PALYNOLOGY OF THE KATHWAI SHALES, SALT RANGE; WEST PAKISTAN. 1. SHALES 25 FT. ABOVE THE TALCHIR BOULDER BED

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ABSTRACT

The present paper deals with the reinvestigation of the study by Virkki (1945) on the Palynology of shales, 25 ft. above the Talchir Boulder bed at Kathwai, Salt Range, W. Pakistan. The spores and pollen recovered have been referred to 28 genera and 33 species.

INTRODUCTION

SEARCH for early remains of Glossopteris flora led Virkki (1945) to study microfossils from horizons, 1½ feet, 4½ feet and 25 feet above the Talchir Boulder bed at Kathwai in the Salt Range. The material for this study was collected by Dr. E. R. Gee in 1936 and sent to Prof. B. Sahni in 1937. In a letter to Prof. Sahni, Dr. Gee wrote "These Gondwana plant fossils belong to as low as — probably lower horizon as any previously found in India. As they occurred within 20-25 feet above the Talchir Boulder bed, I especially examined this 20-25 feet of strata for any evidence of a fault or disconformity, but found none. The sequence was as follows. The Talchir Boulder bed here rests directly on the Purple Sandstone series (Lower Cambrian or Pre-Cambrian). The Boulder bed is here only a foot or two in thickness consisting of boulders up to over a foot in diameter embedded in a gritty matrix. There is no question about its being the Talchir Boulder bed of the base of the Speckled Sandstone series. This boulder bearing sandstone passes up into a gritty greyish and greenish-grey sandstone which includes some shaly bands, carbonaceous in the upper part. The latter passes up into sandy grey shales with carbonaceous bands and these into the black carbonaceous shales containing the plants." (VIRKKI, 1945; pp. ii & iii). The megascopic remains associated with this material was identified as *Glossopteris*, *Gangamopteris*, *Sphenopteris*, *Cardiocarpus*, *Samaropsis* and *Ottokaria*.

Along with this study Virkki (1945) also described microfossils from Warcha, Salt Range, W. Pakistan; Jhallewali, Salt Range, W. Pakistan; Daltonganj coalfield, Palamau district, Bihar, India; Pali beds, Rewa, India and Bacchus Marsh Tillite, Victoria, Australia. From these material she reported 97 types of spores and pollen and used an artificial numerical system of classification.

The present contribution deals with the reinvestigation of the carbonaceous shale at Kathwai, 25 ft. above the Talchir Boulder bed.

About 30 grams of material was first treated with commercial Nitric acid (approximately 40 per cent) for 3-5 days. It was washed with water and treated with Potassium hydroxide solution (5 per cent) for 7 minutes. The macerate after several washings with water was dried on the cover glass with Polyvenyl alcohol and mounted in Canada balsam. The slides, photomicrographs and unused material are preserved at the repository of the Birbal Sahni Institute of Palaeobotany, Lucknow, India.

SYSTEMATIC PALYNOLOGY

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

Genus *Retusotriletes* Naumova, 1953

Type Species — *Retusotriletes simplex* Naumova, 1953.

Retusotriletes aridus sp. nov.

Pl. 1, Figs. 1-2

Holotype — Pl. 1, Fig. 1. Size 92×92 μ. Slide No. 2438/4.

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Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Circular, 59-92 μ × 69-92 μ. Trilete distinct, extending upto half the radius; contact area present, faintly defined, exine thick, faintly microverrucose.

Description — Circular in polar view. Trilete rays narrow, uniformly broad with a faintly delimited contact area. Commissure well marked. Exine upto 2·5 μ thick, faintly microverrucose.

Comparison — *Retusotriletes diversiformis* (Balme & Hennelly) Bharadwaj (1962) is smaller in size. *R. aridus* distinguishes from other Permian species in having trilete rays extending upto half the radius and microverrucose sculptural elements.

Infraturma — *Apiculati* (Bennie & Kidston) Potonié, 1955

Genus *Apiculatisporis* Potonié & Kremp, 1956

Type Species — *Apiculatisporis aculeatus* Ibrahim, 1933.

Apiculatisporis secretus sp. nov.

Pl. 1, Figs. 6-8

Holotype — Pl. 1, Fig. 6. Size 69×69 μ. Slide No. 2438/2.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Circular, 50-73 μ. Trilete ill-developed extending upto half of radius. Exine covered with ±2 μ wide and ±1 μ high, closely placed apiculae.

Description — Circular. Trilete hardly perceptible, rays upto or less than half radius, commissure ill-defined. Exine about 1 μ thick, coni upto 2 μ broad, closely placed apiculae.

Comparison — *Apiculatisporis baccatus* Potonié & Kremp, is comparable to the present species in size range; but differs in having a well developed trilete extending upto margin and less number of coni. *A. levis* Balme & Hennelly, is characterized by irregular distribution of coni on the proximal face.

Genus *Lophotriletes* (Naumova) Potonié & Kremp, 1954

Type Species — *Lophotriletes gibbosus* (Ibrahim) Potonié & Kremp, 1954.

Lophotriletes sp.

Pl. 1, Fig. 9

Description — Spores triangular in polar view, 50-60 μ × 59-78 μ. Apices bluntly rounded, interapical margin straight to convex. Trilete upto three-fourth radius, tapering at ends, sometimes open. Exine ± 1 μ thick, ornamented with sparse coni, 1·5-2·5 μ long.

Genus *Camptotriletes* Naumova, 1937

Type Species — *Camptotriletes corrugatus* (Ibrahim) Potonié & Kremp, 1954.

Camptotriletes bellus sp. nov.

Pl. 1, Figs. 3-5

Holotype — Pl. 1, Fig. 3. Size 73×70 μ. Slide No. 2438/1.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Circular, 65-110 μ. Trilete indistinct, exine vermiculate, distally ornamented with low set muri.

Description — Circular-subcircular spores. Trilete mark indistinct, rays less than 1/4 radius. Exine upto 2 μ thick, proximally laevigate, distally vermiculate with low set muri forming irregular ridges. Muri not anastomosing to form reticulum, negative reticulum seen in lower focii.

Comparison — *Camptotriletes falkenbergensis* Venkatachala & Bharadwaj (1964) differs from the present species in having well developed trilete mark. *C. corrugatus* (Ibrahim) Potonié & Kremp possesses broad, few muri in contrast to the close, lowset, irregular muri in *C. bellus* described here.

Infraturma — *Murornati* Potonié & Kremp, 1954

Genus *Cyclofoveolatispora* gen. nov.

Type Species — *Cyclofoveolatispora caecus* sp. nov.

Generic Diagnosis — Spores circular to subcircular in polar view. Trilete faintly discernible. Exine thin, irregularly folded, proximally laevigate and distally microfoveolate.

Generic Description — Spores mostly circular in overall shape, 50-115 μ. Trilete indistinct, hardly seen, rays equal, generally tapering at ends, restricted to half the radius, commissure ill-defined. Exine

less than 1 μ thick, often irregularly folded, proximally laevigate, distally microfoveolate, meshes about 0·5 μ wide, sometimes they are flattened to form a rugged, coarse surface perhaps, due to maceration.

