STUDIES ON PETROGRAPHY AND MIOFLORISTICS OF COALS OF KARHARBARI AND BARAKAR STAGES FROM PARTS OF NORTH KARANPURA COALFIELD, BIHAR

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ABSTRACT

In the North Karanpura Coalfield, around Bachra-Khalari two coal measures of lower Gondwana age are exposed having diversified coal characters. The coals show marked differences in their physico-chemical and floral conditions of deposition as revealed by detailed petrographic and palynological studies. Based on palynological findings, the status of the two coal measures — the lower measure belonging to upper Karharbari Stage and the upper measure to lower Barakar Stage — is ascertained. Miofloristic aspect of distribution reveals a close affinity of the Karharbari Stage with the Barakar Stage. This is also supported by geological evidences in the area and suggests a gradual passage of one measure to the other.

INTRODUCTION

THE area under study is a part of North Karanpura Coalfield and is situated at the southern fringe of it, bounded by the latitudes 23°38′ and 23°42′-30″ North and longitudes 84°59′30″ and 85°6′30″ East and includes thirteen coal seams of various thicknesses within the lower Gondwana Group of rocks.

The area was investigated by many workers like Jowett (1925), Banerjee (1958), Ghosh (1958), Mukherjee *et al.* (1959), Mehta *et al.* (1963) but attention was given mainly on the eastern sector, i.e. in the Bachra area, Pareek (1965) etc. and Western sector, i.e. Khalari area was least emphasized. From the field study, the following dissimilarities of coal and coal bearing strata between the eastern sector and the western sector are discernible.

EASTERN SECTOR

Dip varies from 6°-10° towards N30°W-W20°W.
Topography is highly undulating.
High grade fire clay association.
Roof rock-sandstone.
Seam thickness varies greatly.
A pebble bed is present at the base, and another occasionally above the lower seams.
Structural disturbances considerable.
Two major coal seams with average thickness of 4·5 metres.
Coal is dull, soft, massive or incipiently banded.
Pyrite content high.
Spontaneous heating common.
Shale bands within coals are almost absent.
Vitrain bands are rare, mostly found as streaks.
Ash is brownish to buff in colour.
Matured coal with high heat value.

WESTERN SECTOR

Dip varies from 12°-15° towards S23°W.
Peneplaned country.
No fire clay.
Roof rock-shale.
Seam thickness more or less persistent.
No association of pebble bed with the coal seams.
Structurally less disturbed.
Ten major coal seams with average thickness of 6·7 metres.
Coal is bright, hard, compact banded and well cleaved.
Low pyrite content.
Spontaneous heating rare.
Numerous shale bands (2·3 cm to 7·6 cm) are always present.
Persistent and numerous thick vitrain bands.
Ash is whitish to bluish grey.
Maturity less and low heat value.

The existence of two coal bearing horizons (i.e. lower measure and upper measure) have been assumed on the basis of aforesaid account, i.e. on the basis of diversified coal characters, occasional presence of a pebble bed between them (only in the eastern sector, which marks the base of the upper horizon) and rarely by the lithological characters of the associated sediments. In this work comparative studies on detailed petrography and miofloral assemblages have been made with a view to understand the genetic history of the coals and paleo-geography of the area. An attempt has also been made to determine and correlate the stratigraphic position of the two measures.

GEOLOGY OF THE AREA

The lower measure occurring in the eastern sector overlies Talchir Formation with a pebble bed at the base. Towards the north, it grades into upper measure in the eastern part of the area, extending ENE and SSW with an inconsistent, thin pebble bed which marks the base of the upper horizon. The lower measure pinches out at the south central part along with the underlying Talchir Formation and in the western sector, the upper measure is seen to rest on the Pre-cambrians along the southern margin. The lower measure contains two coal seams of variable thickness of which the bottom seam (lower Bachra seam) varies in thickness from 4·8-5·5 m and top seam (upper Bachra seam) varies from 3·2-3·7 m and dip 6°-10° towards N30°W to N20°W. The upper measure includes ten major coal seams in the western sector and one in the eastern sector, the order of sequence and average thicknesses of these (as revealed from drilling record) are as follows:

Seam	*Thickness*
Karkata IV	5·8 m
Karkata III	1·83 m
Karkata II	3·96 m
Karkata I	2·73 m
Karkata	3·35 m to 4·25 m
Bisrampur	6·7 m
Bukbuka	19·5 m
Dakra	7·62 m
Dhub	2·13 m
Damodar	17·3 m
Damodar-Saphi (?)	Over 2·9 m

The stratigraphic position of Damodar-Saphi seam could not be ascertained due to lack of data but from other studies it seems to be an independent seam (since its structural attitude and other special coal characters are different from those of the western sector). All the seams dip 12°-15° towards S23°W and excepting Damodar-Saphi seam which has a dip of 2°-3° towards N65°W.

Out of all the mentioned seams, both the seams of lower measure and Karkata II, Karkata, Bisrampur, Bukbuka and Dakra seams of upper measure are economically exploited. The Damodar seam is in its development stage. Lithologically, the lower measure is represented by a basal ortho-quartzitic sandstone unit with intercalation of coal, subarkosic sandstone, shale, fire clay etc. and upper measure is represented by coarse gritty, friable and white subarkosic sandstone, carbonaceous shale, coal, siltstone and medium to coarse grained arkosic sandstone.

