the material, slides and photographic negatives are housed in the repository of Birbal Sahni Institute of Palaeobotany, Lucknow.

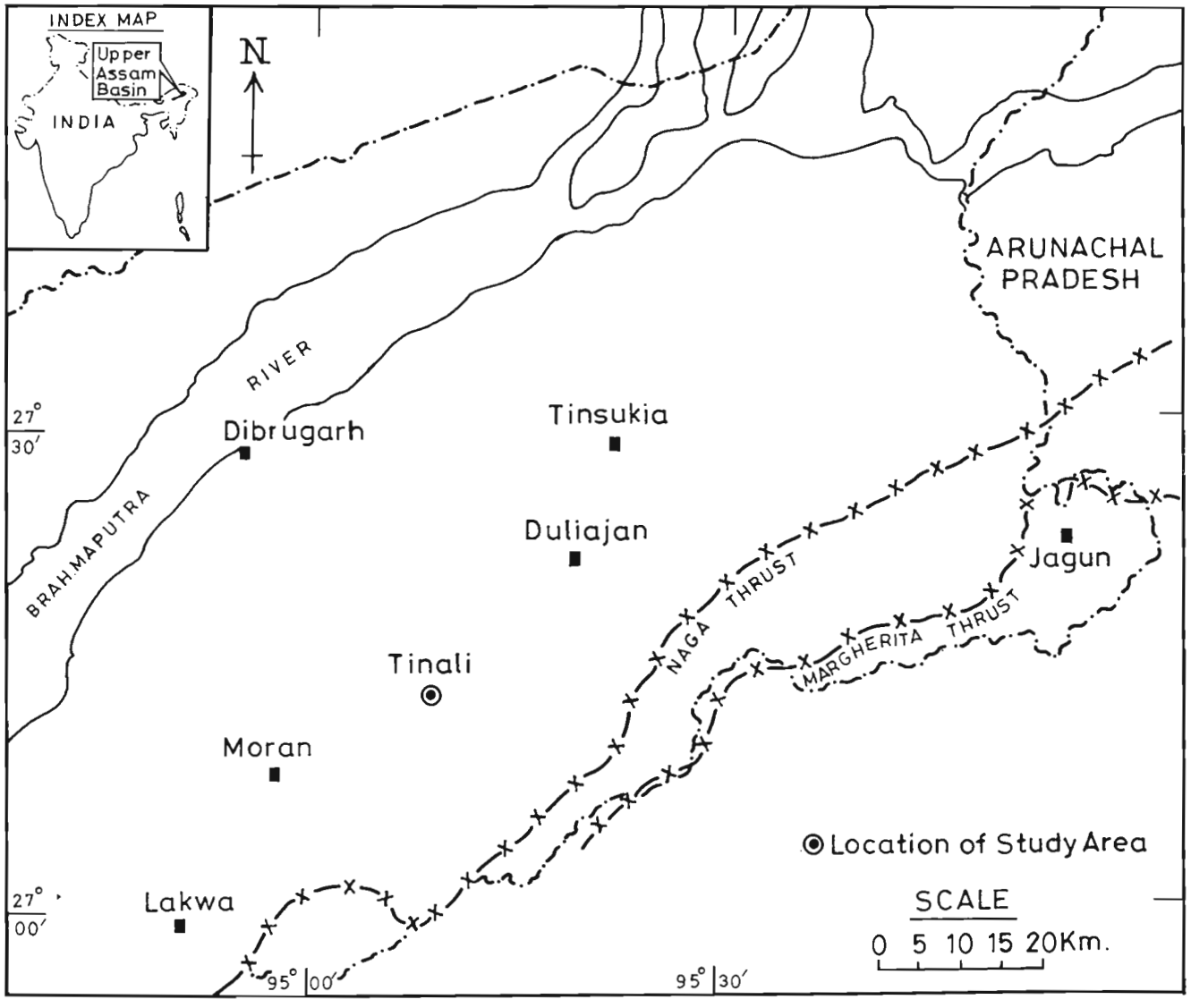


Fig. 1—Location map of Tinali.

## SYSTEMATICS

**Genus—POLYGONACIDITES** Sah & Dutta, 1968
**POLYGONACIDITES FREQUENS** Sah & Dutta, 1968
Pl. 1·1-3

*Horizon*—Tipam Sandstone Formation to Namsang Formation, Miocene to Mio-Pliocene.

*Number of specimens studied*—Five.

*Description*—Pollen grains spherical, 33-35 µm in diameter in polar view; panporate, pores small, circular, 1 µm in diameter. Exine 3·5 µm thick, retibaculate, nexine ± 1·2 µm thick, thinner than sexine; columellae 2 µm high, 0·5 µm thick; surface reticulate, muri 1·2 µm thick, closely undulated, pluribaculate, lumina irregular, free bacula distributed within the lumina. The heads of sexinal elements fuse to form a thin translucent tectum.

*Fossil comparison*—The present specimens are smaller than the holotype of *Polygonacidites frequens*. *Polygonacidites* sp. A described by Jain and Dutta (1978) closely resembles with our specimens but larger in size. *Persicarioipollis meuseli* Krutzsch (1962) appears very close to the present specimens.

