

# REAPPRAISAL OF SOME SUBSACCATE FOSSIL POLLEN GENERA

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## ABSTRACT

*Tsugaepollenites* (Potonié & Venitz) Potonié 1958, *Cerebropollenites* (Nilsson) emend. and *Triangulopsis* (Döring) emend. have been morphographically studied in this paper. *Cerebropollenites* and *Triangulopsis* which were formerly grouped under *Tsugaepollenites* by Dettmann (1963) have been excluded from its limits and evidence has been adduced for this treatment. 6 new species under *Tsugaepollenites*, 1 new species under *Cerebropollenites* and 2 new species under *Triangulopsis* have been described from the coals of the Jabalpur Series of India.

THE present paper deals with the morphographic study of 3 pollen genera namely *Tsugaepollenites* (Pot. & Ven.) Pot. 1958, *Cerebropollenites* (Nilsson) emend. and *Triangulopsis* (Döring) emend. Among these, the first mentioned genus has been critically reviewed and the latter 2 genera have been emended on the basis of the study of specimens recovered from the coals and shales of the Jabalpur Series (Lower Cretaceous) of India. In order to understand the range of variation of the morphographic characters quantitatively as well as qualitatively in each of the 3 mentioned pollen genera, all the available information known to the authors from the published records, in addition to the analysis of the data assembled from the Indian material, has been taken into consideration.

Dev (1961) instituted *Callialasporites* from the carbonaceous shales of Jabalpur Series of India to accommodate the species of *Zonalapollenites* described by Balme (1957) from the Mesozoic strata of Australia. His contention was that *Zonalapollenites* Pflug is without a type species of its own and is equivalent to *Tsugaepollenites*. He selected *C. trilobatus* (Balme) Dev as the type species of his newly created genus and instituted two more new combinations under the same genus, i.e. *C. dampieri* (Balme) Dev and *C. segmentatus* (Balme) Dev. This treatment was followed by some subsequent workers till Dettmann (1963) restated the

diagnosis of *Tsugaepollenites* and merged with it quite a number of miospore genera like *Callialasporites*, *Zonalapollenites*, *Cerebropollenites* Nilsson, *Applanopsis* Döring, *Triangulopsis* Döring and *Pflugipollenites* Pocock. Out of these, *Applanopsis* has by far the similar diagnostics as that of *Tsugaepollenites* and we agree with Dettmann (*l.c.*) in merging the former with the latter and also for treating *Zonalapollenites* as a junior synonym of *Tsugaepollenites*. So far as *Callialasporites* and *Pflugipollenites* (only their respective type species) are concerned, they hardly seem to be distinguishable from *Triangulopsis* and so we have merged both these genera with *Triangulopsis* after emending its generic diagnosis. Thus, we purport to retain *Triangulopsis* as a distinct genus from *Tsugaepollenites*. *Cerebropollenites* has also been emended here and excluded from the limits of *Tsugaepollenites*. So, in fact, all the 3 genera have been considered here in relation to each other. Some species of *Triangulopsis* have been transferred to *Tsugaepollenites* and that of *Tsugaepollenites* to *Cerebropollenites*.

In the revised diagnosis of *Triangulopsis*, we include such type of pollen grains in which the contour of the specimens in flattened condition is subtriangular to subcircular, central body is distinctly convexly triangular with or without folds, having fine to coarse granulose ornamentation of the exine and distally a thinner area of the polar exine. The equatorially attached saccus is also granulose, which may be frilled on account of radial folds and is usually trilobate in appearance. Normally pollen grains are alete but rarely they may bear a non-functional trilete mark. We have described two new species under *Triangulopsis*, viz. *T. plicatus* sp. nov. and *T. varians* sp. nov. and have also included *T. discoidalis* (Döring) here for the reasons discussed later. We have also excluded *Callialasporites dampieri* (Balme) Dev and *C. segmentatus* (Balme) Srivastava from its

limits even after its emendation. Both these species have already been transferred to *Tsugaepollenites* by Dettmann (1963), a treatment to which we agree.

From the illustration of the type species of *Tsugaepollenites*, it is apparent that the type specimen is almost circular in form wherein the central body is also almost circular and may be oval in some other species, and that it may be faintly or well demarcated from the equatorial saccus. Exine ornamentation, in the species of *Tsugaepollenites*, is finely to coarsely granulate. Distal polar exine is usually thinner. Equatorially attached saccus is usually radially folded appearing like a frill. So in our opinion, those specimens in which central body is circular to oval, saccus is equatorially attached and distinct from the intexine, though radially folded, should be assigned to *Tsugaepollenites* only.

Dettmann (1963) merged *Cerebropollenites* (Nilsson) with *Tsugaepollenites* but we differ from this treatment and propose to retain it as an independent taxon on the basis of the study of some specimens belonging to this genus from the Jabalpur Series of India. Nilsson (1958) established this genus from the Liassic of Sweden designating *Cerebropollenites* (*Tsugaepollenites*) *mesozoicus* (Couper) Nilss. as its type species. Pollen grains referable to this genus, in our opinion, are circular to oval with numerous vesiculae of variable size and shape, covering both the faces excepting a thinner distal polar region. In fact, the equatorial identity of the saccus is completely obliterated by its profuse proliferation, resulting into numerous, small, coherent or individually isolated sacci or vesiculae. Thus it is not possible to distinguish the central body from the saccus. This character, in fact, qualitatively distinguishes it from *Tsugaepollenites* and *Triangulopsis*.

Dettmann (1963, p. 9) has recognized *Tsugaepollenites* but with a modified diagnosis. So far as the morphographic interpretation of *Tsugaepollenites* is concerned, the present authors concur with Dettmann (*l.c.*) but at the same time we opine that its circumscription is broad based and does not contain a homogeneous group of species. Thus we propose here to restrict the circumscription of *Tsugaepollenites* as given by its original authors and exclude *Triangulopsis* and *Cerebropollenites* from its circumscription.

## MATERIAL AND METHODS

The specimens figured in the present paper have been illustrated from the coals and shales of the Jabalpur Series represented at Sehora and Hathnapur in the district of Narsinghpur and Lameta, Jabalpur district (Madhya Pradesh). The geological details of Sehora and Hathnapur and the maceration technique adopted for the extraction of miospores have already been described by Singh (1966). Comparable pollen grains figured separately from the Umia beds of Cutch, India by Singh *et al.* (1964) and from the Rajmahal Hills of Bihar, India by Sah and Jain (1965) have also been freshly considered and discussed in this paper.