Comparison — *Microfoveolatispora* Bharadwaj (1962) resembles this genus in the presence of distal microfoveolate ornamentation, but it is, however, characterized by triangular to subtriangular shape with well developed trilete mark, which is often associated with folds. *Cyclobaculisporites* Bhardwaj (1955) shares circular shape with the present genus; but differs in possessing baculate sculptural elements. *Vestispora* (Wilson & Hoffmeister) Wilson & Venkatachala (1963), can be distinguished in having an operculate organization.

Cyclofoveolatispora caecus sp. nov.
Pl. 1, Figs. 10-12

Holotype — Pl. 1, Fig. 10. Size 78×60 μ, Slide No. 2438/3.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Spores circular in polar view. Size range 60-80 μ. Trilete ill-developed. Exine thin, folded; proximally laevigate and distally microfoveolate with closely placed meshes.

Description — Circular often with derived shapes due to folding. Trilete ill-defined, rays tapering at ends, extend upto half the radius, commissure ill-defined. Exine about 1 μ thick, proximally laevigate, distally microfoveolate with closely placed meshes appearing inframicroreticulate, meshes more or less 0·5 μ in diameter, margin serrate due to muri.

Cyclofoveolatispora plicatus sp. nov.
Pl. 1, Fig. 13

Holotype — Pl. 1, Fig. 13. Size 102×70 μ. Slide No. 2438/5.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Circular, 64-115 μ. Trilete obscure, exine thin, folded, proximally laevigate and distally sparsely microfoveolate.

Description — Circular to subcircular. Trilete indistinct and in some specimens hardly perceptible. Exine upto 1 μ thick, irregularly folded, proximal surface smooth, distally microfoveolate, weakly developed to give the appearance of infrareticulation; lumina about 0·5 μ in diameter, muri flat, closely set, margin roughened due to muri.

Comparison — *Cyclofoveolatispora caecus* differs from the present species in having smaller size range, comparatively well developed trilete and more closely spaced meshes.

Turma — ***Zonales*** **(Bennie & Kidston) Potonié, 1956**
Subturma — ***Zonotriletes*** **Waltz, 1936**
Infraturma — ***Zonati*** **Potonié & Kremp, 1954**

Genus *Indotriradites* Tiwari, 1964

Type Species — *Indotriradites korbaensis* Tiwari, 1964.

Indotriradites varius sp. nov.
Pl. 1, Figs. 14-16

Holotype — Pl. 1, Fig. 14. Size 55×50 μ. Slide No. 2438/2.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Spores subtriangular; central body dense, trilete simple, going upto the body limits, not entering into the zona. Body proximally laevigate, distally ornamented with coni or small spines. Zona uniformly wide.

Description — Size range 41-55 μ. Central body subtriangular to subcircular; inner body generally discernible. Zona translucent; faintly granulose. Trilete well developed, uniformly broad, rays equal. Commissure well marked. Exine thin; intrapunctate. Coni on distal side, 1-1·5 μ in size, closely placed; sometimes interspersed with spines.

Comparison — *Indotriradites korbaensis* Tiwari, differs from the present species in the extension of the trilete upto the zona and bigger size range. The coni in *I. sparsus* Tiwari are sparsely placed and the trilete also extends upto the zona. *I. surangei* Tiwari, shares the same size range with the present species but can be distinguished again by the extension of the trilete upto the zona. *Indotriradites varius* distinguishes from the other known species in the extension of the trilete upto the body and uniformly thick zona.

Turma — ***Monoletes*** **Ibrahim, 1933**
Subturma — ***Azonomonoletes*** **Luber, 1935**

Infraturma— *Psilamonoleti* van der Hammen, 1955

Genus *Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall, 1944

Type Species — *Laevigatosporites vulgaris* Ibrahim, 1933.

Laevigatosporites sp.

Pl. 1, Figs. 17-18

Description — Size range 55-82μ × 69-101 μ; monolete open, extends more than half along longer axis. Exine about 1 μ thick, laevigate, occasionally irregularly folded.

Anteturma — *Pollenites* Potonié, 1931
Turma — *Saccites* Erdtman, 1947
Subturma — *Monosaccites* (Chitaley) Potonié & Kremp, 1954
Infraturma — *Apertacorpiti* Lele, 1964

Genus *Plicatipollenites* Lele, 1964

Type Species — *Plicatipollenites indicus* Lele, 1964.

Plicatipollenites gondwanensis (Balme & Hennelly) Lele, 1964

Pl. 2, Fig. 22

Holotype — Balme & Hennelly, 1956b, pl. 7, fig. 66.

Genus *Virkkipollenites* Lele, 1964

Type Species — *Virkkipollenites triangularis* (Mehta) Lele, 1964.

cf. *Virkkipollenites*

Pl. 2, Fig. 21

Description — Subtriangular monosaccate, 101 × 105 μ. Central body subcircular, 57 × 59 μ, dense; exine about 1·5 μ thick, laevigate. Proximal attachment of saccus to central body equatorial, distal attachment not perceptible. Saccus coarsely intrareticulate, meshes apparently arranged radially.

Infraturma — *Triletesacciti* Leschik, 1955

Genus *Barakarites* Bharadwaj & Tiwari, 1964

Type Species — *Barakarites indicus* Bharadwaj & Tiwari, 1964.

Barakarites dubius sp. nov.

Pl. 3, Figs. 28-30

Holotype — Pl. 3, Fig. 28. Size 128 × 128 μ, central body 96 × 85 μ. Slide No. 2438/3.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Spores roundly triangular to circular, central body following closely the contour of the pollen, known size range 100-128 μ. Exine thin, folded along margins, distally pseudoreticuloid grooves present on the body. Trilete. Proximal and distal attachment zone indistinct.

Description — Size 100-128 μ × 105-128 μ, central body 82-105 μ × 82-105 μ. Exine 1-1·5 μ thick; in some specimens pseudoreticuloid grooves seen on distal side due to irregularly channelled furrows anastomosing to form this pattern. Trilete ill-developed, extends upto half the radius of central body, often hardly perceptible. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial. Saccus leathery more or less subsaccate, intragranulose.

Comparison — *Barakarites indicus* Bharadwaj & Tiwari (1964), *B. crassus* and *B implicatus* described by Tiwari (1965) differ from the present species in the presence of a thin, distinct inner body. *B. densicorpus* Tiwari (1965) resembles with *B. dubius* in possessing intramicroreticulate central body; but can be distinguished by the presence of thick, dark inner body.

Remarks — The specimens from the present material that have been referred to *Barakarites* possess mostly an ill-developed saccus in comparison to central body. The saccus in some cases is leathery and the intrastructure is not clearly seen. In other specimens the intrareticulate structure of the saccus is not clearly developed and in some cases it seems to be intrapunctate or intragranulose. The saccus in *Barakarites* for these reasons seems to be not distinctly intrareticulate, as is found in other saccate genera (viz. *Plicatipollenites* Lele; *Virkkipollenites* Lele) from the Lower Gondwanas of India. It shares in common the saccus structure with *Schizopollis* Venkatachala and Kar, 1964.

Genus *Parasaccites* Bharadwaj & Tiwari, 1964

Type Species — *Parasaccites korbaensis* Bharadwaj & Tiwari, 1964.

