PALYNOLOGICAL STUDIES IN THE LOWER KARROO OF RHODESIA AND THE REPUBLIC OF SOUTH AFRICA

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ABSTRACT

Twenty four samples from Lower Karroo deposits in Rhodesia, Malawi, Mocambique and the Republic of South Africa, ranging in age from Middle Ecca to Lower Beaufort (Lower to Upper Permian) were macerated for palynological investigation. Seven samples yielded identifiable miospores and these are systematically described. They include 76 species comprising 45 spore-pollen genera, 13 belonging to triletes, 3 to monoletes, 2 to aletes, 10 to monosaccates, 5 to nonstriate-bisaccates, 10 to striate-bisaccates and 1 each to polyplicates and monocolpates. Two new genera, viz., *Surangeaspora* and *Sahialetes*, and 12 new species are established (*Leiotriletes giganticus*, *Lophotriletes robustus*, *Leschikisporis verrucosus*, *Surangeaspora coniata*, *S. densa*, *Zonareticulatisporis reticulata*, *Laevigatosporites longus*, *Sahialetes cephalus*, *S. minutus*, *Platysaccus monosaccoidus*, *Cuneatisporites juxtasaccus* and *Strotersporites longus*). All 7 assemblages are dominated by bisaccates; pteridophytic spores represented by triletes and monoletes rank second. Monosaccates are ill-representedi n all but one sample and aletes, polyplicates and monocolpates are rarely encountered. The palynological assemblages of the 7 samples are compared with other Gondwana assemblages from Africa and India.

INTORUDCTION

THE Karroo System in Central and South Africa includes a great thickness of both volcanic and freshwater sedimentary rocks. The deposits are almost entirely of continental origin and range in age from Carboniferous to Jurassic. In those parts of Africa from where the present material has been collected, the System is generally subdivided as shown in Table 1

In 1958, one of the authors (W. S. Lacey) undertook a palaeobotanical expedition in Central and Southern Africa and subsequently published a preliminary geological account of the plant-bearing deposits in the then Federation of Rhodesia and Nyasaland (Lacey, 1961). This was followed by accounts of the macrofossil floras found in various parts of Rhodesia (Lacey & Huard-Moine, 1966; Lacey, 1970, 1970a, 1971), Malawi (Lacey & Kulkarni, 1969) and Zambia (Lacey & Smith, 1972; Lacey, in press).

During the same expedition, samples were also collected for palynological investigation. Research on this material was commenced by S. Chandra (née Kulkarni) in Bangor in 1967-1968 and completed in collaboration with R. K. Kar in Lucknow during 1973-74.

MATERIAL STUDIED

In all, 24 samples were macerated, of which only 7 (nos. 4, 5, 6, 7, 10, 13 and 21) yielded identifiable spores. The lithology, locality, horizon and general results of maceration of the 24 samples are given below.

1. Coal; base of Main S am, no. 3 colliery, Wankie, Rhodesia; Lower Ecca; wood fragments and lycopod megaspores (*Triletes* cf. *rugosus* (Loose) — teste S. J. Dijkstra, pers. comm.) but no miospores.

2. Coal; top of Main Seam, open cast pit near no. 1 colliery, Wankie, Rhodesia; Lower Ecca; abundant wood fragments, lycopod megaspores and rare poorly preserved miospores.

3. Coaly shale, with impressions of *Glossopteris* sp.; roof of Main Seam, no. 2 colliery, Wankie, Rhodesia; Lower Ecca; wood fragments, lycopod megaspores, rare poorly preserved miospores.

4, 5. Shale and associated thin coal; at 102-104 ft in a borehole near no. 3 colliery, about 6 miles south-west of Wankie, Rhodesia; Upper Wankie Sandstone; wood

TABLE 1 — THE KARROO SYSTEM IN SOUTH AND CENTRAL AFRICA

SERIES	SOUTH AFRICA (DU TOIT, 1954)	MIDDLE ZAMBEZI REGION (LACEY, 1961; BOND, 1973)	AGE IN EUROPEAN EQUIVALENTS
Stormberg	Drakensberg Basalts	Batoka Basalts and Sandstones	Lower Jurassic
	Cave Sandstone	Forest Sandstone Pebbly Arkose	Upper Triassic
	Red Beds	Fine Red Marly Sandstone	
	Molteno	Ripple-marked Flags Escarpment Grit	Middle Triassic
		Unconformity	
Beaufort	Upper Middle Lower	Upper and Middle Madumabisa Mudstones	? Lower Triassic Upper Permian
Ecca	Upper Middle Lower	Lower Madumabisa Mudstone Upper Wankie Sandstone Black Shale and Coal Group Lower Wankie Sandstone	Lower Permian
Dwyka	Upper Shales Glacial Boulder Beds Lower Shales	Glacial Boulder Beds and Varved Clays	Carboniferous

fragments and a good assemblages of miospores.

6, 7. Shale and associated thin coal; at 89-90 ft in the same borehole as nos. 4 and 5; Upper Wankie Sandstone; wood fragments and good assemblages of miospores. The shale sample nos. 4 and 6 (between 89 & 104 ft) collectively yielded a macroflora including *Phyllotheca* sp., *Sphenophyllum thonii* var. *minor* Sterz., *Glossopteris indica* Schimp., *G. browniana* Brongn.,?*Noeggerathiopsis* sp., and *Carpolithus* sp.

8. Shale with impressions of ?*Phyllotheca* sp., ?*Glossopteris* sp., and *Vertebraria* sp.; railway cutting between Mbarira and Thomson Junction, north of Wankie, Rhodesia; Lower Madumabisa Mudstone; no spores.

9. Shale with impressions of *Phyllotheca* sp., *Glossopteris indica* Schimp., *Glossopteris* sp., *Samaropsis* sp.; cliff section, Sebungwe River, Rhodesia; Lower Madumabisa Mudstone; no spores.

10. Shale with impressions of ?*Gangamopteris* sp., *Glossopteris indica* Schimp., *G. browniana* Brongn., *Vertebraria* sp., and *Noeggerathiopsis hislopii* Feist.; from bore hole near the Bubye River, 51 miles east of Beit Bridge, Rhodesia; horizon not known with certainty but probably Upper Ecca to Lower Beaufort; fairly good assemblage of spores.

11. Coal; natural exposure, Sabi River, south-east Rhodesia; horizon not known with certainty but probably within the Ecca; wood fragments but no spores.

12. Coaly shale; roadside exposure at Moatise, Mocambique; horizon not known with certainty but probably within the Ecca; wood fragments but no spores.

13, 21. (Repeat sample). Hard black shale, with impressions of *Gangamopteris obovata* (Carruthers) White, *Gangamopteris* spp., *Glossopteris* spp. (Williams, 1966); roof of no. 3 Seam, Bellevue Colliery, Ermelo, Transvaal, Republic of South Africa; Middle Ecca; good assemblages of miospores.

14, 20. (Repeat sample). Mudstone, with impressions of *Sphenopsid* axes, *Glossopteris* spp., *Lidgettonia africana* Thomas, *Samaropsis* sp.; stream section, Lidgetton, Natal, Republic of South Africa; Lower Beaufort; poorly preserved unidentified spores.

15, 16. Soft brown shales, with abundant impressions of a rich *Glossopteris* flora (see Lacey, 1961; Lacey & Huard-Moine, 1966); railway cutting (No. 15) and nearby quarry (No. 16), near Thomson Junction, Wankie, Rhodesia; Upper Wankie Sandstone; wood fragments but no spores.

17. Shale, with impressions of *Glossopteris indica* Schimp., *G. browniana* Brongn., *G. stricta* Bunb., *G.* cf. *retifera* Feistm., *G.* cf. *angustifolia*, *Taeniopteris* sp., *Carpolithus* sp., old cliff section near Madziwadzido, Sebungwe, Rhodesia; Middle Madumabisa Mudstone; wood fragments but no spores.

18. Mudstone, with impressions of *Taeniopteris* cf. *lata* Oldham, *Conites* sp.; cliff section, Sebungwe River (loc. now submerged in Lake Kariba); Rhodesia; Uppermost Madumabisa Mudstone; rare poorly preserved unidentified spores.

19. Shale, with impressions of *Glossopteris* spp.; near Mbungwa Hill, 11 miles south-west of Port Herald, Malawi; horizon not known with certainty but possibly Middle Ecca; no spores.

22. Sandy shale, with impressions of *Gangamopteris obovata* (Carruthers) White, *Glossopteris indica* Schimp. *G. browniana* Brongn., *Noeggerathiopsis hislopii* Feist., *Sphenopteris alata* (Brongn.); cliff section, tributary of the Sengwe River, Sebungwe, Rhodesia; Upper Wankie Sandstone; no spores.

23. Shale, with *Vertebraria* sp.; outcrop near borehole no. 6, Umi River, Gorodema, Rhodesia; Lower Madumabisa Mudstone; no spores.

24. Shale, with *Vertebraria* sp.; cliff section near borehole no. 1, Bari Salt Pan, Bumi River, Rhodesia; Lower Madumabisa Mudstone; no spores.

METHOD OF PREPARATION OF SAMPLES

Fifteen to twenty grams of samples were used in each case; crushed to pieces of about 0·5 cm, but was not powdered. The crushed sample was washed in distilled water, then kept in commercial HNO_3 with added $KClO_3$ for 24 hours. After this the sample was heated gently on hot plate for 10 minutes and cooled and thoroughly washed with distilled water by decantation 7 to 10 times, allowing to settle 1/2 hour between decantations. When free of acid, sample was transferred to porcelain dish by washing with a small quantity of distilled water, and 10 to 15 pellets of KOH were added (to provide a 5 to 10% solution). Sample was then washed through a 400-mesh sieve using copious amounts of distilled water. Material retained on sieve transferred by washing with distilled water into small specimen tube; some samples were taken with a clean small pipette and spread on cover-slips. When spore material on the cover-slips dried, it was mounted on slides in canada balsam.

SYSTEMATIC SECTION

The spores and pollen grains recovered from the samples have been placed under 45 genera and 76 species as under:

Anteturma — *Sporites* H. Pot., 1893
Turma — *Triletes* (Rein.) Pot. & Kr., 1954
Subturma — *Azonotriletes* Lub., 1935
Infraturma — *Laevigati* (Ben. & Kids.) Pot., 1956

Genus — *Leiotriletes* (Naum.) Pot. & Kr., 1954

Leiotriletes virkkii Tiw., 1965
L. corius Kar & Bose, 1967
L. giganticus sp. nov.

Genus — *Punctatisporites* (Ibr.) Pot. & Kr., 1955

Punctatisporites gretensis Balme & Henn., 1956

Genus — *Psilalacinites* Kar, 1969b

Psilalacinites triangulus Kar, 1969b

Infraturma — *Apiculati* (Ben. & Kids.) Pot., 1956

Genus — *Apiculatisporis* Pot. & Kr., 1956

Apiculatisporis levis Balme & Henn., 1956

Genus — *Cyclogranisporites* Pot. & Kr., 1954

Cyclogranisporites gondwanensis Bharad. & Sal., 1964
C. burettei Bose & Kar, 1966

Genus — *Lophotriletes* (Naum.) Pot. & Kr., 1954

Lophotriletes rectus Bharad. & Sal., 1964
L. frequensus Tiw., 1965
L. mabuitaensis Bose & Kar, 1966
L. robustus sp. nov.

Genus — *Acanthotriletes* (Naum.) Pot. & Kr., 1954

Acanthotriletes cornutus (Høeg & Bose) Bose & Kar, 1966

Genus — *Leschikisporis* Pot., 1958

Leschikisporis verrucosus sp. nov.

Genus — *Surangeaspora* gen. nov.

Surangeaspora coniata gen. et sp. nov.
S. densa sp. nov.

Subinfraturma — *Varitrileti* Venk. & Kar, 1965

Genus — *Lacinitriletes* Venk. & Kar, 1965

Lacinitriletes badamensis Venk. & Kar, 1965
L. minutus Venk. & Kar, 1968a

Infraturma — *Striasporiti* Kar, 1969b

Genus — *Striasporis* Kar, 1969b

Striasporis striatus Kar, 1969b

Subturma — *Zonaletes* (Lub.) Pot., 1958
Infraturma — *Zonareticulati* Kar, 1969a

Genus — *Zonareticulatisporis* Kar, 1969b

Zonareticulatisporis reticulata sp. nov.
cf. *Zonareticulatisporis* sp.

