PALYNOLOGICAL EVIDENCE ON THE PRESENCE OF LOWER TRIASSIC IN THE DANUBEAN (MOESIAN) PLATFORM, RUMANIA

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ABSTRACT

A palynological assemblage recovered from Calugareni and Viişoara in the Danubean platform, north-west of Bucharest, Rumania is described and assigned Buntsandstein (Lower Triassic) age.

INTRODUCTION

THE present paper deals with palynological dating of drill-core material from borings in the Danubean platform, N.W. of Bucharest, Rumania. Previous palynological works have suggested the presence of Devonian (VENKATACHALA & BEJU, 1961) and Lower Carboniferous (VENKATACHALA & BEJU, 1962) and Triassic (BEJU & VENKATACHALA, 1962; BEJU, 1965) in the same platform. The Geology and stratigraphy of this platform has been summarized by Grigoraş, Pătruţ and Popescu (1963); Patrulius (1960) and Pătruţ, Popescu, Teodorescu and Molnar (1961).

The material investigated here are from the borings at Calugareni [(Drill 2), Sample VI] and Viişoara (Sample VII)].

The spores and pollen recovered from both the samples are assigned to 14 dispersed spore genera and species. The palynological assemblage is closely comparable to the Middle Buntsandstein assemblage described by Schulz (1964) from Germany.

MATERIAL AND METHODS

The material was supplied by the Laboratorul Cercetari Geologice, M.I.P.C., Bucharest, Rumania. The samples are greyish-black, clay intercalations between sandstone layers and is overlain by Triassic dolomite and underlain by red marls. The maceration included initial treatment with Hydrofluoric acid (commercial grade) followed by Nitric acid (commercial grade 40 per cent for one day) and Potassium hydroxide (5 per cent for 10 minutes). Cadmium Iodide of the specific gravity of 1·8-2·0 was used for separating the organic material from the heavy mineral debris. The slides are preserved at Bucharest, Rumania.

SYSTEMATIC PALYNOLOGY

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch) Potonié & Kremp, 1954.
Subturma — *Azonotriletes* Luber, 1935
Infraturma — *Laevigati* (Bennie & Kidston) Potonié, 1956

Punctatisporites (Ibrahim) Potonié & Kremp 1955

Type species — *Punctatisporites punctatus* Ibrahim, 1933.

Remarks — *Punctatisporites* was first described in detail by Schopf, Wilson and Bentall (1944). They emended the original concept of Ibrahim (1933) and included all circular trilete spores with various ornamentation in the genus. It was later recircumscribed by Potonié and Kremp (1954, 1955). Potonié and Kremp included smooth walled and infrastructured spores in this genus and instituted *Apiculatisporis*, *Cycloganisporites*, *Planisporites* and other such genera to accommodate ornamented spores. Presently the authors use the concept of Potonié and Kremp (*l.c.*).

The genus is one of the dominant trilete genera in the Carboniferous of Europe and America (POTONIÉ & KREMP, 1954; VENKATACHALA & BHARADWAJ, 1963; KOSANKE, 1950; WILSON & HOFFMEISTER, 1956; GUENNEL, 1958; and others) and is also

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found in the Permian sediments (BALME & HENNELLY, 1956; PIÉRART, 1959; LESCHIK, 1959; HART, 1960; BHARADWAJ, 1962; and others). In the Triassic sediments it has been reported from Europe (LESCHIK, 1955; KLAUS, 1960; SCHULZ, 1964) and Australia (BALME, 1963; de JERSEY, 1962).

The above mentioned vertical distribution either represents that the group of plants that produced *Punctatisporites* were distributed through a large section of the geological column or spores of different plants are put together in an artificial grouping. The latter seems to be more probable. It is possible that this group of spores were produced by ferns and fern-allies.

Punctatisporites triassicus Schulz, 1964

Pl. 1, Figs. 1, 2, 5-7 and 9

Description — Spore mostly circular, size range 40-80 μ, Exine 1·5-2·5 μ thick, coarsely infrapunctate with a scabrate surface. Trilete, rays well developed, rays equal or unequal, slightly elevated, tapering at ends; commissure well marked.

