PALYNOLOGICAL SUCCESSION IN THE BARAKAR TYPE AREA

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ABSTRACT

The miofloral succession in the Pusai-Shampur area, west of Barakar River in Raniganj Coalfield, has been studied. The importance of this work lies in the fact that this area has been named to be the type area for Barakar Stage and so far it has not been palynologically investigated. The percentage frequencies of different miospore genera reveal that the ex-Talchir depositions are divisible in to five zones. The lowest zone (Zone-1) contains *Callumispora*—rich mioflora and represents an interglacial phase. This has been assigned to the Lower Karharbari Stage. The Zone-2 exhibits the second monosaccate-rich flora (first monosaccate-zone being in the Talchirs), representing the beginning of another glacegene deposition and hence asigned to the Upper Karharbari Stage. The three successionally overlying assemblages (Zone-3, 4 & 5), containing Zonate-cingulate, non-striate disaccate and striate disaccate miospore characterize the Lower, Middle and Upper Barakar Stage, respectively.

INTRODUCTION

Lately, palynological studies have been extensively utilized in the biostratigraphic considerations of the Lower Gondwana Formations of India. BHARADWAJ (1966) has synthesized the informations regarding the distribution of spores and pollen grains in these formations. Thereafter, subsequent contributions by BHARADWAJ (1969, 1970, 1971, 1972a, 1972b, MS), VENKATACHALA (1972) and SHAH, SINGH and SASTRY (1972) for building the palyno-stratigraphy of these depositions, have resulted into a clearer picture of the trend of vertical distribution of miofloras.

However, there remain some lacunae in this sequential story and, probably because of the lack of more information, some important questions are still to be answered. During the last decade we have known the palynological succession in Barakar deposits from several areas of Indian Lower Gondwana (BHARADWAJ & SRIVASTAVA 1973, BHARADWAJ & ANAND-PRAKASH 1972, BHARADWAJ & TIWARI 1964, KAR 1969, 1973, NAVALE & TIWARI 1968, TIWARI 1965, 1968, 1971, VENKATACHALA & KAR 1968a, 1968b). However, the Barakar exposures in the Raniganj Coalfield, which is supposed to be the type area for Barakar Stage, have not been studied so far. And since it is necessary to study the type areas in order to get more authentic information about the bio-stratigraphy of any deposition, the present work on the Barakar Stage of Raniganj Coalfield was undertaken.

In the first phase of the work, the Pusai Nala and Khudia Nala regions of the West Raniganj Coalfield have been taken up. The present work includes the study of successive samples collected in the traverses along the above nalas in Pusai-Shampur regions.

GEOLOGY OF THE AREA

Raniganj Coalfield forms the easternmost member of the Damodar Valley coalfields. Out of the total area of 1550 sq. km, a small portion lies to the west of Barakar River, usually referred to as West Raniganj Coalfield.

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This portion, to the west of the Barakar River, is bound by Archaeans on the north, north-west and south. Very fine sections of the Barakar Stage are exposed in the Khudia Nala, while in the Pusai Nala of the north western corner of the field, the lowest horizons can be equally well observed. In the Pusai-Shampur area, from where the samples for the present study have been collected, the inclinations of the Barakar deposits vary from South-West to due South at gentle to moderate angles. Except in the near vicinity of the main boundary fault, this steady dip continues within the Barakar rocks across the Grand Trunk Road to the Khudia Nala. Within and to the south of the latter stream-section, the Barakar measures crop out in the form of an oval shaped basin, with its longer axis running north-west to south-east, parallel to the boundary fault. Entering from the metamorphics of the west, the Khudia Stream meanders across these Barakar measures of the northern half of this Shampur Basin and exposes a fairly continuous succession traversing the same Barakar horizons at least in two sections, in the north-western and in the eastern parts of the basin (Map 1).

The Barakar rocks of this area have been divided into 7 smaller zones (stages) by GEE (1932) in ascending order as given below:—

1. Pusai conglomerates with coalseams
2. Kanauri Coal Measures
3. Nirsa Grits
4. Khudia shale and sandstone Stage
5. Lower Shampur Coal Measures
6. Middle Shampur Coal Measures
7. Upper Shampur Coal Measures

