THE SPORE GENERA FROM THE UPPER CARBONIFEROUS COALS OF THE SAAR AND THEIR VALUE IN STRATIGRAPHICAL STUDIES

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ABSTRACT

Five new spore genera, viz. *Cyclobaculisporites* gen. nov., *Foveolatisporites* gen. nov., *Savitrisporites* gen. nov., *Zerndtisporites* gen. nov. and *Kosankeisporites* gen. nov., from the coal measures of the Saar, have been described. Detailed descriptions of 6 other, recently proposed spore genera (BHARDWAJ, 1954), viz. *Gravisporites* Bhardwaj, *Angulisporites* Bhardwaj, *Striatosporites* Bhardwaj, *Guthörlisporites* Bhardwaj, *Potonieisporites* Bhardwaj and *Sahnisporites* Bhardwaj, have also been included.

Stratigraphic subdivisions of the Upper Carboniferous succession in the Saar have been suggested on the basis of variation in the microfloral assemblages of the successive periods. The vertical distribution of *Sporae dispersae* as well as that of the megaflora has been compared and shown to be similar. The Westphalian D in the Saar has been found to comprise of the combined zones of *Palaeoweichselia defrancei* and *Neuropteris ovata*. The Stephanian in the Saar consists of two subdivisions, viz. Lower Stephanian lacking Westphalian influence and the Upper Stephanian with pronounced Westphalian character.

INTRODUCTION

THE contents of this paper are the results of a study of *Sporae dispersae* (isolated spores, dispersed in a strata) recovered from the coal seams of the Upper Carboniferous succession in the Saar (Central Europe). Out of the 95 workable seams, 29 seams were selected covering the whole succession (TABLE 1) ranging from Westphalian C through Westphalian D to Stephanian. Mostly two samples from each seam were examined but in a number of cases even three samples were studied.

The Saar coals are mostly of high volatile matter content (High volatile Bituminous: *Flammkohle*) excepting those of the deep-lying seams which produce the valuable coking coals (Medium volatile Bituminous: *Fettkohle*). These coals could be easily macerated by Schulze's or Zetsche and Kälin's (1932) method. The latter method was mostly used.

The palaeobotany of the Upper Carboniferous Coal Measures in the Saar is being studied since a long time. This region is extraordinarily rich in well-preserved plant megafossils which have so far been the only means of stratigraphical correlation in such a highly faulted, limnic basin. As early as the beginning of nineteenth century, Schlotheim (1804) had dealt with fossils from the Saar Coal Measures. Subsequently Brongniart (1828-38), Goldenberg (1855-62), Andrae (1865-69) and also Weiss (1862, 1869-72) described a large number of plant fossils from this basin. Towards the beginning of the present century, H. Potonié and Leppla (1903-13), and then later Bertrand and Corsin (1932), Gothan (1933) as well as Bode (1936, 1941) critically studied plant remains from the Saar basin and drew conclusions regarding the stratigraphy of the beds. Lately Corsin (1951) has resumed his earlier work and Guthörl (1936, 1940, 1940a, 1941, 1943, 1948, 1952, 1952a and 1953), through a series of significant publications, has considerably enhanced our knowledge of the palaeobotany of this area.

The studies on the *Sporae dispersae* of the Saar coals are very few on record. The earliest work is that of Sahabi (1936) who analysed a few coal seams of Westphalian age from Saar basin of which only one yielded well-preserved megaspores (SAHABI, loc. cit., PL. 1, FIGS. 6-9). The only detailed study available is by Zerndt (1940) on the megaspores. Zerndt (loc. cit.) describes 13 of his older megaspore types and two new species which he names *Triletes laxomarginalis* and *T. saarensis*. Zerndt concludes that in Westphalian C, his Types 20, 21 and 24 essentially do not reach the upper limit of Westphalian C and thus their presence is indicative of Westphalian C age; in Westphalian D, Types 11 and 25 reach their upper limit in oldest strata, Type 47 ends in the middle part and in the youngest part, Types 14, 44 and 31 are characteristic, of which the former two reach their upper limit within that part. Stephanian is characterized by a large number of Type 11a, although it appears for the first time as early as youngest Westphalian D.

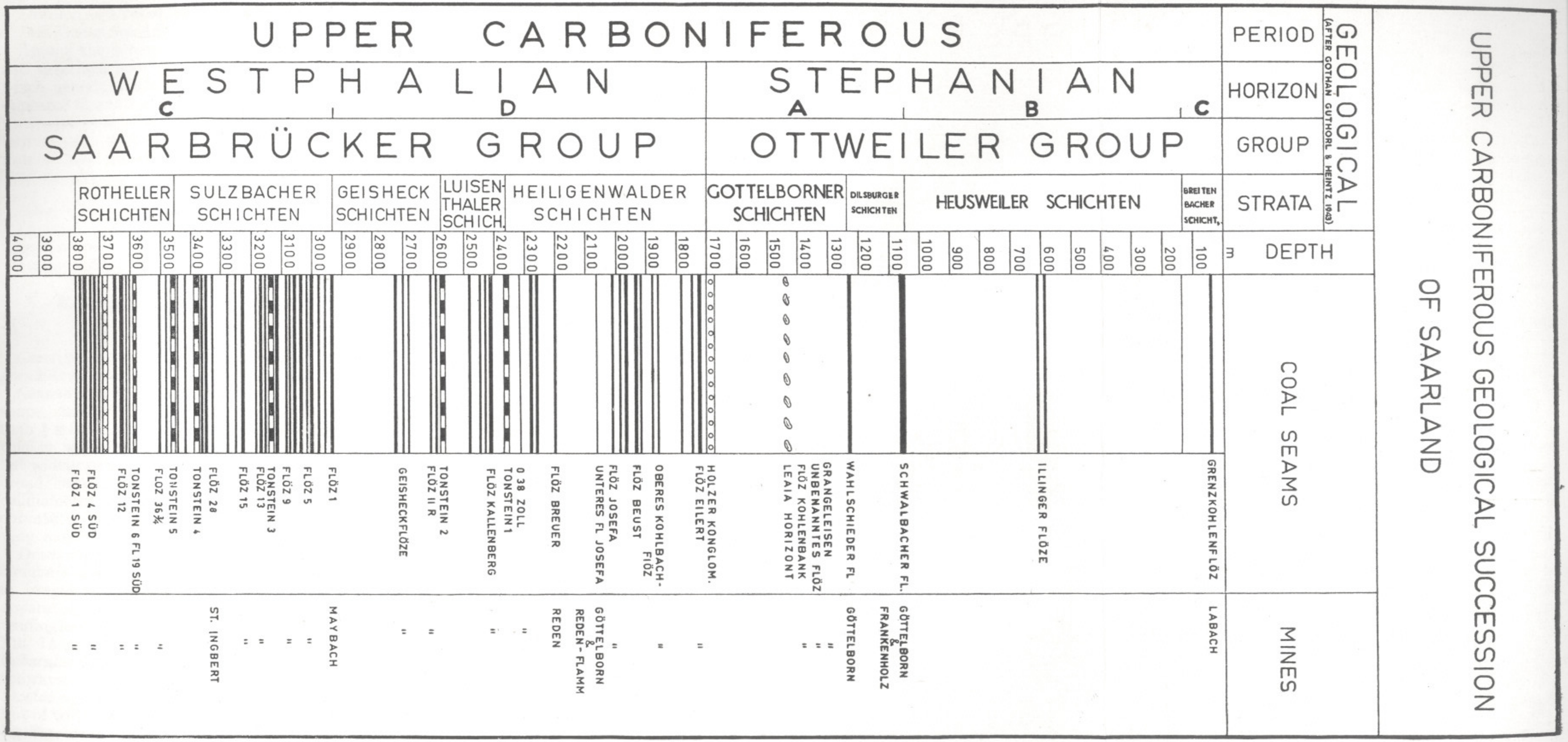
It will be apparent that the miospores of Saar coals have not been studied at all so far and the megaspore studies by Sahabi (loc. cit.) and Zerndt (loc. cit.) are accomplished under the older taxonomic concept, grouping all megaspores into a single genus *Triletes* Reinsch (compare Schopf, 1938; Potonié & Kremp, 1954).

The system of classification followed here is that used by Potonié and Kremp (1954), excepting a few new series which have been proposed to admit some new genera. In spite of the fact that this system can be substantially improved to make it more morphological than at present, I refrain to do so as the time is not yet ripe unless I may venture to suggest a slightly modified new scheme thus adding to the large number of systems already existing. Our express need is to circumscribe homogeneous spore species and genera as far as possible, by detailed morphographic studies so that they are of real utility in the geological work. In the meantime, valuable studies on the *in situ* spores like those by Chaloner (1953, 1953a) will increasingly bring the phylogeny of the dispersed forms to light and give us better knowledge about the structural morphology of the spores to formulate a morphological system of classification.

SYSTEMATIC DESCRIPTION

I have referred the spores and pollen grains recovered from the Saar coals to 45 spore genera as listed below:

- Super-division — **Sporites** H. Pot.
- Division — **Triletes** (Reinsch) Pot. & Kr.
- Subdivision — **Azonotriletes** Luber
- Series — **Laevigati** (B. & K.) Pot. & Kr.
  1. Genus *Leiotriletes* (Naum.) Pot. & Kr.
  2. Genus *Calamospora* S.W. & B.
  3. Genus *Granulatisporites* Ibrahim
  4. Genus *Cyclogranisporites* Pot. & Kr.
- Series — **Apiculati** (B. & K.) Pot. & Kr.
  5. Genus *Planisporites* (Knox) Pot. & Kr.
  6. Genus *Lophotriletes* (Naum.) Pot. & Kr.
  7. Genus *Raistrickia* (S. W. & B.) Pot. & Kr.
  8. Genus *Converrucosisporites* Pot. & Kr.
  9. Genus *Cyclobaculisporites* gen. nov.
  10. Genus *Schopfites* Kosanke
  11. Genus *Tuberculatisporites* (Ibr.) Pot. & Kr.
- Series — **Murornati** Pot. & Kr.
  12. Genus *Microreticulatisporites* (Knox) emend.
  13. Genus *Foveolatisporites* gen. nov.
- Subdivision — **Lagenotriletes** Pot. & Kr.
  14. Genus *Lagenoisporites* Pot. & Kr.
  15. Genus *Setosisporites* Pot. & Kr.
- Division — **Zonales** (B. & K.) Pot. & Kr.
- Subdivision — **Auritotriletes** Pot. & Kr.
- Series — **Auriculati** (Schopf) Pot. & Kr.
  16. Genus *Triquitrites* (Wils. & Coe) Pot. & Kr.
  17. Genus *Savitrisporites* gen. nov.
  18. Genus *Valvisisporites* (Ibr.) Pot. & Kr.
- Subdivision — **Zonotriletes** Waltz.
- Series — **Cingulati** Pot. & Klaus.
  19. Genus *Gravisporites* Bhardwaj
  20. Genus *Lycospora* S.W. & B.
  21. Genus *Densosporites* (Berry) Pot. & Kr.
  22. Genus *Cristatisporites* Pot. & Kr.
  23. Genus *Cirratriradites* Wils. & Coe
  24. Genus *Angulisporites* Bhardwaj
  25. Genus *Bentzisporites* Pot. & Kr.
  26. Genus *Triangulatisporites* Pot. & Kr.
  27. Genus *Zerndtisporites* gen. nov.
- Series — **Zonati** Pot. & Kr.
  28. Genus *Zonalesporites* (Ibr.) Pot. & Kr.
  29. Genus *Radiatisporites* Pot. & Kr.
- Division — **Monoletes** Ibr.
- Subdivision — **Azonomonoletes** Luber
  30. Genus *Laevigatosporites* Ibr.
  31. Genus *Latosporites* Pot. & Kr.
  32. Genus *Punctatosporites* Ibr.
  33. Genus *Verrucososporites* (Knox) Pot. & Kr.
  34. Genus *Striatosporites* Bhardwaj
  35. Genus *Torispora* Balme
- Division — **Cystites** Pot. & Kr.
  36. Genus *Cystosporites* Schopf.
- Super-division — **Pollenites** R. Pot.
- Division — **Saccites** Erdt.
- Subdivision — **Monosaccites** Chitaley
  37. Genus *Endosporites* Wils. & Coe
  38. Genus *Florinites* S.W. & B.
- Series — **Triradites** (Pant) emend.
  39. Genus *Wilsonia* Kos.
  40. Genus *Guthörlisporites* Bhardwaj
- Series — **Vesiculomonoradites** (Pant) emend.
  41. Genus *Potonieisporites* Bhardwaj
- Subdivision — **Disaccites** Cookson
- Series — **Monoradiati** ser. nov.
  42. Genus *Sahnisporites* Bhardwaj
- Series — **Sulcati** ser. nov.
  43. Genus *Kosankeisporites* gen. nov.
  44. Genus *Alisporites* Daugherty


UPPER CARBONIFEROUS GEOLOGICAL SUCCESSION OF SAARLAND
GEOLOGICAL (AFTER GOTHAN GUTHORL & HEINTZ 1943)
PERIOD
HORIZON
GROUP
STRATA
DEPTH
m
COAL SEAMS
MINES
UPPER CARBONIFEROUS
WESTPHALIAN
C
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STEPHANIAN
A
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SAARBRÜCKER GROUP
OTTWEILER GROUP
ROTHELLER SCHICHTEN
SULZBACHER SCHICHTEN
GEISHECK SCHICHTEN
LUISENTHALER SCHICH.
HEILIGENWALDER SCHICHTEN
GOTTELBORNER SCHICHTEN
DILSBURGER SCHICHTEN
HEUSWEILER SCHICHTEN
BREITENBACHER SCHICHT.
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200
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FLÖZ 1 SÜD
FLÖZ 4 SÜD
FLÖZ 12
TONSTEIN 6 FL 19 SÜD
FLOZ 36¾
TONSTEIN 5
TONSTEIN 4
FLÖZ 28
FLÖZ 15
FLÖZ 13
TONSTEIN 3
FLÖZ 9
FLÖZ 5
FLÖZ 1
GEISHECKFLÖZE
FLÖZ II R
TONSTEIN 2
FLÖZ KALLENBERG
TONSTEIN 1
0 38 ZOLL
FLÖZ BREUER
UNTERES FL JOSEFA
FLÖZ JOSEFA
FLÖZ BEUST
OBERES KOHLBACH-FLÖZ
FLÖZ EILERT
HOLZER KONGLOM.
LEAIA HORIZONT
FLÖZ KOHLENBANK
UNBENANNTES FLÖZ
GRANGELEISEN
WAHLSCHIEDER FL
SCHWALBACHER FL.
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FRANKENHOLZ
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LABACH

TABLE 1

Division — **Precolpates** Pot. & Kr.
45. Genus *Schopfipollenites* Pot. & Kr.

Among the genera newly proposed by me and described here in detail, 6 are those of which generic diagnoses (in German) have appeared in another communication (Bhardwaj, 1954) as well. For explanation of the terminology used in description refer to Potonié and Kremp (1955, pp. 9-15) and Text-fig. 1.

Super-division — **Sporites** H. Pot.
Division — **Triletes** (Reinsch) Pot. & Kr.
Subdivision — **Azonotriletes** Luber.
Series — **Apiculati** (B. & K.) Pot. & Kr.

Cyclobaculisporites gen. nov.

Pl. 1, Figs. 1-3

Genotype—Cyclobaculisporites (*Punctatisp.*) *grandiverrucosus* (Kos., 1943) comb. nov.

Generic Diagnosis — Miospores of circular shape, trilete rays distinct, low and less than $\frac{2}{3}$ spore radius in length. Exine surface thickly set with *baculae* of uniform height but widely ranging width. Each *baculum* is broad, basal diameter equal or less than apical diameter and apex truncate or with slight curvature. Interbacular spaces uniformly very narrow.

Description — Medium-sized miospores of circular shape tending to appear sub-circular in irregularly flattened specimens. Trilete apparatus functional, rays distinct, low, extending less than $\frac{2}{3}$ length of the radius (Pl. 1, Fig. 1A). *Labra* thin and appear wavy due to *baculae* which are distributed closely along the rays. Margin irregularly broken due to *baculae* which are of uniformly equal height but of widely differing width. The broadest *baculum* does not exceed twice its height in width. The *baculae* have a truncated or slightly curved top. The diameter of the base of *baculum* is less or equal to that at the top. In surface view the *baculae* are variously shaped and equidistant from adjacent ones. The interbacular spaces appear as a narrow, bright reticulum (negative) in deep focus (Pl. 1, Figs. 1A and 1C).

Comparison — *Verrucosisporites* (Ibr.) Pot. and Kr. distinguishes itself by the nature of its *verrucae* (vide Potonié & Kremp, 1955, Pl. 13, Fig. 196) which are broader at the base than at the top. In *Raistrickia* (S.W. & B.) Pot. & Kr., the nature and distribution of *baculae* is distinctly different from *Cyclobaculisporites*. *Convolutispora*, as the photograph of the diplotype (Hoffmeister *et al.*, 1955, Pl. 98, Fig. 6) shows, has pila for its sculpture. Pilate spores of this type have not been observed in strata younger than Westphalian C. One spore remarkably similar to the diplotype of *Convolutispora* has been figured by Potonié and Kremp (1955, Pl. 13, Fig. 204) as *Verrucosisporites firmus* Loose. As compared to *Cyclobaculisporites*, the ornamentation of *Convolutispora, Verrucosisporites* and *Raistrickia* is given in Text-fig. 2.

Discussion — The species comprising the genus *Cyclobaculisporites* were earlier referred to *Verrucosisporites* by Imgrund (1952). *Verrucosisporites* is a genus instituted by Ibrahim for some forms of Westphalian C. On an examination of Ibrahim's types it became clear that the *verrucae* in *Verrucosisporites* are triangular in sectional view, with a broad base and a narrow rounded apex. The structure of *baculae* in *Cyclobaculisporites* (Text-fig. 2A) is so characteristically distinct from *verrucae* of *Verrucosisporites* (Text-fig. 2C) that the former had to be separated from the latter. So far, *Cyclobaculisporites* has not been observed below uppermost Stephanian of the Saar.