## DESCRIPTION AND ANALYSIS

Anteturma — *Pollenites* Pot. 1931  
 Turma — *Saccites* Erdtm. 1947  
 Subturma — *Monosaccites* (Chit.) Pot. & Kr. 1954

Genus — *Tsugaepollenites* (Pot. & Ven.)  
 Pot. 1958

Type Species — *Tsugaepollenites igniculus* (Pot.) Pot. & Ven., 1939.

Some species now included under *Tsugaepollenites*.

*T. monoalaspuris* (Dev) comb. nov.  
*T. rimalis* (Singh *et al.*) comb. nov.  
*T. demeedi* (de Jersey) comb. nov.

Remarks — Dettmann (1963) has instituted 3 new combinations under *Tsugaepollenites*, i.e. *T. dampieri* (Balme) Dettmann, *T. trilobatus* (Balme) Dettmann and *T. cf. segmentatus* (Balme) Dettmann. Out of these, two species namely *T. dampieri* and *T. segmentatus* have been treated by us under the same genus but *T. trilobatus* has been assigned to the genus *Triangulopsis* as *T. trilobatus* (Balme) because this genus is distinguishable from *Tsugaepollenites* in having triangular—subtrigonal central body and lobate condition of the saccus, the lobes may vary in number but usually exhibit trilobate condition. They may either be completely separated from each other or are partially separated by constrictions.

*Tsugaepollenites dampieri* (Balme) Dettm.  
1963

Pl. 1, Figs 1-2; Text-figs. 1a, b & c

1957 *Zonalasporites dampieri* Balme, pl. 8,  
figs. 88, 90.

1961 *Callialasporites dampieri* (Balme),  
Dev, pl. 4, figs. 26, 27.

1961 *Applanopsis dampieri* (Balme) Döring,  
pl. 16, figs. 11-15.

1962 *Pflugipollenites dampieri* (Balme)  
Pocock (? pl. 12, fig. 184).

*Remarks* — *T. dampieri* (Balme) Dettm. differs from *T. lucidus* (Pocock) Dettm. in having a narrower, radially twisted saccus, thinner intexine and less prominent exine ornamentation. *T. dubius* (Coup.) Dettm. has a prominent Y-mark and also thicker exine. *T. lenticularis* (Döring) Dettm. is distinguishable from *T. dampieri* by virtue of its thicker intexine, low polar vesiculae and intensely folded saccus. *T. rimalis* (Singh *et al.*) and *T. monoalaspuris* (Dev) are distinct from *T. dampieri* in having a thicker exine at the equator of the central body which prominently separates it from the saccus. *T. demeadii* (de Jersey) comb. nov. is reported to have reticulate exine of the central body and hence is not comparable. *Tsugaepollenites dampieri* (Pocock) Dettm. (PL. 12, FIG. 183) possibly does not seem to belong to this species as the photograph of the illustrated specimen appears very much comparable to *T. lucidus* (Pocock) Dettm. excepting its smaller size.

*Tsugaepollenites indicus* sp. nov.

Pl. 1, Figs. 3-5; Text-fig. 2

*Diagnosis* — Pollen grains 52-76  $\mu$  in over all size, oval to subglobose in flattened condition; central body oval to subglobose in shape, thin-walled, granulose, without any vesiculae, usually irregularly folded on proximal as well as distal faces. Saccus equatorially attached, appearing frilled, 4-6

$\mu$  broad, granulose, comparatively thicker than body wall.

*Holotype* — Pl. 1, Fig. 4; Regd. Slide No. 3234.

*Type Locality* — Sehora, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, subcircular to almost oval in flattened condition, holotype measuring 63  $\times$  76  $\mu$ . Central body 58  $\times$  66  $\mu$  in size, oval to subglobose, usually faintly demarcated from the equatorially attached saccus, body exine granulose, grana fine and closely packed, without any noticeable vesiculae either at the polar region or elsewhere on both the faces, light to heavy folds apparent on the proximal as well as distal faces, usually irregularly arranged or occasionally concentrated at one point, presumably a small distal thinner area of the exine, circular to oval in shape is evident in all the specimens. Saccus equatorially attached, undulating, appearing frilled due to radially twisted folds, narrow, 4-6  $\mu$  broad, but thicker in comparison to the body exine, having similar ornamentation of the exine as that of the central body.

*Comparison* — *Tsugaepollenites indicus* sp. nov. is distinctly distinguishable from *T. dampieri* (Balme) Dettm., *T. lenticularis* (Balme) Dettm. and *T. dubius* (Coup.) Dettm. in having a faintly demarcated, thinner central body usually associated with irregular but conspicuous folds both on the proximal and distal faces. *T. rimalis* (Singh *et al.*) and *T. monoalaspuris* (Dev) do not compare with *T. indicus* by having a thick band of exine separating the central body and the saccus.

*Tsugaepollenites primus* sp. nov.

Pl. 1, Figs. 6-8; Text-fig. 3

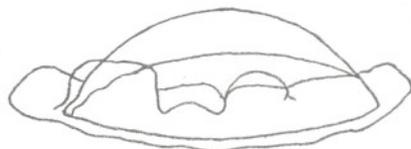
*Diagnosis* — Pollen grains 88-100  $\mu$  in overall size, almost circular in flattened

→

TEXT-FIGS 1-4 — 1a, Organization of *Tsugaepollenites dampieri* (Balme) Dettm., in meridional view. b, Organization of *Tsugaepollenites dampieri* (Balme) Dettm., as evident in meridional compression of the specimen exhibited in Pl. 1, Fig. 2c, *Tsugaepollenites dampieri* (Balme) Dettm., in polar view. 2. *Tsugaepollenites dampieri* (Balme) Dettm., in polar view; showing faintly demarcated, thinner central body associated with irregular but conspicuous folds on both the faces. 3. *Tsugaepollenites primus* sp. nov., in polar view; exhibiting indistinct body wall which is hardly demarcated from the equatorial saccus. 4. *Tsugaepollenites limbatus* sp. nov., in polar view; showing the limbus like nature of the equatorial margin.