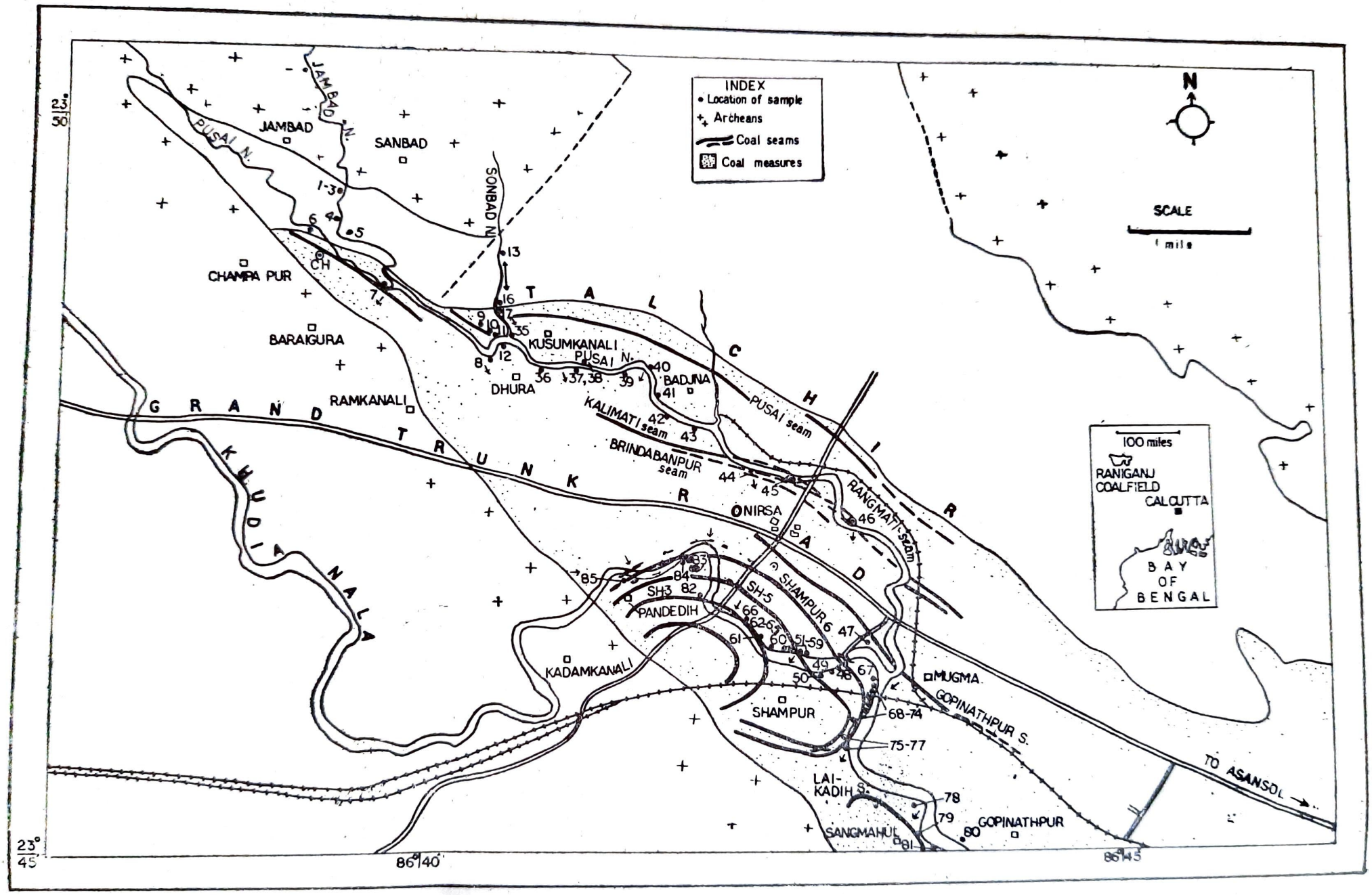
In the traverses taken along the Pusai Nala and the Khudia Nala all these zones are more or less well represented. There are about 14 coal seams associated with mostly carbonaceous shales, attributed to the Barakar Stage of West Raniganj region. However, it has not been possible to pin-point the various working coal seams in the nala-sections, due to concealment by alluvium or vegetation growth.

In the western Pusai area the Pusai conglomerates where best exposed, to the west of Kusum-Kanali, these basal sediments include greenish shale of Talchir type, hard bedded sandstone of softer grey yellow types and some shale bands, Pusai seam and massive coarse to medium textured sandstone with quartzite boulders, in ascending order. The sedimentary strata of this north western area are intersected by a number of mica-peridotite dykes, usually only a few feet in thickness.

In Kanauri region coal seams have been seen in the Pusai nala bank. Massive grey sandstone with some shale intercalation overlie the Pusai conglomerate in the Dhura area.

From the Nirsa grit area the seam locally known as Rangmati Seam has been collected. Nothing much could be seen in the vicinity of Nirsa village due to concealing by human activities and vegetation.

The massive Nirsa grits are overlain by a succession of dark grey, carbonaceous shales and sandstones. These beds are well exposed in Khudia Nala in the vicinity of its junction with Pusai and southwards to the railway bridge, dipping S 60°-W at about 10°. Excluding the upper Shampur Coal Measures the coal bearing sediments of the Shampur basin, dipping south-inclined-west at about 20°, are intersected by the Khudia Nala. To the north east of the village Pandedih the Khudia stream takes a sharp bend to the outh-east and flows along the strike of the basal beds of Upper Shampur Coal Measures and the upper strata of Middle Shampur Coal Measures. To the north of Shampur Colliery,



Map 1. Showing the locations of various samples along the Pusai and Khudia nalas

the Khudia Nala runs eastwards for a distance of about 1 km, and again traverses the Shampur Coal Measures. Within this portion of the nala, a very clear and complete section of Barakar rocks is exposed, dipping in a general west-south-westerly direction with moderate inclination. Again further east, to the south-west of Mugma Village, the nala meanders in a south-easterly and southerly direction along the strike of the Khudia shale beds of the eastern edge of the Shampur basin.

MATERIAL

The material for the present work has been collected from the Pusai Nala and the Khudia Nala of the west Raniganj Coalfield, Bihar (Map 1).

Pusai Nala Traverse

Pusai Nala flows in the West Raniganj Coalfield from north to south in between Jambad and Sonbad villages and joins Jambad Nala at about 1.6 km south-east of Champapur Colliery. To the north of Jambad Village metamorphic/Talchir intercalations are present. The traverse was started downstream from this region. The area is very much disturbed due to bad land topography and most of the bank is covered with alluvium.

The details of samples are given in Table 1; successional or isolated samples are marked so. The thickness of intermediate strata is approximate. The off-the-nala-cutting quarry samples are also indicated in the Map 1 by circled dot.

The succession in the Sonbad Nala, a small tributary of Pusai, is very perfectly exposed and has been completely collected (See Table 1). It exhibits the transition from Talchir to the Barakar lithology with the "first coal" yielding spores and pollen grains.

Rest of the traverse cuts sometimes along the dip, and sometimes along the strike, as and when the Pusai Nala meanders. However, these details have been taken into full consideration in the palynological comparison of individual sample.

Khudia Nala Traverse

This traverse was taken towards downstream from Kadamkanali Village region to Gopinathpur Village. Very good exposures of Barakar, containing typically coal, shale and sandstone sequences, are seen all along the cutting. The important Shampur Coal Measures are represented in this deposition. Off-the-nala-cutting quarry samples were also collected in this traverse. The details of samples have been given in Table 1.

Thus, starting with the Talchir Stage in the Pusai Nala traverse, a massive, typically Barakar sandstone alternating with sometimes very thick coal seams in Khudia Nala, has been encountered.

As far as possible the samples were collected to represent the overall coal seam or a shale band thickness. Their successional position has been determined and are arranged in order of stratigraphical superimposition in the histograms I and II.

Table 1—Details of samples studied in the present work.

Traverse 1—*Along Pusai Nala and associated exposures*, continuing in Khudia Nala after the confluence.