The following species belong to this genus:

1. *C.* (*Punctatisp.*) *grandiverrucosus* (Kos.) comb. nov. (Pl. 1, Fig. 1).
2. *C.* (*Verrucosisp.*) *sinensis* (Imgr.) comb. nov. (Pl. 1, Fig. 2).
3. *C.* (*Verrucosisp.*) *ovimammus* (Imgr.) comb. nov. (Pl. 1, Fig. 3).

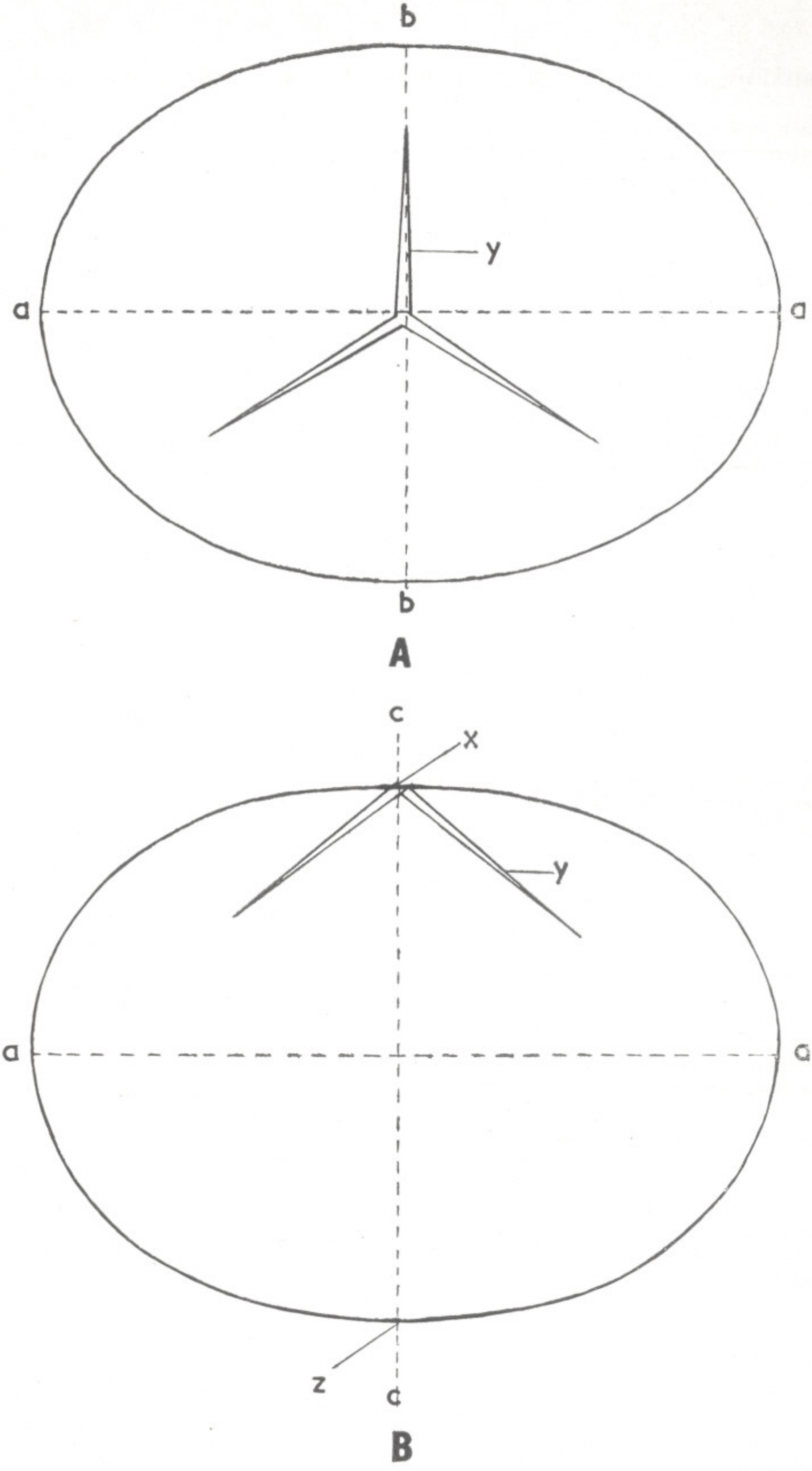
Cyclobaculisporites (*Punctatisp.*) *grandiverrucosus* (Kos.) comb. nov.

Pl. 1, Fig. 1

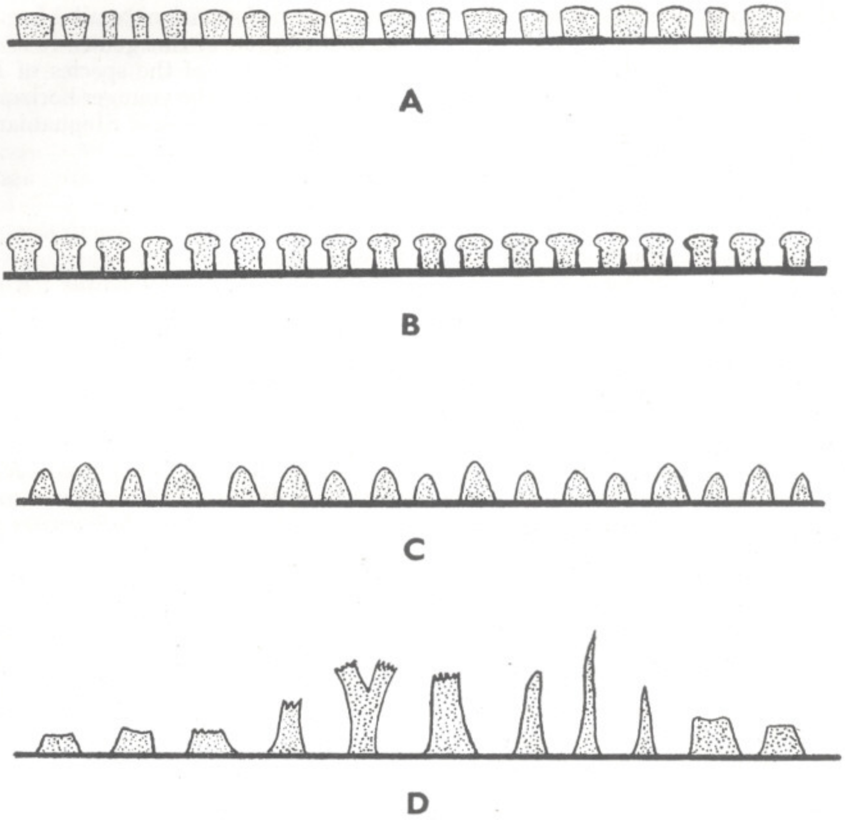
Holotype — Kosanke, 1943, Pl. 3, Fig. 4.

Diagnosis — 70-90 μ, circular, *baculae* 0·5-4 μ, mostly 2-3 μ in diameter, interbacular space not more than 0·5 μ, 70-90 *baculae* along the margin. Rays less than $\frac{2}{3}$ of the radius of the spore.

Description — Trilete, radial, circular, dark brown miospores. The margin is occupied by 70-75 *baculae* which, in the specimens from the Saar coals (Pl. 1A, Fig. 1), stand very closely together. In the largest specimens up to 90 *baculae* could be counted. Trilete mark is distinctly seen. *Vertex* and *labra* are low, partly shaded by the *baculae*. Rays 28 μ, less than $\frac{2}{3}$ of spore radius. Pl. 1, Fig. 1C, shows the unequal size and irregular shapes of *baculae* in sectional view



Text-fig. 1 — A, bilateral spore in equatorial section (plane) or polar (proximal) view. B, bilateral spore in meridional section (plane) or lateral view (a-a, equatorial axis; b-b, lateral axis; c-c, pol-axis; x, vertex; y, labra; z, distalpole).



TEXT-FIG. 2 — Sculptural elements of A, *Cyclobaculisporites*; B, *Convolutispora*; C, *Verrucosisporites*; D, *Raistrickia*.

and a $\frac{1}{2}$ μ thick *negative reticulum* which builds polygonal meshes and reflects upon the closeness of the *baculae*.

Comparison — *Cyclobaculisporites* (*Verrucosisporites*) *ovimammus* (Imgr.) comb. nov. is bigger in spore size and usually has thicker *baculae*. *C.* (*Verrucosisporites*) *sinensis* (Imgr.) comb. nov. is nearly equal in spore size but has distinctly smaller *baculae*.

Occurrence — Grenzkohlen seam (Stephanian C), Labach mine, Saar-Pfalz

Verrucosisporites (Ibr.) emend.

In view of the separation of two new genera, viz. *Cyclobaculisporites* and *Convolutispora*, from the genus *Verrucosisporites* (Ibr.) Pot. and Kr. (1954, 1955), the latter's diagnosis is emended as follows:

"Trilete iso- or microspores of circular outline and without other differentiation than the warty exoexine, its warts being closely set and often bigger than the *grana* of *Granulatisparites* but not so uniform in size. The base of wart broader than its bluntly conical or flat apex."

Series **Murornati** Pot. & Kr.

Foveolatisporites gen. nov.

Pl. 1, Fig. 4

Genotype — *Foveolatisporites* (*Punctatisporites*) *fenestratus* (Kosanke & Brokaw) comb. nov.

Generic Diagnosis — Miospores with circular outline; margin uneven due to low, smooth *muri* which are broader at the base than their height. The *muri* build a continuous *extrareticulum* enclosing oval to polygonal meshes. In the centre of each mesh a *foveola* is present. A distinct trilete mark of the normal type usually not present and instead, thickenings arranged in the form of a Y denoting the contact zone while in tetrad condition, or a vestigial Y-mark may be noticed on the proximal side. Exine thick.

Description — Brown to dark brown miospores of circular form, margin uneven, showing wavy outline due to the presence of *muri* which are triangular in vertical section. The apex of the *mura* is rounded and it is mostly less high than its width at the base. In surface view the *muri* are smooth, i.e. without any projections or teeth, and build a continuous *extrareticulum* which encloses oval to polygonal meshes. The width of the meshes at the top, from *muri* to *muri*, is up to 6 μ but at the bottom of the meshes a smaller *foveola* is usually present. When the *muri* are flattened, the outlines of the meshes become indistinct but the *foveolae* are always distinct. Trilete apparatus is seen only in traces and mostly not visible. The place of contact with other spores of the tetrad is either not at all seen or only as indistinctly raised, slightly curved lines, arranged in a Y-shape, and the *area contagionis* in such cases appears slightly depressed. In only one of the species referred to this genus, viz. *F.* (*Punctatisp.*) *foveatus* (Kosanke), the trilete mark is seen reasonably distinct although the rays are very small, unequal and curved. In this species the outlines of meshes are also not distinct but the characteristic *foveolae* are unmistakable. The exine of spores belonging to this genus is thick and normally no secondary folds are formed on flattening and neither does the spore wall rupture along the Y-mark thus denoting its vestigial nature.

Comparison — The circular form, the regular, continuous *extrareticulum* whose meshes invariably enclose a central *foveola*, and the usual absence of a distinct Y-mark distinguish *Foveolatisporites* from the genus *Microreticulatisporites* (KNOX, 1950) as emended below, which possess triangulate forms with a distinct Y-mark. *Verrucosisporites* (Ibr.) comb. nov., distinguishes itself by the presence of a distinct Y-mark and the absence of *foveolae*.

Distribution — In Saar coals, *Foveolatisporites* is restricted to Westphalian D and Lower Stephanian horizons. In Ruhr coals these are restricted to Westphalian C and in Osnabrück coals to Westphalian D. In Illinois coals, according to Kosanke (1950), this genus extends from Westphalian C to Lower Stephanian. This genus has not been reported either from Kaiping basin (China) by Imgrund (1952) or from Australia. From the information available so far on the distribution of this genus, it is apparent that the presence of the species of *Foveolatisporites* indicates the younger horizons (Westphalian C, D and Lower Stephanian) of the Upper Carboniferous.

The following species are assigned to *Foveolatisporites*:

1. *F.* (*Punctatisp.*) *fenestratus* (Kos. & Brok.) comb. nov.
2. *F.* (*Punctatisp.*) *foveosus* (Kos.) comb. nov.
3. *F.* (*Punctatisp.*) *quaesitus* (Kos.) comb. nov.
4. *F.* (*Punctatisp.*) *foveatus* (Kos.) comb. nov.

Two other species, namely *Reticulatisporites irregularis* Kos. (1950) and *R. magnus* Butt. and Will. (1954), appear to combine the characters of *Foveolatisporites* and *Reticulatisporites*.

Foveolatisporites (*Punctatisp.*) *fenestratus* (Kos. & Brok.) comb. nov.

Pl. 1, Fig. 4

1950 — *Punctatisporites fenestratus* sp. nov. Kosanke and Brokaw in Kosanke (1950) — Ill. Geol. Surv. Rept. Invest. 74, p. 15.

1954 — *Microreticulatisporites* (*Punctatisp.*) *fenestratus* (Kos. & Brok.) Butt. and Will. (1954)— Ann. Mag. Nat. Hist. Ser. 12, Vol. VII, p. 755.

1955 — *M.* (*Punctatisp.*) *fenestratus* (Kos. & Brok.) Butt. and Will. in Potonié and Kremp (1955)— Palaeontogr. 98B. p. 98.

Holotype — Kosanke 1950, p. 15, Pl. 2, Fig. 10.

Diagnosis — Size 68-90 μ, circular, margin with 70 *muri*, each *mura* 1·5 μ high with rounded apex. *Foveola* in the meshes 2-3 μ in diameter and oval to polygonal. Y-mark not visible but instead three curved ridges, probably representing the contact ridges of the tetrad, faintly discernible.

Description — Circular dark brown miospores. Margin wavy due to *muri* which are triangular in sectional view having 1·5 μ broad base. The *muri* are 1·5 μ high and have rounded apices. In surface view the *muri* build a closed network, each mesh including in its centre a *foveola*. A distinct Y-mark has never been seen and presumably does not occur in these spores. Frequently three contiguous depressions with the region between them slightly raised in the form of a Y is all what represents a trilete mark. Exine is thick and may occasionally be folded along the periphery in flattened fossil spores.

Occurrence — Westphalian D — Stephanian A (Saar).

Discussion — Potonié and Kremp (1955) have described a number of circular forms in *Microreticulatisporites*, e.g. *M. microtuberosus* (Loose), *M. reticuloides* (Kos.), *M. sifati* (Ibr.) and *M. verus* n. sp., none of which resembles the type of the species constituting *Foveolatisporites*. At the same time I suspect that in all these species there does not exist any real *extrareticulum* as the *muri* are not continuous and what appears as *reticulum* is mostly due to coalescence of *verrucae*. It is for this reason that what are identified as *muri* are wavy and the meshes are elongated, curved and of various other sorts (*see* POTONIÉ & KREMP, 1955, PL. 15, FIG. 281c). In my opinion it is preferable to refer *M. microtuberosus* (Loose), *M. reticuloides* (Kos.), *M. sifati* (Ibr.) and *M. verus* (Pot. & Kr.) to *Verrucosisporites* (Ibr.) comb. nov.

Microreticulatisporites (Knox) emend.

Genotype: — *Microreticulatisporites lacunosus* (Ibr.) Knox, 1950.

Generic Diagnosis — Trilete miospores, shape triangular, exine *extrareticulate*, *reticulum* toothed and enclosing small meshes whose diameter does not exceed 3 μ. Mostly the meshes are smaller. Trilete mark distinct and well developed.

Division — **Zonales** (B. & K.) Pot. Kr.
Subdivision — **Auritotriletes** Pot. Kr.
Series — **Auriculati** (Schopf) Pot. Kr.

Savitrisporites gen. nov.

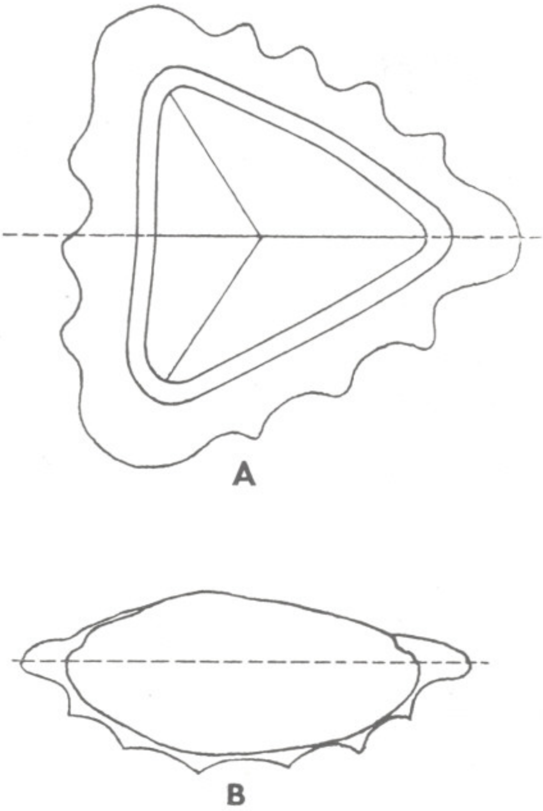
Pl. 1, Fig. 5

Genotype — *Savitrisporites triangulus* sp. nov.

Generic Diagnosis — Triangular miospores having broad angles. Trilete mark distinct, rays not reaching equator but ending at the inner margin of a prominent *cingulum*. Exine irregularly thickened, glossy on the proximal surface but ornamented on the distal side. The angles are slightly thickened.

Description — Triangular, dark brown miospores, having rounded or broadly flattened angles. Sides are straight but crenate in outline due to broad sculpture on dorsal and lateral sides. Proximal side bears a distinct trilete mark, *apex* and *vertex* low, *labra* thin and rays ending at the inner margin of a wide *cingulum* (TEXT-FIG. 3A). The ends of rays are neither broadened nor bifurcated. *Cingulum* wide, up to one fifth diameter of the spore, being broadest at the angles where the exine shows darker colour apparently due to greater thickness. The exine on proximal side is unornamented, transparent and glossy. On distal side the exine is heavily sculptured having large *coni* which frequently join each other into short ridges (TEXT-FIG. 3B).