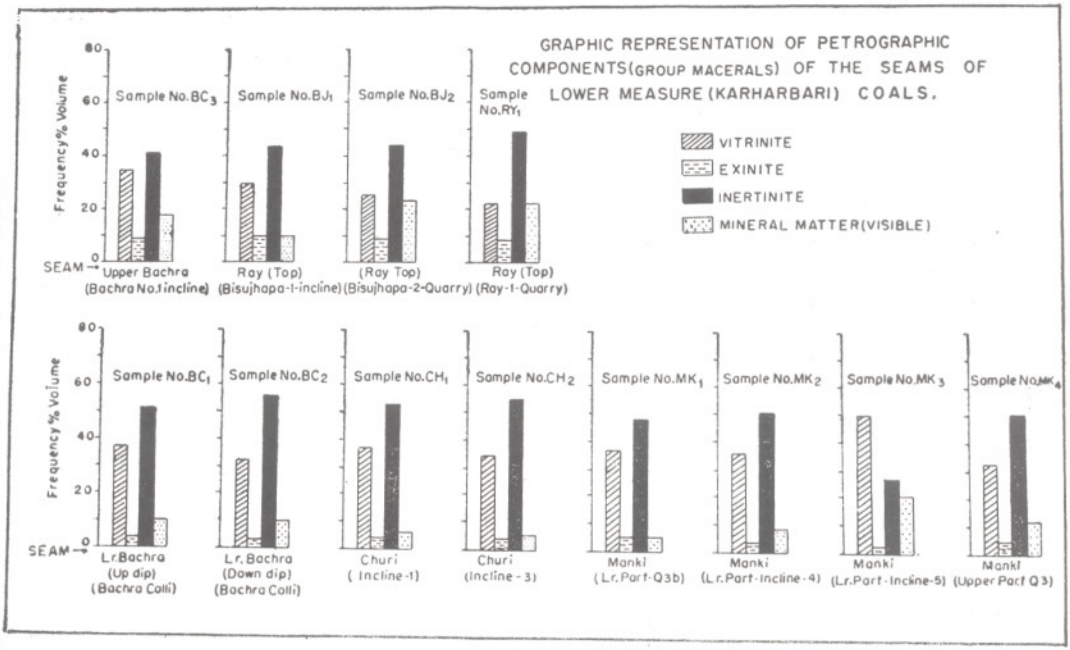
PHYSICAL CHARACTERS OF COALS

The lower measure coals are greyish black in colour, very finely banded and dull in appearance. Durain forms the major bulk of the coal and fusain is subdominantly present.

The upper meausre coals are bright, coarsely banded and hard and compact. Vitrain and durain constitute the major bulk of which vitrain is present in higher fraction.

MATERIALS AND METHODS

Coal samples were collected from all working sections of the inclines, and from the places where coal is otherwise exposed. By choosing a fresh surface, samples were collected by channelling a seam profile and block and pellet samples were prepared for petrographic studies and representative homogeneous coal matrix of 2·5 mm size were taken for palynological studies. To envisage the quantitative distribution of the miospores, pillar samples were critically studied. For separating the miospores, the coal samples were treated with Schulze's solution (HNO_3 and $KClO_3$) in a jar in 1:1 proportion, some nitric acid was added after 24 hours. After 2 to 3 days when the oxidation was complete, the supernated solution was decanted off and the sample was thoroughly washed with distilled water, then the material was treated with 10% KOH solution for about 10 minutes. The residues were then thoroughly washed with distilled water to make them completely