			Sample no.
(i)	*Pusai Nala* (near Jambad Village region)		
	Metamorphic/Talchir intercalations		
	Needle Shale	greenish	1)
			2)
			3)

	About 0.5 km downstream		
	Shale	greenish	4)
		grey	5)
	In the bed of Jambad Nala; just before confluence		
	Mudstones	Yellow to brown grey	6)
			7)
(ii)	*Sonbad Nala* (a tributary of Pusai Nala)		
	Sandstone (Talchir)		13
	Talchir needle shale	21′	14
	Sst. coarse	greenish	15
	Shaly Sst.-1st	9″	16
	Sst.	2′	16A
	1st Coal	3′	17*
	Sst.	2′	18
	Shale	2′	19
	Sst.	2′	20
	Shale (carbonaceous)	2′	21
	Sst.	4′	22
	Shale (carbonaceous)	6″	23
	Sst.	10′	24
	Shale	6″	25*
	Shaly Sst.	6″	26
	Sst. (fine grain)	1′	27
	Shale	1′	28
	Sst.	12′	29
	Shale	9″	30
	Sst.	15′	
	Shale	1′, 6″	31*
	Sst.	2′	32
	Shale with coal	8″	33*
	Sst.	3″	
	Coal	2″	34*
	Sst.	6′	
	Shale with coal	8″	35*
(iii)	*Pusai Nala* (continued after sample 7)		
	Shale	6″ in between Sst.	8*
	about 180 meter downstream		
	Shale		9
	Coal		10*
	Shale		11*
	Seam at the confluence of Sonbad nala with Pusai nala		
	Coal	the seam from the dump	12a*
	Shale	Upper most part of the above seam exposed at junction	12*
	Seam being worked at Champapur Colliery (Pusai seam)		
	Bottom		
	Floor not touched		
	Coal	7′	Ch. 1*
	Shale	9″	Ch. 2
	Coal	5′	Ch. 3*
	Shale	2′	Ch. 4
	Coal	2′ 6″	Ch. 5*
	Shale	9′	Ch. 6*
	Coal	6′	Ch. 7*
	Shale	9″	Ch. 8*
	Coal	1′ 6″	Ch. 9*
	Shale	3′ 6″	Ch. 10*
	Fire clay		
	Sst.		
	Top		
(iv)	*Pusai Nala* (continued after sample 12)		
	About 500 meters downstream		
	Shale	2′	36a*
	Coal	1′ 5″	36b*
	Shale (top)	8″	36c*
	About 500 meter downstream		
	Shale	6′	37a
	Coal	2′	37b
	Shale (top)	2′	37c*

About 100 meter downstream		
Coal	only 3′ exposed	38
About 500 meter downstream		
Coal (bottom)	3′	
Sst.	2′	39a*
Coal (top)	2′	39b*
Opposite Dhura Colliery		
Coal	2′	40*
About 200 meter down stream		
Coal (weathered; only upper part collected)		41
Partly exposed; near Dabiana Village		
Coal (partly exposed)	3′	42*
Seam near the colliery bridge facing Badna Coll.		
Coal	6′	43*
Seam near Butani Coll.		
Coal from dump of Brindabanpur seam facing No. 44 i.e. older to No. 44		
Coal from dump of Brindabanpur seam		45*
Coal	3′	44
Seam being worked out at Khas Badjna Colliery		
Open quarry		
Bottom		
Floor not touched		
Coal with vitrain bands	10′	46/1
Coal with shale bands	9′	46/2
Coal	10′	46/3*
Coal	10′	46/4*
Shale & Shaly Sst.	3′	46/5
Top.		

(v) *Beginning of Khudia nala bed* and associated exposures towards downstream from the point of confluence with Pusai nala.

Near the confluence of Pusai with Khudia stream (in a pit)		
Shale	3′	47*
Just near the confluence with Pusai Nala, downstream		
Shale bottom	1′ 6″	67a
Sst.	5′	
Sandy Shale	2′	67b
Sst.	4′	
Coal	3′	67c
Sst.	4′	
Coal	5′	67d*
Sst.	5′	
Shale	2′	67e*
Just before Elvin bridge		
Shale	7′	68*
Sst.	30′	
Shale	2′	69
Sst.	2′	
Shale	2′	70
Sst.	20′	
Shale	4′	71*
Further down		
Sst.	20′	
Shale	1′	72*
100 meter downstream of Elvin bridge		
Shale	1′	73
Sst.	40′	
Coal	2′	74
100 meter downstream Sudarshan Sampur Coll.		
Coal	1′	75*
Sst.		76
Coal & Shale	4′	
150 meter downstream from Laikdih Coll.		77*
Coal	2′	
About 200 meter downstream from No. 77		78a*
Coal	2′	78b*
Shale	3′	

About 400 meter downstream from Old bridge		
Shale intercalated with Sst.	10′	79
Opposite of Sangmohule		
Shale	2′	80
400 meter downstream of No. 80		
Coal	15′	81*
Shale	35′	81*

Traverse 2—Khudia nala bed and associated exposures upstream from the point of its confluence with Pusai Nala.

Near the Old Bridge		
Shaly Sst.		48
Just down the Shampur Colliery in bed		
Shale	3′	49
Coal	2′	50
Coal	2′	51
Shale	2′	52*
Coal	2′	53*
Shale	1′	54
Shale	2′	55
Coal	3′	56*
Slightly downstream Thaparnagar Rly St., in bed		
Coal (Jhama)		57
Coal (seam in open quarry)	7′ 6″	58
Coal (with shale)	5′	59*
Coal	3′	60*
Shale (seam in open quarry)	6′	60a
Just below Thaparnagar Rly. St., in bed		
Coal	15′	61*
Slightly upstream from Thaparnagar Rly. St. and 500 m downstream from Shampur Coll.		
Shale (bottom)	3′	62d
Coal	8″	62c*
Shale	2′ 6″	62b
Coal	8″	62a*
Sst. (top)		
Seam 30′ thick on the bank of the river		
Coal	15′	64
Only upper part of the seam in bed		
Shale	6′	63a*
Coal	1′	63b
Just below Shampur Colliery		
Sandy shale	3′	65a
Coal	9″	65*
About 180 meters downstream from the road bridge, in bed		
Shale (bottom)	2′	66b
Sst.	1′	
Coal	2′	66*
Shale	4′	66a
Sst. (top)		
Near the bridge, in bed		
Coal (in abandoned pit)	10′	82*
Open quarry (Shampur No. 5)		
Coal (bottom)	6′	83a*
Coal	6′	83b*
Coal	3′	83c*
Sst.	9″	
Coal	4′	83d*
Sst.	2′	
Coal	1′ 6″	83e*
Sst.	15′	
Coal	4′	83f*
Shaly Sst.	2′	83g*
Sst. (Top)		
Shale	4′	84a
Coal	1′	84b*
In Kadamkanli region		
Shale top of an unexposed seam in bed		85*

*Samples with asterisk mark have yielded; the rest are barren of miospores. Traverse 1 indicates a successional arrangements of the sample from the Pusai nala to its junction with Khudia nala and beyond this point downstream in Khudia nala. Traverse 2 indicates the recurring of deposition in upstream of Khudia nala from the point of its junction with Pusai nala.

