PALAEOBOTANICAL EVIDENCE FOR THE PRESENCE OF KARHARBARI STAGE IN THE AURANGA COALFIELD, BIHAR: MIOFLORA

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ABSTRACT
The paper describes for the first time the Karharbari miospore assemblage from the Auranga Coalfield. The mioflora (19 genera and 39 species) is characterized by the dominance of trilete taxa Callumispora and Brevitriletes together with monosaccates, Parasaccites, Caheniasaccites and Virkkipollenites. Other quantitatively significant genera are Faunipollenites, Psilalacinites, Microbaculispora, Kibambaites, Verrucosisporites and Latosporites.

INTRODUCTION
PALAEOBOTANICAL records from the Auranga Coalfield date back to the time of Ball (1880). Feistmantel (1881a, 1881b, 1882, 1886) studied in detail the plant fossils in this area. Bhattacharyya (1959) reported the miospores and plant fossils from the eastern part of Auranga Coalfield. Bhattacharyya (1963) reported the megafossils only from the western part of the Coalfield. Maithy (1971) reported some megafossils and miospores from the Barakar deposits. Srivastava and Anand-Prakash (1973) reported the miospore assemblages from Jagaldagga and Tubed area. Recently, Srivastava (1977) has reported the plant fossils from the Gowa Village. However, no systematic study of the palynological assemblage was so far done on the various Lower Gondwana horizons of the Auranga basin. This work was therefore undertaken and palynological samples were collected systematically from several sites generally marked as Barakar in the geological work of Rizvi (1972). The material which has yielded the present mioflora is also included among the Barakar by Rizvi (loc. cit.), but the palynological evidence now suggests a Karharbari age for it.

MATERIAL AND METHODS
Samples have been collected from a section exposed along north bank of Gowa Nala about 0.5 km west of Gowa Village (see Map; Srivastava, 1977). The rock section is as follows:
Sandstone
Fireclay intercalated with sandstone
Carbonaceous shale (mioflora described here)
rest concealed below
The carbonaceous shale sample was macerated in the conventional manner using Schulz's method. All the type slides are preserved at the Museum, Birbal Sahni Institute of Palaeobotany.

DESCRIPTION
Anteturma —*Sporites* H. Potonie, 1893
Turma —*Triletes* (Reinsch) Potonie & Kremp, 1954
Subturma —*Azonotriletes* Luber, 1935
Infraturma —*Leavigata* (Benné & Kistler) Potonie, 1956

Genus —*Psilalacinites* Kar, 1969
*Psilalacinites triangularis* Kar, 1969
Pl. 1, fig. 1

*Description* — Size range 51-60 × 51-60 μ, apices rounded, trilete rays extend up to three fourth of the body radius, associated with lacinate fold, exine laevigate, rarely fine intramicropunctate.

Genus —*Callumispora* Bharadwaj & Srivastava, 1969
*Callumispora tenuis* var. minor Bharadwaj & Srivastava, 1969
Pl. 1, fig. 2

*Description* — Size range 60-80 × 56-74 μ, circular to subcircular, trilete mark distinct, rays more than 3/4 of the body radius, exine 2-4 μ thick, margin smooth.
Remarks — Only *C. tenuis* var. *minor* is present in this assemblage and *C. tenuis* is not found. This suggests that *C. tenuis* var. *minor* can be raised to specific level.

Infraturma — *Apiculati* (Bennié & Kids-ton) Potonie, 1956
Subinfraturma — *Verrucati* Dybova & Iachowicz, 1957

Genus — *Verrucosisporites* (Ibrahim) Smith & Butterworth, 1967

*Verrucosisporites donarii* Potonie & Kremp, 1956
Pl. 1, fig. 3

*Description* — Size range 45-47 × 52-54 μ, trilete rays extend up to 3/4 of radius, exine covered by verrucae of irregular shape, 2-3 μ in size, 52-60 along margin.

*Verrucosisporites ambiplicatus* Kar, 1968
Pl. 1, fig. 4

*Description* — Size range 35-38 × 38-44 μ, trilete rays extending up to 3/4 of radius, exine folded along equatorial margin, verrucae 2-2.5 μ long and 75-90 along margin.

Subinfraturma — *Baculati* Dybova & Iachowicz, 1957

Genus — *Microbaculispora* Bharadwaj, 1962

*Microbaculispora tentula* Tiwari, 1965
Pl. 1, fig. 5

*Description* — Size range 50-52 × 50-56 μ, trilete rays distinct, reaching corner, covered with closely set 1 × 1 μ bacula.

