PALYNOSTRATIGRAPHY OF LOWER GONDWANA SEDIMENTS IN JHARIA COALFIELD, BIHAR

R. S. TIWARI, SURESH C. SRIVASTAVA, A. TRIPATHI AND VIJAYA SINGH

Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

In Jharia Coalfield, palynological succession in the Lower Gondwana sequence has been determined after studying several samples from outcrop as well as sub-surface. The Talchir miofloras, studied for the first time from this area, indicates a marine influence due to the presence of chitinozoa and acritarcha-type of bodies. The presence of Karharbari Formation has been recognised for the first time in this basin by the miofloral studies. The Barakar and Barren Measure formations, fully developed in this region, have been demarcated palynologically, especially with regard to their mutual boundaries. Brief comparisons with known miofloras from other coalfields have been made.

INTRODUCTION

A large amount of palynological work on the Lower Gondwana (Permian) sediments of the Damodar River Basin, India, has been done during the last two decades (Bharadwaj, 1975). Such studies on the Gondwana sediments in Jharia Coalfield have been confined so far to the Barren Measure Formation (Bharadwaj, Sah & Tiwari, 1965; Kar, 1966, 1968a, 1968b) and the Raniganj Formation (Bandyopadhyaya, 1967). Evidently, the extensive deposits of Talchir, Barakar and Raniganj formations needed an investigation as has been attempted here, in order to demarcate palynozones, inter-formational boundaries and interpretation of the palaeo-environment.

This study is based upon outcrop samples from several sections exposed in Jamunia River, Katri Nala, Kari Jhor, Murlidih Nala, Bansjhor Nala ; bore-core samples (Bore-hole No. MD-11) in Madhuban Block, north-western region, and the colliery samples in Mahuda Block. All together, the sampled strata represent a complete sequence from the Talchir to the Raniganj formations.

GEOLOGY

The Jharia Coalfield—broadly a sickle-shaped area, is situated in the Damodar Valley in Dhanbad district of Bihar, extending over an area of about 450 sq km between 23°38′ : 23°52′ N latitude and 86°7′ : 86°30′E longitude. The crystalline gneisses (archaeans) form the basement of the basin which exhibits a half-graben configuration (Chatterji & Ghosh, 1967). At the southern margin, along the fault, Damodar River flows from west to east. The southern fault is prominent and cuts off the Gondwana rocks which are placed against the archaean metamorphics. The fold-tectonic of this coalfield is post-depositional, and as a result of the block faulting the outliers are preserved in the shield area (Verma & Singh, 1979).

The main tributaries of Damodar River flow from north to south and cut across the sedimentaries whose general dip is towards the south, thus exposing some of the best sections of the Lower Gondwanas in this region (Map 1). Dips at the southern boundary are steep (60°) and are towards the north ; it is probably due to the drag effect of the

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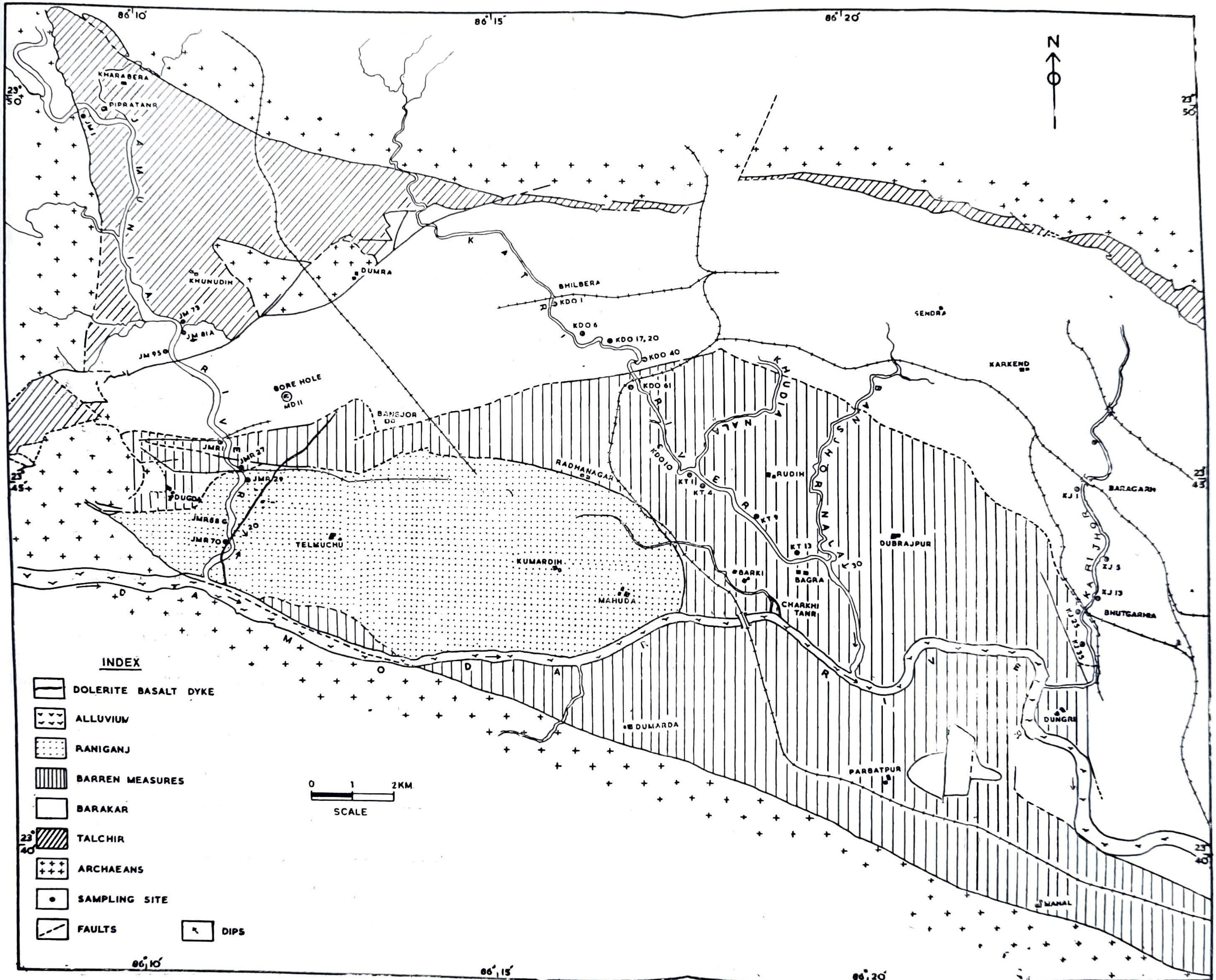


MAP 1—Geological map of Jharia Coalfield showing various sections collected for the palyno-analyses. The locations of a few yielding samples and that of the Bore hole MD-11 are given

southern boundary fault. The Gondwana sediments are represented by the Talchir, Karharbari, Barakar, Barren Measures and Raniganj formations.

In Talchir Formation the basal member is a Boulder Bed (tillite), fluvio-glacial in origin, followed by khaki-green needle shales and fine-grained arenaceous sandstones. It is about 250 m thick, its best exposures being in the north-western and western part of the coalfield. An unconformity between Talchir and Barakar sediments has been noted by Fox (1930) while a slight disconformity has been doubted by MEHTA (1957) at the same horizon. In this coalfield, the presence of Karharbari Formation had not been evidenced earlier (FOX, 1930 ; MEHTA, 1957) till BASU (1964) suggested its presence at the beginning of the coal-bearing strata, including the lower most coalseam. However, in recent investigations, the Karharbari Formation has been estimated to be 10 m to 225 m in thickness which includes coarse clastics close to the basin peripheries.

The Barakar Formation (ca 250-1150 m thick) consists of conglomerates, pebbly sandstones, grit and fine to coarse-grained sandstones, siltstones, shales, carbonaceous shales and coalseams. There are 25 workable coalseams in this formation out of which 18 are of regional extent and the rest are local. The dip of the Barakar sediments, over a greater part of the field, is southerly varying between 5-15°.

Barren Measure Formation is best developed in this coalfield, the type area, the total thickness being 200-850 m. The sediments are similar to those of Barakar Formation except that here the workable coalseams are absent. The Upper Barakar sequence passes conformably into Barren Measures and it is difficult to locate the exact line of Barakar/Barren Measures boundary which is arbitrarily taken to be little above the upper most coalseam of the Barakar Formation. The dip of Barren Measures follows similar pattern as that of the Barakars, except the central part of the basin where it is centripetal.

