PALYNO-STRATIGRAPHY OF THE GIRIDIH COALFIELD

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ABSTRACT

This is the first detailed report of the miofloral succession in the Giridih Coalfield. Stratigraphical setting of the Lower Gondwana sequence has been done on the basis of palynological evidences available from the Talchir sediments and the coal bearing horizons. The study reveals one distinct miofloral change. The older part of Zone No. 1 is exclusively rich in radial monosaccates, chiefly *Parasaccites* and *Plicatipollenites* and is correlatable with the Talchir Stage. The younger part of Zone No. 1 indicates the Karharbari Stage including the Lower Karharbari Seam which is characterised by the dominance of *Callumispora* and *Parasaccites*-Zone No. 2 corresponds with the Barakar Stage and is marked by the dominance of *Sulcatisporites* associated with reticuloid and striated disaccates. This includes the Bhadua, Khandia 1-4, Bali and Jatkuti seams. The Upper Karharbari Seam has been considered to represent the basal part of Zone No. 2 as it shows the dominance of *Illinites* followed by *Sulcatisporites* and thus represents a transition in between the two zones. The Karharbari Stage has been defined as a distinct biostratigraphic unit in the Lower Gondwana sequence.

INTRODUCTION

The microfossils of the Giridih or the Karharbari Coalfield were first described by SEN (1953), who studied the mioflora of two workable coal seams (Lower Karharbari and Bhadua) and tried to bring out their correlation on the basis of their quantitative representation. Later on SURANGE and LELE (1955) studied the Talchir needle shales of the area and reported four types of one winged and three types of two winged spores and pollen grains along with few megafossils. GUHASARKAR (1956) published a brief note on the microfloral contents of Lower and Upper Karharbari seams, Bhadua and Khandia seams and recorded nine genera of trilete, monolete, monosaccate and disaccate pollen grains. MAITHY (1965) studied in detail the mioflora of a shale from Central Pit, Srirampur Colliery. The miofloral assemblage consisted of 42 species belonging to 27 genera and was described as the index-mioflora of Karharbari Stage. Thus, the knowledge of mioflora of Giridih Coalfield is yet incomplete and only scanty.

The significance of the Karharbari Stage as a characteristic, biostratigraphic, a distinct lithostratigraphic and as a definite time-stratigraphic unit has been much debated in the recent years. The recognition of the Karharbari Stage as a biostratigraphic unit is mainly based on the fossil evidences available from the type area, the Giridih Coalfield which are, however, meagre and incomplete. In the present paper a detailed study of the succession of the mioflora of the Giridih Coalfield has been undertaken.

GEOLOGY

The Giridih Coalfield was first reported by McClelland in the year 1848. Later on HUGHES (1870) and SAISE (1894) contributed to the geology of the area in detail. The Giridih Coalfield extends over an area of nearly 28 sq km between latitudes 24° 10′ and 24° 14′ N and longitudes 86° 16′ and 86° 23′ E. Out of this only 7 sq km are covered

by the coal measures (RAMASWAMY, 1971) having a total thickness of 305 metres. The Talchir rocks stretch over an area of 5 sq km and are best exposed in the north-western part of the coalfield along Sookni River, mostly along the northern bank, from about one mile north-west of the Karharbari Village upto Baksidih. The Talchirs consist of compact mudstones, needle shales, sandy shales and sandstones.

A 15 cm carbonaceous shale is exposed near the Giridih-Hazaribagh road bridge and the first coal (15 cm thick) above the Talchirs is exposed at the junction of Sookni and Khakho rivers. A number of coal seams are exposed in Khakho River near Jatkuti, Komaljore River and Komaljore Hill, Bhadua Hill and Srirampur area. The details of the samples collected from these areas are given in Table 1.