*Previous geological records*—In India *P. frequens* was generally recorded in the North-Eastern region. It had been recorded from Upper Assam in the Mio-Pliocene (Sah & Dutta, 1968), Miocene to recent (Banerjee *et al.*, 1973). Jain and Dutta (1978) described *Polygonacidites* sp. A from early Tertiary of Arunachal Pradesh. Pollen grains of *Polygonum serrulatum* Guss. ex Tenore and *P. plebeium* R. Br. types occur in Quaternary sediments (Lakhanpal *et al.*, 1976). *Polygonum persicaria*-type pollen commonly recorded throughout the Tertiary of Europe (Muller, 1981).

*Affinity to pollen of extant taxa and ecology*—Sah and Dutta (1968) mentioned that pollen of extant *Polygonum glabrum* Willd. (Polygonaceae) exhibit comparable characters with fossil specimen. Our study agrees with this observation (Pl. 1·16). However, pollen of *P. glabrum* are larger in size than *Polygonacidites frequens*. Many species of *Polygonum* are herbaceous and cosmopolitan in distribution and mostly grow in aquatic habitats.

**Genus—CORSINIPOLLENITES** Nakoman, 1965
**CORSINIPOLLENITES JUSSIAEENSIS** Jan du Chene, Onyike & Sowunmi, 1978
Pl. 2·11,12

*Horizon*—Barail Group, Oligocene.

*Number of specimens studied*—Three.

*Description*—Pollen grains subtriangular in polar view, grains occasionally folded, 53 x 57 µm; triporate, pore circular, 5·5 µm in diameter, distinctly endoannulate, thickening 5·5

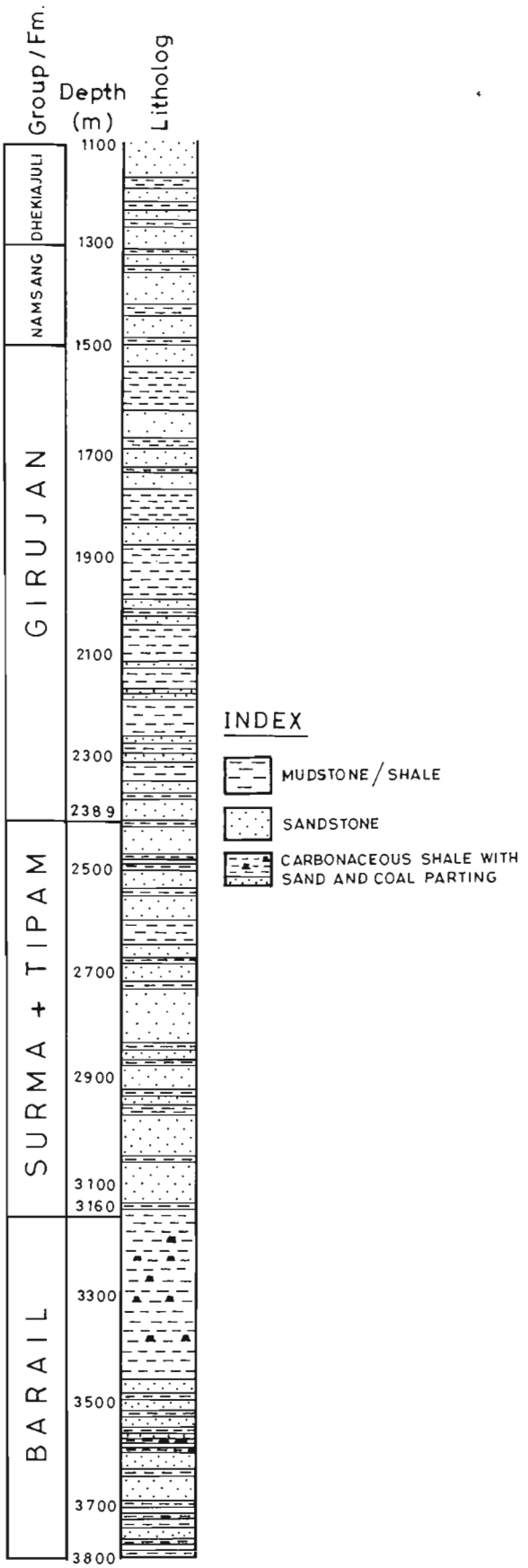


Fig. 2— Lithocolumn of Tinali well-7 (supplied by Oil India Limited, Duliajan).