Raniganj Formation is developed only in Mahuda area, south western part of the coalfield, in an oval-shaped synclinal basin (ca 300-800 m thick). The sediments consist of fine-grained micaceous sandstone, shales, carbonaceous shales and coalseams. There are 9 workable coalseams in this region.

The sediments younger than the Raniganj Formation have not been reported so far from Jharia Coalfield (Fox, 1930) and, therefore, the upper extent of the Raniganj sediments has always been arbitrary. However, lithologically the presence of Panchet Formation is suspected as it has been observed in the field during the course of present studies.

MATERIAL AND METHODS

Samples for the present study were collected from the following sections, bore hole, and the colliery face-cuts (Map 1, Table 1).

Table 1

Section/B.H./Coll.	Formation	No. of samples collected	Details given in Table No.
Jamunia River	Talchir-? Panchet	153	2
Katri Nala	Barakar-Barren Measures	78	3
Kari Jhor	Barakar-Barren Measures	36	4
B. H. No. MD-11, Madhuban Block	Barakar-Barren Measures	99	5
Mahuda Seam, Murlidih colliery	Raniganj	13	6

Samples were also collected from Bans Jhor and Murlidih Nala but all of them were found to be barren of miospores. The samples which yielded palynofossils are marked with asterisk in tables 2-6. The allocation to different formations is done on the basis of lithological characteristics while the assemblage-ranges are given independently. The sections were not measured but approximate thickness, wherever available, was noted for general considerations.

In Map 1, approximate positions of some of the spore yielding samples or group of samples have been given, so that the placement of miofloral assemblage could be determined accordingly.

Maceration, in general, was done by the usual method. The sandstones were treated with hydroflouric acid for 3-4 days. Some of the coal and shale samples—normally difficult to macerate, were kept in commercial nitric acid and potassium chlorate for 10-20 days ; then mild alkaline sodium carbonate was preferred for some samples to liberate the miospores. In some samples, however, it was not required. The processing of shale samples was similar to that of the coal except that it was first treated with hydroflouric acid. In some cases, excess silica in the macerates was removed by heavy liquid (Iodide solution) separation method.

Table 2—Jamunia River Section, Jharia Coalfield

Formation	*Sample No.*	*Lithology*	*Formation*	*Sample No.*	*Lithology*
JM—Series			31.	JM—31	Needle shale
Talchir			*32.	JM—32	Green Sandstone
1.	JM— 1	1st Boulder Bed; Matrix	*33.	JM—33	Grey shale
*2.	JM— 2	Reworked shale within JM1	*34.	JM—34	Needle shale
3.	JM— 3	Mudstone in Boulder Bed	35.	JM—35	Laminated sandstone
*4.	JM— 4	Boulder Bed Matrix	*36.	JM—36	Mudstone
5.	JM— 5	Green sandstone	37.	JM—37	Sandstone
*6.	JM— 6	Muddy sandstone	*38.	JM—38	Mudstone
7.	JM— 7	Muddy sandstone	39.	JM—39	Sandstone
8.	JM— 8	2nd Boulder Bed	*40.	JM—40	Mudstone
9.	JM— 9	,, ,, ,,	41.	JM—41	Sandstone
*10.	JM—10	Muddy sandstone	42.	JM—42	Mudstone
*11.	JM—11	Sandstone	*43.	JM—43	Sandstone
12.	JM—12	Sandstone	*44.	JM—44	Mudstone
*13.	JM—13	Bouldery sandstone	45.	JM—45	Sandstone
14.	JM—14	Muddy sandstone	46.	JM—46	Mudstone
15.	JM—15	Sandstone	47.	JM—47	Sandstone
16.	JM—16	Sandstone with boulders	48.	JM—48	Mudstone
*17.	JM—17	Needle Shale	49.	JM—49	Sandstone
18.	JM—18	Sandstone	*50.	JM—50	Mudstone
19.	JM—19	3rd Boulder Bed	*51.	JM—51	Sandstone
20.	JM—20	Needle Shale	*52.	JM—52	Mudstone
21.	JM—21	Needle Shale	53.	JM—53	Sandstone
22.	JM—22	Needle Shale	*54.	JM—54	Mudstone
*23.	JM—23	Green sandstone	55.	JM—55	Sandstone
24.	JM—24	Needle shale	*56.	JM—56	Mudstone
25.	JM—25	Sandstone	57.	JM—57	Sandstone
26.	JM—26	Mudstone	58.	JM—58	Sandstone
27.	JM—27	Shale	*59.	JM—59	Mudstone
28.	JM—28	Sandstone with pebbles	*60.	JM—60	Silty sandstone
29.	JM—29	Needle shale	61.	JM—61	Sandstone
30.	JM—30	Sandstone	62.	JM—62	Sandstone

Table 2—(*continued*)

Formation	*Sample No.*	*Lithology*
Talchir (contd.)		
63.	JM—63	
64.	JM—64	Grey shale
65.	JM—65	
*66.	JM—66	Grey shale
*67.	JM—67	Mudstone
68.	JM—68	Laminated shale
*69.	JM—69	Mudstone
70.	JM—70	Sandstone
71.	JM—71	Sandstone
72.	JM—72	Sandstone
Karharbari		
73.	JM—73	Sandstone
74.	JM—74	Grey sandstone
75.	JM—75	Sandy shale
76.	JM—76a	Sandy shale
77.	JM—76b	
78.	JM—77	Sandstone
79.	JM—78	
80.	JM—79	Carb. shale
81.	JM—80	Coal
*82.	JM—81, 81a*	Sandstone
83.	JM—82	Shale
84.	JM—83	Coal
*85.	JM—84	Sandstone
86.	JM—85	Shaly sandstone
87.	JM—86	Shale
88.	JM—87	Coalseam
89.	JM—88	Sandstone
Barakar		
90.	JM—89	Coal
91.	JM—90	Shale
92.	JM—91	Coal
93.	JM—92	Shale
94.	JM—93	Coal
95.	JM—94	Shale

JMR Series		
Barren Measures		
*1.	JMR— 1	Sandstone
*2.	JMR— 2	Carb. shale
*3.	JMR— 3	Sandstone
*4.	JMR— 4	Carb. shale
5.	JMR— 5	Sandstone
*6.	JMR— 6	Shale
7.	JMR— 7	Sandstone
*8.	JMR— 8	Shale
9.	JMR— 9	Sandstone
10.	JMR—10-12*, 13	Shale
11.	JMR—14	Sandstone
*12.	JMR—15	Shale
*13.	JMR—16	Carb. Shale

Formation	*Sample No.*	*Lithology*
*14.	JMR—17	Shaly sandstone
*15.	JMR—18	Carb. shale
16.	JMR—19	Sandstone
17.	JMR—20	Shale
18.	JMR—21	Sandstone
*19.	JMR—22	Shale
20.	JMR—23	Sandstone
*21.	JMR—24	Shale
*22.	JMR—25	Sandstone
*23.	JMR—26	Carb. shale
Raniganj		
*24.	JMR—27	Coal
*25.	JMR—28	Carb. shale
26.	JMR—29	Coal
*27.	JMR—30	Sandy shale
*28.	JMR—31	Shale
29.	JMR—32	Coal
*30.	JMR—33	Sandstone with shale
*31.	JMR—34	Sandy shale
*32.	JMR—35	Shaly sandstone
*33.	JMR—36	Shaly sandstone
*34.	JMR—37	Shaly sandstone
*35.	JMR—38	Coal
36.	JMR—39	Shale
37.	JMR—40	Coal
38.	JMR—41	Carb. shale
*39.	JMR—42	Coal
*40.	JMR—43	Shale & sandstone
41.	JMR—44, 45*	Shaly sandstone
*42.	JMR—46	Carb. shale
*43.	JMR—47	Coal
44.	JMR—48	Sandstone
*45.	JMR—49	Shale
*46.	JMR—50	Coal
*47.	JMR—51	Sandstone
*48.	JMR—52	Carb. shale
*49.	JMR—53	Shale
*50.	JMR—54	Shale
*51.	JMR—55	Shale
52.	JMR—56, 57, 58	Shale
*53.	JMR—59*	Shale
54.	JMR—60	Coal
*55.	JMR—61	Coal
*56.	JMR—62	Shale
57.	JMR—63	Coal
*58.	JMR—64	Shale
*59.	JMR—65*, 66	Shale
60.	JMR—67	Shaly Sandstone
*61.	JMR—68	Coal
?Panchet		
62.	JMR—69	Khaki-green shale
63.	JMR—70	Green shale