Table 1—Showing details of the samples collected from Giridih Coalfield

Exposure no.	Lithology	Locality	Sample nos.	Description	Remarks
1	Compact Mudstone.	Sookni River	M/1	North of Maheshmundi village near Maheshmundi to Pachambha Road.	Rich in miospores.
2	Khaki green Needle Shale.	,,	M/2	Overlying sample no. M/1	Poor in miospores.
2a	,,	,,	M/3	Continuation of the same bed 1/4 km. downstream from sample no. M/2.	,, ,,
3	,,	,,	M/4	1/4 km. downstream from sample no. M/3.	,, ,,
4	,,	,,	M/5	1/4 km. downstream from sample no. M/4.	,, ,,
5	Sandy shale	,,	M/6	1/2 km downstream and above Sample no. M/5.	,, ,,
6	Coarse grained	,,	M/7	East of Baksidih village. Above Sample no. M/7.	,, ,,
7	Carbonaceous Shale.	,,	S/1	15 cm thick lense nearly 1/4 km. south from Giridih-Hazaribagh Road bridge.	Rich in tracheids Miospores absent.
8	Coal		SK/1	Coal seam partially exposed, at the confluence of Sookni and Khakho rivers—Top portion.	Rich in tracheids
			SK/2	Coal seam, partially exposed, at the confluence of Sookni and Khakho rivers—Bottom portion.	Rich in miospores.
9	Carbonaceous Shale.	Jatkuti	K1/1	Khandia 1 seam-60 cm thick near Fault.	No miospores
10	Coal	Jatkuti	K2/1	Khandia 2 seam—Top portion) 1 meter thick near	,, ,,
			K2/2	Khadia 2 seam—Bottom portion) Fault.	
11	Coal	Jatkuti pit near Fault.	K3/1	Khandia 4 seam —Top portion	Poor in miospores.
			K3/2	,, ,, —Middle portion	,, ,,
			K3/3	,, ,, —Bottom portion	,, ,,

Exposure no.	Lithology	Locality	Sample nos.	Description	Remarks
12	Coal ..	Jatkuti ..	K4/1	Khandia 3 seam (Upper Khandia). —Top portion	Poor in miospores. Rich in tracheids.
			K4/2	Khandia 3 seam (Lower Khandia). —Middle portion	,, ,,
			K4/3	Khandia 3 seam —Bottom portion	Rich in miospores.
13	Coal ..	Khakho River.	KJ/1	Near Jatkuti Hill in Khakho River. —Top portion	Tracheids profuse.
			KJ/2	Near Jatkuti Hill in Khakho River —Bottom portion	Rich in miospores.
14	Coal ..	Bali Hill ..	J/1	Bali seam —Top portion)	Rich in tracheids.
			J/2	,, —Middle portion) 12 meters thick.	Rich in miospores. Poorly preserved.
			J/3	,, —Middle portion)	,, ,,
			J/4	,, —Bottom portion)	,, ,,
15	Coal ..	Kolimaran pit.	KK/1	Lower Karharbari —Top portion)	Rich in tracheids.
			KK/2	,, ,, ,, —Middle portion) 3 meters thick.	Rich in miospores.
			KK/3	,, ,, ,, —Bottom portion)	Poor in miospores.
16	Coal ..	New Incline	LK/1	Lower Karharbari seam —Top portion)	Rich in tracheids.
			LK/2	,, —Middle portion)	Rich in tracheids. Rich in miospores.
			LK/3	,, — ,, ,,) 3½ meters thick.	,, ,,
			LK/4	,, — ,, ,,)	Rich in tracheids.
			LK/5	,, — ,, ,,)	Rich in miospores.
			LK/6	,, — ,, ,,)	,, ,,
			LK/7	,, —Bottom portion)	Rich in tracheids.
17	Coal ..	17B Incline	B/1	Bhadua seam —Top portion (0-1 meter)	Rich in miospores.
			B/2	,, —Middle portion (1-1.5 meters with 0.2 m. shale)	,, ,,
			B/3	,, — ,, ,, (1.5-2.5 meters)	,, ,,
			B/4	,, — ,, ,, (2.5-3 meters)	,, ,,
			B/5	,, — Botom ,, (3-4 meters)	,, ,,