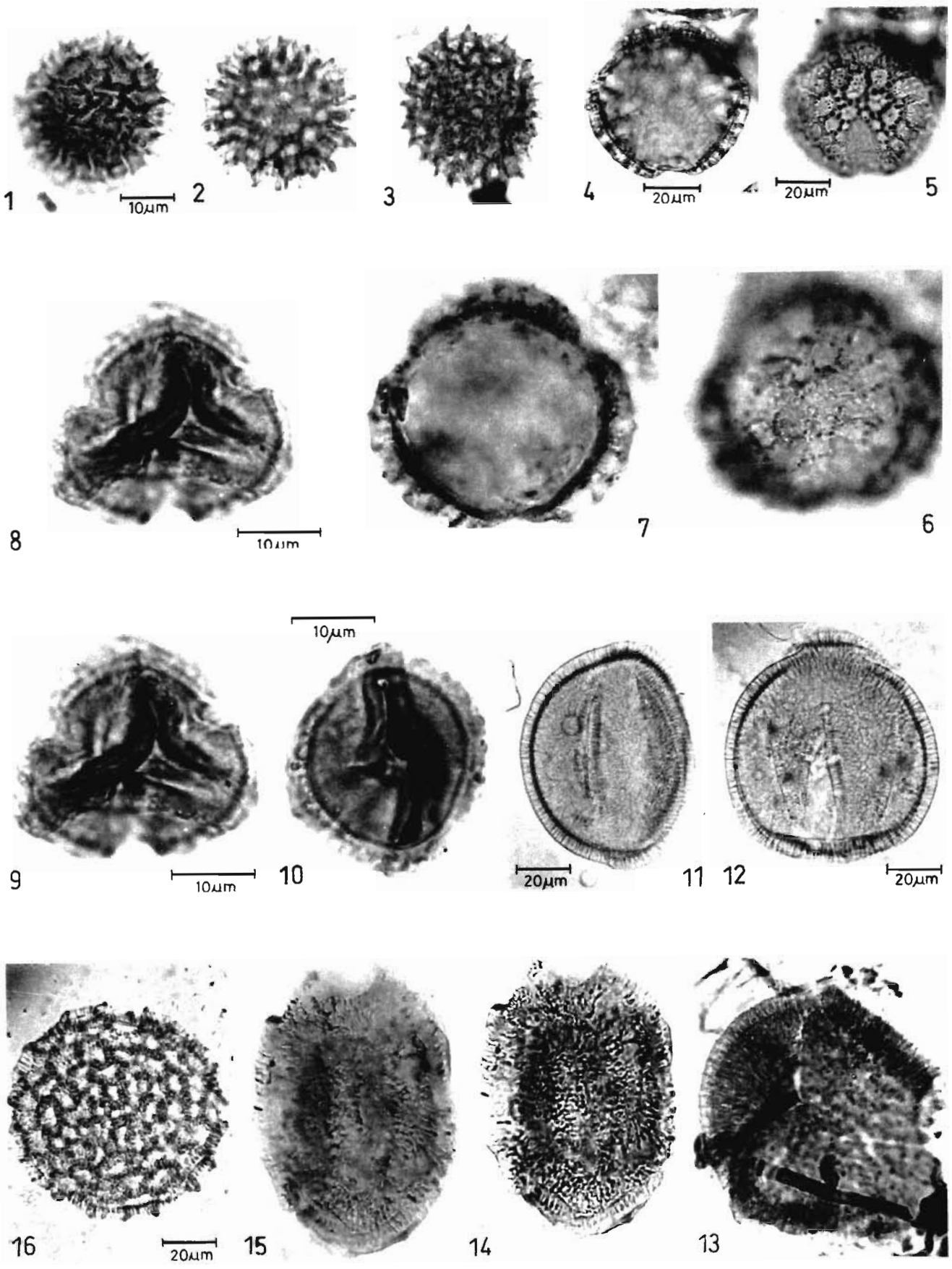
1
10µm
2
3
4
20µm
20µm
5
8
10µm
7
6
10µm
9
10µm
10
20µm
11
12
20µm
16
20µm
15
14
13

PLATE 1

μm, ora protruded; exine up to 4·5 μm thick, sexine-nexine not separable, columellae indistinct; surface laevigate.

*Fossil comparison*—Holotype of *Cricotriporites vimalii* (=*Triporopollenites vimalii* Sah & Dutta, 1966, pl. 2, fig. 32) is missing and character of pores could not be examined. *Cricotriporites vimalii* (Sah & Dutta) Frederiksen (1994) appears comparable to *Corsinipollenites jussiaeensis* in general morphology but differs in size and possessing less thickened annulus. *Jussitriporites undulatus* Guzmán (1967) has psilate-verrucate (undulated) sculpture in contrast to psilate sculpture of *C. jussiaeensis. Corsinipollenites* differs from *Cricotriporites* Leidelmeyer (1966) in possessing peculiar structures of pores due to distinct thickening of endexine.

*Previous geological records*—Several fossil pollen with comparable morphology had been recorded from east and North-East India as well as Pakistan. The records from Palaeocene sediments were of the Garo Hills (Singh, 1977), Assam (Sah & Dutta, 1968) and from the Dras volcanics (Mathur & Jain, 1980). Early Eocene records were from the Bengal Basin (Baksi & Deb, 1980), Assam (Dutta & Sah, 1970; Bose & Sah, 1964 and Ghosh, 1969) whereas, Oligocene record was from Assam (Singh *et al.*, 1987). It was recorded from Palaeocene to Early Eocene sediments of Pakistan (Vimal, 1952). This type of pollen occurred in Palaeocene of Europe, Nigeria and throughout Tertiary in South America (Muller, 1981). This taxon was not discussed from south-east Asia by Germeraad *et al.* (1968) but according to Dr. R. J. Morley (personal communication) the taxon occurs in this region.

*Affinity to pollen of extant taxa and ecology*—Pollen of *Jussieua fissendocarpa* Haines (Onagraceae) show morphological similarity (Pl. 2·13) but lacks thick endoannulus as fossil specimens. This species grows as herb or under shrub in swamps in India and Malayan Peninsula. The plants of *Jussieua* presently distributed in subtropics and temperate regions (Mabberley, 1997).