Parasaccites korbaensis Bharadwaj & Tiwari

Pl. 2. Fig. 26

Remarks — The specimens referable to this species from the present material share

the similar size range as has been described by Bharadwaj and Tiwari (*l.c.*). Trilete is, however, mostly absent and when present hardly perceptible.

Parasaccites bokaroensis Tiwari, 1964

Pl. 2, Figs. 23-25

Remarks — The specimens referred to this species show a great variation in size range and shape. Some are subcircular in shape; with equally well developed central body and saccus; while in others saccus is smaller in size and the shape is predominantly elliptical. In both the forms, however, foldings are well developed with characteristic radial arrangement.

Parasaccites rimosus sp. nov.

Pl. 3, Figs. 31-32

Holotype — Pl. 3, Fig. 31. Size 138×87 μ. central body 87×60 μ. Slide No. 2438/1.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Elliptical, central body elliptical with a longitudinal fissure on one side; attachment zone distinct, subequatorial.

Description — Size range 87-96 μ×138 μ. Central body well defined, size range 60-70 μ×87-87 μ; exine about 1 μ thick, intramicroreticulate. Proximal and distal attachment zone subequatorial; saccus well developed; coarsely intrareticulate, mesh size 1-3 μ; lumina wide.

Comparison — *Parasaccites korbaensis* Bharadwaj & Tiwari compares to this species in having distinct zone of attachment; but the present species can be distinguished by the elliptical shape and the presence of fissure in the central body. *P. bilateralis* Tiwari and *P. bokaroensis* Tiwari share in common the elliptical shape; but differs in the absence of elliptical central body. *P. rimosus* differs from others in having elliptical overall shape and central body with a prominent longitudinal fissure almost going from one end to the other.

Parasaccites bellus sp. nov.

Pl. 2, Figs. 19-20

Holotype — Pl. 2, Fig. 19. Size 142×92 μ, central body 50×41 μ. Slide No. 2438/2.

Type Locality — Shale 25 ft. above the Boulder bed, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Pollen grains monosaccate, elliptical in overall shape, central body distinct, horizontally oval, intramicroreticulate. Proximal and distal attachment of saccus to central body subequatorial on both surfaces, attachment zone distinct. Saccus well developed, intrareticulate.

Description — Size range 63-92μ×105-142 μ. Central body well defined, mostly horizontally oval, sometimes circular, size range 41-64μ×50-92 μ. Haptotypic mark not seen, exine 1·5-2·5 μ thick, intramicroreticulate. Proximal and distal attachment zone well defined, slightly subequatorial on both surfaces. Saccus as well developed as central body, coarsely intrareticulate, mesh-size 1·5-3 μ, apparently radially arranged in some specimens, lumina shallow.

Comparison — *Parasaccites korbaensis* Bharadwaj & Tiwari, is distinguished from the present species in possessing circular — subcircular overall shape. *P. bokaroensis* Tiwari, possesses regular radial foldings in the saccus. *P. rimosus* is differentiated from *P. bellus* in having longitudinal fissure on the central body.

Infraturma — *Aletesacciti* Leschik, 1955

Genus *Potonieisporites* Bhardwaj, 1955

Type Species — *Potonieisporites novicus* Bhardwaj, 1955.

Potonieisporites sp.

Pl. 3, Fig. 33

Description — Broadly oval; 156×96 μ. Central body oval, 82×73 μ, well defined; exine thin, granulose. Monolete well developed, distally covering the whole body, coarsely intrareticulate, mesh size 1-3 μ, lumina shallow.

Remarks — *Potonieisporites* was interpreted by Bhardwaj (1955) as possessing a distinct monolete mark on the proximal side and the saccus entirely covering the distal side of the central body. In a recent study by Wilson and Venkatachala (Ms.) and Bharadwaj (1964) it has been made clear that the central body is also free on the distal side. The same fact is true of the specimens studied here by the present authors.

Infraturma — *Striasacciti* Bharadwaj, 1962

Genus *Striomonosaccites* Bharadwaj, 1962

Type Species — *Striomonosaccites ovatus* Bharadwaj, 1962.

cf. *Striomonosaccites*

Pl. 3, Fig. 34

Description — Circular, 124×105 μ. Central body circular, 55-59 μ×65-73 μ, dense. Exine 1·5 μ thick, intramicroreticulate, 7 grooves present on proximal side. Distally saccus free area of central body circular, exine coarsely intrareticulate, mesh size 1-3 μ, lumina shallow.

Remarks — The grooves in the specimens studied here are incipient. The grooves among the species described by Bharadwaj (1962) are well defined, hence the specimens referred here have only compared with *Striomonosaccites* Bharadwaj (1962).

Subturma — *Disaccites* Cookson, 1947
Infraturma — *Striatiti* (Pant) Bharadwaj, 1962

Genus *Striatites* (Pant) Bharadwaj, 1962

Type Species — *Striatites sewardii* (Virkki) Pant, 1955.

Striatites alius Venkatachala & Kar, 1968

Pl. 4, Figs. 37-38, 41

Holotype — Venkatachala & Kar, 1968, pl. 7, fig. 106.

Genus *Lahirites* Bharadwaj, 1962

Type Species — *Lahirites raniganjensis* Bharadwaj, 1962.

Lahirites angustus Venkatachala & Kar, 1968

Pl. 4, Figs. 39-40

Lahirites naviculus sp. nov.

Pl. 5, Figs. 51-53

Holotype — Pl. 5, Fig. 51. Size 87×36 μ, central body 36×38 μ, sacci 41×50 and 36×50 μ. Slide No. 2438/3.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Bisaccate, oval, central body subcircular; exine 3-5 μ thick, forming marginal thickenings; horizontally grooved, weakly intrapunctate; sulcus boat shaped.

Description — Bilaterally symmetrical, diploxylonoid bisaccate. Size range 35-50μ×80-102 μ. Central body distinct, horizontal grooves 4-8; parallel to each other, sometimes branched. Proximal attachment of central body to sacci equatorial, distal attachment juxtaposed forming boat shaped sulcus, sacci hemispherical, laterally free from each other, coarsely intrareticulate, mesh size 1-2 μ, lumina shallow.

Comparison — *Lahirites angustus* Venkatachala & Kar is characterized by closely placed, straight distal attachment forming a narrow sulcus. The central body is marginally ridged and coarsely intrapunctate. *L. parvus* Bharadwaj & Salujha and *L. rarus* Bharadwaj & Salujha are distinguished by a uniformly broad sulcus. *L. naviculus* differs from all of the known species in having boat shaped sulcus and very thick exine on the central body.

Genus *Strotersporites* Wilson, 1962

Type Species — *Strotersporites communis* Wilson, 1962.

Strotersporites sp.

Pl. 5, Fig. 57

Description — Bisaccate, bilaterally symmetrical pollen grains. Size range 82-92 μ×128-147 μ. Central body vertically oval, distinct, 59-50 μ×82-92 μ; exine upto 2 μ, intramicroreticulate, horizontal striations 8-13, often branched. Proximal attachment of sacci to central body equatorial, distal attachment inclined, straight to slightly concave, sulcus wide. Sacci hemispherical, coarsely intrareticulate, mesh size 1-3 μ, lumina shallow.

Genus *Striatopiceites* Sedova, 1956

Type Species — *Striatopiceites suchonensis* Sedova, 1956.