METHODS

The samples were crushed to 2-4 mm grain size and mixed thoroughly. For each treatment about 15 gms of material was taken. The coal samples were kept in comm. Nitric acid for three days followed by heating in ten per cent KOH. The shales were first treated with cold HF and then kept in HNO_3 if needed. Slides were prepared in glycerin jelly and sealed with paraffin. Two hundred specimens were counted at random sectors on the four slides in each sample and percentage frequency was determined.

PALYNOLOGICAL CONTENTS

The material studied here contains a large number of well preserved trilete, monolete, monosaccate and disaccate miospore genera. A statistical analysis has suggested that the following genera form the dominating association in one or other combination in various sample-groups.

Callumispora Bharad. & Sriv. 1969 (*Punctatisporites*)
Lophotriletes (Naum.) Pot. & Kr. 1954
Brevitriletes Bharad. & Sriv. 1969
Horriditriletes Bharad. & Salujha 1964
Microbaculispora Bharad. 1962
Indotriradites Tiwari 1964
Dentatispora Tiwari 1964
Latosporites Pot. & Kr. 1954
Parasaccites Bharad. & Tiwari 1964
Caheniasaccites Bose & Kar 1966
Potonieisporites Bhard. emend. Bharad. 1964
Plicatipollenites Lele 1964
Virkkipollenites Lele 1964
Primuspollenites Tiwari 1964
Rhizomaspora Wilson 1962
Striatites Pant emend. Bharad. 1962
Lahirites Bharad. 1962
Striatopodocarpites Soritsch. & Sedova emend. Bharad. 1962
Faunipollenites Bharad. 1962
Lunatisporites Lesch. emend. Bharad. 1962
Illinites (Kosanke) Pot. & Kr. 1956 (incl. *Vestigisporites* Balme & Henn. 1955).
Vesicaspora Schemel emend. Wils. & Venkat. 1963
Sulcatisporites Leschik emend. Bharad. 1962 (*Scheuringipollenites* Tiwari 1973)
Ibisporites Tiwari 1967

Beside the above important forms, a number of other genera have been also recorded but they are either meager in representation or sporadic and inconsistent in occurrence, and hence, do not play an important role in the group considerations; however, they are important for qualitative considerations. These genera are:

Leiotriletes (Naum.) Pot. & Kr. 1954
Cyclogranisporites Pot. & Kr. 1954

Hennellysporites Tiwari 1968
Verrucosisporites (Ibr.) Pot. & Kr. 1954
Microfoveolatispora Bharad. 1962
Thymospora Wils. & Venkat. 1963
Barakarites Bharad. & Tiwari 1964
Divarisaccus Venk. & Kar 1966
Crucisaccites Lele & Maithy 1964
Striomonosaccites Bharad. 1962
Cuneatisporites Lesch. 1955
Platysaccus (Naum.) Pot. & Kl. 1954
Schizopollis Venkat. & Kar 1964
Lueckisporites Pot. & Kl. emend. Pot. 1958
Hindipollenites Bharad. 1962
Distriatites Bharad. 1962
Korbapollenites Tiwari 1964
Tiwariasporis Maheshwari & Kar 1967
Vittatina Lub. emend. Wils. 1962
Ginkgocycadophytus Samoilov. 1953 (*Kingiacolpites* Tiwari & Moiz 1971)
Pilasporites Balme & Henn. emend. Tiwari & Navale 1967
Stellapollenites Lele 1964
Circumstriatites Lele & Makada 1972
Densipollenites Bharad. 1962
Decussatisporites Lesch. emend. Janson. 1962

Miofloral Succession

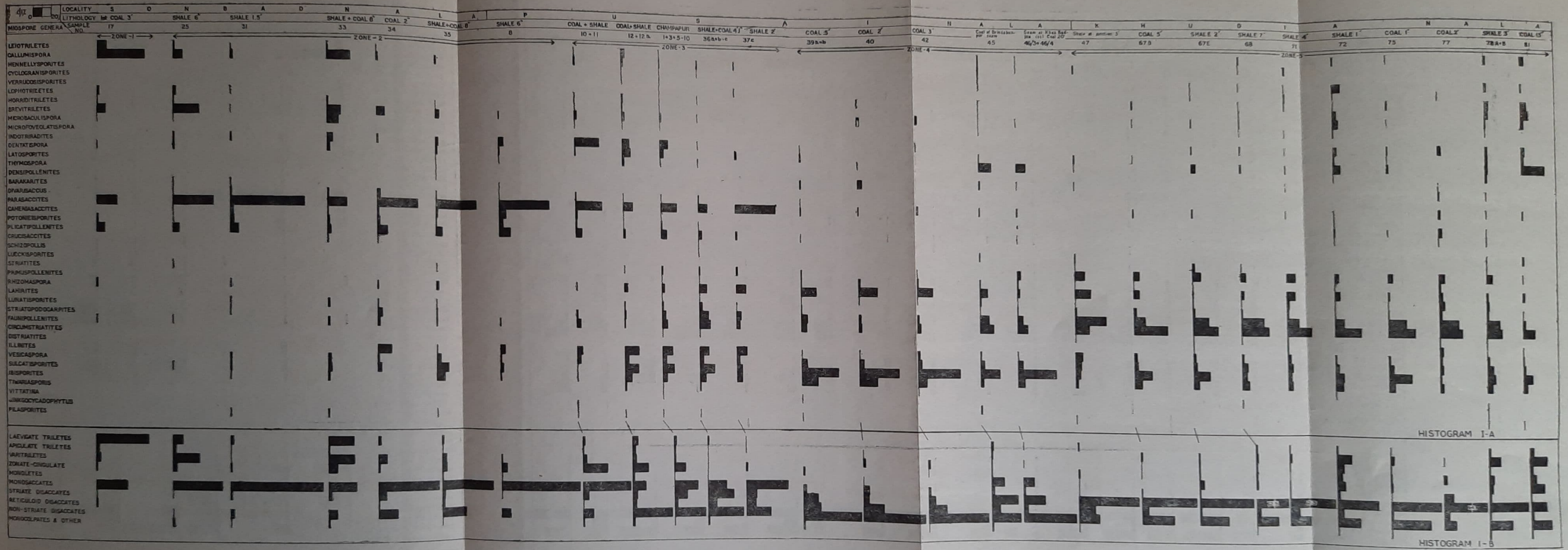
In Histogram Ia, the samples are arranged in successional order, the oldest being the first. The whole succession represents the close of Talchir formation with the appearance of 1st coal, the Pusai coalseam area, Kanauri, Nirsa grit region and the Shampur coal measures in the Khudia nala.

