

# Taxonomic revision of tricolpate pollen from Indian Tertiary

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## ABSTRACT

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Tricolpate pollen have been described under 32 genera and 98 species from the Tertiary sediments of India. Some of these genera are either nomenclaturally illegitimate or invalid but still are being used by different palynologists. Moreover, circumscription and the diagnoses of some genera/species are overlapping each other and thus they need a thorough taxonomic revision to make them more useful in stratigraphy. With this objective, holotypes and related specimens of the tricolpate pollen taxa housed at Birbal Sahni Institute of Palaeobotany Museum have been restudied and in part photodocumented. Character assessment and reallocation of the remaining taxa have been done on the basis of available literature and illustrations. Each taxon has been evaluated and demarcation of morphological limits have been attempted to make them more useful and applicable for stratigraphy and age correlation. In addition, the distribution of different species has been recorded to know their stratigraphic range.

**Key-words**—Palynology. Tricolpate pollen, Tertiary, India.

## टर्शियरी कल्प के भारतीय त्रिकोल्पसी परागकणों का वर्गीकीय पुनरावलोकन

जगन्नाथ प्रसाद मण्डल एवं मुलागलापल्ली रामचन्द्र राव

### सारांश

भारत के टर्शियरी अवसादों से प्राप्त त्रिकोल्पसी परागकणों को 32 वंशों तथा 98 प्रजातियों के अन्तर्गत विवेचित किया गया है। यद्यपि इनमें से कुछ वंश या तो नामकरण के आधार पर विधिसम्मत नहीं है अथवा अयोग्य हैं, किन्तु फिर भी भिन्न-भिन्न परागणुविद् इन्हें अभी भी प्रयुक्त कर रहे हैं। इसके अतिरिक्त कुछ वंशों/प्रजातियों के परिसीमन तथा विश्लेषण परस्पर विरोधाभासी हैं। अतः इन्हें स्तरिकी हेतु उपयोगी बनाने के लिए इनका गहन वर्गीकीय पुनरावलोकन आवश्यक है। इस उद्देश्य को दृष्टिगत रखते हुए बीरबल साहनी पुरावनस्पतिविज्ञान संस्थान के संग्रहालय में संरक्षित त्रिकोल्पसी परागणु वर्गकों के आदि प्ररूपों तथा सम्बन्धित प्रादशों का पुनः अध्ययन हेतु छायाप्रलेखन किया गया। प्राप्त साहित्य तथा पारदर्शियों के आधार पर शेष वर्गकों का अभिलक्षण मूल्यांकन तथा पुनः स्थान निर्धारण किया गया। इन्हें स्तरिकी तथा आयु सहसम्बन्धन हेतु अधिक उपयोगी बनाने के उद्देश्य से प्रत्येक वर्ग का मूल्यांकन किया गया तथा इनकी संरचनात्मक सीमाओं के अंकन का प्रयास किया गया। इसके अतिरिक्त इनकी स्तरिकी सीमाओं को ज्ञात करने हेतु विभिन्न प्रजातियों के वितरण भी अंकित किए गए।

**संकेत शब्द**—परागणुविज्ञान, त्रिकोल्पसी परागकण, टर्शियरी, भारत.

## INTRODUCTION

THE tricolpate pollen are very abundant and diversified in the Tertiary sequences of India and are represented by 98 species belonging to 32 genera. It has been observed that some of these tricolpate palynotaxa are not properly described. Also, some generic diagnoses overlap with others, e.g. those of *Retitrescolpites*, *Tricolpites* and *Tricolpopites*. Moreover, the genus *Tricolpites* has been used as dumping place for tricolpate forms irrespective of their qualitative characters. Further, a number of species have been erected on only minute difference of characters, and have been recorded only once by their original authors, viz., *Tricolpites densiornatus*, *Beaupreaidites tegillatus*, *Clavasyncolpites gracilis*. Many other species have not been properly identified and different taxa have been lumped together. Consequently, these appear long ranging in the stratigraphic column (e.g., *Tricolpites reticulatus* and *Ladakhpollenites levis*) and have lost significance. In some instances palynologists from different centers have followed nomenclature of their own school, and thus one taxon has several names, e.g., synonyms of *Tricolpites reticulatus*.

Genera like *Psilatricolpites*, *Retitricolpites* are nomenclaturally illegitimate (Jansonius & Hills, 1976) and should be merged with the existing genera or given a new name. Similarly, although holotypes of *Tricolpopollenites* and *Retibrevitricolpites* are reported to be colpate, still some tricolpate species are being assigned to these genera. Furthermore, there are no genera to accommodate the forms having a margo (*Tricolpites margocolpites*), granulose exine (*Tricolpites ovatus*) or warty exine (*Tricolpites minutus*). All these nomenclaturally confusing factors conspire to limit the importance of this group of pollen in correlation and determination of precise age.

These anomalies can be eliminated by studying the holotypes or other specimens for their character assessment and correct placement. With the above objectives, Thanikaimoni *et al.* (1984) and Venkatachala *et al.* (1989, 1996) restudied, described and illustrated some selected taxa. They are *Cruciferoipollenites elongatus* Navale & Misra, 1979; *Dakshinipollenites tripakshi* Navale & Misra, 1979 emend. Singh & Misra, 1991; *lcacinoipollenites spinulatus* Navale & Misra, 1979; *Parumbelliferoipollis dulcis* Kar, 1978;

*Plumbaginacipites neyvelii* Navale & Misra, 1979; *Tricolpites reticulatus* Cookson ex Couper, 1953; *Crototricolpites densus* Rao & Ramanujam, 1982; *Intrareticulitis brevis* (Sah & Kar, 1970) Kar, 1985; *Loranthipites elegans* Rao & Ramanujam, 1982 and *Warkallipollenites erdmanii* Ramanujam & Rao in Thanikaimoni *et al.*, 1984.

In the present study, we have endeavored to evaluate the morphological limits, nomenclatural and taxonomic status of the tricolpate species recorded from Indian Tertiary sediments. Only three species from the above mentioned taxa have been incorporated here. For these purposes holotypes and other specimens available at the museum of Birbal Sahni Institute of Palaeobotany, Lucknow have been examined and photodocumented. The critical evaluation and taxonomic reallocation are based on the examination of specimens, descriptions and illustrations from published literature. Simultaneously, the stratigraphic ranges of different species have been tabulated on the basis of records of their occurrences.

## SYSTEMATIC DESCRIPTION

**Genus**—ALBERTIPOLLENITES Srivastava, 1969a

*Type species*—*Albertipollenites rosalindae* Srivastava, 1969a.

*Original Diagnosis*—Tricolpate, angulaperturate, oblate to spheroidal, colpi short or long, meridional; amb triangular to circular, sides straight to convex; sexine thick, tectate; Ornamentation reticulate, reticula of uniform size all over the pollen body; lumina size 1 µm or larger.

**ALBERTIPOLLENITES AQUIFOLIACEAEFORMIS**  
(Biswas, 1962) comb. nov.

*Basionym*—

*Tricolpopites aquifoliaceaeformis* Biswas, 1962, Bull. geol. min. metall. Soc. India 26: 38, pl. 5, fig. 18.

*Original Description*—Equatorial compression; exine moderately thick, with minute rods; tricolpate; 21 µm.

*Occurrence*—Early-Middle Eocene, Tura Formation, Meghalaya (Biswas, 1962).

*Remark*—The photograph (pl. 5, fig. 18) shows that reticula are more than 1 µm in diameter and uniformly present all over the surface.

## PLATE 1

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| <p>1. <i>Pilatisyncolpites triangulatus</i> Kar <i>et al.</i>, 1994, Slide No. BSIP 10922 (E 33/3), Holotype.</p> <p>2-3. <i>Albertipollenites robustus</i> (Sah &amp; Kar, 1970) comb. nov. Slide No. BSIP 3364 (E 29/1). Holotype in different foci.</p> <p>4. <i>Dipterocarpuspollenites retipilatus</i> (Kar &amp; Jain, 1981) Kar, 1992. Slide No. BSIP 5397 (J 8/1).</p> <p>5-6. 9. <i>Ladakhpollenites pachyexinus</i> (Couper) Mathur &amp; Jain, 1980, figs</p> | <p>5-6. Slide No. BSIP 4365 (S 33/3) in polar views; fig. 9. Slide No. BSIP 4365 (N 42) in equatorial view.</p> <p>7-8. <i>Dakshinipollenites tripakshi</i> Navale &amp; Misra emend. Singh, 1991, Slide No. BSIP 10513 (Q 28) in different foci.</p> <p>10-11. <i>Rousea matanomadhensis</i> (Saxena, 1979) comb. nov., Slide No. BSIP 12831 (P 37).</p> <p>12. <i>Discoidites borneensis</i> Muller, 1968. Slide No. BSIP 12144 (X 21/1).</p> |
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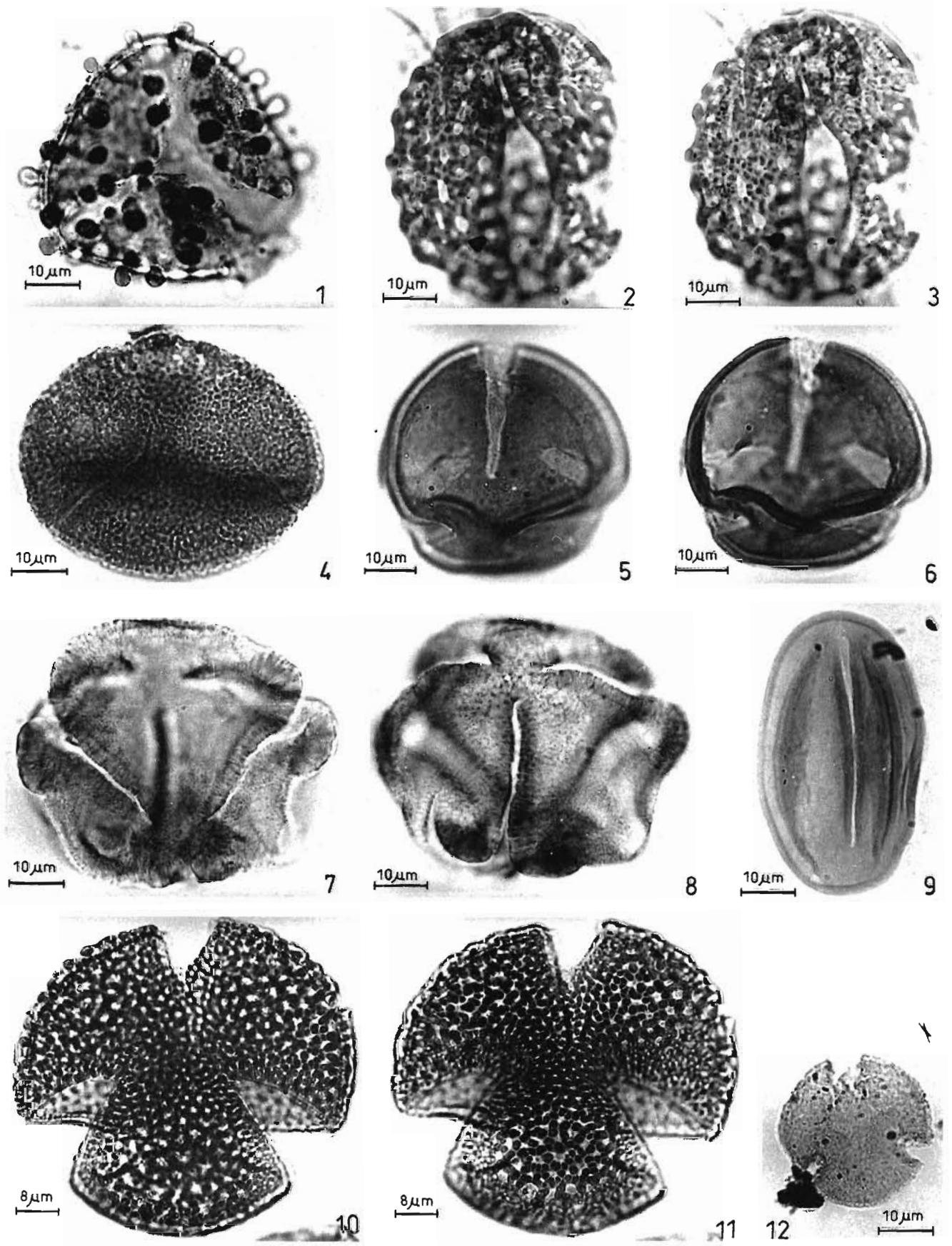


PLATE 1

**ALBERTIPOLLENITES BACULATUS** (Jain *et al.*, 1973)  
comb. nov.

*Basionym*—

*Tricolpites baculatus* Jain *et al.*, 1973, Geophytology 3: 155, pl. 1, figs 23-26, 34, 36. *Illegitimate junior homonym: non Tricolpites baculatus* Kar & Jain, 1981, Palaeobotanist 27: 120, pl. 3, fig. 81 (now *Dipterocarpuspollenites retipilatus*).

*Original Description*—Pollen grains tricolpate, spherical, 30-35 µm, colpi long. Exine moderately thick, tegillate, surface baculate-spinose. Sculptural elements up to 3 µm high.

*Occurrence*—Palaeocene, Barmer clay Bed, Rajasthan (Jain *et al.*, 1973); Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979).

*Remark*—Holotype is missing.

**ALBERTIPOLLENITES CRASSIRETICULATUS**  
(Dutta & Sah, 1970) comb. nov.

*Basionym*—

*Tricolpites crassireticulatus* Dutta and Sah, 1970, Palaeontographica 131: 32, pl. 6, figs 9-12.

*Synonym*—

1973 *Tricolpites crassisexinus* Venkatachala and Rawat, Palaeobotanist 20: 244, pl. 4, fig. 9.

*Original Description*—Size range 25-37 µm; holotype 32 µm, amb roundly triangular to sub-spheroidal, tricolpate, colpi with bulging mesocolpia; exine rather thick, sexine as thick as nexine, pilate, tegillate, surface sculpture coarsely reticulate, crassimurate.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Dutta & Sah, 1970) and subsurface Oligocene-Miocene sediments, Cauvery Basin (Venkatachala & Rawat, 1973).

*Remarks*—*Tricolpites crassireticulatus* described by Saxena (1979, Palaeobotanist, 26, pl. 2, fig. 23) and Kar and Kumar (1986, Pollen Spores, 28, pl. 8, figs 9, 12, 14) are over 60 µm in size and reticula gradually decrease towards pole. These taxa have been placed under *Rousea*.

**ALBERTIPOLLENITES GRACILIS** (Salujha *et al.*, 1972)  
comb. nov.

*Basionym*—

*Tricolpites gracilis* Salujha *et al.*, 1972, Proc. Sem. Palaeopalynol. Indian Stratigr., Calcutta, pp 279, pl. 3, figs 59, 60.

*Original Description*—Golden-yellow, roundly triangular to subcircular with three equidistant furrows; size 20.8-40 µm; tricolpate, colpi 5.4-7.2 µm deep, ± 4.8 µm wide; exine tectate ± 1.5 µm thick, reticulate, muri over 1 µm wide, with an equally wide lumina, muri slightly protruding at the margin.

*Occurrence*—Palaeogene sediments, Meghalaya (Salujha *et al.*, 1972); Oligocene, Meghalaya (Salujha *et al.*, 1974); Early Miocene, Bokabil Formation, Tripura (Salujha *et al.*, 1977).