Exposure no.	Lithology	Locality	Sample nos.	Description	Remarks
18	Coal ..	Bhadua Hill	UB/1	Bhadua seam —Top portion ..	Tracheids profuse. Miospores poor.
			UB/2	,, ,, —Middle portion ..	,, ,,
			UB/3	,, ,, —Bottom portion ..	,, ,,
19	Coal ..	Srirampur—Deep pit area.	1	Khandia-1 (Channel overall) ..	Rich in miospores.
20	Coal ..	,,	2	Khandia- 2 (Channel overall) ..	,, ,,
21	Coal ..	Jatkuti Hill	3	Khandia-4 (Channel overall) ..	,, ,,
22	Coal ..	,,	4	Bali seam (Channel overall) ..	,, ,,
23	Coal ..	,,	5	Jatkuti seam —Top 3 meters ..	,, ,,
			6	,, ,, —Bottom 60 cm. ..	,, ,,
24	Coal ..	Central pit ..	UK/1	Upper Karharbari seam —Top seam Top portion.) 1 meter.	Rich in miospores.
			UK/2	,, —Bottom portion)	,, ,,
			UK/3	Separated by 60 cm. sandstone parting. —Bottom seam	(1 meter) Rich in miospores.
25	Coal ..	Railway cutting near Deep pit.	RK/1	Lower Karharbari seam —Top portion)	Tracheids profuse
			RK/2	,, —Middle portion) 2.2 meters	
			RK/3	,, —Bottom portion)	Miospores absent
26	Coal ..	Komaljore River.	KN/1	Lens of Coal (23 cm) ..	Devoid of miospores.
			KN/2	Same coal 1/4 km. towards Giridih	,, ,,
27	Coal ..	Komaljore	KH/1	1.5 meter thick carbonaceous matter exposed in the central portion of the hill —Top portion ..	Rich in tracheids and cuticles.
			KH/2	,, —Middle portion	,, ,,
			KH/3	,, —Bottom portion	,, ,,
28	Coal ..	Komaljore Hill.	KH/4	Coal seam exposed on the other side of the hill —Top portion ..	Miospores rare, poorly preserved.
			KH/5	,, —Middle portion	,, ,,
			KH/6	,, —Bottom portion	,, ,,

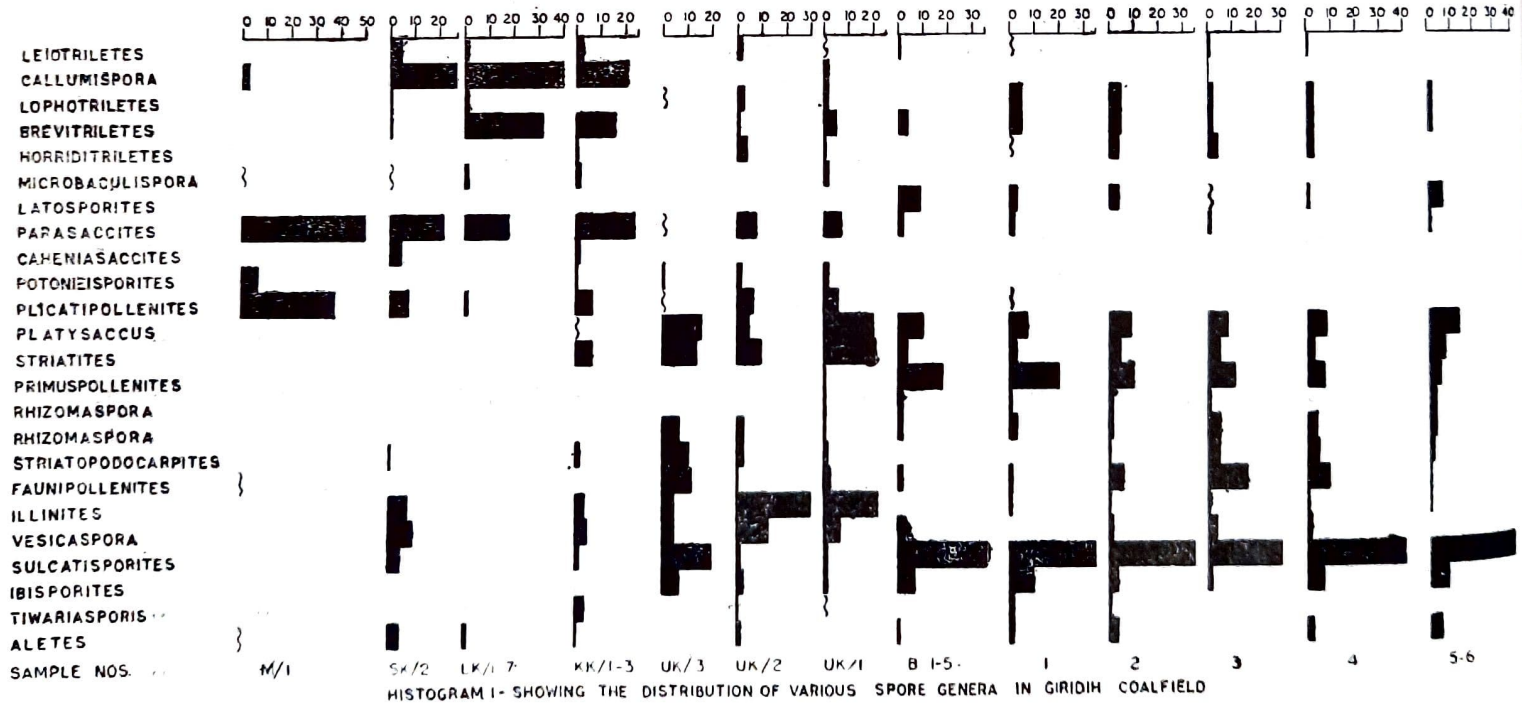
MIOFLORAL COMPOSITION

The miofloral assemblage of the Giridih Coalfield consists of 39 genera which are listed here:

*Leiotriletes, Callumispora, *Hennellysporites, Cyclogranisporites, *Acanthotriletes, Lophotriletes, Brevitriletes, Horriditriletes, Microbaculispora, *Indotriradites, *Jayantisporites, Latosporites, Divarisaccus, Parasaccites, Caheniasaccites, Potonieisporites, Vestigisporites, Plicatipollenites, Virkkipollenites, *Crucisaccites, *Cuneatisporites, Platysaccus, Striatites, Primuspollenites, *Rhizomaspora, Lahirites, Striatopodocarpites, Faunipollenites, Illinites, Vesicaspora, Pilasporites, Hemisphaerium, *Spongocystia, *Foveofussa, and Leiosphaeridia.*

Amongst these *Callumispora, Brevitriletes, Microbaculispora, Parasaccites, Plicatipollenites, Illinites* and *Sulcatisporites* characterise the miofloral spectra by their dominance in various coal seams. Apart from these *Latosporites, Platysaccus, Striatites, Primuspollenites* and *Faunipollenites* closely follow the dominants. The genera marked with an asterisk are poorly represented and occur either in a particular set of samples or as stragglers. The nature and variation of miospore assemblages in various sediments are described hereunder.

Talchir Mudstone—Five samples representing the Talchir Stage of the Giridih Coalfield were collected from the Sookni River. Out of these sample no. M/1 yielded a rich mioflora while in the rest four samples the spores were so poor in occurrence that it was not possible to count them. The mioflora obtained from the sample no. M/1 (Histogram 1) shows the dominance of *Parasaccites* (40%) and *Plicatipollenites* (31%) while *Virkkipollenites* (7%), *Potonieisporites* (5%) , *Callumispora* (3%) and *Vestigisporites* (2%) are present subdominantly. Thus the assemblage has an overall dominance of trilete bearing radial monosaccates (95%).



HISTOGRAM 1- SHOWING THE DISTRIBUTION OF VARIOUS SPORE GENERA IN GIRIDIH COALFIELD

Lower Karharbari Seam—Samples of this coal seam have been collected from the working faces of New Incline (sample nos. LK/1-7), Kolimaran Pit (sample nos. KK/1-3) and from the seam exposed in a railway cutting (sample no. RK/1-3) near Deep Pit. The last of these yielded profuse amount of woody elements and very rare spores while the rest two samples contained a rich assemblage of miospores along with woody fragments.

The Lower Karharbari Seam is 3-5 metres thick in New Incline. The bottom (sample no. LK/7) and the top portions (sample no. LK/1) and sample no. LK/4 in the middle have not yielded miospores. In sample no. LK/6 *Callumispora* is present up to 32 per cent, decreases in sample no. LK/3 and again rises to dominance in sample no. LK/2. *Brevitriletes*, represented by *B. unicus*, is low in LK/6, increases in the middle (38% in LK/5, 29% in LK/3) and again decreases in sample no. LK/2 (24%). *Microbaculspora* also represents a course similar to *Brevitriletes* and is represented by only one species, *M. tentula*.

In Kolimaran Pit the coal seam is 2.1-3.4 metres thick. *Callumispora* has slightly decreased in its overall representation and so has *Brevitriletes* as compared to that in New Incline. *Microbaculispora* has reduced significantly as compared to that in New Incline. On the other hand, *Parasaccites* shows a slight increase in its percentage and becomes equal to *Callumispora*. *Virkkipollenites* also increases slightly. *Illinites* (6%), *Vesicaspora* (9%), *Sulcatisporites* (4%) and *Tiwariasporis* (3%) are present in the bottom portion of the coal seam but decrease towards the top portion.

The coal seem exposed at the confluence of Sookni and Khakho rivers contain a mioflora very closely comparable to the seam present in Kolimaran Pit. Only the bottom portion of the seam (sample no. SK/2) has yielded the miospores which contains the dominance of *Callumispora* (27%) and *Parasaccites* (28%). *Virkkipollenites* (7%), *Illinites* (8%), *Vesicaspora* (10%) and *Sulcatisporites* (5%) are present subdominantly. *Brevitriletes*, which is present subdominantly in Lower Karharbari Seam is however, absent in this seam. *Sulcatisporites* is mostly represented by *S. tentulus* and *Vesicaspora* is represented by *V. ovata*.