Punctatisporites sp.

Pl. 1, Figs. 3, 4

Description — Circular, 50-56 μ, Y-mark distinct, upto two-third radius, labra slightly elevated. Exine laevigate, infrapunctate.

Retusotriletes Naumova, 1953

Type species — *Retusotriletes simplex* Naumova, 1953.

Remarks — The type species of *Retusotriletes* is from the Upper Givetian (Devonian) of U.S.S.R. It has been recorded from the Permian sediments of India and the Triassic of Europe (BHARADWAJ, 1962; KLAUS, 1960). We have found only one specimen referable to this genus and hence no specific name is given.

Retusotriletes sp.

Pl. 1, Fig. 8

Description — Spore circular in polar view, 39 μ. Exine ± 2 μ thick, psilate. Trilete well developed, rays unequal, slightly elevated and tapering at ends; extending up to half-radius. Commissure well marked, inter-radial area demarcated into well differentiated contact area.

Comparison — *Retusotriletes mesozoicus* Klaus (1960) is distinguished from the present specimen in well demarcated curvature along the contact area, extension of the trilete rays upto three-fourth of radius. *R. diversiformis* (Balme & Hennelly) Bharadwaj (1962), is characterized by dark contact area. The specimen described here is closely comparable with ? *Retusotriletes* sp. described by Singh (1964) from the Permian rocks of Iraq.

Osmundacidites Couper, 1953

Type species — *Osmundacidites wellmanii* Couper, 1953.

Osmundacidites senectus Balme, 1963

Pl. 1, Fig. 10

Holotype — Balme, 1963, pl. 4, fig. 1.

For diagnosis and description — See Balme, 1963; p. 17.

Osmundacidites sp.

Pl. 1, Fig. 11

Description — Spore subcircular, size 60-80 μ. Exine upto 2 μ thick. Sculptural elements closely spaced, baculate to spinose, often interspersed with grana. Trilete well developed, mostly open, rays equal, extending up to three-fourth of radius.

Todisporites Couper, 1958

Type species — *Todisporites major* Couper, 1958.

Remarks — *Punctatisporites* an artificial genus described by Schopf, Wilson and Bentall (1944), can also accommodate spores of *Todisporites*. Description of spores of *Todites* illustrated by Couper (*l.c.*) is convincing. Natural affinities no doubt should be given weight when dealing with dispersed spores. We have preferred to use the name *Todisporites* here.

Todisporites sp.

Pl. 1, Figs. 12, 13.

Description — Spore circular-subcircular, size range 60-70 μ. Exine 1·5-2 μ thick, infrastructured. Trilete well developed, extending upto three-fourth of radius, rays equal, tapering at ends, commissure well marked.

Infraturma — *Apiculati* (Bennie & Kidston) Potonié, 1956

***Cyclogranisporites* Potonié & Kremp, 1954**

Type species — *Cyclogranisporites leopoldi* Potonié & Kremp, 1954.

Cyclogranisporites sp.

Pl. 1, Figs. 15, 17

Description — Circular, 44-50 μ. Trilete mark distinct, rays simple, going upto or more than 3/4 radius, one of the rays usually longer than the other two. Exine closely set with less than 2 μ wide grana.

***Cycloverrutriletes* Schulz, 1964**

Type species — *Cycloverrutriletes presselensis* Schulz, 1964.

Cycloverrutriletes presselensis Schulz, 1964

Pl. 2, Figs. 20-22

Holotype — Schulz 1964, pl. 1, fig. 4.

Description — Circular, size range of specimens studied by us 40-70 μ. Trilete mark distinct, going upto 3/4 radius of the spore or sometimes less. Exine 2-3 μ thick, beset with globular, 2-3 μ wide, sculptural elements, the contact areas are devoid of sculptural elements or have finer elements.

Remarks — According to Schulz (*l.c.*) the species is known only from the Middle Buntsandstein Stage.

***Verrucosisporites* (Ibrahim) Smith *et al.*, 1964**

Type species — *Verrucosisporites verrucosus* Ibrahim.