Table 3—Katri Nala Section, Jharia Coalfield

Formation	*Sample No.*	*Lithology*
KDO Series		
Barakar		
1.	KDO— 1	Sandstone
2.	KDO— 2	Shale
3.	KDO— 3	Sandstone
4.	KDO— 4	Sandstone
5.	KDO— 5	Shale
6.	KDO— 6	Coal
*7.	KDO— 7	Shale
8.	KDO— 8	Shale
9.	KDO— 9	Shaly Sandstone
10.	KDO—10	Sandstone
11.	KDO—11	Sandy shale
12.	KDO—12	Shale
13.	KDO—13	Carb. shale
14.	KDO—14	Sandstone
15.	KDO—15	Sandstone
16.	KDO—16	Shaly sandstone
17.	KDO—17	Coal
*18.	KDO—18	Shale
*19.	KDO—19	Sandstone
20.	KDO—20	Coal
21.	KDO—21	Shale
22.	KDO—22	Carb. shale
*23.	KDO—23	Shale
24.	KDO—24	Sandstone
25.	KDO—25	Sandstone
*26.	KDO—26	Shale
27.	KDO—27	Sandstone
28.	KDO—28	Shale
29.	KDO—29	Carb. shale
*30.	KDO—30	Coal
*31.	KDO—31	Sandstone
32.	KDO—32	Coal
*33.	KDO—33	Shale
34.	KDO—34	Sandstone
35.	KDO—35	Coal
36.	KDO—36	Coal
37.	KDO—37	Sandstone
38.	KDO—38	Coal
39.	KDO—39	Shale
*40.	KDO—40	Shale & sandstone
41.	KDO—41	Shale
42.	KDO—42	Shale
*43.	KDO—43	Coal
*44.	KDO—44	Coal
*45.	KDO—45	Coal
46.	KDO—46	Coal
47.	KDO—47	Coal
48.	KDO—48	Shale
49.	KDO—49	Coal
Barren Measures		
50.	KDO—50	Bouldery sandstone
*51.	KDO—51	Carb. shale
52.	KDO—52	Coal
*53.	KDO—53	Sandstone
*54.	KDO—54	Sandstone
*55.	KDO—55	Shale
*56.	KDO—56	Sandy shale
*57.	KDO—57	Carb. shale
*58.	KDO—58	Grey shale
*59.	KDO—59	Sandy shale
*60.	KDO—60	Sandy shale
61.	KDO—61	Shale
*62.	KDO—62	Sandy shale
*63.	KDO—63	Sandstone
*64.	KDO—64	Sandstone
*65.	KDO—65	Shale
66.	KDO—66	Sandstone
37.	KDO—67	Shale
*68.	KDO—68	Shale
*69.	KDO—69	Shale
*70.	KDO—70	Shale
KT-Series		
71.	KT— 7	Carb. shale
*72.	KT— 8	Carb. shale
*73.	KT— 9	Carb. shale
74.	KT—10	Carb. shale
75.	KT—11	Micaceous sandstone
76.	KT—12	Sandstone & shale
77.	KT—13A	Sandstone
78.	KT—13B	Shaly sandstone

LITHO-SEQUENCES AND PALYNOLOGICAL CONTENTS

The general lithological description of various sections and the palynological assemblages found therein are being given below :

Jamunia River Section

(*Map* 1 ; *Sample Nos. JM*-1 to *JM*-94 ; *JMR*-1 to *JMR*- 70)

This section provides the best exposures of Talchir to Raniganj formations in this coalfield. Near Pipratanr village in north-western region, the Talchir Boulder Bed (tillite) is directly laid on gneisses delineating the Precambrian/Gondwana contact.

Table 4—Kari Jhor Nala Section, Jharia Coalfield

Formation	Sample No.	Lithology	Formation	Sample No.	Lithology
Barakar			18.	KJ—18	Sandstone
1.	KJ— 1	Sandstone	19.	KJ—19	Shaly sandstone
2.	KJ— 2	Shale	20.	KJ—20	Micaceous shale
3.	KJ— 3	Sandstone	21.	KJ—21	Shale
4.	KJ-- 4	Sandstone	22.	KJ—22	Shale
*5.	KJ— 5	Coal	*23.	KJ—23	Shale
6.	KJ— 6	Coal	24.	KJ—24	Shale
7.	KJ— 7	Sandy shale	*25.	KJ—25	Shale
8.	KJ— 8	Shale	26.	KJ—26	Shale
9.	KJ— 9	Shale	27.	KJ—27	Sandstone
Barren Measures			*28.	KJ—28	Shale
*10.	KJ—10	Shale	29.	KJ—29	Shale
11.	KJ—11	Sandstone	30.	KJ—30	Sandyshale
*12.	KJ—12	Shale	*31.	KJ—31	Carb. shale
*13.	KJ—13	Shale	32.	KJ—32	Shale
14.	KJ—14	Sandstone	*33.	KJ—33	Sandstone
15.	KJ—15	Shale	34.	KJ—34	Shaly sandstone
16.	KJ—16	Shale	*35.	KJ—35	Shale
17.	KJ—17	Shale	*36.	KJ—36	Carb. shale

The clasts are of variable size consisting of granite, amphibolite, chlorite-schist, etc. The tillites, embedded in an argillaceous matrix, are unstratified and unsorted. This member is overlain by a succession of sandstone, shale and turbidite sequence. The second boulder bed indicates a distinct erosional contact and includes boulders interbedded with poorly-sorted, greenish-grey sandstones. Reworked needle shales also occur in the matrix. This is followed by upper shale and turbidite members. The upper turbidite is persistent over a considerable area. The general lithological succession conforms with those observed by Ghosh and Mitra (1975) ; Sample Nos. JM-1 to JM-18 are collected from cycle I and JM-19 to JM-72 from cycle II of these authors.

Near Matigara village (between Sample Nos. JM-75 to JM-80) the Talchir sediments pass into grey shales, carbonaceous shales and coalseams. The zone of transition between the Talchir and the coal-measures lies in this region. The sandstones are coarse, gritty and greyish-green in colour, suggesting resemblance with the Karharbari Formation. The coarse clastics developed in this succession includes carbonaceous shale and coalseams also, although Sengupta *et al.* (1979) considered it to be devoid of coal. Thus, the presence of Karharbari Formation in Jamunia River section is lithologically definite, though restricted in aerial extent.

The Barakar Formation is not completely exposed in the Jamunia River Section, therefore, its upper and middle portions were not collected. Beyond the Matigara village, the sandstone becomes whitish, and the coal and shale intercalation ratio increases.

In the second phase (Map 1 ; Table 1, JMR-1 to JMR-70) a traverse from the railway bridge near Jamuniatanr up to Lohpiti was undertaken which represented a typical sequence of Barren Measures grading into the Raniganj Formation. The upper part of the Barren Measures consists of carbonaceous shales and sandstones till the first workable coalseam (Sample No. JMR-27) is met with. It is, thus, obvious that the boundary between the two formations under discussion is difficult to draw on the basis

Table 5—Bore hole No. MD-11 (1965), Madhuban area—Western part of Jharia Coalfield (Near Kharkhari)