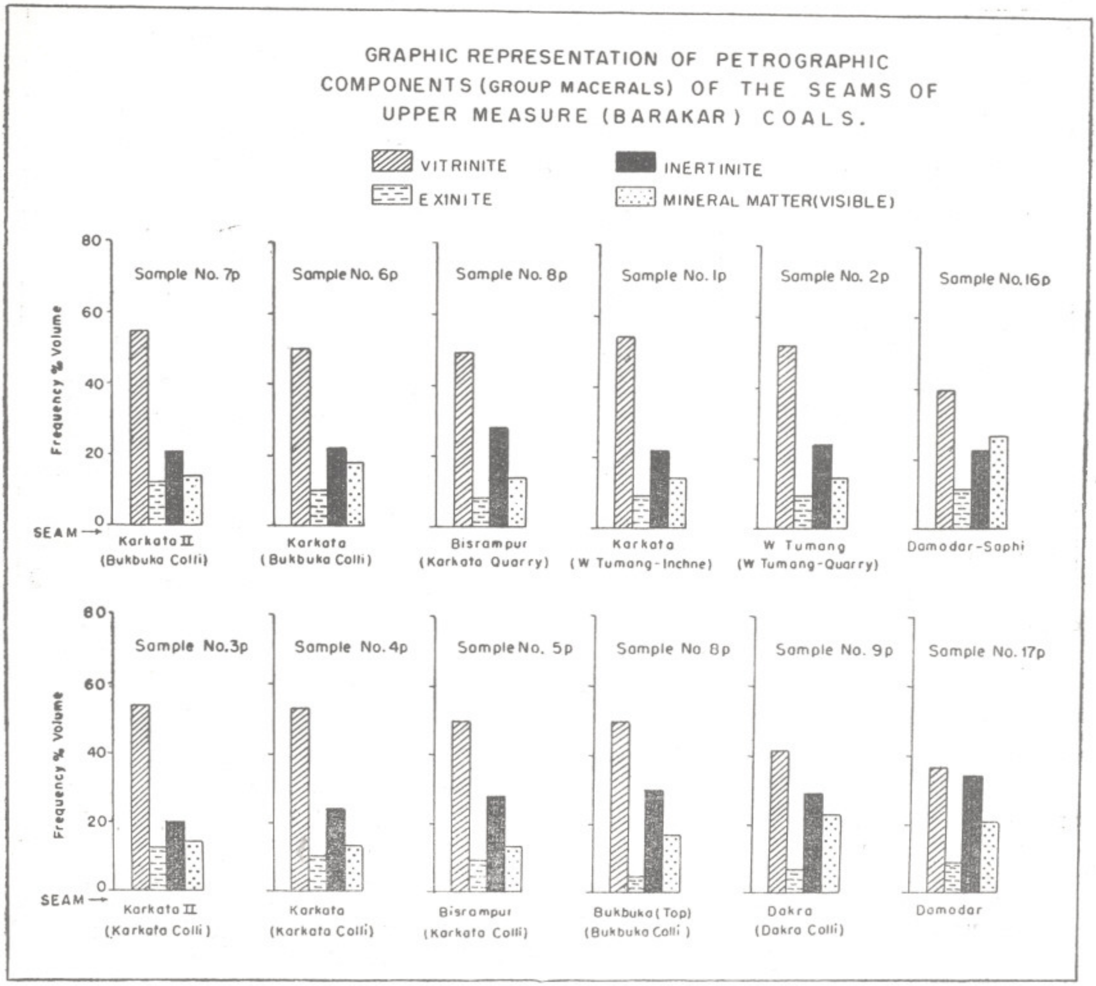
TEXT-FIG. 1

free of alkali. This end product contained miospores whose concentration was increased by series of centrifuge operations. The glycerine soaked material was then mounted in glycerine jelly and formaline was used as hardener.

PETROGRAPHIC STUDIES

From the qualitative maceral study, it was revealed that the lower measure coals show fine bandings of vitrinites and exinites and thick lenses or bands of fusinites or semifusinites (Plate 1; Figs. 1, 2 & 3); whereas upper measure coals constitute thick alternate bands of vitrinitic and exinitic masses with lenses and thin bands of semifusinites (Plate 1; Figs. 4, 5 & 6). Telinite is not very well represented in lower measure and different transitions in fusinites are present (Plate 1, Fig. 2). These coals include resin bodies which are mostly carbonized although resin content is poor. Different types of sclerotia are seen to occur in considerable proportion (Plate 1, Fig. 3). Upper measure coals contain low amount of sclerotia. Micrinite is sporadically distributed in both the measures. Cutinite is represented in both the measures in low amount (Plate 1, Fig. 6). Visible mineral matters are mostly associated with the exinitic masses or sometimes impregnated in the cell cavities of fusinites. The lower measure shows higher mineral concentration whereas it is disseminated in the upper measure. Pyrite is the dominant mineral matter in lower measure coals and clay is present in very high proportion in the upper measure coals.

Quantitatively the general order of abundance of group macerals in lower measure is inertinite (49·2-65·5%), vitrinite (27·6-41·2%) and exinite (3·2-11·5%), and in upper measure is vitrinite (45·9-63·1%), inertinite (23·2-43·1%) and exinite (8·9-15·2%). The quantitative maceral studies have been shown in the tables (Tables 1 & 2) and are illustrated by Histograms (Text-figs. 1 & 2). From the maceral study, the concentration of inertinite group in lower measure is quite distinctive and possibly accounts for an aerobic condition of bacterial attack during the formation of coal which resulted in its concentration. This decay of vegetable debris under the above-mentioned condition provided a direct contact with the atmosphere in a dried up climate which