The coal seam exposed in the railway cutting near Deep Pit contains profuse amount of woody elements and very little spores and pollen grains. However, the qualitative resemblance of the miospores, whatever present, is very close to the Lower Karharbari seam.

Upper Karharbari Seam—The coal samples of this seam were collected from Central Pit No. 2 in Srirampur area. The coal seam has split into two parts. The upper part is slightly less than 1 meter in thickness while the lower part is 1 meter thick and is parted by 0.6 meter thick sandstone. This coal seam contains a mioflora different from that of Lower Karharbari Seam. In the bottom portion (sample UK/3) of the Upper Karharbari Seam , *Sulcatisporites* is present up to 20 per cent and is mostly represented by *S. barakarensis* and *S. maximus*. Next to this genus are *Platysaccus* (19.6%), *Striatites* (14%), *Faunipollenites* (12%) and *Striatopodocarpites* (11%). However, *Sulcatisporites* decreases appreciably in the upper two samples (UK/1, UK/2) and instead *Illinites* rises to dominance (30% & 22% respectively). Striated disaccates also reduce considerably. *Parasaccites*, which is rarely present (0.5%) in sample no. UK/3, rises in sample nos. UK/2 (8%) and UK/1 (7%). Thus, the radial monosaccates (10%) have reduced considerably in Upper Karharbari Seam. The nonstriated disaccates including *Illinites* (16%) rise to dominance (51%) and striated disaccates (34%) follow next to the dominants.

The mioflora of the Giridih Coalfield described by MAITHY (1965) from a shale in Central Pit, near Srirampur has shown an abundance of radial monosaccates, viz. *Parasaccites*, *Plicatipollenites*, *Crucisaccites* and *Potonieisporites*. The position of this sample in the succession is not precisely described by the author. However, a reinvestigation of the same sample quantitatively shows a combination of *Sulcatisporites* (18%), *Vesicaspora* (12%), *Faunipollenites* (15%) and *Parasaccites* (14%). The general dominance of nonstriated disaccates (39%) and striated disaccates (22%) over the monosaccates (23%) is a very interesting feature. The genus *Sulcatisporites* was not described by MAITHY (1965) and the same is represented by *S. maximus* and *S. barakarensis*. Similarly, *Faunipollenites* is represented by

F. goraiensis more commonly than *F. varius*. In this respect the present assemblage shows a close resemblance with the bottom portion of the Upper Karharbari Seam (sample no. UK/3) but the presence of monosaccates in greater percentages differentiates this sample from the same.

Bhadua Seam—It is nearly 3.33 meters in thickness in 17B Incline with a shale band of 0.2 meters in the upper part of the coal seam. *Sulcatisporites* dominates, being present up to 36 per cent. *Primuspollenites* (18%) appears for the first time in the succession and follows next to the dominant component. *Parasaccites* although present, becomes a rare element. *Latosporites* (8%) also invades the assemblage at this stage. Thus, the total dominance of nonstriated disaccates rises to 76 per cent including *Primuspollenites* (20%) while the striated disaccates are present up to 8 per cent only.

Khandia Seams—There are four Khandia seams described from Giridih Coalfield. Out of these mean channel overall samples from Khandia-1, 2 and-4 seams were collected representing the complete thicknesses of each of them. The mioflora shows the dominance of *Sulcatisporites*, similar to Bhadua Seam. *Primuspollenites* rises to 20 per cent in Khandia-1 seam but decrease in Khandia-2 and-4. *Platysaccus* and *Striatites* maintain a uniform level of subdominance. *Faunipollenites* rises from Khandia-2 (6%) to Khandia-4 (16%). *Parasaccites* and *Latosporites* are represented up to 4 per cent in Khandia-1 but decrease further in the younger two seams.

Sample no. KJ/2 contains a mioflora comparable very closely to Khandia-4, although the percentage of *Sulcatisportes* is only up to 20 per cent.