**Genus—PERFOTRICOLPITES** Guzmán, 1967

**PERFOTRICOLPITES NEYVELII** (Navale & Misra, 1979) comb. nov.

Pl. 1·13-15

*Synonyms*—The taxon has been described by various names in India.

*Plumbaginacipites neyvelii* Navale and Misra, 1979, p. 227, pl. 1, figs 4-6.

*Tricolpites radiistriaei* Baksi, 1962, pl. 5, fig. 55.

*Tricolpites* sp. Kar, 1985, pl. 39, fig. 18.

*Striatricolpites semistriatus* Guzmán in Kumar, 1996, pl. 1, fig. 10.

*Plumbaginacipites neyvelii* Saxena and Rao, 1996, pl.2, figs 8, 9.

*Plumbaginacipites navalii* Rao and Nair, 1998, pl. 1, figs 20, 21.

*Horizon*—Barail Group, Oligocene.

*Number of specimen studied*—Four.

*Description*—Pollen grains prolate, 52·5-58 x 59·5-75 μm. Tricolpate, colpi 50 μm long, extended near to the poles. Exine 4·5 μm thick, sexine 3·5 μm, nexine thin, 0·5 μm; columellae 2·5 μm long, 1·2 μm broad, occasionally digitate. Tectum thin, perforate; surface appears perforate-micro-reticulate.

*Fossil comparison—Plumbaginacipites neyvelii* Navale and Misra (1979) has digitate columellae.

*Previous geological records*—The earliest records of the species were from the Early Eocene of the Cambay Basin (Kumar, 1996) and from Kutch (Kar, 1985). Navale and Misra (1979), Saxena and Rao (1996), Rao and Nair (1998) recorded it from Miocene sediments of Tamil Nadu, Meghalaya and Kerala respectively. It was also known from the Miocene of Tripura (Kar, 1991). Baksi (1962) recorded a similar taxon from the Oligocene of North-East India.

*Perfotricolpites* had been recorded from Early Eocene of Colombia (Guzmán, 1967) and Late Eocene and Oligocene of Nigeria and Caribbean areas (Muller, 1981). In Borneo it ranges from Middle Miocene to recent. *Retitrescolpites oblongus* Sah (1967) from Neogene of Congo had some morphological resemblances with this taxon.

*Affinity to pollen of extant taxa*—Navale and Misra (1979) suggested similarity with extant pollen of *Plumbago zeylanica* Linn. (Plumbaginaceae). Germerrad *et al.* (1968) observed that *P. digitatus* was closely comparable to *Merrimia macrocalyx* (Convolvulaceae) type. We consider that the pollen of *Convolvulus arvensis* Linn. (Pl. 1·11, 12) is very similar to

## PLATE 1

(The scale for plate 1, figure 1 is correct for all other figures without scale bars)

1-3. *Polygonacidites frequens* Sah & Dutta (1968), figs 1. & 2. same grain in different foci. Slide no BSIP 12123, L22/2; fig. 3. Slide no. BSIP 12128, S22/3.

4-5. *Delonix regia* modern pollen in mid (fig. 4) and high (fig. 5) focus Slide no BSIP (Herbarium) 11502.

6-7. *Retitrescolpites africanus* Sah, 1967, pollen in low (fig. 6) and mid (fig. 7) focus. Slide no BSIP 12128, F27/3.

8-10. *Tinalipollenites duttae* Gen. *et* sp. nov., figs 8, 9. polar view (holotype). Slide no. BSIP 12143, S20/3; fig. 10. equatorial view. Slide no. BSIP 12144, T12/4.

11-12. *Convolvulus arvensis* modern pollen. Slide no. BSIP (Herbarium) 11271.

13-15. *Perfotricolpites neyvelii* (Navale & Misra, 1979) Comb. nov., fig. 13-polar view. Slide no. BSIP 12172, U24/2; figs 14, 15. equatorial view in interference contrast and normal view. Slide no. BSIP 12160, J 18.

16. *Polygonum glabrum* modern pollen. Slide no. BSIP (Herbarium) 4843.

