

# PALYNOLOGICAL SUCCESSION IN PERMIAN-TRIASSIC SEDIMENTS IN BORE-HOLE RNM-3, EAST RANIGANJ COALFIELD, W. BENGAL

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## ABSTRACT

Palynological succession through Barren Measures, Raniganj and Lower Triassic sediments cutting 930 m in Bore-hole RNM-3, which is located beyond the eastern limits of East Raniganj Coalfield, W. Bengal, has been analysed. The conclusions corroborate the earlier results of investigations in the subsurface strata in this area. The Upper Barren Measures mioflora is characterised by the prominence of striate-disaccate miospore genera and the genus *Densipollenites*. The main coal-bearing Raniganj sediments show—except at certain level of distinction—a continuity of striate-disaccate dominant miofloral spectrum; the closing phase of Raniganj Formation, once again indicates the *Densipollenites*-rich assemblage but the incoming Triassic elements determine the difference from Barren Measures. The yielding Triassic sample contains pollen-spore complex of typical Upper Panchet Formation (late Lower Triassic). The general paucity of trilete spores in the Raniganj strata is an indicator of ecological variation with respect to the main, central part of the Raniganj Basin where they are abundant. The precise Raniganj/Panchet boundary could not be determined due to non-availability of assemblages for a considerably thick sediments near the boundary region, yet a non-representation of lower part of a Panchet sediment is suspected in this area.

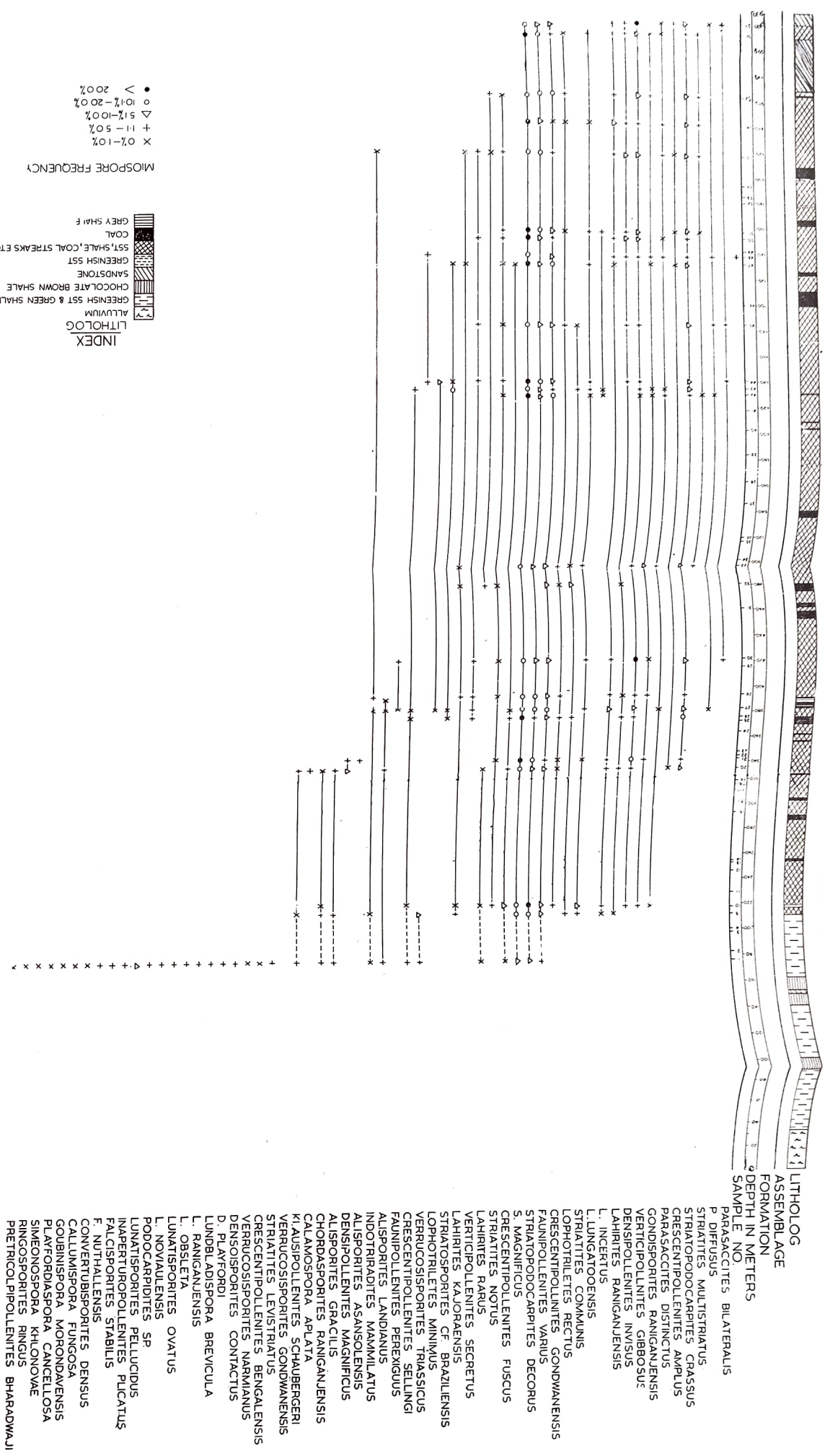
## INTRODUCTION

Sequel to the palynological analysis of Bore-hole Nos. RD-1 (TIWARI, 1979), and RNM-2 and RNM-4 (TIWARI & RANA, 1980a, b) the present investigation of Bore-hole No. RNM-3 from the same area, i.e. beyond the conventionally recognised eastern limits of the Raniganj Coalfield, W. Bengal was taken up in order to understand the lateral variation, correlation and position of the coal-bearing Raniganj beds in this region. In this eastern-most region of the Raniganj Coalfield the Gondwana sediments are covered under alluvium. The presence of Barren Measures, Raniganj, Panchet and Supra-Panchet formations has been already proved palynologically by the studies of other bore-hole material (for details of earlier palynological works, geology, etc. *see* TIWARI & RANA, 1980a). The importance of this communication lies in the fact that the bore-hole studied here (i.e. RNM-3) cuts across the Panchet, Raniganj, and infringes into the Upper Barren Measures strata and thus provides sequential material for analysis in a single bore-core.

## MATERIAL AND METHODS

In all, fifty-nine samples covering a 930 m run of the bore-core were sent to us for palynological analysis by the Coal Division (II), Geological Survey of India, Calcutta. The details of depth from the surface, lithology and the presence of miospores are given in Table 1. The location of the Bore-hole (Bore-hole No. RNM-3 : Lat. 23° 35' 45", Long. 87° 13' 55" E) is about 2.5 km east-north-east of Bore-hole RNM-2 and 2.75 km north-east of Bore hole RNM-4 (TIWARI & RANA, 1980b).