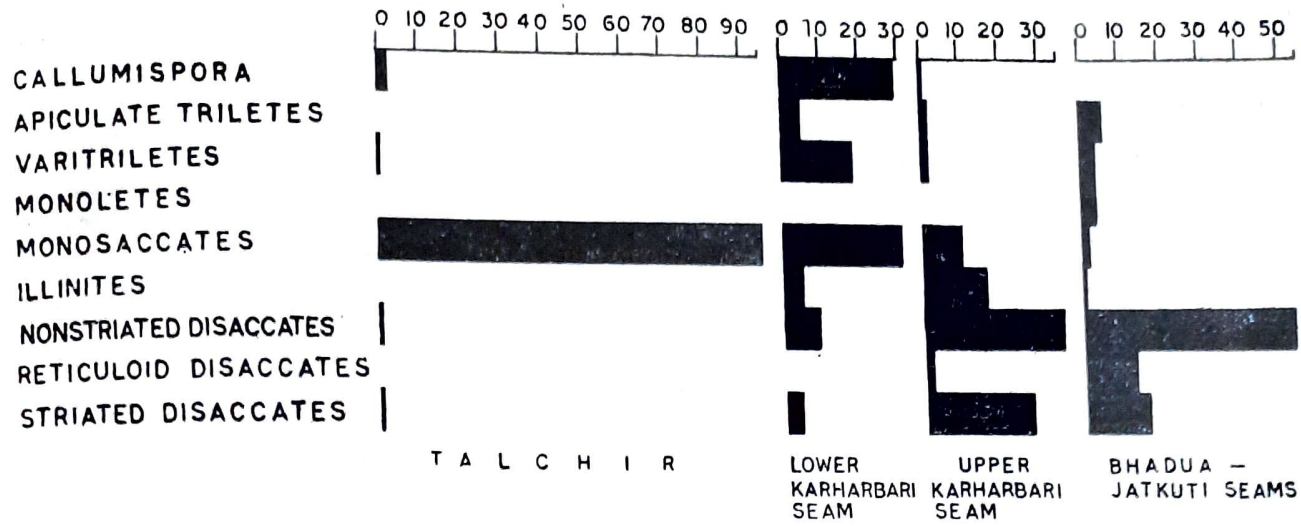
Bali Seam—This seam is exposed in Jatkuti Hill and overall sample is collected from the complete thickness (12.4 meters) of the seam. *Sulcatisporites* increases to 40 per cent while *Platysaccus* (9%), *Primuspollenites* (7%) and *Faunipollenites* (9%) remain subdominant. The nonstriated disaccate total up to 66 per cent and striated disaccates are present up to 20 per cent. The trilete miospores are present up to 10 per cent only.

Jatkuti Seam—This seam is exposed at the top of the Jatkuti Hill and is about 4 meters in thickness with a low grade coal and high ash. The bottom 0.6 meter of the seam is shaly. The coal and shale both were macerated separately. The mioflora shows the dominance of *Sulcatisporites* (40%) similar to Bali Seam. *Primuspollenites* is present up to 9 per cent in the coaly portion of the seam but decreases in the shale. *Latosporites* is present up to 10 per cent in shaly part of the seam. The nonstriated disaccates remain dominant (69%) while striated disaccates reduce to 12 per cent. Trilete miospores total only 6.5 per cent.

PALYNOSTRATIGRAPHY

The quantitative as well as the qualitative distribution of various palyno-taxa among the Lower Gondwana sediments of the Giridih Coalfield have suggested that the succession of mioflora has essentially undergone one distinct miofloral change (Histogram 2).

The miofloral assemblage in the first phase (Zone no. 1) commences with the dominant association of *Parasaccites*, *Plicatipollenites*, *Virkkipollenites* an *Potonieisporites*. This type of mioflora is associated with the compact mudstone immediately underlying the Talchir Needle Shales. Such an assemblage can be compared very closey to that described from the Talchir Boulder Bed in Jayanti Coalfield (Lele & Karim, 1971; Lele & Makada, 1972), from Manendragarh (Lele & Anil-Chandra, 1972) and the older part of Zone no. 1 of Korba Coalfield (Bharadwaj & Srivastava, 1973). Evidently the present mioflora of Giridih Coalfield should be assigned to the Talchir Stage.