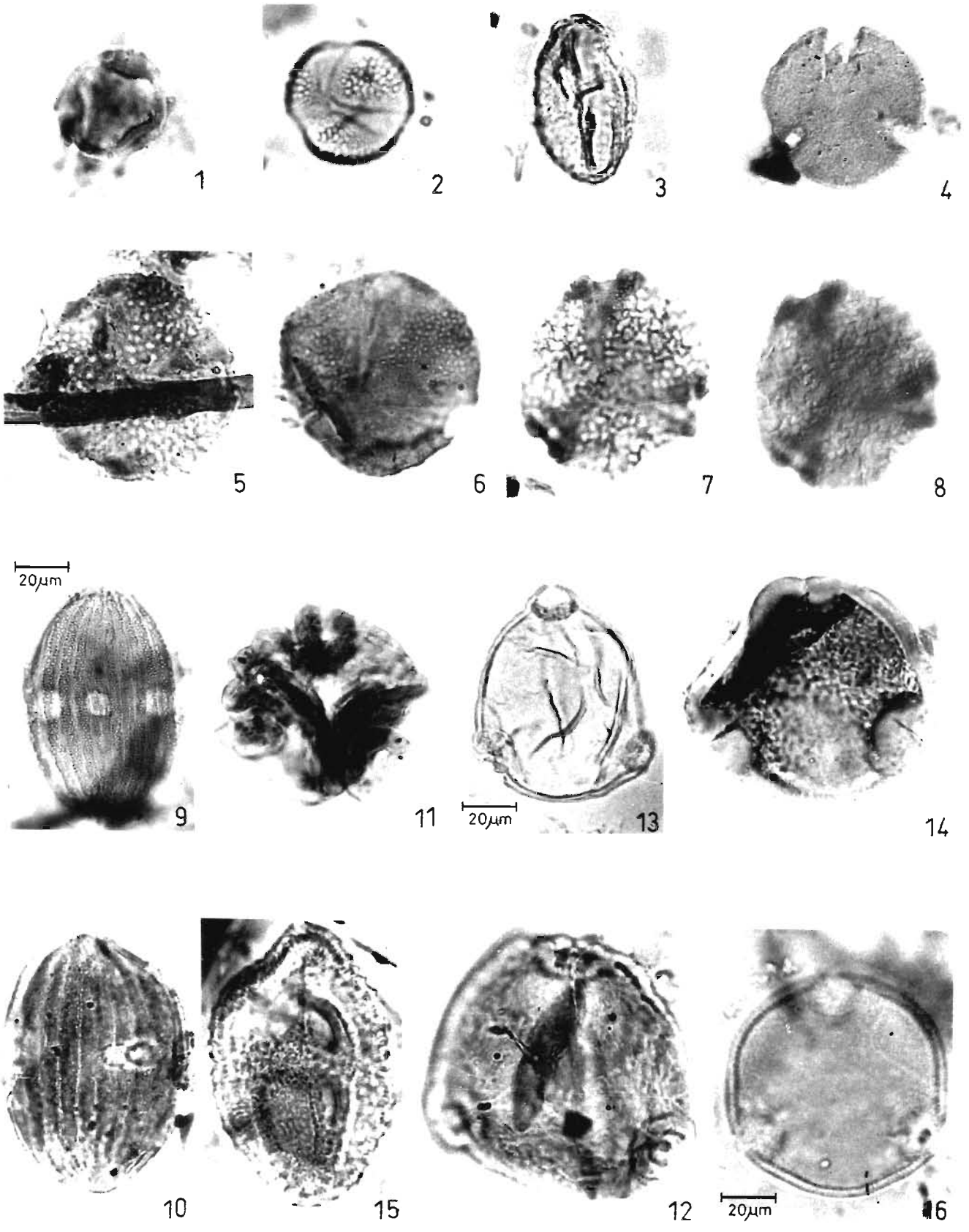


PLATE 2

the fossil species. At present *Convolvulus arvensis* grows as herb in wet places of the Western Ghats, Assam and the Gangetic plains in India.

**Genus—LANAGIOPOLLIS** Morley, 1982
**LANAGIOPOLLIS EOCAENICUS** (Krutzsch, 1969) comb. nov.
Pl. 2·7, 8

*Synonymy—Alangiopollis eocaenicus* Krutzsch, 1969 (in Reitsma, 1970, p. 280; pl. 33, figs A-H).

*Horizon*—Barail Group, Oligocene.

*Number of the specimen studied*—One.

*Description*—Pollen grain subtriangular in polar view, 38·5 x 44 µm. Tricolporate, colpi long, nearly reaching to the poles, funnel shaped in polar view. Pores lalongate, 4 µm wide, endoannulate, ora slightly protruding. Exine 2·5 µm thick, retipilate. Nexine less than 1µm thick, thinner than sexine, more thickened (up to 2 µm) at colpi margins, gradually thins toward poles, columellae 1·2 µm long; surface reticulate, lumina variable in size, 0·5-3·5 µm, broader at mesocolpial region, smaller on colpi margin; muri simpli-baculate, meshes occasionally incomplete.

*Fossil comparison*—Krutzsch (1962) proposed the genus *Alangiopollis* characterized by reticulate-striate sculpture and thinner nexine than sexine. Following the classification of Morley (1982) this species should be referred to the genus *Lanagiopollis*.

*Previous geological records*—In India several fossil taxa comparable with pollen of modern *Alangium* have been recovered from Tertiary sediments. Fossil *Alangium* pollen type showing a broad reticulum like *Lanagiopollis eocaenicus* is being recorded first time from Oligocene sediments of Assam. *Retitriporites curvinurati* described by Ramanujam (1966, pl. 5, fig. 93) from Miocene of southern India showed some resemblance with *Lanagiopollis eocaenicus*.

*Lanagiopollis eocaenicus* had been reported from the several locations of the Northern hemisphere. Reitsma (1970) reported its occurrence from Eocene of Germany and England but till now this species had not been recorded from tropical areas.

*Affinity to pollen of extant taxa*—The fossil specimen closely resembles with modern *Alangium chinense* type A (section Marlea) by its broad reticulation. *A chinense* presently occurs in south east Asia and North-East India as deciduous tree (Bose *et al.*, 1998).

**Genus—DISCOIDITES** Muller, 1968
**DISCOIDITES BORNEENSIS** Muller, 1968
Pl. 2·4

*Horizon*—Namsang Formation, Mio-Pliocene.

*Number of specimen studied*—One.