The maceration of coal was done, as usual, by treating the samples with comm. nitric acid, and that of shale and sandstone by hydrofluoric acid; it is followed by the



MOSPORE FREQUENCY

- 0.1% - 20%
- △ 5.1% - 10%
- + 1.1 - 5.0%
- × 0.7 - 1.0%

INDEX

LITHOLOGY

ALLUVIUM

GREENISH SST & GREEN SHALE

CHOCOLATE BROWN SHALE

SANDSTONE

GREENISH SST

SST, SHALE, COAL STREAKS ETC

COAL

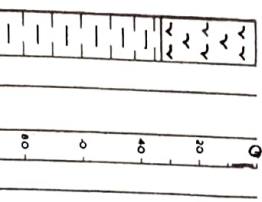
GREY SHALE

Text-fig. 1 : Relative abundance of important species through the run of Bore-hole RNM-3.

- LITHOLOG
- ASSEMBLY AGE
- FORMATION
- DEPTH IN METERS
- SAMPLE NO.
- PARASACCITES BILATERALIS
- P. DIFFUSUS
- STRATIATES MULTISTRIATUS
- STRATIOPODOCARPITES CRASSUS
- CRESCENTIPOLLENITES AMPLUS
- PARASACCITES DISTINCTUS
- GONDISPORITES RANIGANJENSIS
- VERTICIPOLLENITES GIBBOSUS
- DENSIPOLLENITES INVISUS
- LAHIRITES RANIGANJENSIS
- L. INCERTUS
- L. LUNGATODENSIS
- STRATIATES COMPLANUS
- LOPHOTRILETES RECTUS
- CRESCENTIPOLLENITES GONDWANENSIS
- FAUNIPOLLENITES VARIUS
- STRATIOPODOCARPITES DECORUS
- S. MAGNIFICUS
- CRESCENTIPOLLENITES FUSCUS
- STRATIATES NOTUS
- LAHIRITES RARUS
- VERTICIPOLLENITES SECRETUS
- LAHIRITES KAJORAENSIS
- STRATIOPORITES CF. BRAZILIENSIS
- LOPHOTRILETES MINIVUS
- VERRUCOSIPORITES TRIASSICUS
- CRESCENTIPOLLENITES SELLINGI
- FAUNIPOLLENITES PEREQUUS
- ALISPORITES LANDIANUS
- INDOTRIRADITES MANMILATUS
- ALISPORITES ASANSOLENSIS
- DENSIPOLLENITES MAGNIFICUS
- ALISPORITES GRACILIS
- CHORDASPORITES RANIGANJENSIS
- CALAMOSPORA APLATA
- KI.AUSIPOLLENITES SCHAUBERGERI
- VERRUCOSIPORITES GONDWANENSIS
- STRATIATES LEVISTRATUS
- CRESCENTIPOLLENITES BENGALENSIS
- VERRUCOSIPORITES NARMIANUS
- DENSIPORITES CONTACTUS
- D. PLAYFORDI
- LUNDBLADISPORA BREVICULA
- L. RANIGANJENSIS
- L. OBSOLETA
- LUNATISPORITES OVATUS
- L. NOVAULENSIS
- PODOCARPIDITES SP.
- LUNATISPORITES PELLUCIDUS
- INAPERTURIPOLLENITES PLOCATUS
- FALCISPORITES STABILIS
- F. NUTHALLENSIS
- CONVERTIBISPORITES DENSUS
- CALLUMISPORA FUNGOSA
- GOURBINSPORA MORONDWENSIS
- PLAYFORDIASPORA CANCELOSA
- SIMONOSPORA KHONOWAE
- RINGOSPORITES RINGUS
- PRETRICOLPIPOLLLENITES BHARADWAJI







LITHOLOG  
ASSEMBLAGE  
FORMATION  
DEPTH IN METERS  
SAMPLE NO.

PARASACCITES BILATERALIS  
P. DIFFUSUS  
STRIATITES MULTISTRIATUS  
STRIATOPODOCARPITES CRASSUS  
CRESCENTIPOLLENITES AMPLUS  
PARASACCITES DISTINCTUS  
GONDISPORITES RANIGANJENSIS  
VERTICIPOLLNITES GIBBOSUS  
DENSIPOLLENITES INVISUS  
LAHIRITES RANIGANJENSIS  
L. INCERTUS  
L. LUNGATOOENSIS  
STRIATITES COMMUNIS  
LOPHOTRILETES RECTUS  
CRESCENTIPOLLINITES GONDWANENSIS  
FAUNIPOLLENITES VARIUS  
STRIATOPODOCARPITES DECORUS  
S. MAGNIFICUS  
CRESCENTIPOLLENITES FUSCUS  
STRIATITES NOTUS  
LAHIRITES RARUS  
VERTICIPOLLENITES SECRETUS  
LAHIRITES KAJORAENSIS  
STRIATOSPORITES CF. BRAZILIENSIS  
LOPHOTRILETES MINIMUS  
VERRUCOSISPORITES TRIASSICUS  
CRESCENTIPOLLENITES SELLINGI  
FAUNIPOLLENITES PEREXIGUUS  
ALISPORITES LANDIANUS  
INDOTRIRADITES MAMMILATUS  
ALISPORITES ASANSOLENSIS  
DENSIPOLLENITES MAGNIFICUS  
ALISPORITES GRACILIS  
CHORDASPORITES RANIGANJENSIS  
CALAMOSPOA APLATA  
KLAUSIPOLLENITES SCHAUBERGERI  
VERRUCOSISPORITES GONDWANENSIS  
STRIATITES LEVISTRIATUS  
CRESCENTIPOLLENITES BENGALENSIS  
VERRUCOSISPORITES NARMIANUS  
DENSOISPORITES CONTACTUS  
D. PLAYFORDI  
LUNDBLADISPOA BREVICULA  
L. RANIGANJENSIS  
L. OBSLETA  
LUNATISPORITES OVATUS  
L. NOVIAULENSIS  
PODOCARPIDITES SP.  
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FALCISPORITES STABILIS  
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CONVERTUBISPORITES DENSUS  
CALLUMISPOA FUNGOSA  
GOUBINISPOA MORONDAVENSIS  
PLAYFORDIASPOA CANCELLOSA  
SIMEONOSPOA KHLONOVAE  
RINGOSPORITES RINGUS  
PRETRICOLPIPOLLENITES BHARADWAJI



treatment with ten per cent potassium hydroxide, if needed. About two hundred specimens were counted at specific level to determine the percentage frequency.

## PALYNOLOGICAL SEQUENCE

Out of fifty-nine samples, twenty-four yielded good number of miospores whose percentage could be determined by counting. A list of species recorded is given in Table-2. A perusal of the frequency (Histogram-I) reveals that basically the miofloral sequence could be divided into five assemblages :

### 1. *Assemblage-1*

(Sample No. 59 ; grey shale ; depth from the surface 920 m ; Histogram I, Text-fig. 1 ; Table 1).

This assemblage, contained in one sample—the oldest in the sequence studied here, shows the dominance of *Densipollenites* along with striate disaccate group—*Striatopodocarpites*, *Lahirites*, *Faunipollenites*, *Crescentipollenites* ; among other genera, *Scheuringipollenites*, *Parasaccites* and *Gondisporites* have also been recorded in fair representation.