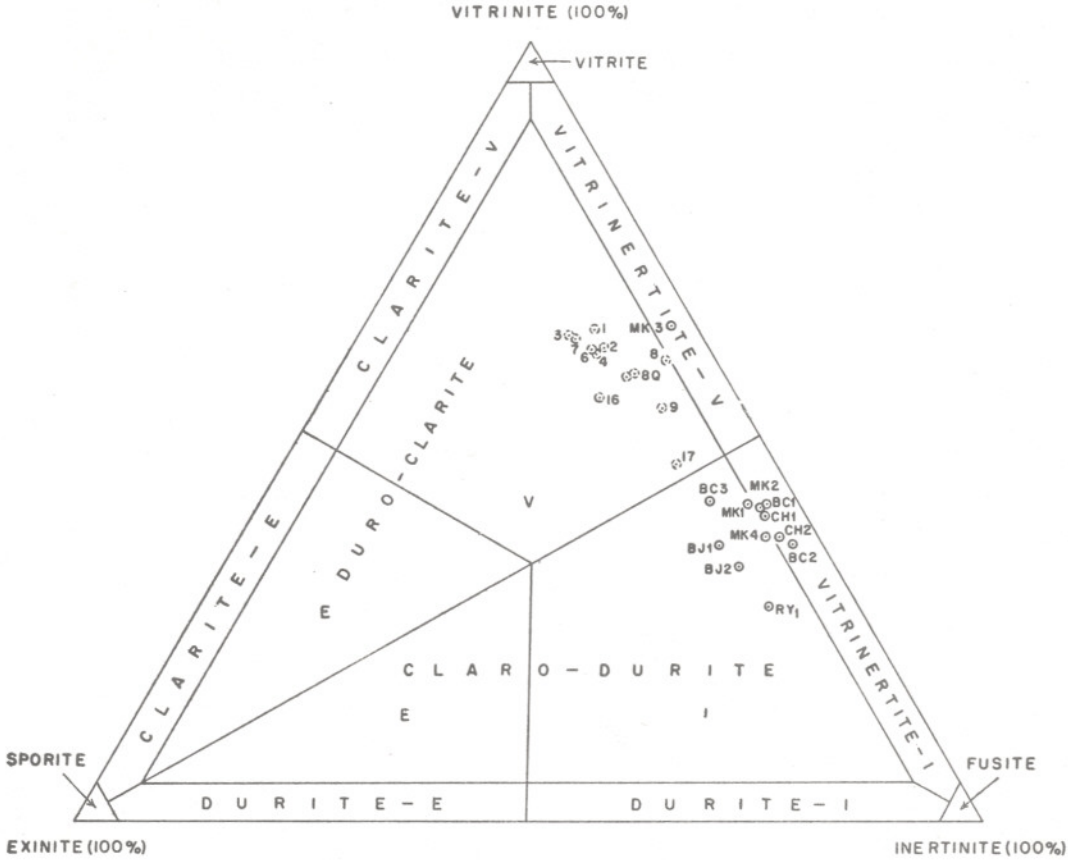


TEXT-FIG. 2

allowed a rapid loss of volatiles. On the other hand, the condition of formation of coals of upper measure was considerably wet and water being sole preservative promoted an anaerobic condition which resulted in the concentration of homogeneous collinite from a colloidal stage.

The maceral study was further aided by microlithotype analysis to get a better understanding of the coal characters. From the quantitative analyses, it was revealed that in the lower measure coals clarodurite and in upper measure coals duroclarite predominates. This is also evident from tri-component triangular diagram (Text-fig. 3). Vitrite is low in lower measures whereas it is significantly high in upper measures. Durite is high and clarite is low in lower measure and reverse is true for the upper measure. The variation is also marked in the intra-formational seams. Vitrite decreases in top seam of lower measure with increase of duroclarite whereas upper measure coals show increasing proportion of vitrite in the upper seams. The results have been tabulated (Tables 3 & 4) and illustrated by pillar diagrams (Text-fig. 4).

From the study of the reflectance, vitrinite masses of all the samples also gave some supporting idea about the maturity and rank of the coal. Reflectances were measured in a MOP microscope fitted with photovoltmeter and the scale was calibrated with respect to carborandum and reflectance



MODAL COMPOSITION OF LOWER MEASURE (KARHARBARI) AND UPPER MEASURE (BARAKAR) COALS.

(Group Macerals on visible mineral matter free basis)

⊙ UPPER MEASURE (BARAKAR) COALS, ⊙ LOWER MEASURE (KARHARBARI COALS.

TEXT-FIG. 3

values in comparison to the upper measure coals suggesting a higher maturity of the lower measure coals. Coal metamorphism due to superincumbent pressure is also observed in both the measures where the values increase considerably from upper part to the lower part of the formation. Some variations having considerably high values may be explained due to the effect of local faulting which is very common in this field. The samples from Bisujhapa Quarry and Ray Colliery show considerably high values which could be explained by the existence of a concealed fault running NE-SW.

SYSTEMATIC PALYNOLOGY

The spore and pollen grains recovered from the materials of both the measures have been arranged as follows (according to Potonié's 1956, 1958, 1960 classification):

* = Restricted to lower measure
** = Restricted to upper measure

Anteturma — *Sporites* H. Potonié, 1893
Turma — *Triletes* (Reinsch) Pot. & Kremp, 1954
Subturma — *Azonotriletes* Luber, 1935
Infraturma — *Laevigati* (Bennie & Kidston) Potonié, 1956

TABLE 1 — MODAL ANALYSIS OF MACERAL COMPOSITION OF LOWER MEASURE (KARHARBARI) COALS

Sample No.	Seam	Location	Vitrinite			Exinite			Inertinite			Visible Mineral Matter
			Collinite	Tellinite	Total	Sporinite	Cutinite	Total	Fusinite & Semifusinite	Micrinite & Sclerotinite	Total	
BC_3 (⊥)	Up. Bachra	Bachra Colliery	30·4	3·6	34·0 (41·12)	6·8	1·2	8·0 (9·68)	37·2	3·5	40·7 (49·20)	17·3
BJ_1 (⊥)	Ray (Top)	Bisujhapa Colliery (Incline 1)	27·7	1·2	28·9 (35·3)	8·1	1·3	9·4 (11·5)	40·7	2·8	43·5 (53·2)	18·2
BJ_2 (⊥)	Ray (Top)	Bisujhapa Colliery (Quarry 2)	22·8	2·6	25·4 (32·7)	6·2	1·9	8·1 (10·5)	42·2	1·6	43·8 (56·8)	22·7
RY_1 (⊥)	Ray (Top)	Ray Colliery (Quarry 1)	20·6	1·1	21·7 (27·6)	6·5	1·3	7·8 (9·9)	46·5	2·6	49·1 (62·5)	21·4
BC_1 (⊥)	Lr. Bachra	Bachra Colliery (Up dip)	35·1	1·7	36·8 (40·72)	2·9	0·2	3·1 (3·43)	45·8	4·7	50·5 (55·85)	9·6
BC_2 (⊥)	Lr. Bachra	Bachra Colliery (Down dip)	31·4	0·6	32·0 (35·43)	2·6	0·3	2·9 (3·21)	50·5	4·9	55·4 (61·36)	9·7
CH_1 (⊥)	Churi Seam (Incline 1)	Churi Colliery N.E. of CH_2	35·1	1·6	36·7 (39·09)	3·1	1·1	4·2 (4·47)	51·1	1·9	53·0 (56·49)	6·1
CH_2 (⊥)	Churi Seam (Incline 3 — near local fault)	Churi Colliery	34·03	0·07	34·10 (36·48)	2·7	1·3	4·0 (4·27)	54·2	1·2	55·4 (59·25)	6·5
MK_1 (⊥)	Manki Seam (Lower)	Manki Colliery (Quarry 3)	34·6	1·9	36·5 (40·54)	4·3	0·9	5·2 (5·78)	45·2	3·1	48·3 (53·68)	10·0
MK_2 (⊥)	Manki Seam (Lower)	Manki Colliery (Incline 4)	36·1	1·02	37·12 (40·6)	3·7	0·1	3·8 (4·1)	44·1	6·48	50·58 (55·3)	8·5
MK_3 (‖)	Manki Seam (Lower)	Manki Colliery (Incline 5)	50·1	—	50·1 (63·41)	1·3	0·9	2·2 (2·70)	20·6	6·2	26·8 (33·9)	20·9
MK_4 (⊥)	Manki Seam (Upper)	Manki Colliery (Quarry 3)	30·3	2·1	32·4 (36·8)	3·6	1·2	4·8 (5·41)	44·7	6·1	50·8 (57·8)	12·0