Remarks — The genus *Verrucosisporites* has been the subject of several taxonomic revisions (POTONIÉ, 1958). The genus has recently been emended and restricted to trilete spores with closely set verrucae, whose height is equal to or less than their breadth, truncate but the profile shape is variable from more or less parallel sided to slightly rounded or tapering varrucae, in plan view irregular in outline, round, polygonal, slightly elongated or indented. The trilete mark is generally simple without tectum or thickenings.

The genus is predominantly a Palaeozoic genus, however, it has been recorded from the Triassic rocks by Klaus (1960), Schulz (1964) and Bharadwaj and Singh (1964).

Verrucosisporites morulae Klaus, 1960

Pl. 1, Fig. 14

Holotype — Klaus, 1960, pl. 29, fig. 11.

Description — Circular, 60-65 μ. Trilete mark reaching upto 3/4 radius. Verrucae closely spaced, irregularly shaped in plan view of the spore, upto 3 μ wide and upto 4 μ high, on both the surfaces. Exine ± 3 μ thick.

Verrucosisporites triassicus sp. nov.

Pl. 2, Figs. 23-26

Holotype — Pl. 2, Fig. 23.

Diagnosis — Circular, 75-110 μ. Trilete. Outline undulate or notched with prominent indentations, sculptural elements distinct with rounded apices, 4-8 μ wide and 3-6 μ high, forming a pseudoreticulum in surface view. Trilete mark generally obscured by ornamentation, rays simple, going upto 1/2 radius.

Description — Holotype 106 μ with a distinct trilete mark. In many specimens the mark is obscured by ornamentation. Verrucae of various shapes and sizes. Generally they are wider than high, often forming a pseudoreticulum in surface view. In Pl. 2, Figs. 25 and 26 are illustrated two smaller specimens.

Comparison — *Verrucosisporites morulae* Klaus (1960) though falling in the same size range of *V. triassicus* has smaller sculptural elements for its ornamentation. *Verrucosisporites* sp. A & B described by Bharadwaj and Singh (1964) from the Triassic of Lunz are smaller in size. Schulz (1964) and Bharadwaj and Singh (1964) have also recorded *V. morulae* from the Triassic sediments of Germany and Austria.

Subturma — *Zonotriletes* Waltz, 1935
Infraturma — *Crsassiti* Bharadwaj & Venkatachala, 1962

***Lundbladispora* Balme, 1963**

Type species — *Lundbladispora willmotti* Balme, 1963.

Remarks — *Lundbladispora* has recently been described by Balme (*l.c.*). He includes spores with an equatorial thickening and a scabrate exine under this genus. He also characterizes the genus as possessing an inner body with three interapical papillae. Inner bodies are rather common among dispersed spores. In a recent communi-

cation Wilson and Venkatachala (in press) have examined all available evidence and opined that spores of Sphenopsida and those of Lycopsida produce spores with an inner body while spores of Pteropsida do not possess inner bodies. In current literature such conditions have often been referred to as "cavate" (BALME, 1963; DETTMANN, 1963). Faegri and Iversen (1950) defined the term cavate as synonymous with saccate.

Lundbladispora cf. *L. willmotti*

Pl. 2, Figs. 28-31

Holotype — Balme, 1963; pl. 5, figs. 1 and 2.
Description — Circular, 68 μ; spinose with a distinct inner body. Trilete indistinct, crassitudinous thickening present.
Comparison — *L. willmotti* described by Balme is slightly larger and possesses closely packed finer sculptural elements. The specimens studied by us have larger spines for their ornamentation. The equatorial thickening is in the form of a faintly discernible crassitudo in both the species.

Lundbladispora brevicula Balme, 1963

Pl. 2, Fig. 27

Holotype — Balme, 1963, pl. 4, fig. 9,
Diagnosis — See Balme, 1963, p. 24.

Lundbladispora nejburgii Schulz, 1964

Pl. 1, Figs. 18, 19

Holotype — Schulz, 1964, pl. 2, fig. 9.
Remarks — Schulz diagnoses the species as possessing perine. The authors do not agree that these spores are perinous.

Bascanisporites Balme & Hennelly, 1956

Type species — *Bascanisporites undosus* Balme & Hennelly, 1956.