Rare forms are : *Cuneatisporites*, *Dentatispora* ?, *Ibisporites*, *Limitisporites*, *Rhizomaspora* and *Vesicaspora*.

At specific level, the assemblage is not a diversified one, and has no characters of its own. However, the absence of the cavates, triletes and taeniate-disaccates distinguishes it from another *Densipollenites*—rich assemblage found in this succession in closing phase of the Raniganj Formation. The presence of *Densipollenites invisus*, *Parasaccites diffusus*, *P. distinctus*, along with striate group determines its coeval position with the known Barren Measures assemblages (BHARADWAJ, SAH & TIWARI, 1965 ; TIWARI & RANA, 1980a).

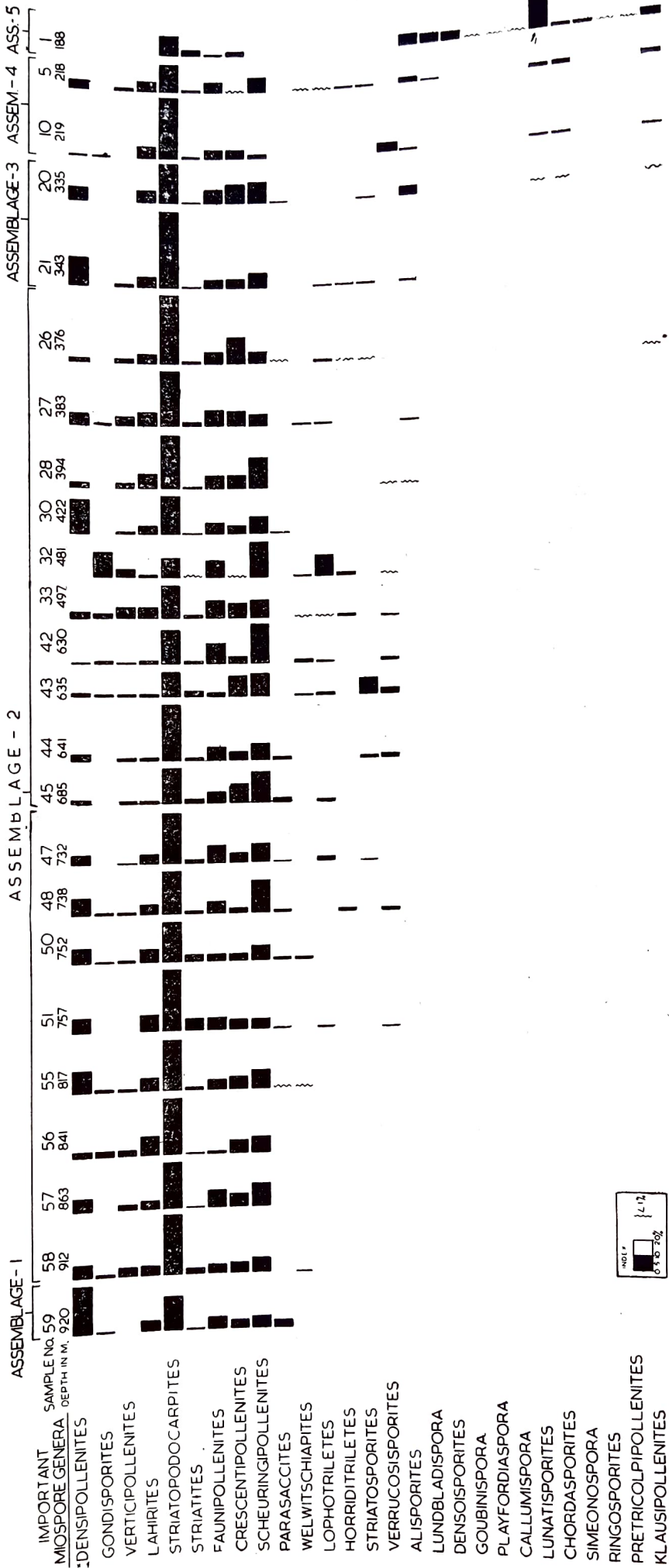
### 2. *Assemblage-2*

(Sample Nos. 58, 57, 56, 55, 51, 50, 48, 47, 45, 44, 43, 42, 33, 32, 30, 28, 27, 26 ; depth from the surface 912 to 376 m ; Histogram I, Text-fig. 1 ; lithological characters : grey shale, shaly coal, coal, etc. ; Table 1).

The striate-disaccate group of genera dominates the scene in this assemblage. *Striatopodocarpites* is the most dominant, followed by *Faunipollenites*, *Lahirites*, *Crescentipollenites*, *Verticypollenites* and *Striatites*. The non-striate genus *Scheuringipollenites* is significant in its occurrence and increases in the middle of the run but again declines towards the upper reaches. *Gondisporites* and *Densipollenites* occur more or less throughout the run of samples included herein. Their behaviour varies at certain levels of depth but no tendency of sharp miofloral break is visible.

Among the simple triletes, *Lophotriletes*, *Horriditriletes*, and *Verrucosisporites*, although rare and inconsistent, are noteworthy, since they start appearing at the level of Sample No. 51. Another interesting genus worthy of recording here is *Striatosporites* which occurs only in and above Sample No. 47, and maximum in Sample No. 43, being 11 per cent. However, these trends of variation in the distribution of the above genera, do not help in finer zonation because apparently their behaviour indicates lateral variability, with respect to the central region of the Raniganj Coalfield.

At the specific level, the following species are on record which characterise this assemblage : *Striatopodocarpites decorus*, *S. magnificus*, *Crescentipollenites amplus*, *Gondisporites raniganjensis*, *Densipollenites invisus*, *Lahirites raniganjensis*, *Verticypollenites gibbosus*, *Faunipollenites varius*. The absence of *Indospora* is outstanding since no specimen assignable to this genus has been encountered, although in the central region of this coalfield it is one of the quali-



Histogram I. Percentage frequency of important miospore genera in different samples of Bore-hole RNM-3. Mode of variation exhibited in each assemblage.







Table 1—Details of samples, limits and characters of Assemblages in the run, and (\*) Sample No. yielding miospores, which could be counted. Oblique lines in the remarks denote a gap in the characters.