*Figures within parentheses are on visible mineral-matter-free basis.
(⊥) = Section perpendicular to bedding.
(‖) = Section parallel to bedding.

TABLE 2 — MODAL ANALYSIS OF MACERAL COMPONENTS OF UPPER MEASURE (BARAKAR) COALS

SAMPLE No.	SEAM	LOCATION	VITRINITE			EXINITE			INERTINITE			VISIBLE MINERAL MATTER
			COLLINITE	TELLINITE	TOTAL	SPORINITE	CUTINITE	TOTAL	FUSINITE & SEMIFUSINITE	SCLEROTINITE & MICRINITE	TOTAL	
7	K_2	Bukbuka Colliery	51·2	2·3	54·4 (62·2)	10·6	1·5	12·1 (14·2)	18·6	1·9	20·5 (23·6)	13·0
3	K_2	Karkata Colliery	50·5	2·9	53·4 (62·0)	11·6	1·2	12·8 (14·8)	18·2	1·8	20·0 (23·2)	13·8
6	Karkata	Bukbuka Colliery	46·5	3·3	49·8 (60·6)	10·0	0·2	10·2 (12·4)	21·1	1·2	22·3 (27·0)	17·7
4	Karkata	Karkata Colliery	50·0	2·8	52·8 (60·6)	10·5	0·1	10·6 (12·2)	22·8	0·9	23·7 (27·2)	12·8
2	W. Tumang	W. Tumang Colliery	50·0	2·1	52·1 (60·9)	9·1	0·6	9·7 (11·3)	21·9	1·9	23·8 (27·8)	14·4
1	Karkata	W. Tumang Colliery (Incline)	51·4	2·6	54·0 (63·1)	9·2	0·2	9·4 (11·1)	20·7	1·4	22·1 (25·8)	14·5
5	Bisrampur	Karkata Colliery	47·9	1·7	49·6 (57·1)	8·6	0·8	9·4 (10·8)	23·1	4·8	27·9 (32·1)	13·1
8Q	Bisrampur	Karkata Colliery (Quarry)	48·4	1·3	49·7 (57·7)	7·3	0·9	8·2 (9·5)	22·5	5·7	28·2 (32·8)	13·9
8	Bukbuka	Bukbuka Colliery	46·7	2·5	49·2 (59·0)	4·2	0·3	4·5 (5·4)	26·6	3·1	29·7 (35·6)	16·6
9	Dakra	Dakra Colliery	38·6	2·5	41·1 (53·1)	6·4	0·5	6·9 (8·9)	26·7	2·7	29·4 (38·0)	22·6
17	Damodar Seam	Pit	36·0	0·3	36·3 (45·9)	6·6	2·1	8·7 (11·0)	31·5	2·6	34·1 (43·1)	20·9
16	Damodar-Saphi Seam	Pit	38·1	1·7	39·8 (54·1)	10·2	1·0	11·2 (15·2)	20·4	2·2	22·6 (30·7)	26·4

*Figures within parentheses are on visible mineral-matter-free basis.

TABLE 3 — MODAL ANALYSIS OF MICROLITHOTYPES OF LOWER MEASURE (KARHARBARI) COALS

SAMPLE NO.	VITRITE	FUSITE	VITRINERTITE	DURITE	CLARITE	DURO-CLARITE	CLARO-DURITE
BC_3	9·5	5·1	8·3	14·4	8·6	23·9	30·2
BJ_2	6·9	6·1	3·6	16·2	11·9	25·1	30·2
BJ_1	6·1	4·3	5·5	20·6	9·2	22·9	31·4
RY_1	2·1	6·5	11·3	16·2	7·6	20·1	36·2
BC_1	7·1	10·6	13·4	3·5	1·2	19·8	44·4
BC_2	5·9	13·7	18·2	6·3	0·8	17·2	37·9
CH_1	8·6	16·5	14·9	4·5	1·1	20·3	34·1
CH_2	7·2	15·1	19·2	5·1	2·3	16·9	34·2
MK_1	8·1	6·8	12·6	3·2	5·6	22·9	40·8
MK_2	7·2	8·1	13·2	16·9	3·2	20·8	30·6
MK_4	5·2	10·6	10·1	6·2	5·1	18·1	44·7