**ALBERTIPOLLENITES Karii** sp. nov.

Pl. 5.8-9 (holotype)

*Holotype*—*Tricolpites* sp. A; in Kar & Kumar, 1986; Pollen Spores 28: 196, pl. 9, fig. 1, slide no. 9395 (reillustrated here: Pl. 5.8-9).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Shillong-Cherra Road Section, Meghalaya, Late Palaeocene.

*Description*—Pollen grain subprolate, 58 x 70-66 x 73 µm in equatorial view. Tricolpate, colpi 52 µm long, margin smooth. Exine 5-6 µm at equator, gradually decreases to 3 µm at poles, nexine almost uniform, 1-1.5 µm; columellae stout, 3.5 µm long, 1 µm broad at base and gradually widens upward, apex 1.5-2 µm, 2-4 µm apart near equator, closer (1-1.5 µm) at poles; tectum smooth, nearly uniform, 1.5 µm. Surface reticulate, reticulum nearly squarish all over the surface, uniform in size; muri simplicolumellate, 1-1.5 µm thick; lumina 3 x 4 µm, free columellae rarely present within lumina.

*Comparison*—*Albertipollenites karii* compares *A. kutchensis* having large size, thick exine and long colpi. But

**PLATE 2**

(All photographs are of same magnification)

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| <p>1-2. <i>Ladakhipollenites elongatus</i> Tripathi &amp; Singh, 1985, Slide No. BSIP 8768. Holotype in different foci.</p> <p>3, 7. <i>Tricolpites delicatus</i> (Kar, 1979) comb. nov., Slide No. BSIP 5097. Holotype in different foci.</p> <p>4, 14. <i>Foveotricolpites alveolatus</i> sp. nov. fig. 4, Slide No. BSIP 8785 in equatorial view: fig. 14. Slide no. BSIP 8784 in polar view (Holotype).</p> <p>5-6. <i>Ladakhipollenites levis</i> (Sah &amp; Dutta, 1966) Mathur &amp; Jain, 1980. Slide No. BSIP 4364. Neotype (here designated) in different foci.</p> | <p>8-9. <i>Ladakhipollenites minutus</i> (Sah &amp; Kar, 1970) Mathur &amp; Jain, 1980. Slide No. BSIP 3350 (Q 4). Holotype in different foci.</p> <p>10-11. <i>Tricolpites paucireticulatus</i> Sah &amp; Kar, 1974, Slide No. BSIP 4361 (P 43/2). Holotype in different foci.</p> <p>12. <i>Foveotricolpites</i> sp. Kar &amp; Kumar, 1986. Slide No. BSIP 9448.</p> <p>13. <i>Dipterocarpuspollenites retipilatus</i> (Kar &amp; Jain, 1981) Kar, 1992. Slide No. BSIP 5397. Holotype.</p> <p>15-16. <i>Tricolpites incognatus</i> Kar &amp; Jain, 1981. Slide No. BSIP 5414 (G 17/4). Holotype in different foci.</p> |
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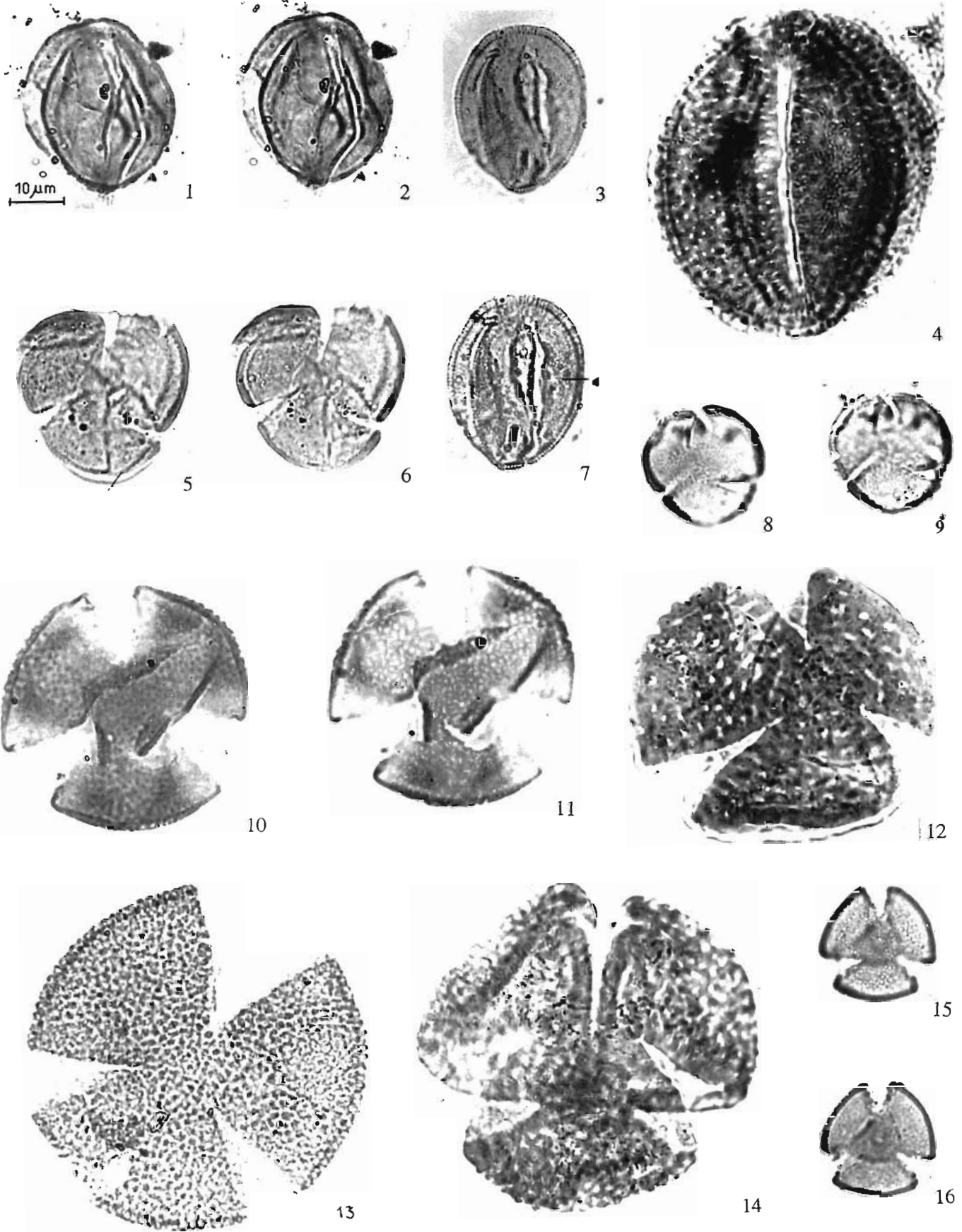


PLATE 2

*A. karii* differs possessing nearly squarish large reticula and well spaced columellae (2-4  $\mu$ m).

*Occurrence*—Late Palaeocene, Lakadong Sandstone Member, Meghalaya (Kar & Kumar, 1986).

### ALBERTIPOLLENITES KUMARII sp. nov.

Pl. 4.6-8 (holotype)

*Holotype*—*Tricolpites* sp. B; in Kar & Kumar, 1986, Pollen Spores 28: 198, pl. 9, fig. 8, slide no. 9400 (reillustrated here: Pl. 4.6-8).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Shillong-Cherra Road Section, Meghalaya, Late Palaeocene.

*Description*—Pollen grain 100  $\mu$ m (polar axis) and 61  $\mu$ m (folded equatorial axis) in equatorial view. Tricolpate, colpi 93  $\mu$ m long, nearing to poles, margin smooth. Exine 5.5  $\mu$ m thick at equator, 4.5  $\mu$ m at poles; nexine uniformly thick, ca. 1  $\mu$ m; tectum smooth, 1-1.5  $\mu$ m thick; columellae two types; one set supports tectum, 2.5-3  $\mu$ m long, 1-1.5  $\mu$ m broad, 2-3.5  $\mu$ m apart, other set mainly present in equatorial areas between two long columellae, smaller, 2  $\mu$ m long, 1  $\mu$ m broad and does not touch tectum (free). Surface reticulate, reticula vary in size; muri 1.5-2  $\mu$ m broad, simplicolumellate; lumina vary in shape (oval-elongated) and size, largest lumen 4 x 3  $\mu$ m, 1-3 free columellae within each lumen.

*Comparison*—The taxon is very large (100  $\mu$ m polar axis), has two sets of columellae and bear free columellae within each lumen. These characters distinguish *Albertipollenites kumarii* from known species of *Albertipollenites*.

*Occurrence*—Late Palaeocene, Lakadong Sandstone Member, Meghalaya (Kar & Kumar, 1986).

### ALBERTIPOLLENITES KUTCHENSIS sp. nov.

Pl. 4.3-5 (holotype)

*Holotype*—*Tricolpites crassireticulatus* Dutta & Sah, 1970, in Kar & Saxena, 1981 (*non* Dutta & Sah, 1970), Geophytology, 11, pl. 3, fig. 56, slide no. 6351 (reillustrated here: Pl. 4.3-5).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Near Rataria (sub-surface), southern Kutch, Gujarat, Middle-Late Eocene.

*Description*—Pollen grain spherical in polar view, 85 x 88  $\mu$ m. Tricolpate, longicolpate, colpi 33  $\mu$ m deep, wide at equator. Exine thick, 7  $\mu$ m at mesocolpium and gradually thins out towards colpi, 4  $\mu$ m at colpi margins, nexine as thick as or thicker than sexine, tectate, columellae 3.5  $\mu$ m long mixed with pila, capita 1.5  $\mu$ m broad, closely placed. Surface uniformly reticulate, lumina elongated 1.5-2.5  $\mu$ m, muri simplicolumellate.

*Comparison*—The present species resembles *Albertipollenites crassireticulatus* in their crassireticulate sculpture but differs in being very large in size and having thick exine. Tips of columellae are occasionally swollen (pilate) in *Albertipollenites kutchensis* but not in *A. crassireticulatus*.

*Occurrence*—Middle-Late Eocene, southern Kutch (Kar & Saxena, 1981).

### ALBERTIPOLLENITES MEDIRETICULATUS

(Mathur, 1966) comb. nov.

*Basionym*—

*Retitricolpites medireticulatus* Mathur, 1966, Q. J. geol. Min. metall. Soc. India 38:41, pl. 1, fig. 18.

*Original Description*—Isopolar, radiosymmetric, almost round, 36.5  $\mu$ m in diameter, tricolpate, colpi long, 11  $\mu$ m broad, margins not smooth. Exine 2  $\mu$ m thick, sexine almost as thick as nexine with medium size reticulations. Nexine slightly thickened near the colpi, yellow.

*Occurrence*—Palaeocene (Supratrappeans), Kutch (Mathur, 1966).

### ALBERTIPOLLENITES PROBOSCIDEUS (Biswas,

1962) comb. nov.

*Basionym*—

*Tricolpopites proboscideus* Biswas, 1962, Bull. geol. min. metall. Soc. India 26: 42, pl. 8, fig. 44.

*Original Description*—Polar compression, exine thick, uniformly reticulate; tricolpate.

*Occurrence*—Palaeocene, Tura Formation, Meghalaya (Biswas, 1962).

## PLATE 3

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| 1-2. <i>Retitrisyncolpites reimannii</i> Mandal <i>et al.</i> , 1994, Slide No. BSIP 11007 (J 32/4), Holotype in different foci. | 4-6. <i>Albertipollenites retibaculatus</i> (Saxena, 1979) comb. nov., Slide No. BSIP 4953 (O 22), in different foci.  |
| 3. <i>Retitrisyncolpites thaungii</i> Mandal <i>et al.</i> , 1994, Slide No. BSIP 11006 (K 52/2), Holotype.                      | 7-9. <i>Rousea matanomadhensis</i> (Saxena, 1979) comb. nov., Slide No. BSIP 4953 (F 4/2), Holotype in different foci. |

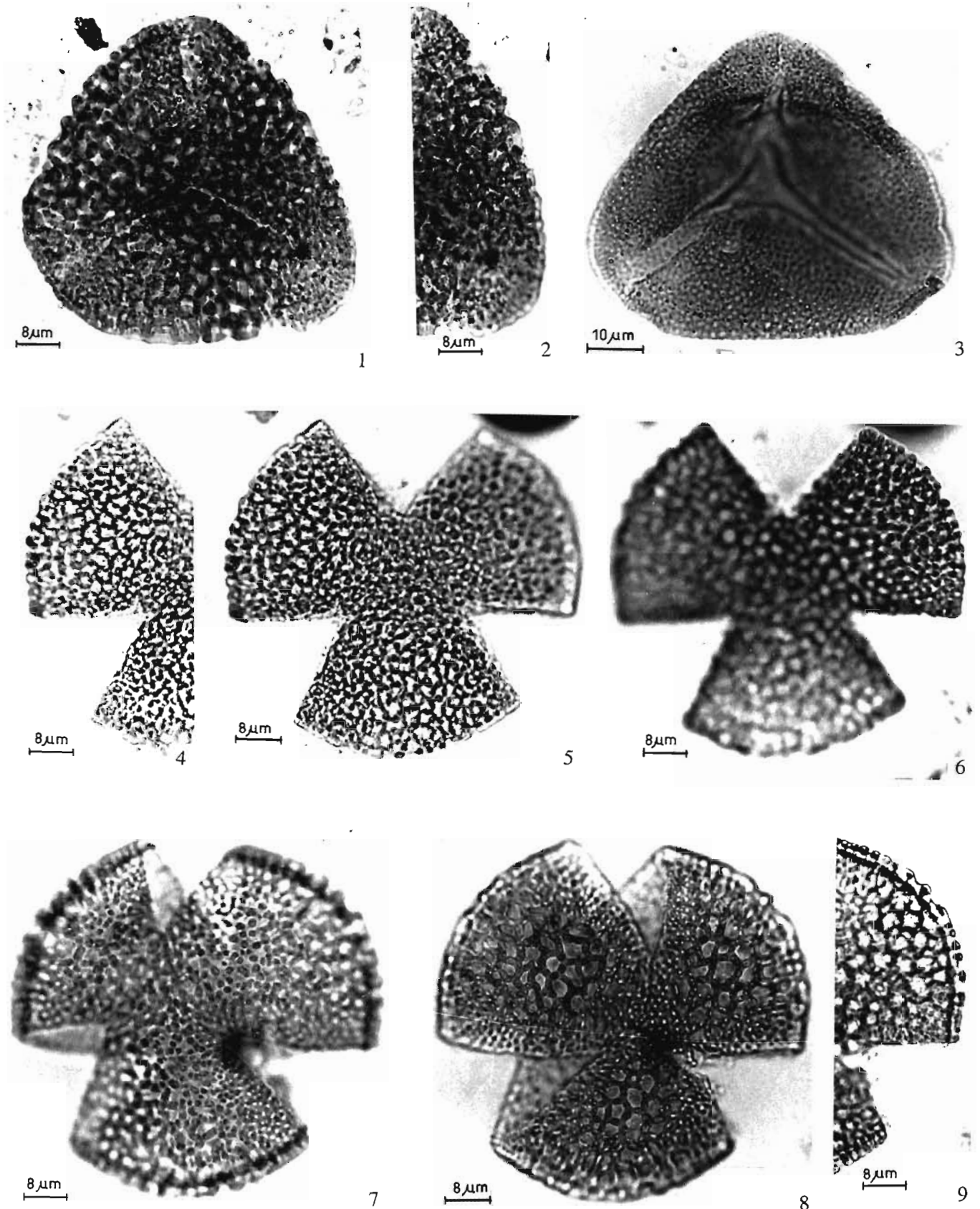


PLATE 3

**ALBERTIPOLLENITES RETIBACULATUS** (Saxena, 1979)  
comb. nov.

Pl. 3.4-6

*Basionym*—

*Tricolpites retibaculatus* Saxena, 1979, *Palaeobotanist* 26: 133, pl. 2, figs 27-28.