Sample no.	Depth in m from surface	Main Lithology	Miospore Present +	Assemblage	Level and thickness of Coal seam	Age
1.	176	Green shale	+	Assemblage-5		Late Upper Panchet
2.	182	"				
3.	188	"				
4.	200	"				
*5.	218	Grey shale	+	Assemblage-4	Local Seam M-XIII (1.75 m) Hirekhan seam R-X/M-XII (4 m) Local Seam M-XI (1.10 m)	Raniganj/Panchet Upper Raniganj
*10.	219	Grey sandstone	+			
11.	229	Grey shale	+			
12.	246	Grey sandstone				
13.	253	Grey shale				
14.	254	Coal	+			
15.	293	Shaly Coal				
16.	302	Shale with coal				
17.	311	Grey shale	+	Assemblage-3	Upper Kajora R-IX/M-X (5.82 m)  R-IX? M-X (0.75)	
18.	316	Carb. Shale	+			
19.	318	Shaly coal	+			
*20.	335	Grey shale	+			
*21.	343	"	+			
22.	345	Grey sh. + coal	+			
23.	348	Shaly coal	+			
24.	364	Grey sh. + coal.	+			
25.	373	Shaly coal				
*26.	376	Grey shale	+			
*27.	383	Grey sh. + coal streaks	+	Lr. Kajora R-VIII? M-IX Top (6.55 m) Lr. Kajora-R-VII? M-IX (bottom (2.70 m) Local M-VIII (6.8) m)	Banbahal R. VII ?/M-VII (5.70m)	
*28.	394	Shale + coal	+			
29.	416	Grey sandy shale	+			
*30.	422	Grey shale	+			
31.	461	Grey sh. + coal.				
*32.	481	Shaly coal	+			
*33.	497	Grey shale	+			
34.	502	Coal + sh. band		M-VI A (0.50 m)  Local /M-VI B (0.50 m)  Kenda Chora R.VI? (12.62 m) Sonpur-R-V M-IV? (2.80 m)	M-VI A (0.50 m)	
35.	517	Grey shale				
36.	520	Grey sh. + coal.				
37.	546	Grey shale	+			
38.	563	Shale	+			
39.	584	Grey sandy shale	+			
40.	602	Shaly coal				
41.	618	Grey shale	+			
*42.	630	"	+			
*43.	635	Shale + coal	+			
*44.	641	Grey shale	+			
*45.	658	"		Bamanbad-R-III ?/M-II (9.71 m)  Poniati-R-II ?/M-I		
46.	700	Altern. sh. sst.				
*47.	732	Grey shale	+			
*48.	738	"	+			
49.	742	"	+			
*50.	752	"				
*51.	757	Grey sandy sh.	+			
52.	780	Grey sh. + coal	+			
53.	785	Shale	+			
54.	793	"				
*55.	817	Grey shale	+	Assemblage-1		Lower Raniganj Raniganj/Barren Measures— Upper Barren Measures
*56.	841	Sh. + coal.	+			
*57.	863	Grey shale	+			
*58.	912	Grey shale	+			
*59.	920	Grey shale	+			

The presence of miospores in other samples points their meagre occurrence but bracketed with particulars assemblage on the basis of qualitative Triassic sediments. For other details see lithology in Text-fig. 1.

Important genera	Important species	Remarks
<i>Lunatisporites</i> , <i>Alisporites</i> , <i>Lundbladispora</i> , <i>Densoisporites</i> , <i>Chordasporites</i> , <i>Simeonospora</i> , <i>Klausipollenites</i> , <i>Playfordiaspora</i> , striatidisaccate.	<i>Alisporites landianus</i> , <i>Conwertubisporites densus</i> , <i>Falcisporites nuthallensis</i> , <i>Lunatisporites pellucidus</i> , <i>Piceapollenites</i> sp., <i>Simeonospora khlonouae</i> .	Appearance of <i>Ringosporites</i> , <i>Goubinispora</i> significant.
<i>Striatopodocarpites</i> , <i>Crescentipollenites</i> , <i>Lahirites</i> , <i>Verrucosisporites</i> , <i>Alisporites</i> , <i>Lunatisporites</i> , <i>Pretricolpipoollenites</i> , <i>Klausipollenites</i> .	<i>Lophotriletes rectus</i> , <i>Horriditriletes curvibaculosus</i> , <i>Densipollenites invisus</i> , <i>Alisporites asansolensis</i> , <i>Klausipollenites schaubergeri</i> , <i>Falcisporites nuthallensis</i> , <i>Lahirites</i> sp., <i>Crescentipollenites amplus</i> , <i>C. fuscus</i> , <i>C. santalensis</i> , <i>Striatopodocarpites</i> sp., <i>Gnetaceapollenites grandis</i> .	<i>Crescentipollenites</i> showing specific diversity in S. No. 10.
<i>Striatopodocarpites</i> , <i>Densipollenites</i> <i>Faunipollenites</i> , <i>Crescentipollenites</i>	<i>Calamospora exila</i> , <i>Lophotriletes frequens</i> , <i>Densipollenites densus</i> , <i>D. magnicarpus</i> , <i>Faunipollentes varius</i> , <i>Lahirites</i> sp., <i>Striatites</i> sp., <i>Striatopodocarpites</i> sp., <i>Verticipoollenites gibbosus</i> , <i>Klausipollenites schaubergeri</i> , <i>Chordasporites raniganjensis</i> , <i>Alisporites gracilis</i> .	Relatively more <i>Densipollenites</i> .
<i>Striatopodocarpites</i> , <i>Funipollenites</i> , <i>Striatites</i> , <i>Lahirites</i> , <i>Verticipoollenites</i> , <i>Gondisporites</i> , <i>Striatosporites</i> , <i>Scheuringipollenites</i>	<i>Calamospora exila</i> , <i>Densipollenites indicus</i> , <i>D. invisus</i> , <i>Scheuringipollenites maximus</i> , <i>Lahirites lepidus</i> , <i>Striatites communis</i> , <i>Striatopodocarpites</i> sp., <i>Striatosporites</i> cf. <i>brazilensis</i> , <i>Gondisporites raniganjensis</i> .	
		<i>Gondisporites</i> abundant in S. No. 32.
		Appearance of <i>Striatosporites</i> , max. in S. No. 43
		Appearance of more pteridophytic spores.
		In samples 52 to 58 relatively more <i>Densipollenites</i> than the younger samples ; a continuity of the Barren Measures tendency.
<i>Densipollenites</i> , <i>Striatopodocarpites</i> , <i>Lahirites</i> , <i>Faunipollenites</i> .	<i>Parasaccites diffusus</i> , <i>Densipollenites indicus</i> , <i>D. invisus</i> , <i>Lahirites raniganjensis</i> , <i>Striatites multi-striatus</i> , <i>Striatopodocarpites</i> sp., <i>Gondisporites raniganjensis</i> .	More <i>Densipollenites</i> , less triletes.

tatively important genera for the coal-bearing beds of the Raniganj Formation (BHARADWAJ, 1962 ; BHARADWAJ & SALUJHA, 1964, 1965a).

In comparison to the Assemblage-1 described above, Assemblage-2 has diversified constituents in striate-disaccates at specific level. The genus *Densipollenites* declines considerable except in Sample No. 30.

The present mioflora, in general, shows close resemblance with so-far-known miofloras of the Raniganj Formation having coal-beds (BHARADWAJ & SALUJHA, 1965a,b ; TIWARI & RANA, 1980a). The dearth of trilete spores—including the characteristic genus *Indospora*, which are abundantly found in the central region of the Raniganj Coalfield in the sediments of Raniganj Formation, is indicator of lateral variation (also see TIWARI & RANA, 1980a).