TABLE 4 — MODAL ANALYSIS OF MICROLITHOTYPES OF UPPER MEASURE (BARAKAR) COALS

SAMPLE NO.	VITRITE	FUSITE	VITRINERTITE	DURITE	CLARITE	DURO-CLARITE	CLARO-DURITE
7	20·2	3·1	4·7	5·6	24·5	28·8	13·1
3	19·8	1·2	3·0	6·3	26·2	30·9	12·6
6	13·9	3·5	6·8	11·6	22·9	32·1	9·2
4	16·7	2·8	5·6	10·3	25·1	30·0	9·5
2	11·2	3·1	6·9	10·4	27·9	30·8	9·7
1	14·3	1·7	4·6	12·7	25·9	30·6	10·2
5	9·99	4·4	5·2	11·3	20·6	31·7	16·9
8	13·2	5·9	4·1	10·5	19·9	30·1	16·3
8	10·5	10·5	2·1	9·6	16·1	28·9	22·3
9	13·6	9·1	4·9	10·3	18·2	30·7	13·2
17	8·9	11·6	10·2	13·1	6·2	23·9	26·1
16	21·9	8·3	16·3	3·9	14·1	26·2	9·3

Leiotriletes (Naum.) Pot. & Kr. 1954
Punctatisporites (Ibr.) Pot. & Kr. 1954
Retusotriletes Naum. 1953

Infraturma — *Apiculati* (Benn. & Kids.) Pot. 1956

Sub-Infraturma — *Granulati* Dyb. & Jacho. 1957
Cyclogranisporites Pot. & Kr. 1954

Sub-Infraturma — *Verrucati* Dyb. & Jacho. 1957
Verrucosisporites (Ibr.) Pot. & Kr. 1954

Sub-Infraturma — *Hodati* Dyb. & Jacho. 1957
Lophotriletes (Naum.) Pot. & Kr. 1954
Apiculatisporites (Ibr.) Pot. & Kr. 1956

Sub-Infraturma — *Baculati* Dyb. & Jacho. 1957
Horriditriletes Bharad. & Salujha 1964
***Cyclobaculisporites* Bharad. 1955

Sub-Infraturma — *Varitrileti* Venk. & Kar 1965
***Microbaculispora* Bharad. 1962
***Microfoveolatispora* Bharad. 1962
**Lacinitriletes* Venk. & Kar 1965

Turma — *Zonales* (Benn. & Kids.) Pot. 1956
Subturma— *Zonotriletes* Waltz 1935
Infraturma—*Cingulati* Pot. & Kr. 1954
***Dentatispora* Tiwari 1964

Infraturma — *Zonati* Pot. & Kr. 1954
***Inditriradites* Tiwari 1964

Turma — *Monoletes* Ibr. 1933
Subturma — *Azonomonoletes* Luber 1935
Infraturma—*Psilamonoleti* Hamm. 1955
***Latosporites* Pot. & Kr. 1954

Infraturma — *Ornati* Pot. 1956
***Punctatosporites* Ibr. 1933

Anteturma — *Pollenites* Pot. 1931

TABLE 5 — SUMMARY OF REFLECTANCE STUDY OF COALS

SL. No.	SAMPLE No.	LOCATION	REFLECTANCE IN AIR	REFLECTANCE IN OIL
1	7	K_{II} Seam (Bukbuka Colliery)	7·670	0·778
2	3	K_{II} Seam (Karkata Colliery)	7·912	0·821
3	6	Karkata Seam (Bukbuka Colliery)	7·988	0·771
4	4	Karkata Seam (Karkata Colliery)	7·655	0·840
5	2	West Tumang Seam (Bisrampur-W. Tumang Quarry)	7·971	0·794
6	1	Karkata Seam (West Tumang Colliery)	7·992	0·829
7	5	Bisrampur Seam (Karkata Colliery)	7·763	0·854
8	8	Bukbuka Seam (Bukbuka Colliery)	7·938	0·873
9	9	Dakra Seam (Dakra Colliery)	7·953	0·897
10	17	Damodar-Saphi Seam	7·126	0·719
11	16	Damodar Seam	7·931	0·837
12	BC_3	Upper Bachra Seam (Bachra Colliery)	8·465	0·972
13	BJ_1	Ray (Top) Seam (Bisujhapa Colliery — Incline)	8·018	0·913
14	BJ_2	Ray (Top) Seam (Bisujhapa Colliery — Quarry)	8·321	1·061
15	RY_1	Ray (Top) Seam (Ray Colliery — Quarry)	8·226	0·987
16	BC_1	Lower Bachra Seam (Bachra Colliery — Down dip)	9·332	1·279
17	BC_2	Lower Bachra Seam (Bachra Colliery — Up dip)	9·137	1·183
18	CH_1	Churi Seam (Churi Colliery — Incline 1)	8·935	1·168
19	CH_2	Churi Seam (Churi Colliery — Incline 3)	9·216	1·220
20	MK_1	Manki (Lower) Seam (Manki Colliery)	9·153	1·019
21	MK_2	Manki (Lower) Seam (Manki Colliery)	9·937	1·230
22	MK_4	Manki (Upper) Seam (Manki Colliery)	9·716	1·129

Turma — *Saccites* Erdtm. 1947
Subturma — *Monosaccites* (Chit.) Pot. & Kr. 1954
Infraturma — *Monosaccireticuloidi* Tiwari 1964
**Potonieisporites* Bharad. 1962