Comparison — In view of the angular thickening and triangular shape I refer it to the Series *Auriculati* (Schopf) Pot. & Kr. The presence of *cingulum* makes it equally eligible for inclusion in series *Cingulati*. This form cannot belong to series *Zonati* as the *cingulum* is thick. As compared to the other



TEXT-FIG. 3 — A, polar view; B, lateral view.

miospore genera of these series the form under consideration is distinctly different. *Rotaspora* Schemel is not only very small but also its *cingulum* is more developed in between the angles than along them, a condition which is just opposite to what is found here. As compared to *Simozonotriletes* (Naumova) Pot. & Kr., *Savitrisporites* differ in having *crenate* sculpture on the distal and lateral sides, otherwise it agrees with *Simozonotriletes* in other details. In view of the development of thickening on the angles, this form can be compared to *Triquitrites* from which it differs in having a continuous *cingulum* all round. Therefore, I regard this form as a new genus, naming it in honour of Mrs. Savitri Sahni, President of the Palaeobotanical Society and the Governing Body of Birbal Sahni Institute of Palaeobotany, Lucknow (India).

Discussion — Morphologically, the presence of *cingulum* is a noteworthy characteristic. The *cingulum* is a continuous broad band outside the germinal area, as the trilete rays do not continue over it. This condition is different from many cingulate genera grouped under *Cingulati*. A more significant combination of features is the triangular shape and the thickening on the angles which suggest close morphographic affinities with *Triquitrites*. I consider the characteristics in *Savitrisporites* to have originated as a result of extreme specialization in some variation of *Triquitrites* comparable to that found in *Tripartites*.

Savitrisporites triangulus sp. nov.

Holotype — Pl. 1, Fig. 5.

Diagnosis — Size 53-65 μ, holotype 60 μ; triangular miospores with rounded angles, Y-mark distinct, lips very thin and low, rays 25 μ long, *vertex* and *contravetrex* not visible. Spore body with equatorial, 5-6 μ broad, continuous *cingulum* which is slightly more developed at the angles. Distal side strongly sculptured bearing *coni* united together in the form of peaked ridges.

Description — Brown, triangulate spores with straight sides and broadly rounded angles. Spore is surrounded by a continuous, thick equatorial *cingulum* which is toothed along the sides and appears more developed at the angles being darker and denser in this region. The Y-mark is very distinct but the rays are very slender and extend right up to the *cingulum*. Between the rays the exine is smooth and appears to be thin as compared to the *cingulum* where it is darker. The distal side is strongly sculptured having peaked ridges.

Occurrence — Stephanian A (Saar).

Sub-division — **Zonotriletes** Waltz.
Series — **Cingulati** Pot. & Klaus.

Gravisporites Bhardwaj (1954)

Pl. 1, Fig. 6

Genotype — *Gravisporites sphaerus** (Butt. & Will.) Bhardwaj (1954, TEXT-FIG. 2).

Generic Diagnosis — Oval to cyclo-triangulate. Miospores with massive, equatorial *crassitudo*. Trilete mark with thick straight rays not extending up to the equator; vertex higher than the width of *tecta*. Exine, apart from the *crassitudo*, thin; over all ornamented with closely spaced, fine *grana*.

Description — Brown, medium-sized miospores of roundly triangular oval to subcircular shape. Trilete mark prominent due to dark colouration of its heavy rays. Rays do not reach the equator but end subequatorially. *Labra* broad, apex and vertex high, the latter ending abruptly a short distance behind the equator. Along the margin, a broad, dark and dense zone of 5-10 μ width is seen. In between this peripheral, dense zone and the darkened trilete rays, the exine is translucent and lighter in colour. Evidently the peripheral zone is darker due to the heavily thickened exine in this region (TEXT-FIG. 5). On the distal side, beyond the dense peripheral zone the exine is thin. The surface ornamentation consists of minute, densely placed *grana* with irregularly interspersed groups of large *verrucae*.

Reconstruction — The usually polar flattening suggests a smaller polaxis than equatorial axis. The same conclusion is also conveyed by the presence of a narrow fold on the distal side of spores indicating small curvature of the distal side (*see* figures of diplotype — BUTTERWORTH & WILLIAMS, 1954). The secondary fold on distal side never extends to the equator but ends at the inner margin of the dense peripheral

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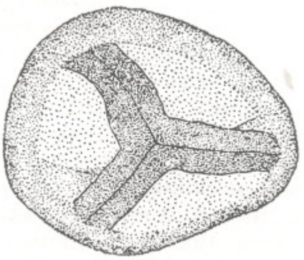
*I take this opportunity to correct the ending in the specific name which was published earlier (BHARDWAJ, 1954) as *sphaera*, to *sphaerus* in keeping with the generic name *Gravisporites*.

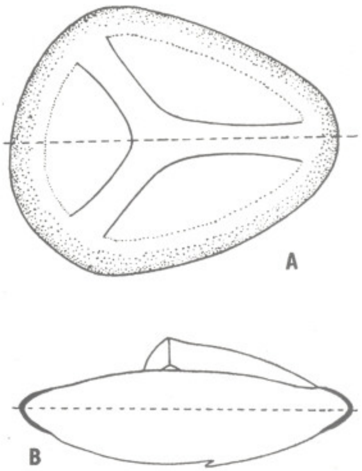
zone (TEXT-FIG. 4) indicating that the exine, in the denser equatorial zone, is thicker and hence the fold does not extend through it. The thickened nature of exine along the equator is also suggested by the dense and dark appearance of this zone like that of the elevated rays of trilete mark.

Comparison — The broad and elevated trilete apparatus and the broad peripheral thickened zone are the most characteristic distinguishing features of this genus. Some miospores at present included in *Planisporites* also have subequatorially thickened spore wall (*Crassitudo*) but lack the elevated and prominent trilete mark. *Cadiospora* Kosanke differs in having a broad equatorial *cingulum* and broad rays with bifurcated ends. The latter character, as concluded by Kosanke, suggests that the equatorial zone is constituted by thickened arcuate ridges. Unfortunately the morphology of the equatorial zone is not clearly described by Kosanke, still from what can be made out of the photograph of the genotype, it appears that the thickening is more prominent towards the inner side rather than along the equator where it is distinctly thin, implying thereby that such an equatorial thickening could not be of the nature of *crassitudo* as is met with in *Gravisporites*. The *cingulum* in *Cadiospora* is more of the type met with in *Lycospora*.

Discussion — The sub-triangulate shape and smaller polaxis brings this genus near to other triangulate genera as *Triquitrites*, *Savitrisporites* and the like. The sub-equatorial thickening of the exine is comparable to the sub-equatorial *cingulum* observed in some megaspore genera, e.g. *Bentzisporites*. Although apparently this genus indicates some relation to *Cingulati*, still its inclusion within the latter should preferably be treated as provisional.



TEXT-FIG. 4



TEXT-FIG. 5 — A, polar view; B, lateral view.

Angulisporites Bhardwaj (1954)

Pl. 1, Figs. 7, 8

Genotype—*Angulisporites splendidus* Bhardwaj (1954, TEXT-FIG. 4).

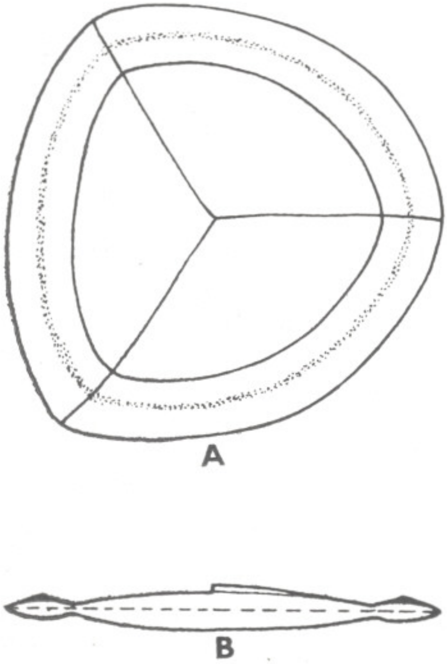
Generic Diagnosis — Triangular miospores with broad equatorial *cingulum*. Angles bluntly pointed and sides convex. Trilete mark with thin, straight rays reaching up to the equator of the *cingulum*. Exine ornamented with *grana*.

Description — Triangular, bright brown miospores having bluntly pointed angles and convex sides. Central body denser, of the same outline as the shape of the spore and distinctly demarcated by a thin line from a peripheral, uniformly broad, lighter coloured *cingulum*. Trilete mark distinct and always seen without difficulty. *Apex* and *vertex* slightly elevated, *labra* little developed, rays straight and extend to the equator of the *cingulum* reaching the tip of the angles. The median region of the *cingulum* shows a subperipheral, darker, dense line which glistens and is evidently due to greater thickening of the exine in the middle of the *cingulum*. Exine translucent, minutely granulate or rugate and mediumly thick.

Reconstruction — The separation of the central body from the surrounding *cingulum* by a well-defined line and also the difference in the density and colour of the two parts leave no doubt that these are distinct from each other (TEXT-FIG. 6A). That in such cases where the spore shows secondary folds, these should be restricted to the central body, suggests that the body is not continuous with the *cingulum*. The *cingulum*, which is never folded, is presumably solid. The glistening, sub-peripheral thickening in the middle of the *cingulum* denotes that the latter is pyramidal in cross-section (TEXT-FIG. 6B).

Comparison — Among the triangular, cingulate miospore genera, none corresponds to such simple structure as described here. *Galeatisporites* Pot. & Kr. has a dissected *cingulum* with large *coni* and *Mirisporites* Pot. & Kr. has a broad *cingulum* of wavy outline, having large peg-like radial outgrowths extending into the *cingulum*. *Cirratriradiates* Wils. and Coe has a radially striated *cingulum* with dentate margin and thick, heavy central body with characteristic depressions on the distal side. Another morphographically comparable genus is *Triangulatisporites* which, however, is a megaspore.

Discussion — The *cingulum*, in view of its individualistic nature, appears to be equatorial although still forming a part of the trilete apparatus. Morphographically the genus appears to be highest evolved of all cingulate genera. The variable characteristics of taxonomic importance are overall size and greater width of the *cingulum* in proportion to spore radius.



TEXT-FIG. 6 — A, polar view; B, lateral view.

Zerndtisporites gen. nov.

Pl. 1, Figs. 9, 10

Genotype — *Zerndtisporites* (*Triletes*) *laxomarginalis* (Zerndt) comb. nov.

Generic Diagnosis — Trilete megaspores with an equatorial, very broad, delicate and thus usually broken, *cingulum*. Central body sub-circular or circular. Trilete rays distinct, not high and not extending into the *cingulum*. Exine brownish, matt and sculptureless.

Description — Trilete, medium-sized megaspores of presumably circular or triangular shape. The spore possesses a delicate, wavy, very broad *cingulum* along the equator. This *cingulum* has never been found completely preserved as it crumbles easily. Central body is sub-circular or circular. Trilete rays distinct and ending at the margin of central body. *Tecta* usually open, *labra* flattened and slightly wavy. Exine brownish, 10-20 μ thick, having matt and sculptureless surface. Sometimes small swellings have been observed on distal surface of the spores which are not original.

Comparison — *Triangulatisporites* Pot. & Kr. distinguishes itself through the extension of its *tecta* into the *cingulum* as well as the radially striated sculpture on proximal side and reticuloid sculpture on distal side. *Triangulatisporites* is also smaller in size. *Zonalesporites* shows a sub-equatorial, radially striated *zona* in which the trilete rays extend to the margin. *Zonalesporites glaber* Pot. & Kr. has a wide, wavy, sculptureless *zona*, but it is thick and heavy as well as the trilete rays extend into it.

Discussion — This spore was described by Zerndt (1940) from the Saar basin and has not been reported from any other basin so far. Zerndt supposed the organization of this spore to be like *Triangulatisporites* (*T. triangulatus* Zerndt) so much so that he did not assign this spore any new type and retained it as a form of Type 17 (17a). For stratigraphic considerations *Z. laxomarginalis* was always considered by Zerndt as included in *T. triangulatus* (Type 17). From the redescription of this spore it is evident that it is quite distinct from *Triangulatisporites*, the chief distinction being in the nature of the *cingulum* in the two cases. The extension of the trilete rays into the *cingulum* in *Triangulatisporites* and their restriction to the central body in *Zerndtisporites* gives a different morphological status to the *cingulum* in these two contending genera. It may be interpreted that whereas the *cingulum* in *Triangulatisporites* is a modification of arcuate ridges and thus a part of germinal features, in *Zerndtisporites* it has no such relation and is presumably an independently developed equatorial extension (perisporial ?).

Zerndtisporites (*Triletes*) *laxomarginalis* (Zerndt) comb. nov.

Pl. 1, Figs. 9, 10

1940. *Triletes laxomarginalis* n. sp.; Type 17a. Zerndt. Palaeontographica. Bd. LXXXIV, Part B, p. 136, Pl. X, Figs. 24-28.

1944. *Triletes laximarginalis* Zerndt. Schopf, Wilson and Bentall. Illinois Geol. Surv. Rept. Invest. 91, p. 23. (The difference in the spelling of the specific name as compared to the original, apparently, is due to an error in printing.)

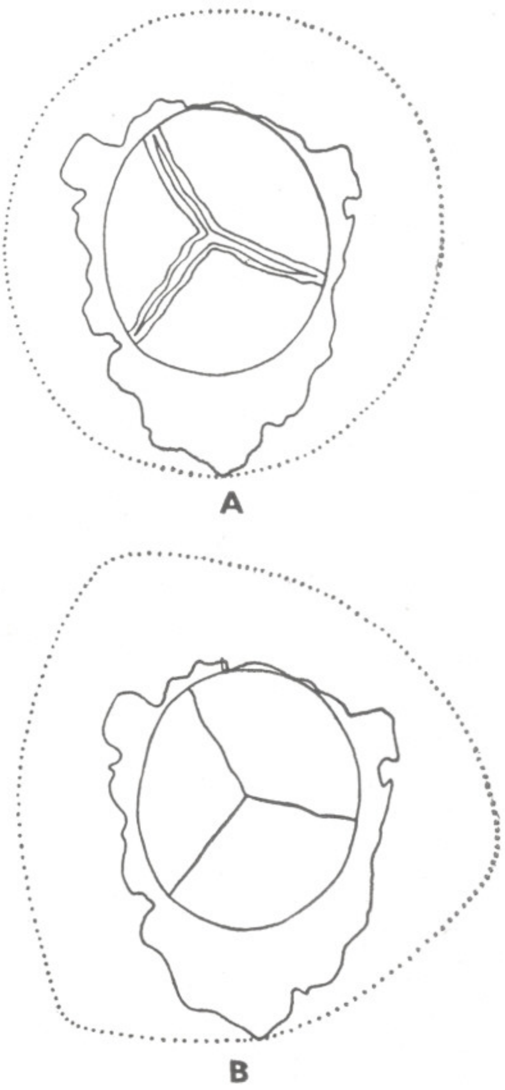
1946. *Triletes laxomarginalis* Zerndt. Dijkstra *et al.* Medeelingen Geol. Sichting. Serie C-III-1-Nr. 1, p. 54.

Holotype — Zerndt, 1940, Pl. 10, Fig. 28.

Diagnosis — Spore diameter 1·1-1·4 mm.; holotype 1·38 mm., central body oval to circular, surrounded equatorially by a broad membraneous and wavy *cingulum* but without regular radial streaks. So far, in all the macerated specimens, *cingulum* has always been found to be fragmented and evidently membraneous and fragile. From a comparison of all specimens found by me and also from the illustrations of Zerndt (1940), it is evident that the *cingulum* is equally broad all around the central body and the spore apparently had either an oval-circular or triangular outline (TEXT-FIG. 7A and B). The width of the *cingulum* must have been at least $\frac{2}{3}$ the radius of the central body. The trilete rays reach up to the edge of the central body. The *labra* are mostly a little meandering presumably due to raised nature of *tecta*. Arcuate ridges not discernible. The surface, especially of the central body, is so finely verrucose as to appear almost smooth by normal (× 50) magnification. The *cingulum* is also of similar sculpture.

Occurrence — Seam D, Mine Reden-Flamm, Saarland.

Division — **Monoletes** Ibr.
Subdivision — **Azonomonoletes** Luber.



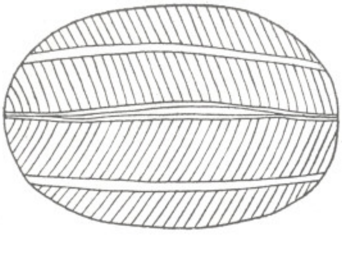
TEXT-FIG. 7.

Striatosporites Bhardwaj (1954)

Pl. 2, Fig. 11

Genotype — *Striatosporites major* Bhardwaj (1954, TEXT-FIG. 6).

Generic Diagnosis — Monolete spores, equatorial form ovaloid, meridian form bean shaped; monolete mark straight and extending up to the equator. *Extrema lineamenta* sparsely notched. Canaliculate canals are of two kinds, firstly, some broader ones which run parallel to monolete mark, and secondly, many thin ones which run across, between the broad canals.



TEXT-FIG. 8.

Description — These spores are among the largest of the monolete spores so far described. Usual shapes are elliptical, subcircular or bean shaped, depending upon the plane of flattening. Monolete mark seems to extend from one end to the other although the functional part is not more than three-fourths of the length of the spore. *Labra* is little developed. Exine translucent, yellowish brown and is strongly folded on being flattened. These secondary folds run in all directions. The surface is ornamented in two series including the fewer and broader band-like canals extending longitudinally, parallel to the monolete mark, from one end to the other and the more numerous, thinner canals obliquely extending from one of the broad canals to the other (TEXT-FIG. 8). Both series of ornamentation are more distinct and pronounced in the middle region of the spore. The canals are lighter in colour than the spore exine. Each canal corresponds to a groove or an indentation, seen at the margin.