Bascanisporites triassicus sp. nov.

Pl. 2, Figs. 36-37

Holotype — Pl. 2, fig. 37, size 34 μ.
Specific diagnosis — Circular-subcircular pollen, size range 30-48 μ. Central body circular, faintly granulose; trilete; saccus fine to coarsely infrareticulate.
Description — Circular in polar view. Central body well defined, light or dense. Trilete well developed, rays equal, extending half to three-fourth radius of central body. Commissure well marked. Exine of central body thin, mostly granulose. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial, attachment zone distinct. Saccus as broad as central body or slightly smaller. Saccus finely to coarsely infrareticulate, margin sometimes undulated (PL. 2, FIG. 36), mesh size 1-2 μ, lumina shallow.
Comparison — *Bascanisporites undosus* Balme is from the Permian of Australia and differs in possessing a faint trilete mark. Some of the immature or abnormal pollen grains of *Ulmannia frumentaria* described by Potonié and Schweitzer (1960) closely resemble the pollen described here.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Monosaccites* (Chitaley) Potonié & Kremp, 1954
Infraturma — *Triletesacciti* Leschik, 1955

Cordaitina Samoilovich, 1953

Type species — *Cordaitina uralensis* (Luber) Samoilovich, 1953.
Remarks — Luber (1939, 1941) proposed the genera *Circella*, *Lubumella* and *Zonaletes* to accommodate monosaccate pollen grains having Cordaitalean affinities. Samoilovich (1953) combined the above three genera (*Zonaletes* was taken in part) to institute the genus *Cordaitina* designating *Zonaletes* (*Latensina*) *uralensis* as the type species. The vertical range of this genus in the opinion of Samoilovich (1953) varies from Upper Carboniferous to Triassic.
The various species attributed to *Cordaitina* by Samoilovich (*l.c.*) show a good deal of variation. The pollen may be circular (e.g. *Cordaitina subrotata* — pl. 2, fig. 10); subcircular (e.g. *Cordaitina ornata*; pl. 3, figs. 1a, 1b); oval (e.g. *Cordaitina* cf. *spongiosa*, pl. 3, fig. 3) or elliptical (e.g. *Cordaitina convallata*, pl. 2, fig. 9) in overall shape. *Cordaitina rugulifer* (Luber) Samoilovich shows a thickening in the middle region of the central body (pl. 2, fig. 8) which may be regarded as the inner body. The photomicrographs given by Samoilovich (*l.c.*) are not clear but the text-figure shows that the saccus was subequatorially attached on both the sides to the central body (pl. 2, fig. 10; pl. 3, figs. 1a, 1b). Mention should here be made that such a condition of saccus attachment to the central body

has also been reported from the Lower Gondwana sediments of India (e.g. *Parasaccites* BHARADWAJ & TIWARI, 1964). Lele (1964) opined that the central body in *Cordaitina* is completely enclosed by the saccus.

Cordaitina sp.

Pl. 2, Figs. 32, 33

Description — Monosaccate pollen, known size range 110-120 μ. Central body oval-elliptical; haptotypic mark absent; exine about 1·5 μ thick, finely intramicroreticulate at periphery; but coarser in central part simulating a ruguose-vermiculate appearance. Saccus attachment indistinct, seems to be subequatorially attached on both sides, smaller in size than central body; mesh-size 2-3 μ, lumina shallow.

Comparison — *Cordaitina convallata* (Luber) Samoilovich and *C.* cf. *spongiosa* (Luber) Samoilovich, are comparable to the present species in size range and shape; but differ in lacking rugose-vermiculate ornament on the central body. *C. rugulifer* (Luber) Samoilovich is distinguished by its subcircular shape and possesses a thickening in the middle part of the central body.

Subturma — *Disaccites* Cookson, 1947
Infraturma — *Disacciatriletes* (Leschik) Potonié 1958

***Alisporites* (Daugherty) Nilsson, 1958**

Type species — *Alisporites opii* Daugherty, 1941.