Formation	Sample No.	Lithology	Depth from surface
Barakar			
*1.	MD 11/1	Sh.	362.50—358.90
2.	MD 11/2	Sst.	358.90—357.80
3.	MD 11/3	Sh.	357.80—357.40
*4.	MD 11/4	Coal	357.40—357.00
5.	MD 11/5	Sh.	357.00—356.40
6.	MD 11/6	Sh.+Coal	356.00—354.00
7.	MD 11/7	Sst. Argill.	354.00—353.20
8.	MD 11/8	Coal	353.20—352.20
9.	MD 11/9	Sst.	352.20—350.70
10.	MD 11/10	Sst. Argill.	350.70—348.10
11.	MD 11/11	Sst.	348.00—345.00
12.	MD 11/12	Sh.+Coaly Sh.	345.00—343.20
13.	MD 11/13	Sst.	343.20—342.60
*14.	MD 11/14	Sh.	342.60—341.70
15.	MD 11/15	Sst. Argill.	341.70—340.20
*16.	MD 11/16	Coaly Sh.	339.80—339.20
17.	MD 11/17	Sst. Sh.+Sludge	339.20—332.30
18.	MD 11/18	Sh. sst.	332.30—314.75
19.	MD 11/19	Sst.	314.75—311.70
20.	MD 11/20	Coal+Sh.	311.70—310.60
21.	MD 11/21	Sst.	310.60—307.75
22.	MD 11/22	Coal	307.75—308.65
23.	MD 11/23	Sh.+Coal band	308.65—301.05
24.	MD 11/24	Sst.	301.05—300.00
25.	MD 11/25	Sh.	300.00—299.55
26.	MD 11/26	Coal	299.55—299.00
27.	MD 11/27	Ss.+Sh.	299.00—287.60
28.	MD 11/28	Sh.	287.60—287.00
29.	MD 11/29	Sst.	287.00—280.80
30.	MD 11/30	Sh.	280.80—278.85
31.	MD 11/31	Sst.	278.85—278.00
32.	MD 11/32	Sh.	278.00—277.40
33.	MD 11/33	Sst.	277.40—276.00
34.	MD 11/34	Sh.+Sst. band.	276.60—272.00
35.	MD 11/35	Sst.	272.00—265.00
36.	MD 11/36	Sst.	285.00—261.20
37.	MD 11/37	Argill. Sst.	261.20—244.50
38.	MD 11/38	Sst.	244.50—243.20
*39.	MD 11/39	Sh.	243.20—242.30
40.	MD 11/40	Sst.	242.20—241.60
*41.	MD 11/41	Sh.	241.60—240.20
42.	MD 11/42	Coal	240.20—239.60
*43.	MD 11/43	Sst. intercoal	239.60—233.00
44.	MD 11/44	Sst.	233.00—232.60
45.	MD 11/45	Sh.	232.60—231.00
46.	MD 11/46	Coal	231.00—229.80
47.	MD 11/47	Sh.	229.80—227.90
*48.	MD 11/48	Sst.+intercal	227.90—224.50
49.	MD 11/49	Coal	224.50—223.50
50.	MD 11/50	Sst. intercal.	223.50—222.20
51.	MD 11/51	Coal	222.20—220.50
*52.	MD 11/52	Sh.	220.50—214.50
53.	MD 11/53	Sst.	214.35—210.50
*54.	MD 11/54	Sh.	210.50—210.00
55.	MD 11/55	Sst. with intercal	210.00—195.70
56.	MD 11/56	Sst. with Argill.	195.70—193.70
*57.	MD 11/57	Sh.	193.70—192.00
58.	MD 11/58	Sst.	192.00—190.70
*59.	MD 11/59	Sh.	190.70—189.70
60.	MD 11/60	Sst.	189.70—187.60
61.	MD 11/61	Sst. Argill.	187.60—181.45
62.	MD 11/62	Coaly Sh.	181.45—181.00
*63.	MD 11/63	Sst.+Sh.	181.00—174.00
*64.	MD 11/64	Sst.+Sh.	174.00—172.00
65.	MD 11/65	Sst.	172.00—170.00
66.	MD 11/66	Sst. Streaks of Argill.	170.00—159.75
*67.	MD 11/67	Black Sh.	159.75—156.40
68.	MD 11/68	Coarse sst.	156.40—150.90
*69.	MD 11/69	Sst. with Sh.	150.90—132.00
70.	MD 11/70	Coarse sst.	132.00—124.80
*71.	MD 11/71	Carb. Sh.	124.80—123.40
72.	MD 11/72	Sst.	123.40—123.00
*73.	MD 11/73	Sst.+Carb. band	123.00—118.00
74.	MD 11/74	Coarse Sst.	118.00—116.40
Barren Measures			
*75.	MD 11/75	Sh.	116.40—114.80
*76.	MD 11/76	Coarse Sst.	114.80—111.70
77.	MD 11/77	Sst.	111.70—110.00
*78.	MD 11/78	Coal band	110.00—109.80
*79.	MD 11/79	Sst.	109.80—108.75
80.	MD 11/80	Coal	108.75—108.40
*81.	MD 11/81	Witish Sst.+Sh. band	108.40—102.85
*82.	MD 11/82	Coaly Sh.	102.85—102.55
83.	MD 11/83	Coarse sst.	102.55—95.35
84.	MD 11/84	Sh.	95.35—94.90
85.	MD 11/85	Sst.	94.90—93.70
*86.	MD 11/86	Shaly sst.	93.70—91.20
*87.	MD 11/87	Sst. with intercal.	92.20—84.00
*88.	MD 11/88	Sst. with sh. streaks	84.00—79.10
*89.	MD 11/89	Sst. with streaks	79.10—73.30
90.	MD 11/90	Coarse Sst.	73.30—72.75
*91.	MD 11/91	Whitish sst. with sh.	72.75—46.85
*92.	MD 11/92	Coarse sst.	46.85—37.00
*93.	MD 11/93	Sst. with intercal	37.00—27.00
			27 to 25-missing
*94.	MD 11/94	Shale	25.00—19.70
*95.	MD 11/95	Reddish sst.	19.70—15.10
*96.	MD 11/96	Pinkish sst.	15.10—13.50
97.	MD 11/97	Weathered Sh.	13.50—12.20
98.	MD 11/98	Weathered sst.	12.20—11.90
99.	MD 11/99	Weathered Sh.	11.90—8.50

Table 6—Mahuda Seam, Murlidih Colliery (Pit No. 20/21), Jharia Coalfield

Formation	*Sample No.*	*Lithology*	*Seam*	*Formation*	*Sample No.*	*Lithology*	*Seam*
Raniganj				*7.	M—3 B	Coal	Mahuda Bottom
*1.	M—2 T	Coal	Mahuda Top	*8.	M—4 B	,,	
*2.	M—3 T	,,		*9.	M—5 B	,,	
*3.	M—4 T	,,		*10.	M—6 B	,,	
*4.	M—5 T	,,		*11.	M—7 B	,,	
*5.	M—6 T	,,		*12.	M—8 B	,,	
*6.	M—2 B	Carb. Sh.	Mahuda Bottom	*13.	M—9 B	,,	

of lithology alone because the shale and sandstone facies passes into coal-shale-sandstone suite conformably. A thick succession of the Raniganj Formation represented a more or less complete sequence within a shorter distance in the Mahuda-oval.

On top of the Raniganj Formation, near Telmuchu, beyond the dyke, a 2m thick band shows greenish and khaki-green colour which appears to be similar to the Panchet lithology in the Raniganj Coalfield. Its presence is significant because no Panchet sediments have been reported, so far, from the Jharia Coalfield. Probably this patch represents the only remnance of Panchet Formation in this region, while in the neighbouring areas thick deposits of the same are still present, viz. in Bokaro Coalfield—Lugu Hill; Raniganj Coalfield—Panchet Hill, etc.

The Talchir Formation shows the following tendency in the occurrence of miospores :

From Sample Nos. JM-1 to 18 representing the first cycle of Talchir sedimentation, miospores have been recovered only sporadically ; the following genera were recorded : *Plicatipollenites*, *Parasaccites*, *Jayantisporites*, *Potonieisporites*, *Vesicaspora*, *Striatopodocarpites*. Alete miospores, on the other hand, represented by *Leiosphaeridia*, *Peltacystia*, *Spongocystia*, *Foveofusa* and 'spinose acritarchs' are more frequent.

Sample No. JM-19, the second boulder bed (Tillite) marks the beginning of the second cyclic deposits of the Talchir Formation, but it is devoid of miospores. In Sample No. JM-23 (green sandstone) *Plicatipollenites* is more frequent than *Parasaccites*. However, it was difficult to ascertain the percentage of miospores because of their paucity. In sample No. JM-32 *Parasaccites* increases to balance with *Plicatipollenites*, but in sample No. JM-33, the former increases further to attain overall dominance and, this trend continues up to Sample No. JM-59. The other notable genera—rare but persistent, are *Virkkipollenites*, *Potonieisporites*, *Callumispora* and *Caheniasaccites*. In Sample No. JM-59 some flask-shaped vesicles are present resembling 'chitinozoa'. Sample Nos. JM-60 to 72 of the Talchir Formation did not yield miospores.

Sample Nos. JM-73 to 88 representing the Karharbari Formation opposite Matigara village have not yielded miospores except the Sample No. 81a. It is rich in the genus *Parasaccites* (58%), followed by *Jayantisporites* (12%), *Callumispora* (9%), *Plicatipollenites* (5%), *Caheniasaccites* (5%), *Crucisaccites* (2%) and *Potonieisporites* (2%).

Sample Nos. JM-89 to 94, which represented the Barakar Formation in Jamunia River were barren of miospores. The Upper Barren Measures sequence collected near the railway bridge (Map 1) showed dominance of striated-disaccate genera (*Striatopodocarpites*, *Faunipollenites*, *Verticipollenites*, *Lahirites*) associated with the monosaccate genus *Densipollenites*. The latter is remarkably abundant—an observation corroborating with earlier results (BHARADWAJ, SAH & TIWARI, 1965; KAR, 1966). Rare incidence of pteridophytic spores is also noteworthy.