Genus — *Horriditriletes* Bharadwaj & Salujha, 1964

*Horriditriletes concavus* Maheshwari, 1969
Pl. 1, fig. 7

*Description* — Size range 45-50 × 40-43 μ, trilete rays weak, exine thin, ornamented with 5-10 μ long and 1-2.5 μ wide bacula, apex conate, spinose or blunt, proximal ornamentation few, 30-35 bacula present along the equator.

Remarks — The bacula are long in size as compared to holotype (3-5 μ) and they are few on proximal side.

Subinfraturma — *Variatrileti* Venkatachala & Kar, 1965

Genus — *Brevitriletes* Bharadwaj & Srivastava, 1969

*Brevitriletes unicus* (Tiwari) Bharadwaj & Srivastava, 1969
Pl. 1, fig. 6

*Description* — Size range 36-47 × 37-42 μ, exine thin, trilete rays equal, associated with minute folds, distally bears sparsely set spines, 2-4 μ long and 2-3 μ broad, rounded tips, 12-18 spines present along margin.

*Brevitriletes levis* (Balme & Hennelly) Bharadwaj & Srivastava, 1969
Pl. 1, fig. 8

*Description* — Size range 26-31 × 20-27 μ, trilete rays distinct, exine thin, distally bears small compound sparsely set spines, 1-2 μ long and 0.5-1 μ wide, 13-19 spines present along margin.

Turma — *Monoletes* Ibrahim, 1933
Subturma — *Azonomonoletes* Luber, 1935
Infraturma — *Laevigatomoenatei* Dybova & Iachowicz, 1957

Genus — *Latosporites* Potonie & Kremp, 1954

*Latosporites colliensis* (Balme & Hennelly) Bharadwaj, 1962
Pl. 1, fig. 9

*Description* — Size range 75-82 × 80-84 μ, monoilet extends up to three fourths, exine 1-1.5 μ thick, folded.

Turma — *Aletes* Ibrahim, 1933
Subturma — *Azonaletes* (Luber) Potonie & Kremp, 1954
Infraturma — *Tuberini* Pant, 1954
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Genus — *Mammialletes* Kar, 1969

*Mammialletes mammus* Kar, 1969

*Description* — Size range 40-50 × 50-55 μ, exine sculptured with 6-8 μ high, mammilate process with swollen tips.

Anteturma — *Pollonites* Potonié, 1931
Turma — *Sacrites* Erdtman, 1947
Subturma — *Monosaccites* (Chitaley) Potonié & Kremp, 1954
Subinfraturma — *Parasaccites* Diber, 1971

Genus — *Parasaccites* Bharadwaj & Tiwari, 1964

*Parasaccites diffusus* Tiwari, 1965

*Description* — Size range 105-115 × 90-115 μ, body ill-defined, mark indistinct, saccus attachment diffused.

*Parasaccites korbaensis* Bharadwaj & Tiwari, 1964

*Description* — Size range 123-132 × 95-100 μ, body 95-100 × 68-71 μ, exine mark obscure, saccus intrareticulation fine with radially elongated muri.

*Parasaccites singraulienis* Sinha, 1972

*Description* — Size range 80-60 μ, body distinct 40-46 × 35-37 μ, exine without wrinkles, mark obscure, saccus attachment indistinct, intrareticulation fine to medium.

Remarks — The size of holotype is more (116-136 μ) than the present specimen.

*Parasaccites bilateralis* Tiwari, 1965

*Description* — Size range 121-128 × 90-105 μ, body 57-65 × 62-65 μ, mark absent, saccus attachment zones ill-defined, intrareticulation fine to medium.

Genus — *Caheniasaccites* Bose & Kar, 1966

*Caheniasaccites flavatus* Bose & Kar, 1966

*Description* — Size range 120-125 × 62-65 μ, body 1-5 μ thick, saccus attachment subequatorial, sulcus horizontally oval, intrareticulation coarse.

*Caheniasaccites granulatus* Lele & Chandra, 1972

*Description* — Size range 62-70 × 40-46 μ, body 38-40 × 40-44 μ, mark ill-defined, saccus attachment subequatorial, intrareticulation medium.

*Caheniasaccites ovalis* Bose & Kar, 1966

*Description* — Size range 70-117 × 45-50 μ, body 33-51 × 33-44 μ, saccus attachment subequatorial, sulcus subcircular to circular, intrareticulation coarse.

*Caheniasaccites indicus* Srivastava, 1970

*Description* — Size 156 × 88 μ, body 80-92 μ, saccus attachment subequatorial, intrareticulation fine to medium.