HISTOGRAM 2 – SHOWING THE DISTRIBUTION OF SPORE-POLLEN GROUPS IN GIRIDIH COALFIELD

The younger phase of the miofloral Zone No. 1 includes the coal bearing sediments lying immediately above and in a confirmable contact with the Talchir rocks, i. e. the well dated Lower Karharbari Seam of the Giridih Coalfield. The first sandstone (sample no. M/7) lying confirmably over the sandy shales of Talchir Stage in Sookni River west of Baksidih, contains only sporadic and ill-preserved monosaccate pollen grains and therefore the quantitative estimation of the same was not possible. Similarly the carbonaceous shale (sample no. S/1) also proved barren. However, the first coal above the Talchir rocks, exposed at the confluence of Sookni and Khakho rivers, yielded a mioflora dominant in *Callumispora* and *Parasaccites*. *Plicatipollenites* and *Potonieisporites*, which were present significantly in older part of the Zone No. 1, have reduced considerably. The coal seam worked out in New Incline and Kolimaran Pit also contains a similar mioflora. This represents the typical Lower Karharbari mioflora of the Giridih Coalfield. Similar mioflora is also described from the coal bearing sediments above the Talchirs of Jayanti Coalfield (Lele & Makada, MS) and the younger part of Zone No. 1 in Korba Coalfield (Bharadwaj & Srivastava, 1973).

The miofloral Zone No. 2 encompasses the Upper Karharbari Seam at the base and Jatkuti Seam at the top. In Upper Karharbari Seam the percentage of radial monosaccates reduces significantly and probably represents the fag end of this group of miospores. *Callumispora* also meets a similar end in this coal seam. On the other hand, the nonstriated disaccates mark a rising trend from the Upper Karharbari Seam which is chiefly represented by *Illinites*. *Sulcatisporites* and *Vesicaspora* still remain at a low ebb. The striated disaccates also show an increase in their percentage. Such a mioflora is not described from any other Lower Gondwana sediments of India so far.

The mioflora described by Maithy (1965) has been reinvestigated here and its quantitative estimation emplaces itself in between the Lower and Upper Karharbari seams. However, its mioflora is more closer to the lower part of the Upper Karharbari Seam in view of the higher presence of striated and nonstriated disaccates.

The genus *Sulcatisporites* marks its general dominanace for the first time in Bhadua Seam and has a tendency to increase in the younger coal seams to become maximum in Jatkuti. *Primuspollenites* is present significantly in the older coal seams while it decreases in the younger ones. *Faunipollenites* appears comparatively later in Khandia-2, increases in Khandia-4 and again decreases in Bali Seam. The overall resemblance of Bhadua Seam is very close to Khandia-1 Seam while Khandia-2 and-4 show a closer relationship

to Bali Seam. This type of mioflora is known from the Zone No. 3 of Korba Coalfield (Bharadwaj & Srivastava, 1973) and should represent the Barakar Stage of Giridih Coalfield.

Thus the succession of mioflora in the Giridih Coalfield is as follows:

Zone 2	Nonstriated disaccates (chiefly *Sulcatisporites*)	—	dominant	Jatkuti seam Bali seam	Barakar
	Reticuloid and striated disaccates	—	subdominant	Khandia seam Bhadua seam	Stage
	Trilctes and Monoletes	—	rare		
	Nonstriated disaccates including *Illinites*	—	dominant	Upper Karharbari	
	Striated disaccates	—	subdominant	Seam	
	Trilctes and monosaccates	—	rare		
Zone 1	Laevigate + apiculate triletes	—	dominant	Lower Karharbari seam	Karharbari
	Monosaccates	—	subdominant		Stage
	Varitriletes and disaccates	—	next to subdominants		
	Monosaccates	—	dominant	Talchir	Talchir
	Other groups	—	rare		Stage

It may be worth while mentioning here that the Karharbari Stage encompasses the younger part of Zone No. 1, Zone Nos. 2, 3 in the subsurface sediments of Korba Coalfield (Bharadwaj & Srivastava, 1973). In view of the present investigation of the Giridih Coalfield it becomes essential to reallocate the palynological zones of Korba Coalfield. Sample nos. 132-117A of the bore hole NCKB-19 equate with the Lower Karharbari Seam while sample nos. 114-101 shows continuation of the same group of miospores as has been seen in the sample nos. 145-134. Sample nos. 98A-92 represent the transitional stage from monosaccate dominant mioflora to disaccate dominant mioflora. In this manner the sample nos. 145-134 should represent the Talchir Stage, sample nos. 132-101 be equivalent to the Karharbari Stage and sample nos. 98A-8A should be the representative of Barakar Stage in Korba Coalfield.