Sample No. JMR-29 represents a coalseam and thus indicates a change in facies above the Barren Measures. This change is also marked by a decline in the percentage of the genus *Densipollenites* and relative rise in the striated-disaccates. The same tendency continues in the still younger sediments, with, of course, more trilete spores. The Raniganj Formation is not divisible on the basis of miofloral assemblage. This is, however, partly because of the poor yield of samples as well as bad preservation of miospores. Nevertheless, the continuity of *Densipollenites* in a fair percentage indicates that the change of climate was not sharp at the advent of Raniganj sedimentation in comparison to the Barren Measures time. Obviously, because of this reason, the palynological boundary is not demarcated sharply between the two.

The topmost two samples collected near the dyke (JMR-69, 70) are khaki-green shale and compare with the Panchet lithology of the type area. Although at present no other evidence is at hand, the presence of Panchet in conformable succession with Raniganj is evidenced lithologically.

Bore-hole No. MD-11, Madhuban Area

(Map 1, Sample Nos. MD-11/1 to 99)

The Bore-hole No. MD-11 drilled in the Madhuban Area (depth 362.50 m) passes through a sequence of coal, shale and sandstone representing the Barakar Formation. The mioflora recovered revealed the presence of *Striatopodocarpites*, *Faunipollenites*, *Scheuringipollenites*, *Striatites*, *Microbaculispora*, *Densipollenites*, *Cyclogranisporites and Indotriradites*. Quantitatively rare genera *Barakarites* and *Horriditriletes* also contribute to the characteristics of this assemblage.

There are minor fluctuations in the spectrum of the mioflora through the run of the core but the overall composition is broadly uniform at generic level. It compares with the known Barakar miofloras of Peninsular Gondwana. Presence of *Densipollenites* in good percentage in sample nos. MD-11/71-95 indicates a younger aspect in the assemblage—a nearness towards the Barren Measures mioflora. However, the presence of fair amount of triletes and few monosaccates indicates its Barakar affinity. In the top 115 m, the Barren Measures elements exhibit their importance, hence such an affinity is indicated.

Katri Nala Section

(Map 1 ; Sample Nos. KDO-1 to KDO-90, KT-1 to KT-13)

This section provides good exposures of Barakar and Barren Measure formations. The traverse was taken from the railway bridge near Bhilbera village. Sample Nos. KDO-1 to KDO-49 represent the Barakar sediments. Beyond this there is a sandstone bed having boulders and pebbles and thereafter the sandstones become ferruginous. Workable coalseams disappear and a massive thickness of carbonaceous shales occur. This horizon (Sample Nos. KDO-54 to 61) represents the Shibabudih Shale Beds of Barren Measures. The rest of samples (KDO-62 to KDO-70 and KT-7 to KT-13) have been collected from Barren Measures sequence up to Bagra village. Mostly the sequence consists of coarse-grained sandstone, shales—micaceous at places, carbonaceous shale and sandy shales.

Palynologically the Barakar succession is characterised by *Striatopodocarpites*, *Scheuringipollenites*, *Parasaccites*, *Barakarites*, *Potonieisporites*, *Microbaculispora* and *Densi-*

pollenites. This assemblage continues up to sample No. KDO-49, the last workable coal-seam, over which there is a bouldery sandstone (Sample No. KDO-50). A trend of change is seen above this line of demarcation and at KDO-55 level a sudden fall in *Scheuringipollenites* and a slight increase in *Barakarites* has been recorded. However, at this plane, the iron content of the sandstones increases and the general constituent of the macerate is dark wood-shreds rather than spores. The mioflora establishes itself with dominance of *Densipollenites* at a higher level than at the Barakar/Barren Measures boundary as demarcated lithologically. In other words, *Densipollenites*-rich assemblage starts and establishes itself at about 50 m above the lithological boundary.

Murlidih Nala Section

(*Map* 1)

Murlidih Nala exposes Upper Barren Measures to the Raniganj Formation. However, the cuttings being not very deep, most of the sections are covered under alluvium. The traverse was taken from near Charkhitanr and upstream up to railway bridge near Mahuda. Most of the exposures consist of massive sandstone, rarely with shale intercalations. This massive sandstone represents the lowermost bed of the Raniganj Formation. However, no line of demarcation could be generally drawn between the Barren Measures and the Raniganj Formation. All the samples collected proved barren of miospores.

Mahuda Seam

(*Map* 1, *Table* 6)

Mahuda seam is the lowermost coalseam of the Raniganj Formation in Jharia Coalfield. Fifteen foot-wise samples of this seam were collected from Murlidih Colliery (9 samples from Mahuda Bottom Seam and 6 from Mahuda Top Seam).

The mioflora of Mahuda Seam is rich in disaccate striate genera, viz. *Striatopodocarpites*, *Crescentipollenites*, *Lahirites*, *Hindipollenites* and *Faunipollenites*. Other characteristic forms in this assemblage are—*Horriditriletes*, *Verrucosisporites*, *Scheuringipollenites*, *Indospora* and *Cyclogranisporites*. The genus *Densipollenites* is as low as 4 per cent. A specific-level determination reveals that this lowermost coalseam of Raniganj Formation is having following species: *Cyclogranisporites indicus* Bharad. & Sal., 1964; *Indospora clara* Bharad., 1962 ; *Gondisporites raniganjensis* Bharad., 1962 ; *Horriditriletes curvibaculosus* Bharad. & Sal., 1964 ; *Thymospora* sp. Their presence establishes the identification of the mioflora, qualitatively.

Mahuda Top and Mahuda Bottom seams contain similar assemblage of miospores and, therefore, are palynologically indistinguishable.

Kari Jhor Nala Section

(*Map* 1, *Sample Nos. KJ*-1 *to KJ*-36)

The upper part of Barakar and lower part of Barren Measure formations are exposed in Kari Jhor Nala. A traverse was undertaken from south of the road bridge near Baragarh Colliery. The succession consists of massive sandstone, shale, few coal-bands or thin coalseams. The sandstones are micaceous, coarse-grained showing ferruginous nature towards the top (Sample No. KJ-14). In the upper part, the sandstone becomes bouldery (Sample No. KJ-17).

Just before the rail-bridge near Bhutgariya railway station towards south, the Barakar/Barren Measures boundary is marked by the appearance of hard, compact, relatively lesser coarse, ferruginous sandstone (Sample No. KJ-10). Immediately following this change, a very thick deposition of carbonaceous shale is located which could be equated with the Shibabudih Shale in Katri Nala Section (Sample Nos. KJ-21 to KJ-26). Above this, a continuous sequence of sandstone and shale has been collected till the section obliterates in the alluvium (up to Sample No. KJ-36).

Between Sample Nos. KJ-1 and KJ-18 the sequence consists of shale, coarse-grained micaceous sandstone and thin coalseams. The sandstone at KJ-17, KJ-18 gets bouldery with some iron effect. The boundary is demarcated here. Palynologically the overlying and underlying samples proved barren but in Sample No. KJ-25 a change is evident. The genus *Scheuringipollenites*, which is more in Barakar mioflora, suddenly declines in younger three samples which lithologically represent the Barren Measures Formation. However, as such, there is no sharp break and even the pteridophytic spores appear to have continued in lower part of the Barren Measures sequence. The genus *Densipollenites* also does not establish at this level—that is, at the early phase of the Barren Measures.