Infraturma — *Zonati* Pot. & Kr., 1954

Genus — *Indotriradites* Tiw., 1964

Indotriradites sparsus Tiw., 1965
I. surangei Tiw., 1965

Turma — *Monoletes* Ibr., 1933
Subturma — *Azonomonoletes* Lub., 1935
Infraturma — *Psilamonoleti* v.d. Ham., 1955

Genus — *Laevigatosporites* (Ibr.) Sch., Wil. & Bent., 1944

Laevigatosporites colliensis (Balme & Henn.) Venk. & Kar, 1968a
L. longus sp. nov.

Infraturma — *Perinomonoliti* Erdt., 1947

Genus — *Kendosporites* Sur. & Chan., 1974

Kendosporites striatus (Sal.) Sur. & Chan., 1974

Genus — *Tiwariasporis* Maheshw. & Kar., 1967

Tiwariasporis flavatus Maheshw. & Kar, 1967

Turma — *Aletes* Ibr., 1933
Subturma — *Azonaletes* (Lub.) Pot., 1956
Infraturma — *Tuberini* Pant, 1954

Genus — *Mammialetes* Kar, 1969b

Mammialetes mammus Kar, 1969b

Genus — *Sahialetes* gen. nov.

Sahialetes cephalus gen. et sp. nov.
S. minutus sp. nov.

Anteturma — *Pollenites* Pot., 1931
Turma — *Saccites* Erdtm., 1947
Subturma — *Monosaccites* (Chit.) Pot. & Kr., 1954
Infraturma — *Apertacorpiti* Lele, 1964

Genus — *Cannanoropollis* Pot. & Sah, 1960

Cannanoropollis mehtae (Lele) Bose & Maheshw., 1968
C. corius (Bose & Kar) comb. nov.
C. obscurus (Lele) Bose & Maheshw., 1968
C. congoensis (Bose & Maheshw.) comb. nov.

Infraturma — *Triletesacciti* Lesch., 1955

Genus — *Barakarites* Bharad. & Tiw., 1964a

Barakarites densus Bose & Kar, 1966

Infraturma — *Amphisacciti* Lele, 1965

Genus — *Parasaccites* Bharad. & Tiw., 1964a

Parasaccites korbaensis Bharad. & Tiw., 1964a
Parasaccites sp.

Infraturma — *Caheniasacciti* Bose & Kar, 1966

Genus — *Caheniasaccites* Bose & Kar, 1966

Caheniasaccites ovatus Bose & Kar, 1966

Genus — *Crucisaccites* Lele & Maithy, 1964

Crucisaccites latisulcatus Lele & Maithy, 1964

Infraturma — *Aletesacciti* Lesch., 1956

Genus — *Densipollenites* Bharad., 1962

Densipollenites indicus Bharad., 1962

Genus — *Vestigisporites* (Balme & Henn.) Hart, 1960

Vestigisporites hennellyi Hart, 1960

Infraturma — *Divarisacciti* Bose & Kar, 1966a

Genus — *Divarisaccus* Venk. & Kar, 1966a

Divarisaccus lelei Venk. & Kar, 1966a

Infraturma — *Striasacciti* Bharad., 1962

Genus — *Striomonosaccites* Bharad., 1962

Striomonosaccites ovatus Bharad., 1962

Infraturma — *Vesiculomonoraditi* (Pant) Bharad., 1955

Genus — *Potonieisporites* (Bhard.) Bharad., 1964

Potonieisporites distinctus Bose & Maheshw., 1968

Subturma — *Disaccites* Cook., 1947

Infraturma — *Podocarpoiditi* Pot. & Thierg., 1950

Genus — *Platysaccus* (Naum.) Pot. & Kl., 1954

Platysaccus papilionis Pot. & Kl., 1954
P. leschiki Hart, 1960
P. katriensis Kar, 1968
P. monosaccoidus sp. nov.

Genus — *Cuneatisporites* Lesch., 1955

Cuneatisporites fundiensis Bose & Kar, 1966
C. rarus Kar, 1968
C. juxtasaccus sp. nov.

Genus — *Valiasaccites* Bose & Kar, 1966

Valiasaccites validus Bose & Kar, 1966
V. elilaensis Bose & Kar, 1966

Genus — *Scheuringipollenites* Tiw., 1973

Scheuringipollenites maximus (Hart) Tiw., 1973
S. barakarensis (Tiw.) Tiw., 1973
S. tentulus (Tiw.) Tiw., 1973

Infraturma — *Disaccimonoletes* Kl., 1963

Genus — *Limitisporites* Lesch., 1956

Limitisporites plicatus Bose & Kar, 1966

Infraturma — *Striatiti* (Pant) Bharad., 1962

Genus — *Striatites* (Pant) Bharad., 1962

Striatites communis Bharad. & Sal., 1964
S. ornatus Venk. & Kar, 1968a
S. alius Venk. & Kar, 1968a

Genus — *Verticipollenites* Bharad., 1962

Verticipollenites crassus Bharad. & Sal., 1964
V. debilis Venk. & Kar, 1968a

Genus — *Lahirites* Bharad., 1962

Lahirites angustus Venk. & Kar., 1968a

Genus — *Hindipollenites* Bharad., 1962

Hindipollenites formosus Venk. & Kar, 1968a

Genus — *Strotersporites* Wil., 1962

Strotersporites magnificus (Bharad. & Sal.) Venk. & Kar, 1964
S. longus sp. nov.

Genus — *Striatopiceites* (Zor. & Sed.) Sed., 1956

Striatopiceites varius (Bharad.) Venk. & Kar, 1968a
S. minutus Venk. & Kar, 1968a

Genus — *Crescentipollenites* Bharad., Tiw. & Kar, 1974

Crescentipollenites fuscus (Bharad.) Bharad., Tiw. & Kar, 1974

Genus — *Rhizomaspora* Wil., 1962

Rhizomaspora costa Venk. & Kar, 1968b

Genus — *Hamiapollenites* Wil., 1962

Hamiapollenites incestus Venk. & Kar, 1968b

Genus — *Corisaccites* Venk. & Kar, 1966b

Corisaccites alutas Venk. & Kar, 1966b

Turma — *Plicates* (Naum.) Pot., 1960
Subturma — *Polyplicates* Erdtm., 1952

Genus — *Gnetaceaepollenites* (Thieg.) Jans., 1962

Gnetaceaepollenites biplicatus Kar, 1968
G. pachydermatus Kar, 1968

Turma — *Monocolpates* Iver. & Tr.-Sm., 1950
Subturma — *Intortes* (Naum.) Pot., 1958

Genus — *Ginkgocycadophytus* Sam., 1953

Ginkgocycadophytus cymbatus (Balme & Henn.) Pot. & Lele, 1961

Genus — *Leiotriletes* (Naum.) Pot. & Kr., 1954

Leiotriletes giganticus sp. nov.

Pl. 1, figs. 1, 2

Holotype — Pl. 1, fig. 1, size 104 μ. Slide no. 21-3/20.

Type Locality — Bellevue Colliery, Transvaal, Republic of South Africa; Middle Ecca.

Diagnosis — Spores triangular-subtriangular, 82-109 μ, apices bluntly rounded. Trilete rays generally distinct extending upto three-fourths radius, exine upto 2·5 μ thick, laevigate, sometimes intrapunctate.

Comparison — *Leiotriletes virkkii* Tiw. (1965) is somewhat comparable to the present species in size range (52-78 μ) but the latter is easily separated from the former by its still bigger size range. Other species of *Leiotriletes* described from the Lukuga Series of Zaïre (Congo), viz., *L. congoensis*, *L. lukugaensis* and *L. psilatus* by Kar and Bose (1967) are much smaller in size range than the present one.

Occurrence — Sample nos. 21 and 13.

Genus — *Cyclogranisporites* Pot. & Kr., 1954

Cyclogranisporites burettei Bose & Kar, 1966

Pl. 1, fig. 3

Description — Spore subcircular, 60 μ. Trilete rays distinct, extending less than half-radius; exine 1·5 μ thick, granulose, grana 1-1·5 μ high, sparsely placed, intergranular space laevigate.

Remarks — *Cyclogranisporites burettei* described originally by Bose and Kar (1966) from Kindu-Kalima and Walikale regions of Zaïre (Congo) has grana of various sizes and the trilete rays, though ill-defined, extend upto three-fourths radius.

Occurrence — Sample no. 13.

Genus — *Lophotriletes* (Naum.) Pot. & Kr., 1954

Lophotriletes robustus sp. nov.
Pl. 1, figs. 4, 5

Holotype — Pl. 1, fig. 4, size 69 μ. Slide no. 6-3/4.

Type Locality — Bore-core sample, depth 89′-90′, drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Spores subtriangular-subcircular, 61-93 μ, interapical margin generally convex. Trilete rays well-developed, extending two-thirds to almost equatorial margin. Exine 1-1·5 μ thick, ornamented with sparsely placed coni, coni upto 2·5 μ high, strongly built with broad base and pointed tip.

Comparison — Of all the known species of *Lophotriletes* from the Lower Gondwanas of India, Australia and Africa, *L. frequensus* Tiw. (1965) approximates the present species in size range but the former is distinguished by its less strongly built coni. *L. rectus* Bharad. & Sal. (1964) and *L. mabuitaensis* Bose & Kar (1966) are very much smaller in size compared with the present one.

Occurrence — Sample no. 6.

Genus — *Leschikisporis* Pot., 1958

Leschikisporis verrucosus sp. nov.
Pl. 1, figs. 6-8

Holotype — Pl. 1, fig. 6, size 43 μ. Slide no. 5-1/5.

Type Locality — Bore-core samples, depth 102′-104′, drilled 6 miles south-west to Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Spores subcircular-oval, 36-57 μ. Trilete rays variable, one ray may be reduced or not traceable to approximate monolete mark. Exine about 2 μ thick, verrucosed, verrucae closely placed, mostly joined together to provide vermiculate appearance, sometimes it also appears as negative reticulum on surface view.

Comparison—Leschikisporis baccatus Venk. & Kar (1968) described from the Barakar Formation (Middle Permian) of India is comparable to the present species in subcircular shape and in the presence of variable trilete mark sculptured with coni while in the present one it is densely verrucosed.

Remarks — Leschik (1959) described *Verrucososporites detritus* and *V. obscurus* (Kos.) Pot. & Kr. (1954) from "Karroo Sandstone" near Norronaub, South-West Africa. These two species have monolete mark and verrucose exine. In the present material also, similar specimens along with the typical trilete ones are found. So it seems that the specimens referred by Leschik (1959) as *Verrucososporites* are the variants of *Leschikisporis*. It may also be stated here that *Verrucososporites*, originally proposed by Knox (1950), is an invalid genus and Wilson and Venkatachala (1963) instituted *Thymospora* for the spores hitherto known as *Verrucososporites* (Knox) Pot. & Kr. (1954).

Occurrence — Sample no. 5.

Genus — *Surangeaspora* gen. nov.

Type Species — *Surangeaspora coniata* sp. nov.

Generic Diagnosis — Spores triangular-subtriangular in fully proximo-distally flattened specimens. Proximal side of spore thinner, laevigate and concave; distal side thicker, heavier, convex and sculptured with coni; exine in between intrapunctate. Incipient inner body may be present. Trilete rays distinct or indistinct.

Description — Spores either found in solitary or tetrahedral tetrad condition. Due to the unequal thickness of surfaces, thinner proximal side caves in to distal forming a cup-like configuration. Fully proximo-distally flattened specimens for this reason in the material rare. Size of solitary specimens 36-112 μ while tetrad varies from 67-152 μ. In tetrad condition, thicker distal side generally observed while proximal side found along attachment area, the distal side always bigger in size in all the tetrads. Exine differentially thickened, proximally about 1 μ thick, laevigate, wrinkled, intrapunctate; distally exine about 2 μ thick, conied, coni 1-2·5 μ high, closely or sparsely placed; some parts of distal side generally cover the proximal side. In some specimens, an incipient inner body observed, it generally confront the overall shape of spore and may be slightly thickened at borders. Zona thus formed in these specimens — not uniformly broad and uneven at margin. Trilete rays generally ill-defined, rays uniformly broad or tapering at ends, in some specimens one ray shorter than two, rays extend from two-thirds to almost upto margin, commissure not pronounced.