Striatopiceites sp.

Pl. 5, Figs. 58-59

Description — Bisaccate, bilaterally symmetrical, haploxylonoid pollen grains. Size range 73-101 μ×119-128 μ. Central body ill-defined, seems to be horizontally oval; exine upto 2 μ thick, intramicroreticulate, horizontal grooves 5-8, not branched, converging at ends. Proximal attachment of sacci to central body equatorial, distal attachment straight, closely placed. Sulcus

narrow, uniformly broad. Sacci hemispherical, coarsely intrareticulate, mesh size upto 3 μ, lumina shallow.

Genus *Rhizomaspora* Wilson, 1962

Type Species — *Rhizomaspora radiata* Wilson, 1962.

Rhizomaspora costa sp. nov.
Pl. 5, 54-55

Holotype — Pl. 5, Fig. 54. Size 124×46 μ, central body 46×36 μ, sacci 69×69 and 59×79 μ. Slide No. 2438/1.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Bisaccate, bilaterally symmetrical, diploxylonoid pollen grains, central body dense, subcircular to horizontally oval; grooves on proximal surface diverging, distal attachment close, sacci on lateral sides free from each other.

Description — Diploxylonoid, size range 32-50 μ×96-128 μ. Central body distinct, size range 32-50 μ×32-50 μ, exine 1-2 μ thick, ornamented with tuberoid processes, irregularly anastomosing on the proximal side of the central body. Proximal attachment of sacci to central body equatorial, distal attachment very close, sacci free area on distal surface narrow and indistinct. Sacci almost spherical, sometimes radially folded; coarsely intrareticulate, mesh size 1-3 μ.

Comparison — *Rhizomaspora radiata* Wilson compares with this species in having closely placed distal attachment; but can be distinguished by the reniform, laterally overlapping sacci. *R. divaricata* Wilson and *R. lemniscata* Wilson differ in possessing uniformly broad sulcus and fewer radiating ribs.

Rhizomaspora sp.
Pl. 5, Fig. 56

Description — Bisaccate, bilaterally symmetrical, diploxylonoid pollen grain, 78× 151 μ. Central body subcircular, 57×69 μ, exine about 2·5 μ thick, faintly microverrucose, ill-developed diverging ribs present on proximal surface. Proximal attachment of sacci to central body equatorial, distal attachment more or less straight, sulcus narrow, not well defined. Sacci hemispherical, intrareticulate, mesh size upto 2·5 μ, lumina shallow.

Comparison — The present specimen is distinguished from *Rhizomaspora costa* by its large size and ill-developed, diverging ribs. *R. divaricata* Wilson and *R. lemniscata* Wilson are comparable to the *Rhizomaspora* sp. in possessing fewer radiating ribs but can be distinguished by the presence of uniformly broad sulcus.

Genus *Hamiapollenites* Wilson, 1962

Type Species — *Hamiapollenites saccatus* Wilson, 1962.

Hamiapollenites saccatus Wilson, 1962
Pl. 4, Fig. 47

Holotype — Wilson, 1962; Pl. 3, Fig. 7.

Description — Broadly oval with long horizontal and comparatively shorter vertical axis, ratio approximately 1:2. Bisaccate, 50-69 μ×96-138 μ. Central body subcircular to horizontally oval, 50-60 μ×55-73 μ; exine thick, intrapunctate, puncta about 0·5 μ in diameter; puncta closely placed and ribs are distinctly punctate. Horizontal grooves on proximal face 8-12; converging at ends; 3-6 vertical grooves perpendicular to horizontal grooves present distally. Proximal attachment subequatorial, straight to slightly concave forming large sacci free area on central body. Sacci less than semicircle, often unequal in size; coarsely intrareticulate, mesh size 1-2 μ, meshes apparently radially arranged.

Hamiapollenites incestus sp. nov.
Pl. 4, Figs. 44-46

Holotype — Pl. 4, Fig. 44. Size 105×46 μ, central body 64×64 μ, sacci 23×46 and 18×41 μ. Slide No. 2438/6.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Bisaccate, central body subcircular, horizontal and vertical grooves well developed; exine laevigate.

Description — Elliptical, 46-110 μ×87-110 μ. Central body well defined, exine 1-1·5 μ thick, laevigate. Proximally 6-12 grooves present with converging ends forming a spindle; 4-10 grooves present perpendicular to horizontal grooves on distal surface. Proximal attachment of central body to sacci equatorial, distal attachment subequatorial; sacci free area of central body wide. Sacci less than semicircle, sometimes unequal

in size, meshes sometimes not well developed, mesh size when distinct 1-2 μ.

Comparison — *Hamiapollenites saccatus* Wilson resembles the present species in shape and general organization. *H. incestus* has a laevigate body exine while in *H. saccatus* it is intrapunctate.

Genus *Corisaccites* Venkatachala & Kar, 1966

Type Species — *Corisaccites alutas* Venkatachala & Kar, 1966.

Corisaccites alutas Venkatachala & Kar

Pl. 2, Fig. 27, Pl. 3, Figs. 35-36

Corisaccites vanus Venkatachala & Kar, 1966 (*Not illustrated here*).

Infraturma—*Disacciatrileti* (Leschik) Potonié, 1958

Genus *Sulcatisporites* (Leschik) Bharadwaj, 1962

Type Species — *Sulcatisporites interpositus* Leschik, 1955.

Sulcatisporites sp.

Pl. 4, Fig. 48

Description — Subcircular, 92×87 μ, central body indistinct, seems to be vertically oval, exine thin, intramicroreticulate. Distal attachment straight, closely placed; coarsely intrareticulate, mesh size 1-2 μ.

Remarks — As compared to *Labiisporites* the sulcus in *Sulcatisporites* is thin and narrow and the central body is imperceptible.

Genus *Labiisporites* (Leschik, 1956) Klaus, 1963

Type Species — *Labiisporites granulatus* Leschik, 1956.

General Remarks — Bharadwaj (1962) opined that *Labiisporites* Leschik is a variant of *Sulcatisporites* (Leschik) Bharadwaj (1962). *Sulcatisporites* differs from *Labiisporites* in possessing a distinct distal sulcus and an ill-defined central body. Klaus (1963), however, maintained the separate entity of *Labiisporites* and subsequently emended it; in his opinion *Labiisporites* has a monolete mark; which, however, is not mentioned by Leschik (1956) and Bharadwaj (1962). No monolete mark has also been observed by the present authors.

Labiisporites (Leschik) seems to be comparable with *Pityosporites* (Seward) Manum and *Alisporites*. *Pityosporites* as circumscribed by Manum (1960) has distinct cap on the central body as in pollen grains of the extant genus *Pinus*. This character appears to be different and distinct and thus hitherto known species of *Pityosporites* should be placed elsewhere as such distinct cap has not been observed in the specimens referred to *Pityosporites* from the Permian sediments. The type species of *Pityosporites* is illustrated by a section and is presumably from the Lower Mesozoic sediments of Antartica. *Alisporites* is distinctly bisaccate with proximal equatorial attachment and distal attachment forming a very broad sacci free area (sulcus on the distal side). A restudy of the holotype of the type species *Alisporites opii* by Wilson and Venkatachala (in press) points out that it is distinct from *Pityosporites* and other bisaccate types. Hence *Labiisporites* is maintained here as a distinct genus and not considered a synonym of *Alisporites* or *Pityosporites*.