*Description*—Pollen grain nearly circular in polar view, 34·5 x 36 µm; brevitricolpate. Exine 2 µm thick, tectate; sexine 1·5 µm, nexine 0·5 µm thick, slightly thickened at pore margin. Columellae project slightly above the tectum. Surface foveolate to microreticulate, lumina uniform in size, circular, meshes thin, less than 0·5 µm.

*Fossil comparison—Discoidites borneensis* Muller (1968) is comparable to *Tiliaepollenites paucus* Sah (1967) but differs in having vestibule underneath each pore. *Subtriporopollis scabratus* (Venkatachala & Rawat, 1973; p.252, pl. 5, fig. 17, 19) appears similar in morphology but described as triporate.

*Previous geological records*—Comparable form of *Discoidites borneensis* had been recorded from Miocene of the Ratnagiri area (Phadtare & Kulkarni, 1984). Moreover, it was also known from the Palaeocene-Miocene of the Cambay Basin (Khosal & Uniyal, 1986; Venkatachala & Rawat, 1973).

This taxon was recorded from early Tertiary sediments of south-east Asia (Muller, 1968).

*Affinity to pollen of extant taxa*—The fossil specimen is similar to the pollen of *Berrya cordifolia* (Willd.) Burret (= *Berrya ammonilla* Roxb.) of Tiliaceae (Pl. 2.16). Muller (1968) suggested affinity with *Brownlowia* or *Pentace*. The genus *Berrya* is presently distributed in Indo-Malayan region (Mabberley, 1997). According to Bose *et al.* (1998) *B. cordifolia* is native of South India and Andaman rain forests and is used as timber.

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**PLATE 2**

(The scale in plate 1, figure 1 is correct for all other figures without scale bars)

1. *Tiliaepollenites* cf. *rotundus* Venkatachala & Rawat, 1973. Slide no. BSIP 12285, C35.
2. *Polygonum aviculare* modern pollen. Slide no. BSIP (Herbarium) 5252.
3. *Retitricolporites* cf. *guianensis* v. d. Hammen & Wymstra, 1964. Slide no. BSIP 12286, V 17.
4. *Discoidites borneensis* Muller, 1968. Slide no. BSIP 12144. X 21/1.
5-6. *Durgaipollenites galsii* Mathur & Chopra, 1987, fig. 5. Slide no. BSIP 12135 A, T22/2; fig. 6. Slide no. 12287, P53/1.
7-8. *Lanagiopollis eocaenicus* (Krutzsch, 1962), comb. nov. Slide no. BSIP 12288, V17/2.
9. *Strobilanthus adenoforus* modern pollen. Slide no. BSIP (Herbarium) 10320.
10. *Strobilanthidites* cf. *africanus* Sah, 1967. Slide no. BSIP 12123, U30.
11-12. *Corsinipollenites jussiaeensis* Jan du Chene *et al.*, 1978. Slide nos 12148, V53/3; 12125, P26.
13. *Jussieua fissendocarpa* modern pollen. Slide no. BSIP (Herbarium) 10496.
14. *Tiliaepollenites* sp. A. Slide no BSIP 12285, R 45/2.
15. *Grewia obtusifolia* modern pollen. Slide no. BSIP (Herbarium) 780.
16. *Berrya cordifolia* modern pollen. Slide no. BSIP (Herbarium) 825.

**Genus—TILIAEPOLLENITES** ( Potonié) Potonié & Venitze, 1934

**TILIAEPOLLENITES** cf. **ROTUNDUS** Venkatachala & Rawat, 1973

Pl. 2·1

*Horizon*—Barail Group, Oligocene.

*Number of specimen studied*—One.

*Description*—Pollen grain circular in polar view, 17·5 µm in diameter, brevitricolporate, pore small, >1 µm in diameter, colpi 3 µm long in polar view, narrow. Exine 2 µm thick, sexine-nexine thickness equal. Sexine 1 µm thick; nexine 2·2 µm thick around aperture forming a band like structure, columellae indistinct, surface smooth.

*Fossil comparison*—The present specimen differs from *T. rotundus* (described by Venkatachala & Rawat, 1973) in exinal characters specially thickening around the apertures. This taxon needs suitable placement.

*Previous geological record*—The probable record of this pollen is from the Oligocene-Miocene of Cauvery Basin (Venkatachala & Rawat, 1973).

*Affinity to pollen of extant taxa*—Venkatachala and Rawat (1973) postulated affinity with Tiliaceae but comparable pollen could not be traced out during the present study.

**TILIAEPOLLENITES** sp. A

Pl. 2·14

*Horizon*—Barail Group, Oligocene.

*Number of specimen studied*—One.

*Description*—Pollen grain rounded triangular in polar view, 44 x 46 µm. Anguloaperturate, tricolpate (?colporoidate), brevicolpate, colpi slit like, 6 µm long in polar view, pore not distinct. Exine 3·5 µm thick, aspidote distinct, sexine 3 µm, thicker than nexine (0·5µm); nexine 8 µm thick near apertures. Columellae 1·5 µm x 1 µm, heads project above tectum forming irregular negative reticulum on surface; reticulum absent around colpi margins. This pollen has been attributed in *Tiliaepollenites* due to very thick nexine around apertures.