Comparison — *Altitriletes* Venk. & Kar (1968) is comparable to the present genus in the presence of differential ornamentation pattern, i.e. it has also proximally laevigate and distally sculptured exine. But *Altitriletes* has subcircular-circular shape, very well developed trilete rays and no intrapunctate structure. The various genera of the subinfraturma *Varitrileti*, viz., *Microbaculispora* Bharad. (1962), *Didecitriletes* Venk. & Kar (1965) have triangular-subtriangular shape, proximally laevigate and distally sculptured exine but they are easily separated by the association of folds along the trilete rays on the distal surface. In *Anapiculatisporites* Pot. & Kr. (1954) like *Surangeaspora* the distal side is only ornamented but the former is distinguished from the latter by smaller size range and circular shape. Moreover, in the present genus, the proximal side of the spore is thinner and concave. *Cyclopilisporites* Maheshw. (1969) is circular-subcircular and distally ornamented with closely placed verrucae, warts and pila. *Jayantisporites* Lele & Mak. (1972) is conspicuous by its presence of pseudozona formed by the clubbing together of the distal sculptural elements. By its presence of incipient inner body the present genus also approximates *Dentatispora* Tiw. (1964), *Indotriradites* Tiw. (1964), *Potonieitriradites* Bharad. & Sinha (1969) and *Cingulizonates* (Dyb. & Jach.) Butterw. *et al.* (1964) but *Surangeaspora* proposed here is differentiated from all the known trilete spore genera by its presence of thinner, laevigate and concave proximal side while the distal surface is thicker, bigger, convex and bedecked with coni.

Derivation of Name — After Dr K. R. Surange, Director, Birbal Sahni Institute of Palaeobotany, Lucknow.

Surangeaspora coniata sp. nov.

Pl. 1, figs. 9-13; Pl. 2, fig. 19

Holotype — Pl. 1, fig. 9, size 49 μ. Slide no. 21-1/4.

Type Locality — Bellevue colliery, Transvaal, Republic of South Africa; Middle Ecca.

Diagnosis — Spores triangular-subtriangular in fully proximo-distally flattened specimens, subcircular in partially flattened specimens, while in tetrads they are in tetrahedral condition, individual spore 43-70 μ, tetrads 81-157×70-141 μ. Exine proximally thin, laevigate and intrapunctate, proximal side concave and caves into distal side, distal exine up to 2.5 μ thick, heavier than distal side, conied, 1·5-2·5 μ high, sparsely placed.

Occurrence — Sample nos. 21 and 13.

Surangeaspora densa sp. nov.

Pl. 2, figs. 15-18

Holotype — Pl. 2, fig. 15, size 86 μ. Slide no. 21-3/15.

Type Locality — Bellevue colliery, Transvaal, Republic of South Africa; Middle Ecca.

Diagnosis — Spores triangular-subcircular in proximo-distally flattened specimens, 78-102 μ. Exine proximally thin, laevigate and occasionally intrapunctate, distally exine thicker than proximal side, sculptured with sparsely placed coni, coni 1-2·5 μ high. Trilete rays well-developed, rays broad and extending generally up to margin.

Comparison — The present species resembles *Surangeaspora coniata* in overall shape and ornamentational pattern but the former is distinguished by its bigger size range and well-developed trilete rays extending up to margin.

Occurrence — Sample nos. 13 and 21.

Genus — *Lacinitriletes* Venk. & Kar, 1965

Lacinitriletes badamensis Venk. & Kar, 1965

Pl. 2, fig. 20

Remarks — More or less similar specimens figured here have also been described by Hart (1960) as *Verrucosisporites pseudoreticulatus* Balme & Henn. (1956). *Verrucosisporites*, it may be mentioned here is subcircular-circular in shape and has ornamentation on both sides. But the spore illustrated by Hart (1960, pl. 3, fig. 36) seems to have ornamentation only on one side and the trilete rays are associated with folds.

Occurrence — Sample nos. 13 and 21.

Genus — *Zonareticulatisporis* Kar, 1969a

Zonareticulatisporis reticulata sp. nov.

Pl. 2, figs. 21-23

Holotype — Pl. 2, fig. 21, size 56 μ. Slide no. 5-1/14.

Type Locality — Bore-core sample, depth 102'-104', drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Spores subcircular-circular, 38-71 μ; zonate, zona ill-developed, flange like, translucent. Exine up to 2·5 μ thick, reticulate on both surfaces, meshes square-hexagonal.

Comparison — The present species resembles *Zonareticulatisporis goubinii* Kar (1969a) in size range and character of the meshes. But in the latter, the reticulum is mostly restricted only on one surface whereas in the present one they are well-developed on both sides. Moreover, in *Z. goubinii*, the zona is distinct but in *Z. reticulata* it is incipient.

Occurrence — Sample nos. 5 and 6.

cf. *Zonareticulatisporis* sp.

Pl. 2, fig. 24

Description — Spore subcircular, 50 μ, alete; exine 2 μ thick, reticulate on both surfaces, meshes more or less rounded, 6-12 μ, projecting muri form an uneven margin.

Remarks — The specimen described above resembles *Zonareticulatisporis* in the absence of any haptotypic mark and in the presence of reticulate exine. The present specimen is, however, devoid of zona and hence it has only been compared with *Zonareticulatisporis*.

Occurrence — Sample no. 6.

Genus — *Laevigatosporites* (Ibr.) Sch., Wil. & Bent., 1944

Laevigatosporites longus sp. nov.

Pl. 2, figs. 25-26

Holotype — Pl. 2, fig. 25, size 99×42 μ. Slide no. 6-2/8.

Type Locality — Bore-core sample, depth 89'-90', drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Spores elliptical, 76-114×32-62 μ, length is generally more than double the breadth. Monolete present or absent, extending up to three-fourths radius; exine 1-2·5 μ thick, laevigate, irregularly folded.

Comparison — *Laevigatosporites colliensis* (Balme & Henn.) Venk. & Kar (1968) is differentiated from the present species by its broadly oval shape. The latter species is also distinguished from the other known species of the genus by having its length more than double the breadth.

Occurrence — Sample nos. 5, 6 and 7.

Genus — *Kendosporites* Sur. & Chan., 1974

Kendosporites striatus (Sal.) Sur. & Chan., 1974

Pl. 2, figs. 27-28

Remarks — The spores, hitherto described as *Kendosporites striatus* was previously reported under *Latosporites* from Raniganj Formation (Upper Permian) of India by Bharadwaj (1962), Bharadwaj and Salujha (1964) and Salujha (1965). Surange (1957), however, already described similar spores from a male cone of *Glossopteris*. Surange and Chandra (1974) reinvestigated the material along with fresh collection and instituted *Kendostrobus* for the male cone which yielded the monolete spores. They also instituted *Kendosporites* to accommodate those monolete spores with perinal ridges and furrows.

Kendosporites striatus described here is quite common in some samples and is found in all kinds of variations meticulously described by Surange and Chandra (1974). It seems possible that in South Africa also *Kendostrobus* was present in Lower Gondwanas and was responsible for producing these monolete spores.

Occurrence — Sample nos. 4, 5, 6, 7 and 10.

INCERTAE SEDIS

SPORE NO. 1

Pl. 2, fig. 29

Description — Spore subcircular, 78 μ, zonate, zona well-developed, ± uniformly broad; inner body triangular, 50 μ. Trilete rays ill-defined but extend upto two-thirds of inner body. Exine profusely ornamented with verrucae, warts and mamillate processes, sculptural elements 6-14 μ high.

Remarks — The present specimen approximates *Mammialetes* Kar (1969b) in ornamentational pattern but the former is easily distinguished by its zona and trilete mark.

Occurrence — Sample no. 13.

Genus — *Sahialetes* gen. nov.

Type Species — *Sahialetes cephalus* sp. nov.

Generic Diagnosis — Spores subcircular-circular, haptotypic mark not observed, exoexinous layer mostly present, variously ornamented with verrucae, bacula and other processes on both surfaces.

Description — Spores generally very dark brown, margin uneven due to protuberance of sculptural elements, 42-139 μ. Trilete or monolete mark not seen, only in one specimen a fracture approximating an open trilete observed which may be due to accidental breaking of the spore coat. Exine 2-4 μ thick, ornamented with various elements; mostly verrucae or baculate processes observed, sometimes coni and spines also seen interspersed with other elements; verrucae and processes robustly built, 6-15 μ long and 4-12 μ broad; ornamentation profuse on both surfaces and appears as negative reticulum on surface view. Exoexinal layer well recognisable, translucent and feebly intrapunctate.

Comparison — *Undulatasporites* Lesch. (1955) comes near to the present genus in subcircular-circular shape, but the former is easily separated by its rugose sculptural elements. *Spongiocysta* Seg. (1967) has also subcircular shape but is foveolate. *Peltacystia* Balme & Seg. (1966) is conspicuous by its nature of equatorial splitting to divide into two equal halves and has also circumpolar ridges joining each other to form reticulate pattern.

Derivation of Name — After Dr S. C. D. Sah, previously Head, Department of Oil Palynology, Birbal Sahni Institute of Palaeobotany, Lucknow, now Director, Wadia Institute of Himalayan Geology, Dehra Dun.

Sahialetes cephalus sp. nov.

Pl. 3, figs. 30,31

Holotype — Pl. 3, fig. 30, size 120 μ. Slide no. 13-1/20.

Isotype — Pl. 3, fig. 31, size 99 μ. Slide no. 13-3/30.

Type Locality — Bellevue colliery, Transvaal, Republic of South Africa; Middle Ecca.

Diagnosis — Spores dark brown, subcircular-circular, 81-149 μ. Haptotypic mark not seen; exine 2-4 μ thick, profusely ornamented with verrucae, bacula and other processes on both surfaces, sometimes interspersed with coni and spines; exoexinal layer translucent and mostly preserved.

Occurrence — Sample no. 13.

Sahialetes minutus sp. nov.

Pl. 3, figs. 32,33

Holotype — Pl. 3, fig. 32, size 58 μ. Slide no. 13-1/28.

Type Locality — Bellevue colliery, Transvaal, Republic of South Africa; Middle Ecca.

Diagnosis — Spores subcircular-circular, 41-71 μ, trilete or monolete not seen. Exine 2-3.5 μ thick, variously ornamented with verrucae, bacula, coni and spines on both surfaces, sculptural elements not very closely placed; exoexinal layer translucent.

Comparison — *Sahialetes cephalus* resembles *S. minutus* in subcircular-circular shape and variously sculptured exine but the former is separated by its bigger size range.

Occurrence — Sample no. 13.

Genus — *Cannanoropollis* Pot. & Sah, 1960

Cannanoropollis corius (Bose & Kar) comb. nov.

Pl. 3, fig. 34

1966 — *Virkkipollenites corius* Bose & Kar, 1966, p. 79, pl. 21, figs. 1-2.

Holotype — Hφeg and Bose, 1960, pl. 28, fig. 3.

Description — Pollen grains subcircular, 76-112 μ, margin slightly undulated, central body subcircular, distinct-indistinct, intramicroreticulate. Trilete rays well-developed, extending upto two-thirds radius. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial. Saccus leathery, radially folded.

Occurrence — Sample no. 13.

Cannanoropollis obscurus (Lele) Bose & Maheshw., 1968

Pl. 3, fig. 35

Remarks — Specimens referable to *Cannanoropollis obscurus* (Lele) Bose & Maheshw. (1968) have been described as *Accinctisporites exundatus* from Karroo Sandstone near Norronaub, South-West Africa by Leschik (1959). It may be mentioned here that *Accinctisporites* was instituted by Leschik (1955) from Keuper (Upper Triassic) of Europe and entirely of different complex from that of the Karroo flora. So there is hardly any possibility of the existence of *Accinctisporites* in the Permian sediments of South-West Africa. The geological and geographical differences also provide additional support to this view.

Occurrence — Sample no. 13.

Cannanoropollis congoensis (Bose & Kar) comb. nov.

Pl. 3, fig. 36

1966 — *Virkkipollenites congoensis* Bose & Kar, p. 80, pl. 21, figs. 3-4.

Holotype — Bose and Kar, 1966, pl. 21, fig. 3.