Remarks — *Alisporites* is widely distributed in different Mesozoic sediments. Daugherty first reported it from Triassic sediments of Arizona. Couper (1958), Nilsson (1958) and Klaus (1964) reported it from Triassic-Jurassic sediments of New Zealand, Sweden and Austria. Klaus regarded *Alisporites grauvogeli* Klaus and *A. progrediens* Klaus as characteristic pollen species of Lower and Middle Triassic of Germany respectively. *Alisporites* however, has also been reported from Zechstein (Upper Permian) by Schaarschmidt (1963). Jansonius (1962) reported *Alisporites ovatus* (Balme & Hennelly) Jansonius from Upper Permian and Triassic sediments of Western Canada. Rouse (1959) recorded *Alisporites* from the Jurassic of British Columbia, Pocock (1962) from Jurassic — Cretaceous and Chaitanya Singh (1964) from Lower Cretaceous of Alberta, Canada.

The specimen described by Balme (1957) as *Pityosporites* cf. *ellipticus* (pl. 10, fig. 106) seems to be *Alisporites*. Dettmann (1963) reported *Alisporites* from Mesozoic sediments of South-eastern Australia.

Pityosporites sp. described by Dev (1961) from Jabalpur Stage appears to belong to *Alisporites*. Sah and Jain (1965) described three species of *Alisporites* from the Rajmahal Stage (Lower Jurassic) of India.

Alisporites and *Cuneatisporites* Leschik (1955) are comparable to each other in possessing non-straited, vertically oval central body. The central body in *Alisporites* is more pointed on the lateral sides than *Cuneatisporites*. Moreover in most of the cases the length and breadth ratio of the sacci is ± 1 : 2 in *Alisporites* and ± 1 : 1 in *Cuneatisporites*.

Alisporites cymbatus sp. nov.

Pl. 3, Figs. 38-41

Holotype — Pl. 3, Fig. 38, Size 160 × 110μ.

Isotype — Pl. 3, Fig. 39. Size 126 × 110 μ.

Specific diagnosis — Bisaccate, bilaterally symmetrical pollen, size range 90-110 × 128-160 μ. Central body vertically oval with pointed ends. Sulcus boat shaped, sacci coarsely intrareticulate.

Description — Pollen grains large in size, oval, with constriction in middle. Central body well defined; exine upto 2 μ thick, intramicroreticulate. Proximal attachment of sacci to central body equatorial, distal attachment inclined, covering the major part of central body forming a boat shaped sulcus. Sulcus mostly distinct; but may be indistinct in some cases. Sacci hemispherical, coarsely intrareticulate, mesh 1·5-2·5 μ wide, lumina shallow.

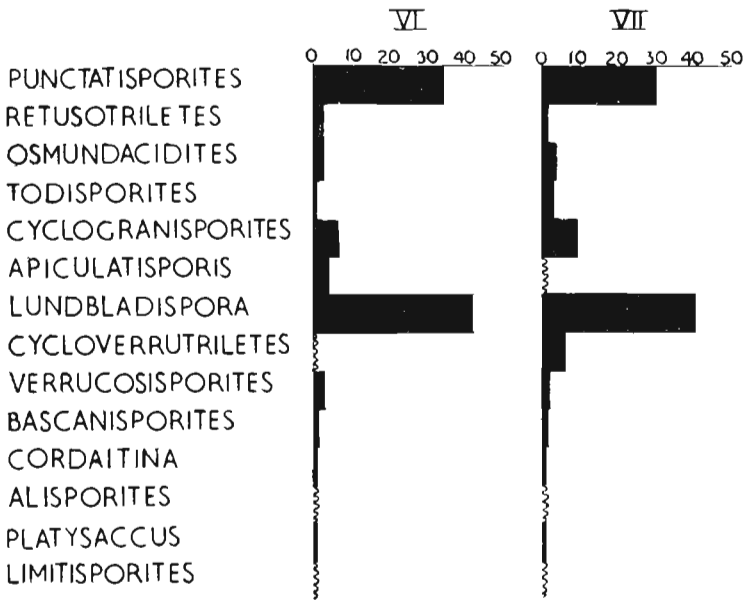
Comparison — *Alisporites robustus* Nilsson (1958) is closely comparable to the present species in possessing vertically oval central body with pointed and boat shaped sulcus; but is distinguished by its smaller size range. *A. progrediens* Klaus (1964) is similar in size range.