On a critical perusal of this histogram, the whole palynological assemblage can be divided into the following 5 zones.

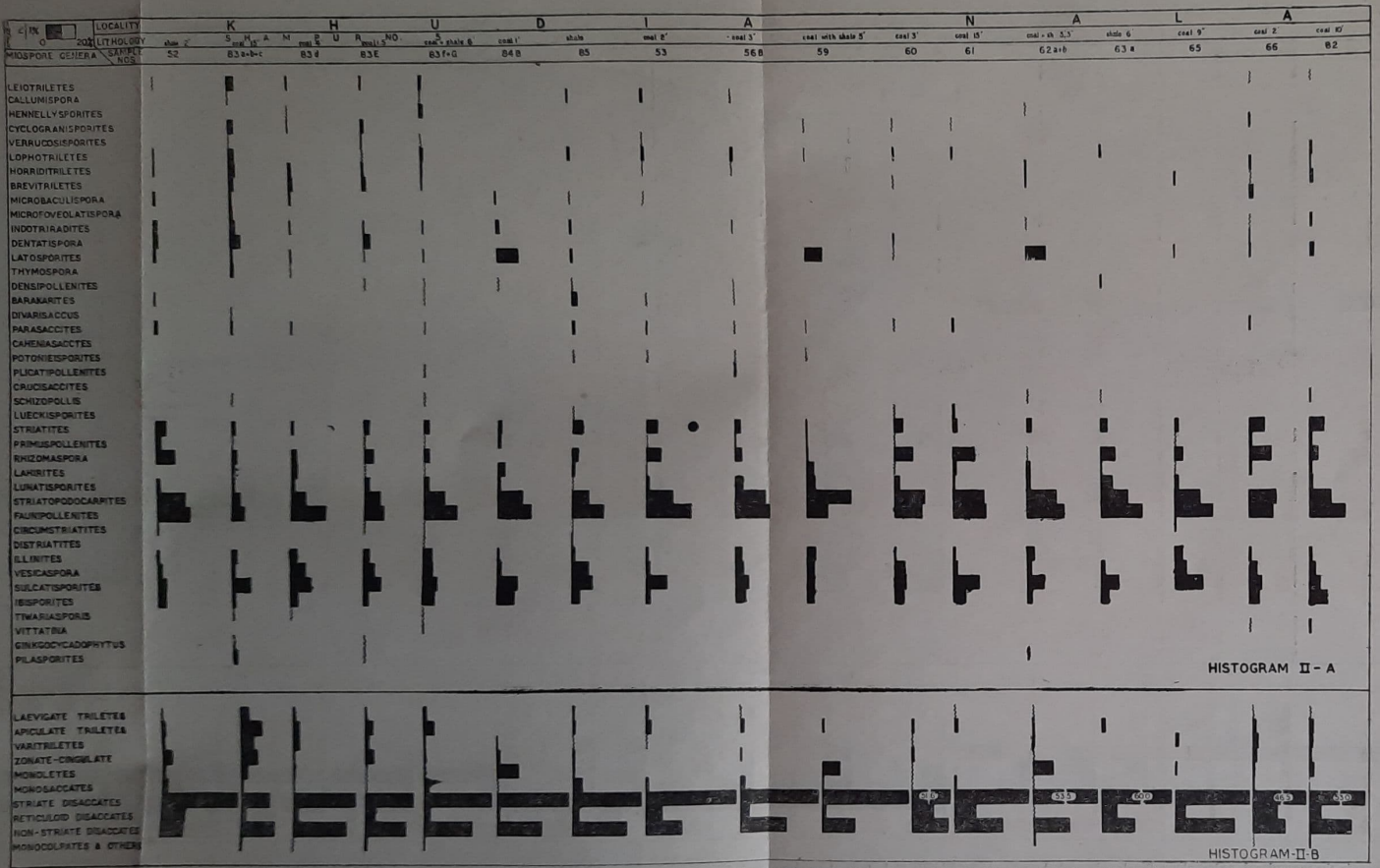
(1) *Callumispora*—Zone (includes sample no. 17)
Dominatnt genus—*Callumispora* (*Punctatisporites*)
Subdominant genus—*Parasaccites*
Other significant genera—*Virkkipollenites*, *Brevitriletes*

(2) *Parasaccites*—Zone (includes sample nos. 25, 31, 33, 34, 35, 8)
Dominant genus—*Parasaccites*
Subdominant or significant genera—*Brevitriletes*, *Callumispora*, *Plicatipollenites*, *Virkkipollenites*