Description — Pollen grains ± elliptical in overall shape, 132-182×84-137 μ. Central body subcircular-circular, distinct, 56-84 μ, exine about 2 μ thick, intramicroreticulate. Trilete rays while present ill-developed. Proximal attachment of saccus to central body equatorial, distal attachment subequatorial. Saccus intrareticulate, mesh-size 1-2 μ, lumina shallow.

Occurrence — Sample no. 4.

Genus — *Parasaccites* Bharad. & Tiw., 1964

Parasaccites sp.

Pl. 3, fig. 37

Description — Pollen grains elliptical in shape with slight undulated margin, 107-133×76-99 μ, central body distinct, elliptical in shape, laevigate-intramicroreticulate. Trilete rays generally absent, sometimes extend upto half of central body. Proximal and distal attachment of saccus to central body is in para condition, saccus intrareticulate, meshes in some specimens radially placed.

Comparison — *Parasaccites korbaensis* Bharad. & Tiw. (1964) is distinguished from *Parasaccites* sp. by its subcircular-circular shape.

Occurrence — Sample nos. 4 and 13.

Genus — *Crucisaccites* Lele & Maithy, 1964

Crucisaccites latisulcatus Lele & Maithy, 1964

Pl. 4, fig. 38

Remarks — The present specimen is quite small in comparison to those described by Lele and Maithy (1964) from the Karharbari Formation (Lower Permian), Giridih Coalfield, India.

Occurrence — Sample no. 4.

Genus — *Potonieisporites* (Bharad.) Bharad., 1964

Potonieisporites distinctus Bose & Maheshw., 1968

Pl. 4, fig. 39

Description — Pollen grains elliptical, 114-148×73-97 μ, central body distinct, subcircular. Monolete slightly bent, extending almost one margin to another. Proximal attachment of saccus to central body equatorial, associated generally with circular body fold. Saccus strongly built, intrareticulate.

Occurrence — Sample no. 4.

Genus — *Platysaccus* (Naum.) Pot. & Kl., 1954

Platysaccus papilionis Pot. & Kl., 1954

Pl. 4, fig. 40

Description — Pollen grains strongly diploxylonoid, 84-113×41-62 μ, central body subcircular-circular, dense, up to 2·5 μ thick, laevigate. Proximal attachment of sacci to central body equatorial, distal attachment closely placed, allowing hardly any room for development of sulcus. Sacci very well developed, sacci intrareticulate.

Occurrence — Sample nos. 4, 7, 10, 13 and 21.

Platysaccus monosaccoidus sp. nov.

Pl. 4, figs. 41,42

Holotype — Pl. 4, fig. 41, size 74×47 μ. Slide no. 6-2/10.

Type Locality — Bore-core sample, depth 89′-90′, drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Pollen grains bisaccate but monosaccoid in appearance, 67-88×41-58 μ, central body subcircular, dense, laevigate. Proximal attachment equatorial, distally sacci very closely placed and laterally almost continuous, sacci intrareticulate.

Comparison — By its monosaccoid appearance, *Platysaccus umbrosus* Lesch. (1956) comes nearest to the present species but the former is distinguished by its presence of unequal sacci. Other known species of *Platysaccus* are differentiated by the presence of typical bisaccate appearance.

Occurrence — Sample nos. 6, 13, 14 and 21.

Genus — *Cuneatisporites* Lesch., 1955

Cuneatisporites juxtasaccus sp. nov.

Pl. 4, figs. 43,44

Holotype — Pl. 4, fig. 43, size 92×74 μ. Slide no. 7-2/8.

Type Locality — Bore-core sample, depth 89′-90′, drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Pollen grains strongly diploxylonoid, 68-114×54-89 μ, central body vertically oval, distinct, ± laevigate-intramicroreticulate. Proximal attachment of sacci to central body equatorial, distally sacci closely placed, hardly allowing any room for development of sulcus. Sacci intrareticulate.

Comparison — The present species is distinguished from *Cuneatisporites flavatus* Bose & Kar (1966), *C. fundiensis* Bose & Kar (1966) and other species of *Cuneatisporites* by its strongly diploxylonoid condition and absence of recognizable sulcus.

Occurrence — Sample nos. 7 and 21.

Genus — *Limitisporites* Lesch., 1956

Limitisporites plicatus Bose & Kar, 1966

Pl. 4, figs. 45, 46

Description — Pollen grain oval, 76×44 μ, central body subcircular, distinct, exine granulose. Proximal attachment of sacci to central body equatorial, distal attachment straight, closely placed, semilunar fold on each side present. Sacci intrareticulate.

Occurrence — Sample no. 5.

Genus — *Strotersporites* Wil., 1962

Strotersporites longus sp. nov.

Pl. 4, figs. 49-50

Holotype — Pl. 4, fig. 49, size 108×48 μ. Slide no. 7-3/16.

Type Locality — Bore-core sample, depth 89′-90′, drilled 6 miles south-west of Wankie and 6½ miles south-south-west of Thomson Junction; Upper Wankie Sandstone.

Diagnosis — Pollen grains bisaccate, ± haploxylonoid, elliptical in overall shape, 81-114×37-49 μ. Central body distinct, horizontally oval, intramicroreticulate, horizontally striated. Proximal attachment of sacci to central body equatorial, distal attachment closely placed, sulcus narrow, in some specimens slit-like. Sacci intrareticulate.

Comparison — The present species is distinguished from *Strotersporites decorus* (Bharad. & Sal.) Venk. & Kar (1964), *S. magnificus* (Bharad. & Sal.) Venk. & Kar

(1964) and *S. diffusus* (Bharad. & Sal.) Venk. & Kar (1964) by its elliptical shape and the length being always more than double the breadth.

Occurrence — Sample nos. 5, 6 and 7.

Genus — *Corisaccites* Venk. & Kar., 1966b

Corisaccites alutas Venk. & Kar, 1966b

Pl. 4, fig. 51

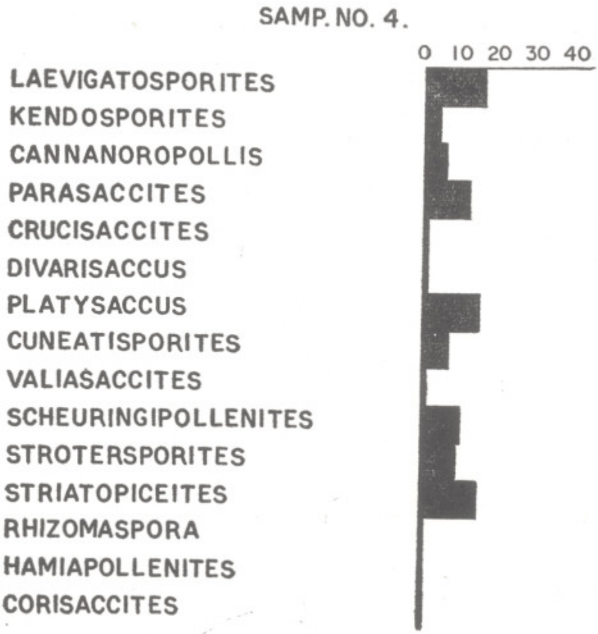
Remarks — Hart (1960, 1969) described *Lueckisporites nyakapendensis* from the Permian coalfield of Tanganyika. The specimens figured by him (Hart, 1960, pl. 1, figs. 11, 12) do not show any exoexinal thickening on the central body which is a diagnostic character of *Lueckisporites* (Pot. & Kl.) Pot. (1958). These specimens thus seem to belong to *Corisaccites*. Moreover, some additional specimens figured by him (Hart, 1969, pl. 1, figs. 2, 4, 5) as *Lueckisporites nyakapendensis* may be assigned to *Guttulapollenites* (Goub.) Venk., Goub. & Kar, 1967.

Occurrence — Sample nos. 7 and 21.

COMMENTS ON THE ASSEMBLAGES

The palynological assemblages comprise triletes, monoletes, aletes, monosaccates, nonstriate-bisaccates, striate-bisaccates, polyplicates and monocolpates. Of the total 45 dispersed spore-pollen genera, 13 belong to triletes, 3 to monoletes, 2 to aletes, 10 to monosaccates, 5 to nonstriate bisaccates, 10 to striate-bisaccates, 1 each to polyplicates and monocolpates. The nonstriate and striate-bisaccates dominate in all the samples followed by pteridophytic spores represented by triletes and monoletes. Monosaccates are found in good percentage only in one sample (No. 4) while aletes, polyplicates and monocolpates are hardly encountered in the counts. 200 specimens were counted from each sample to find out the percentage.

Sample No. 4— This sample is dominated by nonstriate-bisaccates (33%) closely followed by striate-bisaccates (27%). Monosaccates and monoletes are also common and they contribute 20% each to the assemblage. Triletes, aletes, polyplicates and monocolpates though present are not found within the counted specimens.



TEXT-FIG. 1 — Showing the percentage of different genera present in sample no. 4.

The following 27 genera constitute the assemblage: *Leiotriletes*, *Apiculatisporis*, *Cyclogranisporites*, *Leschikisporis*, *Striasporis*, *Indotriradites*, *Laevigatosporites*, *Kendosporites*, *Cannanoropollis*, *Parasaccites*, *Caheniasaccites*, *Crucisaccites*, *Divarisaccus*, *Potonieisporites*, *Platysaccus*, *Cuneatisporites*, *Valiasaccites*, *Scheuringipollenites*, *Striatites*, *Lahirites*, *Hindipollenites*, *Strotersporites*, *Striatopiceites*, *Rhizomaspora*, *Hamiapollenites*, *Corisaccites* and *Ginkgocycadophytus*.

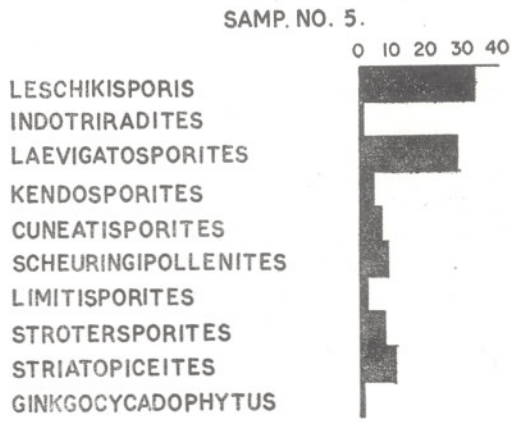
Of these, 15 genera are found in the count. *Laevigatosporites* (16%) is most common. *Platysaccus* (15%) and *Striatopiceites* (15%) are equally abundant in the assemblage. *Parasaccites* (12%), *Scheuringipollenites* (10%), *Strotersporites* (9%), *Cuneatisporites* (7%), *Cannanoropollis* (6%) and *Kendosporites* (4%) are also common. *Crucisaccites*, *Divarisaccus*, *Valiasaccites*, *Rhizomaspora*, *Hamiapollenites* and *Corisaccites* each contribute 1% to the assemblage (Text-figs. 1, 2).

Sample No. 5 — Apiculate triletes (33%) and monoletes (32%) are abundant. Striate and nonstriate-bisaccates contribute 17% and 16% respectively while zonate triletes and monocolpates each provide 1% to the assemblage.

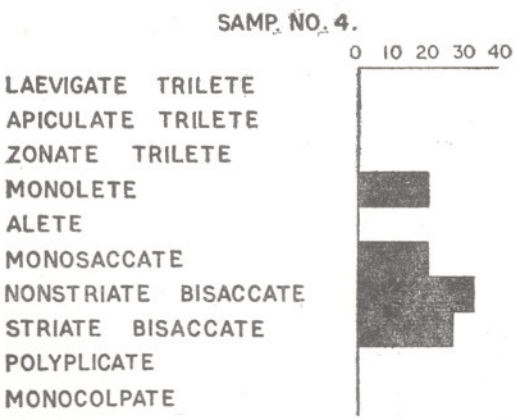
The sample yielded the following 26 genera: *Leiotriletes*, *Punctatisporites*, *Psilalacinites*, *Apiculatisporis*, *Cyclogranisporites*, *Lophotriletes*, *Leschikisporis*, *Zonareticulatisporis*, *Indotriradites*, *Laevigatosporites*, *Kendosporites*, *Cannanoropollis*, *Parasaccites*, *Densipollenites*, *Platysaccus*, *Cuneatisporites*, *Scheuringipollenites*, *Limitisporites*, *Striatites*, *Lahirites*, *Strotersporites*, *Striatopiceites*, *Crescentipollenites*, *Rhizomaspora*, *Corisaccites* and *Ginkgocycadophytus*.