Labiisporites nectus sp. nov.

Pl. 4, Figs. 42-43

Holotype — Pl. 4, Fig. 42. Size 96×64 μ, central body 55×64 μ, sacci 46×59 and 50×50 μ. Slide No. 2438/1.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Bisaccate, bilaterally symmetrical, haploxylonoid pollen; elliptical, central body vertically oval; distal attachment juxtaposed forming a close, narrow sulcus.

Description — Size 60-85 μ × 90-135 μ. Central body well defined, size range 50-50 μ × 55-85 μ. Proximal attachment of sacci to central body equatorial, distal attachment inclined and covers the whole part of central body except a narrow slit like area forming a narrow sulcus. Sacci semicircular, coarsely intrareticulate, mesh size 1-2 μ.

Comparison — *Labiisporites granulatus* Leschik has a wider sulcus in comparison to the present species.

Subturma — *Polysaccites* Cookson, 1947

Genus *Trochosporites* Wilson, 1962

Type Species — *Trochosporites reniformis* Wilson, 1962.

Trochosporites tripus sp. nov.

Pl. 4, Fig. 49

Holotype — Pl. 4, Fig. 49. Size 69×64 μ, central body 48×46 μ, sacci 22×40, 25×48 and 23×41 μ. Slide No. 2438/5.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Trisaccate, central body well defined, finely microreticulate. Saccus reniform, coarsely intrareticulate.

Description — Size range 64-92 μ×69-92 μ, central body subtriangular to subcircular, size range 46-50 μ×46-55 μ, exine thin. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial. Sacci less than semicircle; mesh size 1-2 μ; lumina shallow.

Comparison — *Trochosporites reniformis* Wilson differs from *T. tripus* in possessing intrapunctate and subcircular to circular central body.

cf. *Trochosporites*

Pl. 4, Fig. 50

Description — Circular, tetrasaccate pollen grain. Central body circular, well defined, exine about 2 μ thick, intramicroreticulate. Proximal attachment of sacci to central body equatorial, distal attachment subequatorial. Sacci semicircular, mesh size 1-2 μ.

Remarks — The pollen grain is tetrasaccate while *Trochosporites* is trisaccate, hence the present specimen has only been compared with *Trochosporites*.

Turma — *Monocolpates* Iversen & Troels-Smith, 1950

Subturma— *Monoptyches* (Naumova) Potonié 1958

Genus *Ginkgocycadophytus* Samoilovich, 1953

Synonym — *Entylissa* Naumova, 1937.

Type Species — *Ginkgocycadophytus caperatus* (Luber) Samoilovich.

Ginkgocycadophytus cf. *G. cymbatus* (Balme & Hennelly) Potonié & Lele, 1960

Pl. 6, Fig. 60

Genus *Decussatisporites* Leschik, 1955

Type Species — *Decussatisporites delineatus* Leschik, 1955.

Decussatisporites pilus Venkatachala & Kar, 1968

Pl. 6, Figs. 70-72

Genus *Striasulcites* gen. nov.

Type Species — *Striasulcites tectus* sp. nov.

Generic Diagnosis — Subcircular, oval to spindle-oval, horizontally striated. Distal sulcus along the whole length of pollen, exine infragranulose.

Generic Description — Pollen grains mostly subcircular; oval or spindle-oval. 54-82 μ×82-101 μ. Sulcus well developed, biconcave, more or less straight or funnel shaped with flappy lips. Exine 1-1·5 μ thick, mostly infragranulose, sometimes indistinct or sparsely represented. Horizontal grooves 6-18 in number, almost parallel, some grooves branching.

Comparison — *Decussatisporites* Leschik differs in possessing horizontal and vertical grooves. Bharadwaj & Singh (1964) opine that the grooves (striations) are exo-exinous in origin. *Marsupipollenites* Balme & Hennelly (1956a) is characterized by a trilete mark and horizontal as well as vertical striations. *Vittatina* (Luber) Wilson (1962) is disaccate and also characterized by striations on both sides. *Ginkgocycadophytus* Samoilovich, *Monosulcites* (Cookson) Couper, are devoid of any striation. *Aumancisporites* Alpern (1958) is devoid of sulcus.

Striasulcites tectus sp. nov.

Pl. 6, Figs. 61-66

Holotype — Pl. 6, Fig. 61. Size 82×69 μ. Slide No. 2438/6.

Isotype — Pl. 6, Fig. 62. Size 96×73 μ. Slide No. 2438/1.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Oval to spindle shaped; sulcus biconcave, extending the whole length of the pollen. Exine infragranulose, horizontal grooves 6-18 in number.

Description — Size range 54-69 μ×82-101 μ; sulcus wide, funnel shaped or broadened at ends, sulcus often ruptured. Exine 1-1·5 μ thick, infragranulose, horizontal striations 6-18 in number, parallel to each other, sometimes branched; vertical striation absent.

Striasulcites ovatus sp. nov.
Pl. 6, Figs. 67-69

Holotype — Pl. 6, Fig. 67. Size 97×82 μ. Slide No. 2438/1.

Isotype — Pl. 6, Fig. 68. Size 92×78 μ. Slide No. 2438/3.

Type Locality — Shale 25 ft. above the Boulder bed, Kathwai, Permian, Salt Range; West Pakistan.

Specific Diagnosis — Subcircular, sulcus extending from one end to other, narrow at one end and broad at other. Exine infragranulose, horizontally striated, with 10-15 striations.

Description — Size range 73-87 μ×78-92 μ. Sulcus broad and distinct, margin sometimes folded. Exine 1-1·5 μ thick, infragranulose. Horizontal striations 10-15, more or less parallel to each other, often branched.

Comparison — *Striasulcites tectus* differs from the present species in having a biconcave sulcus and oval to spindle-oval shape.

PALYNOLOGICAL COMPOSITION AND COMPARISON

The carbonaceous shale 25 ft. above the Talchir Boulder bed from Kathwai, Salt Range Series, yielded a good assemblage of spores and pollen. Trilete, monolete, monosaccate, bisaccate and monocolpate spore-pollen genera are well represented. Among the trilete spore genera, *Camptotriletes* Naumova, *Indotriradites* Tiwari dominate. *Cyclofoveolatispora* a new genus proposed here is also abundant. Monolete spores are represented only by *Laevigatosporites* (Ibrahim) Schopf, Wilson & Bentall. Monosaccate pollen as a group is in overwhelming majority. *Plicatipollenites* Lele, *Barakarites* Bharadwaj & Tiwari, *Parasaccites* Bharadwaj & Tiwari are all well represented. The nonstriate disaccate genera are not well represented. The grooved bisaccate pollen genera are represented mostly by *Corisaccites* Venkatachala & Kar, *Hamiapollenites* Wilson, *Rhizomaspora* Wilson, *Striatites* (Pant) Bharadwaj and *Lahirites* Bharadwaj. Among the monocolpate genera *Ginkgocycadophytus* Samoilovich and *Decussatisporites* Leschik are rare, while *Striasulcites* gen. nov. is well represented.