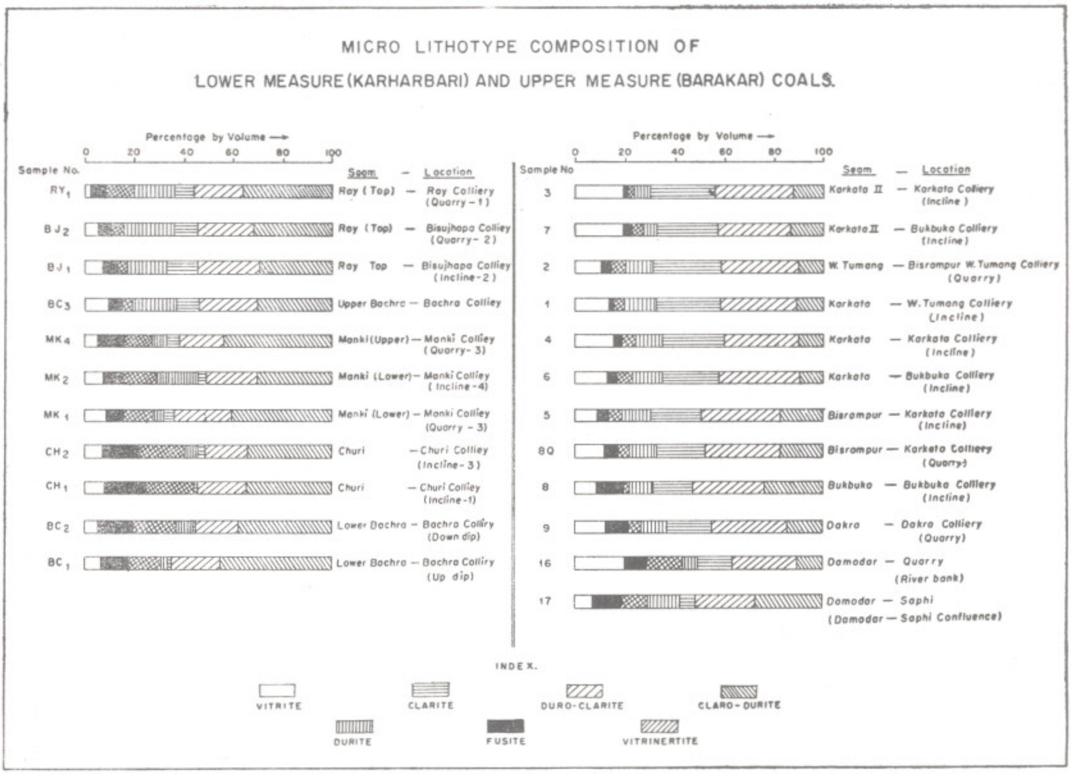
Infraturma — *Amphisacciti* Lele 1963
Parasaccites Bharad. & Tiwari 1964
**Crucisaccites* Lele & Maithy 1964

Infraturma — *Apertacorpiti* Lele 1964
Plicatipollenites Lele 1964
Virkkipollenites Lele 1964
***Divarisaccus* Venk. & Kar 1965

Subturma — *Disacciti* Cookson 1947
Infraturma — *Striateticuloiditi* Tiwari 1964
Rhizomaspora Wilson 1962
***Primuspollenites* Tiwari 1964

Infraturma — *Striatiti* Pant 1954
Striatites (Pant) Bharad. 1962
Faunipollenites Bharad. 1962
***Verticipollenites* Bharad. 1962

Infraturma — *Disacciatrileti* (Lesch) Pot. 1958
**Vesicaspora* Schemel 1951
***Sulcatisporites* (Lesch) Bharad. 1962



TEXT-FIG. 4

TABLE 6 — DISTRIBUTION OF DIFFERENT MIOSPORES IN THE SEAMS OF LOWER MEASURE (KARHARBARI) OF THE PRESENT AREA AND THAT OF KARHARBARI FORMATION OF GIRIDIH COALFIELD

SPORE GENERA SEAM AND LOCATION	LOWER BACHRA (BACHRA COLLIERY)	CHURI (CHURI COLLIERY)	MANKI (LOWER MANKI COLLIERY)	MANKI (UPPER MANKI COLLIERY)	RAY (TOP) (BISUJHAPA COLLIERY)	UPPER BACHRA (BACHRA COLLIERY)	GIRIDIH COALFIELD (MAITHY, 1965)
Punctatisporites	18·0	17·2	18·3	17·6	10·2	12·5	0·3
Apiculatisporites	6·2	6·5	5·8	4·8	8·3	8·0	—
Lophotriletes	9·5	8·9	7·6	8·9	4·3	5·2	0·3
Horriditriletes	4·8	5·0	6·4	4·5	4·1	2·5	0·3
Parasaccites	6·5	7·2	6·4	6·1	11·9	10·0	24·1
Virkkipollenites	18·2	19·9	18·1	18·3	14·3	16·5	0·6
Plicatipollenites	10·5	9·6	11·3	9·2	11·1	12·5	16·6
Faunipollenites	5·5	5·1	5·6	5·6	3·9	4·0	14·8
Striatites	1·5	2·7	2·0	1·1	0·7	1·0	15·4
Vestigisporites	3·5	2·6	4·2	2·8	1·5	2·5	—
Others	15·8	15·3	14·3	21·1	29·6	25·3	27·6

Infraturma — *Disaccimonoleti* Pot. & Kr. 1954
Vestigisporites Lele & Maithy 1964