Of these, only 10 genera are found within the counted specimens. *Leschikisporis* (33%) is dominant, *Laevigatosporites* (28%) is also very common. *Striatopiceites* (10%), *Scheuringipollenites* (8%), *Strotersporites* (7%), *Cuneatisporites* (6%) and *Kendosporites* (4%) are frequently found in the assemblage. *Limitisporites* contributes 2% while *Indotriradites* and *Ginkgocycadophytus* contribute 1% each (Text-figs. 3, 4).

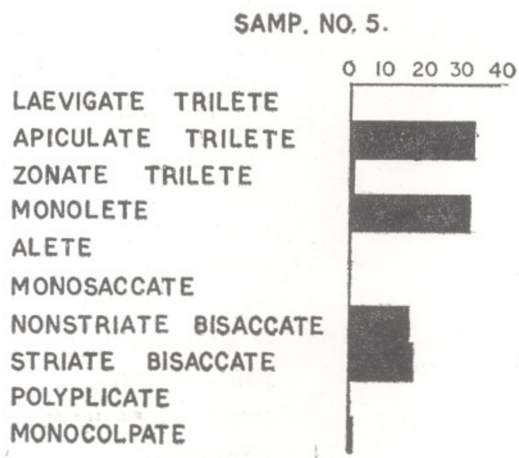
Sample No. 6 — Striate-bisaccates (44%) dominate over the nonstriate-bisaccates



TEXT-FIG. 3 — Showing the percentage of different genera present in sample no. 5.



TEXT-FIG. 2 — Showing the distribution of different major groups present in sample no. 4.



TEXT-FIG. 4 — Showing the distribution of different major groups present in sample no. 5.

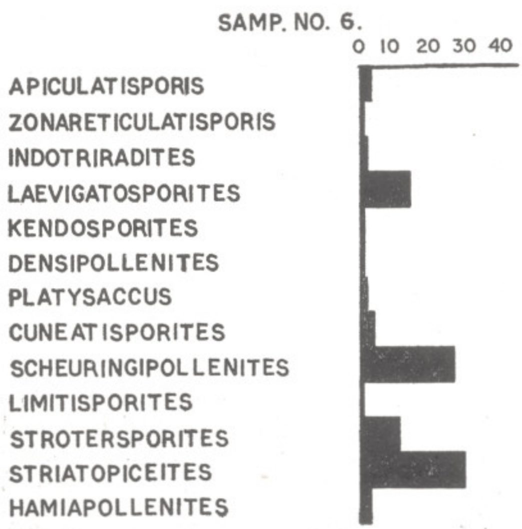
(34%). Monoletes are found in 15% while apiculate (3%) and zonate triletes (2%) are meagrely represented. Aletes and monosaccates contribute 1% each to the assemblage. Polyplicates and monocolpates are not found within the counted specimens.

The sample has yielded the following 21 genera:

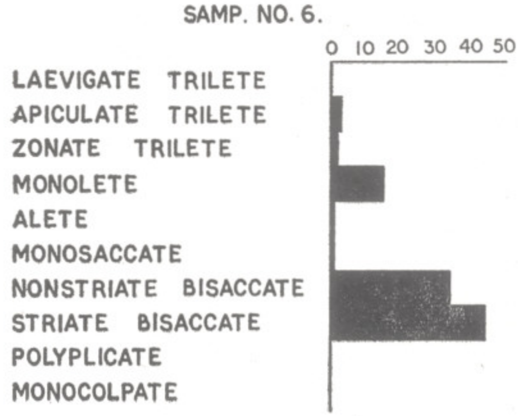
Leiotriletes, *Apiculatisporis*, *Cyclogranisporites*, *Lophotriletes*, *Surangeaspora*, *Zonareticulatisporis*, *Indotriradites* *Laevigatosporites*, *Kendosporites*, *Densipollenites*, *Vestigisporites*, *Platysaccus*, *Cuneatisporites*, *Valiasaccites*, *Lahirites*, *Strotersporites*, *Striatopiceites*, *Rhizomaspora*, *Hamiapollenites*, *Corisaccites* and *Ginkgocycadophytus*.

Of the 13 genera present in the count, *Striatopiceites* (30%) and *Scheuringipollenites* (27%) are abundant, *Laevigatosporites* (14%) ranks third and *Strotersporites* (11%) fourth. *Cuneatisporites* (4%), *Apiculatisporis* (3%) and *Hamiapollenites* (3%) are occasionally found. *Indotriradites* (2%), *Platysaccus* (2%), *Zonareticulatisporis* (1%), and *Limitisporites* (1%) are meagrely represented (Text-figs. 5, 6).

Sample No. 7 — Striate-bisaccates (54%) are dominant and monoletes (25%) subdominant. Nonstriate-bisaccates are found in 17% and apiculate triletes (2%), laevigate (1%) and zonate triletes (1%) are rare.



TEXT-FIG. 5 — Showing the percentage of different genera present in sample no. 6.



TEXT-FIG. 6 — Showing the distribution of different major groups present in sample no. 6.

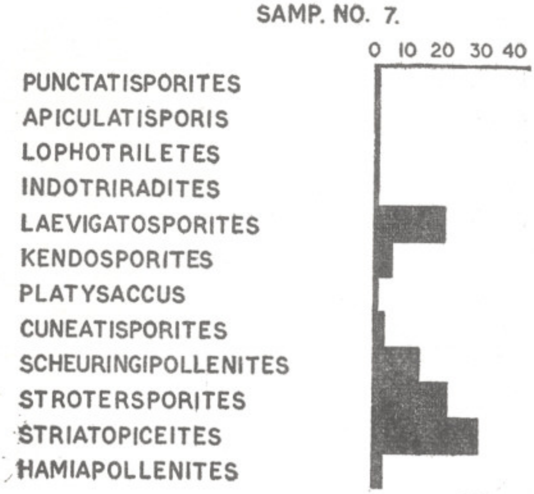
Aletes, monosaccates, polyplicates and monocolpates are either absent or hardly encountered in the assemblage.

Twenty three genera are found in the assemblage and they are: *Leiotriletes*, *Punctatisporites*, *Apiculatisporis*, *Cyclogranisporites*, *Lophotriletes*, *Leschikisporis*, *Zonareticulatisporis*, *Indotriradites*, *Laevigatosporites*, *Kendosporites*, *Parasaccites*, *Divarisaccus*, *Platysaccus*, *Cuneatisporites*, *Scheuringipollenites*, *Striatites*, *Lahirites*, *Strotersporites*, *Striatopiceites*, *Crescentipollenites*, *Rhizomaspora*, *Hamiapollenites* and *Corisaccites*.

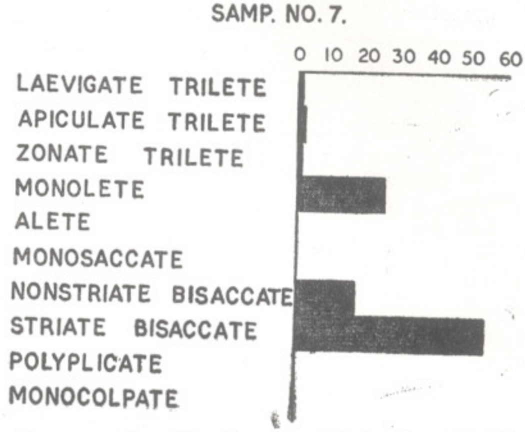
Of these, only 12 genera are observed amongst the counted specimens. *Striatopiceites* (30%), *Strotersporites* (21%) and *Laevigatosporites* (20%) are commonest. *Scheuringipollenites* contributes 13% and *Kendosporites* (5%), *Cuneatisporites* (3%) and *Hamiapollenites* (3%) are occasionally found. *Punctatisporites*, *Apiculatisporis*, *Lophotriletes*, *Indotriradites* and *Platysaccus* each contribute 1% to the assemblage (Text-figs. 7, 8).

Sample No. 10 — Striate-bisaccates dominate the assemblage (60%). Nonstriate-bisaccates contribute 27% and monoletes 10%. Apiculate triletes, monosaccates and monocolpates contribute 1% each.

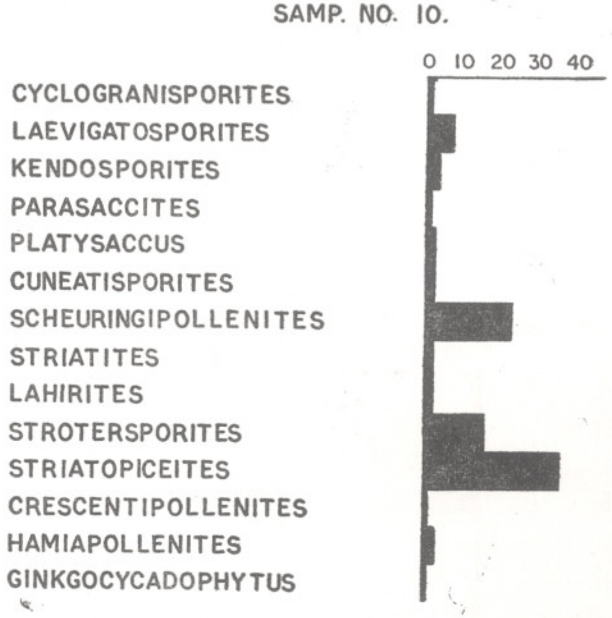
The following 25 genera have been identified: *Leiotriletes*, *Punctatisporites*, *Apiculatisporis*, *Cyclogranisporites*, *Striasporis*, *Indotriradites*, *Laevigatosporites*, *Kendosporites*, *Cannanoropollis*, *Parasaccites*, *Crucisaccites*, *Densipollenites*, *Striomonosaccites*, *Platysaccus*, *Cuneatisporites*, *Scheuringipollenites*, *Striatites*, *Lahirites*, *Strotersporites*, *Striatopiceites*,



TEXT-FIG. 7 — Showing the percentage of different genera present in sample no. 7.



TEXT-FIG. 8 — Showing the distribution of different major groups present in sample no. 7.

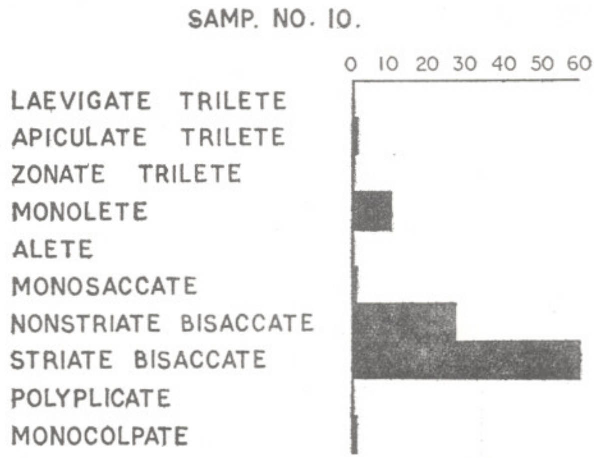


TEXT-FIG. 9 — Showing the percentage of different genera present in sample no. 10.

Crescentipollenites, Rhizomaspora, Hamiapollenites, Corisaccites and *Ginkgocycadophytus.*

Of these, 14 genera are found within the count. *Striatopiceites* (36%) is most common, *Scheuringipollenites* (23%) comes next. *Strotersporites* (16%) and *Laevigatosporites* (7%) are frequent. *Kendosporites* and *Hamiapollenites* each contribute 3% while *Platysaccus, Cuneatisporites, Striatites* and *Ginkgocycadophytus* are rare and contribute 1% each to the assemblage (Text-figs. 9, 10).