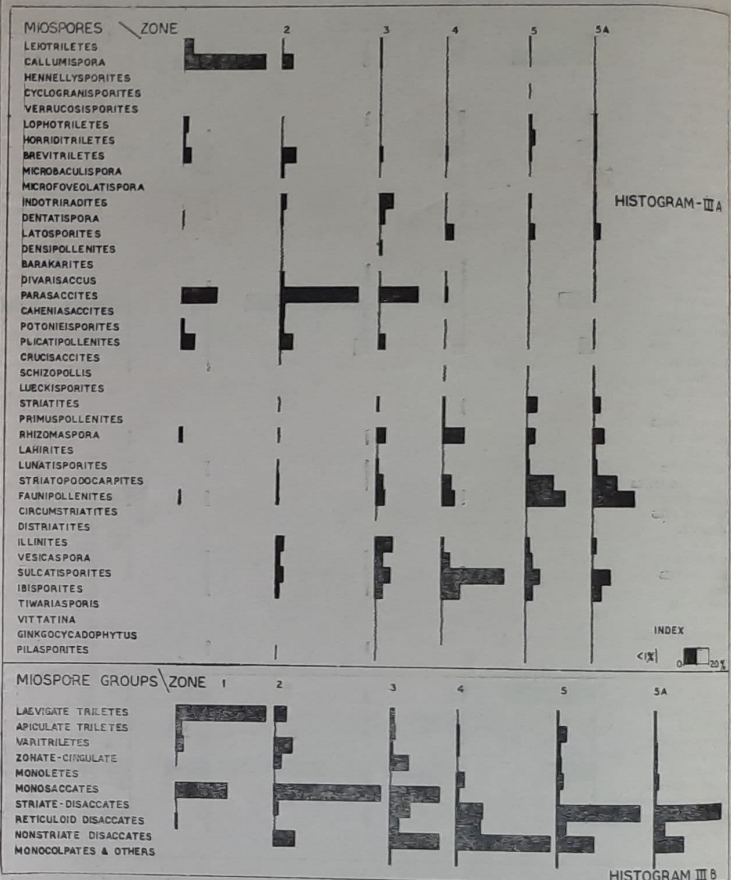
(3) *Parasaccites*-zonate-cingulate—Zone
(includes sample nos. 10+11, 12+12a, Ch. 1 to Ch. 10, 36a+b, 37c)
Dominant genus—*Parasaccites*/*Indotriradites*
Subdominant or significant genera—*Dentatispora*, *Illinites*, *Vesicaspora*, *Sulcatisporites*, *Rhizomaspora*, *Virkkipollenites*



Histograms I—A, B. I—A, Miospore frequency in the successional order along Pusaj-nala and downstream in Khudia Nala from the point of their junction.
I—B, Miospore-groupwise percentage frequency in the various samples in succession.



Histogram II—A, B. II—A, Miospore assemblage in the Khudia nala upstream from the point of its junction with Pusai Nala. This mioflora named as Zone-5a is repetition of Zone-5 in Histogram Ia and Ib.
II—B, Miospore groupwise percentage frequency in various samples in succession.



Histogram III—A, B. III—A, Details of miospore percentage frequency in various zones.
III—B, Showing the miospore group representation in different zones.

(4) *Sulcatisporites-Ibisporites*—Zone (includes sample nos. 39a+b, 40, 42, 45, 46/3+46/4)
Dominant genus—*Sulcatisporites*
Subdominant genera—*Ibisporites, Rhizomaspora*
Significant genera—*Latosporites, Striatopodocarpites, Faunipollenites, Vesicaspora*

(5) *Faunipollenites-Striatopodocarpites*—Zone (includes sample nos. 47, 67d, 67e, 68, 71, 72, 75, 77, 78a, 78b, 81)
Dominant genus—*Faunipollenites/Striatopodocarpites*
Subdominant genera—*Sulcatisporites, Vesicaspora, Ibisporites, Striatites*
Significant genera—*Rhizomaspora, Lahirites, Lunatisporites, Cyclogranisporites, Lophotriletes, Brevitriletes, Horriditriletes*

(5a) Histogram IIa represents the miofloral contents of the coal-shale exposures along the upstream of Khudia Nala from the point of its meeting with Pusai Nala. This is actually a repetition of the mioflora in the Zone 5 of Histogram Ia. This includes sample nos. 52, 53, 56, 59, 60, 61, 62c, 62a, 63a, 65, 66, 82, 83a to 83g, 84b, 85. The quantitative composition of miospore genera is the same as in Zone 5.

The Group representation in various zones

Histograms Ib and IIb depict the major groups of *sporae dispersae* in successional order. All the miospore genera have been classified under 10 major groups, as given below:

1. Laevigate triletes
2. Apiculate triletes
3. Varitriletes (incl. *Brevitriletes*)
4. Zonate-Cingulates
5. Monoletes
6. Monosaccates
7. Striate disaccates
8. Reticuloid-striate disaccates
9. Non-striate disaccates
10. Monocolpates and other

This brings out the picture more clearly. Referring to histograms Ia and IIa, we can clearly see that Zone-1 is dominated by laevigate triletes, (*Callumispora*—most dominant), followed by the monosaccate dominant zone (Zone-2); the zonate-cingulate groups of spores, along with monosaccates come in prominence in the Zone-3. Between Zones 3 and 4, i.e. between Zonate-Cingulate and Non-striate disaccate zone, there is a very sharp miofloral change and consequently a clear line of demarcation has been revealed.

The Composite Zone

Histogram IIIa (also Table 2) exhibits the mean values of various generic behaviour in the major zones. The clearcut zonations have emerged in the following order of miospore combinations:

Zone 1. *Callumispora, Parasaccites, Plicatipollenites, Leiotriletes, Brevitriletes.*
Zone 2. *Parasaccites, Plicatipollenites, Brevitriletes, Potonieisporites, Callumispora, Indotriradites.*

Table 2—Zone-wise percentage frequency of miospore genera.