*Fossil comparison*—Comparable fossil forms of *Tiliaepollenites* sp. A could not be traced out. *Tiliaepollenites indubitabilis* Potonié (1931) shows minor similarities in morphology but differs in being vestibulate.

*Previous geological record*—None.

*Affinity to pollen of extant taxa*—None.

**RETITRICOLPORITES** (van der Hammen) ex van der Hammen & Wymstra, 1964

**RETITRICOLPORITES** cf. **GUIANENSIS** van der Hammen & Wymstra, 1964

Pl. 2·3

*Horizon*—Namsang Formation, Mio-Pliocene.

*Number of specimen studied*—One.

*Description*—Pollen grain subprolate, 20 x 34 µm, equatorial margin undulated. Tricolporate, colpi 22 µm long, narrow; pores small, 0·5 µm, not distinct, simple. Exine 1·5 µm thick, tectate, sexine about 1 µm thick, columellae 0·5 µm long, nexine 0·5 µm, surface loose-meshed microreticulate, lumina more or less uniform, 0·7 µm, muri simplicolumellate, thin.

*Fossil comparison*—The present specimen compares well with *R. guianensis* described by v. d. Hammen and Wymstra (1964) and Germeraad *et al.* (1968) but differs from the present specimen in having larger meshes.

*Previous geological record*—None.

*Affinity to pollen of extant taxa*—The present specimen shows affinity with pollen of *Grewia obtusifolia* Eckl. & Zeyh. and *G. asiatica* Linn. of family Tiliaceae. However, *G. obtusifolia* has much resemblance in apertural and sculptural patterns (Pl. 2·15) but is larger in size. *G. obtusifolia* is mostly distributed in the tropics. It occurs as bushy shrub on the edges of the forests in North-East and south India (Kanjilal *et al.*, 1982; Bose *et al.* 1998).

**Genus—DURGAIPOLLENITES** Mathur & Chopra, 1987

**DURGAIPOLLENITES GALSII** Mathur & Chopra, 1987

Pl. 2·5, 6

*Horizon*—Barail Group, Oligocene, Tinali well-7, Assam.

*Number of specimens studied*—Three.

*Description*—Pollen grain circular in polar view, 39 x 41·5 µm. Tricolporate, colpi about 20 µm long in polar view, funnel shaped; pores lalongate, 6·5 µm in length. Exine ± 3 µm; sexine uniformly 2 µm thick, nexine about 0·5 µm thick, more thickened around colpi margin (2 µm). Columellae 0·5 µm long, 1 µm apart. Surface reticulate, reticulum restricted in mesocolpial area, lumina mostly circular, 1 µm in diameter, muri about 1 µm thick.

*Fossil comparison*— The present specimens are larger in size than the holotype of *D. galssi. Favitricolporites retiformis* Sah, 1967 has similar aperture characters but are uniformly reticulate.

*Previous geological record*—Similar pollen are known from Middle Eocene subsurface sediment of Bengal Basin (Mathur & Chopra, 1987).

*Affinity to pollen of extant taxa*—The pollen of *Polygonum aviculare* Linn. (Polygonaceae) show minor similarity with fossil species (Pl. 2·2). The plants grow as herbaceous weed in field and waste places. They are native of Europe and North Asia and are distributed in the sub-temperate zone of the Himalaya.

**Genus—STROBILANTHIDITES** Sah, 1967

**STROBILANTHIDITES** cf. **AFRICANUS** Sah, 1967

Pl. 2·10

*Horizon*—Namsang Formation, Mio-Pliocene.

*Number of specimens studied*—Two.

*Description*—Pollen grains prolate, 38 x 50 µm; triporate, pore nearly circular, 4 µm in diameter. Exine 4·5 µm thick; nexine 2 µm thick, more thickened (up to 3·5 µm) near pore. Sexine pattern banded; bands 1 µm apart, 3·5 µm broad, coalescing at poles. Columellae thin, 1 µm long, closely placed. Tectum areolate. Surface microreticulate, lumina circular, about 0·5 µm in diameter.

*Fossil comparison*—The present specimens show similarity with *Strobilanthidites africanus* (Sah, 1967) but due to sculptural variation on the polar costae it has been considered as *Strobilanthidites* cf. *africanus*.

*Previous geological record*—*Strobilanthidites* recorded from Miocene of Assam (Kar *et al.* 1994). Similar pollen also occur frequently in Quaternary sediments.

*Affinity to pollen of extant taxa*—*Strobilanthidites* cf. *africanus* closely resembling modern pollen of *Strobilanthus adenoforus* Bedd., Acanthaceae (Pl. 2·9), which occurs widely in India, Asia and Madagascar as undergrowth shrubs (Good, 1953).

**RETITRESCOLPITES** Sah, 1967

**RETITRESCOLPITES AFRICANUS**, Sah, 1967

Pl. 1·6, 7

*Horizon*—Dhekiajuli Formation, Pleistocene.

*Number of specimen studied*—One.

*Description*—Pollen grain radially symmetrical, subspherical; 50 x 52 µm. Tricolporate, colpi funnel shaped in polar view, pores 3·5 µm in diameter. Exine 6-8·5 µm thick, sexine 4 µm thick, triming towards colpi, nexine 2·2 µm, more thickened around pore. Columellae robust, 4·5 µm long, bulbous heads 2·5 µm, 3 µm apart. Surface retipilate-retibaculate, reticulum faint, lumina large, size variable (4·5-5·5 µm), free bacula within; muri supported by few short bacula.