### 3. Assemblage-3

(Sample No. 21, 20; grey shale; depth from the surface 343-335 m; Histogram-I ; Text-fig. 1 ; Table 1).

This assemblage is separated from Assemblage-2, on the basis of sudden rise in the percentage of the genus *Densipollenites* and appearance of a few younger forms, such as—*Lunatisporites*, *Chordasporites*, *Klausipollenites*. In other genera, however, the continuity of the main striate-disaccate bearing assemblage is evident. Assemblage-3 essentially represents the *Densipollenites*—rich, striate-disaccate dominant mioflora of the upper reaches of the Raniganj Formation (BHARADWAJ, TIWARI & ANAND-PRAKASH, 1979 ; TIWARI & RANA, 1980a). These two samples also record the presence of *Klausipollenites schaubergeri*, *Calamospora aplata*, *Chordasporites raniganjensis*, *Alisporites asansolensis*, *A. gracilis*, *Densipollenites magnicarpus*. These species, although rare, forecast the characteristics of younger assemblage where they become significant. The absence of *Striatosporites* sp., *Lophotriletes minimus*, *Crescentipollenites sellongi* and *Verticipollenites secretus*, among other forms, also indicates an ebbing of the main Raniganj miofloral phase.

### 4. Assemblage-4

(Sample Nos. 10, 5 ; light grey sandstone.; grey shale ; depth from the surface 219-218m ; Histogram I ; Text-fig. 1 ; Table 1).

In these two samples, the genus *Densipollenites* again declines and the genera with younger aspect—*Lunatisporites*, *Chordasporites*, *Alisporites*, along with *Crescentipollenites* get better representation. The striate-disaccate and the triletes have an overall similar pattern of incidences as in Assemblage 2 and 3, except that in Sample No. 10, the genus *Crescentipollenites* shows specific diversity. Thus, a continuity of the Raniganj mioflora in this assemblage is clear but with a difference given above.

At specific level, there is a similarity between the Assemblage 3 and 4, but for the tendency of certain species to become more pronounced (Text-fig. 1).

### 5. Assemblage-5

(Sample No. 1, dark green shale ; depth from the surface 76 m; Histogram I, Text-fig. 1 ; Table 1).

A solitary sample contains this assemblage having *Lunatisporites* as the dominating genus. The other significant miospores, besides the striate-disaccate group, are—*Alisporites*, *Lundbladispota*, *Densoisporites*, *Chordasporites*, *Simeonospora*, *Klausipollenites*. The rare but qualitatively important forms are *Goubinispora*, *Ringosporites*, *Pretricolpispollenites*, *Callumispota*, *Playfordiaspora*.



Table-2—List of taxa recorded in Assemblages 1 to 5  
(BM=Barren Measures)

Pollen and Spore Taxa	Formations	BM	RANIGANJ			PANCHET
	Assemblages	1	2	3	4	5
Triletes (Non-cavate)						
<i>Callumispora</i> Bharad. & Sriv., 1969						+
<i>C. fungosa</i> (Balme) Bharad. & Sriv. emend. Tiw., 1977						
<i>C. gretensis</i> (Balme & Henn). Bharad. & Sriv. 1969					+	
<i>Calamospora</i> Schopf, Wilson & Bentall, 1944			+	+		
<i>C. exila</i> Bharad. & Sal., 1964					+	
<i>C. aplata</i> Bharad. & Sal., 1964						
<i>Simeonospora</i> Balme, 1970						+
<i>S. khlonovae</i> Balme, 1970						
<i>Lacinitriletes</i> Venkatach. & Kar emend. Tiw. & Rana, 1980						+
<i>L. minutus</i> Venkatach. & Kar emend. Tiw. & Rana, 1980						
<i>Cyathidites</i> Couper, 1953						+
<i>C. sp.</i>						
<i>Ringosporites</i> Tiw. & Rana, 1980c						+
<i>R. ringus</i> Tiw. & Rana, 1980c						
<i>Microfoveolatispora</i> Bharad., 1962						+
<i>M. raniganjensis</i> Bharad. emend. Tiw. & Rana, 1980					+	
<i>M. foveolata</i> (Tiw.) emend. Tiw. & Rana, 1980						+
<i>Guttatisporites</i> Vischer, 1966						+
<i>G. ambiguus</i> Tiw. & Rana, 1980b						
<i>Lycopodiumsporites</i> (Thierg.) ex.Delc.& Sprum., 1955			+	+		+
<i>L. sp.</i>						
<i>Cyclogranisporites</i> Pot. & Kr. 1954						+
<i>C. gondwanensis</i> Bharad. & Sal., 1964					+	
<i>Granulatisporites</i> Ibr. emend. Pot & Kr., 1954			+			
<i>G. sp.</i>						
<i>Lophotriletes</i> Naum. emend. Pot. & Kr., 1954						+
<i>L. frequens</i> Tiw., 1965			+	+		
<i>L. rectus</i> Bharad. & Sal. 1964			+	+		
<i>L. sp.</i>					+	
<i>Microbaculispora</i>						+
<i>M. gondwanensis</i> (Bharad.) Tiw.& Rana, 1980			+			
<i>Brevitriletes</i> Bharad. & Sriv. emend. Tiw. & Rana, 1980.						+
<i>B. unicus</i> Bharad. & Sriv. emend. Tiw. & Rana, 1980						
<i>Horriditriletes</i> Bharad. & Sal. 1964				+	+	+
<i>H. curvibaculosus</i> Bharad. & Sal., 1964				+	+	
<i>Verrucosisorites</i> Ibr. emend. Smith <i>et al.</i> 1967						+
<i>V. gondwanensis</i> Sriv., 1970						
<i>V. triassicus</i> Bharad. & Tiw., 1977			+	+	+	+