Comparison — None of the Palaeozoic, monolete spore genera shows a comparable ornamentation as described for *Striatosporites*. The genus *Cicatricososporites* Pot. & Gell., also has canaliculate structure but the canals run parallel to the long axis only and they are of one kind. The genus *Cicatricososporites* is known only from Cretaceous (WEYLAND & KRIEGER, 1953) and Tertiary (THOMSON & PFLUG, 1953).

Discussion — This spore may be precursor of the younger genus *Cicatricosoprites* and the forms similar to this.

Super-division — **Pollenites** R. Pot.
Division — **Saccites** Erdtman.
Subdivision — **Monosaccites** Chitaley.
Series — **Triradites** (PANT, 1954) emend.

Series Diagnosis — Trilete miospores with well-developed Y-mark on proximal side, rays not extending beyond central body. Bladder without equatorial or sub-equatorial thickening or a *limbus*.

Guthörlisporites Bhardwaj (1954)

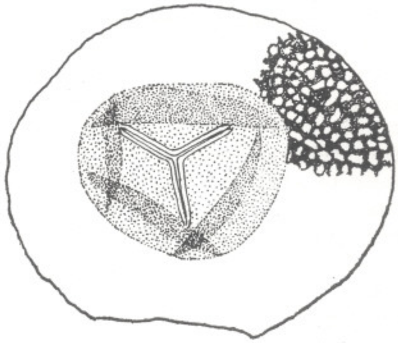
Pl. 2, Fig. 12

Genotype — *Guthörlisporites magnificus* Bhardwaj (1954, TEXT-FIG. 8).

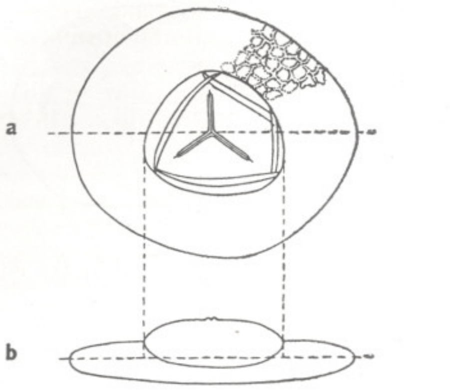
Generic Diagnosis — Circular to oval miospores. Central body distinctly recognizable and circular to oval; wall strongly folded. Proximal side of central body free, showing a distinct Y-mark; rays extending more than ½ radius of central body but never reaching its margin. Bladder *intrareticulate*, without a *limbus* or an equatorial, thickened zone. Bladder wall mostly without folds.

Description — Trilete, circular, broadly elliptical or oval miospores of large size. Central body circular or sub-circular with many peripheral secondary folds, dark brown in colour and bearing a distinct trilete mark (TEXT-FIG. 9). *Vertex* and *apex* low, labra slightly elevated, rays straight and extending up to two-thirds of the radius of the central body. Bladder continuous all around, covering the central body but for the free proximal side bearing the trilete mark. Surface of bladder *laevigate*, internal surface *intrareticulate* enclosing small meshes. On flattening, the bladder does not fold. The margin of the bladder lacks a *limbus* or a marginal thickening.

Reconstruction — In view of the well-developed trilete mark borne by the central body it seems that the proximal side of the spore is free, the bladder covering the distal side. The many small or large secondary folds observed in the wall of central body



TEXT-FIG. 9 — Line drawing of the diplotype. × 500.



TEXT-FIG. 10 — a, polar view; b, lateral view.

are suggestive that the central body is ± spherical having strong curvature in its wall. To accommodate this curvature on flattening, the wall was folded into a number of semi-lunar folds along the periphery of the central body (TEXT-FIG. 10).

Comparison — *Florinites* lacks a distinct trilete mark, the central body is free on distal side and is very thin walled as well as faintly distinguishable. In *Endosporites* the wall of the central body is not secondarily folded, trilete rays extend beyond central body, the bladder has a *limbus* and the structure of the bladder wall is finer. *Wilsonia* has a very faintly discernible central body.

Discussion — The genus appears to be allied to such monosaccate genera as *Wilsonia* and *Schulzospora*. *Endosporites* and *Microsporites*, which possess equatorial extensions what have been called *limbus* (POTONIÉ, 1952) or thickening (CHALONER, 1953), are, evidently, morphologically different from *Guthörlisporites*.

Series — **Vesiculomonoradites** (Pant) emend.

Series Diagnosis — Miospores with one bladder and a monolete slit of dehiscence.

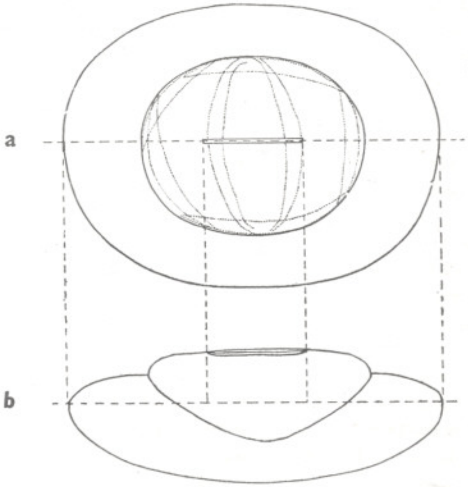
Potonieisporites Bhardwaj (1954)

Pl. 2, Figs. 13, 14

Genotype — *Potonieisporites saarensis* Bhardwaj (1954, TEXT-FIG. 10).

Generic Diagnosis — Monosaccate miospores with an elliptical or oval outline and a monolete rectilinear slit running parallel to the long axis. Central body oval to circular. Bladder *intrareticulate*.

Description — The spores belonging to this genus are monosaccate and bilateral having a monolete suture as the germinal mark. The spore has mostly been observed to have flattened in a transverse plane with the germinal features fully observable in a polar view and the shape of the flattened spore is always broadly oval to sub-circular. Rather regular flattening of the spore in transverse plane apparently suggests that the spore, before fossilization, was elliptical in sectional view (TEXT-FIG. 11). The central body is thin walled and translucent, of light brown colour and in flattened condition it is usually more rounded than the spore outline although still retaining its elliptical nature. Due to flattening, the wall of the central body is folded secondarily, but with surprising regularity, into two series. The folds of the first series run along the margin of the central body indicating strong curvature of the body wall in that region or near it where the central body joins the bladder. The folds of the second series are located nearer the centre of the spore, are usually biconvex or elliptical in outline but with their longer axis along the lateral axis of the spore. The occurrence of these folds suggests a greater curvature in the wall of the central body in the distal region and, presumably, to accommodate this on flattening, these folds have been formed. The positions of these curvatures in the body wall are represented in Text-fig. 11, as would be seen in polar and sectional views. The bladder is *laevigate* on the surface but *intra-*



TEXT-FIG. 11 — a, polar view; b, lateral view.

reticulate on the inner surface. The margin of the bladder in flattened condition does not show a *limbus*.

Comparison — The distinguishing features of this miospore are the monolete mark, free proximal side and the characteristic two series of secondary folds which distinguish it from all the monosaccate genera described by Potonié and Kremp (1954). Among the spore forms described by Virkki, spore 38 (1946, Pl. 10, Figs. 135, 136) and spore 59 (Pl. 14, Fig. 187) seem to have somewhat similar structure as this genus but the descriptions and illustrations are too poor to decide their true taxonomic position. Spore type 33b of Dulhunty (1946) is a monolete monosaccate spore. On the other hand, spore 52 (Virkki, 1946, Pl. 5, Fig. 49; Text-fig. 30, p. 122) shows comparable secondary folds but lacks the monolete suture and instead, as stated by Virkki, the body is supposed to show a trilete mark.

Discussion — This genus indicates the presence of monosaccate miospores with monolete suture among the *Monosaccati* as well. Its relationship to other monosaccate genera is obscure. It is very likely that this spore genus persisted through the Permian as forms closely similar to this genus are on record from the Permian of India and Australia.

Balme and Hennelly (1955) describe a new saccate miospore genus showing a monolete suture on the central body (Balme & Hennelly, 1955, Pl. 6, Fig. 54) as *Vestigisporites*. These spores, as is evident from the figures, are distinctly bisaccate. The exoexine on the lateral faces of the central body is often thickened and simulates a connective between the bladders which separate the tow opposite bladders distinctly.

Subdivision — **Disaccites** Cookson

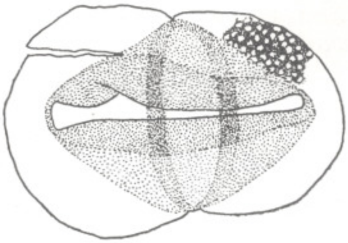
Series — **Monoradiati** ser. nov.

Series Diagnosis — Miospores with two distally inclined bladders and possessing a *sulcus* on the proximal side of the central body lying along the long axis of the spore.

Sahnisporites Bhardwaj (1954)

Pl. 2, Fig. 15

Genotype — *Sahnisporites saarensis* Bhardwaj (1954, Text-fig. 12).



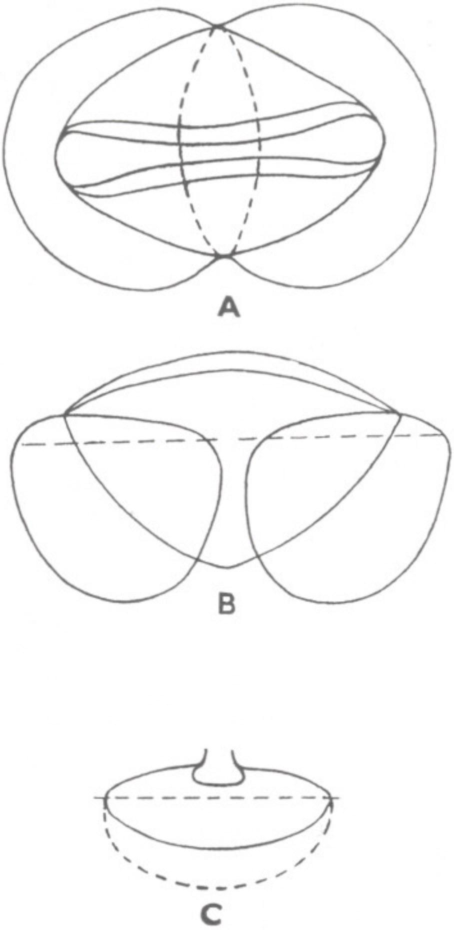
Text-fig. 12 — Line drawing of the diplotype. × 500.

Generic Diagnosis — Bisaccate miospores without trilete mark. Central body tetragonal in polar view and elliptical in equatorial view. One side of central body having a *sulcus* (*Ruga* — sensu R. Pot. 1934) along the long axis. The sides of *sulcus* elevated. The *intrareticulate* bladder attached to the central body, equatorially on the proximal side but strongly approaching each other on distal side. The distal lines, of bladder attachment to the central body, are seen as oval ring of bands in polar view.

Description — Bilateral, bisaccate miospores of medium size. No trilete or monolete mark is to be seen. Central body tetragonal in outline and darker in colour than the sacs. Running the entire length of the central body, parallel to the equatorial axis is a *sulcus* with highly elevated sides (Pl. 2, Fig. 15; Text-fig. 12). The bottom of the *sulcus* is structureless and more translucent than the rest of the body wall. The two bladders are equatorially attached and laterally the edges of the two bladders approach each other very closely. In the median region of the spore a ring-like biconvex band of darker colour is seen extending laterally. The exine of central body is matt. The bladders are finely *intrareticulate*.

Reconstruction — As already pointed out, the central body is totally free from the bladders on the side which bears the *sulcus*. The zone of bladder attachment on this side is along the equator of the central body. At the ends of the lateral axis, the two bladders approach each other very closely. The biconvex ring like bands, as seen in polar view, though seem to be lying across the *sulcus* still do not distort it. Evidently these bands are on the side opposite of the one bearing the *sulcus*. These bands originate from the median region on lateral side where the two bladders approach each other very closely. Apparently these bands are the secondary folds along the zone of attachment of bladder to the body wall, on the side opposite to the *sulcus*. The small distance between the two bands as compared to the length of the central body indicates that the bladders were strongly inclined evidently on distal side, the *sulcus* being on the proximal side (*see* TEXT-FIG. 13).

Comparison — *Lueckisporites* Pot. & Klaus distinguishes itself by the presence of one or more fissures and not a *sulcus* on the proximal side. The bladders in *Lueckisporites* are also too widely separated on distal as well as lateral sides. *Pityosporites* (Sew.) Pot. & Kr. distinguishes by the absence of any *sulcus* on the proximal side. Other bisaccate genera, e.g. *Vesicaspora* Schemel (1951) and *Alisporites* Daugherty (1943), also lack the equatorially elongated *sulcus* on the proximal side.



TEXT-FIG. 13 — A, equatorial section; B, meridional section; C, lateral section.

Discussion — The organization of this miospore shows a unique combination of features distinguishable from all other bisaccate genera described so far. *Vestigisporites* differs by having a monolete slit rather than a *sulcus*. *Sahnisporites* does not belong either to the group including *Vesicaspora*, *Pityosporites* and *Lueckisporites* or to that including *Alisporites* and *Kosankeisporites* but forms a distinct group of its own.

Series — **Sulcati** ser. nov.

Series Diagnosis — Miospores with two distally inclined bladders and possessing an elongated *sulcus* lying on the distal side of the central body, between the zones of bladder attachment.

Kosankeisporites gen. nov.

Pl. 2, Figs. 16A, B, C, D; 17

Genotype — *Kosankeisporites* (*Illinites*) *elegans* (Kosanke) comb. nov.

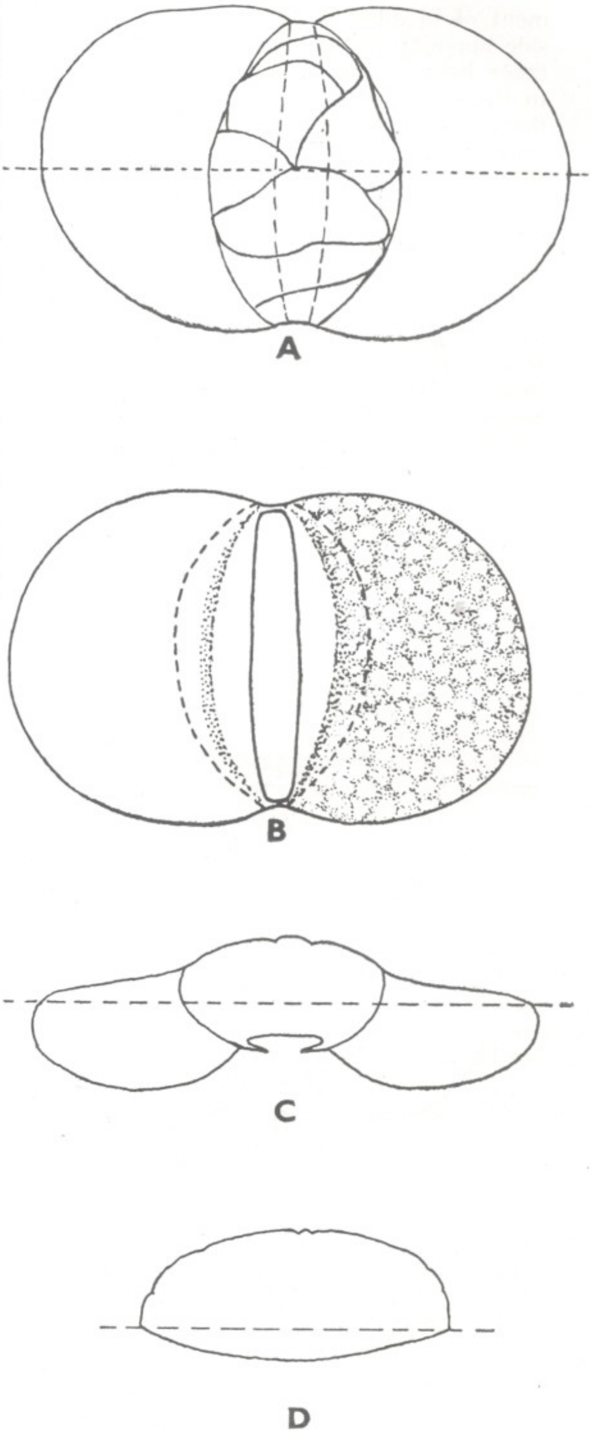
Generic Diagnosis — Bisaccate miospores without trilete mark. Bladders *intrareticulate*, equatorially attached to central body on proximal side but approaching each other on distal side thereby distally inclined. Central body ellipsoid with a longer lateral axis and narrower equatorial axis, having a deep narrow *sulcus* on the distal side parallel to the lateral axis. The *sulcus* is equally broad along most of its length, narrowing a little near the ends and its floor is without any special structure. The proximal side of the central body bears a few *rugulae* (grooves, as observed by L-O analysis), running irregularly in a zigzag pattern.

Description — Bisaccate, bilateral miospores, usually flattened in equatorial plane. The bladder is attached to the central body along the equator on the proximal side (PL. 2, FIG. 17) but the line of bladder attachment on distal side lies between the edges of the *sulcus* and the equator of the central body (PL. 2, FIGS. 16C, D). The bladders approach each other closely on the lateral equator where they appear to be connected by a narrow connective of exoexine. The upper surface of the bladder is *laevigate* but the under surface is *intrareticulate* having meshes not exceeding 1μ in diameter. The reticulation appears to have *muri perfectae.* Central body, usually well demarcated by its dark brown colour, has ellipsoid shape and is characterized by the presence of a narrow *sulcus* on the distal side (TEXT-FIG. 14C). The floor of the sulcus is lighter in colour than the rest and has no special germinal structures. The proximal side of the central body shows *rugulae* which are notched grooves running irregularly in a zigzag manner (PL. 2, FIGS. 16A, B, 17).