PALYNOSTRATIGRAPHY

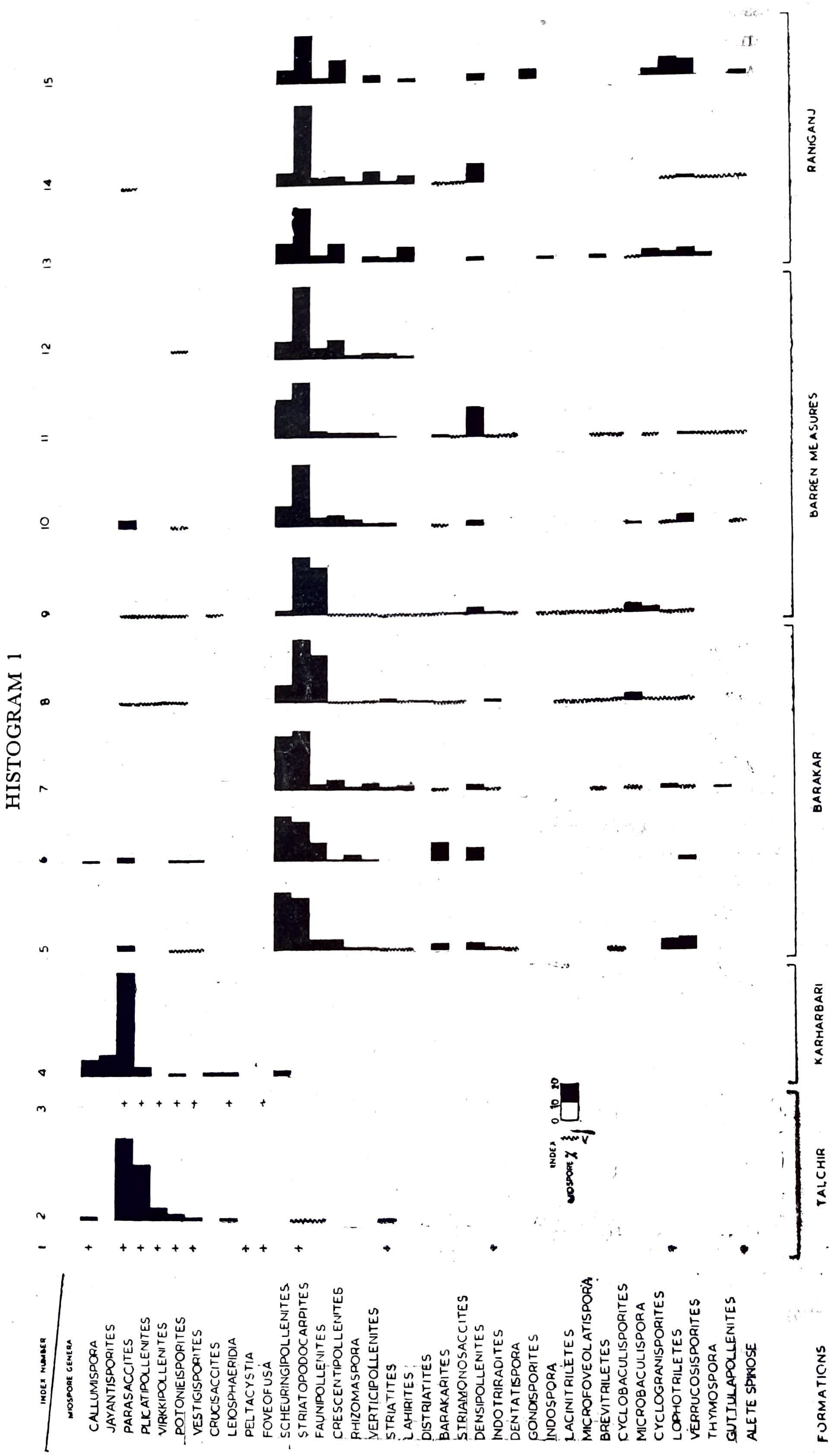
A composite histogram showing the succession of various miofloral assemblages in Jharia Coalfield has been prepared (Histogram 1). In doing so, the palynologically coherent samples have been clubed together (Index Nos). The miofloras are characterised as given below :

Talchir Mioflora—The palynoflora recorded from the Jamunia River Section exhibits a closer resemblance with the one recorded from Hasia Nala Section of Manendragarh (Bharadwaj, Srivastava & Anand-Prakash, 1979). Although the presence of Palynozone-I of Manendragarh, characterised by the dominance of *Plicatipollenites*, is not very well documented in Jamunia River Section, this trend is evident in sample No. JM-23 and continues till sample No. JM-32, in which *Plicatipollenites* is still more than *Parasaccites* (Index Nos. 1, 2, 3). In younger sediments the situation reverses and *Parasaccites* gradually attains dominance over *Plicatipollenites*, a case similar to Palynozone-II of Manendragarh. Similar pattern in succession of miofloras within Talchir Formation of India was arrived at by the synthesis of data proposed by Tiwari (1973) and Chandra and Lele (1979).

'Spinose acritarchs' described from Manendragarh (Bharadwaj *et al.*, 1979 ; pl. 1, figs. 12-14) and *Veryhachium* from Palar Basin (Venkatachala *et al.*, 1973) are, however, morphologically different from those recorded here in the Talchir sediments of Jamunia River. *Foveofusa* and *Leiosphaeridia* present in the marine beds of Umaria, M. P. (Lele & Chandra, 1972) and *Peltacystia* and *Spongocystia* present in Perth Basin, Australia are recorded in the Jamunia River Talchir.

The lithological set-up of the Talchir Formation shows a regular pattern of two cycles of sedimentation commencing with a basal tillite. The 'acritarchs' Chitinozoire-like-bodies and other alete miospores associated with them indicate a glacio-marine model of sedimentation.

Karharbari Mioflora—The sediments representing Karharbari Formation in Jamunia River bear only limited miospore taxa (Index No. 4). The Sample No. JM-81a contains a mioflora marked by the dominance of *Parasaccites*. It may be mistaken as a continuation of the Talchir mioflora but, however, the presence of *Crucisaccites*, *Caheniasaccites* and *Callumispora* in significant percentages distinguishes the Karharbari mioflora. In view of the above constituents, the Sample No. JM-81a compares with the Upper Karharbari


HISTOGRAM 1
INDEX NUMBER
MIOSPORE GENERA
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
CALLUMISPORA
JAYANTISPORITES
PARASACCITES
PLICATIPOLLENITES
VIRKKIPOLLENITES
POTONIEISPORITES
VESTIGISPORITES
CRUCISACCITES
LEIOSPHAERIDIA
PELTACYSTIA
FOVEOFUSA
SCHEURINGIPOLLENITES
STRIATOPODOCARPITES
FAUNIPOLLENITES
CRESCENTIPOLLENITES
RHIZOMASPORA
VERTICIPOLLENITES
STRIATITES
LAHIRITES
DISTRIATITES
BARAKARITES
STRIAMONOSACCITES
DENSIPOLLENITES
INDOTRIRADITES
DENTATISPORA
GONDISPORITES
INDOSPORA
LACINITRILETES
MICROFOVEOLATISPORA
BREVITRILETES
CYCLOBACULISPORITES
MICROBACULISPORA
CYCLOGRANISPORITES
LOPHOTRILETES
VERRUCOSISPORITES
THYMOSPORA
GUTTULAPOLLENITES
ALETE SPINOSE
FORMATIONS
TALCHIR
KARHARBARI
BARAKAR
BARREN MEASURES
RANIGANJ
INDEX
MIOSPORE %
0 10 20

mioflora of Korba Coalfield (BHARADWAJ & SRIVASTAVA, 1973 ; Zone-2, older phase) which is essentially a *Parasaccites*-dominant-zone and contained in a coal-bearing horizon above the Talchirs. Such recurrence of *Parasaccites*-dominant-assemblage is known in the lowermost coal-measures of the Lower Gondwana of India (SRIVASTAVA, 1974). The *Callumispora* + monosaccate-dominant-assemblage representing early Karharbari mioflora of Korba Coalfield (BHARADWAJ & SRIVASTAVA, 1973 : Zone-1, younger phase) and Lower Karharbari seam of Giridih Coalfield (SRIVASTAVA, 1975) is not recorded in Jamunia River section.

Barakar Mioflora—In the Jamunia River section, the Lower Barakar sediments did not yield very effectively. In the Katri Nala section (Index No. 5 & 6 in Histogram 1) as well as in Kari Jhor Nala section (Index No. 7 in Histogram 1) the samples make a coherent group, characterized by more of *Scheuringipollenites* and less *Striatopodocarpites* combination. Therefore, the assemblage compares with the middle Barakar assemblages described from Raniganj Coalfield (TIWARI, 1973). This tendency is slightly changed in the two closely-resembling groups of samples in Bore-hole MD-11 (Index Nos. 8, 9 in Histogram 1) where *Striatopodocarpites* becomes more prominent than *Scheuringipollenites* —a trend indicating an affinity with the late Barakar miofloras from the Damodar Basin (TIWARI, 1974). Within the bore hole MD-11 the younger group of samples (Index No. 9 in Histogram 1) represents a transitional mioflora.

Barren Measures Mioflora—In the tendency of the occurrence of major components, the younger group of samples in Bore-hole MD-11 (Index No. 9) the samples from near the Barakar/Barren Measures boundary in Kari Jhor Nala (Index No. 10), Sample Nos. KDO-65 and KT-Series in Katri Nala (Index No. 11), and Sample Nos. JMR-2 to JMR-30 (Index No. 12) in the Jamunia River, form a broad group of Barren Measures miospore assemblage which is comparable with the already known miofloras from this age (BHARADWAJ, SAH & TIWARI, 1965 ; SRIVASTAVA & MAHESHWARI, 1974 ; KAR, 1969, 1971, 1973 ; LELE & SRIVASTAVA, 1977, 1979). However, it appears in the case of the Jharia Coalfield palynological succession that the genus *Densipollenites* starts appearing in fair representation well within the upper reaches of Barakar Formation, a condition not recorded from other areas. Thus, the early advent of this important

Histogram 1 : Composite Histogram showing the pattern of mioflral behaviour from different sections in Jharia Coalfield representing Talchir, Karharbari, Barakar, Barren Measures and Raniganj miospore assemblages.