Alisporites progrediens Klaus, 1964

Pl. 3, Figs. 42-43

Holotype — Klaus, 1964, pl. 4, fig. 35.

Description — Bisaccate, bilaterally symmetrical pollen grains. Size range 94-124 × 130-140 μ. Central body distinct, vertically oval with smooth lateral ends; exine



TEXT-FIG. 1

upto 2 μ wide, intramicroreticulate. Proximal attachment equatorial, distal inclined, sulcus mostly narrow. Sacci hemispherical, coarsely intrareticulate.

***Platysaccus* Potoiné, & Klaus, 1954**

Type species — *Platysaccus papilionis* Potonié & Klaus, 1954.

Platysaccus sp.

Pl. 2, Fig. 34

Description — Bisaccate, bilaterally symmetrical pollen. Central body dense, circular. Exine about 2 μ thick, laevigate. Proximal attachment of sacci to central body equatorial, distal attachment juxtaposed, straight. Sacci coarsely intrareticulate, mesh-size 1·5-2·5 μ, lumina shallow.

***Limitisporites* Leschik, 1956**

Type species — *Limitisporites rectus* Leschik, 1956.

Limitisporites sp.

Pl. 2, Fig. 35

Description — Bilateral, bisaccate pollen; 120×58 μ. Central body well defined, vertically oval; exine about 1·5 μ thick; intramicroreticulate. Monolete distinct, slightly elevated and wavy. Proximal attachment of sacci to central body equatorial, distal attachment straight, juxtaposed. Sacci more than hemisphere; coarsely intrareticulate; mesh-size 1-2·5 μ; lumina shallow.

STRATIGRAPHICAL PALYNOLOGY

Palynological assemblage

The following genera are present in both the samples studied:

Punctatisporites
Retusotriletes
Osmundacidites
Todisporites
Cyclogranisporites
Apiculatisporis
Lundbladispora
Cycloverrutriletes
Verrucosisporites
Bascanisporites
Cordaitina
Alisporites
Limitisporites and
Platysaccus.

Lundbladispora and *Punctatisporites* are dominant followed by *Cyclogranisporites*. *Retusotriletes*, *Osmundacidites*, *Todisporites*, *Apiculatisporis*, *Cycloverrutriletes*, *Verrucosisporites*, *Bascanisporites*, *Cordaitina*, *Alisporites*, *Platysaccus* and *Limitisporites* are meagerly represented (*see* TEXT-FIG. 1).

Palynological comparison

The Rumanian assemblage is closely comparable with the spores and pollen described by Schulz (1964) from the Middle Buntsandstein of Germany. The common spores and pollen are as follows:

Punctatisporites triassicus
Verrucosisporites morulae
Verrucosisporites sp.
Cycloverrutriletes presselensis
Lundbladispora nejburgii
Alisporites (=*Platysaccus*) *leschiki* HART, 1960 in SCHULZ, 1964; PL. 2, FIG. 12) sp.

The German assemblage has only 3 taxa that are not present here:

Lueckisporites cf. *noviaulensis* (Leschik) Potonié
? *Nuskoisporites dulhuntyi* Potonié and Kalus
and *Varirugosisporites* sp.

In both the assemblages *Lundbladispora nejburgii*, *Punctatisporites triassicus* and *Cycloverrutriletes presselensis* are relatively dominant. Schulz (*l.c.*) states that these three species are characteristic of the Middle Buntsandstein of Germany.

The Lower Triassic (Scythian) spores assemblage described by Balme (1963) from Kockatea shales, a marine Early Triassic formation of Western Australia, is also comparable to the Rumanian assemblage.

The following genera are common to both the assemblages:

Punctatisporites, *Osmundacidites*, *Lundbladispora* and *Platysaccus*. *Lycopodiacidites*, *Kraeuselisporites*, *Taeniaesporites*, *Vitreisporites*, *Striatites* described by Balme are not recorded in the Rumanian assemblage.