KARHARBARI STAGE

The Karharbari Stage was initially recognised by Hughes (1870) in the Giridih Coalfield and grouped the basal coal measures containing the Lower and Upper Karharbari seams as the basal part of the Barakar (Lower Permian). Later on Blanford (1876) studied the plant fossils of the area and suggested their separation from the Barakar Stage. Thus the Karharbari Stage was accepted as the upper part of Talchir Series. Feistmantel (1876), Oldham (1893) and Wadia (1957) preferred to accept the latter view while Fox (1931) , Krishnan (1960) and Pascoe (1959) always regarded the Karharbari Stage as the basalmost part of the Damuda Series. Since then considerable information has come to our knowledge. Basu (1964) established the widespread occurrence of the Karharbari Stage in most of the Lower Gondwana coalfields on the basis of the quality of coal. Simultaneously the significance of this stage as a mapable lithostratigraphic horizon was

recognised by GHOSH *et al.* (1964) in a number of Lower Gondwana coalfields. Actuated with the above findings GHOSH and BASU (1969) defined the Karharbari Stage as a separate horizon in between the Talchir and Barakar stages of the Lower Permian of India and assigned an Artinskian age to it.

Lithologically the Karharbari Formation is mainly characterised by: (i), the dominance of reworked Talchir material in the matrix (GHOSH, *et al.* 1964), (ii), the greywacke to sub-greywacke composition of its sandstone (GHOSH and BASU, 1969) and (iii) a distinct heavy mineral assemblage being rich in zircon, rutile and hornblende. Contrary to this the Talchir rocks are dominated by garnets and the Barakars by tourmaline. The coal of the Karharbari Stage is by an large dull and non-banded in appearance in contrast to the banded nature of the Damuda coals.

The palaeobotanical evidences of the Karharbari Stage are chiefly derived from the type area, the Giridih Coalfield. FEISTMANTEL (1879), KHAN and SINGH (1965) and MAITHY (1965, 1966, 1969) studied the plant fossisls in detail and opined that the Karharbari flora is more akin to the Talchirs than the overlying Barakars. Among the plant megafossils *Gangamopteris*, *Noeggerathiopsis*, *Gondwanidium* and *Buriadia* characterise the Karharbari Stage. The younger portion of this stage shows a gradual invasion of the *Glossopteris* element along with *Phyllotheca*.

Palynologically the Karharbari spores and pollen indicate the continuation and diversification of the Talchir mioflora while quite a few forms of the Barakar Stage also record their appearance initially at this stage.

The present investigation has given perhaps the first comprehensive account of the various stages of the miofloral succession in the Giridih Coalfield. The data obtained clearly indicates one distinct and a major change in the mioflora . The older zone is dominated by the abundance of radial monosaccates in the Talchir sediments which continue confirmably into the Lower Karharbari Seam and get associated in greater abudance with *Callumispora*, *Brevitriletes* and *Microbaculispora*. Thus, the Lower Karharbari Seam forms an integral part of the monosaccate dominant complex and although more diversified should represent the Karharbari Stage within the Talchir Series.

The radial monosaccates and *Callumispora*, which were dominant in Lower Karharbari Seam, decrease in the Upper Karharbari Seam and become rarer in the successively younger coal seams. Instead, the nonstriated (including *Illinites*) and striated disaccates increase and get profusely diversified in Bhadua and other younger seams. In this manner the Upper Karharbari Seam shows the fag end of the monosaccate dominant assemblage of the underlying horizons while the disaccate elements increase significantly and become dominant in the younger horizons. Thus, the Upper Karharbari Seam represents a phase of transition in between the two miofloras. Further the overall dominance of this coal seam is more towards the disaccate dominant mioflora and hence, represents the basal most part of the Damuda Series in the Giridih Coalfield.

Traditionally the Lower and Upper Karharbari seams were treated to represent the typical Karharbari Stage of the type area and therefore, the separation of the two may appear striking at the present juncture. This is the first attempt when the miofloras of these two coal seams have been described separately. However, the plant fossil evidences of the two coal seams individually are not known which forms the basis of recognition of the Karharbari Stage. Also the two coal seams are separated with a 60.9-106.6 metres thick parting of standstone. Therefore, the separation of the Upper Karharbari Seam from the Lower Karharbari Seam, and its inclusion at the base of the Damuda Series (Barakar Stage) deems plausible on palynological grounds so long as the megafossil evidences of the two seams

are not known completely or some additional information is available from other contemporaneous horizons of the Lower Gondwanas of India.

The above observations confirm the earlier concepts that : (i) the Karharbari Stage shows a distinct miofloral assemblage, (ii) the mioflora represents a diversified form of the Talchir mioflora, (iii) the lithologial observations agree with the palynological observations and (iv) the Karharbari Stage represents a distinct chronostratigraphic unit of the Lower Gondwana sequence in India.

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