Index Nos. are given to the average percentage of the miofloristically similar group of samples.

Talchir—	*Index No.* 1	(Sample Nos. JM—2, 4, 6, 10, 11, 13, 17, 23)
	Index No. 2	(Sample Nos. JM—32, 33, 34, 38, 40, 44, 52, 54)
	Index No. 3	(Sample Nos. JM—56, 59, 60, 66, 67, 69—Only presence recorded by +)
Karharbari—	*Index No.* 4	(Sample No. JM—81 a)
Barakar—	*Index No.* 5	(Sample Nos. KDO—7, 18, 19, 23, 33, 40, 44, 51)
	Index No. 6	(Sample Nos. KDO—55, 62)
	Index No. 7	(Sample Nos KJ—5, 10, 13)
	Index No. 8	(Sample Nos. Bore hole MD—11/69, 67, 64, 63, 62, 59, 57, 54, 52, 48, 43, 41, 16, 14, 4).
Barren Measures—	*Index No.* 9	(Sample Nos. MD—11/95, 94, 92, 91, 89, 88, 87, 86, 82, 81, 79, 77, 76, 75, 73, 71).
	Index No. 10	(Sample Nos. KJ—25, 28, 33)
	Index No. 11	(Sample Nos. KDO—65, KT—1, 4, 7, 9)
	Index No. 12	(Sample Nos. JMR—2, 4, 6, 8, 10, 12, 15, 17, 18, 24, 26, 28, 30).
Raniganj—	*Index No.* 13	(Mahuda Top, Mahuda Bottom seams)
	Index No. 14	(Sample Nos. JMR—33, 34, 38, 42, 45, 46, 47, 55, 57, 62, 67)
	Index No. 15	(Sample No. JMR—68).

element seems to be related with the beginning of colonization of this area by the *Densipollenites*-producing plants at the closing phase of the Barakar times—probably due to an early deterioration of the climate.

The rise in the percentage of *Densipollenites* within the Barren Measures sediments is remarkable in the Katri Nala and the Jamunia River exposures (Index Nos. 11 & 12 respectively in Histogram 1). However, no tripartite division for the Barren Measures could be established on the basis of *Densipollenites* dominance as suggested by KAR (1972).

Raniganj Mioflora—Inspite of a general conformity in the palynological contents of the Barren Measures and the Raniganj Formation, the diversification in the striated-disaccate pollen, and the pteridophytic spores in the latter has been noticed in this coalfield. The genus *Densipollenites* also declines considerably in Raniganj although not so significantly in the Jamunia River section (Index No. 12 & 14 in Histogram 1).

The depositions of the Raniganj Formation are localised and abridged in being restricted to a smaller oval-shaped area and also in having lesser vertical extension when compared to its counter parts in the eastern region of the Damodar Basin. Although the distinction of sub-zones within this formation has not been indicated palynologically, the complex and diversified spore-pollen population has been recorded indicating contribution of a more luxuriant vegetational complex than the older times.

This study also revealed that the Raniganj and the Barren measures are broadly similar but at the same time the former has a distinctive assemblage in having a number of new entrants, which are already established as Raniganj marker.

In the general constituents, the Raniganj mioflora here desdribed from the Jamunia River (the Mahuda-oval section : Index No. 14, 15) and Mahuda Seam (Index No. 13) closely resembles other assemblages from the same age (TIWARI, 1976 ; LELE & SRIVASTAVA, 1979). Qualitative characteristics discussed earlier also conform to the known data. The uppermost sample in the Raniganj sediments (Index No. 15) showed a characteristic representation of *Gondisporites*, *Cyclogranisporites*, *Indospora*, *Thymospora*, etc. (*cf*. BHARADWAJ & SALUJHA, 1965, 1965a ; SALUJHA, 1965). However, no spores have been recovered from the srata younger than this.

DISCUSSION AND CONCLUSIONS

The presence of smooth-walled "acritarcha" in the miospore assemblages from Lower Gondwana horizons is not unknown (SINHA, 1969 ; LELE & CHANDRA, 1973) but their referred association with the marine-type of environment has created great interest as well as controversy (BHARADWAJ, TIWARI & ANAND-PRAKASH, 1978). The association of some of these forms with the fresh water deposits, such as in the Jhingurdah Seam (SINHA, 1969), creats uncertainity of their being valuable environment indicators but, at the same time, the forms like *Leiofusa* and *Foveofusa* are, to a greater extent—although by inference and indirect derivation—serve to suggest a possibility of marine influence in the area of deposition. Such is the case with the Talchir of the Jharia Coalfield.

Here the above named two alete genera occur in association with the "Chitinozoa-like" remains and a few "spinose alete" miospores which point towards a possibility of having marine influence during this time in this area. More evidence is needed in order to project a better picture; till then further comments on palaeoecology are reserved.

Besides the evidences provided by the chemical analysis (BASU, 1964) in case of coalseams, and the distinctive megaflora—if at all available to rely upon, palynology had proved to be dependable in identifying the Karharbari strata in the Lower Gondwana of Peninsular India (BHARADWAJ & SRIVASTAVA, 1973 ; TIWARI, 1973 ; LELE & SRIVASTAVA, 1977). In Jharia Coalfield also, the earliest coal-bearing levels in Jamunia River Section showed the dominance of girdling monosaccate pollen, confirming thereby the presence of the Karharbari Formation. This conclusion is also corroborated by the lithological observations.

The Barakar, Barren Measures and the Raniganj miospore assemblages are luxuriant and fully expressive of their diversified nature similar to the other region of the Damodar Valley. One important observation, also mentioned earlier, is the fair commencement of the pollen genus *Densipollenites* right in the late Barakar sediments, and its marked continuation in the Raniganj Formation. This leads to the conclusion that in the area of Jharia Coalfield the drier and warmer conditions were heralded relatively earlier in comparison to the other areas in Damodar Valley and continued to remain so during the early Raniganj times also. The massive nature of the muri and fineness of the meshes of the sacci in the saccate grains as well as the leathery, thick nature of the exine of the miospores found in Barren Measures in general approves an existence of unfavourable climatic conditions. The extreme rarity of the pteridophytic spores is also suggestive of the drier phase.

Lithologically the remnant of the Panchet Formation have been suspected ; however, it is only the recovery of spores and pollen which would confirm its true affiliation. There is, therefore, a prospect for future work which should be based on the subsurface samples in the Mahuda-oval region because the outcrops are not sufficient in many respects. Palynologically, the uppermost strata in the Raniganj Formation are not represented.