The present palynological assemblage seems to be closely comparable to the assemblages of the Barakar Stage described by Bharadwaj and Tiwari (1964) and Venkatachala and Kar (1968) in some respects but differs in the abundance of monosaccate pollen.

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EXPLANATION OF PLATES

(All photomicrographs are enlarged *ca.* × 500)

PLATE 1

1-2. *Retusotriletes aridus* sp. nov. Photo Nos. 66/31, 66/13.
3-5. *Camptotriletes bellus* sp. nov. Photo Nos. 64/7, 64/20, 67/25.
6-8. *Apiculatisporis secretus* sp. nov. Photo Nos. 65/20, 67/23, 66/16.
9. *Lophotriletes* sp. Photo No. 64/3.
10-12. *Cyclofoveolatispora caecus* gen. et sp. nov. Photo Nos. 66/17, 66/4, 67/18.
13. *Cyclofoveolatispora plicatus* sp. nov. Photo No. 67/21.
14-16. *Indotriradites varius* sp. nov. Photo Nos. 65/32, 67/6, 66/9.
17-18. *Laevigatosporites* sp. Photo Nos. 67/27, 66/12.

PLATE 2

19-20. *Parasaccites bellus* sp. nov. Photo Nos. 65/2, 68/13.
21. cf. *Virkkipollenites.* Photo No. 67/18.
22. *Plicatipollenites gondwanensis* Lele. Photo No. 68/12.
23-25. *Parasaccites bokaroensis* Tiwari. Photo Nos. 67/11, 65/30, 68/14.
26. *Parasaccites korbaensis* Bharadwaj & Tiwari Photo No. 66/33.
27. *Corisaccites alutas* Venkatachala & Kar. Photo No. 67/36.

PLATE 3

28-30. *Barakarites dubius* sp. nov. Photo Nos. 67/5, 66/22, 65/7.
31-32. *Parasaccites rimosus* sp. nov. Photo Nos. 64/6, 66/2.
33. *Potonieisporites* sp. Photo No. 64/4.
34. cf. *Striomonosaccites.* Photo No. 66/3.
35-36. *Corisaccites alutas* Venkatachala & Kar. Photo Nos. 64/22, 65/4.

PLATE 4

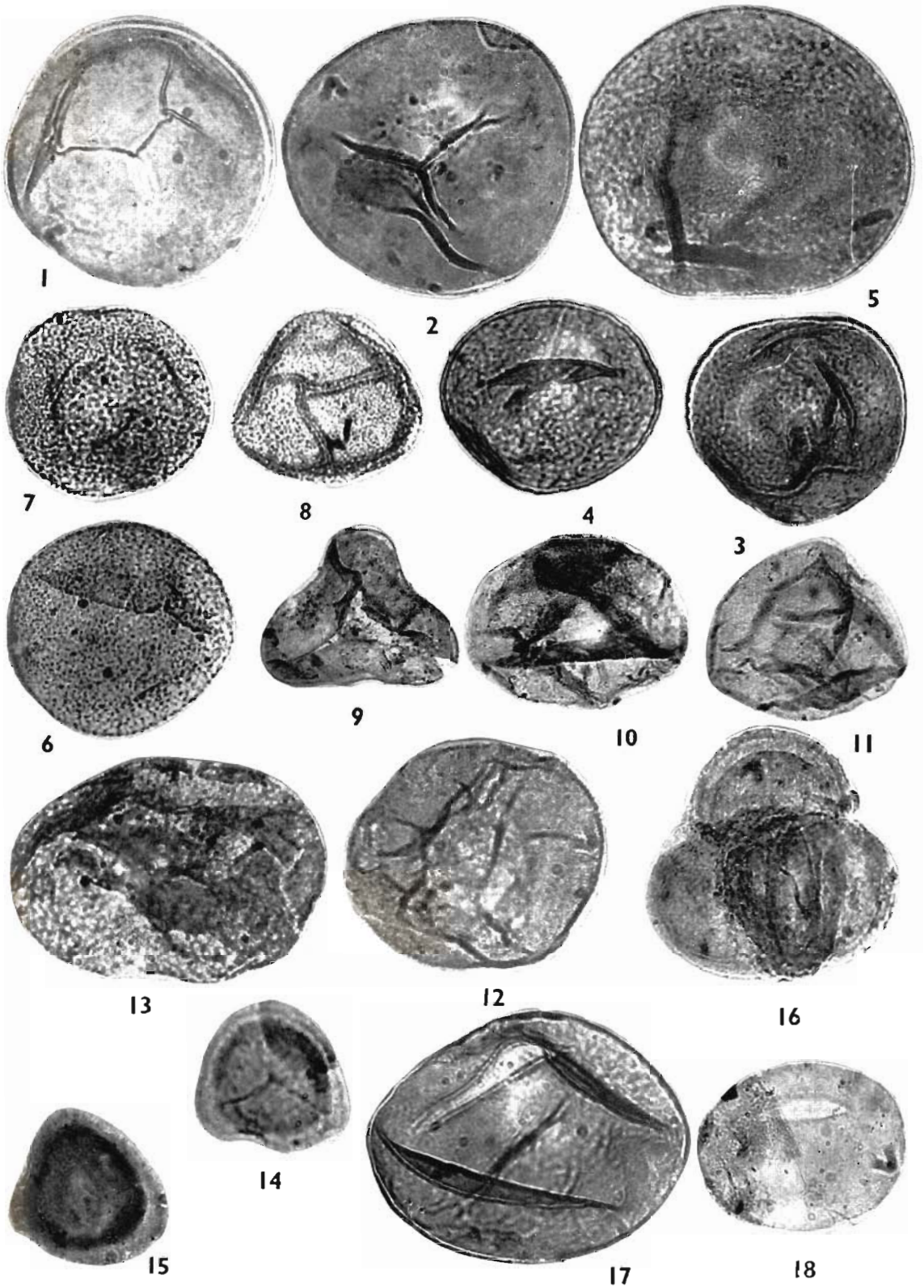
37-38, 41. *Striatites alius* Venkatachala & Kar. Photo Nos. 66/30, 64/12, 64/2.
39-40. *Lahirites angustus* Venkatachala & Kar. Photo Nos. 67/3, 66/15.
42-43. *Labiisporites nectus* sp. nov. Photo Nos. 64/13, 64/21.
44-46. *Hamiapollenites incestus* sp. nov. Photo Nos. 68/19, 67/15, 65/10.
47. *Hamiapollenites saccatus* Wilson. Photo No. 66/28.
48. *Sulcatisporites* sp. Photo No. 67/29.
49. *Trochosporites tripus* sp. nov. Photo No. 68/32.
50. cf. *Trochosporites.* Photo No. 66/21.

PLATE 5

51-53. *Lahirites naviculus* sp. nov. Photo Nos. 66/23, 67/34, 66/27.
54-55. *Rhizomaspora costa* sp. nov. Photo Nos. 64/18, 66/20.
56. *Rhizomaspora* sp. Photo No. 66/5.
57. *Strotersporites* sp. Photo No. 68/5.
58-59. *Striatopiceites* sp. Photo Nos. 64/8, 65/15.