*Original Description*—Pollen grains subcircular-subtriangular in polar view, 58-114  $\mu\text{m}$ . Tricolpate, colpi long, well-developed, mesocolpia wide. Exine 2.5-7 on surface view.

*Description* (Present study)—Pollen grains subtriangular in polar view, 88 x 90  $\mu\text{m}$ . Tricolpate, colpi wide at equator, 38  $\mu\text{m}$  deep. Exine 3  $\mu\text{m}$  thick, sexine thicker than nexine (1  $\mu\text{m}$ ), uniformly thick, tectate, columellae slender, 2-3  $\mu\text{m}$  apart, 1.5  $\mu\text{m}$  long, capita 1.5  $\mu\text{m}$  in diameter, mostly fused. Surface retipilate, reticulum almost uniform, lumina irregular, 1-3  $\mu\text{m}$ , muri simplicolumellate, 1.5  $\mu\text{m}$  wide.

*Occurrence*—Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979); subsurface Middle to Late Eocene sediments, Kutch (Kar & Saxena, 1981).

**ALBERTIPOLLENITES ROBUSTUS** (Sah & Kar, 1970) comb. nov.

Pl. 1.2-3 (holotype)

*Basionym*—

*Retitricolpites robustus* Sah & Kar, 1970, *Palaeobotanist* 18: 131, pl. 1, fig. 30.

*Original Description*—Pollen grains subcircular, 40-54 x 38-52  $\mu\text{m}$ . Tricolpate, colpi well developed. Exine thick, reticulate, meshes duplibaculate.

*Description* (present study)—Pollen grain oblate, 44 x 60  $\mu\text{m}$  in equatorial view. Tricolpate, colpi long, 30  $\mu\text{m}$ , end pointed. Exine 4  $\mu\text{m}$  thick, sexine uniformly thick, about 3  $\mu\text{m}$ ; nexine layer not very distinct at all places, about 1  $\mu\text{m}$  at mesocolpia, tectate, tectum 2.5  $\mu\text{m}$  thick, smooth, columellae slender, 1  $\mu\text{m}$  long and 1.5  $\mu\text{m}$  apart. Surface reticulate, muri mostly duplibaculate, 2  $\mu\text{m}$  wide, lumina oval to elongate, 2.5-4.5  $\mu\text{m}$ , smaller on apocolpial areas.

*Occurrence*—Early Eocene, Naredi Formation, Kutch (Sah & Kar, 1970).

**Genus—BACUBREVITRICOLPITES** Rao & Ramanujam, 1982

*Type Species*—*Bacubrevitricolpites rotundus* Rao & Ramanujam, 1982.

*Original Diagnosis*—Pollen grains subprolate equatorially, amb rounded, tricolpate, brevicolpate, colpi narrow, exine intectate, beset with numerous prominent bacules, heads of bacules generally rounded in surface view.

**BACUBREVITRICOLPITES ROTUNDUS** Rao & Ramanujam, 1982

*Original Description*—Pollen grains isopolar, amb rounded, subprolate equatorially, polar diameter 21-26.5  $\mu\text{m}$ ; tricolpate, brevicolpate, colpi narrow, margins thin, ends blunt. Exine 2-3  $\mu\text{m}$  thick, intectate, baculate, bacules fine, densely distributed all over, up to 2.2  $\mu\text{m}$  high, heads of bacules usually rounded in surface view.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remark*—The aperture is tricolpate and not zoniaperturate.

**Genus—BEAUPREAITITES** Cookson, 1950 ex Couper, 1953

*Type Species*—*Beaupreaidites elegansiformis* Cookson, 1950 ex Couper, 1953.

*Original Diagnosis*—This spore type is characterized by its medium size, straight sides, colpoid apertures, tapering exine, and finely reticulate sexine.

*Emended Diagnosis* (after Martin, 1973)—Pollen grains triaperturate, subangular to semiangular in polar view, oblate or nearly so in equatorial view, more or less isopolar, apertures forming short colpoids, meridionally elongated, with irregular thin margins and tapering exine, angles smoothly rounded, internally the aperture bounded by an area or zone ('Solution', Thomson & Pflug, 1953) of roughened, foveolate or warty endexine corresponding to the postatrium of a porate grain; annulus, vestibule and costae absent; exine reticulate, foveolate or areolate, often the reticulum combined with raised low verrucae; size of grain medium to rather large.

After Milne (1998)—Pollen grains tricolpate to tricolpoidate, angulaperturate, isopolar or subsipolar, oblate to peroblate; amb triangular with straight or gently convex or concave sides. Colpi meridionally aligned, sides more or less straight, termini sharp if grain well preserved. Exine stratified, ektexinous; nexine thicker than or equal to sexine,

PLATE 4



- 1-2. *Perforicolpites neyvelii* (Navale & Misra, 1979) Mandal & Kumar, 2000, Slide No. BSIP 10992 (F 26), Holotype in different foci.  
3-5. *Albertipollenites kutchensis* Mandal and Rao sp. nov., Slide No. BSIP 6351(O41/2), Holotype in different foci.

- 6-8. *Albertipollenites kumarii* Mandal and Rao sp. nov., Slide No. BSIP 9400 (P52/1), Holotype in different foci.



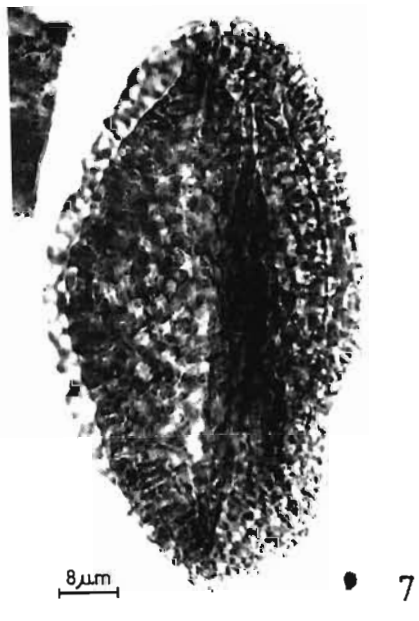
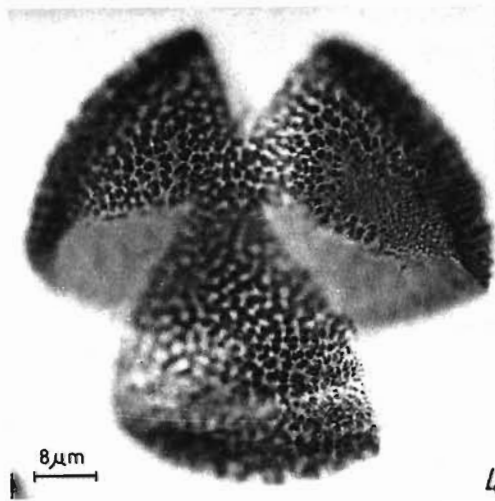
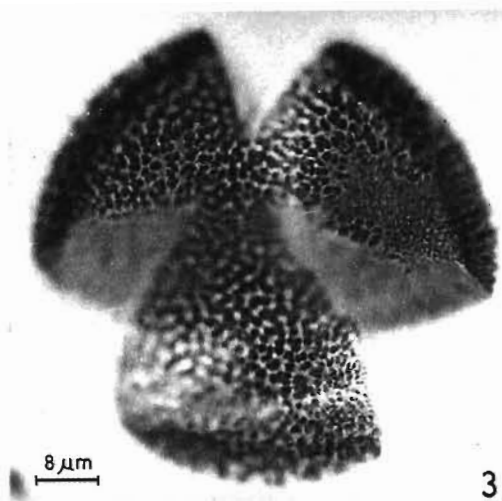
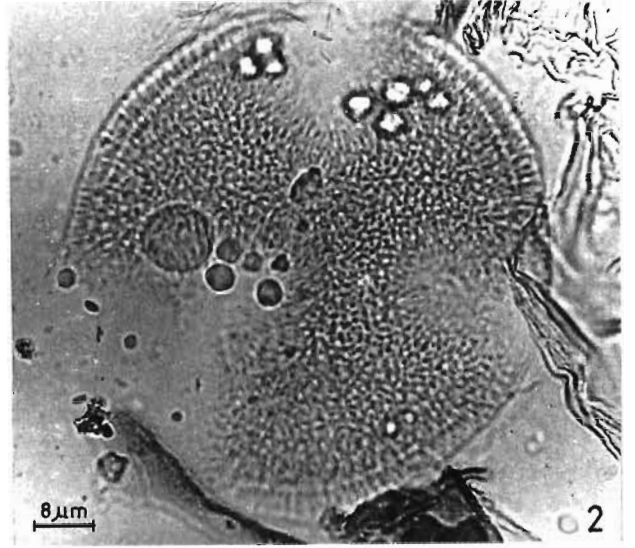
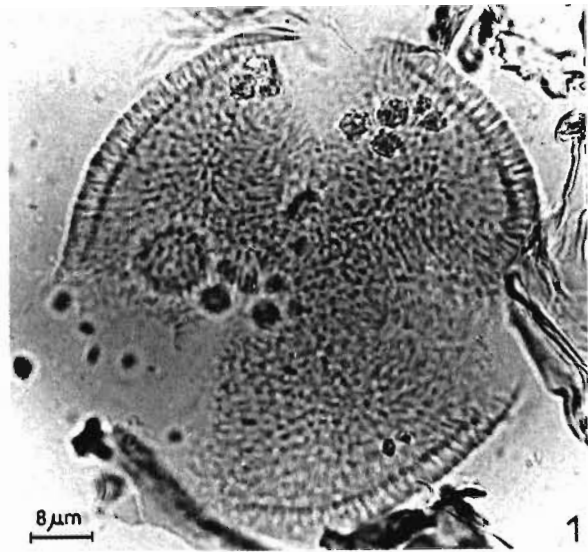


PLATE 4

infractectum thin and densely columellate. Apertural exine thinner than mesocolpial exine. Nexine homogeneous in mesocolpia; thinning abruptly adjacent to colpi termini delineating base of aperture area, then tapering to aperture margin; may partially fragment in aperture area. Tectum of similar width overall or tapering towards grain apices before nexine thin; infractectum same width over grain or thinning slightly in aperture area. If exinal thinning pronounced, apertural area pale in colour compared to rest of grain. Sexine columellate, tectate-perforate or semi-TECTATE; tectum surface perforate, microreticulate, reticulate; fossulate or foveo-areolate; with or without irregular tectal thickenings, verrucae and/or gemmae. Sculptural elements diminished in aperture area; uniformly developed over remainder of grain or coarser at poles and finer in mesocolpia.

**BEAUPREAITES TEGILLATUS** Venkatachala & Rawat, 1973

*Original Description*—Pollen grain roundly triangular with slightly convex sides and rounded angles; 23.2 x 23.7 µm in polar view; tricolpate, angulaperturate. Colpi very short, slit like. Exine about 1.5 µm, sexine thicker than nexine except at aperture region where nexine thickenings are prominent, puncti-tegillate, puncta 0.5 to 1.0 µm in diameter forming a reticulate surface.

*Occurrence*—Subsurface Oligocene-Miocene sediments, Cauvery Basin (Venkatachala & Rawat, 1973).

**Genus—CLAVASYNCOLPITES** Rao & Ramanujam, 1982

*Type Species*—*Clavasyncolpites gracilis* Rao & Ramanujam, 1982.

*Original Diagnosis*—Pollen grains with triangular-rounded triangular amb, tricolpate, syncolpate. Exine intectate, clavate, clavae locally seen in a reticuloid alignment.

**CLAVASYNCOLPITES GRACILIS** Rao & Ramanujam, 1982

*Original Description*—Pollen grains isopolar, amb triangular to rounded triangular, sides convex, polar diameter 22-31 µm; tricolpate, syncolpate, colpi wide and gaping at equatorial region, margins slightly thickened and beset with clavate-baculate processes. Exine 2.5-3.5 µm thick, sexine thicker than nexine, intectate, clavate, clavae 1.5-2 µm high,

locally mixed with bacula, densely and uniformly distributed all over, here and there seen in reticuloid alignment.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remark*—The specimen is tricolpate and not zonaperturate.

**Genus—DAKSHINIPOLLENITES** Navale & Misra, 1979; emend. Singh & Misra, 1991

*Type Species*—*Dakshinipollenites tripakshi* Navale & Misra, 1979; emend. Singh & Misra, 1991.

*Original Diagnosis*—Pollen grain isopolar, triangular to subtriangular (in polar view), subprolate to suboblate (equatorial view): 48-70 x 48-66 µm in size. Tricolpate, angulaperturate, colpi long, narrow and deep, apocolpi small. Ora faint to indistinct, lalongate, slit-like. Exine thin (1-5 µm) in middle part of the mesocolpi where it is projected out like a hump, gradually thickens laterally, being thickest (3-4.5 µm) on the colpal margins. Surface microgranulate to granulate, granulation more prominent towards colpi margins.

*Emended Diagnosis* (Singh & Misra, 1991)—Pollen isopolar, tricolpate, triangular to subtriangular in polar view; prolate-oblate, spheroidal or sub-spheroidal in equatorial view; exine thin in the middle of mesocolpium where ambitus shows a bulge, gradually thickening towards colpi and thickest at colpus margins, exine comprised of a perforate tectum, columellae layer and unstructured nexine, columellae shorter at mesocolpium gradually becoming longer towards colpi margin; ornamentation finely granulate to finely reticulate as gaps between the granules appear like pits or lumina.

**DAKSHINIPOLLENITES TRIPAKSHI** Navale & Misra, 1979; emend. Singh & Misra, 1991

Pl. 1.7-8

*Original Description*—Isopolar pollen grain, subprolate to suboblate in equatorial view, triangular to subtriangular in polar view. Size range 48-70 x 48-66 µm. Tricolpate, angulaperturate, longicolpate, colpi deep and narrow, extending quite up to the poles, apocolpium small. Pore obscure, lalongate, like a slit. Exine thin (1.5-2 µm) in the middle part of the mesocolpi (clearly visible in the polar view) projecting outwards like a hump, gradually thickening laterally; being thickest (3-4.5 µm) at the colpi margins.