1a



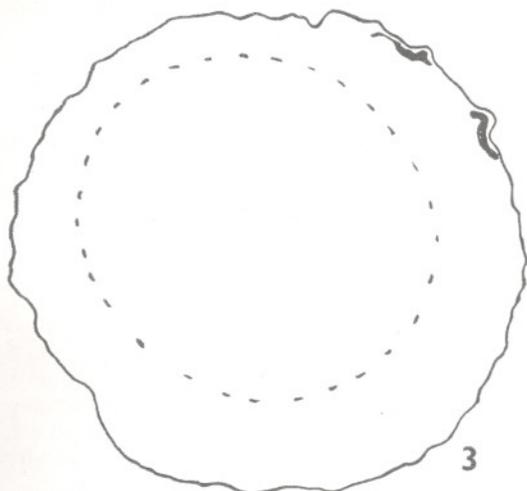
1b



1c



2



3



4

TEXT-FIGS. 1-4. × approx. 750

condition; central body almost circular, 50-70  $\mu$  across in diameter, granulose, thin walled, hardly distinguishable (from the equatorially attached saccus), non-vesiculate, sparsely shrivelled in some specimens. Saccus equatorial in disposition, 10-15  $\mu$  broad, granulose, usually without radially disposed frills.

*Holotype* — Pl. 1, Fig. 6; Regd. Slide No. 3235.

*Type Locality* — Sehora, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, biconvex, almost circular in equatorial contour, holotype 96  $\mu$  across in diameter. Central body circular,  $\pm 60 \mu$  in diameter, hardly demarcated from the equatorial saccus by any distinct body wall, body exine thin ornamented with medium sized grana, not very closely spaced, folds absent, vesiculae absent on both the faces, (occasionally some specimens showing shrivelled exoexine of the central body), distally a thinner oval area, 20-30  $\mu$  broad apparent. Y-mark not perceptible. Equatorial saccus 10-15  $\mu$  broad, almost uniform in width, usually without frills and radially twisted folds, granulose.

*Comparison* — *Tsugaepollenites primus* sp. nov. differs from *T. dampieri* (Balme) Dettm. by having larger size, indistinct body wall and thinner exoexine of the central body. *T. indicus* is distinct by virtue of its oval-subglobose shape, characteristically folded central body and narrower saccus as compared to *T. primus*. *T. rimalis* (Singh *et al.*) and *T. monoalaspuris* (Dev) Dettm. are closely comparable but for their thickened band of exine. *T. lenticularis* (Döring) Dettm. and *T. segmentatus* (Balme) Dettm. have thicker intexine, polar vesiculae and profusely radially folded saccus. In *T. lucidus* (Pocock) Dettm., the intexine is thicker, usually accompanied by folds and almost matt ornamentation of the exoexine and hence it is not comparable to *T. primus*.

*Tsugaepollenites limbatus* sp. nov.

Pl. 1, Figs. 9-11; Text-fig. 4

*Diagnosis* — Pollen grains 52-80  $\mu$  in overall size, apparently subtriangular in flattened condition; central body circular-subcircular 40-60  $\mu$  across in diameter,

mediumly thick walled, granulose, non-vesiculate. Equatorial saccus 8-14  $\mu$  broad, usually unequal in width, appearing trilobate, *extrema lineamenta* limbate, limbus 2-3  $\mu$  thick, granulose.

*Holotype* — Pl. 1, Fig. 9; Regd. Slide No. 3227.

*Type Locality* — Sehora, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, biconvex, holotype measuring about 60  $\mu$ . Central body subcircular, 45-50  $\mu$ , outline of the body wall perceptible, exine granulose, grana fine but not very closely spaced on both the faces, distally a thinner polar area visible, irregular in shape. Y-rays absent. Equatorial saccus 8 to 14  $\mu$  in width (at places limited to about 4  $\mu$  in thickness), usually unequal in one and the same specimen, constricted thrice and giving pseudotrilocate appearance, radially broadly frilled, folds few, margin of the saccus limbus-like, 2-3  $\mu$  in thickness, exine distinctly granulose.

*Comparison* — In the case of *T. limbatus* sp. nov. saccus is of unequal width in most of the specimens and often appear trilobate but the lobes are usually united by a narrow ledge of the saccus. The margin of the saccus is 2-3  $\mu$  thick appearing like a limbus. Thus, *T. limbatus*, though agreeing in other characters with *T. dampieri* (Balme) Dettm., has been described as a distinct species here. The rest of the species of *Tsugaepollenites* do not compare with *T. limbatus*.

*Remarks* — Sah and Jain (1955; PL. 4, FIG. 91) have described one specimen under *Callialasporites trilobatus* (Balme) Dev in which the saccus appears to have a distinct thickening of the margin.

*Tsugaepollenites sehorensis* sp. nov.

Pl. 1, Figs. 12, 13; Text-fig. 5

*Diagnosis* — Pollen grains more or less 84  $\mu$  in overall size, almost circular in flattened condition; central body almost circular, distinct, without polar vesiculae. Equatorial saccus narrow 4-6  $\mu$  broad, granulose, without frilling and radially disposed folds.

*Holotype* — Pl. 1, Fig. 12; Regd. Slide No. 3244.

*Type Locality* — Hathnapur, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, biconvex, subcircular in flattened condition, holotype measuring 82  $\mu$  across in diameter. Central body subcircular, 72  $\mu$  in diameter, body wall distinct, exine granulose, grana very fine and densely spaced on both the faces, distal exine revealing a small, central, thinner area, folds absent, polar vesiculae not discernible. Y-mark absent, saccus equatorially attached, small  $\pm 5 \mu$  in width usually uniformly broad, granulose, grana slightly bigger, sparser and coarser as compared to the central body, no frilling, radial folds conspicuously absent.

*Comparison* — *T. primus* sp. nov. compares most closely with *T. sehorensis* sp. nov. but differs from it in having indistinct central body and broader saccus. Species like *T. segmentatus* (Balme) Dettm., *T. lenticularis* (Döring) Dettm. and *T. indicus* sp. nov. are distinguishable from *T. sehorensis* in having radially folded, usually broader saccus and less distinct ornamentation of the exoexine. The intexine in *T. lucidus* (Pocock) Dettm. appears to be thicker and the saccus is conspicuous, broader, with almost matt type of ornamentation. *T. limbatus* sp. nov. is distinct from *T. sehorensis* in having an unequally broad saccus, the margin of which is considerably thickened.

*Tsugaepollenites segmentatus* (Balme) Dettm.  
1963

Pl. 1, Fig. 14

1955 *Lophotriletes* type 2, in Sah, pl. 1, fig. 31.

1957 *Zonalapollenites segmentatus* Balme, pl. 9, figs. 93-94.