Reconstruction — The usual equatorial plane of flattening as well as bilateral form are suggestive of an oblong miospore in original condition having small polaxis. The edges of the *sulcus* being raised and straight, converging only near the ends and the thinner exoexine of the floor of the *sulcus,* suggest that the latter is a definite structural feature and not formed by overlapping of the body wall by the bladder. On the same side which bears the *sulcus* the bladders are attached to the central body midway between the edges of the *sulcus* and the equator of the central body and thus are more inclined towards each other. On the opposite side, the zone of bladder attachment lies along the equator of the central body.

On the analogy of the occurrence of inclined bladders in comparable coniferous pollen on the distal side I presume that the *sulcus* in this spore lies on the distal side. On the other side, i.e. the proximal side, the central body is wholly free from the bladder and has zigzag *rugulae* which, by their constant occurrence in all the forms examined so far, constitute a valuable diagnostic feature. A reconstruction of the genus in various planes, based on the deductions discussed above, is given in Text-fig. 14.

Comparison — *Alisporites* distinguishes itself by the presence of a laterally elongated *suture* (instead of a *sulcus*) on the distal side, absence (?) of distal inclination of the bladders and the occurrence of a rounded central body. *Alisporites* also lacks the zigzag *rugulae* on the proximal side. *Parasporites* and *Illinites* distinguish themselves by having trilete mark on the proximal side, lack of the *sulcus* on distal side, of distal inclination of the bladders and of zigzag *rugulae* on the proximal side. *Pityosporites* (Sew.) Pot. & Klaus has a rounded or equatorially elongated central body and lacks the *sulcus* on the distal side and zigzag *rugulae* on the proximal side. *Lueckisporites* and *Sahnisporites* have a round or equatorially elongated central body and one or



TEXT-FIG. 14 — A, equatorial section (proximal); B, equatorial section (distal); C, meridional section; D, lateral section.

more than one *laesurae* or a *sulcus* respectively, lying along equatorial axis on the proximal side and they lack the distal *sulcus*. The *laesurae* of *Lueckisporites* and the zigzag *rugulae* of *Kosankisporites* appear to have some aspects in common. *Vesicaspora* lacks the *sulcus* on distal side and zigzag *rugulae* on the proximal side.

Discussion — Kosanke (1950, p. 52; PL. 1, FIGS. 1-2) described the genotype of *Kosankeisporites* as a species of *Illinites*, interpreting the zigzag *rugulae* as a trilete mark and the *sulcus* having been formed due to overlapping of the bladder upon the central body. The holotype from Illinois and other similar examples from Saar revealed on examination that none of these conclusions of Kosanke (loc. cit.) with regard to the structure of this spore were tenable. The diplotype is an equatorially flattened specimen with distal side up, showing the *sulcus* in highest focus and the zigzag *rugulae* in lowest focus. In some of the specimens from the Saar which were ideally flattened (PL. 2, FIG. 17), the proximal side was up and showed the real nature of *rugulae* clearly in high focus and the *sulcus* in low focus. Whereas the distally inclined attachment of the bladders was not clear from the Saar specimens, this was clearly established from a study of the diplotype. A close examination of the *rugulae* on the proximal side reveals that these are grooves of uniform width and lack anything like a *tectum*. The *sulcus* on distal side is a narrow, elongated channel (PL. 2, FIG. 16C, TEXT-FIGS. 14B, C). The zone of bladder attachment is distinctly seen to lie beyond the edge of the *sulcus* (PL. 2, FIGS. 16c, d) and hence the latter cannot be supposed to be formed by the overlapping of the bladder upon the central body. This spore combines a set of features, e.g. the distal *sulcus*, lack of trilete mark, the presence of *rugulae* on proximal surface of the central body, a laterally elongated central body and distally inclined bladders which constitute an association so far not known from any of the described genera. The apparently functional nature of the *sulcus* on distal side suggests affinities with *Alisporites* although the latter appears to be less specialized. On the other hand, *Pityosporites* (Sew.) Pot. & Kl., which lacks trilete mark and distal differentiation of a germinal apparatus though already possessing distally inclined bladders is presumably a forerunner of *Kosankeisporites*. This new genus is named after Dr. R. M. Kosanke of Illinois Geological Survey, U.S.A., who described this spore for the first time and also as a tribute to his notable work on the *Pennsylvanian Sporae dispersae* of Illinois coals.

Kosankeisporites (*Ill.*) *elegans* (Kos.) comb. nov.

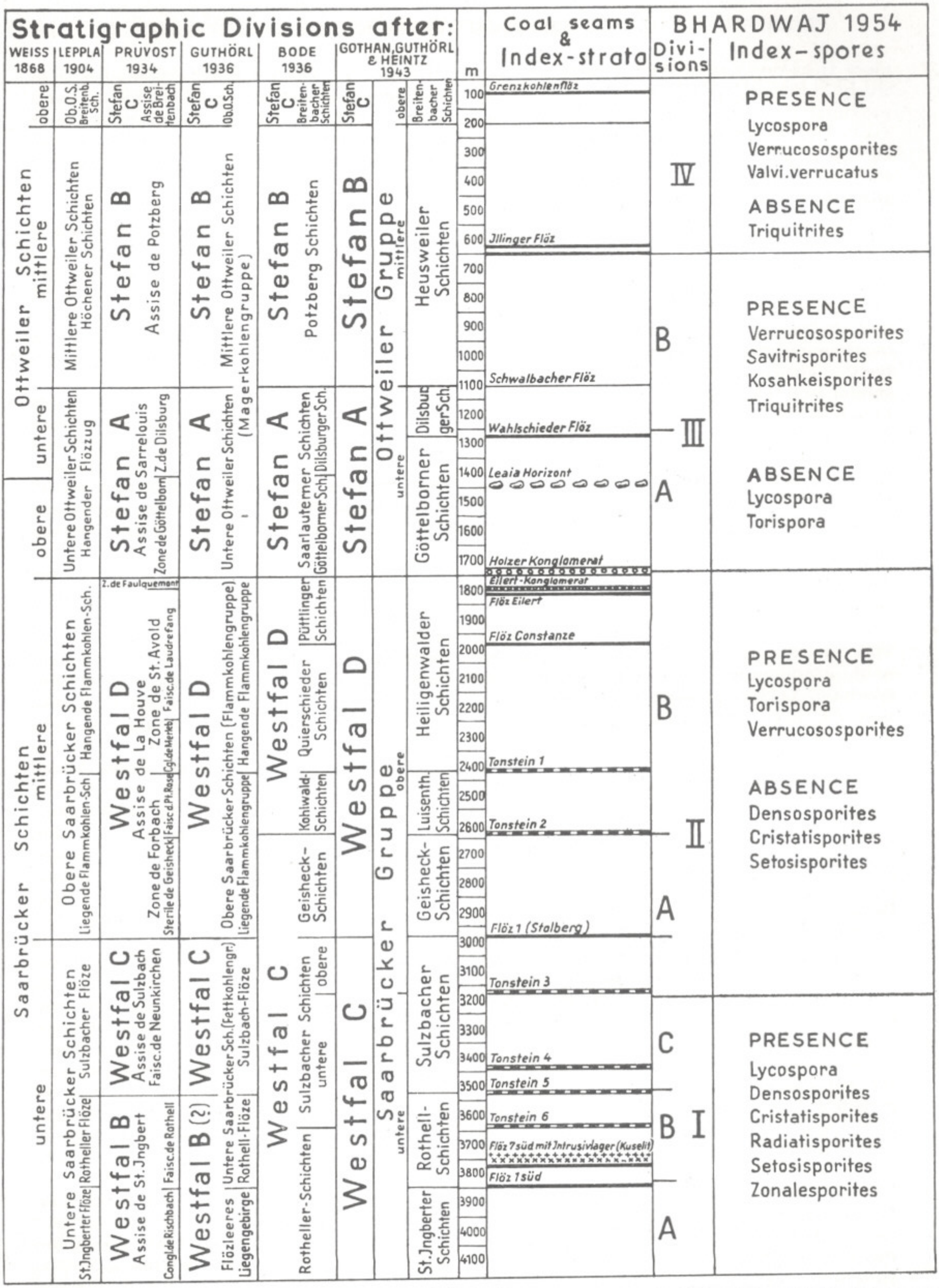
Holotype — Kosanke, 1950, Pl. 1, Figs. 1, 2; maceration 490-A, slide 5.

Diagnosis — 56-67 × 45-56 μ; holotype 59·8 × 46·2 μ; central body 30 × 46 μ; distal *sulcus* 41-44 × 6-10 μ.

Description — Bilateral, oblong spores with two large, distally inclined bladders opposite each other at the end of equatorial axis. Usually flattened in an equatorial plane, without any secondary folding in the bladders or the central body. Bladders alveolate on the surface, *intrareticulate* on the under surface with small meshes not exceeding 1 μ in diameter. Central body dark brown in colour, laevigate, ellipsoid with longer lateral axis, bearing a well-shaped *sulcus* on distal side. *Sulcus* lies along the lateral axis, being almost as long as the central body but only 6-10 μ broad along most of its length. On the proximal side of the central body the surface shows thin grooves (*rugulae*) running in a zigzag pattern.

Discussion — The holotype from North America and the specimens recovered from Saar coals (PL. 2, FIG. 17) show significant congruity in overall size as well as the size of the central body. The only notable differences are in the width of the *sulcus* which is 6-7 μ in the holotype and 9-10 μ in Saar specimens and in the number of *rugulae* which are more in holotype. It is apparent that the variation in the latter character is difficult to define and hence of little use for specific distinction but the difference in the width of the *sulcus* is of significance and may prove to be of taxonomic value. In spite of the fact that the difference in the width of the *sulcus* in the two types is as much as 3 μ where the maximum width is only 10 μ, I have put these forms in a single species till we know more about the range of variation from other areas.

Distribution — McCleary's Bluff coal bed (3½ in.) Wabash County, Illinois, U.S.A.; Wahlschieder seam (Dilsburger Schichten) and seam Grangeleisen (Stephan A), Saar coal basin.



Stratigraphic Divisions after:											BHARDWAJ 1954	
WEISS 1868		LEPPLA 1904	PRUVOST 1934	GUTHÖRL 1936	BODE 1936	GOTHAN, GUTHÖRL & HEINTZ 1943			m	Coal seams & Index-strata	Divisions	Index-spores
Ottweiler Schichten	obere	Ob.O.S. Breitenb. Sch.	Stefan C Assise de Breitenbach	Stefan C Ob.O.Sch.	Stefan C Breitenbacher Schichten	Stefan C	Ottweiler Gruppe obere	Breitenbacher Schichten	100	Grenzkohlenflöz	IV	PRESENCE Lycospora Verrucososporites Valvi.verrucatus ABSENCE Triquitrites
	mittlere	Mittlere Ottweiler Schichten Höchener Schichten	Stefan B Assise de Potzberg	Stefan B Mittlere Ottweiler Schichten (Magerkohlengruppe)	Stefan B Potzberg Schichten	Stefan B	mittlere	Heusweiler Schichten	200			
									300			
									400			
									500			
									600	Jllinger Flöz		
									700		III B	PRESENCE Verrucososporites Savitrisporites Kosankeisporites Triquitrites ABSENCE Lycospora Torispora
									800			
									900			
									1000			
	untere	Untere Ottweiler Schichten Flözzug	Stefan A Assise de Sarrelouis Z. de Dilsburg	Stefan A Untere Ottweiler Schichten	Stefan A Saarlauterner Schichten Dilsburger Sch.	Stefan A	untere	Dilsburger Sch.	1100	Schwalbacher Flöz		
									1200	Wahlschieder Flöz		
								Göttelborner Schichten	1300		A	
Saarbrücker Schichten	obere	Hangender	Zone de Göttelborn		Göttelborner Sch.				1400	Leaia Horizont		
									1500			
									1600			
									1700	Holzer Konglomerat		
	mittlere	Obere Saarbrücker Schichten Hangende Flammkohlen-Sch.	Westfal D Z. de Faulquemont Assise de La Houve Zone de St. Avold Faisc. de Laudrefang	Westfal D Obere Saarbrücker Schichten (Flammkohlengruppe) Hangende Flammkohlengruppe	Westfal D Püttlinger Schichten	Westfal D	Saarbrücker Gruppe obere	Heiligenwalder Schichten	1800	Ellert-Konglomerat Flöz Eilert	II B	PRESENCE Lycospora Torispora Verrucososporites ABSENCE Densosporites Cristatisporites Setosisporites
									1900	Flöz Constanze		
					Quierschieder Schichten				2000			
									2100			
									2200			
									2300			
		Liegende Flammkohlen-Sch.	Cgl. de Merleb.	Liegende Flammkohlengruppe	Kohlwald-Schichten			Luisenth. Schichten	2400	Tonstein 1		
			Zone de Forbach Faisc. d. Pt. Rose						2500			
									2600	Tonstein 2		
			Sterile de Geisheck		Geisheck-Schichten			Geisheck-Schichten	2700		A	
									2800			
									2900	Flöz 1 (Stalberg)		
	untere	Untere Saarbrücker Schichten Sulzbacher Flöze	Westfal C Assise de Sulzbach Faisc. de Neunkirchen	Westfal C Untere Saarbrücker Sch. (Fettkohlengr.) Sulzbach-Flöze	Westfal C Sulzbacher Schichten obere	Westfal C		Sulzbacher Schichten	3000			
									3100	Tonstein 3		
					untere		untere		3200		I C	PRESENCE Lycospora Densosporites Cristatisporites Radiatisporites Setosisporites Zonalesporites
									3300			
									3400	Tonstein 4		
		Rotheller Flöze	Westfal B Assise de St. Jngbert Faisc. de Rothell	Westfal B (?) Rothell-Flöze				Rothell-Schichten	3500	Tonstein 5	B	
					Rotheller-Schichten				3600	Tonstein 6		
									3700	Flöz 7 süd mit Jntrusivlager (Kuselit)		
									3800	Flöz 1 süd		
		St. Jngberter Flöze	Congl. de Rischbach	Flözleeres Liegengebirge				St. Jngberter Schichten	3900		A	
									4000			
									4100			

TABLE 2.

(Adopted from Guthörl, 1952, Fig. 1.)

STRATIGRAPHY OF THE UPPER CARBONIFEROUS SUCCESSION IN THE SAAR

The stratigraphic subdivision of the Upper Carboniferous succession in the Saar basin and the adjacent basins was for the first time attempted by Weiss (1868). His system, though changed to a certain extent in subsequent years, still forms the basis of the currently used system (TABLE 2). W. Van. Gumble (1894, p. 928) proposed a different arrangement dividing the strata, lying below conglomerate of Holz, into two stages, the *Ingberter* and *Saarbrücker* stages. The former corresponded to the present *St. Ingberter Schichten* (GOTHAN, GUTHÖRL & HEINTZ, 1943) whereas the latter was divided into lower or *Sulzbacher*, middle or *Friedrichsthaler* and upper or *Geislautern-Gernharder* stage. The *Ottweiler Schichten*, which corresponds to the present-day Stephanian, was called by Gumble as the *Pfalzer* stage. The lower section, lying above conglomerate of Holz, was named by Gumble as *Leaia* stage, the middle as *Potzberg* stage and the upper as *Breitenbacher* stage. The arrangement of V. Gumble was adopted by Leppla (1904) with the addition of a few new names for some layers. Pruvost (1934) retained the system of Leppla, changed a few names and assigned the international stratigraphical terms, Westphalian and Stephanian, to the profile. He contended that the oldest strata (incl. *St. Ingberter* and *Rotheller Schichten*) are equivalent to Westphalian B. Guthörl (1936) doubted the existence of Westphalian B in the Saar Carboniferous but otherwise oriented his system exactly as Pruvost (loc. cit.) had done. In the same year Bode (1936) proposed his system indicating significant changes not only in the subdivision of the succession and in the names of the *Schichten* but also in their assignment to divisions of Westphalian. The important features of his arrangement being that Westphalian B does not exist in the Saar Carboniferous, the upper limit of Westphalian C lies along *Tonstein* 2 and that *St. Ingberter Schichten* is merged into *Rotheller Schichten* (*see* TABLE 2). The latest system, jointly agreed upon by Gothan, Guthörl and Heintz (1943, *see* GUTHÖRL, 1952) and currently followed, represents an agreement on the earlier proposed systems. Thus Bode's contention of absence of Westphalian B is upheld, but *St. Ingberter Schichten* is still retained. Guthörl's opinion that *Geisheck Schichten* does not contain any typical plant fossils of Westphalian C but instead of this contains a number of Westphalian D forms and thus it should be included in Westphalian D has been agreed to.

FLORISTIC SUBDIVISION ON THE BASIS OF SPORE STUDIES

The applied object of the present study was to detect the floral changes that might have occurred during the time the whole succession of Upper Carboniferous strata in the Saar was laid down and thereby to enable its division into stratigraphic sections and sub-sections, easily distinguishable from each other on the basis of the spore assemblages. This object has been achieved by fine taxonomic methods of spore study and it has been possible to conclude regarding broad stratigraphic subdivisions of the succession from an analysis of the vertical distribution of spore genera.

It is well known that a change from one flora over to the succeeding one, in continuously bedded strata, is usually gradual. Thus a floral change is expected to be exhibited in a fair-sized packet of strata. The plant assemblage of such stratum, which lies in between the older and the younger floras, is usually known as a transitional flora, containing a mixture of some of the older types and the newer ones. These transition floras often present serious difficulties in the interpretation of their florisitic status, i.e. whether they are to be considered as parts of the older or the newer flora or should be recognized as independent of the two. While interpreting my results I have followed the principle that the first appearance of one or more prominent spore genera of the younger divisions marks the beginning of the younger flora. In my opinion the appearance of younger genera heralds the beginning of the change to the next floral division, thus a transition flora is a part of the younger flora. Some of the characteristic types from the older horizons, which continue to be associated with the newer ones in the transition zone for sometime, are to be considered merely as stragglers, unsuccessfully trying to adjust themselves in the changing conditions.

Among the 45 spore genera represented in these coals, only 30 have restricted distribution and thus have proved to be of stratigraphical value (TABLE 3A). The remaining genera, which have not been taken into consideration for stratigraphy, have really a long range of distribution (e.g. *Cystosporites, Granulatisporites, Florinites, Calamospora*, etc.).