PLATE 6

60. *Ginkgocycadophytus* cf. *G. cymbatus* Potonié & Lele. Photo No. 67/28.
61-66. *Striasulcites tectus* gen. et sp. nov. Photo Nos. 68/29, 64/17, 68/28, 67/32, 67/8, 66/32.
67-69. *Striasulcites ovatus* sp. nov. Photo Nos. 64/19, 66/1, 64/10.
70-72. *Decussatisporites pilus* Venkatachala & Kar Photo Nos. 66/35, 64/5, 68/31.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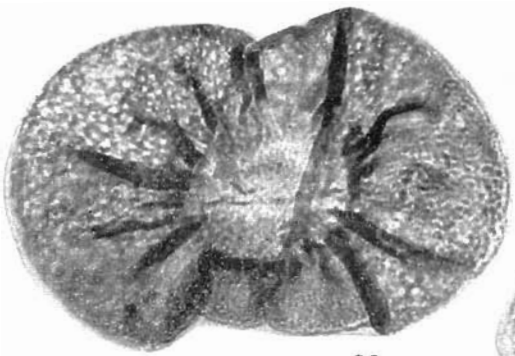

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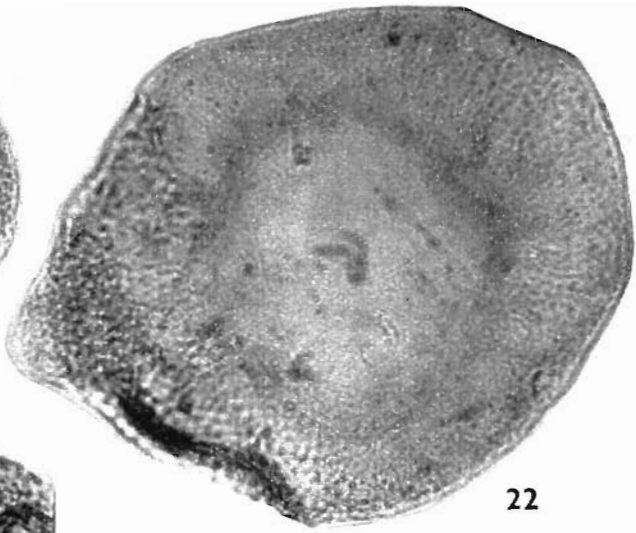

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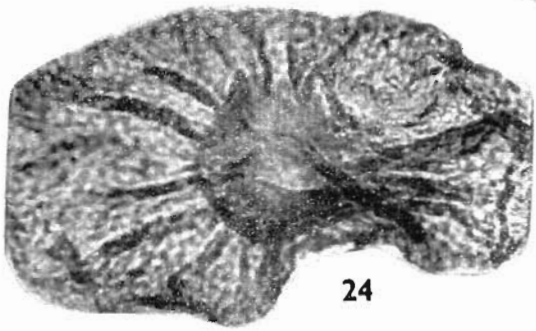

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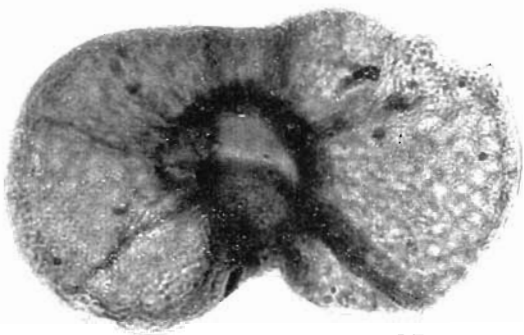

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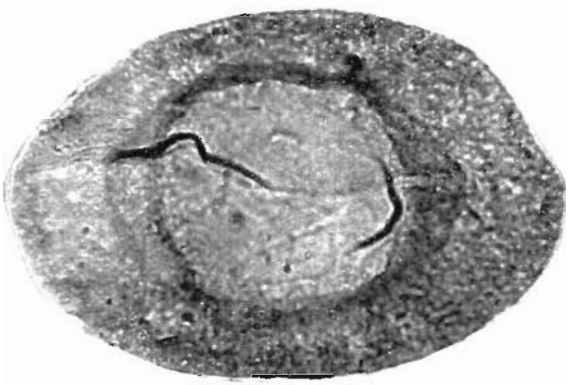

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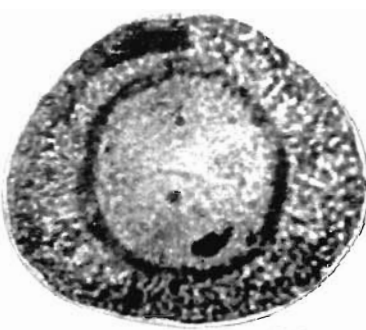

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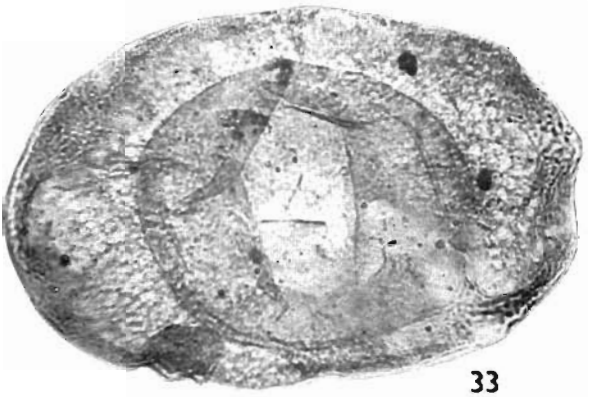
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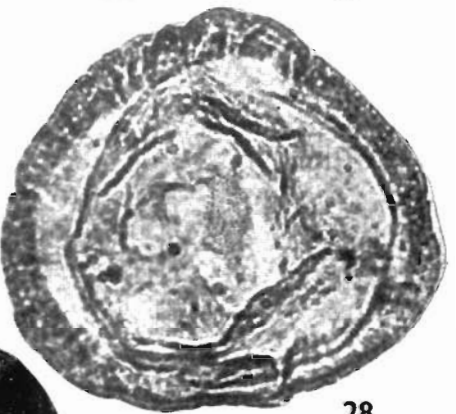
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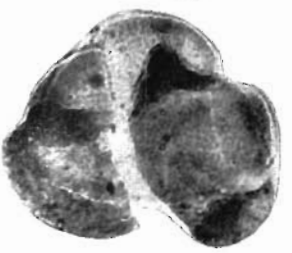
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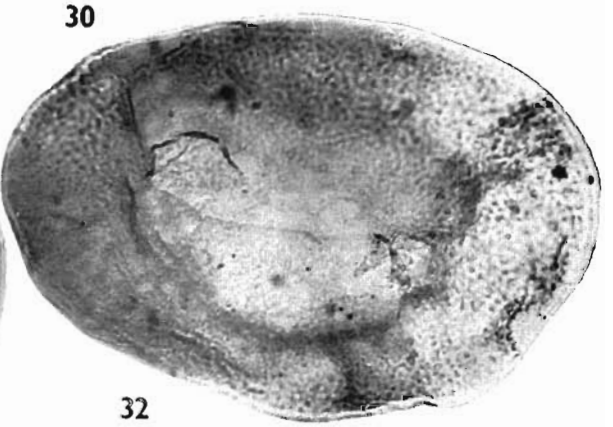
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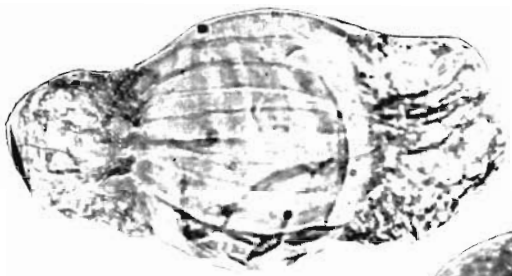