1958 *Zonalapollenites segmentatus* Balme in Lantz, pl. 4, figs. 41-42.

1963 *Callialasporites segmentatus* (Balme) Srivastava.

1963 *C. segmentatus* (Balme) Srivastava, in de Jersey, pl. 3, fig. 6.

1964 *C. segmentatus* (Balme) Srivastava 1963, in Singh *et al.*

1965 *C. segmentatus* (Balme) Srivastava 1963, in Sah & Jain, pl. 3, fig. 77 and pl. 4, Figs. 90, 93.

*Remarks* — Perhaps due to oversight de Jersey (1963) has referred *Callialasporites segmentatus* (Balme) Dev in his paper

whereas Dev so far as we are aware, has never been the author of this combination. In fact, this combination was first instituted by Srivastava (1963). So in the above given synonymy the citation has been altered accordingly.

*Tsugaepollenites lenticularis* (Döring) Dettm.  
1963

Pl. 1, Figs. 15-17; Text-figs. 6a, b

1961 *Applanopsis lenticularis* Döring.

1965 *Callialasporites segmentatus* (Balme) Srivastava, in Sah & Jain, pl. 4, fig. 94.

*Remarks* — *T. indicus* sp. nov. is distinguishable from *T. lenticularis* in having oval to subglobose central body with thinner (folded) intexine and non-vesiculate polar regions. *T. segmentatus* (Balme) Dettm. is closely comparable with *T. lenticularis* but differs from it in having thinner central body and narrower saccus.

*Tsugaepollenites enigmaticus* sp. nov.

Pl. 2, Figs. 19, 20; Text-fig. 7

*Diagnosis* — Pollen grains 60-80  $\mu$  in overall size, almost circular in flattened condition; central body  $\pm$  subcircular, body wall hardly distinct, granulose, proximal exine differentially thickened exhibiting vermiculate pattern of vesiculae. Equatorial saccus 7-10  $\mu$  broad, intensely indented and twisted.

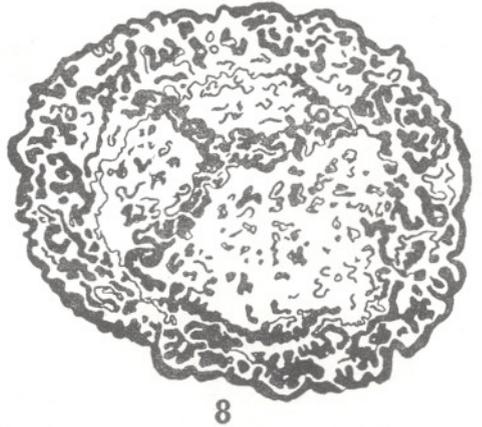
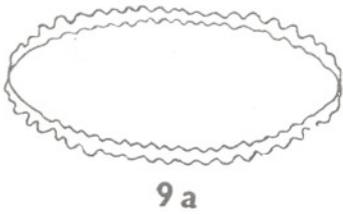
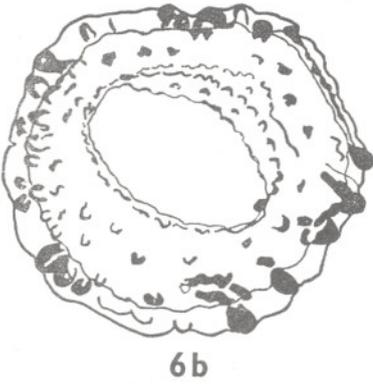
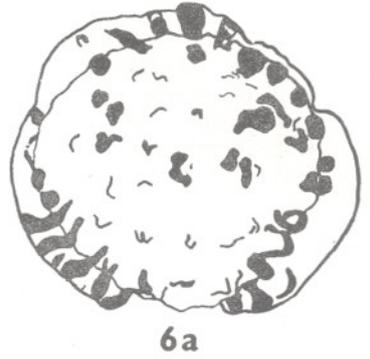
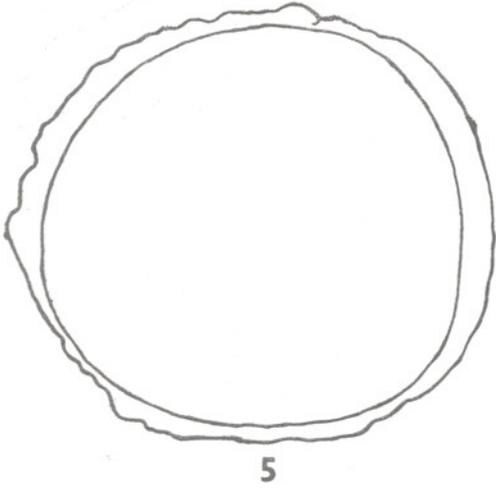
*Holotype* — Pl. 2, Fig. 20; Regd. Slide No. 3230.

*Type Locality* — Sehora, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, biconvex, almost subcircular in flattened condition, holotype 62  $\mu$  in size (including the saccus). Central body outline indistinct (partially traceable in some specimens as also in the holotype), exine granulose on both the faces, proximally usually thickened, forming a circular area in the vicinity of proximal pole, distally thinner exine perceptible, proximal surface beset with conspicuous polar vesiculae, tending to cover the major area of the body, occasionally assuming densely vermiculate pattern (as in specimen 19). Equatorial identity of the saccus noticeable, 8-10  $\mu$  broad, highly



TEXT-FIGS. 5-9a. X approx. 750

indented, intensely twisted due to radially directed folds, perceptibly granulose.

*Comparison* — *Tsugaepollenites enigmaticus* sp. nov. is distinguishable from *T. dampieri* (Balme) Dettm., *T. indicus* sp. nov., *T. primus* sp. nov., *T. limbatus* sp. nov. and *T. sehorensis* sp. nov. in having profusely radially folded saccus, proximally conspicuously thickened intexine and vermiculate type of vesiculae. *T. segmentatus* (Balme) Dettm. and *T. lenticularis* (Döring) Dettm. are closely comparable to *T. enigmaticus* but the former differs from it in having thinner intexine and lesser vesiculae whereas the latter is distinct by having lesser radial folds and elongated vesiculae.

*Tsugaepollenites fimbriatus* sp. nov.

Pl. 2, Figs. 21-23; Text-fig. 8

*Diagnosis* — Pollen grains 70-90  $\mu$  in overall size, subcircular-oval in flattened condition; central body almost indistinct but perceptible, granulose, proximal exine thicker and beset with sparsely spaced and low vesiculae. Y-rays faint. Equatorial saccus wide, 12-18  $\mu$  broad, proliferating into small numerous vesiculae.