In the vertical distribution of the *Sporae dispersae* (TABLE 3) four successive divisions, each having its own characteristic spore assemblage, are apparent. I regard these divisions as major because in each case the association of more characteristic components in the spore assemblage is different from those of the divisions preceding or succeeding them. Most of these major divisions are further divisible into two or more subdivisions (TABLES 2 and 3A, bold broken lines). The spore assemblage in these subdivisions is marked by the replacement of some less prominent components by others without affecting the general nature of the microflora in the division. In older divisions (I and II), evidences of still smaller changes in the composition of spore assemblage between succeeding groups of coal seams has been noted (TABLE 3A, thin broken lines) and these changes have been used to distinguish sections within the subdivisions.

Division I — The spore assemblage of this oldest division in the Upper Carboniferous succession of the Saar consists of the following characteristic spore genera, e.g. *Setosisporites, Radiatisporites, Lycospora, Densosporites* and *Cristatisporites*. Less prominent spore genera are *Zonalesporites, Bentzisporites, Triquitrites, Florinites, Calamospora* and *Laevigatosporites*. In the youngest section, lying between coal seam 12 and *Tonstein* 5, the assemblage consists chiefly of *Radiatisporites, Densosporites, Cristatisporites, Lycospora, Zonalesporites* and *Laevigatosporites*. In the succession below *Tonstein* 5, the distribution of dominant spore genera becomes unusual. Thus seams 33, 36 3/4 *Nord* and 19 *Süd* show absence of *Radiatisporites, Densosporites* and *Cristatisporites* as well as the less prominent genera *Zonalesporites* and *Bentzisporites*. To replace these genera *Setosisporites, Florinites* and *Lycospora* increase in amount. In the oldest part of this section the flora again appears to be of the type that is prevalent above *Tonstein* 5, having all the dominant megaspore genera (after ZERNDT, 1940) such as *Radiatisporites, Zonalesporites* and *Bentzisporites*. Seam 1 *Süd* has none of the dominant spore genera of the younger part of this division, instead indicates a spore assemblage comparable to the older part of Division II. The nature of discontinuity in the spore assemblage between narrow zones such as is evident here is rarely met with in continuously sedimented basin.

Coal seam 12 (*Nord*) is the youngest limit of the spore assemblage of Division I. The next young seam, i.e. seam 11, as well as the whole younger succession in the Saar do not contain any of the prominent genera of Division I excepting *Lycospora*. In seam 11 lies the well-known horizon *Tonstein* 3. Although *Tonstein* 3 does not correspond to the level of change in spore assemblage but all the same, to accept that this well-known bed nearly corresponds to the actual boundary between Divisions I and II will not be too far from truth.

Division II — The youngest limit of this division has been provisionally set along conglomerate of Holz, as the microflora of the section overlying conglomerate of Holz and extending to *Leaia* horizon has not been studied since no coal seams in this section are accessible. The spore assemblage of Division II consists of following prominent components, e.g. *Tuberculatisporites, Bentzisporites, Torispora, Verrucososporites* and *Lycospora*; the other components are *Lagenoisporites, Zerndtisporites, Cyclogranisporites* Sec. A, and *Foveolatisporites*. The prominent components continue throughout the vertical extent of this division. *Torispora* and *Verrucososporites* begin in the oldest part of this division and while the former ends itself with the close of this division, the latter continues into Divisions III and IV. *Bentzisporites*, which originated in Division I, reaches its maximum growth in Division II and also dies out with the close of this division. *Tuberculatisporites*, which is rarely represented in Division I, is regularly met with throughout Division II. As compared to Division I, *Setosisporites, Densosporites* and *Cristatisporites* completely disappear from Division II having been replaced by *Torispora* and *Verrucososporites*.

Division II is characterized by a minor break, roughly along *Tonstein* 2, which divides it into two subdivisions. It must be remarked here that general nature of the spore assemblage is not affected by this minor break as only the less prominent components get replaced.

The older subdivision (IIA) is characterized by the sporadic appearance of *Lageniosporites* and *Zerndtisporites*. The older section of this subdivision, comprised of

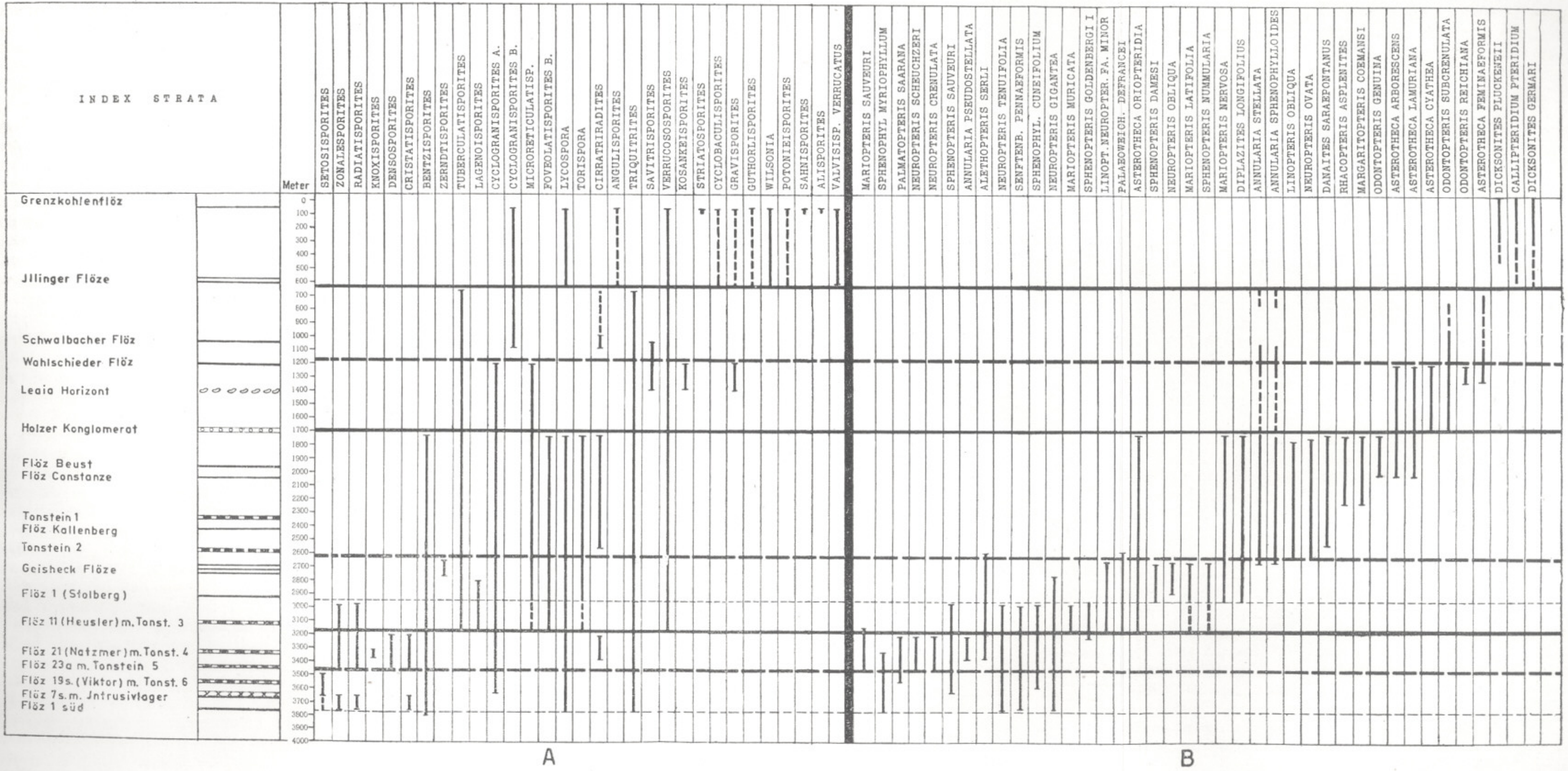

INDEX STRATA
Meter
Grenzkohlenflöz
Jllinger Flöze
Schwalbacher Flöz
Wahlschieder Flöz
Leaia Horizont
Holzer Konglomerat
Flöz Beust
Flöz Constanze
Tonstein 1
Flöz Kallenberg
Tonstein 2
Geisheck Flöze
Flöz 1 (Stolberg)
Flöz 11 (Heusler) m. Tonst. 3
Flöz 21 (Natzmer) m. Tonst. 4
Flöz 23a m. Tonstein 5
Flöz 19s. (Viktor) m. Tonst. 6
Flöz 7s. m. Jntrusivlager
Flöz 1 süd
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
SETOSISPORITES
ZONALESPORITES
RADIATISPORITES
KNOXISPORITES
DENSOSPORITES
CRISTATISPORITES
BENTZISPORITES
ZERNDTISPORITES
TUBERCULATISPORITES
LAGENOISPORITES
CYCLOGRANISPORITES A.
CYCLOGRANISPORITES B.
MICRORETICULATISP.
FOVEOLATISPORITES B.
LYCOSPORA
TORISPORA
CIRRATRIRADITES
ANGULISPORITES
TRIQUITRITES
SAVITRISPORITES
VERRUCOSOSPORITES
KOSANKEISPORITES
STRIATOSPORITES
CYCLOBACULISPORITES
GRAVISPORITES
GUTHORLISPORITES
WILSONIA
POTONIEISPORITES
SAHNISPORITES
ALISPORITES
VALVISISP. VERRUCATUS
MARIOPTERIS SAUVEURI
SPHENOPHYL MYRIOPHYLLUM
PALMATOPTERIS SAARANA
NEUROPTERIS SCHEUCHZERI
NEUROPTERIS CRENULATA
SPHENOPTERIS SAUVEURI
ANNULARIA PSEUDOSTELLATA
ALETHOPTERIS SERLI
NEUROPTERIS TENUIFOLIA
SENFTENB. PENNAEFORMIS
SPHENOPHYL. CUNEIFOLIUM
NEUROPTERIS GIGANTEA
MARIOPTERIS MURICATA
SPHENOPTERIS GOLDENBERGI I
LINOPT.NEUROPTER. FA. MINOR
PALAEOWEICH. DEFRANCEI
ASTEROTHECA ORIOPTERIDIA
SPHENOPTERIS DAMESI
NEUROPTERIS OBLIQUA
MARIOPTERIS LATIFOLIA
SPHENOPTERIS NUMMULARIA
MARIOPTERIS NERVOSA
DIPLAZITES LONGIFOLIUS
ANNULARIA STELLATA
ANNULARIA SPHENOPHYLLOIDES
LINOPTERIS OBLIQUA
NEUROPTERIS OVATA
DANAITES SARAEPONTANUS
RHACOPTERIS ASPLENITES
MARGARITOPTERIS COEMANSI
ODONTOPTERIS GENUINA
ASTEROTHECA ARBORESCENS
ASTEROTHECA LAMURIANA
ASTEROTHECA CYATHEA
ODONTOPTERIS SUBCRENULATA
ODONTOPTERIS REICHIANA
ASTEROTHECA FEMINAEFORMIS
DICKSONITES PLUCKENEII
CALLIPTERIDIUM PTERIDIUM
DICKSONITES GERMARI
A
B

TABLE 3

seams 11 to 2 (north), is poor in new spore forms. Among most characteristic megaspores are *Bentzisporites, Triangulatisporites, Cystosporites* and *Schopfipollenites.* The characteristic miospores are *Lycospora, Verrucososporites, Punctatosporites* and *Florinites.* The younger section of this subdivision is poor in coal seams, the oldest being seam 1 (*Stolberg*) and the youngest is Seam D, lying below *Tonstein* 2. This part has *Lagenoisporites* and *Zerndtisporites* as characteristic megaspore genera and *Torispora* makes its appearance in seam 1 (*Stolberg*) and is well represented in other younger seams of this part.

The younger subdivision (IIB) lacks *Lagenoisporites* and *Zerndtisporites* but *Tuberculatisporites, Bentzisporites, Verrucososporites* and *Torispora* are strongly represented. A characteristic species, *Valvisisp. saarensis* (Zerndt) Pot. and Kr., is also found in the older part of this subdivision.

Division III — The spore assemblage of Division III is characterized by the absence of *Lycospora.* The more characteristic components are *Valvisisporites auritus, Calamospora, Endosporites, Cyclogranisporites* Sec. B, *Triquitrites* and *Verrucososporites.* The less prominent components are *Latosporites, Laevigatosporites, Raistrickia, Planisporites, Florinites* and two new genera, *Savitrisporites* and *Kosankeisporites. Tuberculatisporites* and *Triquitrites* reach their end in this division. The boundary between Division III and the younger Division IV lies somewhere within the over 400 meter thick sediments, which lie between Schwalbach and Illinger seams and are barren of coal seams. Tentatively it has been marked a little below Illinger seams (TABLES 2 and 3A).

Division III is subdivided into two subdivisions each of which have their characteristic spore assemblage. The boundary between these subdivisions lies between coal seams Schwalbach and Wahlschied with the result that Subdivision IIIA continues from above conglomerate of Holz to a little above the seam Wahlschied and overlying these is the Subdivision IIIB. The characteristic spore genera of Subdivision IIIA are *Endosporites, Calamospora, Cyclogranisp.* Sec. B, *Verrucososporites, Latosporites* and *Kosankeisporites.* In Subdivision IIIB, which is poor in spore contents, *Calamospora, Cyclogranisp.* Sec. B, *Latosporites, Microreticulati* Sec. A are noteworthy. Out of the two species of *Savitrisporities,* one is restricted to Subdivision IIIA and the other to Subdivision IIIB.

Division IV — The commencement of Division IV is characterized by the reappearance of *Lycospora* in the spore assemblage. In *Illinger* seams *Lycospora* is subdominant but in *Grenzkohlen* seam it becomes very conspicuous. The other characteristic components of the spore assemblage in Division IV are *Laevigatosporites, Calamospora* and *Florinites.* Among megaspores, *Valvisi. verrucatus* sp. nov. (BHARDWAJ, 1954a) is very common. This division is also characterized by a large number of infrequent but new genera such as *Cyclobaculisporites, Gravisporites, Angulisporites, Striatosporites, Guthörlisporites, Potonieisporites* and *Sahnisporites* as well-as the well known genera *Wilsonia* and *Alisporites.*

COMPARISON OF SPORE DISTRIBUTION WITH PLANT MEGAFOSSIL DISTRIBUTION

As already referred to earlier in this paper, a considerable amount of palaeobotanical work has been done on the fossils of this basin by a number of workers. These palaeobotanists have often discussed the stratigraphic subdivisions of the geological succession in this region. As the stratigraphic divisions indicated after my study of the *Sporae dispersae* did not conform in all cases to the major divisions decided upon by the palaeobotanists, I tried to check upon and compare the vertical distribution of *Sporae dispersae* with that of megafossils. This was also necessitated in view of the opinions held by certain authorities that the palaeobotanical stratigraphic subdivisions may or may not conform to the stratigraphic subdivisions proposed on grounds of *Sporae dispersae.* On the contrary, in my opinion, if plant megafossils employed for Upper Carboniferous stratigraphical work, which are mostly fern-like foliage apparently belonging to Filicinae and Cycadofilicales, constituting only a part of the Palaeozoic flora, can indicate floral changes, the *Sporae dispersae,* which represent the whole flora of the basin, should be capable of denoting every floral change at least equally distinctly if not more.

Palaeobotanical literature on the plant fossils of the Saar basin is prodigious. But there is a lot of taxonomic non-agreement between the French and German authors who were alternatingly concerned with its geology during the past. To enable comparison of the vertical distribution of *Sporae dispersae* with that of plant megafossils, my first task was to determine the exact (as nearly as possible) vertical distribution of all the species reported from this region. This eliminated most of the works accomplished earlier than 1930, because they usually lacked exact location of each fossil find. Most of the data regarding distribution, utilized here (TABLE 3B), has been collected from Gothan (1933), Bode (1936, 1941) and Guthörl (1936, 1940, 1940a, 1943, 1948, 1951, 1953). The nomenclature followed here is based on German authors. Some latest taxonomic changes proposed by Gothan (1953) have not been incorporated here. All possible effort has been made to correct the distribution of a species described under synonymous names. None of the species, usually considered important for stratigraphical purposes, have been excluded from consideration here.

In Table 3B, the horizontal lines representing floral changes are simply extensions of the lines from Table 3A. Now we may examine the megafossil distribution in relation to these lines. It is clearly seen that in the region of the oldest floral change so few megafossils have been found that it is difficult to confirm the evidence given by *Sporae dispersae*. The next floral change is very sharply distinguishable, along *Tonstein* 5, where *Neuropteris scheuchzeri* Hoffm., *Mariopteris Sauveuri* (Begt.) Stur, *Annularia pseudostellata* H. Pot. and *Neuropteris crenulata* appear for the first time.

The third notable floral change is indicated closely below *Tonstein* 3 along seam 12. At this horizon *Palmatopteris saarana* Guth., *Nauropteris scheuchzeri*, *N. crenulata*, *Sphenopteris sauveuri* Crepin and *Annularia pseudostellata* reach their youngest limit whereas *Mariopteris muricata* (Schloth.) Zeiller, *Sphenopteris goldenbergii* Andr., *Linopteris neuropteroides* Stbg. fo. *minor*, *Palaeoweichselia defrancei* (Brgt.), *Diplazites longifolius* and *Asterotheca oriopteridia* appear for the first time.

With the fourth notable floral change indicated closely below seam 1 (Stolberg) *Neuropteris tenuifolia* Schloth., *Mariopteris muricata*, *Senftenbergia pennaeformis* (Brgt.) Stur and *Sphenophyllum cuneifolium* Stbg. disappear and *Sphenopteris damesi* Stur. and *S. nummularia* Gutb. originate. At the same time *Mariopteris latifolia* Brgt., *M. nervosa* Brgt. and *Neuropteris obliqua* (Brgt.) Zeiller become more common.