*Fossil comparison*—*Reticolporites irregularis* v.d. Hammen and Wymstra (1964) described by Germeraad *et al.* (1968) and *Retitrescolpites typicus* Sah (1967) show minor similarity in shape, size and ornamentation. The present specimen differs in having thin sexine around colpi, free bacula within the lumina and nexinous thickening around pore.

*Previous geological record*—None.

*Affinity to pollen of extant taxa*—Pollen of modern *Delonix regia* Rafin. (Caesalpiniaceae) show very close resemblance with the fossil type (Pl. 1·4, 5). *Delonix*, a genus of about 12 species is distibuted in Madagascar, tropical Africa and India (Mabberley, 1997).

**Genus—TINALIPOLLENITES** gen. nov.

*Type species*—*Tinalipollenites duttae* sp. nov.

*Holotype*—Pl. 1, figs 8, 9, slide no. 12143, S20/3.

*Syntype*—Pl. 1, fig. 10, slide no. 12144, T12/4.

*Horizon*—Namsang Formation, Mio-Pliocene, Tinali well-7, depth 1390 m., Upper Assam.

*Number of specimens studied*—Seven.

*Diagnosis*—Pollen grains triangular—subtriangular in polar view, radially symmetrical. Tricolporate, planaperturate, apertures frequently associated with exinal folds. Exine thick, sexine thicker than nexine, tectum semiperforate, surface scabrate.

*Etymology*—The generic name is given after the type locality Tinali, Assam, from where this pollen recovered. The species name is proposed in honour of Late Prof. S. K. Dutta, the eminent palynologist of Assam, India.

**TINALIPOLLENITES DUTTAE** sp. nov.

Pl. 1·8-10

*Description*—Polar axis 30-35 µm (5 specimens), triangular to sub triangular, equatorial axis 28-30 µm ( 2 specimens), subprolate, holotype 30 x 33 µm. Tricolporate, planaperturate; colpi narrow, 16 µm long, frequently bordered by 2-2·5 µm thick folds; pores lalongate, 5·5 µm wide, simple. Exine thick, 3·5-6·5 µm; sexine thicker than nexine, 5 µm thick at poles, forming cap like structure, thin towards colpi (1·5 µm). Columellae not prominent, 3 µm x 1µm, 2 µm apart, tectum perforate, forming loose fibrilous layer. Nexine 1·5 µm, thickend near aperture. Surface uneven, faintly scabrate.

*Previous geological record*—None.

*Fossil comparison*—The grains do not show similarity with any of the known fossil taxa.

*Affinity to pollen of extant taxa*—None.

## DISCUSSION

The purpose of this study has been to find stratigraphic marker pollen and to relate the fossil pollen types with modern plants. Three taxa *Corsinipollenites, Perfotricolpites* and *Polygonacidites* among the 12 fossil taxa studied were found to be useful palaeoecologic markers.

The regional records show that *Corsinipollenites* ranges from Palaeocene to Oligocene in Africa, S. E. Asia. and Indian subcontinent. They have been recovered mostly from coal or coal associated samples. This suggests that the plant grew in swampy conditions. The related modern part *Jussieua fissendocarpa* (Onagraceae) which has pollen with notable similarity to the fossil taxon grows in swampy areas throughout the tropics.

The genus *Perfotricolpites* is recorded from the western part of India in Early Eocene sediments, whereas it is not found until the Miocene in Southern India, or in Oligocene-Miocene of Assam. This taxon also occurs in coal and coal-associated sediments in these regions. Comparable pollen of extant taxon *Convolvulus arvensis* grows in a swampy habitat. The lithological characters also indicate swampy conditions. The palaeogeographical distribution of this taxon is indicative of a probable migration from Africa during the Eocene in both easterly and westerly directions. It appears to have reached

the Caribbean, Australia and west coast of India during the Eocene but did not reach Borneo until the mid-Miocene.

There are several records of *Polygonacidites* from the eastern part of India. The plants were members of a marshy vegetation. The Miocene sediments of Assam were deposited under riverine conditions. The modern species *Polygonum glabrum* closely resembling the fossil genus, grows in marshy places.

It appears that *Discoidites* has vertical distribution within the Miocene and Mio-Pliocene in India with less frequency. The taxon has potential for palynodating. It is an important taxon of early Tertiary in Borneo (Muller, 1968).

The broadly reticulate *Alangium* related fossil taxon *Lanagiopollis eocaenicus* is not recorded from pantropical areas. It is known from the Eocene of Europe (Reitsma, 1970). This is the only record from the Oligocene of North-East India and also from tropical areas but is difficult to explain the time of occurrence in India and Europe.

Habitat of *Delonix regia* indicates that *Retitricolpites africanus* producing plants were members of deciduous forest.

The other genera described here have very few or no previous records from India. Different form-generic names for fossil taxa make it difficult to trace the documents. Moreover, time of distribution of a few taxa is different in different basins and has restricted this assignment as useful stratigraphic markers. Their significance as markers can only be ascertained during future studies. The suggested affinities with recent pollen has provided some thoughts on the possible habitat of the fossil taxa.

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