Miofloral Zones	1	2	3	4	5	5a
Sample Nos.	17	25, 31, 33 34, 35, 8	10+11, 12+12a, Ch-1 to Ch-10, 36a+b, 37c	39a+b, 40, 42, 45, 46/3+46/4	47, 67d, 67e, 68, 71, 72, 75, 77, 78a, 78b, 81	52, 53, 83a+b, 83d, 83e, 83f+g, 84b, 56b, 59, 60, 61, 62a+c, 63a, 65, 66, 82, 85
Genera						
Leiotriletes ..	5.0	0.4	1.1	0.1	1.0	0.6
Callumispora ..	50.0	6.2	1.4	0.2	0.3	0.3
Hennellysporites ..	..	..	0.2	0.1	..	0.1
Cyclogranisporites ..	..	..	0.2	0.1	0.5	0.6
Verrucosisporites ..	..	..	0.3	..	..	0.2
Lophotriletes ..	2.5	0.5	0.5	0.2	1.5	1.3
Brevitriletes ..	4.5	9.2	1.9	1.1	1.7	1.1
Horriditriletes ..	1.0	0.4	0.3	0.1	3.5	1.0
Microbaculispora ..	..	2.0	0.2	0.1	0.2	0.6
Microfoveolatispora ..	..	..	..	..	..	0.2
Indotriradites ..	..	3.1	8.3	0.2	1.7	1.1
Dentatispora ..	0.5	1.1	3.1	0.4	1.0	1.0
Latosporites ..	..	0.1	0.5	5.0	3.7	3.3
Thymospora ..	..	0.1	..	..	0.2	0.2
Densipollenites ..	..	0.1	1.6	..	0.1	0.2
Barakarites ..	..	0.1	..	..	0.1	0.4
Divarisaccus ..	..	2.0	0.6	0.2	0.1	0.2
Parasaccites ..	21.5	46.2	23.9	1.4	0.5	0.7
Caheniasaccites ..	..	2.2	0.6	..	0.2	..
Potonieisporites ..	2.5	2.2	0.9	0.1	0.1	0.2
Plicatipollenites ..	1.5	4.0	2.0	0.1	0.1	0.1
Virkkipollenites ..	7.0	4.0	2.1	..	0.1	0.1
Crucisaccites ..	..	0.1	0.2	..	..	..
Stellapollenites ..	..	0.1	..	..	..	..
Striomonosaccites ..	..	..	..	0.1	..	0.1
Cuneatisporites ..	..	0.1	..	0.1	0.1	0.2
Platysaccus ..	..	..	0.2	0.1	0.5	0.5
Schizopollis ..	..	..	..	0.2	0.3	0.1

Lueckisporites	--	..	--	--	..	0.4	0.2
Striatites	--	--	0.1	1.1	1.3	6.3	4.5
Korbapollenites	--	--	..	0.1	0.6	..	--
Primuspollenites	--	--	--	--	1.2	0.5	0.8
Rhizomaspora	..	1.5	0.9	5.4	13.0	5.3	6.7
Lahirites	..	..	--	0.1	0.7	1.5	1.5
Lunatisporites	..	--	0.2	1.5	0.5	1.9	2.8
Striatopodocarpites	..	..	1.0	4.5	5.5	16.3	14.1
Hindipollenites	..	..	--	--	0.2	0.2	..
Faunipollenites	..	0.5	1.0	5.4	7.4	23.7	25.0
Circumstriatites	--	--	--	0.2	--	0.2	0.2
Distriatites	..	--	--	--	..	0.2	0.2
Illinites	..	..	4.0	10.5	1.2	3.0	2.8
Vesicaspora	..	..	2.5	5.0	5.2	4.5	0.2
Sulcatisporites	..	..	4.0	9.7	37.6	9.2	11.0
Ibisporites	..	..	1.5	5.0	11.3	5.1	6.0
Tiwariasporis	..	..	..	0.7	0.4	0.2	0.2
Vittatina	..	..	..	0.2	0.2	0.2	0.1
Decussatisporites	..	..	..	..	..	..	0.1
Ginkgocydadophytus	..	..	..	0.2	0.3	..	0.1
Pilasporites	..	..	0.4	0.2	..	0.2	0.1
Unidentified	..	2.0	0.5	0.1	1.5	1.0	2.0

Zone 3. *Parasaccites, Indotriradites, Dentatispora, Illinites, Sulcatisporites, Ibisporite.*
Zone 4. *Sulcatisporites, Ibisporites, Rhizomaspora, Striatopodocarpites, Faunipollenites, Latosporites.*
Zone 5. *Faunipollenites, Striatopodocarpites, Sulcatisporites, Ibisporites, Vesicaspora, Rhizomaspora, Striatites.*
Zone 5a. Same as in Zone 5.

Group representation in composite zone

Histogram IIIb has been plotted to show the miospore group representation in these five zones. These groups represent the zonations as given below:

1. Laevigate trilete—Zone-1
2. Monosaccate—Zone-2
3. Monosaccate-Zonate-Cingulate—Zone-3
4. Non-striate disaccate—Zone-4
5. Striate disaccate—Zone-5 & 5a.

COMPARISON

The synthesis of the data on the Lower Gondwana palyno-stratigraphy by BHARADWAJ (1966) has revealed that the monosaccate genera dominate in the Talchir Formation of Indian Lower Gondwana. Some of the recent informations by LELE and MAKADA (1972) from the Jayanti Coalfield and by BHARADWAJ and SRIVASTAVA (1973) from a deep bore-core from Korba Coalfield, also support the monosaccate-rich findings of the earlier workers in the Talchirs.

A *Callumispora* (*Punctatisporites*)-rich zone has been reported by BHARADWAJ and SRIVASTAVA (1973) from Korba Coalfield, to divide two monosaccate rich zones. So also KAR (1973) has reported a second monosaccate rich zone above the *Callumispora*-Zone in the North Karanpura Coalfield. In the present work, the Zone-1 contains *Callumispora* dominating flora and is about 1.53 m above the Talchir needle shale (see Table 1). The first appearance of the assemblage, however, could not be determined due to the barren nature of the underlying samples. Further down, along the Pusai Nala traverse, the typical sandstone-coal-shale sequence is exposed. There are no megafossil reports from this area. Palynologically, the samples 25, 31, 33, 34, 35, and 8 show an affiliation with each other in having the monosaccate dominance. Recently, BHARADWAJ (in press) has opined that the early Lower Gondwana sedimentation occurred during two successive glacial cycles, each comprising a glacial phase and an inter-glacial phase. The dominance of radial monosaccate has been suggested to be associated with the glacigene sediments, the two monosaccate rich zones (e.g. one of the Talchirs and the other Zone-2 of the present work) therefore represent these two glaciations, intersepted by a *Callumispora*—rich zone (Zone-1). The recent findings of SRIVASTAVA (1973) has revealed the presence of *Callumispora* rich assemblage in the Lower Karharbari Seam of Girdih Coalfield, type area of Karharbari Stage. Hence, the *Callumispora*-Zone (Zone-1) of the Pusai area in the present work, also represents the Lower Karharbari Stage, while the monosaccate rich-zone (here Zone-2) represents the Upper Karharbari Stage.