Along the fifth floral change indicated just above *Tonstein* 2, *Palaeoweicheselia defrancei*, *Mariopteris latifolia*, *Sphenopteris nummularia* and probably *Neuropteris obliqua* and *Alethopteris serli* reach their end whereas *Neuropteris ovata* Hoffm., *Danaeites sarepontanus* and *Linopteris obliqua* Bunb., appear for the first time.

At the sixth floral change, closely below the conglomerate of Holz, a large number of species, e.g. *Neuropteris ovata*, *Mariopteris nervosa*, *Asterotheca oreopteridia*, *Diplazites longifolius*, *Danaeites saraepontanus*, *Linopteris obliqua*, *Rhacopteris asplenites*, Ettgsch., *Margaritopsis coemansi* Andr. and *Odontopteris genuina* Gr. Eury, die out and *Asterotheca cyathea* and *Odontopteris subcrenulata* appear for the first time.

Along the seventh floral change, *Asterotheca arborescens*, *A. lamuriana*, *A. cyathea* and *Odontopteris reichiana* probably disappear. *A. cyathea* and *Odontopteris subcrenulata* appear for the first time in this zone with the latter culminating finally in the eighth zone. In this zone *Asterotheca cyathea* (Schloth.) Kid., and *Odontopteris subcrenulata* appear in the younger strata overlying conglomerate of Holz for the first time. *Annularia stellata* Schloth., *A. sphenophylloides* and *Asterotheca feminaeformis* end below Schwalbach seam or above it. Above the ninth floral change Guthörl (1952) reports *Callipteridium pteridum*, *Dicksonites germari* and *Neuropteris cordata-ovata* as the new species.

Table 2 gives on the left side a comparison of the important stratigraphic systems proposed by various authorities in the past. On the right side of the profile the stratigraphic subdivision proposed by me on the basis of *Sporae dispersae* together with the list of index spore genera is given. It will be worth while to point out that the subdivisions proposed by me are based upon positive evidence of the presence of easily recognizable spores. The absence of certain spores genera, which are characteristic of adjacent divisions, has been noted (TABLE 2) only for comparative distinction.

It is apparent that in Division I the sections A and B almost exactly correspond to *St. Ingberter* and *Rotheller Schichten* respectively. The section C is, however, truncated as compared to the original *Sulzbacher Schichten* and the reason for doing so has already been discussed in detail as to why I have not accepted seam 1 (*Stolberg*) or *Tonstein* 2 as the upper limit of Division I. Megafloristically, seam 12 presents as strong a floral change as seam 1 (*Stolberg*) or *Tonstein* 2. Along *Tonstein* 1, I have neither been able to detect a microfloral change nor is there any megafloral evidence for it. The boundary between Divisions III and IV is a major deviation from the older conceptions. I have decided upon inclusion of *Illinger* seams together with *Grenzkohlen* seam in one division on strong microfloristic grounds whereas those by earlier authors are more on petrological basis than palaeobotanical. The paucity of megafossils in this part of the profile did not enable satisfactory stratigraphical subdivision in the past, as is evident from the observations of Bode (1936, p. 66) who expresses rightly that " Die Unterscheidung der einzelnen Stufen auf palaeobotanischer Grundlage bietet deshalb noch gewisse Schwierigkeiten ", and subsequently (BODE, 1941, p. 26), " Bisher ist eine Einteilung des Stefans auf floristische Grundlage nicht möglich gewesen ".

STRATIGRAPHIC ARRANGEMENT OF THE SAAR COAL MEASURES

On microfloristic grounds I have recognized four divisions in the Saar coal measures and I accept these divisions also as the basis of the stratigraphical horizons. In Table 2 the relation of these divisions to the standard Upper Carboniferous system has been given.

Westphalian C (Microflora of Division I) — *St. Ingberter Schichten, Rotheller Schichten* and *Lower Sulzbacher Schichten* constitute Westphalian C in the Saar coal measures. At one time *Rotheller* and *St. Ingberter Schichten* were considered to represent Westphalian B (PRUVOST, 1934). The spore flora contained in *Rotheller Schichten* shows significant floral unity with *Lower Sulzbacher Schichten* which overlies it but the spore flora of *St. Ingberter Schichten* (Seam 1, *Süd*) is significantly different from both *Sulzbacher* as well as *Rotheller Schichten*. This floral difference may even represent a major floral change. Unfortunately so far we know very little of the characteristic spore genera (if any) which distinguish Westphalian B from C. Floristically, as already opined by Jongmans (1952, p. 320), Westphalian B and C cannot be distinguished as the flora on both sides of *Aegir* horizon is the same. In absence of any other option the whole strata lying below seam 12 is tentatively referred as Westphalian C.

Westphalian D (Microflora of Division II) *Upper Sulzbacher Schichten, Geisheck Schichten, Luisenthaler Schichten* and *Heiligenwalder Schichten* constitute Westphalian D in Saar coal measures. The spore assemblage contained in the strata lying between seam 12 and conglomerate of Holz has uniform character but for the minor fluctuations which apparently cannot be regarded as very significant. In the oldest zone of this division, i.e. *Upper Sulzbacher Schichten*, the spore assemblage is poor in the number of genera. It contains a few of the characteristic genera of the older strata, e.g. *Zonalesporites* and *Radiatisporites*, which, according to Zerndt (1940), are sporadically met with and ultimately die out within this zone. On the other hand, *Lagenoisporites* and *Verrucososporites*, the latter being characteristic of the younger strata, appear for the first time. *Torispora*, another very characteristic genus of the younger strata, has not been found so far in the investigated samples of *Upper Sulzbacher Schichten*. However, in view of the finding of Balme and Butterworth (1952) that *Torispora* can appear simultaneously as or shortly after the disappearance of *Densosporites*, I presume that *Torispora* might be actually extending further down into this zone in some region of the Saar basin. It is apparent that this zone contains a mixed spore flora of the older and the younger divisions and thus appears to be a zone of transition. However, on the basis of positive evidence of the occurrence of spore genera, restricted to younger horizons, this zone is to be floristically considered as a part of the overlying younger section. From seam 1 (*Stolberg*) and upwards till conglomerate of Holz the dominant genera *Verrucososporites* and *Torispora* are uniformly present. In *Geisheck Schichten* a few short-range forms including the genus *Zerndtisporites* appear and die out. Likewise the *Heiligenwalder Schichten* is characterized by some short-lived species.

A perusal on the left side of Table 2 will reveal that there has been significant difference of opinion with regard to the lower limit of Westphalian D in the Saar coal measures. Bode (1936) considers the boundary between Westphalian D and C to lie along *Tonstein* 2, thus including *Geisheck Schichten* and *Upper Sulzbacher Schichten* in Westphalian C. His contention is to recognize only "Zone der *Neuropteris ovata*" as Westphalian D. Bode thinks to have acted in accordance with the agreement reached at the II Congress of Carboniferous Stratigraphy in Heerlen (1935) where Westphalian D was defined as "Stufe der *Neuropteris ovata* als Gesamtart". On the other hand, Guthörl (1936, 1952), disregarding the importance of a single species in determining a stratigraphic horizon, stresses more upon the rich assemblage of pecopterids as a whole in the flora which is so characteristic of Westphalian D and thus has added *Geisheck Schichten* to the zone of *Neuropteris ovata* in the Saar basin.

Opposed to both these contentions I have shifted the lower boundary of Westphalian D further down, adding a part of what was earlier considered as *Sulzbacher Schichten* but is now referred here as *Upper Sulzbacher Schichten*. The fact that such a decision should be adhered to, in spite of a different international definition of Westphalian D and also that the zone of *N. ovata* in the Saar basin is restricted only to *Luisenthaler* and *Heiligenwalder Schichten*, needs explanation. As discussed earlier, the primary basis of this conclusion is the finding that the lower limit of a floral change culminating into the flora of Westphalian D lies along seam 12. This floral change ended by the time seam 1 (*Stolberg*) was deposited and during the course of this change *Densosporites* and the associated group of genera characteristic of Westphalian C were replaced by new genera, *Verrucosoporites* and *Torispora*, characteristic of Westphalian D.

In support of this contention I have also found corroborative evidence from the distribution of the megaflora that my Westphalian D which encompasses the combined zones of *Palaeoweichselia defrancei* and *N. ovata*, as the former begins above seam 12 and the latter ends at conglomerate of Holz, is really equivalent to the zone of *N. ovata* in other paralic coal basins of N.W. Europe and N. America. The fact which led me to this interpretation was that just at the same level where *Densosporites* and other associated genera disappear from the microflora, *P. defrancei*, which happens to be a characteristic endemic species of the Saar flora, is reported (GUTHÖRL, 1952) to appear for the first time. This, however, seemed a bit too striking to be without any significance, and I made a critical comparison of the data from other regions as to whether or not the disappearance of *Densosporites* has any relation to the appearance of some important species in their megaflora. Evidence of both micro-floral and megafloral studies by different authors are available only from some basins such as Illinois and West Virginia coal basins in North America and Osnabrück coal measures in W. Germany. And in these basins it was found that in close proximity to the level at which *Densosporites* disappears, *N. ovata* appears for the first time.

In Illinois basin, according to Kosanke (1950, spore distribution chart), the level of disappearance of *Densosporites* is along seam Dekoven. The next seam above Dekoven is Coal No. 2 and from the top of this seam Jongmans (1937, p. 379) records *N. ovata*. According to Cady (1952, FIGS. 34-37), seam Dekoven lies at an average depth of only 30 metres from Coal No. 2, in a conformable succession.

From West Virginia coal basin, Cross and Schemel (1952) report the level of disappearance of *Densosporites* in lower Allegheny Series. From the same horizon Jongmans (1937, p. 374) describes *N. ovata*. This strata was concluded by Jongmans (loc. cit.) to be high Westphalian C or lower D. The reason for considering the probabilities of its being Westphalian C, in spite of *N. ovata*, was that the zone of *N. ovata* and the typical flora of Westphalian B lie in close vertical proximity.

In Osnabrück coal measures, Kremp (1952) found *Densosporites* group of spores in seam Glücksburg. This is the next seam lying below seam Dickenberg, which, according to Bode (1952, p. 434), forms the lowest limit of *N. ovata* in Ibbenbüren Carboniferous profile.

From the analogy of the facts gathered above it can at least be presumed with fair chances of accuracy that *N. ovata*, an index-fossil of Westphalian D, seems to have appeared in all such paralic basins of which evidence is available, simultaneously or closely after the disappearance af *Densosporites* in the course of one and the same floral change.

Now the question arises as to whether or not the appearance of *P. defrancei* in the Saar stands at the same level as the appearance of *N. ovata* in the paralic basins? We know that in the Saar, the level of disappearance of *Densosporites* and the appearance of *N. ovata* are widely separated from each other by a zone of more than 500 metre thick strata. The apparent cause for such a deviation could either be that *Densosporites* disappeared earlier in the Saar than in the paralic basins or that *N. ovata* appeared later than usual. If one compares the level of disappearance of *Densosporites* and vertical distribution of *N. tenuifolia*, *N. scheuchzeri* and *Mariopteris sauveri* in the Saar basin to the same in other paralic basins of N.W. Europe and N. America, it seems that the disappearance of *Densosporites* was more or less contemporaneous in all these coal basins and apparently *N. ovata* appeared later than usual in the Saar. In this *N. ovata*-free zone (upper part of *Sulzbacher Schichten* and *Geisheck Schichten*), the rich assemblage of Pecopterids (GUTHÖRL, 1952), which is otherwise characteristic of the zone of *N. ovata*, further supports this contention that it was *N. ovata* which appeared later rather than *Densosporites* vanished earlier. Thus it is evident that the appearance of *P. defrancei* in the Saar is at the same stratigraphic level as the appearance of *N. ovata* in the N.W. European and N. American coal basins. One of the important reasons for the appearance of *P. defrancei* rather than *N. ovata* in the Saar, in contrast to the paralic nature of other coal basins, could have been the limnic nature of the Saar basin which helped to establish *P. defrancei*, an endemic species, and hold *N. ovata* out of the basin for the time being after the disappearance of *Densosporites*.

I might recall here that Pruvost (1934) and subsequently Bertrand (1937) had also suggested to designate the combined zones of *P. defrancei* and *N. ovata* in the Saar basin as Westphalian D. However, till then (PRUVOST, 1934) *P. defrancei* was not known to extend below seam 1 (*Stolberg*). It was only subsequent search of Guthörl which led to establish the oldest extent of this species to be above seam 13, which lies in close proximity to the level of disappearance of *Densosporites*.

With the detection of such a correlation of the disappearance of *Densosporites* and other associated spore genera belonging to one and the same floral period, to the appearance of *N. ovata* and the spore genera *Verrucososporites* and *Torispora* during the course of the same floral change, the task of palaeobotanists to establish the boundary between Westphalian C and D will become considerably easier. Not only this but also synchronization of microfloristic evidence with macrofloristic evidence and vice versa, in strata where for practical difficulties one or the other method of study has not been possible, would be facilitated.

Lower Stephanian (Microflora of Division III) — *Göttelborner Schichten*, *Dilsburger Schichten* and *Lower Heusweiller Schichten* constitute the pure Stephanian under the present scheme. The microflora of this Division is distinctly different from the underlying as well as the overlying strata. The *Göttelborner* on the one hand and *Dilsburger* and *Lower Heusweiler Schichten* on the other may also be termed as Stephanian A and B respectively. As suggested by the micro-flora, the vegetation of this period had lost much of its Westphalian character.

Upper Stephanian (Westphalian E) (Microflora of Division IV) — *Upper Heusweiler Schichten* and *Breitenbacher Schichten* may represent in a way what has been termed as Westphalian E from N. America, Turkey, Spain and Donetz basins by Jongmans (1952). Microfloristically *Lycospora* and *Raistrickia*, which are essentially Westphalian spore genera, stage a come back after they had disappeared from the Saar basin during the Lower Stephanian. At the same time traces of some of the Permian spore genera are also evident in this horizon (BHARDWAJ, 1954) suggesting the transitional nature of its microflora. The microflora of this horizon is also closely comparable to that of Upper Stephanian coal from Decazeville in South France (unpublished observations — POTONIÉ & BHARDWAJ). By assigning *Breitenbacher Schichten* to Stephanian C (Westphalian E), I wish to emphasize that even in basins, a flora not much different from the limnic older Westphalian type or Westphalian type of the paralic basins existed, but this followed only after an intervening truly Stephanian flora. Stephanian C forms the upper limit of Carboniferous period. The strata immediately overlying this, as correlated in the nearby Pfalz (W. Germany), belong to Lower Rotliegend (Lower Permian). In what relation does the microflora of Stephanian C stand to that of Lower Rotliegend is not known for the present.

REFERENCES

ANDRAE, J. (1865-1869). Vorweltliche Pflanzen aus dem Steinkohlengebirge der Preussischen Rheinlande und Westfalens. **1-3**. *Bonn*.

BALME, B. E. & HENNELLY, J. P. F. (1955). Bisaccate sporomorphs from Australian Permian Coals. *Aust. Jour. Bot.* **3**: 89-98.

BALME, B. E. & BUTTERWORTH, M. A. (1952). Observations on the distribution of certain microspores in the central group of English coalfields. *Trans. Inst. Min. Engin.* **111**: 1-17.

BENNIE, J. & KIDSTON, R. (1886). On the Occurrence of Spores in the Carboniferous Formation of Scotland. *Proc. Roy. Phy. Soc. Edinb.* **9**: 82-117.

BERTRAND, P. & PROVOST, P. (1937). La Question du Westphalien et du Stephanien en France. II. *Congr. Stratigr. Carbonif.* 81-83. *Heerlen*.

BHARDWAJ, D. C. (1954). Einige neue Sporengettungen des Saarkarbons. *Neues Jb. Geol. Palaeontol., Mh.* **11**: 512-525.

Idem (1954a). Palynologische Untersuchungen der Saarkohlen. *Diss. Bot. Inst. Univ. Bonn.* 1-162. Pl. 1-10. 1955.

BODE, H. (1936). Palaobotanisch-stratigraphische Untersuchungen im Saarbrücker Karbon. *Abh. Preuss. Geol. Landesanstalt.* N.F. **171**: 39-82.

Idem (1941). Einige Bemerkungen zur Stratigraphie des Saarbrücker Karbons. *Z. dtsch. Geol. Ges.* **93**: 24-33.

Idem (1952). Zur stratigraphie des Osnabrücker Karbons. *Z. dtsch. Geol. Ges.* **104**: 431-440.

BRONGNIART, A. (1828-38). Histoire des vegetaux fossiles. *Paris*.

BUTTERWORTH, M. A. & WILLIAMS, R. W. (1954). Descriptions of nine species of small spores from the British Coal Measures. *Ann. Mag. Nat. Hist.* **7**: 753-764.

CADY, G. H. (1952). Minable Coal Reserves of Illinois. *Ill. Geol. Surv. Bull.* **78**: 1-138.

CHALONER, W. G. (1953). A New Species of *Lepidostrobus* containing unusual Spores. *Geol. Mag.* **90**: 97-110.

Idem (1953a). On the Megaspores of Four Species of *Lepidostrobus*. *Ann. Bot.* N.S. **17**: 263-293.

CORSIN, P. (1932). Bassin houiller de la Sarre et de la Lorraine I. Flore fossile. 3. Mariopteridees. *Etudes des Gites min. de la France. Lille*.

CROSS, A. T. & SCHEMEL, M. P. (1952). Representative microfossil floras of some Appalachian coals. III. *Congr. Stratigr. Geol. Carbonif.* C.R. **1**: 123-130.

DAUGHERTY, L. R. (1941). The Upper Triassic flora of Arizona. *Carnegie Inst. Wash., Pub.* **526**: 1-108. *Washington*.

DIJKSTRA, S. J. & VAN VIERSSEN TRIP, J. P. H. (1946). Eine monographische Bearbeitung der karbonischen Megasporen mit besonderer Berücksichtigung von Südlimburg (Niederlande). *Mededeel. Geol. Sticht.* Series C (III): 1-101.

DULHUNTY, J. A. (1946). Principal microspore types in the Permian coals of New South Wales. *Proc. Linn. Soc. N.S.W.* **70**: 147-157.