PLATE 5

- |      |  |        |  |
|------|--|--------|--|
| 1    | <i>Rousea meghalayaensis</i> Mandal and Rao sp. nov., Slide No. BSIP 9398 (K52/3), Holotype.                   | 8-9.   | <i>Albertipollenites kari</i> Mandal and Rao sp. nov., Slide No. BSIP 9395 (J 15/3), Holotype in different foci. |
| 2-4. | <i>Intrareticulitis brevis</i> (Sah & Kar) Kar, 1985, Slide No. BSIP 3348 (P34/3), Holotype in different foci. | 10-11. | <i>Tricolpites reticulatus</i> Cookson ex Couper, 1953, Slide No. BSIP 3348 (M31) in two foci.                   |
| 5-7. | <i>Tricolpites reticulatus</i> Cookson ex Couper, 1953, Slide No. BSIP 3350 (Q 4/2) showing weak reticulation. | 12-14. | <i>Rousea saxenae</i> Mandal and Rao sp. nov., Slide No. BSIP 4960 (D/6), Holotype in different foci.            |

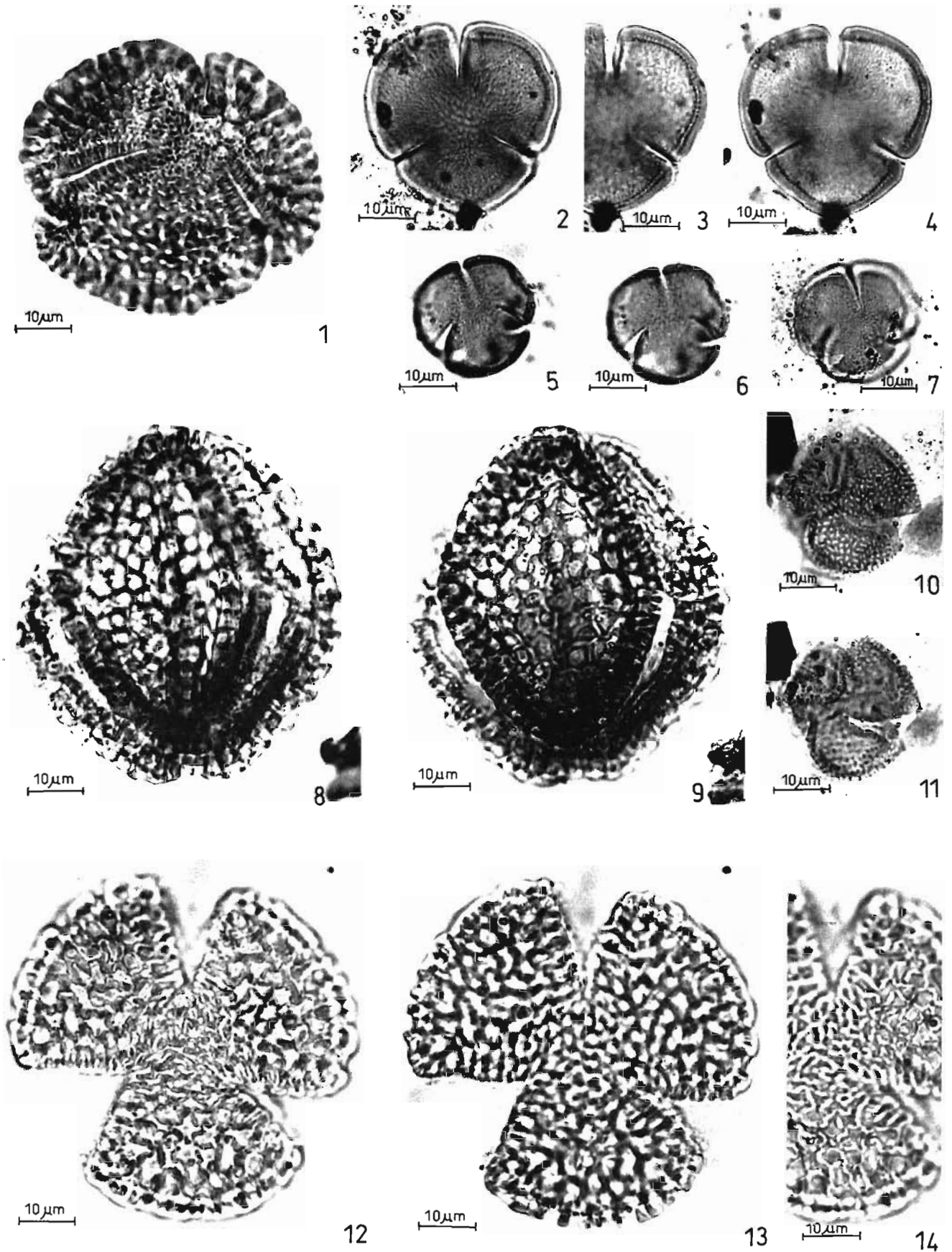


PLATE 5

Microgranulate to granulate, granulation becoming more prominent towards colpi margins.

*Emended Description* (Singh & Misra, 1991)—Pollen 40-90  $\mu\text{m}$ , isopolar, triangular to subtriangular in polar view, prolate-oblate spheroidal to sub-spheroidal in equatorial view, tricolpate, colpi medium to long; exine comprised of a perforate tectum, columellae layer and unstructured smooth nexine; exine 1-4  $\mu\text{m}$  in the middle of mesocolpium, gradually thickening towards colpi and 3-8  $\mu\text{m}$  at colpus margins, where exine is 2-4 times thicker than at the equatorial bulge; nexine smooth, gradually thickens towards the margin, sexine and nexine thickness is  $\pm$  equal; surface ornamentation finely granulate to finely reticulate.

*Occurrence*—Miocene, Neyveli lignitefield, Tamil Nadu (Navale & Misra, 1979; Singh & Misra, 1991).

**Genus—DIPTEROCARPUSPOLLENITES** Kar, 1992;  
here emended

*Type Species*—*Dipterocarpuspollenites retipilatus* (Kar & Jain, 1981) Kar, 1992.

*Original Diagnosis*—Pollen grains subcircular and oval in polar and equatorial views respectively. Size range 51-68  $\mu\text{m}$ . Tricolpate, very rarely tricolporoidate, colpi long. Exine 1.5-3.5  $\mu\text{m}$  thick, pilate, pilae up to 3  $\mu\text{m}$  long, 1-1.5  $\mu\text{m}$  broad, closely placed, sometimes fused together, pila provide pseudoreticulate appearance in surface view.

*Emended Diagnosis*—Pollen spheroidal in polar and subprolate in equatorial view. Tricolpate, longicolpate; sexine thicker than nexine. Exine columellate, with (strongly) perforate tectum, which tends to be pushed up between each two columellae. Surface pseudoreticulate at lower focus and verrucate at top focus.

**DIPTEROCARPUSPOLLENITES RETIPILATUS** (Kar & Jain, 1981) Kar, 1992

Pl. 1.4; Pl. 2.13 (holotype)

*Synonyms*—(after Kar, 1992)

1981 *Tricolpites baculatus* Kar and Jain, *Palaeobotanist* 27: 120, pl. 3, figs 81-82.

1982 *Retitricolpites dipteroarpoides* Rao and Ramanujam, *Palaeobotanist* 30: 69-70, pl. 1, fig. 3.

*Non*: *Tricolpites baculatus* Jain, *et al.*, 1973 (now *Albertipollenites baculatus*)

*Original Description*—Pollen grains subcircular in equatorial view, 56-66  $\mu\text{m}$ . Tricolpate, colpi long, prominent, wide in polar view. Exine up to 2  $\mu\text{m}$  thick, sexine thicker than nexine, reticulate, forming negative reticulum.

*Description* (present study)—Pollen grain rounded triangular in polar view and subprolate in equatorial view, 45-50 x 49-62  $\mu\text{m}$ . Tricolpate, longicolpate, colpi 19.5  $\mu\text{m}$  deep, often gaping at equator. Exine 2  $\mu\text{m}$ , uniformly thick,

sexine thicker than nexine, tectate, columellae 1.5  $\mu\text{m}$  long, with strongly perforate tectum, which tends to be pushed up between each two columellae. Surface appear pseudoreticulate at low focus and verrucate at top focus.

*Occurrence*—Miocene, Kerala Basin (Kar & Jain, 1981; Rao & Ramanujam, 1982).

**Genus—DISCOIDITES** Muller, 1968

*Type Species*—*Discoidites borneensis* Muller, 1968.

*Original Diagnosis*—Tricolpate disc-shaped pollen grains with short colpi and a columellate wall structure covered by a tectum, through which the tops of the columellae project slightly in a finely verrucate pattern. Columellae may be arranged in a reticuloid pattern.

**DISCOIDITES BORNEENSIS** Muller, 1968

Pl. 1.12

*Original Description*—Tricolpate, peroblate, disc-shaped; equatorial contour circular or slightly triangular; colpi fairly short, flat, reaching less than halfway to the poles; wall  $\pm$  1.5  $\mu\text{m}$  thick; endexine very thin; columellae indistinctly visible,  $\pm$  1  $\mu\text{m}$  long, < 1  $\mu\text{m}$  in diameter, slender, straight, covered by and partly projecting through a psilate to finely verrucate tectum.

*Occurrence*—Miocene, Ratnagiri (Phadtare & Kulkarni, 1984), Mio-Pliocene, Upper Assam (Mandal & Kumar, 2000).

*Remark*—Indian specimens range between 34-36  $\mu\text{m}$  in diameter.

**DISCOIDITES BENGALENSIS** Mathur & Chopra, 1987

*Original Description*—Pollen grains tricolpate, disc shaped, amb circular to oval, diameter 22-25  $\mu\text{m}$ ; colpi narrow and short, with 1-2  $\mu\text{m}$  thick margo, extending less than half the distance to the poles; tectate, columellate, columellae distinct, columellae tops projecting slightly through the tectum; exine finely scabrate, giving microreticulate surface pattern.

*Occurrence*—Subsurface Late Miocene-Early Pliocene sediments, Bengal Basin (Mathur & Chopra, 1987).

*Remarks*—*Discoidites bengalensis* differs from *D. borneensis* (specimen from Assam 34.5 x 36  $\mu\text{m}$ ) in being smaller in size and having comparatively longer colpi with margo.

**Genus—FOVEOTRICOLPITES** Pierce, 1961

*Type Species*—*Foveotricolpites sphaeroides* Pierce, 1961.

*Original Diagnosis*—Tricolpate, colpi elongate with conspicuously thickened aperture margins; subprolate, 18 x 21.5  $\mu\text{m}$ ; three polar and one equatorial planes of symmetry;

exine ca. 1.5  $\mu\text{m}$  thick, tectate; foveolate, foveolae small, closely placed.

*Remarks*—The diagnosis presented by Pierce (1961) is too short. While dealing with the Indian foveolate species we observed that colpal characters show variation, otherwise they resemble *Foveotricolpites*.

#### FOVEOTRICOLPITES ALVEOLATUS sp. nov.

Pl. 2.4, 14 (holotype)

*Holotype*—*Foveotricolpites alveolatus* Couper, 1953; in Tripathi & Singh, 1985, Geophytology 15: 164, pl. 3, fig. 46, slide no. 8784 (reillustrated here, Pl. 2.14)

*Non:* *Tricolpites alveolatus* Couper, 1953

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Therria Formation, Meghalaya, Palaeocene.

*Description* (Present study)—Pollen grains subprolate to subspheroidal, 60-71  $\mu\text{m}$ . Tricolpate, colpus 50.5  $\mu\text{m}$  long, wide. Exine 3.5-4.5  $\mu\text{m}$  thick, nexine about 1  $\mu\text{m}$ , sexine pilate, pila  $\pm$  3  $\mu\text{m}$  long, capita 2.5-3  $\mu\text{m}$  broad, pila head generally fused forming 2.5  $\mu\text{m}$  thick perforated tectum. Surface foveolate, lumina circular,  $\pm$  1  $\mu\text{m}$ , 2-3  $\mu\text{m}$  apart, interfoveolate space smooth.

*Occurrence*—Palaeocene, Therria Formation, Meghalaya (Tripathi & Singh, 1985).

*Remarks*—Elsik (1968) studied the holotype of *Tricolpites alveolatus* Couper, 1953 and found it to be colporate. He transferred the same to *Tricolporopollenites baculoferis* Pflug, 1953. The specimen recorded by Tripathi and Singh (1985) is colpate and has foveolate exine, hence we transfer it to *Foveotricolpites*.

#### FOVEOTRICOLPITES INIQUUS (Salujha *et al.*, 1974) comb. nov.

*Basionym*—

*Tricolpites iniquus* Salujha *et al.*, 1974, Palaeobotanist 21: 276, pl. 2, figs 52, 53.

*Original Description*—Golden yellow, roundly triangular to subcircular, size 19.8-34.6 x 18.2-28.6  $\mu\text{m}$ , tricolpate, colpi 5.2-9.6  $\mu\text{m}$  wide, extending to almost  $\frac{1}{2}$  the radial distance; exine over 1  $\mu\text{m}$  thick, smooth to sparsely foveolate, uneven, giving a mat-like appearance.

*Occurrence*—Middle Oligocene, Jenam Formation, Assam (Salujha, *et al.*, 1974).

#### FOVEOTRICOLPITES PERFORATUS van der Hammen & Garcia de Mutis, 1965

*Occurrence*—Subsurface Oligocene-Miocene sediments, Cauvery Basin, Tamil Nadu (Venkatachala & Rawat, 1973).

#### FOVEOTRICOLPITES PIERCEI Rao & Ramanujam, 1982

*Original Description*—Pollen grains isopolar, amb rounded, lobes distinct, polar diameter 16-33  $\mu\text{m}$ , tricolpate, brevicolpate (colpoidate), colpi margins thin, ends rounded or blunt. Exine 1.8  $\mu\text{m}$  thick, sexine thicker than nexine, tectate, tectum perforated, surface foveolate, foveolae of uniform size all over, locally coalescing, up to 3  $\mu\text{m}$  in diameter.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

#### FOVEOTRICOLPITES PROLATUS Rao & Ramanujam, 1982

*Original Description*—Pollen grains isopolar, amb triangular to rounded triangular, lobes distinct, prolate equatorially, 26-38 x 17.5-32  $\mu\text{m}$ ; tricolpate, longicolpate, colpi gaping wide at equator, margins uneven, thin, ends pointed. Exine 1.8  $\mu\text{m}$  thick, surface foveo-reticulate, foveolae small, closely placed.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

#### FOVEOTRICOLPITES SIJUENSIS (Baksi, 1962) comb. nov.

*Basionym*—

*Tricolpopites sijuensis* Baksi, 1962, Bull. geol. min. metall. Soc. India 26: 16, pl. 1, fig. 6.

*Description*—Equatorial compression; larger diameter 32  $\mu\text{m}$ , surface ornamentation granular to punctate; tricolpate, colpi wide.

*Occurrence*—Lower-Middle Eocene, Meghalaya (Baksi, 1962).

#### FOVEOTRICOLPITES SIMPLEX (Rao & Ramanujam, 1982) comb. nov.

*Basionym*—

*Retibrevitricolpites simplex* Rao & Ramanujam, 1982, Palaeobotanist 30: 71, pl. 1, fig. 9.

*Original Description*—Pollen grains isopolar, amb triangular to rounded triangular, sides convex, polar diameter 25-42  $\mu\text{m}$ ; tricolpate, brevicolpate, margins thin, ends pointed. Exine 1.8  $\mu\text{m}$  thick, sexine as thick as nexine. Surface reticulate, brochi small  $\pm$  1  $\mu\text{m}$  in diameter, finer at mesocolpia.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remark*—The photograph (pl. 1, fig. 9) shows reticula nearly circular and can be termed as foveolate.