*Holotype* — Pl. 2, Fig. 21; Regd. Slide No. 3225.

*Type Locality* — Sehora, District Narsingpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains monosaccate, biconvex, subcircular — somewhat oval in flattened condition, holotype 70  $\times$  90  $\mu$  in size. Central body indistinct, only marked by central thinner exine, about 20  $\times$  50  $\mu$  in size, granulose on both the faces, distal face having a thinner oval, polar area, with almost smooth ornamentation, being surrounded by an equatorially developed fringe of twisted vesiculae, proximal exine thicker, vesiculae low and sparsely spaced at the polar region. Y-mark faint, Y-rays sinuous, 2-4  $\mu$  broad, extending from the pole to

the margin of the central body. Saccus equatorial in attachment, 12-18  $\mu$  wide, split up into numerous vesiculae, basically granulose in ornamentation.

*Comparison* — *Tsugaepollenites lenticularis*. (Döring) Dettm. and *T. enigmaticus* sp. nov. are different from *T. fimbriatus* in having thicker intexine, narrower saccus and larger vesiculae. In general appearance, *T. segmentatus* (Balme) Dettm. compares closely with *T. fimbriatus* but it is distinguishable from the latter in having thinner intexine, narrower saccus and smaller polar vesiculae. The rest of the species of *Tsugaepollenites* do not compare with *T. fimbriatus*.

*Genus* — *Cerebropollenites* Nilsson. emend.

*Type Species* — *Cerebropollenites mesozoicus* (Coup.) Nilss., 1958.

*Remarks* — Nilsson (1958) instituted *Cerebropollenites* designating *C. (Tsugaepollenites) mesozoicus* (Coup.) as its type species. He described *Cerebropollenites* as 'azonate'. That is to say that the equatorial identity of the monosaccus in *Cerebropollenites* as observed by us is completely obliterated by profuse proliferation of the saccus, resulting into numerous small, coherent or individually isolated sacci or vesiculae. Subsequently, Dettmann (1963) merged *Cerebropollenites* with *Tsugaepollenites* ignoring the apparent non-equatorial manifestation of the monosaccate nature in the former genus. In the present treatment we have modified the diagnosis of *Cerebropollenites* as given below.

*Emended Diagnosis* — Pollen grains oval to circular in flattened condition, numerous vesiculae of variable size present on both the faces, distal exine marked by a thinner polar region small, circular or of variable shape having smooth to granulose ornamentation, the remaining surface being rough and covered by vesiculae, individual vesiculae variable in size and shape, *extrema lineamenta* usually deeply corrugated.

TEXT-FIGS 5-9a — 5. *Tsugaepollenites sehorensis* sp. nov., in polar view; showing the narrower saccus in comparison to the central body. 6. *Tsugaepollenites lenticularis* (Döring) Dettmann 1963, in polar view; a & b. 7. *Tsugaepollenites enigmaticus* sp. nov., in polar view; showing vermiculate type of vesiculae. 8. *Tsugaepollenites fimbriatus* sp. nov., in polar view; showing thicker intexine, narrower saccus and larger vesiculae. 9. Organization of *Cerebropollenites nilssonii* sp. nov., a, in meridional view.

*Comparison* — *Tsugaepollenites* (Pot. & Ven.) Pot. distinguishes itself from *Cerebropollenites* Nilsson emend. in having a distinct equatorial saccus which may or may not be radially folded. In *Triangulopsis* (Döring) emend. intexine is distinctly triangular and saccus is equatorially attached.

*Cerebropollenites nilssonii* sp. nov.

Pl. 2, Figs. 24-26; Text-figs. 9a, b

*Diagnosis* — Pollen grains 60-70  $\mu$  in size, oval to broadly elliptical in flattened condition, exoexine profusely proliferating into small vesiculae of variable size and shape on both faces, vesiculae 3-6  $\mu$  high, usually smaller in size and sparsely disposed in vicinity of thinner, distal polar area.

*Holotype* — Pl. 2, Fig. 26; Regd. Slide No. 3248.

*Type Locality* — Hathnapur, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grain saccate, oval to broadly elliptical in flattened specimens, holotype 54  $\times$  64  $\mu$ . Exine mediumly thick, granulose on both the faces. Distal polar area thinner, almost matt, more or less oval in shape, measuring 24  $\times$  30  $\mu$ , the remaining surface densely covered by numerous, intensely twisted vesiculae of variable size usually 3-6  $\mu$  high. Individual sacchi near distal polar area smaller and sparser but abruptly enlarging and aggregating towards the periphery, appearing minutely and closely frilled. Proximal exine beset all over with vesiculae, having almost similar pattern as on the distal face though in a more rugged manner.

*Comparison* — *Cerebropollenites mesozoicus* (Coup.) Nilsson appears to have thicker exine, uniformly larger vesiculae and hence is not comparable to *C. nilssonii*.

*Genus* — *Triangulopsis* (Döring) emend.

*Type Species* — *Triangulopsis discoidalis* Döring.

1961 *Callialasporites* Dev.

1962 *Pflugipollenites* Pocock (excl. *P. lucidus* & *P. dampieri*, 1961).

*Remarks* — Döring (1961) created *Triangulopsis* from the Mesozoic rocks of E. Germany. This genus, by virtue of its priority, accommodates *Callialasporites* Dev which was described by Dev (1961) from the shales of the Jabalpur Series of India. Later Dettmann (1963) merged *Callialasporites* and *Tsugaepollenites* (Pot. & Ven.) Pot. after restating the diagnosis of the latter genus. But during the course of our present study, we have noted that both *Tsugaepollenites* and *Triangulopsis* are different from each other as the former is chiefly represented by forms which have circular central body whereas in the latter the forms have triangular — convexly triangular central body. The occurrence of trilobate condition of the saccus can also be partly correlated with the shape of the central body. This morphographic tendency, in our opinion, is quite significant in keeping these two genera distinct from each other and accordingly we have emended the diagnosis of *Triangulopsis* as given below.

*Emended Diagnosis* — Pollen grains subtriangular to subcircular in flattened condition; central body distinctly convexly triangular with or without folds, fine to coarsely granulose, distal polar exine thinner having variable shape. Equatorial saccus trilobate with or without radial folds having similar ornamentation as that of the central body.