	1	2	3	4	5
<i>V. narmianus</i> Balme, 1970					
<i>V. warti</i> Tiw. and Rana, 1980					+
<i>Convertubisporites</i> Ban. & Maheshw., 1975					+
<i>G. densus</i> Ban. & Maheshw., 1975					
Cavate :					+
<i>Densoisporites</i> Weyland & Krieg. emend. Dettm., 1963					
<i>D. playfordi</i> (Blame) Dettm., 1963					+
<i>D. contactus</i> Bharad. & Tiw., 1977					+
<i>Lundbladispora</i> Balme emend. Playf., 1965					
<i>L. brevicula</i> Balme, 1970					
<i>L. raniganjensis</i> Tiw. & Rana, 1980					+
<i>L. microconata</i> Bharad. & Tiw. 1977					+
<i>L. obsleta</i> Balme, 1970					+
<i>L. warti</i> Tiw. & Rana, 1980c					+
<i>L. Sp.</i>					+
<i>Gondisporites</i> Bharad., 1962				+	
<i>G. raniganjensis</i> Bharad., 1962					+
<i>Indotrivradites</i> Tiw., 1964		+			
<i>I. mammilatus</i> Bharad. & Tiw., 1977		+			
<i>I. sp.</i>		+			+
<i>Monoletes</i>				+	
<i>Latosporites</i> Pot., & Kr. 1954					
<i>L. colliensis</i> (B. & H.) Bharad., 1962					
Monosaccates		+			
<i>Parassaccites</i> Bharad. & Tiw., 1964					
<i>P. diffusus</i> Tiw., 1965		+	+		
<i>P. distinctus</i> Tiw., 1965	+	+			
<i>Plicatipollenites</i> Lele, 1964	+	+	+		
<i>P. indicus</i> Lele, 1964					
<i>Goubinispota</i> Tiw. & Rana 1980c		+	+		+
<i>G. inidca</i> Tiw. & Rana, 1980c					
<i>Densipollenites</i> Bharad., 1962					+
<i>D. indicus</i> Bharad., 1962					
<i>D. invisus</i> Bharad. & Sal., 1964	+	+	+	+	
<i>D. densus</i> Bharad. & Sriv., 1969	+	+	+	+	
<i>D. magnicorpus</i> Tiw. & Rana., 1980c			+	+	
<i>D. raniganjensis</i> Bharad., 1962			+	+	
<i>Playfordiaspora</i> Maheshw. & Ban., 1975				+	
<i>P. cancellosa</i> (Playf. & Dettm.) Maheshw. & Ban., 1975					
Disaccate (Non-striate)					+
<i>Vitreisporites</i> Lesch. emend. Janson., 1962					
<i>V. sp.</i>					
<i>Illinites</i> (Kosanke) Pot. & Kr., 1954					+
<i>I. sp.</i>					
<i>Alisporites</i> Daugh. emend. Nils., 1958					+
<i>A. asansolensis</i> Maheshw. & Ban., 1975					
<i>A. landianus</i> Blame, 1970			+	+	+
<i>A. indicus</i> Bharad. & Sriv., 1969			+		+
<i>A. gracilis</i> Segroves, 1969					+
<i>A. damudicus</i> Tiw. & Rana, 1980c			+		
<i>Ibisporites</i> Tiw., 1968					+
<i>I. diplosaccus</i> Tiw., 1968	+	+	+	+	

	1	2	3	4	5
<i>Klausipollenites</i> Janson, 1962					
<i>K. schaubergeri</i> Janson., 1962			+	+	+
<i>Scheuringipollenites</i> Tiw., 1973					
<i>S. maximus</i> (Hart) Tiw., 1973	+	+	+	+	
<i>S. barakarensis</i> (Tiw.) Tiw., 1973		+	+	+	
<i>S. tentulus</i> (Tiw.) Tiw., 1973				+	
<i>Limitisporites</i> (Lesch.) Pot., 1958					
<i>L. disectus</i> (Hart) Bharad. & Sal., 1965	+	+	+	+	
<i>Ptatysaccus</i> (Naum.) Pot. & Klaus, 1965					
<i>P. sp.</i>		+	+		+
<i>Cuneatisporites</i> Lesch., 1955					
<i>C. rarus</i> Kar., 1968	+			+	
<i>Vesicaspora</i> Schemel, 1951					
<i>V. distincta</i> Tiw., 1965	+	+	+	+	
<i>V. luteus</i> Sal., 1965			+	+	
<i>Falcisporites</i> Lesch. emend. Kl., 1963					
<i>F. nuthallensis</i> (Clarke) Blame, 1970					+
<i>F. stabilis</i> Balme, 1970				+	+
<i>Pinuspollenites</i> Raatz, 1937					
<i>P. thoractus</i> Balme, 1970					+
<i>P. sp. 1</i>					+
<i>P. sp. 2</i>					
<i>Podocarpidites</i> Cookson ex Couper, 1953					
<i>P. sp.</i>				+	+
<i>Jugasporites</i> Leschik emend. Klaus, 1963					
<i>J. sp.</i>					+
Disaccate (Striate)					
<i>Faunipollenites</i> Bharad., 1962					
<i>F. varius</i> Bharad., 1962		+	+	+	+
<i>F. sp.</i>					+
<i>Lahirites</i> Bharad., 1962					
<i>L. lepidus</i> Bharad., & Sal., 1965			+	+	+
<i>L. raniganjensis</i> Bharad., 1962			+	+	+
<i>L. incertus</i> Bharad. & Sal., 1964		+	+	+	+
<i>L. rarus</i> Bharad. & Sal., 1964		+	+	+	+
<i>L. alutus</i> Venkatach. & Kar., 1968			+	+	+
<i>L. kajoraensis</i> Sal., 1965			+		
<i>L. angustus</i> Venkatach. & Kar., 1968			+	+	+
<i>Welwitschiapites</i> Bolchowittina, 1953				+	
<i>W. sp.</i>					+
<i>Crescentipollenites</i> Bharad., Tiw. & Kar., 1974			+		
<i>C. sellingi</i> (Sal.) Tiw. & Rana, 1980			+		+
<i>C. implicatus</i> (Bose & Maheshw.) Tiw. & Rana, 1980			+	+	+
<i>C. amplus</i> (Balme and Henn.) Tiw. & Rana, 1980				+	+
<i>C. fuscus</i> (Bharad.) Bharad., Tiw. & Kar., 1974	+	+	+	+	+
<i>C. bengalensis</i> (Maheshw. & Ban.) Tiw. & Rana, 1980a			+	+	+
<i>C. santalensis</i> (Maheshw.) Bharad., Tiw. & Kar., 1974					+
<i>Striatites</i> Pant emend. Bharad. 1962				+	+
<i>S. communis</i> Bharad. & Sal., 1964					
<i>S. notus</i> Bharad. & Sal. 1964			+	+	+
<i>S. subtilis</i> Bharad., & Sal., 1964			+	+	+
				+	