The other Triassic assemblages described by Jansonius (1962), Klaus (1960, 1964), Bharadwaj and Singh (1964), Pautsch (1958), Leschick (1955), de Jersey (1962), Venkatachala and Góczán (1964) are all younger in aspect.

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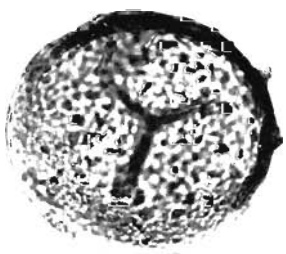

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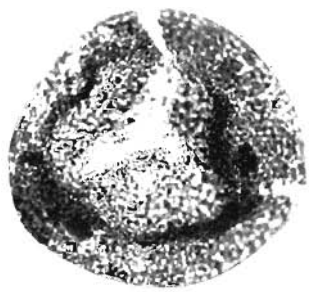

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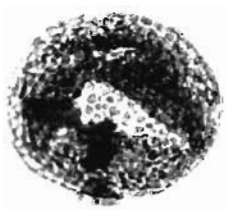

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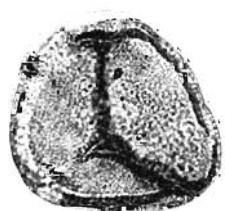

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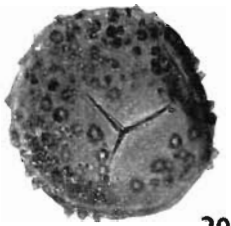

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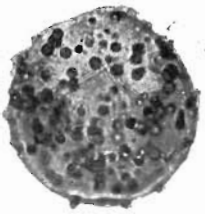

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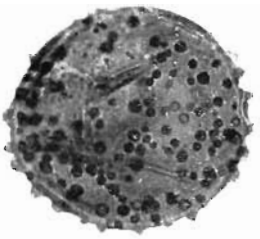

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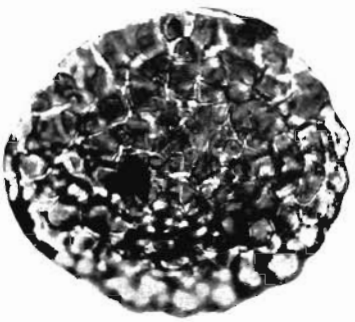

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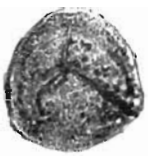

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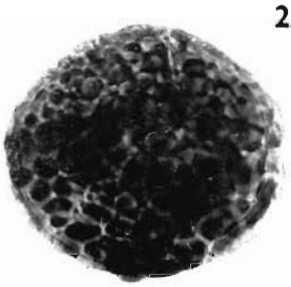

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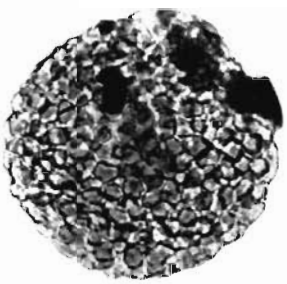

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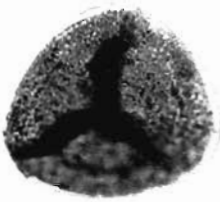

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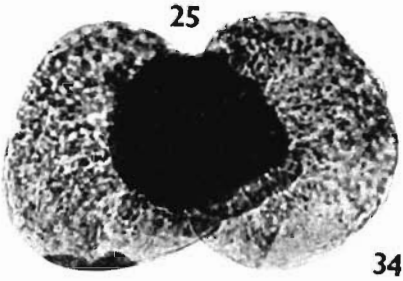

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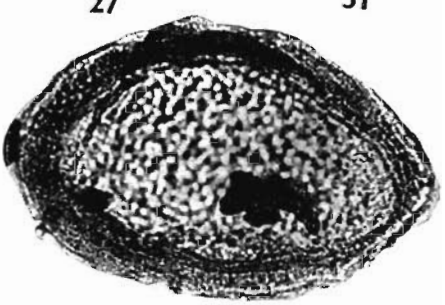