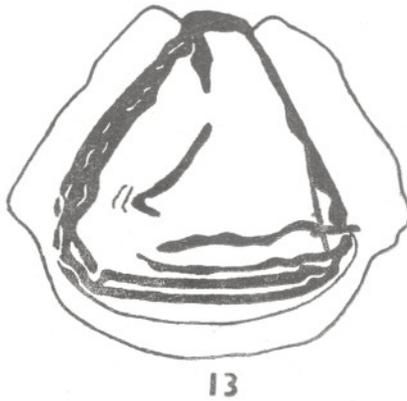
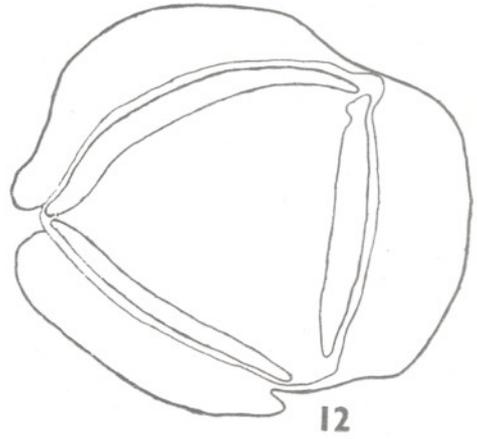
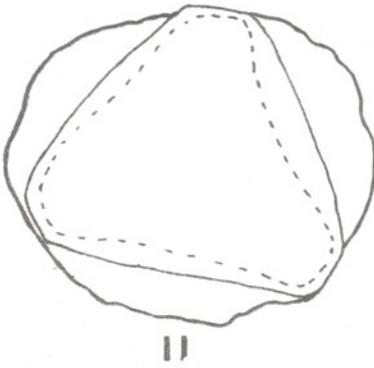
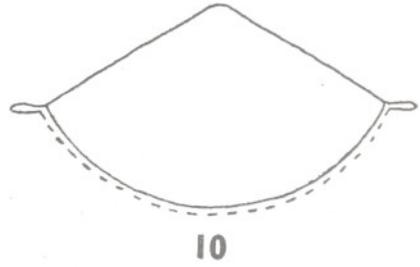
*Triangulopsis trilobatus* (Balme) Döring

Pl. 1, Fig. 18; Text-fig. 10

1953 *Euryzonotriletes*, Sah, pl. 1, fig. 14.

1954 Monolete spore, Vishnu-Mittre, pl. 2, fig. 36.

TEXT-FIGS. 9b-13 — b, in polar view; showing intensely twisted vesiculae of variable size. 10. Organization of *Triangulopsis trilobatus* (Balme) Döring in meridional view. 11. *Triangulopsis discoidalis* Döring, in polar view; showing flat apices of the central body where the saccus is comparatively narrow. 12. *Triangulopsis plicatus* sp. nov., in polar view; exhibiting thick folds, three in number, each fold running parallel to each side of the body wall. 13. *Triangulopsis varians* sp. nov., in polar view; showing folds running parallel to or in variable directions with respect to the body wall.



TEXT-FIGS. 9b-13.  $\times$  approx. 750

- 1957 *Zonalapollenites trilobatus* Balme, pl. 8, figs. 91-92.  
 1958 *Sporopollenites zonalis* var. *triangulus* Pautsch, Pl. 1, Fig. 13.  
 1958 *Zonalapollenites trilobatus* Balme, in Lantz, pl. 4, figs. 37-40.  
 1961 *Callialasporites* (al. *Zonalapollenites*) *trilobatus* (Balme) Dev, pl. 4, figs. 28-29.  
 1962 *Pflugipollenites trilobatus* (Balme) Pocock, pl. 12, figs. 186-187.  
 1963 *Tsugaepollenites trilobatus* (Balme) Dettm., pl. 24, figs. 6-10.  
 1964 *Callialasporites trilobatus* (Balme) Dev, in Singh *et al.*, pl. 7, fig. 90.

*Triangulopsis discoidalis* Döring

Pl. 2, Fig. 27; Text-fig. 11

*Remarks* — *Triangulopsis trilobatus* (Balme) Döring differs from *C. discoidalis* in having thinner intexine with its narrower apices and vesiculate exoexine.

*Triangulopsis plicatus* sp. nov.

Pl. 2, Figs. 28-30; Text-fig. 12

*Diagnosis* — Pollen grains 60-94  $\mu$  in overall size, subtriangular in flattened condition; central body triangular in shape having convex sides, each side accompanied by a thick fold, apices broad, exine granulose, Y-mark not noticeable. Equatorial saccus, 3-lobed, 12-17  $\mu$  broad.

*Holotype* — Pl. 2, Fig. 28; Regd. Slide No. 3253.

*Type Locality* — Lameta Ghat, District Jabalpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains saccate, usually indistinctly 3-lobed, holotype measuring 72 $\times$ 79  $\mu$ . Central body 55 $\times$ 59  $\mu$ , triangular in shape, usually with convex sides and broad apices, having 4-6  $\mu$  thick folds, 3 in number, each fold running parallel to each side of the body wall, usually dark brown in colour, exine granulose on both the faces distally thinner subcircular area on the polar region evident, proximally no Y-mark noticeable. Equatorial saccus 10-17  $\mu$  broad, appearing trilobed, lobes sometimes connected with a narrow ledge, exine granulose, *extrema lineamenta* not rough.

*Comparison* — *Triangulopsis trilobatus* (Balme) Döring does not compare with *T.*

*plicatus* sp. nov. in having vesiculate exoexine and lacking folds along the sides of the body wall. *T. discoidalis* Döring has thicker intexine with broader apices and lacks folds on its sides and hence is not comparable to *T. plicatus*.

*Triangulopsis varians* sp. nov.

Pl. 2, Figs. 31-34; Text-fig. 13

*Diagnosis* — Pollen grains 50-88  $\mu$  in size, almost subtriangular in flattened condition; central body triangular to subtriangular with convex sides and almost flat and unequally thickened apices, folds present but irregularly distributed, exine microreticulate — granulose, nonvesiculate. Saccus equatorial in disposition, 3-lobed, each lobe 6-10  $\mu$  wide and sometimes appearing connected by narrow ledge.

*Holotype* — Pl. 2, Fig. 33; Regd. Slide No. 3250.

*Type Locality* — Hathnapur, District Narsinghpur, Madhya Pradesh.

*Horizon* — Jabalpur Series.

*Age* — Lower Cretaceous.