ORIGINAL NAME	NEW COMBINATION
<i>Tricolpopites aquifoliaceaeformis</i>	<i>Albertipollenites aquifoliaceaeformis</i>
<i>Tricolpites baculatus</i>	<i>A. baculatus</i>
<i>T. crassireticulatus</i>	<i>A. crassireticulatus</i>
<i>T. gracilis</i>	<i>A. gracilis</i>
<i>Retitricolpites medireticulatus</i>	<i>A. medireticulatus</i>
<i>Tricolpopites proboscideus</i>	<i>A. proboscideus</i>
<i>Retitricolpites robustus</i>	<i>A. robustus</i>
<i>Tricolpites retibaculatus</i>	<i>A. retibaculatus</i>
<i>T. alveolatus</i>	<i>Foveotricolpites alveolatus</i>
<i>T. iniquus</i>	<i>F. iniquus</i>
<i>T. paucireticulatus</i>	<i>F. paucireticulatus</i>
<i>Tricolpopites sijuensis</i>	<i>F. sijuensis</i>
<i>Retibrevitricolpites simplex</i>	<i>F. simplex</i>
<i>Trifossapollenites constatus</i>	<i>Ladakhipollenites constatus</i>
<i>Tricolpopites prolatus</i>	<i>L. prolatus</i>
<i>T. shortii</i>	<i>L. shortii</i>
<i>Tricolpites horridus</i>	<i>Retitrescolpites horridus</i>
<i>Retitricolpites megareticulatus</i>	<i>R. gareticulatus</i>
<i>R. robustus</i>	<i>R. robustus</i>
<i>Tricolpites globus</i>	<i>Rousea globus</i>
<i>T. matanomadhensis</i>	<i>R. matanomadhensis</i>
<i>Retitricolpites sitholeyi</i>	<i>R. sitholeyi</i>
<i>R. delicatus</i>	<i>Tricolpites delicatus</i>

Fig. 1—List of reallocated species with original names and new combinations.

### FOVEOTRICOLPITES sp.

Pl. 2.12

*Description*—Pollen grains tricolpate, isopolar, subprolate, 3-lobed, 52–60  $\mu\text{m}$ . Exine 2–3  $\mu\text{m}$  thick, foveolate, lumina deep.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Kar & Kumar, 1986).

*Remark*—The specimen having large size, thick tectum and irregular foveolae are not comparable to any known species.

### Genus—INTRARETICULITIS Kar, 1985

*Type Species*—*Intrareticulitis brevis* (Sah & Kar, 1970) Kar, 1985.

*Original Diagnosis*—Pollen grains subcircular-subtriangular in polar view. Tricolpate, colpi distinct, long. Exine intrareticulate-intraretibaculate, structural elements restricted to base of exine.

### INTRARETICULITIS BREVIS (Sah & Kar, 1970) Kar, 1985

Pl. 5.2-4 (holotype)

*Original Description*—Pollen grains subcircular-subtriangular in polar view, 23–34 x 20–32  $\mu\text{m}$ . Tricolpate, colpi distinct, long. Exine 1–3  $\mu\text{m}$  thick, sexine much thicker than nexine, intrareticulate-intraretibaculate, ornamentation confined only to basal part of exine.

*Description* (present study)—Pollen grains subtriangular, 23 x 25.5–34 x 38  $\mu\text{m}$  in polar view, amb lobate, one lobe angular, mesocolpia convex. Tricolpate, colpi long, 11  $\mu\text{m}$ , pointed, rarely gaping at equator, inconspicuous thickening about 2  $\mu\text{m}$  around colpi especially at polar end. Exine 2  $\mu\text{m}$  at mesocolpia which gradually thickens to 2.5  $\mu\text{m}$  at colpus margins; sexine thicker than nexine, mesocolpial sexine 1.5  $\mu\text{m}$ , both sexine and nexine little thicker near colpi; columellate, columellae distinct, slender, closely placed, 0.5  $\mu\text{m}$  long, longer near colpi; tectate, tectum smooth, 1  $\mu\text{m}$  thick uniformly. Surface granular on top focus and faintly microreticulate in polar area with discontinuous striations in equatorial areas on low focus; lumina nearly circular, about 0.5  $\mu\text{m}$ , muri low.

*Occurrence*—Early Eocene, Naredi Formation, Kutch (Sah & Kar, 1970; Venkatachala & Kar, 1969; Kar, 1985).

*Remarks*—Venkatachala *et al.* (1989) treated *Intrareticulitis brevis* as *Tricolpites reticulatus*. But the study of holotype shows that *I. brevis* is distinct possessing thicker sexine than nexine, thick tectum and weak reticulation in polar area and discontinuous striations in equatorial areas. Few specimens illustrated by Kar (1985, pl. 14, figs 1, 2) as *I. brevis* are *Tricolpites reticulatus* having weak reticulation all over the surface.

**Genus**—LADAKHIPOLLENITES Mathur & Jain, 1980

*Type Species*—*Ladakhipollenites levis* (Sah & Dutta, 1966) Mathur & Jain, 1980.

*Original Diagnosis*—Pollen grains oblate to subspherical, generally preserved as polar compressions, oval, circular to subcircular; tricolpate, colpi long and not brevicolpate, fairly broad, ends generally pointed; exine laevigate to faintly and obscurely sculptured under high magnification (x 1000).

*Remarks*—Mathur and Jain (1980) instituted *Ladakhipollenites* for psilate, tricolpate pollen and selected *Tricolpites levis* Sah & Dutta (1966) as its type species. The holotype of *T. levis* Sah & Dutta (1966) is not traceable. Here, we select the specimen recorded by Sah & Kar (1974) as neotype.

Mathur & Jain (1980) transferred the following species to *Ladakhipollenites*:

- Tricolpites brevis* Sah & Kar 1970;
- T. levis* Sah & Dutta 1966;
- T. longicarpus* Sah & Dutta 1966;
- T. minutus* Sah & Kar 1970;
- T. pachyexinus* Couper 1953;

Kar (1985) instituted *Intrareticulitis* by selecting *Tricolpites brevis* Sah & Kar (1970) as holotype. The specimens referred to this species are, therefore, placed accordingly.

**LADAKHIPOLLENITES CONSTATUS** (Dutta & Sah, 1970) comb. nov.

*Basionym*—

*Trifossapollenites constatus* Dutta & Sah, 1970, *Palaeontographica*, 131: 27, pl. 6, figs 21-23.

*Original Description*—Size 32  $\mu\text{m}$  (this value was obtained from a count of 36 pollen grains), amb ovoid, oval-elongate or sub-spheroidal; tricolpate, colpi long, tenuimarginate; sexine thicker than nexine, surface ornamentation psilate to faintly scabrate.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Dutta & Sah, 1970); Early Miocene, Bhuban Formation, Meghalaya and Assam (Rao *et al.*, 1985).

*Remarks*—The description of this taxon (Dutta & Sah 1970, pl. 6, figs 21-23) does not conform with the diagnosis of *Trifossapollenites* as the lateral two colpi are not shorter than the middle one.

**LADAKHIPOLLENITES ELONGATUS** Tripathi & Singh, 1985

Pl. 2.1-2 (holotype)

*Original Description*—Pollen grains prolate to perprolate in equatorial view; tricolpate, colpus narrow, long; exine 1-1.5  $\mu\text{m}$  thick, tectate, indistinctly sculptured, exine thickened at the two poles.

*Occurrence*—Palaeocene, Therria Formation, Meghalaya (Tripathi & Singh, 1985).

**LADAKHIPOLLENITES LEVIS** (Sah & Dutta, 1966) Mathur & Jain, 1980

Pl. 2.5-6 (neotype)

*Holotype*—Sah and Dutta, 1966, pl. 2, fig. 9, slide no. 3/3.

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow; not traceable, and presumed lost.

*Neotype*—Sah and Kar, 1974, *Palaeobotanist* 21: 169, pl. 2, fig. 41, slide no. 4364/4, (here designated).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality, Horizon and Age*—Mawkma, Khasi Hills, Meghalaya, Cherra Formation; Palaeocene.

*Original Description*—Size 24-30  $\mu\text{m}$ , amb spherical to subspherical; tricolpate, longicarpate, furrows thin, exine also thin, less than 1  $\mu\text{m}$ , smooth, in some specimens a faint sculpture is discernible under oil immersion.

*Description* (present study)—Pollen grain spherical in polar view, 30 x 32  $\mu\text{m}$ . Tricolpate, longicarpate, colpi 7.5  $\mu\text{m}$  deep, pointed at poles. Exine 2  $\mu\text{m}$  thick and slightly thicker near colpi margins, sexine-nexine not separable, columellae indistinct. Surface smooth and intrastriated under high magnification.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Sah & Dutta, 1966); Early Eocene, Naredi Formation, Kutch (Sah & Kar, 1970); Early Eocene, Palana lignite, Rajasthan (Sah & Kar, 1974); Palaeocene-Eocene, Akli lignite, Rajasthan (Naskar & Baksi, 1978); Palaeocene, Dras volcanics, Ladakh (Mathur & Jain, 1980); Late Cretaceous-Palaeocene, Subsurface Bengal Basin, W. Bengal (Baksi & Deb, 1980); Palaeocene, Mikir Formation, Meghalaya (Mehrotra, 1983), Subsurface Early Miocene sediments, Meghalaya (Nandi & Sharma, 1984), Oligocene, Barail Group, Meghalaya and Assam (Singh *et al.*, 1985, 1986).

*Remarks*—*Ladakhipollenites levis* compares with *Tricolpites reticulatus* in shape, size and in the presence of

exinal thickenings near colpi. However, nearly smooth surface in *L. levis* separates the two taxa.

#### LADAKHIPOLLENITES LONGICOLPUS

(Sah & Dutta, 1966) Mathur & Jain, 1980

*Original Description*—Size range 23-28  $\mu\text{m}$ ; grains spherical to lobate in polar view; tricolp (or) ate, tenuimarginate, colpi long, extending to more than  $\frac{3}{4}$  the radial distance; exine up to 3.5  $\mu\text{m}$  thick, surface  $\pm$  smooth to finely matted.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Sah & Dutta, 1966); Palaeocene, Dras volcanics, Ladakh (Mathur & Jain, 1980).

#### LADAKHIPOLLENITES MINUTUS (Sah & Kar, 1970)

Mathur & Jain, 1980

Pl. 2.8-9 (holotype)

*Original Description*—Pollen grains subcircular-subtriangular, 18-25 x 17-24  $\mu\text{m}$ , tricolpate, brevicolpate. Exine thin, laevigate-finely scrobiculate.

*Description* (present study)—Pollen grain nearly circular in polar view, slightly bulging at mesocolpia, 24 x 24  $\mu\text{m}$ . Tricolpate, colpi pointed, minutely gaping at equator, 6.5  $\mu\text{m}$  in diameter. Exine 2  $\mu\text{m}$ , slightly thickens at colpi margins, sexine-nexine uniformly thick, nexine thicker near colpi, tectate, columellae not distinct. Surface uniformly scabrate at high magnification.

*Occurrence*—Early Eocene, Naredi Formation, Kutch (Sah & Kar, 1970); Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979); Oligocene, Barail Group, Assam & Meghalaya (Singh *et al.*, 1985, 1986).

*Remarks*—*Ladakhipollenites minutus* resembles *Tricolpites reticulatus* in shape, size and exinal characters i.e., sexine thicker near colpus but surface reticulation is not distinct as *Tricolpites reticulatus*.

#### LADAKHIPOLLENITES PACHYEXINUS (Couper,

1953) Mathur & Jain, 1980

Pl. 1.5-6, 9

*Original Description*—Free, isopolar, tricolpate, occasionally tetracolpate, colpi long, broad. No trace of ora. Grains spheroidal to prolate-spheroidal. Exine very thick, 2.5-3  $\mu\text{m}$ , psilate.

*Description* (present study)—Pollen subcircular in polar view, 44 x 58  $\mu\text{m}$ ; prolate in equatorial view, 38 x 48  $\mu\text{m}$ . Tricolpate, colpi 44  $\mu\text{m}$  long, end rounded, margin moderately thick. Exine 2  $\mu\text{m}$  thick, sexine as thick as nexine, columellae indistinct. Surface psilate.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Dutta & Sah, 1970); Early Eocene, Palana lignite, Rajasthan (Sah & Kar, 1974).

#### LADAKHIPOLLENITES PROLATUS (Baksi, 1962) comb.

nov.

*Basionym*—

*Tricolpopites prolatus* (nom. corr. pro *T. prolatus*) Baksi, 1962, Bull. geol. min. metall. Soc. India 26: 19, pl. 4, fig. 44.

*Description*—Equatorial compression; longer diameter 19  $\mu\text{m}$ , surface more or less smooth; tricolpate, colpi thick and straight, extend from pole to pole, no pores visible.

*Occurrence*—Oligocene, Barail Group, Meghalaya (Baksi, 1962).

#### LADAKHIPOLLENITES SHORTII (Baksi, 1962)

comb. nov.

*Basionym*—

*Tricolpopites shortii* Baksi, 1962, Bull. geol. min. metall. Soc. India 26: 19, pl. 4, fig. 45.

*Description*—Equatorial compression; longer diameter 18  $\mu\text{m}$ ; surface rough; tricolpate; colpi comparatively thin; do not extend from pole to pole.

*Occurrence*—Miocene, Surma Group, Meghalaya (Baksi, 1962).

*Remark*—Photograph (pl. 4, fig. 45) shows psilate exine.

#### Genus—PERFOTRICOLPITES Garcíá Guzmán, 1967

*Type Species*—*Perfotricolpites digitatus* Garcíá Guzmán, 1967.

*Original Diagnosis*—Tricolpate pollen grains with perforate tectum, digitate columellae and psilate-scabrate sculpture.

#### PERFOTRICOLPITES NEYVELII (Navale & Misra,

1979) Mandal & Kumar, 2000

Pl. 4.1-2 (holotype)

*Original Description*—Isopolar pollen, oblate to spheroidal, 60-95 x 60-70  $\mu\text{m}$  in size. Tricolpate, colpi longicolpate, deep but do not reach the poles, mesocolpi are rounded at the periphery. Exine 5-7  $\mu\text{m}$  thick, sexine thicker (2-3 times) than nexine, gradually thinning towards the colpi margins. Distinct rod layer is present in the sexine, rods are long, papillate to clavate forming a granulate to finely microreticulate surface structure.

*Description* (Mandal & Kumar, 2000)—Pollen grains spheroidal, 52.5-58 x 57-59  $\mu\text{m}$ . Tricolpate, colpi 50  $\mu\text{m}$  long, extended near to the poles. Exine 4.5  $\mu\text{m}$  thick, sexine 3.5  $\mu\text{m}$ , nexine thin, 0.5  $\mu\text{m}$ ; columellae 2.5  $\mu\text{m}$  long, 1.2  $\mu\text{m}$



broad, occasionally digitate. Tectum thin, perforate; surface appears perforate-microreticulate.

*Occurrence*—Miocene, Surma Group (Baksi, 1962); Boldamgiri Formation (Saxena & Rao, 1996), Miocene, Warkalli Formation, Kerala (Rao & Nair, 1998); Oligocene, Kutch Basin (Kar, 1985); Oligocene, Barail Group (Mandal & Kumar, 2000).

*Remark*—Oligocene forms are comparatively smaller in size and may represent different species.

**Genus—PILATRISYNCOLPITES** Kar *et al.*, 1994;  
emended here

*Type Species*—*Pilatriscyncolpites triangulatus* Kar *et al.*, 1994.