Sample No. 13 — Striate-bisaccates (29%), nonstriate-bisaccates (26%) and apiculate triletes (23%) contribute more or less



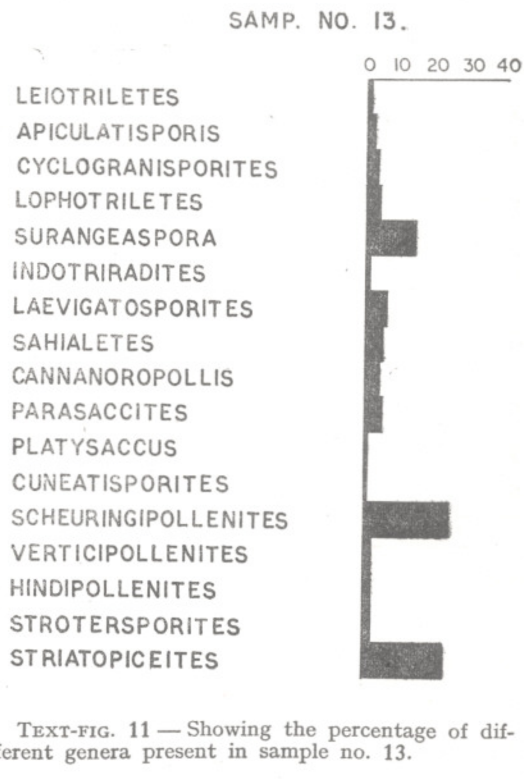
TEXT-FIG. 10 — Showing the distribution of different major groups present in sample no. 10.

equally to the assemblage. Monosaccates (9%), monoletes (6%) and aletes (5%) are frequently observed. Laevigate and zonate triletes contribute 1% each.

The following 32 genera are observed in the assemblage: *Leiotriletes, Punctatisporites, Psilalacinites, Apiculatisporis, Cyclogranisporites, Lophotriletes, Acanthotriletes, Surangeaspora, Lacinitriletes, Striasporis, Indotriradites, Laevigatosporites, Kendosporites, Tiwariasporis, Mammialetes, Sahialetes, Cannanoropollis, Parasaccites, Caheniasaccites, Divarisaccus, Platysaccus, Cuneatisporites, Scheuringipollenites, Limitisporites, Striatites, Verticipollenites, Lahirites, Hindipollenites, Strotersporites, Striatopiceites, Gnetaceaepollenites* and *Ginkgocycadophytus*.

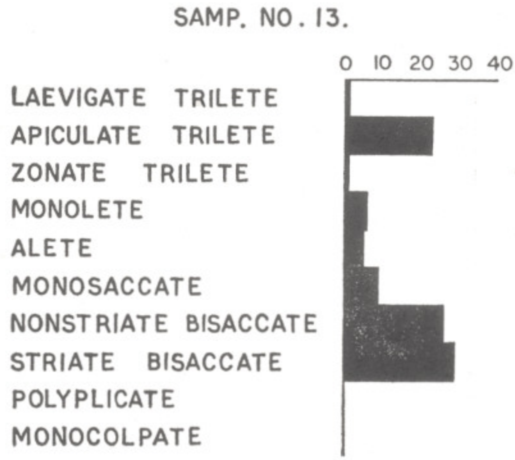
Of these, 17 genera are quantitatively important. *Scheuringipollenites* (24%) and *Striatopiceites* (23%) are most common and *Surangeaspora* (14%) ranks third. *Laevigatosporites* (6%) *Sahialetes* (5%), *Parasaccites* (5%), *Lophotriletes* (4%) and *Cannanoropollis* (4%) are occasionally met with. 4 genera, viz., *Apiculatisporis, Verticipollenites, Hindipollenites* and *Strotersporites* represent 2% each while *Leiotriletes, Platysaccus* and *Cuneatisporites* contribute 1% each (Text-figs. 11, 12).

Sample No. 21 — Apiculate triletes (34%) and striate-bisaccates (32%) dominate the assemblage. Nonstriate-bisaccates (20%) rank third. Monoletes (9%) and monosaccates (4%) are occasionally observed and the aletes (1%) are rare. Zonate triletes, polyplicates and monocolpates though present in the assemblage are not present within the counted specimens.



TEXT-FIG. 11 — Showing the percentage of different genera present in sample no. 13.

This sample yielded the following 33 genera: *Leiotriletes, Punctatisporites, Psilalacinites, Apiculatisporis, Cyclogranisporites, Lophotriletes, Surangeaspora,*



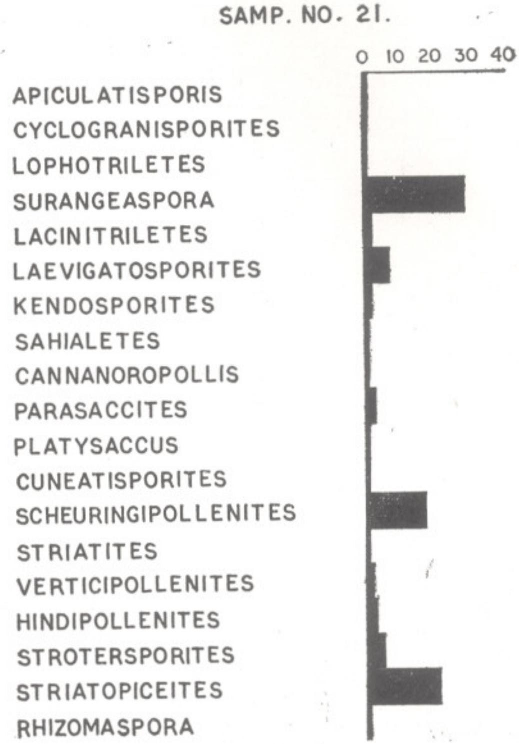
TEXT-FIG. 12 — Showing the distribution of different major groups present in sample no. 13.

Lacinitriletes, Laevigatosporites, Kendosporites, Tiwariasporis, Mammialetes, Sahialetes, Cannanoropollis, Barakarites, Parasaccites, Caheniasaccites, Densipollenites, Divarisaccus, Platysaccus, Cuneatisporites, Valiasaccites, Scheuringipollenites, Striatites, Verticipollenites, Lahirites, Hindipollenites, Strotersporites, Striatopiceites, Rhizomaspora, Corisaccites, Gnetaceaepollenites and *Ginkgocycadophytus*.

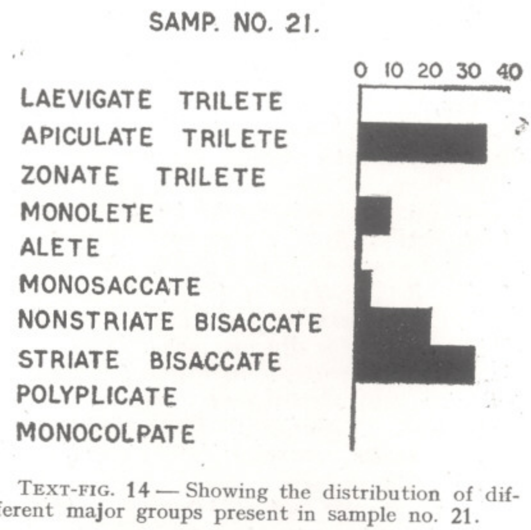
Of these genera, 19 are found within the count. *Surangeaspora* (29%), *Striatopiceites* (21%) and *Scheuringipollenites* (17%) are very common. *Laevigatosporites* (7%), *Strotersporites* (5%) and *Parasaccites* (3%) are generally noticed in the assemblage. *Lacinitriletes, Kendosporites* and *Striatites* contribute 2% each. The following 9 genera are rare and represent 1% each: *Apiculatisporis, Cyclogranisporites, Lophotriletes, Sahialetes, Cannanoropollis, Platysaccus, Cuneatisporites, Striatites* and *Rhizomaspora* (Text-figs. 13, 14).

COMPARISONS BETWEEN THE ASSEMBLAGES

Of the seven samples studied, number 4 is the richest in monosaccates, represented by *Parasaccites, Cannanoropollis, Crucisaccites* and *Divarisaccus*. Sample nos. 13 and 21 are not so rich in monosaccates, having 9% and 4% respectively. In these samples also it is mainly the monosaccate genera mentioned above that are encoun-



TEXT-FIG. 13 — Showing the percentage of different genera present in sample no. 21.



TEXT-FIG. 14 — Showing the distribution of different major groups present in sample no. 21.

tered. In other samples, monosaccates are hardly found within the counted specimens.

Palynological investigations of the Lower Gondwanas from the Buckeye tillite of

Antarctica by Rigby and Schopf (1969), Dwyka tillite of South Africa by Hart (1969), *Assises glaciaires et périglaciaires* of Zaïre by Bose and Kar (1966), Bacchus Marsh tillite of Australia by Virkki (1946), Pant and Mehra (1963) and Evans (1969), Lower Itararé of Brazil by Bharadwaj, Kar and Navale (1976), glacial beds of Uruguay by Macchiavelo (1963), glacial tillites of Argentina by Menéndez (1969, 1971) and lastly from Talchir tillite and needle shales of India by Potonié and Lele (1961), Lele and Makada (1971, 1972), Lele and Chandra (1973) have revealed that the monosaccates are abundant in the lowermost formations.

They gradually disappear in the upper horizons and yield to triletes and bisaccates. In India, however, the monosaccates again come into prominence in the Upper Karharbari Formation (Lower Permian) as has been shown by Bharadwaj (1970), Kar (1973), Tiwari (1973) and Srivastava (1973).

The presence of monosaccates in appreciable percentages in samples 4, 13 and 21 suggests that they are older than the rest. Amongst the three samples, no. 4 appears to be the oldest because it contains 20% monosaccates while the other two samples are more or less similar in spore-pollen representation. This is also expected because they belong to the same exposure and horizon. Indeed, the close similarity of the assemblage obtained from samples 13 and 21 testifies to the reproductibility of results with the maceration technique used.

Sample no. 5 is conspicuous by the absence of monosaccates in the assemblage. The pteridophytic spores represented both by triletes and monoletes are abundant while striate and nonstriate-bisaccates are found almost in equal percentage. Absence of monosaccates suggests that this sample lies above the horizon of sample nos. 13 and 21. Presence of apiculate triletes in abundance in no. 5 also distinguishes this assemblage from those of nos. 6 and 7 and places it stratigraphically below them.

The suggested position of samples 13 and 21 from Ermelo in relation to samples 4, 5 and 7 from near Wankie, based largely on the presence of monosaccates in appreciable amount, may not be exactly correct. Nevertheless, the close correlation of the two groups of samples strongly suggests a Middle Ecca age for the Upper Wankie Sandstone horizon, since this age is already known on other grounds for the Ermelo horizon.

It may be mentioned here that triletes are found in abundance in Lower Karharbari Formation of India (Kar, 1973) and in *Assise des schistes noirs de la Lukuga* of Zaïre (Kar & Bose, 1967). But in both the formations monosaccates are also found in substantial percentage.

Sample nos. 6 and 7 have a more or less similar spore content except that in no. 6 nonstriate-bisaccates are more abundant while the striate-bisaccates are better represented in sample no. 7.

Sample no. 10 is the youngest of the 7 assemblages as the striate-bisaccates are found in abundance. The nonstriate-bisaccates come next and monoletes come third.

In India, striate-bisaccates come into prominence in the Barakar Formation. They are also dominant in Barren Measures and Raniganj formations. In Barakar, they are either associated with triletes or monosaccates. In Barren Measures, one monosaccate genus, viz., *Densipollenites* is quite common though the assemblage is dominated by striate-bisaccates. It is only in Raniganj that the striate-bisaccates are associated with good percentage of monolete spores. The presence of monoletes in appreciable numbers along with the dominance of striate-bisaccates in sample no. 10 suggests that it is near to Raniganj Formation, and hence of Upper Ecca or possibly Lower Beaufort age.

COMPARISON WITH SOUTH AFRICAN ASSEMBLAGES

Falcon (1973) studied the palynological fossils recovered from the Matabola flats borehole core drilled in the Middle Zambezi Valley. The miospore assemblages represent Dwyka glacial beds to Lower Beaufort Series. She observed the dominance of trilete genera like *Punctatisporites*, *Apiculatisporis*, *Acanthotriletes* and *Microbaculispora* in the Dwyka Series. The triletes decrease gradually and the bisaccates become prominent in the Madumabisa Stage. Some of the common bisaccate genera are *Alisporites*, *Scheuringipollenites* (*Sulcatisporites*), *Platysaccus*, *Protohaploxypinus* and *Strotersporites* (*Striatopodocarpites*).

The Madumabisa miospore assemblage reported by Falcon (1973) closely resembles the present one by its dominance of bisaccates. The samples studied here also show the abundance of both nonstriate and striate-bisaccates followed by pteridophytic spores. Most of the genera are also common in both the assemblages.

Tiwari (1974) investigated palynologically a borehole core from Springbok colliery, near Johannesburg ranging in age from Dwyka glacial beds to Ecca Series. He divided the whole assemblage into 5 palynological zones. Of them, zones 1, 3 and 4 are dominated by triletes, while zone 2 shows the high percentage of monosaccates. Zone 5 is the uppermost palynological zone, and is dominated by bisaccates including both the nonstriates and striates. This zone also broadly corresponds to the present one.