Genus — *Kibambaites* Bose & Kar, 1967

*Kibambaites corius* Bose & Kar, 1967

*Description* — Size range 60-65 × 50-55 μ, body distinct, 33-42 × 30-34 μ, ± laevigate, proximal attachment equatorial, distally covers major part of the body, sulcus well defined; saccus intramicroreticulate.

Remarks — The specimens are smaller in size as compare to holotype (99 × 78 μ).

*Kibambaites sp.*

*Description* — Size 108 × 91 μ, circular to subcircular, central body distinct 55 × 80 μ, circular, ± intramicroreticulate, slit like
Genus — *Gondwanapollis* Lele & Maithy, 1969

*Gondwanapollis ganjrensis* Lele & Maithy, 1969
Pl. 2, fig. 19

*Description* — Size range 130-135 × 60-65 μ, body 58-63 × 42-45 μ, monolete mark obscure, two concave vertical body infold present, saccus attachment amphilateral, proximally circular, distally vertically oval, intrareticulation medium to coarse.

*Remarks* — The specimens have a subcircular to oval body in comparison to distinct circular body present in the holotype.

*Gondwanapollis* sp.
Pl. 2, fig. 19

*Description* — Size 100 × 82 μ, circular to subcircular, central body distinct, 54 × 53 μ, subcircular to polygonal, thin, intramicoreticulate, monolete mark weakly developed, eccentric, 1/2-2/3 of the body diameter, not straight, proximal attachment very marginal, producing a rim-like thickening, 2-3 μ thick, distal encroachment deep, associated with a thin subcircular body infolds up to 7 μ wide and thinning down to 2 μ, saccus longer axis nearly twice as wide as on the shorter axis, may be notched and developed few stronger frills along the shorter axis, saccus fine intramicoreticulate, lumina circular to elongated, ± radially directed.

*Comparison* — In general shape and organization the specimens resemble with *Kiambaites* but it is not known to possess the haplotypic mark, whereas in the present specimen a slit is present which recalls the mark. Specific name has not been given due to lack of sufficient number of specimens.

**Genus — *Stellapollenites* Lele, 1965**

*Stellapollenites talchirensis* Lele, 1965
Pl. 2, fig. 16

*Description* — Size 114 × 103 μ, body indistinct, amphilateral zones of saccus attachment ± concavely triangular, saccus fine to medium intrareticulate.

*Remarks* — The present specimen closely compares with the diagnosis and description of *Stellapollenites talchirensis* (Lele & Maithy, 1969, pl. 3, fig. 28) in its smaller size, subcircular central body and indistinct body infolds and *G. concavus* (Lele & Maithy, 1969, pl. 3, fig. 30) has a biconcave vertical body infolds which is quite distinct. Due to lack of specimens no specific name has been given here.

**Genus — *Plicatipollenites* Lele, 1964**

*Plicatipollenites gondwanensis* (Balme & Hennelly) Lele, 1964
Pl. 2, fig. 22

*Description* — Size range 148-152 × 125-130 μ, body distinct, 80-82 × 90-95 μ, exine marks weak, rays asymmetrical, body infold polygonal, well-developed, saccus intrareticulation medium to coarse.

*Remarks* — The present specimen closely compares with the diagnosis and description of *Plicatipollenites gondwanensis* (Lele, 1964, pl. 2, fig. 11). However, the grains assigned to this species have symmetrical trilete mark whereas in the present specimen the trilete mark is asymmetrical. Two rays are longer, measuring 8 μ, with blunt ends and meeting at wide angle. At their junction a third ray emerges which is 3 μ long with a pointed end. The two long rays are nearly aligned parallel to the longer
axis of the grain which is comparable with Polonieisporites neglectus (Potonie & Lele, 1961) and with some species of Plicatipollenites. In such marginal forms it is difficult to choose between Polonieisporites and Plicatipollenites only on the basis of the mark. However, the overall shape and width of saccus is very similar to Plicatipollenites gondwanensis (Lele, 1964, pl. 2, fig. 7). Probably the grain demonstrates that in P. gondwanensis the mark becomes heterotrophic as in P. indicus (Lele, 1964, pl. 2, fig. 7).

cf. Plicatipollenites magnus Tiwari, 1965
Pl. 1, fig. 8

Description — Size range 153-195 × 135-162 μ, body 65-67 × 62-65 μ, indistinct, mark weak, exine laevigate, sometimes intramicropunctate or intramicroreticulate, 3 folds present along the attachment zone of saccus.
Remarks — The specimens in overall shape and size resemble with the diagnosis and description of Plicatipollenites magnus (Tiwari, 1965, pl. 5, fig. 91). However, it differs in having a ± circular body and smooth exine with weakly developed mark. Due to lack of specimens it has been described under cf. P. magnus.