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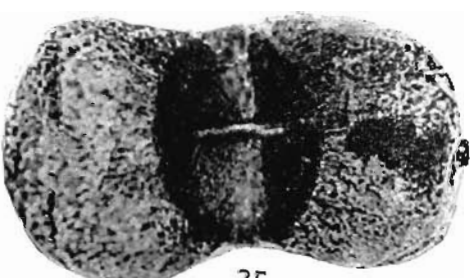

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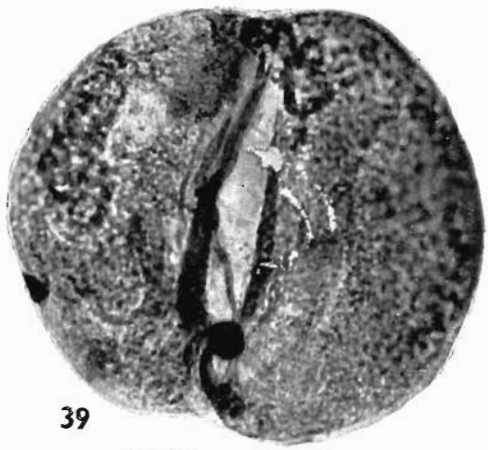

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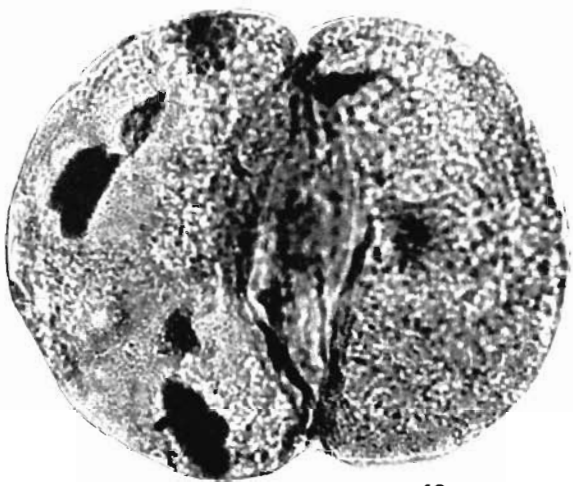

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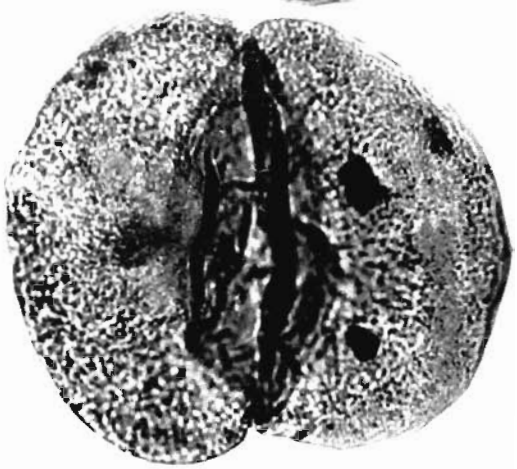

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WILSON, L. R. & VENKATACHALA, B. S. (in press) Inner bodies in Carboniferous Micospores *Okla. Geol. Notes*.

EXPLANATION OF PLATES

(*All photomicrographs are enlarged* 500 ×)

PLATE 1

1,2,5-7,9. *Punctatisporites triassicus* Schulz.
3,4. *Punctatisporites* sp.
8. *Retusotriletes* sp.
10. *Osmundacidites senectus* Balme.
11. *Osmundacidites* sp.
12-13. *Todisporites* sp.
14. *Verrucosisporites morulae* Klaus.
15-17. *Cyclogranisporites* sp.
18-19. *Lundbladispora nejburgii* Schulz.

PLALE 2

20-22. *Cycloverrutriletes presselensis* Schulz.
23-26. *Verrucosisporites triassicus* sp. nov.
27. *Lundbladispora brevicula* Balme.
28-31. *Lundbladispora* cf. *L. willmotti* Balme.
32-33. *Cordaitina* sp.
34. *Platysaccus* sp.
35. *Limitisporites* sp.
36-37. *Bascanisporites triassicus* sp. nov.

PLATE 3

38-41. *Alisporites cymbalus* sp. nov.
42-43. *Alisporites progrediens* Klaus.