GOLDENBERG, F. (1855-1862). Flora saraepontana fossilis. *Saarbrücken*.

GOTHAN, W. (1933). Zur Palaeontologie und Stratigraphie des Saarbeckens. *Zeitschr. dtsch. Geol. Ges.* **85**: 398-412.

Idem (1953). Die Steinkohlenflora der westlichen paralischen Steinkohlen-reviere Deutschlands. *Beih. Geol. Jb.* **10**: 1-83.

GUTHÖRL, P. (1936). Die Karbonflora als Mittel zur Horizont-und Flözbestimmung unter besonderer Berücksichtigung der Verhältnisse an her Saar. *Zeitschr. B-H-S. Berlin.* **84**: 161-169.

Idem (1940). *Sphenopteris damesi* (Stur) und ihre Bedeutung für die Stratigraphie des Saarkarbons. *Palaeontogr.* B. **84**: 117-132.

Idem (1941). Neue Feststellungen stratigraphischer Art im Saarbrücker Steinkohlengebirge. *Glückauf.* **77**: 248-252.

Idem (1943). Pflanzenreste aus dem Rothell-Aufschlussen der Grube Ingbert-Saar und ihre Bedeutung für die Stratigraphie und Tektonik des Saarkarbons. *Palaeontogr.* B. **87**: 137-153.

Idem (1948). Querschnitt durch das Saar-Lothringische Karbon. 2. Neue Geologische Untersuchungsergebisse auf Grund von Pflanzen-und Tierresten aus dem Bereich der südlichen Randüberschiebung im Felder der Grube Frankenholz-Saar, 11. Sohle. *Palaeontogr.* B. **88**: 87-112.

Idem (1952). Die Leitfossilien und Stratigraphie des saarlothringischen Karbons III. *Congr. Stratigr. Geol. Carbonif. Heerlen* (1951). C.R.: 233-242.

Idem (1952a). Die Tonsteine und Konglomerate des saar-lothringischen Karbons und ihre stratigraphische Bedeutung. *Ibid.*: 243-252.

Idem (1953). Querschnitt durch das saar-lothringische Karbon. 3. Pflanzen-und Tierreste aus dem Hauptquerschlag I (Rothell-Querschlag). 5. Sohle der Grube Hirschbach-Saar und ihre Austwertung zur Klarung der Stratigraphie und Tektonik im Bereich der Haupt-Überschiebung. *Palaeontogr.* B. **94**: 139-191.

VAN GUMBLE, W. (1894). Geologie von Bayern. 2. *Kassel*.

IBRAHIM, A. C. (1933). Sporenformen des Ägirhorizontes des Ruhr-Reviers. 1-47. *Berlin*.

IMGRUND, R. (1952). Die *Sporites* des Kaipingbeckens, ihre palaontologische und stratigraphische Bearbeitung im Hinblick auf eine Parallelisierung mit dem Pennsylvanian von Illinois. *Diss. T.H. Aachen.* 1-96.

JONGMANS, W. J. (1937). Some remarks on *Neuropteris ovata* in the American Carboniferous. II. *Congr. Stratigr. Carbonif. Heerlen* (1935). C.R. I: 417-422.

Idem (1952). Some problems on Carboniferous stratigraphy. III. *Congr. Stratigr. Geol. Carbonif. Heerlen* (1951). C.R. I: 295-306.

JONGMANS, W. J. & GOTHAN, W. (1937). Betrachtungen über die Ergebnisse des zweiten Kongresses fur Karbonstratigraphie. II. *Congr. Stratigr. Carbonif. Heerlen* (1935). C.R. I: 1-40.

KNOX, E. M. (1950). The Spores of *Lycopodium*, *Phylloglossum*, *Selaginella* and *Isoetes* and their value in the study of microfossils of Palaeozoic age. *Trans. & Proc. Bot. Soc. Edinb.* **35**: 209-357.

Kosanke, R. M. (1943). The characteristic plant microfossils of the Pittsburgh and Pomeroy coals of Ohio. *Amer. Midland Nat.* **29**(1): 119-132.

Idem (1950). Pennsylvanian spores of Illinois and their use in correlation. *Illinois Geol. Surv. Bull.* **74**: 1-128.

Leppla, A. (1904). Geologische Skizze des Saarbrücker Steinkohlengebirges. *Festschr. Allg. Bergmannstag.* **9**: 1-57.

Luber, A. A. & Waltz, J. E. (1938). Classification and stratigraphic value of some Carboniferous coal deposits in the USSR. *Trans. Gen. Geol. Prosp. Inst.* **105**: 1-5; **105**: 1-46.

Pant, D. D. (1954). Suggestions for the Classification and Nomenclature of fossil spores and pollengrains. *Bot. Rev.* **20**: 33-60.

Potonié, H. & Leppla, J. (1903-13). Abbildungen und Beschreibung fossiler Pflanzenreste. **1-9**. *Berlin.*

Potonié, R. (1951). Gesichtespunkte zu einer palaobotanischen Gesellschaftsgeschichte (Soziogensese). *Beitr. Geol. Jb.* **5**: 1-116.

Idem (1952). Zur Morphologie und morphologischen Nomenclature der *Sporites* H. Potonié 1893. *Palaont. Z.* **25**: 143-154.

Potonié, R. & Klaus, W. (1954). Einige Sporengattungen des alpinen Salzgebirges. *Geol. Jb.* **68**: 517-546.

Potonié, R. & Kremp, G. (1954). Die Gattungen der Palaozoischen *Sporae dispersae* und ihre stratigraphie. *Geol. Jb.* **69**: 111-193.

Idem (1955). Die *Sporae dispersae* des Ruhrkarbons. *Palaeontogr.* B. **98**: 1-136.

Pruvost, P. (1928). Structure du Bassin houiller de la Saare. *Rev. Univ. Mines.* **7**(17): 62-79. *Liége.*

Pruvost, P. (1934). Bassin houiller de la Saare et de la Lorraine. III. Description geologique. *Etudes des Gites min. de la France,* Lille.

Sahabi, Y. (1936). Recherches sur les spores des houilles francaise. *Diss. Lille.* 1-59.

Schemel (1951). Small spores of the Mystic Coals of Iowa. *Amer. Midland Nat.* **46**: 743-750.

Schlotheim, E. F. Von. (1804). Beschreibung merkwürdiger Kräuterabdrücke und Pflanzen versteinerungen. *Gotha.*

Schopf, J. M. (1938). Spores from the Herring (Nr. 6) Coal bed in Illinois. *Rept. Invest.* Nr. **50**, *Geol. Surv. Illinois.* 1-55.

Schopf, J. M., Wilson, L. R. & Bentall, R. (1944). An annotated synopsis of palaeozoic fossil spores and the definition of generic groups. *Rept. Invest.* Nr. **91**, *Geol. Surv. Illinois.* 1-77.

Virkki, C. (1946). Spores from the lower Gondwana of India and Australia. *Proc. Nat. Acad. Sci. India.* **15**: 93-176.

Weiss, Ch. E. (1869-1872). Die Flora der jungsten Steinkohlenformation und des Rotliegenden im Saar-Rhein Gebiet. *Bonn.*

Weyland, H. & Krieger, W. (1953). Die Sporen und Pollen der Aachener Kreide und ihre Bedeutung fur die Charakterisierung des mittleren Senons. *Palaeontogr.* B. **95**: 6-29.

Zerndt, T. (1930). Megasporen aus einem Floz in Libiqz (Stephanien). *Bull. Int. de L' Academie Polonaise des Sci. et des. Lett.,* Serie B, **(1)**, **39-70.**

Idem (1940). Megasporen des Saarkarbons. *Palaeontogr.* B. **84**: 133-150.

Zetsche, F. & Kälin, O. (1932). Eine Methode zur Isolierung des Polymerbitumens (Sporen membranen, Kutikulen usw.) aus Kohlen-*Braunkohle.* **31**: 363-366.

EXPLANATION OF PLATES

Plate 1

1a, b, c. *Cyclobaculisporites* (Punctatisp.) *grandiverrucosus* (Kos.) comb. nov. Slide No. 10705/3d; (A) in top focus × 500; (B) in low focus × 500; (C) same as (B) × 1000.

2. *Cyclobaculisporites* (*Verrucosisp.*) *sinensis* (Imgr.) comb. nov. Slide No. 7314/4. × 500.

3. *Cyclobaculisporites* (*Verrucosisp.*) *ovimammus* (Imgr.) comb. nov. Slide No. 10705/3d. × 500.

4. *Foveolatisporites* (*Punctatisp.*) *fenestratus* (Kos. & Brok.) comb. nov. Slide No. 7316/11. × 500.

5. *Savitrisporites triangulus* Gen. et sp. nov. Slide No. 7316/6. × 500.

6. *Gravisporites sphaerus* (Butt. & Will.) Bhardwaj. Slide No. 10705/3b.

7. *Angulisporites splendidus* Bhardwaj. Slide No. 10705/1d. × 500 (diplotype).

8. *Angulisporites splendidus* Bhard. Slide No. 10705/1e. × 500.

9. *Zerndtisporites laxomarginalis* (Zerndt) comb. nov. Slide No. 9606. × 50.

10. *Zerndtisporites laxomarginalis* (Zerndt) comb. nov. Slide No. 9606. × 50.

Plate 2

11. *Striatosporites major* Bhard. Slide No. 10705/1f. × 500. (diplotype).

12. *Guthörlisporites magnificus* Bhard. Slide No. 10705/3g. × 500 (diplotype).

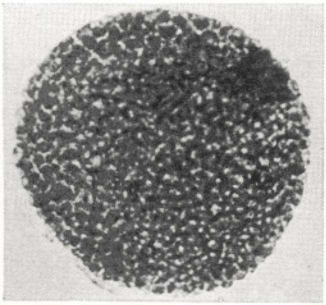
13. *Potonieisporites novicus* Bhard. Slide No. 10705/1f. × 500 (diplotype).

14. *Potonieisporites novicus* Bhard. Slide No. 10705/1c. × 500 (diplotype).

15. *Sahnisporites saarensis* Bhard. Slide No. 10705/1f. × 500 (diplotype).

16a, b, c, d. *Kosankeisporites* (*Illinites*) *elegans* (Kos.). comb. nov. Slide No. 490-A/5. Kosanke, **1950;** (A) in deep focus (proximal) × 500; (B) same as (A) ×670; (C) in high focus (distal) ×670; (D) a part of (C) × 1000 (diplotype).

17. *Kosankeisporites* (*Illinites*) *elegans* (Kos.) comb. nov. Slide No. 7316/2. × 500.



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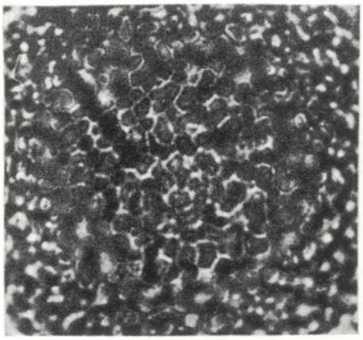

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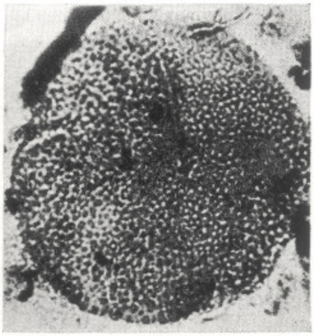

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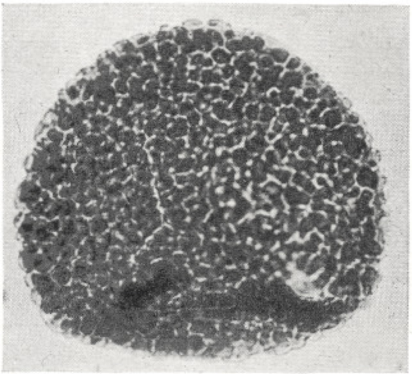

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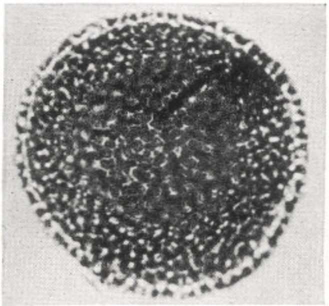

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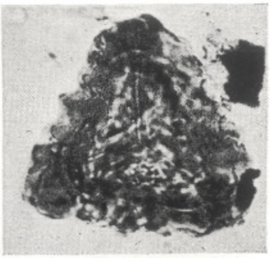

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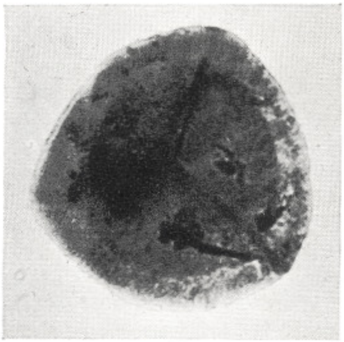

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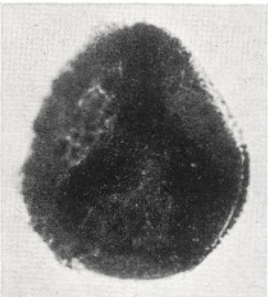

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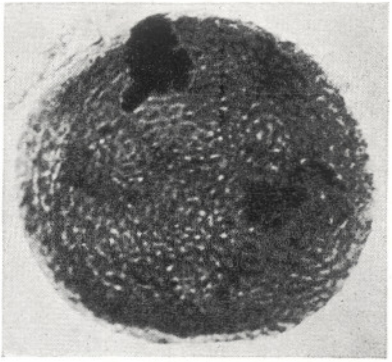

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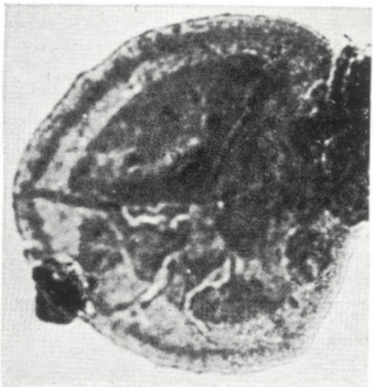

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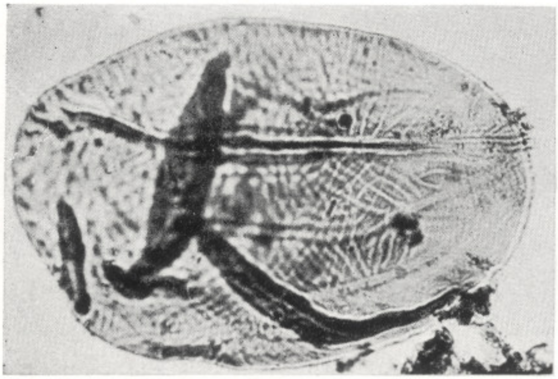

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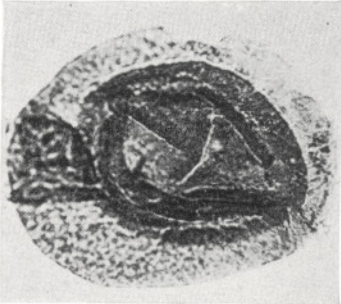

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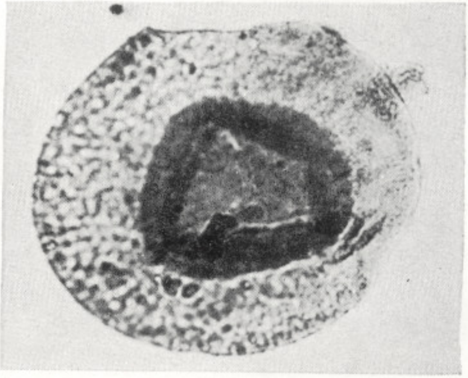

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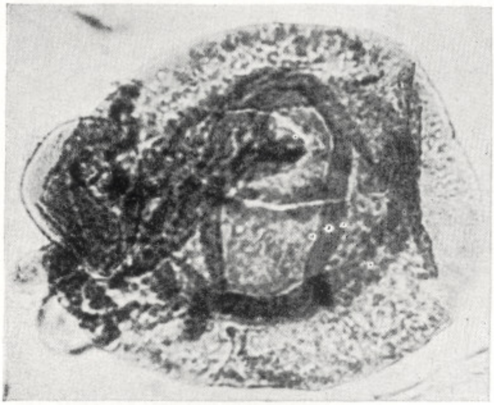

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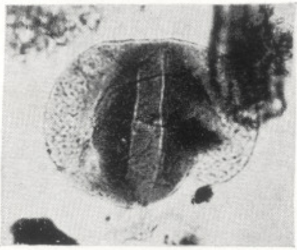

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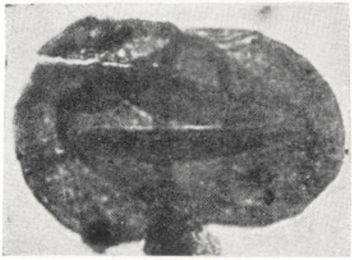

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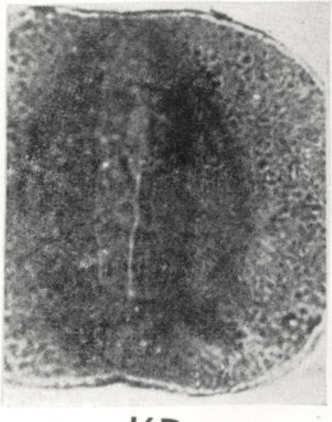

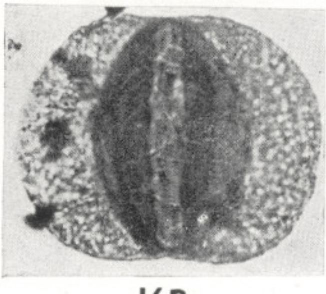

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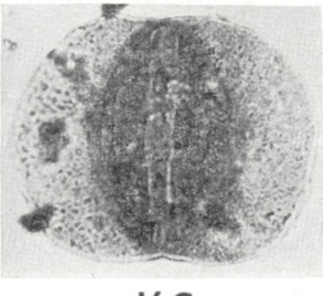

16C

16D