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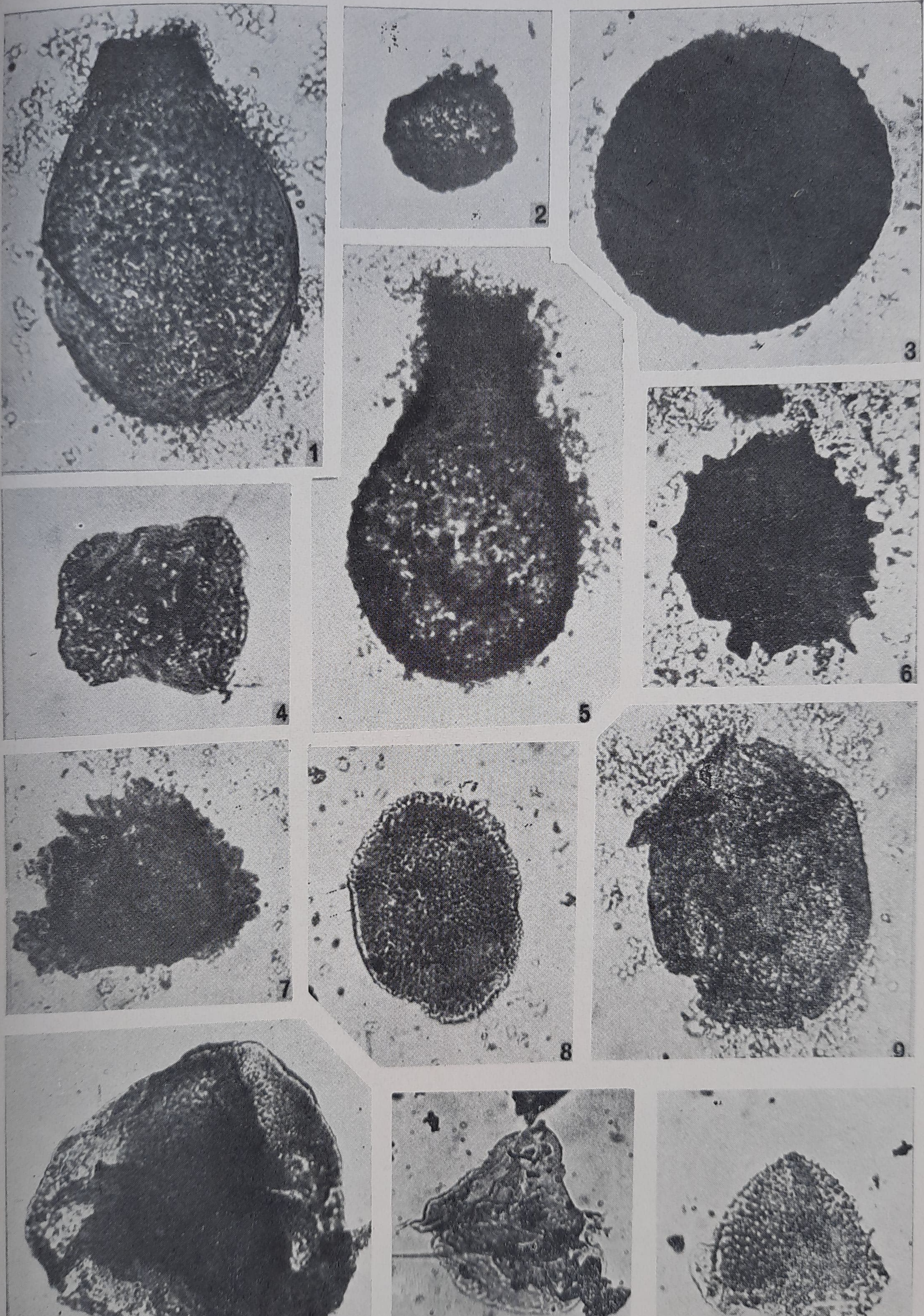
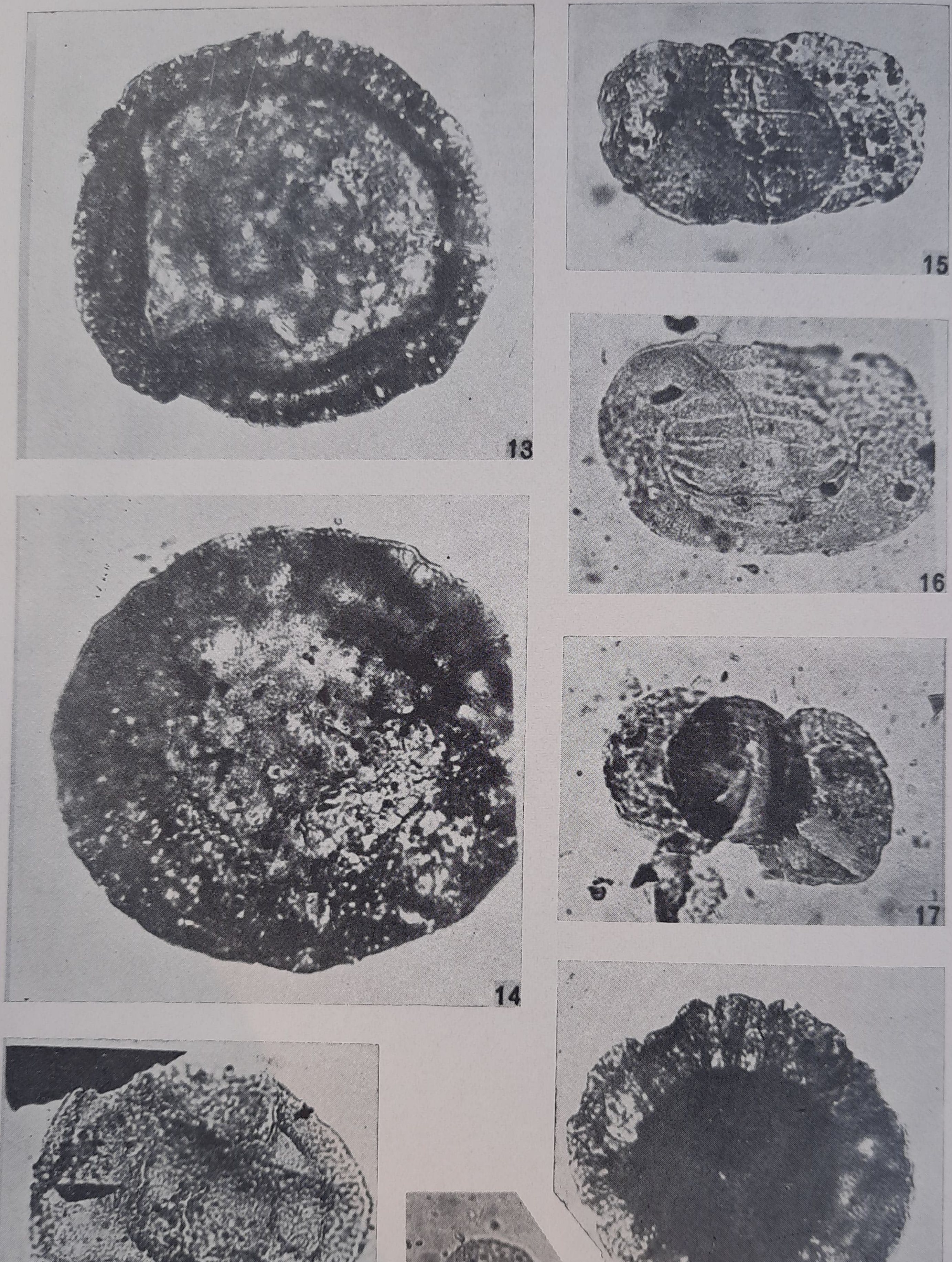


Tiwari, Srivastava, Tripathi & Singh—Plate 1



Tiwari, Srivastava, Tripathi & Singh—Plate 2

EXPLANATION OF PLATES

All figures are × 500

All the slides of the present investigation have been deposited at the Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow, vide museum statement no. 488.

PLATE 1

1, 5. '*Chitinozoa*—type' vesicles, BISP Reg. No. 6646; Sl. No. JM 59/3-6.6 ×101 & Reg. No. 6645; JM 59/1-21 × 106.
2. *Maculatasporites*................Reg. No. 6639; Sl. No. JM 10/5-11 × 94.6
3, 6. 'Alete' spinose and conate spores Reg. No. 6636; Sl. No. JM 2/2-8.6 ×100, & Reg. No. 6637; JM 2/3-39 ×94.
4. *Balmeella* ....Reg. No. 6638; Sl. No. JM 33/6-16 × 99.
7. *Jayantisporites* ....Reg. No. 6635; Sl. No. JM 2/1-8.5 ×106.
8. *Thymospora* ....Reg. No. 6648; Sl. No. JMR 65/1-14 ×106.
9. *Leiosphaeridia*..................Reg. No. 6638; Sl. No. JM 2/6-37.3 ×101.
10. *Densipollenites* ....Reg. No. 6648; Sl. No. JMR 65/1-26 ×105.
11. *Indospora* ....Reg. No. 6651; Sl. No. MD—3/3-13 ×109.
12. *Didecitriletes* ....Reg. No. 6649; Sl. No. JMR 68/1-12 ×99.

PLATE 2

13. *Plicatipollenites* ....Reg. No. 6640; Sl. No. JM 33/4-13.5 ×104.5.
14. *Parasaccites*....................Reg. Ne. 6642; Sl. No. JM 32/4-22 ×107.6.
15. *Striatopodocarpites* ....Reg. No. 6644; Sl. No. JM 34/6-21.5 × 98.
16. *Faunipollenites*..................Reg. No. 6647; Sl. No. JMR 47/1-12 ×107.
17. *Striatites* ....Reg. No. 6647; Sl. No. JMR 47/1-35.5 ×109.
18. *Gondisporites* ....Reg. No. 6650; Sl. No. JMR 68/2-62.2 ×95.
19. *Cyclogranisporites*................Reg. No. 6651; Sl. No. MD 3/3-29 ×93.
20. *Virkkipollenites* ....Reg. No. 6643; Sl. No. JM 34/1-41 ×104.