Zone-3 continues to show the significance of the radial monosaccate genera but at the same time the cingulate-zonate (*Indotriratites-Dentatispora*) spores and the non-striate disaccate also come in the picture. The zonati group was earlier named to be the marker of Lower Barakar by BHARADWAJ (1966). However, this was not proved to be so by other works and hence another group—Varitriletes, was also incorporated in the Lower Barakar characteristics, which could replace the zonati in abundance. The present study suggests that there is a significant change from the radial monosaccate zone (i.e. Zone-2) to the radial monosaccate+zonate-cingulate zone (i.e. Zone-3). Although, the radial monosaccate genera still remain important constituents of the Zone-3 these two zones in question represent a discontinuation of the single major miofloral sequence, and represent variability in time periods, hence Zone-3 represent the Lower Barakar Stage.

Zone-4 (*Sulcatisporites-Ibisporites*-rich-zone) begins with a clearcut demarcation in contrast to the Zone-3. The zonates as well as monosaccates decline considerably, the striates start struggling for the singificance. Thus, there is a definite miofloral change, in which the dominance of the non-striate disaccates is established. This *Sulcatisporites*-rich assemblage could not be given much importance up to the year 1966, but recent researches by BHARADWAJ and ANAND-PRAKASH (1972), and BHARADWAJ and SRIVASTAVA (1973) have established the importance of the *Sulcatisporites*-rich assemblage. The significant change in the mioflora between Zone-3 and Zone-4, the declination of monosaccate as well as the appearance of significant striated in Zone-4, evidences that the *Sulcatisporites*-rich zone represents a major alteration in the vegetational constituents of that depositional time and

hence, a change within the Barakar. Thus, sample nos. 39, 40, 42, 45 of the Pusai Nala traverse containing the non-striated disaccate rich miofloral has been assigned to the? Middle Barakar deposition.

Zone-5 (striate-disaccate-rich-zone) commences from the sample no. 47 in Pusai-Khudia junction-area and continues up to sample no. 81, all along the down-stream of Khudia Nala. BHARADWAJ (1966) has shown the striated disaccate group to be characteristic of the Barren Measures and Raniganj Stages, as far its dominance was concerned. However, later studies (BHARADWAJ, 1972; BHARADWAJ & SRIVASTAVA, 1973) revealed that the striated disaccates begin to dominate much earlier. The present study evidences that the type exposures for Barakars in Khudia Nala possess the *Faunipollenites-Striatopodocarpites* rich flora, and hence the striated disaccates are the typical of Barakar Formation; this assemblage represents the Upper Barakar Stage because of its marked differences with the underlying assemblage (i.e. Zone-4).

DISCUSSION AND CONCLUSION

The typical Talchir needle shale and green shales of the Pusai Nala area have not yielded any spores; however, it has been established from other areas that the Talchirs, in general, contain monosaccate dominant assemblage. The first coal seam (3′ thick) ex Talchir in the sequence contains *Callumispora* and *Parasaccites* as prominent genera. However, the beginning of *Callumispora*-zone could not be ascertained due to the sterility of the older samples, yet the lithological evidences (Table 1) put this in an immediate younger position to the Talchir Formation. Its affiliations with the known Talchir assemblages support the view that the *Callumispora-Parasaccites* rich flora (here Zone-1) is Lower Karharbari in age.

In sequence to the *Callumispora*-Zone, the second zone of *Parasaccites* representing second glacial phase, has been found (BHARADWAJ, in press). This second zone of monosaccate rich flora represents the Upper Karharbari Stage. This observation could also be ascertained on the basis of the trend of certain disaccate genera which show their inception right here in this Zone (Zone-2).

Zone-3, the *Parasaccites*/Zonate-cingulate-rich-zone, shows a discontinuity of Zone-2, with a difference. The zonate dominant miofloras were earlier referred to the Lower Barakar Stage (BHARADWAJ, 1966); these miofloras were exclusively over-dominated by the zonate-cingulate genera (e.g. see BHARADWAJ & TIWARI, 1964) and *Parasaccites* was in rarity there. In the present material, on the contrary, the trend of monosaccate prominence continues even in the zonate-cingulate zone(i.e. Zone-3). Therefore, it is concluded that the zonate-cingulate rich flora is the opening phase of the Barakar Stage; it could be associated with prominent *Parasaccites*, as in the present case, or even without it, where only the lycopsid spores dominate the scene as in the Korba Coalfield (BHARADWAJ & TIWARI, 1964).

There is a clearcut miofloral break between Zone-3 (*Parasaccites*/*Indotriradites* rich) and Zone-4 (*Sulcatisporites*/*Ibisporites* rich). The monosaccates have been reduced to rarity and a new group of non-striate disaccates has come in the prominence. This zone, for certain, has no close relationship with the monosaccate prominent-miofloras, and hence, a line of demarcation below the non-striate disaccate phase could be drawn. The latter mioflora, therefore, represents the Middle Barakar Stage.

The Zone-5, found in the Shampur-basin containing the striate disaccates, is a representative of yet another phase over the non-striate disaccate zone. It is interesting

to note that the striate disaccates have already come in picture in the preceding phase (i.e. Zone-4), and *vice versa* the non-striate disaccates have not lost their significance in Zone-5; this establishes their relationship and yet they are different by virtue of the dominance. Thus, the striate-disaccate zone represents the Upper Barakar Stage.

To conclude in nut shell, following is the position of various miofloral zones discovered in the present work.

Upper Barakar Stage	Zone 5	*Faunipollenites* + *Striatopodocarpites*, *Sulcatisporites*, *Vesicaspora*.
Middle Barakar Stage	Zone 4	*Sulcatisporites* + *Ibisporites*, *Rhizomaspora*, *Striatopodocarpites*, *Latosporites*.
Lower Barakar Stage	Zone 3	*Parasaccites/Zonate—Cingulate* + *Illinites*, *Sulcatisporites*.
Upper Karharbari Stage	Zone 2	*Parasaccites* + *Brevitriletes*, *Callumispora*, *Sulcatisporites*.
Lower Karharbari Stage	Zone 1	*Callumispora* + *Parasaccites*, *Plicatipollenites*.
Talchir Stage		*Parasaccites/Plicatipollenites* + *Virkkipollenites*.

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