Utting (1975) described two palynological assemblages from the Luwumbu Coal Formation (Lower Karroo), Zambia. The lower assemblage is mostly populated by monosaccate genera like *Cannanoropollis* and *Plicatipollenites*. In the upper assemblage, the nonstriate and striate-bisaccates are dominant and closely followed by triletes. Besides monosaccates, polyplicates, monocolpates, monoletes and aletes are also frequently found. This assemblage also approximates the present one.

COMPARISON WITH TANZANIAN ASSEMBLAGES

The palynological investigations of the Karroo sediments in Tanzania have been thoroughly worked out by Hart (1960, 1962, 1963, 1965, 1969b, 1971), particularly in Mchuchuma and Songwe-Kiwira coalfields. He divided the Lower coal-measures of the Mchuchuma Coalfield into three palynological zones. The lowermost zone (K2C) is dominated by triletes and monosaccates come next in abundance. The bisaccates are rare. The next zone (K2C1) shows the abundance of striate and nonstriate-bisaccates while the triletes and monosaccates are also common. The third zone (K2C2) shows still more dominance of bisaccates and the triletes rank second; the monosaccates and monocolpates are meagrely represented.

The second palynological zone (K2C1) instituted by Hart broadly resembles the sample nos. 4, 13 and 21 of the present material by the dominance of bisaccates and also good representation of pteridophytic spores and monosaccates. Some of the very common genera of the present material,i.e. *Surangeaspora*, *Laevigatosporites* and *Scheuringipollenites* are, however, either totally absent or ill represented in the Mchuchuma coalfield assemblage.

Sample no. 10 is comparable to the uppermost zone (K2C2) of Hart by its overwhelming dominance of bisaccates. But the triletes, colpates and monosaccates which are quite common in Mchuchuma coalfield are hardly encountered in the sample. Instead, monoletes are well-represented in the assemblage.

Sample No. 4 — The miospore content of this sample is slightly comparable to the assemblage described from *Assise des schistes noirs de Walikale* by Bose and Kar (1966) from Zaïre in its good representation of saccates. In Walikale, the pteridophytic spores are mostly represented by triletes while in the present one they are contributed by monoletes. Besides, the Walikale assemblage is also rich in polyplicates and monocolpates while in the present one they are meagrely represented.

The palynological assemblage reported from Kathwai shales, situated 25 ft above the Talchir boulder bed in Salt Range, West Pakistan by Venkatachala and Kar (1968b) is also distinguished by its presence of triletes and monocolpates in good number.

The present assemblage comes closer to the one reported by Kar (1973) from the bore core no. KBM 19 at the depth of 83·7 m belonging to Upper Karharbari (Lower Permian) of North Karanpura sedimentary basin, Bihar, India. Here the bisaccates dominate the assemblage but the monosaccates and monoletes are also commonly met with. Dominant genera of the bisaccates like *Striatopiceites*, *Stroterosporites* and *Scheuringipollenites* are common to both except *Platysaccus* which is well-represented (15%) in sample no. 4 but absent within the counted specimen in Indian material. Among the monosaccates, *Parasaccites* and *Cannanoropollis* contribute most in both the samples. Of the monoletes, *Laevigatosporites* is more common (16%) in the present sample than in Upper Karharbari assemblage. *Punctatosporites* and *Tiwariasporis* are also found only in the latter one. Despite these differences, the two samples come very close to one another and are correlatable.

Sample Nos. 13 & 21 — The two samples are very similar to each other except that in no. 21, the apiculate triletes (34%) are more common than in no. 13 (23%). The two assemblages are comparable to the assemblages described by Bharadwaj and Tiwari (1964b) and Tiwari (1965) from Korba and West Bokaro coalfields, India. The horizon A of Korba Coalfield is dominated by zonate triletes, viz., *Indotriradites* and *Dentatispora* and the apiculate and laevigate trilete genera are also well represented. Bisaccates come next and monosaccates are frequently found. The spore assemblage of this horizon is not much comparable due to its dominance of *Indotriradites* and *Dentatispora* genera which are rarely found in the present count. The horizon B of Korba Coalfield and West Bokaro assemblages, however, closely resemble the present assemblages due to its good representation of striate and non-striate-bisaccates, apiculate triletes and monoletes. In all these assemblages *Striatopiceites* (*Faunipollenites*), *Scheuringipollenites* (*Sulcatisporites*) and *Laevigatosporites* (*Latosporites*) are found in significant percentages. The apiculate trilete genera like *Apiculatisporis*, *Cyclogranisporites* and *Lophotriletes* are also common in these assemblages. Sample nos. 13 and 21 have *Surangeaspora* and *Sahialetes* in good numbers but these genera are not found in the Indian material. Monosaccate genera are, however, common in both and it seems that these assemblages are correlatable to one other.

Sample No. 5 — The assemblage is comparable to that of the Coal Measures near Lake Tanganyika, south of Albertville, described by Bose and Maheshwari (1968). In both, the triletes are dominant, but the common genera in Tanganyikan assemblage like *Leiotriletes*, *Punctatisporites*, *Acanthotriletes*, *Apiculatisporis* and *Dentatispora* are hardly found in the present one. Besides, the alete genera like *Pilasporites*, *Balmeella* and *Kagulubeites* which are quite common in the Coal Measures are absent in the present one.

This assemblage approximates to the zone B assemblage of the North Karanpura sedimentary basin, Bihar described by Venkatachala and Kar (1968a) by its dominance of triletes. The present sample is dominated by *Leschikisporis* while in North Karanpura assemblage the triletes are mostly contributed by *Apiculatisporis* and *Lophotriletes*. Monosaccates are ill-represented in both the assemblages and striate and nonstriate-bisaccate genera are common in both. In North Karanpura, polyplicates and monocolpates are quite common while they are very rare in the present one.

The Upper Permian assemblage depicted by Jekhowsky and Goubin (1965) from the Morandava basin, Madagascar is not much comparable to the present assemblage as most of the important forms photographed by them (fig. 5, nos. 947, 1002, 1034, 1077 and 981) are not found in the present one.

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EXPLANATION OF PLATES

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

PLATE 1

1-2. *Leiotriletes giganticus* sp. nov.; Slide nos.— holotype 21-3/20, 13-3/22.

3. *Cyclogranisporites burettei* Bose & Kar; Slide no. 13-1/14.

4-5. *Lophotriletes robustus* sp. nov.; Slide nos.— holotype 6-3/4, 6-3/15.

6-8. *Leschikisporis verrucosus* sp. nov.; Slide nos. — holotype 5-1/5, 5-3/10, 5-3/6.

9-13. *Surangeaspora coniata* gen. et sp. nov.; Slide nos.— holotype 21-1/4, 13-1/5, 21-3/28, 21-1/11, 21-2/3.

14. *Psilalacinites triangulus* Kar; Slide no.— 13-2/2.

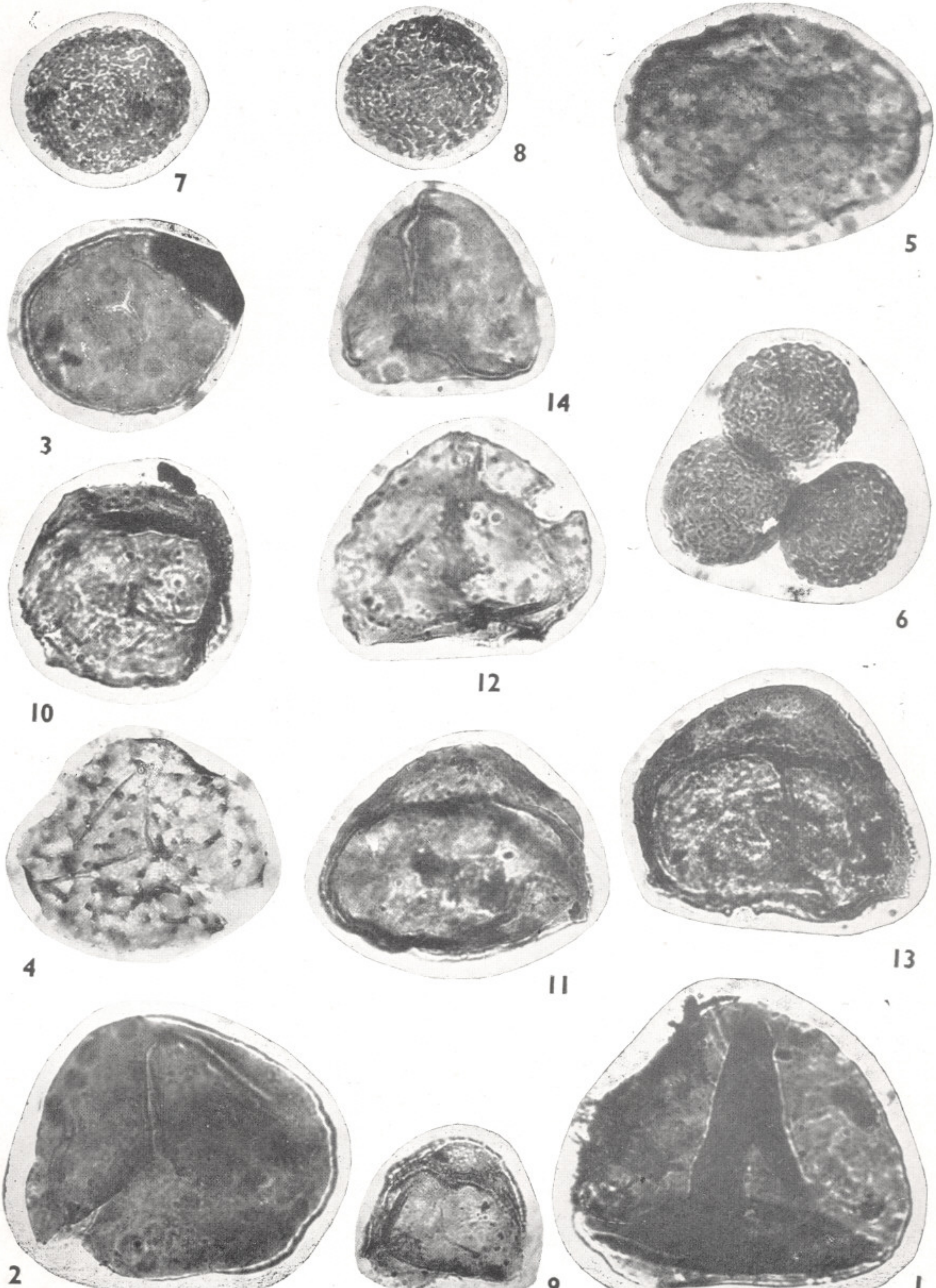
PLATE 2

15-17. *Surangeaspora densa* sp. nov.; Slide nos.— holotype 21-3/15, 21-3/17, 13-2/11.