Plicatipollenites densus Srivastava, 1970
Pl. 3, fig. 27

Description — Size range 60-63 × 41-43 μ, body 35 × 37 μ, mark obscure, exine intramicroreticulate, saccus outline frilled and undulated.
Remarks — The specimens are smaller in size than the holotype (84 μ).

Genus — Virkiipollenites Lele, 1964

Virkkipollenites mehtae Lele, 1964
Pl. 3, fig. 28

Description — Size range 77-83 × 74-80 μ, body 42-50 × 40-48 μ, fine intramicroreticulate, mark obscure, saccus attachment zone discernible.

Virkkipollenites obscurus Lele, 1964
Pl. 2, fig. 21

Description — Size range 105-125 × 100-110 μ, body 65-72 × 55-62 μ, mark faintly discernible, saccus attachment zone indistinct.

Virkkipollenites densus Lele, 1964
Pl. 2, fig. 15

Description — Size range 98-102 × 80-84 μ, body 62-55 × 64-66 μ, mark not visible, saccus attachment zone obscure.

Virkkipollenites triangularis (Mehta) Lele, 1964

Description — Size 133 × 112 μ, body 52 × 41 μ, mark faintly visible, saccus attachment clear, surface ± frilled.

Subturma — Disaccites Cookson, 1947
Infraturma — Striatiti Pant, 1954

Genus — Faunipollenites Bharadwaj, 1962

Faunipollenites varius Bharadwaj, 1962
Pl. 3, fig. 29

Description — Size 123 × 85 μ, horizontal striations 8-10, sulcus 30 μ wide.

Faunipollenites goraiensis (Potonié & Lele) Maithy, 1965
Pl. 3, fig. 32

Description — Size range 96-102 × 65-90 μ, horizontal striations, 7-10, sulcus 2-5 μ wide.

Faunipollenites parvus Tiwari, 1965
Pl. 3, fig. 34

Description — Size range 66-70 × 45-47 μ, horizontal, striations 7-9, sulcus 5-7 μ wide.

Faunipollenites perexiguus Bharadwaj & Salujha, 1965a
Pl. 3, fig. 33

Description — Size range 70-80 × 60-75 μ, horizontal striations 4-6, branched, sulcus 6-7 μ wide.
Genus — *Crescentipollenites* (Leschik)
Bharadwaj, Tiwari & Kar, 1974

*Crescentipollenites limpidus* (Balme & Hennelly) comb. novo.
Pl. 3, fig. 35

1955 *Lunatisporites limpidus* Balme & Hennelly, pl. 3, figs. 29-32.

*Lectoholotype* — Balme and Hennelly, 1955, pl. 3, fig. 29.

*Emended Diagnosis* — Size range 42-76 \( \times \) 37-67 \( \mu \), body 32-41 \( \times \) 35-50 \( \mu \), striations 8-11, some striations may become thicker by folding, sulcus biconvex, 11-17 \( \mu \) wide, saccus hemispherical, saccus root convex, associated with two semilunar body fold, fine intramicroreticulate.

*Remarks* — The present specimens compare with *Lunatisporites brevis* (Bose & Kar, 1966, pl. 29, fig. 11) but distinguished by smaller size, haploxylonid, organization oval to subcircular shape (not diploxylonid as mentioned by the author), thicker body and lesser number of striations (2-5). Balme and Hennelly (1955) originally described *Lueckisporites limpidus* (pl. 3, figs. 29-32; pl. 4, figs. 33-35) from Australian Lower Gondwana. Of the several specimens illustrated, the one (pl. 3, fig. 29) resembles the present specimens, in size, body shape, and of striations. Balme and Hennelly, however, gave no information about the nature of the sulcus and the infolds which border the sulcus. The diagnosis of this species is, therefore elaborated and emended here on the basis of the present material and the illustrations of Balme and Hennelly (1955).

*Infraturma* — *Circumstriati* Lele & Makada, 1972

Genus — *Circumstriatites* Lele & Makada, 1972

cf. *Circumstriatites obscurus* Lele & Makada, 1972
Pl. 3, fig. 25

*Description* — Size range 75-80 \( \times \) 40-44 \( \mu \), body distinct, 45-60 \( \times \) 37-41 \( \mu \), grooves 9, perfect to imperfect, branched, proximally not reaching the periphery, tapering on either ends, in between the grooves exine verrucate, verrucae up to 1 \( \mu \), saccus attachment not clear, sulcus 10 \( \mu \) wide.