*Original Diagnosis*—Pollen triangular in polar view; trisyncolpate, colpi long, distinct. Exine up to 2 µm thick, sculpture pilate, interpilar exine ornamentation pseudomicroreticulate.

*Emended Diagnosis*—Pollen triangular-subtriangular in polar view; trichotomosulcate, colpi long and join at pole. Exine moderately thick, sculpture pilate, interpilar exine ornamentation pseudomicroreticulate.

**PILATRISYNCOLPITES TRIANGULATUS** Kar *et al.*,  
1994; emended here

Pl. 1.1 (holotype)

*Emended Description*—Pollen grains triangular in polar view, size range 36-52 x 34-50 µm, apices rounded, interapical margin convex. Trichotomosulcate, colpi distinct, broader at equator and tapering at pole. Exine pilate, pila 4-8 µm long, 2-5 µm broad, narrow at base and swollen at tip, sparsely placed, interpilar exine granulose, very closely placed forming pseudoreticulate ornamentation in surface view.

*Occurrence*—Oligocene, Barail Group, Assam (Kar *et al.*, 1994); Early Eocene, Naredi Formation, Kutch (Mandal, 2000).

**Genus—POLYGONACEAEPITES** Baksi, 1962

*Type Species*—*Polygonaceaepites zonoides* Baksi, 1962.

*Original Combined Description*—Equatorial compression; longitudinal diameter 34 µm; body zoned, outward portion appears like a flange which becomes appreciably wider near the poles, a few discrete radiating striae mark the flange, otherwise more granular-reticulate than the main body; tricolpate, colpi extend from pole to pole (out limit the inner margin), adjacent.

**POLYGONACEAEPITES ZONOIDES** Baksi, 1962

*Occurrence*—Miocene, Surma Group, Meghalaya (Baksi, 1962).

**Genus—RETITRESCOLPITES** Sah, 1967

*Type Species*—*Retitrescolpites typicus* Sah, 1967.

*Original Diagnosis*—Grains tricolpate or colporoidate, spheroidal to sub-spheroidal to rounded triangular. Exine retipila (ria) to sometimes reticulate.

*Remarks*—Generic diagnosis proposed by Sah (1967) is very broad and overlaps circumscription of *Tricolpites*, *Albertipollenites* and *Rousea*. We have assigned tricolpate/colporoidate pollen having strongly retipilate to retibaculate ornamentation under this genus.

**RETITRESCOLPITES BELLUS** Sah, 1967

*Original Description*—Known size range 34-43 µm; amb spheroidal to sub-spheroidal; tricolpate, brevicolpate, tenuimarginate. Exine rather thin, sexine slightly thicker than nexine, retipilate.

*Occurrence*—Palaeocene, Dras Volcanics, Ladakh (Mathur & Jain, 1980).

**RETITRESCOLPITES HORRIDUS** (Salujha *et al.*,  
1974) comb. nov.

*Basionym*—

*Tricolpites horridus* Salujha *et al.*, 1974, *Palaeobotanist* 21: 276, pl. 2, figs 54, 55.

*Original Description*—Brown, roundly triangular with three prominent slits, size 25.6-36.6 µm; tricolpate, colpi 3-6.5 µm deep; exine 2-2.5 µm thick, pilate, pila 2.5-3 µm long with globular heads, closely spaced; occasionally coalescing to give a reticulate appearance.

*Occurrence*—Oligocene sediments, Assam (Salujha *et al.*, 1974).

**RETITRESCOLPITES MEGARETICULATUS**  
(Mathur, 1966) comb. nov.

*Basionym*—

*Retitricolpites megareticulatus* Mathur, 1966, *Q. J. geol. Min. metall. Soc. India* 38: 41, pl. 1, fig. 19.

*Synonym*—

1982 *Retitrescolpites indicus* Rao and Ramanujam, *Palaeobotanist* 30: 70, pl. 1, fig. 6.

*Original Description*—Polar view. Isopolar, radiosymmetric, amb trilobed, lobes deep and broad, 42 µm in diameter, tricolpate. Colpi 17 µm broad and long, margins smooth. Exine 3 µm thick, reticulate, lumina large, ca. 3 µm, muri with a beaded appearance.

*Occurrence*—Palaeocene (Supratrapean) Kutch (Mathur, 1966), Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remarks*—Rao and Ramanujam, 1982 commented that *R. indicus* resembles *R. typicus* Sah (1967) except in the

Name of Taxa	Late Palaeocene	Early Eocene	Middle Eocene	Late Eocene	Oligocene	Miocene	Pliocene
<i>Albertipollenites aquifoliaceaeformis</i>		++++++	++++++				
<i>A. baculatus</i>	++++++						
<i>A. crassireticulatus</i>	++++++	————	————	————	————	++++++	
<i>A. gracilis</i>	++++++	++++++	++++++	++++++	++++++	++++++	
<i>A. medireticulatus</i>	++++++						
<i>A. kutchensis</i>			++++++	++++++			
<i>A. kari</i>	++++++						
<i>A. kumarii</i>	++++++						
<i>A. proboscideus</i>	++++++						
<i>A. retibaculatus</i>	++++++	————	++++++	++++++			
<i>A. robustus</i>		++++++					
<i>Bacubrevitricolpites rotundus</i>						++++++	
<i>Beaupreaidites tegillatus</i>					++++++	++++++	
<i>Clavasyncolpites gracilis</i>						++++++	
<i>Dakshinipollenites tripakshi</i>						++++++	
<i>Dipterocarpuspollenites retipilatus</i>							++++++
<i>Discoidites borneensis</i>	++++++	++++++					
<i>D. bengalensis</i>						++++++	++++++
<i>Foveotricolpites alveolatus</i>	++++++						
<i>F. iniquus</i>					++++++		
<i>F. perforatus</i>					++++++	++++++	
<i>F. piercei</i>						++++++	
<i>F. prolatus</i>						++++++	
<i>F. sijuensis</i>		++++++	++++++				
<i>F. simplex</i>						++++++	
<i>Intrareticulitis brevis</i>		++++++					
<i>Ladakhipollenites constatus</i>	++++++					++++++	
<i>L. elongatus</i>	++++++						
<i>L. levis</i>	++++++	++++++	++++++	++++++	++++++	++++++	
<i>L. longicarpus</i>	++++++						
<i>L. minutus</i>	++++++	++++++	————	————	++++++		
<i>L. pachyexinus</i>	++++++	++++++					
<i>L. prolatus</i>					++++++		
<i>L. shortii</i>						++++++	
<i>Perforitricolpites neyveli</i>					++++++	++++++	
<i>Pilatisyncolpites triangulatus</i>		++++++	————	————	++++++		
<i>Polygonaceaepites zonoides</i>						++++++	
<i>Retitrescolpites bellus</i>	++++++						

<i>R. horridus</i>					++++++	
<i>R. megareticulatus</i>	++++++	—	—	—	—	++++++
<i>R. minor</i>	++++++					
<i>R. minutus</i>						++++++
<i>R. singularis</i>						++++++
<i>R. splendens</i>						++++++
<i>R. typicus</i>		++++++	++++++	++++++		
<i>Retitrisyncolpites</i>		++++++				
<i>reimannii</i>						
<i>R. thaungii</i>		++++++				
<i>Rousea globus</i>	++++++					
<i>R. marginata</i>						++++++
<i>R. matanomadhensis</i>	++++++					
<i>R. meghalayaensis</i>	++++++					
<i>R. saxenae</i>	++++++					
<i>R. sitholeyi</i>						++++++
<i>Striatopollis bellus</i>	++++++	++++++	++++++	—	—	++++++
<i>S. indicus</i>						++++++
<i>Tricolpites delicatus</i>					++++++	
<i>T. densiornatus</i>	++++++	++++++	++++++	++++++		
<i>T. foxii</i>			++++++	—	—	++++++
<i>T. incognatus</i>						++++++
<i>T. microreticuloides</i>						++++++
<i>T. minor</i>					++++++	
<i>T. parvireticulatus</i>	++++++					
<i>T. paucireticulatus</i>		++++++				
<i>T. reticulatus</i>	++++++	++++++	++++++	—	++++++	++++++
<i>Verrutricolpites</i>	++++++					++++++
<i>perverrucatus</i>						

Fig. 2—Range chart of studied tricolpate species from India (+ Present, — Not recorded)

possession of a wide gap between the colpi. A further comparison of them reveals that they also differ in their surface sculpture.

**RETITRESCOLPITES MINOR** Dutta & Sah, 1970

*Original Description*—Size range 22 to 28 µm; amb ± spheroidal to sub-prolate in polar view; tricolpate, colpi long; exine thick, sexine thicker than nexine, pilate, non-tegillate, surface sculpture retipilariate, reticulum formed of thick, irregular muri and small lumina.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Dutta & Sah, 1970).

**RETITRESCOLPITES MINUTUS** Saxena *et al.*, 1984

*Original Description*—Pollen grains subcircular in polar view, size range 23-30 µm. Tricolporoidate, colpi small, thin; pore small in size, circular in shape. Exine ± 2.5 µm thick, stratified, sexine thicker than nexine, retipilariate, pila very

small, pin-head like, closely placed, imparting a pseudoreticulate appearance.

*Occurrence*—Mio-Pliocene, Lower Siwalik, Himachal Pradesh (Saxena *et al.*, 1984)

*Remark*—The study of the holotype reveals that it has a reticulate exine that is thicker in the intercolpium region.

**RETITRESCOLPITES SINGULARIS** Rao & Ramanujam, 1982

*Original Description*—Pollen grains isopolar, amb subspheroidal to rounded triangular, lobes prominent, polar diameter 20-28 µm, zonaperturate, tricolpate, longicolpate, colpi reaching poles but not uniting, colpal surface finely granular. Exine up to 4 µm thick, sexine much thicker than nexine, surface irregularly retipilate, heterobrochate, brochi hexa- to polygonal, 3-5 µm in diameter, curvimuroid, lumina irregular with free baculoid processes.

*Occurrence*—Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remarks*—From the illustrations and description it appear that *R. singularis* Rao & Ramanujam (1982) is similar to *R. splendens* Sah (1967) in exomorphic characters but the latter is bigger in size (57-78 µm).

#### RETITRESCOLPITES SPLENDENS Sah, 1967

*Original Description*—Size range 57-78 µm; amb ± spheroidal to sub-prolate; tricolpate, colpi fairly long; sexine thicker than nexine, retipilate, oligobrochate, muri of reticulum formed of free pila.

*Occurrence*—Subsurface Early Miocene sediments, Meghalaya (Nandi & Sharma, 1984); Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

#### RETITRESCOLPITES TYPICUS Sah, 1967

*Original Description*—Size range 50-65 µm; amb spheroidal to sub-spheroidal in equatorial and sub-oblate in lateral view; tricolpate (or tricolporoidate) fossaperturate; exine well stratified, retipilate, pila prominent, surface sculpturing reticulate, polybrochate.

*Occurrence*—Subsurface Eocene sediments, Kerala (Raha *et al.*, 1987).

**Genus**—RETITRISYNCOLPITES Mandal *et al.*, 1994; emended here

*Type Species*—*Retitrisyncolpites reimannii* Mandal *et al.*, 1994.

*Original Diagnosis*—Pollen grains trisyncolpate, sometimes colporoidate, triangular-subtriangular in shape. Colpi distinct, long, occasionally funnel shaped or bifurcated at tips. Exine thick, sexine thicker than nexine; tectate, tectum perforated; infratectum columellar, columellae either of same size or coarser at polar and inter-apertural areas. Surface reticulate.

*Emended Diagnosis*—Pollen trichotomosulcate, rarely colporoidate, colpi join together at pole; other characters are as above.

**RETITRISYNCOLPITES REIMANNII** Mandal *et al.*, 1994; emended here

Pl. 3.1-2 (holotype)

*Emended Description*—Triangular-subtriangular pollen, size range 41-47 µm. Trichotomosulcate, sometimes open, funnel shaped, rarely seems to be colporoidate. Exine tectate, perforate, size of perforation variable, infratectum columellar, columellae stronger at polar and interapertural region. Columellae 1-2 µm long and 1-1.5 µm broad, 0.5-0.8 µm long at corners. Exine 1-2.5 µm thick, sexine thicker than nexine, nexine very thin, 0.5 µm, always not distinct. Surface reticulate, meshes coarse and irregular, muri ± 1 µm high.

*Occurrence*—Early Eocene, Middle Andaman (Mandal *et al.*, 1994).

**RETITRISYNCOLPITES THAUNGII** Mandal *et al.*, 1994; emended here

Pl. 3.3 (holotype)

*Emended Description*—Trichotomosulcate pollen grains with size range of 31.5-45.5 µm, triangular in shape. Colpi meet at poles, sometimes open at apertural end. Exine 0.7-1 µm thick, tectate, perforate, perforation more or less same size, ± 0.7 µm high. Sexine and nexine not separable. Surface reticulate, lumina circular, ± 0.5 µm, more or less equal in size.

*Occurrence*—Early Eocene, Middle Andaman (Mandal *et al.*, 1994).

**Genus**—ROUSEA Srivastava, 1969a

*Type Species*—*Rousea subtilis* Srivastava, 1969a.

*Original Diagnosis*—Tricolpate, angulaperturate, colpi long, reaching polar area; amb subtriangular or rounded, sides convex; sexine thick, reticulate, lumina larger in mesocolpia becoming smaller at colpus margins and apocolpia.

**ROUSEA GLOBUS** (Dutta & Sah, 1970) comb. nov.

*Basionym*—*Tricolpites globus* Dutta and Sah, 1970, *Palaeontographica* 131: 33, pl. 7, fig. 28.

*Original Description*—Known size range 16-20 µm, holotype 18 µm, amb lobate, triangular in polar view, oblate-spheroidal to spheroidal in equatorial; trizonaperturate, colpate, colpi tenuimarginate, fairly long, extending to more than ¾ the distance to the poles; exine thin, sexine pilate-tegillate, surface sculpture coarsely reticulate, meshes forming the reticulum decrease in size towards the aperture.

*Occurrence*—Palaeocene, Cherra Formation, Meghalaya (Dutta & Sah, 1970).

**ROUSEA MATANOMADHENSIS** (Saxena, 1979) comb. nov.

Pl. 1.10-11; Pl. 3.7-9 (holotype)

*Basionym*—

*Tricolpites matanomadhiensis* Saxena, 1979, *Palaeobotanist* 26: 134, pl. 2, fig. 29.

*Original Description*—Pollen grains ± subcircular in polar view, 72-90 µm. Tricolpate, colpi well-developed, long. Exine 2-4 µm thick, retibaculate to retipilate, duplibaculate/pilate, tegillate, bacula closely placed, almost joined with each other, forming a perfect reticulum, meshes bigger in mesocolpate region.

*Description* (present study)—Pollen grain subspherical in polar view, 93 x 95 µm. Tricolpate, colpi long, 40 µm

deep, widely gaping at equator. Exine 4.5  $\mu\text{m}$ , sexine as thick as nexine, thins out towards colpi, tectate, pilate, columellae 2.5  $\mu\text{m}$  long, 1  $\mu\text{m}$  broad, 1-3  $\mu\text{m}$  apart, closer near colpi, capita up to 2.5  $\mu\text{m}$  in diameter. Surface retipilate, reticulum bigger at mesocolpia (4.5  $\mu\text{m}$ ), narrower towards colpi and apocolpia (1  $\mu\text{m}$ ), lumina irregular shape, muri simplicolumellate, 2  $\mu\text{m}$  broad.