18. Tetrad of *Surangeaspora densa* sp. nov.; Slide no. 13-3/39.

19. Tetrad of *Surangeaspora coniata* sp. nov.; Slide no. 21-3/4.

20. *Lacinitriletes badamensis* Venk. & Kar; Slide no. 13-3/35.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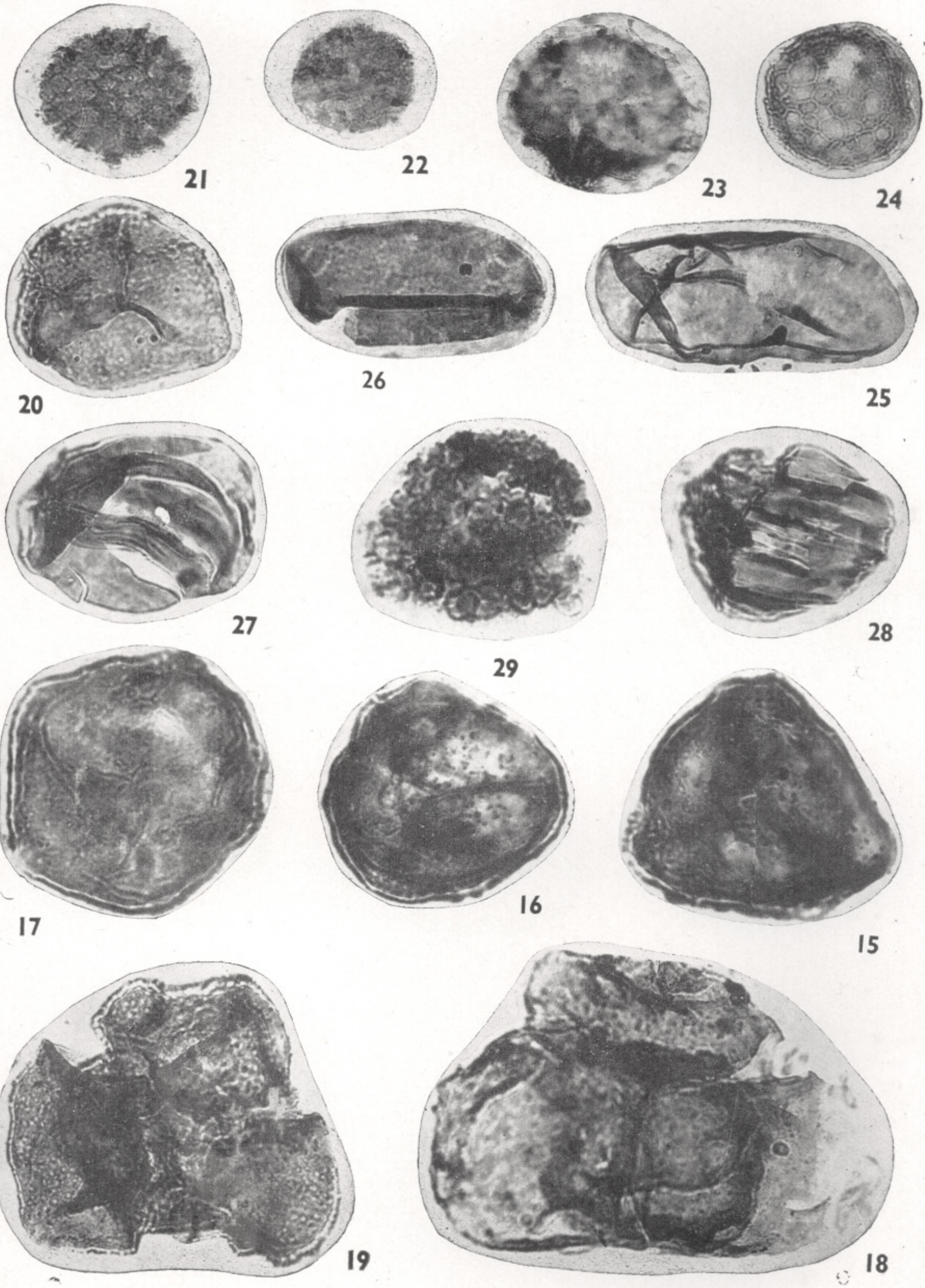
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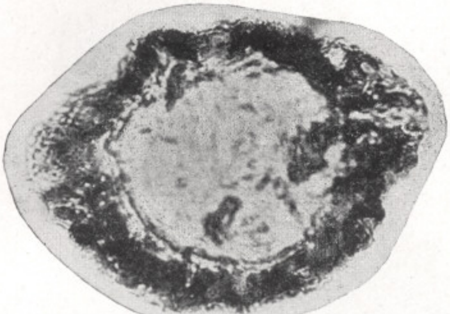

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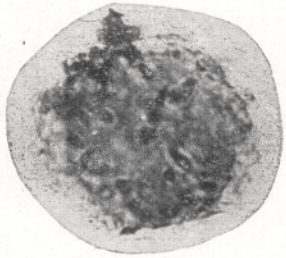

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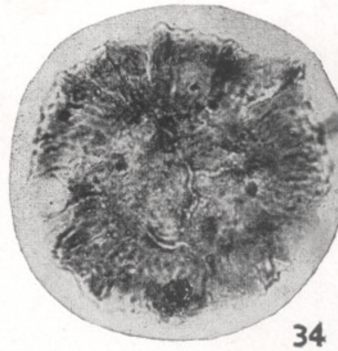

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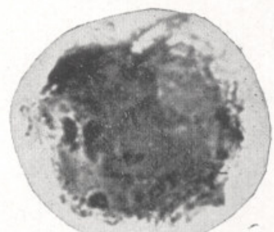

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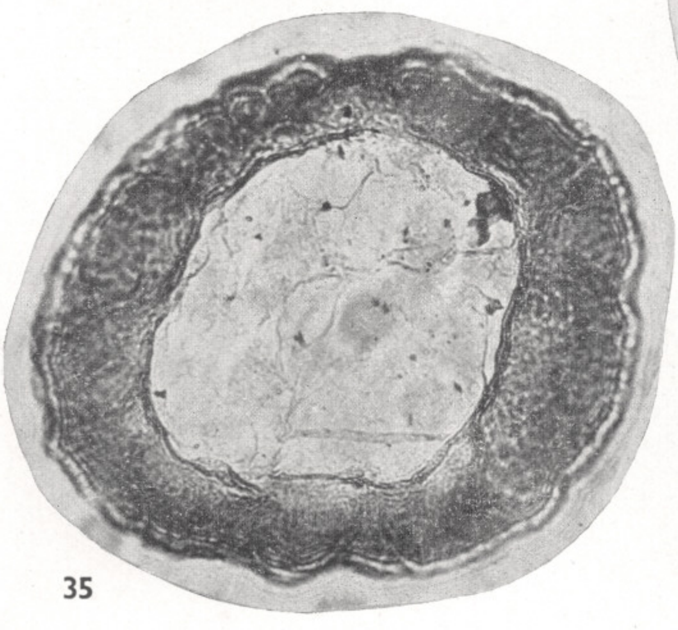

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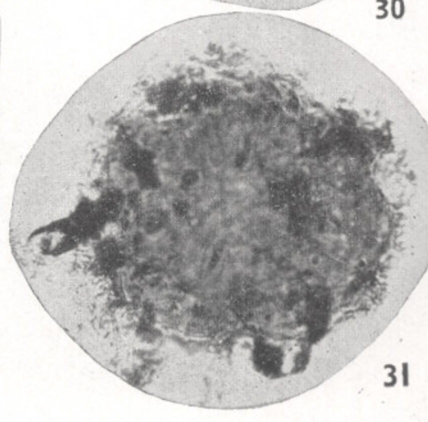

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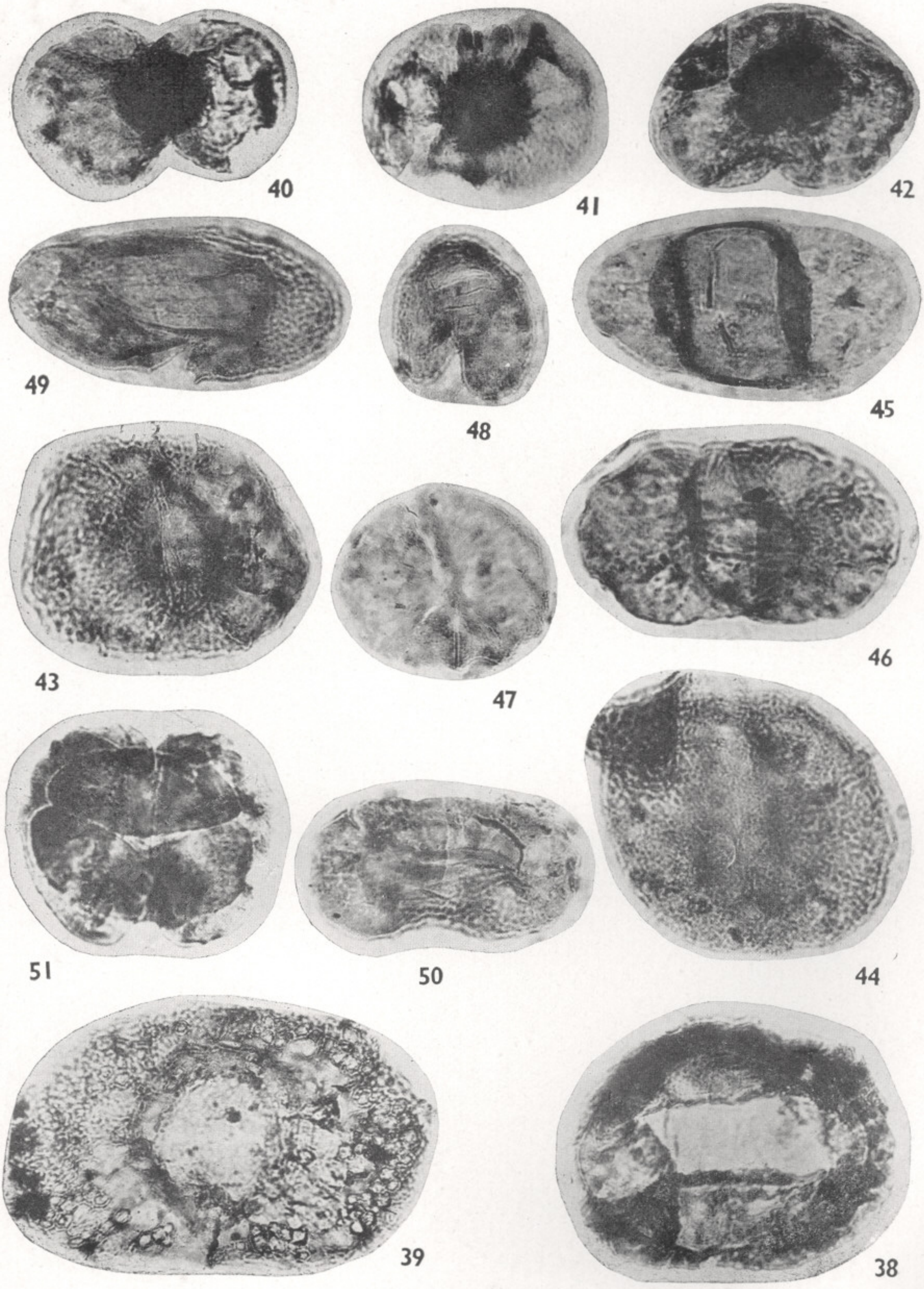
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21-23. *Zonareticulatisporis reticulata* sp. nov.; Slide nos.— holotype 5-1/14, 6-3/1, 5-3/30.

24. cf. *Zonareticulatisporis* sp.; Slide no. 6-1/8.

25-26. *Laevigatosporites longus* sp. nov.; Slide nos.— holotype 6-2/8, 7-3/4.

27-28. *Kendosporites striatus* (Sal.) Sur. & Chan.; Slide no. 5-2/13, 5-2/1.

29. Spore no. 1; Slide no. 13-2/20.

PLATE 3

30-31. *Sahialetes cephalus* gen. et sp. nov.; Slide nos.— holotype 13-120, 13-3/30.

32-33. *Sahialetes minutus* sp. nov.; Slide nos.— holotype 13-1/28, 13-2/5.

34. *Cannanoropollis corius* (Bose & Kar) comb. nov.; Slide no. 13-3/31.

35. *Cannanoropollis obscurus* (Lele) Bose & Maheshw.; Slide no. 13-3/29.

36. *Cannanoropollis congoensis* (Bose & Kar) comb. nov.; Slide no. 4-3/10.

37. *Parasaccites* sp.; Slide no. 4-3/6.

PLATE 4

38. *Crucisaccites latisulcatus* Lele & Maithy; Slide no. 4-2/4.

39. *Potonieisporites distinctus* Bose & Maheshw.; Slide no. 4-2/3.

40. *Platysaccus papilionis* Pot. & Kl.; Slide no. 7-3/12.

41-42. *Platysaccus monosaccoidus* sp. nov.; Slide nos.— holotype 6-2/10, 7-2/10.

43-44. *Cuneatisporites juxtasaccus* sp. nov.; Slide nos.— holotype 7-2/8, 7-3/5.

45-46. *Limitisporites plicatus* Bose & Kar; Slide nos. 7-1/6, 21-3/22.

47. *Scheuringipollenites tentulus* (Tiw.) Tiw.; Slide no. 6-2/2.

48. *Striatites alius* Venk. & Kar; Slide no. 7-2/7.

49-50. *Strotersporites longus* sp. nov.; Slide nos.— holotype 7-3/16, 5-2/10.

51. *Corisaccites alutas* Venk. & Kar; Slide no. 21-3/18.