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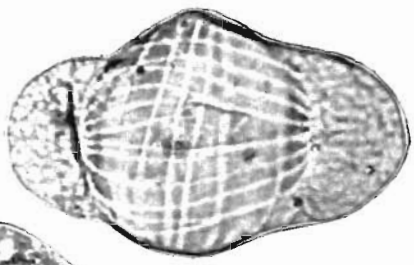

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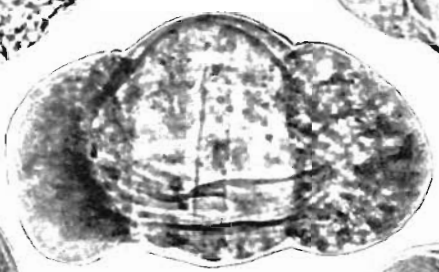

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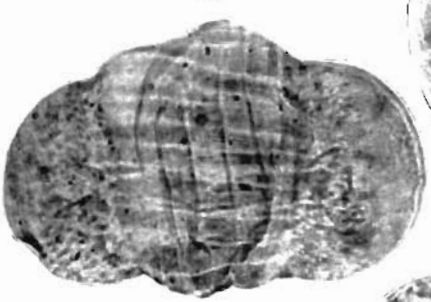

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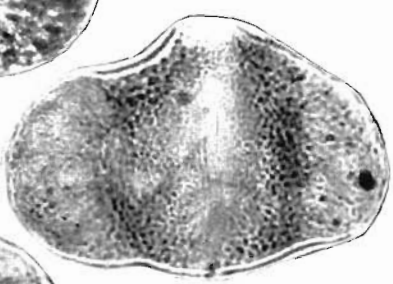

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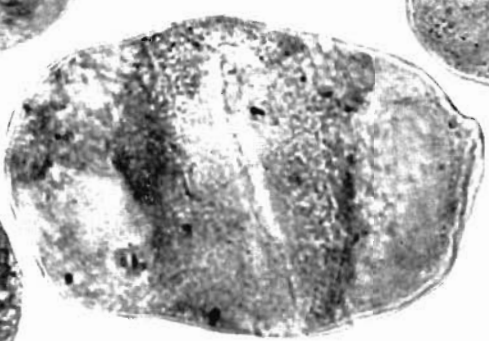

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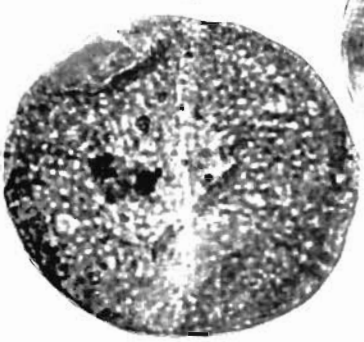

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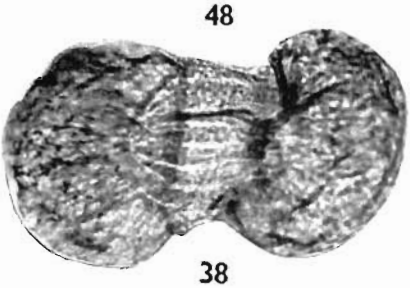

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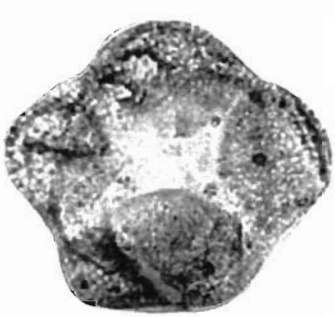

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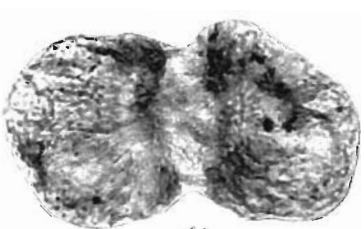

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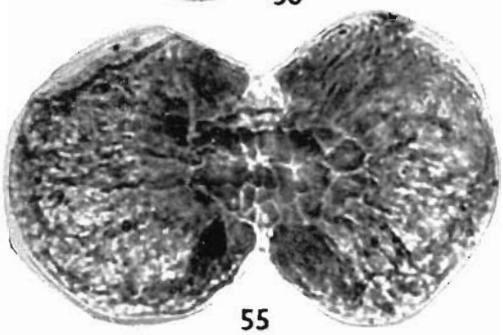

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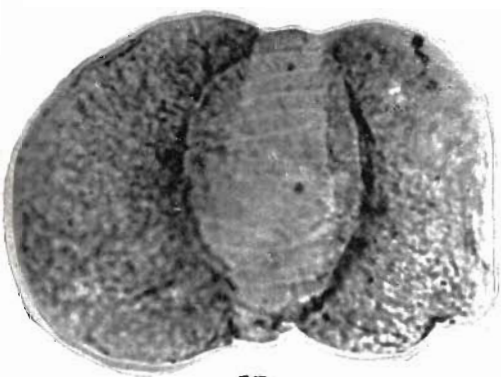

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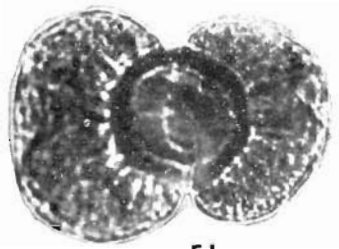

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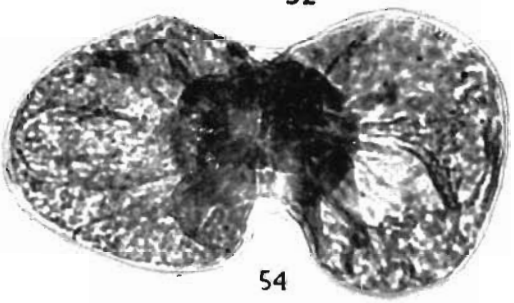

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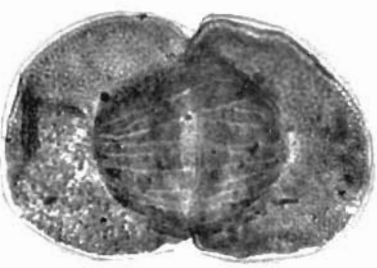

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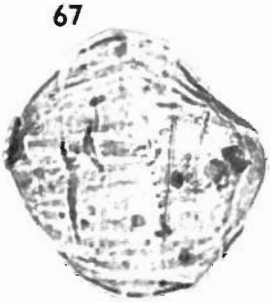

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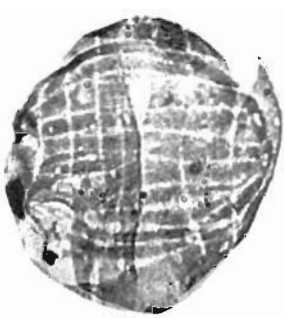

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