*Occurrence*—Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979).

### ROUSEA MEGHALAYAENSIS sp. nov.

Pl. 5.1 (holotype)

*Holotype*—*Tricolpites crassireticulatus* Dutta & Sah, 1970; in Kar & Kumar, 1986, Pollen Spores 28, pl. 8, fig. 9, slide no. 9398 (reillustrated here: Pl. 5.1).

*Non*: *Tricolpites crassireticulatus* Dutta & Sah, 1970, Palaeontographica 131 (now *Albertipollenites crassireticulatus*).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Upper Cherrapunji, Meghalaya, Late Palaeocene.

*Description* (Present study)—Pollen grain spheroidal, 56.5 x 60  $\mu\text{m}$  in polar, 60 x 63  $\mu\text{m}$  in equatorial view, mesocolpia convex. Tricolpate, colpi long, 50-52  $\mu\text{m}$ , narrow and gaping at equator, margin uniformly 2  $\mu\text{m}$  thick and smooth. Exine 5-6  $\mu\text{m}$  thick, tectum at mesocolpia 2-2.5  $\mu\text{m}$ ; columellae robust, 2-2.5  $\mu\text{m}$  long, 1  $\mu\text{m}$  broad, 1-1.5  $\mu\text{m}$  apart, capita 1.5-2.5  $\mu\text{m}$  broad. Surface crassireticulate, reticulum larger at equator and gradually narrow towards pole; muri simplicolumellate, 1.5-2.5  $\mu\text{m}$  wide, narrower near pole; lumina oval to elongated, 1-2  $\mu\text{m}$  long, 1  $\mu\text{m}$  wide at mesocolpia, wall smooth, nearly circular (less than 1  $\mu\text{m}$ ) at poles.

*Comparison*—*Rousea meghalayaensis* differs from other species of *Rousea* having thick muri, smooth lumina wall, small circular reticula at poles and thick colpi wall.

*Occurrence*—Late Palaeocene, Lakadong Sandstone Member, Meghalaya (Kar & Kumar, 1986).

### ROUSEA SAXENAE sp. nov.

Pl. 5.12-14 (holotype)

*Holotype*—*Tricolpites crassireticulatus* Dutta & Sah, 1970; in Saxena, 1979, Palaeobotanist 26: 133, pl. 2, fig. 23, slide no. 4960 (reillustrated here, Pl. 5.12-14).

*Non*: *Tricolpites crassireticulatus* Dutta & Sah, 1970, Palaeontographica 131 (now *Albertipollenites crassireticulatus*).

*Repository*—Birbal Sahni Institute of Palaeobotany, Lucknow, India.

*Type Locality and Age*—Near village Matanomadh, Kutch Basin, Gujarat, Late Palaeocene.

*Description* (Present study)—Pollen grains spheroidal, 68 x 70  $\mu\text{m}$  in polar view, mesocolpia convex. Tricolpate, colpi long, 24  $\mu\text{m}$ , gaping at equator, margin minutely wrinkled. Exine 4.5  $\mu\text{m}$ ; sexine 3  $\mu\text{m}$ , nexine uniformly 1.5  $\mu\text{m}$ ; semitectate, tectum 1.5  $\mu\text{m}$  at equator, less thick at colpus margins; columellae, baculate to club-shaped, 1.5  $\mu\text{m}$  long, 1  $\mu\text{m}$  broad and about 1  $\mu\text{m}$  apart, capita 1.5-2.5  $\mu\text{m}$  wide. Surface reticulate, reticulum larger at equator and colpi margins, smaller at poles, larger reticula often broken; muri wavy, 1-1.5  $\mu\text{m}$  thick, often broken at mesocolpia, simplicolumellate; lumina irregular, narrow and elongated at poles, larger lumina 5  $\mu\text{m}$  long.

*Comparison*—The taxon distinguishes from other species of *Rousea* possessing large reticula at equator and colpi margins, wavy muri and club-shaped columellae supporting thick tectum.

*Occurrence*—Late Palaeocene, Matanomadh Formation, Kutch Basin (Saxena, 1979).

### ROUSEA SITHOLEYI (Ramanujam, 1966) comb. nov.

*Basionym*—

*Retitricolpites sitholeyi* Ramanujam, 1966, Pollen Spores 8: 163, pl. 2, fig. 30.

*Original Description*—Pollen grains isopolar, subprolate, trizonicolpate, equatorial diameter 26-30  $\mu\text{m}$ . Amb rounded, 3-lobed, lobes not bulging. Colpi broadly gaping at equator, ends sharply pointed, longicolpate. Exine 2.2  $\mu\text{m}$  thick, sexine thicker than nexine, columellae faint, surface reticulate, meshes polygonal, larger at poles, smaller at mesocolpia, muri simplibaculate, look finely beaded under high magnification.

*Occurrence*—Miocene, Neyveli lignite, Tamil Nadu (Ramanujam, 1966).

### Genus—STRIATOPOLLIS Krutzsch, 1959

*Type Species*—*Striatopollis sarstedtensis* Krutzsch, 1959.

*Original Diagnosis*—(English translation from Jansonius & Hills, 1976, card no. 2775)—With three colpi; side view oval-rhombic, amb subcircular but with rather deep and up to 5  $\mu\text{m}$  wide gaping colpi; figura fusiform; wall outside the colpi relatively thick (ca. 2  $\mu\text{m}$  or more); wall two layered, outer layer with a coarse rib sculpture, the ribs being separated by narrow, deep incisions; the ribs are not smooth, but have an extrapunctate sculpture (which is not a "corrosion sculpture", but a primary feature); the ribs are vertical (meridians), about 5-8 per sector, crossing the equator; their number reduces toward the poles in such a manner, that those of two sections are continuous, those of third section butting and joining them, or ending before reaching the polar area. The colpus area is

free of sculpture, and has a very thin inner wall layer; probably each germinal has a narrow opening or slit of 6-8  $\mu\text{m}$  length; differentiation of the inner layer in the equatorial plane could not be observed. Polar axis, so far measured, 18-20  $\mu\text{m}$ .

#### **STRIATOPOLLIS INDICUS** Mathur and Chopra, 1987

*Original Description*—Pollen grains tricolpate, amb spheroidal, diameter 15-18  $\mu\text{m}$ ; colpi streak-like, long; exine ca. 1  $\mu\text{m}$  thick, striate, ridges and furrows of almost equal breadth, ridges broken near the poles.

*Occurrence*—Subsurface Late Miocene sediments, Bengal Basin (Mathur & Chopra, 1987).

*Remarks*—Comparing their characters and illustrations' *Striatopollis indicus* Mathur and Chopra (1987) and *S. catatumbus* (García Guzmán) Mathur and Chopra (1987) appear closely comparable, but *S. indicus* is much smaller in size.

#### **Genus—TRICOLPITES** Cookson, 1947 ex Couper, 1953

*Type Species*—*Tricolpites reticulatus* Cookson 1947 ex Couper, 1953.

*Original Diagnosis*—Free, isopolar, tricolpate. Exine variable in thickness and sculpture. Size variable.

*Emended Diagnosis*—(After Potonié, 1960)- Shape spherical to ovoid, tricolpate, mesocolpium bulging, colpi broad, exine on either side stronger, causing the equator to be trilobate, exine finely reticulate.

After Belsky, *et al.*, 1965- (English translation from Jansonius & Hills, 1976). The diagnosis as given in Potonié 1960 should be changed so that also strongly reticulate forms may be included, as well as forms in which the exine is not thickened at either side of colpi, overall shape oblate to subspheroidal.

After Jarzen and Dettmann 1989- Pollen grains free, tricolpate, isopolar, oblate to subprolate; amb circular to trilobate with convex mesocolpia. Colpi meridionally aligned, parallel sided, but often gaping, margin entire; membrane absent or reduced, without free standing bacula. Exine stratified, sexine baculate, semitectate with reticulate surface. Reticulum regular, composed of smooth-crested muri and elongate to equidimensional lumen that are of uniform size and less than 1  $\mu\text{m}$  in diameter over entire surface of grain.

*Remarks*—*Tricolpites* was diagnosed by Couper (1953) to accommodate tricolpate pollen with variable ornamentation. Potonié (1960) emended its diagnosis to accommodate only finely reticulate forms. Srivastava (1966, p. 547) discussed at length the nomenclatural and taxonomical status of *Tricolpites* and *Retitricolpites*. Srivastava (1969a, p. 55) accepted the emendation of Potonié 1960, and proposed to include pollen having meshes larger than 1  $\mu\text{m}$  under *Albertipollenites* and *Rousea*.

#### **TRICOLPITES DELICATUS** (Kar, 1979) comb. nov.

Pl. 2.3.7 (holotype)

Basionym—

*Retitricolpites delicatus* Kar, 1979, Palaeobotanist 26: 28, pl. 2, figs 31, 32.

*Original Description*—Pollen grains mostly found in equatorial view, 18-36 x 14-30  $\mu\text{m}$ . Tricolpate, colpi narrow, extending almost from one margin to another. Exine microreticulate.

*Description* (present study)—Pollen grain prolate, 27 x 36  $\mu\text{m}$  in equatorial view. Tricolpate, colpi long, 24  $\mu\text{m}$ . Exine 2  $\mu\text{m}$  thick, sexine-nexine not separable, semitectate, columellae distinct, 1.5  $\mu\text{m}$  long, slender, closely placed. Surface microreticulate, lumina irregular in shape, less than 1  $\mu\text{m}$  in size, muri thin and low.

*Occurrence*—Oligocene, Kutch Basin (Kar, 1979).

#### **TRICOLPITES DENSIORNATUS** Venkatachala & Rawat, 1972

*Original Description*—Pollen grain roundly triangular, 35.4-39.6 x 35-41.7  $\mu\text{m}$ ; tricolpate. Colpi long, wedge-shaped, 15  $\mu\text{m}$  deep in polar view, not reaching the poles. Exine about 3.3  $\mu\text{m}$  thick, slightly thickening towards apertural region, sexine thicker than nexine, closely pilate forming a pseudoreticulum.

*Occurrence*—Subsurface Palaeocene-Eocene sediments, Cauvery Basin (Venkatachala & Rawat, 1972).

#### **TRICOLPITES FOXII** (Biswas, 1962) Ramanujam, 1966

*Original Description*—Longer diameter 42  $\mu\text{m}$ , exine moderately thick, reticulate, furrows deep, extending to the subpolar region.

*Emended Description* (Ramanujam, 1966)—Pollen isopolar, spheroidal, 34 x 25  $\mu\text{m}$ ; 3-zonicolpate. Amb prominently 3-lobed, lobes widely spaced. Colpi deep, long, ends pointed. Exine 1.8  $\mu\text{m}$  thick, surface minutely reticulate.

*Occurrence*—Lower-Middle Eocene. Um Sohryngkew River section, Meghalaya (Biswas, 1962); Miocene. Neyveli lignite, Tamil Nadu (Ramanujam, 1966).

#### **TRICOLPITES INCOGNATUS** Kar & Jain, 1981

Pl. 2.15-16 (holotype)

*Original Description*—Pollen grains subtriangular-subcircular in equatorial view, 18-22  $\mu\text{m}$ . Tricolpate, colpi long, funnel-shaped in equatorial view. Sexine as thick as nexine, scrobiculate.

*Description* (present study)—Pollen subtriangular in polar view, 22 x 24  $\mu\text{m}$ . Tricolpate, colpi 7.5  $\mu\text{m}$  deep, gaping at equator, colpi margin irregular, triangular shaped apocolpial area slightly thickened (not parasyncolpate). Exine 1.5  $\mu\text{m}$ , sexine thicker than nexine, uniformly thick, tectate, columellae

0.5  $\mu\text{m}$  long, slender, uniformly spaced. Surface uneven, uniformly microreticulate, lumina circular, nearly 0.5  $\mu\text{m}$ , muri low.

*Occurrence*—Miocene, Warkalli Formation, Kerala (Kar & Jain, 1981).

**TRICOLPITES MICRORETICULOIDES** Ramanujam, 1966

*Original Description*—Pollen grains isopolar, prolate spheroidal, 26 x 24  $\mu\text{m}$ . Trizonicolpate. Poles rounded. Colpi long, almost reaching poles, of uniform breadth for greater part. Exine 2.5  $\mu\text{m}$  thick, columellae indistinct, surface microreticulate.

*Occurrence*—Miocene, Neyveli lignite, Tamil Nadu (Ramanujam, 1966).

*Remarks*—From the photograph (pl. 2, fig. 26) the nature of reticulation is not discernible.

**TRICOLPITES MINOR** Sah, 1967

*Original Description*—Size 23-29  $\mu\text{m}$ ; amb spheroidal; tricolpate, colpi tenuimarginate; sexine pilate, surface sculpturing finely microreticulate.

*Occurrence*—Oligocene, Barail, Meghalaya (Singh *et al.*, 1985).

**TRICOLPITES PARVIRETICULATUS** Sah, 1967

*Original Description*—Size range 36-42  $\mu\text{m}$ ; amb prolate-spheroidal to sub-prolate; tricolpate, colpi deep; exine sculpture finely reticulate.

*Occurrence*—Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979; Kar, 1985).

**TRICOLPITES PAUCIRETICULATUS** Sah & Kar, 1974

Pl. 2.10-11 (holotype)

*Original Description*—Pollen grains subcircular-circular, 38-46  $\mu\text{m}$ ; tricolpate, colpi broad, colpi margin laevigate. Exine reticulate only in middle part of mesocolpate region.

*Description* (present study)—Pollen grain circular-subcircular in polar view, 50 x 54  $\mu\text{m}$ . Tricolpate, colpi 16.5  $\mu\text{m}$  deep, end pointed, wide at equator. Exine 2.5  $\mu\text{m}$  thick at mesocolpia and gradually thins out towards colpi margin (0.5  $\mu\text{m}$ ), nexine as thick as sexine, semitectate, columellae distinct at mesocolpia, 1  $\mu\text{m}$  in length and width, indistinct near colpi margins. Surface reticulate, lumina nearly circular, larger (1  $\mu\text{m}$ ) at mesocolpia and apocolpia, almost absent at colpi margins, muri simplicolumellate, thin, narrow, smooth.

*Occurrence*—Early Eocene, Palana lignite, Rajasthan (Sah & Kar, 1974).

**TRICOLPITES RETICULATUS** Cookson ex Couper, 1953

Pl. 5.5-7, 10-11

*Synonyms*—

1966 *Retitricolpites microreticulatus* Mathur, Q. J. geol. Min. metall. Soc. India 38: 41, pl. 1, fig. 17 (non van der Hammen & Wijmstra, 1964).

1972 *Tricolpites longicolpatus* Venkatachala and Rawat, Proc. Sem. Palaeopalynol. Indian Strat. Calcutta, pp 301, pl. 2, figs 16-19.

1974 *Retitricolpites prooblatus* in Bakshi and Deb (*non* Muller, 1968), Geophytology 10: 205, pl. 1, fig. 8.

1985 *Intrareticulitis brevis* (Sah & Kar) Kar; *in part*, Palaeobotanist 34: 40, pl. 14, figs 1-2.

*Original Description* (Couper, 1953)—Free, isopolar, tricolpate. Exine variable in thickness and sculpture. Size variable.