*Description* — Pollen grains saccate, usually distinctly 3-lobed, holotype measuring about 76 $\times$ 88  $\mu$ . Central body 64 $\times$ 68  $\mu$ , subtriangular in shape, sides more or less convex, apices broad, unequally thickened, accompanying folds light to dark brown, running parallel to or in variable directions with respect to the body wall, exine microreticulate on both the faces, distally polar exine thinner forming a subcircular area, without any polar vesiculae, proximal exine alete. Equatorial saccus 6-10  $\mu$  in width, trilobate, each lobe running up to the adjacent apices, sometimes appearing constricted, but usually without radial folds. *Extrema lineamenta* not indented.

*Comparison* — *Triangulopsis varians* sp. nov. is more closely comparable to *T. plicatus* sp. nov. than any other species of the genus but is distinguishable from it in having unequally thickened intexine, irregularly distributed folds and minutely reticulate exine.

DISCUSSION

From the preceding account of the morphographic analysis of many subsaccate specimens from the Jabalpur Series (Lower Cretaceous) of India, *Cerebropollenites*

(Nilsson) emend. and *Triangulopsis* (Döring) emend. have been maintained as separate independent taxa. *Tsugaepollenites* (Pot. & Ven.) Pot., 1958, in which both these genera were included by Dettmann (1963), has been revised with remarks that it should include such species in which the central body is circular to oval and the saccus is equatorially attached. The saccus may or may not be radially folded. Distal polar exine of the pollen grains is invariably thinner. With this delimitation of *Tsugaepollenites* which, of course, has been based on a restudy of the illustration of its type species, *Cerebropollenites* and *Triangulopsis* have been excluded from its circumscription. *Cerebropollenites*, with its emended diagnosis, differs from *Tsugaepollenites* by the presence of small numerous sacchi covering the whole surface of the pollen grain excepting its distal polar region. *Triangulopsis*, as apparent from the illustration of its type species, has triangular central body and is distinct from the former two genera on this ground.

In the present study, 9 species have been assigned to *Tsugaepollenites* from the coals and shales of the Jabalpur Series of India. Out of these, one species namely *T. primus* has a broad saccus, two species namely *T. dampieri* and *T. limbatus* have a mediumly broad saccus, two species namely *T. indicus* and *T. sehorensis* have a narrow saccus and the remaining four species, i.e. *T. segmentatus*, *T. lenticularis*, *T. enigmaticus* and *T. fimbriatus* are conspicuous in having a profusely radially folded saccus. From this comparative range of morphographic characters met within the species of *Tsugaepollenites*, it is apparent that this genus manifests four distinct categories of morphographic variation. First set of species as enumerated earlier exhibits a very broad saccus, second set of species has a mediumly broad saccus (which, of course, is a typical representative for *Tsugaepollenites*), third set of species is conspicuous by having a narrow saccus while the remaining set of forms represents the extreme variation of the narrow saccus and it is highly indented. *T. primus*, which has a very broad saccus, compares very well with *Araucariacites cooksonii* Singh *et al.*, so far as the thinner central region in the vicinity of polar areas is concerned, but it differs from the latter in having a faint demarcation of the central body and by the presence of a distal, thinner

polar area which is quite pronounced. The apparent similarity of *A. cooksonii* with *T. primus*, though remote, may probably represent a stage intermediate between the morphographic characteristics of *Araucariacites* on one hand and *Tsugaepollenites* on the other. Our general observations on the Mesozoic assemblages (BALME, 1957; COUPER, 1958; POCKOCK, 1962; DEV, 1962; DETTMANN, 1963; SINGH *et al.*, 1964; SAH & JAIN, 1965 and unpublished information SINGH & KUMAR) reveal that generally *Araucariacites* and *Tsugaepollenites* occur together and so much so that in the last mentioned unpublished report (SINGH & KUMAR) the assemblage comprises of *Araucariacites* and *Tsugaepollenites* constituting more than 90 per cent of the whole assemblage. In view of this close association of these two genera in most of the Mesozoic assemblages, it can be suspected that the pollen grains of *Tsugaepollenites* may have been derived from plants having araucarian affinities. Gamarro (1965) has studied *in situ* pollen grains from the fructification of *Apterocladus lanceolatus* Archang. (Coniferales) which probably may be a member of Podocarpaceae as indicated by him. The pollen grains are comparable to the dispersed form of *Tsugaepollenites dampieri*. *T. dampieri* is more commonly represented as compared to other species and possesses a mediumly broad saccus usually lacking profuse radial folds. This morphographic pattern is a usual feature of the genus *Tsugaepollenites*. Other species like *T. segmentatus*, *T. lenticularis*, *T. enigmaticus* and *T. fimbriatus* have profusely radially folded saccus and represent another extreme within the genus *Tsugaepollenites*. If this very extreme and especially of the type met with in *T. fimbriatus* extends further, a qualitative change in the morphology of the pollen grains occurs so conspicuously that the saccus, in such cases, exhibits numerous small vesiculae which enclose the pollen grains all over excepting the distally thin polar area. Thus it is necessary to refer such forms to *Cerebropollenites*. *Cerebropollenites* is rare in occurrence and its affinities are obscure at the moment.

*Triangulopsis* is another ally of *Tsugaepollenites* but it is distinct from the latter in having a triangular central body along with mostly a trilobate saccus which is equatorial in disposition. Döring (1962) has reported a probably planktonic origin

to the form genus *Triangulopsis* (= *Callialasporites*) but Dettmann (1963) has questioned it for lack of evidence. The botanical affinities of *Triangulopsis* are not very well clear at the moment although it appears

to be closely related to *Tsugaepollenites*. We have recognized *Triangulopsis* on priority grounds. The same view has been held by Goubin, Taugourdeau and Balme (1965) for this genus.