	1	2	3	4	5
<i>S. panchetensis</i> Tiw. & Rana, 1980c					
<i>S. levistriatus</i> Bharad. & Tiw., 1977					
<i>S. multistriatus</i> (Balme & Henn.) Tiw., 1968	+	+			
<i>Striatopodocarpites</i> (Sedova, 1956) emend. Hart, 1964					
<i>S. magnificus</i> Bharad. & Sal., 1964	+	+	+	+	+
<i>S. decorus</i> Bharad., & Sal., 1964	+	+	+	+	+
<i>S. crassus</i> Tiw., 1965	+	+		+	
<i>S. diffusus</i> Bharad. & Sal., 1964		+	+	+	
<i>S. rotundus</i> Maheshw., 1967		+	+		
<i>S. globosus</i> Maheshw., 1967			+	+	
<i>S. venustus</i> Sal., 1965				+	
<i>S. perfectus</i> Maheshw., 1957			+		
<i>S. ovalis</i> Sinha, 1972		+	+	+	
<i>Tumoripollenites</i> Bharad. 1962					
T. sp.		+			
<i>Rhizomaspora</i> Wilson, 1962					
<i>R. indica</i> Tiw., 1965	+	+		+	
<i>R. biharia</i> Ban. & Maheshw., 1975				+	
<i>Verticipollenites</i> Bharad., 1962					
<i>V. gibbosus</i> Bharad., 1962		+	+		
V. sp.				+	
<i>Hindipollenites</i> Bharad., 1962					
<i>H. indicus</i> Bharad., 1962		+		+	
Disaccate : (Taeniate)					
<i>Lunatisporites</i> Lesch. emend. Bharad., 1974					
<i>L. rhombicus</i> Bharad. & Tiw. 1977			+	+	+
<i>L. pellucidus</i> (Goubin) Maheshw. & Ban., 1975			+	+	+
<i>L. asansoli</i> Tiw. & Rana 1980c					+
<i>L. damudicus</i> Tiw. & Rana, 1980b					+
<i>L. ovatus</i> (Goubin) Maheshw. & Ban., 1975					+
<i>L. noviaulensis</i> (Lesch.) Tiw. & Rana 1980c					+
<i>Chordasporites</i> Klaus, 1960					
<i>C. raniganjensis</i> Maheshw. & Baner., 1975				+	+
Colpates					
<i>Weylandites</i> Bharad. & Sriv., 1969					
W. sp.					+
<i>Gnetaceapollenites</i> Thiery., 1958					
<i>G. sinuosus</i> (Balme & Henn.) Balme, 1970			+		
<i>G. grandis</i> Maheshw., 1967			+	+	
<i>Ephidripites</i> Bolkhovittina et Potonie, 1958					
E. sp.				+	
<i>Piceapollenites</i> Pot., 1931					
P. sp.					+
<i>Cycadopites</i> (Woodh.) ex Wils., & Webst., 1946					
<i>C. follicularis</i> Wils., & Webst., 1946					+
<i>Pretricolpipollenites</i> Danze, Corsin & Laveime, 1963					
<i>P. bharadwaji</i> Balme, 1970					+
Aletes					
<i>Inaperturopollenites</i> Thoms. & Pflug. emend. Pot., 1958					
<i>I. nebulosus</i> Balme, 1970				+	+
Incertae sedis					
<i>Striatosporites</i> Bharad., 1954					
<i>S. cf. brazilliensis</i> Bharad., Kar & Navale, 1976		+	+	+	

The absence of *Densipollenites*, *Verticypollenites*, *Gondisporites* and *Lahirites*, and the decline in the percentages of striate-disaccate miospores suggest a complete change in the mioflora with respect to the Assemblage-4.

At specific level, the proliferation of the species belonging to the genera listed above is indicative of well established nature of this assemblage. Some of these species are : *Alisporites landianus*, *A. indicus*, *A. asansolensis*, *Chordasporites raniganjensis*, *Convertubisporites densus*, *Densoisporites playfordi*, *Falcisporites nuthallensis*, *Inaperturopollenites plicatus*, *Lunatisporites pellucidus*, *L. noviaulensis*, *Lundbladispora obsleta*, *L. brevicula*, cf. *Piceapollenites* sp., *Pinuspollenites* sp., *Podocarpidites* sp., *Ringosporites ringus*, *Simeonospora khlonovae*, *Verrucosisporites triassicus*, *V. narmianus*.

Thus, the composition of Assemblage-5 indicates its age to be late Lower Triassic (BHARADWAJ, TIWARI & ANAND-PRAKASH, 1979 ; TIWARI, 1979 ; TIWARI & RANA, 1980a, b).

## DISCUSSION

Assemblage-1, the oldest in the sequence in a Bore-hole RNM-3 presently described, comes from the depth level 920 m (Sample No. 59). This qualifies, on the basis of palynological contents, to be assigned to Barren Measures (BHARADWAJ, SAH & TIWARI, 1965 ; SRIVASTAVA & MAHESHWARI, 1974 ; TIWARI & RANA, 1980a). The next yielding sample above it (Sample No. 58 ; depth level 912 m) is separated by only 8 meter of sandstone and sandstone with shaly bands, but shows the presence of a different assemblage, i.e. the Assemblage-2, of Raniganj Stage (compare BHARADWAJ, 1962 ; BHARADWAJ & SALUJHA, 1964 ; TIWARI, 1976 ; TIWARI & RANA, 1980a). Thus, it is obvious that the Raniganj/Barren Measures boundary lies somewhere between depth level 912 and 920 m (Table 1).

Sample No. 57 (depth 864 m) also shows similar percentage frequency of pollen-spore genera as the Sample No. 58, indicating thereby that the 48 m coal-less strata below the first coalseam, i.e. oldest one (864-865 m), is also within the Raniganj Formation and is palynologically distinguishable from the Barren Measures. Most of the samples containing Assemblage-2 are shales from the interbedded strata between the coalseams. One coalseam sample (Sample No. 27 ; Seam R-IX ?/M-X ; depth 382.80-383.55 m) yielded good miospores but it does not show any remarkable difference from the other member samples containing this assemblage.

The pteridophytic spores start appearing after about 160 meters of sediments (at the Samla Seam level) above the Raniganj/Barren Measures boundary. This observation reflects towards the ecological conditions suited for establishment of this plant-group at this level. The occurrence of *Striatosporites* at the level of Sonpur Seam and Kenda Chora Seam is very significant in identifying this horizon. Similarly the relative higher percentage of *Densipollenites* in the older samples (Zone of Poniaty, Banbahal & Samla seams) and that of *Gondisporites* at just below the Lower Kajora group of seams is the indicator of fluctuations in the conditions of deposition and change in relative abundance of floral components at these levels. Such tendencies shall prove very useful in defining further subzones within the coal bearing part of Raniganj, when more similar data comes at hand.

Assemblage-3, identified in Sample No. 21 and 20 compares closely with the other known *Densipollenites*-rich assemblages showing the incoming of the Triassic elements ; it is characteristic of the upper, coal-less facies of the Raniganj Formation (MAHESHWARI, 1974 ; BHARADWAJ, TIWARI & ANAND-PRAKASH, 1979) in the central region of this coal-



field. However, in the present area of investigation, i.e. eastern-most region of the Raniganj Coalfield, this *Densipollenites*—rich assemblage starts (from sample 24 ; Table -1) within the coaly facies (the upper three coalseams being above it) of the Upper Raniganj sequence. The Upper Kajora-Seam—although not sampled here, in all probabilities contains Assemblage-2 because its lower portion has the same assemblage (Table-1). This indicates that probably these 3 coalseams (i.e. Local seam M-XI ; Hirekhan Seam R-X/M—XII & Local seam M—XIII) are of local importance only and their equivalents are not to be found in the main Raniganj Coalfield.

Assemblage-4 is not much different except that here *Densipollenites* declines and *Crescentipollenites* shows certain variation as well as proliferation. This is in correspondence with the results derived by BHARADWAJ, TIWARI AND ANAND-PRAKASH (1979) from Raniganj, East Bokaro and Karanpura Coalfields that before the beginning of the Lower Triassic, the *Densipollenites* declines and *Crescentipollenites* becomes significant. Assemblage-4, however, cannot be included in Panchet because quantitatively the genus *Crescentipollenites* is not dominating.