*Remarks* — In its general shape and organization the specimens compare with *Circumstriatites obscurus* (Lele & Makada, 1972, pl. 4, fig. 46) but differs in having small size with distinct central body and a narrow sulcus (10 \( \mu \)).

*Circumstriatites* sp.
Pl. 3, fig. 36

*Description* — Size 70 \( \times \) 44 \( \mu \), bisaccate, bilateral, central body indistinct, 48 \( \times \) 34 \( \mu \), horizontally oval, 8 horizontal grooves present over the body, sometimes associated with fold, exine thin ± laevigate, saccus hemispherical, variously folded, saccus root straight, proximally equatorial, sulcus 10-12 \( \mu \) wide, straight, saccus fine intramicroreticulate.

*Comparison* — The specimen compares in the nature of grooves with *Circumstriatites* but differs from all the known species in its small size and having a characteristically folded saccus.

*Turma* — *Plicates* (Naumova) Potonie, 1960
*Subturma* — *Monocolpates* Iversen & Troels Smith, 1950
*Infraturma* — *Intortes* (Naumova) Potonie, 1958

Genus — *Ginkgocycadophytus* Samoilovich, 1953

*Ginkgocycadophytus cymbatus* (Balme & Hennelly) Potonie & Lele, 1961
Pl. 3, fig. 31

*Description* — Size range 40-60 \( \times \) 70-80 \( \mu \), exine 1-5-2 \( \mu \) thick, grana 0-5 \( \mu \) high, colpus funnel shape, extending from one margin to other.

**COMPARISON AND DISCUSSION**

The spore assemblage is dominated by triletes and monosaccates. The quantitatively important genera individually or forming characteristic association with other genera are *Parasaccites*, *Callumispora*, *Fanis-
pollenites, Cahaniasaccites, Breviririletes and Psilalacinites.

The other quantitatively significant genera are Microbaculispora, Virkkipollenites, Kibambiotes, Verrucosissipites and Latosipites.

The following genera are also rarely present: Plicatipollenites, Gondvanopolis, Crescentipollenites, Circumstriatites, Mammiinaletes, Stellapollenites and Ginkgocycadophyta.

Morphologically the assemblage approaches closest to the known Karharbari miosfloras in the dominance of trilete and monosaccate taxa. Srivastava (1973) has recognized two zones in the type area of Giridih Coalfield, Bihar. The Upper Karharbari is dominated by disaccates like Scheuringipollenites (=Sulcatisporites), Platysaccus, Striaftites, Faunipollenites and Strialpodocarpites. The Lower Karharbari is dominated by trilete and radial monosaccates in general and particularly by the association of the genera Callumispora and Parasaccites (Srivastava, 1973). Similarly studies in the North Karanpura Basin (Kar, 1973), Korba bore core (Bharadwaj & Srivastava, 1973) and Jayanti Coalfield (Lele & Makada, 1974) also confirm this palynological characteristic of the Lower Karharbari Assemblage. Now in the Auranga Coalfield also the striking association of Callumispora and Parasaccites has been discovered. There is, therefore, no doubt that the Karharbari Stage is represented in the Auranga Coalfield as well.

REFERENCES


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### EXPLANATION OF PLATES

(All magnifications. x 500)

| PLATE 1 | 1. Psilalacinites triangularis Kar. Slide no. 4990. |
| 2. Callumispora tenuis var. minor Bharad. & Sriv. Slide no. 4990. |
| 4. V. ambiplicatus Kar. Slide no. 4990. |
| 9. Latosiporites coliensis (Balm & Henn.) Bharad. Slide no. 4990. |

| 15. Virkhipollenites densus Lele. Slide no. 4990. |
| 22. Plicatipollenites gondwanensis (Balm & Henn.) Lele. Slide no. 4991. |

| PLATE 3 | 23. Cateniasaccites indicus Sriv. Slide no. 4990. |
| 24. Kibambaites sp. Slide no. 4991. |
| 27. Plicatipollenites densus Sriv. Slide no. 4990. |
| 29. Faunipollenites varius Bharad. Slide no. 4991. |
| 32. Faunipollenites goraiensis (Sriv & Sriv) Maithy. Slide no. 4991. |
| 33. F. peregrinus Bharad. & Sal. Slide no. 4990. |
| 34. F. parvus Tiw. Slide no. 4992. |
| 35. Crescentipollenites limpidus (Balm. & Henn). Comb. nov. Slide no. 4990. |
| 36. Circumsipitites sp. Slide no. 4991. |