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## EXPLANATION OF PLATES

(All photomicrographs are from unretouched negatives and are  $\times 500$ )

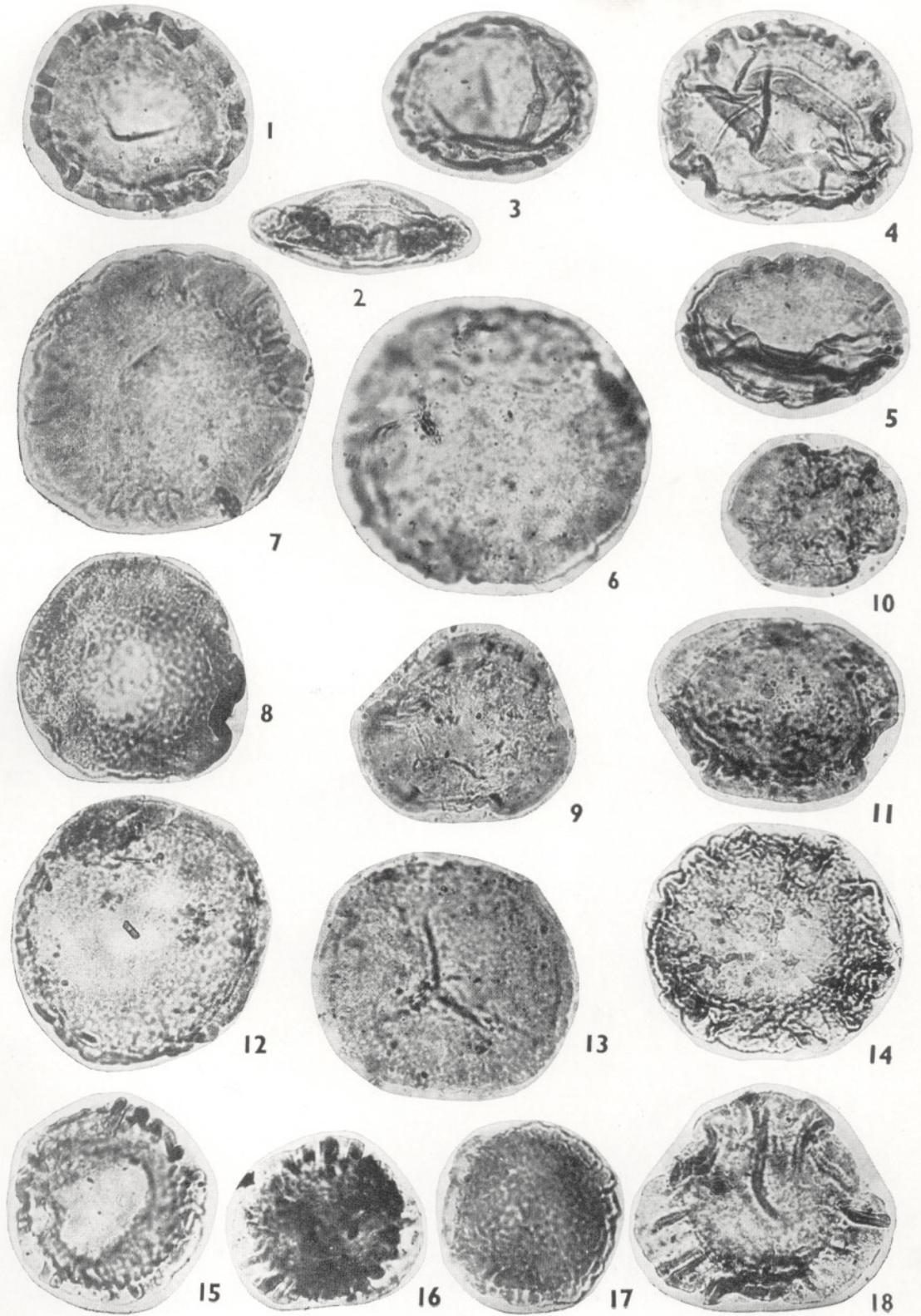
## PLATE 1

- 1-2. *Tsugaepollenites dampieri* (Balme) Dettmann; Regd. Slide Nos. 3233 & 3247.
- 3-5. *T. indicus* sp. nov.; Regd. Slide Nos. 3232, 3234 & 3229.
- 6-8. *T. primus* sp. nov.; Regd. Slide Nos. 3235, 3223 & 3243.
- 9-11. *T. limbatus* sp. nov.; Regd. Slide Nos. 3227, 3242 & 3251.
- 12, 13. *T. sehorensis* sp. nov.; Regd. Slide Nos. 3244 & 3226.
14. *T. segmentatus* (Balme) Dettmann; Regd. Slide No. 3246.
- 15-17. *T. lenticularis* (Döring) Dettmann 1963; Regd. Slide Nos. 3231, 3236 & 3239.

18. *Triangulopsis trilobatus* (Balme) Döring; Regd. Slide No. 3252.

## PLATE 2

- 19-20. *Tsugaepollenites enigmaticus* sp. nov.; Regd. Slide Nos. 3228 & 3230.
- 21-23. *T. fimbriatus* sp. nov.; Regd. Slide Nos. 3225, 3222 & 3222.
- 24-26. *Cerebropollenites nilssonii* sp. nov.; Regd. Slide Nos. 3239, 3249 & 3248.
27. *Triangulopsis discoidalis* Döring; Regd. Slide No. 3231.
- 28-30. *T. plicatus* sp. nov.; Regd. Slide Nos. 3253, 3228 & 3237.
- 31-34. *T. varians* sp. nov.; Regd. Slide Nos. 3219, 3249, 3250 & 3249.





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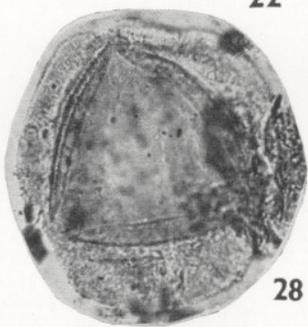
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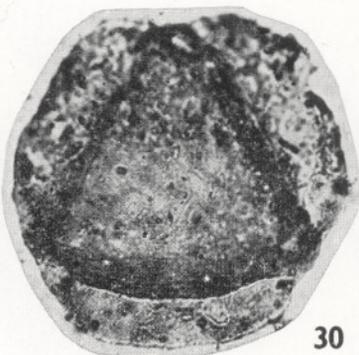
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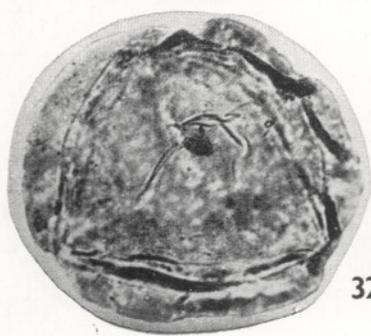
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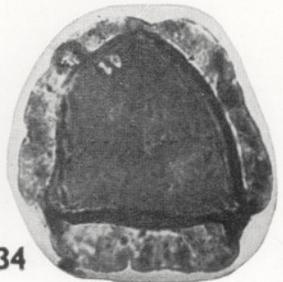
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