It is concluded that more or less complete Raniganj Formation, particularly at its upper reaches, is represented in this region of the coalfield.

Assemblage-5, by virtue of the high percentages of *Lunatisporites*, *Densoisporites*, *Lundbladispora*, *Alisporites*, *Chordasporites*, *Simeonospora* and *Klausipollenites*, compares closely with Assemblage-A in Bore-hole No. RNM-4 (TIWARI & RANA, 1980a) but with a somewhat older aspect. Similar miofloras are known from Dhardharia Nala, East Bokaro Coalfield, Bihar (BHARADWAJ *et al.*; 1979) and in Bore-hole RD-1 (in the area of presently investigated bore-hole : TIWARI, 1979).

When compared with the sequence of assemblages given by BHARADWAJ, TIWARI AND ANAND-PRAKASH (1979), the present Assemblage-5 seems to have superimposed three distinct assemblages below it. This means that between Assemblage-4 and the Assemblage-5, three assemblages, i.e. (i) *Striatopodocarpites*, *Klausipollenites*, *Lunatisporites*, *Alisporites*, (ii) *Verrucosisporites*, *Callumisporea*, *Alisporites*, *Lunatisporites*, *Chordasporites* and (iii) *Lunatisporites*, *Chordasporites*, *Verrucosisporites*, *Lundbladispora* (Assemblages 4, 5 & 6 of BHARADWAJ *et al.*; 1979, respectively), have not been encountered in this bore hole.

The thickness of the strata between Sample No. 5 (Assemblage-4) and Sample No. 1 (Assemblage-5) is 42 meter containing mainly dark green shales and grey sandstones (Table-1). Palynologically the bed at 176 m level (the first yielding sample from the top) is of late Lower Triassic (Upper Panchet) in age but the extent of this Assemblage is not determinable down below towards Raniganj/Panchet boundary because the intermediate samples did not yield miospores. The log of Bore-hole RNM-3 indicates that the total thickness of green-shale alternating with sandstones is about 50 m, (160 to 210 m depth) ; above it the chocolate coloured shales are developed (Text-fig. 1). The Sample No. 1, at 176 m level, thus finds its place towards the top of the green shale facies. The total thickness of the khaki-green shales is about 72 to 92 m in the Raniganj Coalfield (central region) while it is about 50 m in the present bore hole. This discrepancy in the thickness may be, in all probability, due to a hiatus between Raniganj-Panchet boundary in this region. Since, the upper portion of the Raniganj-Formation seems to be complete (as derived above on the basis of palynology), it is concluded that the lower part of the Lower Panchet Formation in this area is absent. GHOSH (1973) has also noted erosional unconformity in the eastern region of this coalfield, which corroborates with the present conclusions. Similar derivations are arrived at by GEE (1932) and BHARADWAJ AND TIWARI (1977).



## CONCLUSION

The five assemblages recorded in Bore-hole RNM-3 representing Barren Measures, Raniganj and Upper Panchet miofloras, corroborate other findings made earlier in this eastern-most part of the East Raniganj Coalfield. The coal-bearing Raniganj beds show some incipient tendencies of miofloral differentiation at certain level which should be followed in future studies in order to establish seam distinction in the Raniganj Coalfield. The thickness of Raniganj Formation in this area amounts to be about 700 meters which is more than what has been estimated in bore hole RNM-2 (530 m ; TIWARI & RANA, 1980a). Thus, there is an indication that the thickness of the coal-bearing strata has a tendency to increase towards north-eastern side, with respect to G. T. Road in this region.

The Raniganj Formation at its upper reaches seems to be completely represented in this area while a part of Lower Panchet is missing. The distribution of Assemblages is as given below :

LR.			
T		Upper	Assemblage-5
R	Panchet Formation	-----	
I		Lower	
A			
S			
S			
I			
C			
U			Assemblage-4
P			
P			
E			
R			
P	Raniganj Formation		Assemblage-3
E			
R			
M			
I			
A			Assemblage-2
N	Barren Measures Formation		Assemblage-1

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## EXPLANATION OF PLATES

(All figures are ca  $\times 500$ )

### PLATE I

1. *Densipollenites invisus*, Slide no. BSIP 5584
2. *Lophotriletes rectus*, Slide no. BSIP 5706
3. *Horriditriletes curvibaculosus*, Slide no. BSIP 5582
4. *Scheuingipollenites maximus*, Slide no. BSIP 5707
5. *Faunipollenites varius*, Slide no. BSIP 5584
6. *Striatopodocarpites decorus*, Slide no. BSIP 5705
7. *Calamospora aplata*, Slide no. BSIP 5705
8. *Gondisporites raniganjensis*, Slide no. BSIP 6201
9. *Lahirites communis*, Slide no. BSIP 6200
10. *Latosporites colliensis*, Slide no. BSIP 5708
11. *Verticypollenites secretus*, Slide no. BSIP 5708
12. *Crescentipollenites amplus*, Slide no. BSIP 5705
13. 15. *Striatopodocarpites magnificus*, Slide no. BSIP 5575
14. *Welwitschiapites* sp., Slide no. BSIP 5580
16. *Chordasporites raniganjensis*, Slide no. BSIP 5709
17. *Weylandites* sp., Slide no. BSIP 5584
18. *Tumoriipollenites* sp., Slide no. BSIP 6202
19. *Striatosporites* cf. *braziliensis*, Slide no. BSIP 5584

1. *Callumispora gretensis*, Slide no. BSIP 5580
2. *Verrucosisporites senectus*, Slide no. BSIP 5705
3. *Densoisporites playfordi*, Slide no. BSIP 5580
4. *Inaperturopollenites nebulosus*, Slide no. BSIP 5580
5. *Leiotriletes* sp., Slide no. BSIP 5575
6. *Simeonospora khlonovae*, Slide no. BSIP 5575
7. *Ringosporites ringus*, Slide no. BSIP 5575
8. *Verrucosisporites warti*, Slide no. BSIP 5575
9. *Lundbladispora* sp., Slide o. BSIP 5575
10. *Ephidripites* sp., Slide no. BSIP 5575
11. *Falcisporites nuthallensis*, Slide no. BSIP 5575
12. *Platysaccus* sp., Silde no. BSIP 5575
13. *Illinites* sp., Slide no. BSIP 5575
14. *Striatites levistriatus*, Slide no. 5575
- 15, 18. *Klausipollenites schaubergeri*, Slide no. BSIP 5575
16. *Chordasporites* sp., Slide no. BSIP 5575
17. *Alisporites damudicus*, Slide no. BSIP 5575
19. *Lunatisporites damudicus*, Slide no. 5575
20. *Lunatisporites asansoli*, Slide no. BSIP 5580
21. *Cyathidites* sp., Slide no. BSIP 5575
22. *Lunatisporites rhombicus*, Slide no. BSIP 5575
23. *Guttatisporites ambiguus*, Slide no. BSIP 5575
24. *Lunatisporites pellucidus*, Slide no. BSIP 5575
25. *Piceapollenites* sp., Slide no. BSIP 5580