*Emended Description* (Jarzen & Dettmann, 1989)—Pollen grains tricolpate, fossaperturate, isopolar, radially symmetrical, suboblate to prolate spheroidal. Amb lobate with convex mesocolpia and inset apocolpia. Colpi meridionally aligned, incised 1/2-3/4 distance to pole, often gaping at equator; margins entire, composed of thickened nexine that projects beyond sexine. Exine 0.8-1.2  $\mu\text{m}$  thick at mesocolpia slightly thicker and beveled at colp margins. Sexine baculate, semitectate, 0.5-0.8  $\mu\text{m}$  thick; surface with even meshed reticulum. Nexine as thick as, or slightly thinner than, sexine; thickest and protruding beneath sexine at colp margins. Surface reticulum composed of smooth-crested, simplibaculate muri ca. 0.2  $\mu\text{m}$  wide that enclose angular, almost isodiometric to elongated lumen up to 0.8  $\mu\text{m}$  in maximum dimension.

*Occurrence*—Miocene, Neyveli lignite, Tamil Nadu (Ramanujam, 1966); Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979); Palaeocene, Mikir Formation, Meghalaya (Mehrotra, 1983); Subsurface Early Miocene sediments, Meghalaya (Nandi & Sharma, 1984); Lower Eocene, Naredi Formation and Middle Eocene, Harudi Formation, Kutch (Kar 1985); Oligocene, Barail Group, Meghalaya and Assam (Singh *et al.*, 1985, 1986); Late Cretaceous-Palaeocene, Jalangi Formation, Bengal Basin (Bakshi & Deb, 1980), Palaeocene, Supratrappean Kutch (Mathur, 1966) and subsurface Pleistocene to Holocene sediments, Bengal Basin (Mathur & Chopra, 1987).

*Remarks*—A few specimens show very weak reticulation in comparison to holotype of the species (Pl. 5.5-7). Moreover, some of the specimens described under this species are large in size with larger reticula and they have been transferred to *Albertipollenites* and *Rousea*. *Retitricolpites microreticulatus* Mathur, 1966 described by Rao & Ramanujam (1982) appears as colporate from the photograph (pl. 1, fig. 4). The specimens recorded by Sah and Kar (1974: slide no. 4353/25), Kar (1985,

slide nos. 3363/14, 3370/2) and Kar & Kumar (1986, slide no. 9376) as *T. reticulatus* are colporate.

**Genus—VERRUTRICOLPITES** Pierce, 1961

*Type Species—Verrutricolpites sphaeroides* Pierce, 1961

*Original Diagnosis—*Verrucate tricolpate pollen.

**VERRUTRICOLPITES PERVERRUCATUS**

Ramanujam, 1966

*Original Description—*Pollen grains isopolar, prolate, 3-zonicolpate, 26 x 22  $\mu\text{m}$ . Amb rounded. Colpi short, with ends blunt. Exine 1.5  $\mu\text{m}$  thick, loosely verrucate. Verrucae not much raised from the surface, 1.5  $\mu\text{m}$  high.

*Occurrence—*Miocene, Neyveli Lignite, Tamil Nadu (Ramanujam, 1966); Palaeocene, Matanomadh Formation, Kutch (Saxena, 1979; Kar, 1985).

**TENTATIVE ASSIGNMENTS**

**CRANWELLIA INDICA** Venkatachala & Rawat, 1972

*Original Description—*Pollen grain roundly triangular in polar view, angulaperturate, sides convex; 59.4 x 60.0  $\mu\text{m}$ . Tricolpate, colpi short, about 10.0  $\mu\text{m}$  deep in polar view, tapering, broader in the equatorial region, about 6.6  $\mu\text{m}$  wide. Exine about 4.6  $\mu\text{m}$  thick, tectate; sexine thicker than nexine, formed of pila with rounded distal heads; surface striate. Striation about 1  $\mu\text{m}$  thick, closely placed running from pole to pole, sometimes bifurcating and dwindling at the poles, giving a linear pseudoreticulum to the surface.

*Occurrence—*Subsurface Palaeocene-Eocene sediments, Cauvery Basin (Venkatachala & Rawat, 1972).

*Remarks—*The photograph of the holotype shows striate ornamentation formed by round-headed pila. The species appears to be closer to *Striatopollis* Krutzsch (1959) than to *Cranwellia* (interapical margins are also not concave, as found in *Cranwellia*). But the present species is larger in size than holotype of *Striatopollis*.

**RETITRICOLPITES MARGINATUS** van Hoeken  
Klinkenberg, 1966; in Rao and Ramanujam, 1982

*Description* (after Rao & Ramanujam)—Pollen grain isopolar, amb rounded to subcircular, polar diameter 24-29  $\mu\text{m}$ ; zonaperturate, tricolpate, medicolpate. colpi often obscured by heavy sculpturing, margins thin, ends pointed. Exine 2.5  $\mu\text{m}$  thick, sexine thicker than nexine, surface reticulate, heterobrochate, brochi larger at poles, smaller along a margin around colpi, polygonal, muri simplibaculate, lumina angular with 1-5 free bacules.

*Occurrence—*Miocene, Quilon Formation, Kerala (Rao & Ramanujam, 1982).

*Remarks—*The specimen described by Rao & Ramanujam (1982) is different from *Retitricolpites marginatus* van Hoeken Klinkenberg (1966) and should be treated as new species under *Rousea* as *Retitricolpites* is invalid. However, Rao & Ramanujam's specimen is not available for examination at present and thus it is kept in tentative assignment.

**RETIBREVITRICOLPITES SEMILUNARIS**

Ramanujam *et al.*, 1985

*Original Description—*Pollen grains isopolar, radially symmetrical, oblate, amb triangular, 36-55.5  $\mu\text{m}$  in diameter, apices  $\pm$  truncate, sides straight to concave; zonaperturate, angulaperturate, tricolpate, brevicolpate, colpi narrow slit-like with conspicuous costae (nexinous thickenings) surrounding them, costae up to 4.5  $\mu\text{m}$  thick; exine up to 5  $\mu\text{m}$  thick, subtectate, mesocolpia with prominent semilunar, cushion-like nexinous thickenings (up to 3.5  $\mu\text{m}$ ) sweeping from aperture to aperture, surface finely reticulate, muri high, meshes polygonal, lumina smooth.

*Occurrence—*Miocene, Neyveli lignite mine-II, Tamil Nadu (Ramanujam *et al.*, 1985).

*Remarks—*The present species is unique in the possession of straight to concave amb, prominent semilunar, cushion-like nexinal thickening and conspicuous costae bordering the short colpi. Since these are qualitative characters, we feel that this taxon should be placed under a separate genus.

**STRIATOPOLLIS BELLUS** Sah, 1967

*Original Description—*Size range 50-54 x 64-76  $\mu\text{m}$ , amb sub-spheroidal to oval; tricolpate, brevicolpate; sexine thicker than nexine, tegillate, striate.

*Occurrence—*Subsurface Palaeocene-Eocene sediments, Cauvery Basin (Venkatachala & Rawat, 1972); Subsurface Miocene sediments, Meghalaya (Nandi & Sharma, 1984).

*Remark—**Striatopollis bellus* is larger in size than *Striatopollis sarstedtensis* and thus *S. bellus* needs suitable placement.

**STRIATOPOLLIS CATATUMBUS** (García Guzmán,  
1967) Mathur & Chopra, 1987

*Original Description—*Pollen grain tricolpate, prolate; furrow C 1 - 2, C 1, C 1; sculpture type striate. Width of striae about 1  $\mu\text{m}$ , but finer at the poles. Sometime furrows show a margo. Thickness of exine about 3  $\mu\text{m}$ ; ectexine thicker than endexine. Grains semitectate. Polar area 3  $\mu\text{m}$ . Size of holotype 53 x 41  $\mu\text{m}$ .

*Occurrence—*Subsurface Late Miocene sediments, Bengal Basin (Mathur & Chopra, 1987).

*Remarks—*Mathur and Chopra (1987) merged *Striatocolpites* (van der Hammen, 1956) García Guzmán (1967)



into *Striatopollis* because the former is illegitimate and a later synonym of *Acer* (Jansonius and Hills, 1976). The size of the present species is larger than the holotype of *Striatopollis*.

**TRICOLPITES MARGOCOLPITES** Venkatachala & Rawat, 1972

*Original Description*—Pollen grain triangular in polar view, sides straight to convex; 35.7-37 x 37  $\mu\text{m}$ ; tricolpate, angulaperturate. Margocolpate, colpi long, 15.2  $\mu\text{m}$  deep in polar view, reaching almost to the poles, wide in the equatorial region, margo about 2.7  $\mu\text{m}$  thick. Exine 1.5  $\mu\text{m}$  thick, thickening towards the pore region; sexine as thick as nexine or slightly thicker, intrapunctate, surface finely reticulate.

*Occurrence*—Subsurface Palaeocene-Miocene sediments, Cauvery Basin (Venkatachala & Rawat, 1972, 1973).

*Remarks*—Presence of margo is very characteristic feature and does not come within the circumscription of *Tricolpites*.

**TRICOLPITES MINUTUS** Jain *et al.*, 1973

*Non: T. minutus* Sah & Kar, 1970

*Description*—Pollen grains tricolporoidate, spheroidal, 15-25  $\mu\text{m}$  in diameter, prolate, sexine thicker than nexine, surface ornamented with warts, 0.5-1  $\mu\text{m}$  in height.

*Occurrence*—Palaeocene, Barmer Hill, Rajasthan (Jain *et al.*, 1973).

*Remarks*—Holotype of this species is missing. This taxon is junior homonym of *Tricolpites minutus* (now *Ladakhipollenites minutus*) but distinct having warty exine.

**TRICOLPITES STRIGOSUS** Salujha *et al.*, 1974

*Original Description*—Golden yellow, subcircular, measuring 24-35.2 x 22.4-30.8  $\mu\text{m}$ ; occasionally bearing folds; tricolpate, colpi 2.5-4.5  $\mu\text{m}$  deep with a 2-3  $\mu\text{m}$  wide thickening; exine  $\pm$  1.2  $\mu\text{m}$  thick, finely granulate, grana  $\pm$  1  $\mu\text{m}$  in diameter.

*Occurrence*—Palaeogene sediments, Meghalaya (Salujha *et al.*, 1974)

*Remarks*—Salujha *et al.* (1974) mentioned that *T. strigosus* has 2-3  $\mu\text{m}$  thick colpus margins which is not clear from the photograph. Since this species has granulate exine, it differs from other species placed under *Tricolpites*.

**TRICOLPITES OVATUS** Salujha *et al.*, 1974

*Original Description*—Golden yellow, oval, size 30.6-38.4 x 21.2-27.8  $\mu\text{m}$ ; occasionally bearing folds, tricolpate, colpi 2-3.5  $\mu\text{m}$  wide extending almost from one pole to the other; exine  $\pm$  1.5  $\mu\text{m}$  thick, granulate, grana  $\pm$  1  $\mu\text{m}$  wide, closely placed.

*Occurrence*—Palaeocene-Eocene, Disang Group, Meghalaya (Salujha *et al.*, 1974); Early Miocene, Bokabil Formation, Tripura (Salujha *et al.*, 1977).

*Remarks*—Since this species has granulate exine, it should not be placed under *Tricolpites*.

**TRICOLPOPITES GRANULOSUS** Baksi, 1962

*Description*—Polar compression; longer diameter 26  $\mu\text{m}$ , surface dense granular to slightly spinulose, tricolpate, colpal furrow extending right up to the pole.

*Occurrence*—Miocene, Surma Group, Meghalaya (Baksi, 1962).

**TRICOLPOPITES SPINOSUS** Baksi, 1962

*Description*—Oblique equatorial compression; longer diameter (without spines) 44  $\mu\text{m}$ , spines medium based; more or less obtuse termination; infrequent; tricolpate.

*Occurrence*—Oligocene, Barail Group, Meghalaya (Baksi, 1962).

## DISCUSSION

In this paper 98 species of tricolpate pollen recorded from Tertiary sediments of India have been compiled. The taxonomic study reveals that the characters overlap among the genera *Tricolpites*, *Tricolpopites* and *Retitrescolpites*. The genus *Tricolpites* has been conceived here as per emended diagnosis of Jarzen & Dettmann (1989). The segregation of the genus *Tricolpites* (*sensu lato*) into *Albertipollenites*, *Rousea* and *Tricolpites* (*sensu stricto*) is followed here after Srivastava (1969b) and the species are reallocated accordingly. *Tricolpopites* Biswas, (1962) was not validly proposed (Jansonius & Hills, 1976) and the genus shows characters identical with *Tricolpites*. The species described under *Tricolpopites* are transferred to different genera. Similarly, species of *Retitricolpites* and *Retibrevitricolpites* are also placed under different genera according to their characters (Fig. 1). *Retitrescolpites* is delimited here as colpate/colporoidate pollen having strongly retipilate to retibaculate exine. Still, the distinction with other genera is not sharp. While dealing with the genus *Ladakhipollenites* it is found that *Ladakhipollenites minutus* lies in the border of *Ladakhipollenites* and *Tricolpites* because in *L. minutus* surface structure appears as muri but they do not join to form reticulum. A few species viz., *Tricolpopollenites microhenrii* (Ambwani, 1982), *Retitrescolpites africanus* (in Saxena *et al.*, 1984), *R. assamicus* (Dutta & Sah, 1970), *Retibrevitricolpites foveolatus* (Venkatachala & Rawat, 1972), *Tricolpites matauraensis* (in Sah & Kar, 1974), *T. thomasi* (in Ramanujam, 1966) and *T. speciosum* (Ramanujam, 1966) are found to have colporate aperture on reexamination of specimens and/or from the illustrations.

*Dakshinipollenites*, *Intrareticulitis* and *Tricolpites reticulatus* have been dealt here because new information have emerged since Thanikaimoni *et al.* (1984) and Venkatachala *et al.* (1989) studied them. The three species *Tricolpites ovatus*, *T. strigosus* and *Tricolpites granulatus* are characterized by granular ornamentation and do not compare with the circumscription of existing tricolpate genera. Same is the case with *Tricolpites margocolpites* where a margo is very prominent along the colpi. Similarly, *Tricolpites spinosus* and *T. minutus* bear spinulose and warty exine respectively. *Retibrevitricolpites semilunaris* also shows characteristic nexinal thickening and does not come within the circumscription of any known genus. Similarly, *Striatopollis bellus*, *S. catanumbus* and *Cranwellia indica* show striate exine and appear close to *Striatopollis* but are much larger in size. *Retitricolpites marginatus* needs proper taxonomic treatment. We could not place them properly without examining the types and thus listed them at the end as "Tentative assignments"

The above study is partly based on holotypes and other specimens available in Birbal Sahni Institute of Palaeobotany. Help of literature has been taken for rest of the taxa. Still few distinct taxa could not be reallocated properly and kept under tentative assignments. These taxa require examination of the original specimens for suitable assignment. However, this evaluation has enabled satisfactory taxonomic placement of majority of unsorted tricolpate taxa from India.

The stratigraphic ranges of the studied species, on the basis of their records of occurrence, are presented in Fig. 2. However, it should be noted that some species show long vertical distributions by bringing together in this chart shorter distributions documented from individual basins, e.g., *Tricolpites reticulatus*, that cumulatively translate in to a long range. The role of shifting ecology and climate in this phenomenon has not yet been analyzed.

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