Turma — *Plicates* (Naum.) Pot. 1960
Subturma — *Polyplicates* Erdtm. 1952
Welwitschiapites Bolch. 1953

Subturma — *Monocolpates* Ivers. & Troels-Smith 1950

Infraturma — *Intortes* (Naum.) Pot. 1958
***Vittatina* (Luber.) Wilson 1962
***Ginkgocycadophytus* Samoilowitz 1953

TABLE 7 — FREQUENCY DISTRIBUTION OF DIFFERENT SPORE GENERA IN THE BARAKAR COAL SEAMS UNDER STUDY

Spore Genera	Coal Seams (with Names of Mines)										
	Karkata (W.Tumang)	W.Tumang (Bisrampur)	K II (Karkata)	Karkata (Karkata)	Bisrampur (Karkata)	Karkata (Bukbuka)	K II (Bukbuka)	Bukbuka (Bukbuka)	Dakra (Dakra)	Damodar (Pit)	Damodar (Pit)
1. Leiotriletes	3·5	3·0	4·8	4·0	3·5	3·2	3·0	3·5	2·8	3·0	3·8
2. Retusotriletes	0·8	1·0	0·5	0·5	—	0·8	0·5	1·0	1·0	1·2	0·5
3. Punctatisporites	1·2	1·0	0·8	0·5	0·8	1·0	1·5	1·2	2·0	1·5	1·8
4. Verrucosisporites	0·5	—	0·5	—	0·8	1·0	0·8	—	0·5	—	—
5. Horriditriletes	6·5	8·0	7·5	8·8	7·2	7·5	6·8	6·5	6·0	6·2	4·8
6. Apiculatisporites	4·5	6·2	4·2	5·5	5·0	5·2	4·8	4·2	5·0	4·6	3·5
7. Lophotriletes	3·2	4·0	4·8	4·5	4·0	4·8	3·5	4·0	4·5	2·8	3·8
8. Cyclogranisporites	2·8	2·0	1·8	2·0	2·0	1·8	1·5	2·0	1·8	2·2	2·8
9. Cyclobaculisporites	3·0	2·5	3·2	2·5	2·5	3·0	2·8	1·2	1·5	3·2	2·5
10. Microbaculispora	4·5	4·0	3·5	3·0	3·5	3·2	4·0	4·0	3·5	3·4	2·5
11. Microfoveolatispora	7·8	6·2	6·0	6·0	6·5	7·0	6·8	6·5	6·0	3·6	4·8
12. Indotriradites	1·2	1·5	1·0	1·2	0·8	0·5	1·0	0·8	0·5	1·6	1·8
13. Dentatispora	0·8	0·5	—	0·8	1·0	0·8	1·0	0·5	0·5	—	—
14. Latosporites	2·5	3·0	4·5	4·0	3·2	3·0	2·8	3·0	2·5	2·4	2·6
15. Punctatosporites	2·0	1·8	2·0	1·5	1·8	1·5	2·0	1·8	1·5	3·0	2·8
16. Plicatipollenites	5·0	4·8	6·0	5·0	4·5	4·0	5·0	4·8	6·5	3·6	4·8
17. Virkkipollenites	4·2	4·0	6·5	4·5	6·5	4·0	4·5	5·0	6·0	4·8	5·4
18. Divarisaccus	1·8	1·5	0·7	1·2	—	1·0	1·0	1·5	0·8	1·2	0·2
19. Parasaccites	1·0	1·8	2·0	0·8	1·0	2·0	1·5	1·8	2·0	1·6	2·8
20. Rhizomaspora	2·0	3·0	1·0	2·2	2·5	2·8	2·0	2·3	2·8	1·8	2·4
21. Primuspollenites	1·5	1·2	—	0·8	0·8	—	1·0	—	0·8	1·2	0·8
22. Striatites	12·0	10·5	10·0	11·2	10·5	8·9	9·6	8·5	8·0	11·2	10·8
23. Verticipollenites	3·5	2·0	1·5	1·8	1·2	1·5	1·8	1·6	2·6	1·4	11·2
24. Faunipollenites	6·5	8·0	8·5	9·5	10·0	11·2	10·5	10·0	10·5	14·2	14·8
25. Schizopollis	2·4	2·0	1·5	2·5	2·0	2·8	2·5	1·8	1·5	1·8	1·6
26. Vittatina	1·6	0·8	0·5	—	2·1	1·0	0·8	0·5	1·0	0·5	0·8
27. Ginkgocycadophytus	0·5	—	0·2	0·4	—	0·8	0·5	1·0	1·0	0·8	1·2
28. Welwitschiapites	1·2	1·0	—	0·8	0·8	—	1·0	1·5	1·5	0·8	0·8
29. Sulcatisporites	12·0	14·0	13·0	12·5	11·5	12·5	13·0	13·5	13·5	15·2	14·2
30. Vestigisporites	—	0·7	3·5	2·0	4·0	3·2	2·5	6·0	3·5	—	—

Infraturma — *Monoptyches* (Naum.) Pot. 1958

Incertae Sedis ***Schizopollis* Venk. & Kar 1964

The spore and pollen grains of both the measures have been illustrated by photographs (Plates 2-5).

DISTRIBUTION OF MIOSPORES AND STRATIGRAPHIC EVALUATION

Lower Measure — From the stated types taxonomically described above, only 20 miospore genera are present in this measure; out of them 9 genera are triletes, 5 genera are monosaccates, 3 genera are non-striated disaccates, 2 genera are striated disaccates, 1 genus is plicate and monolete each. Alete and monocolpate grains are totally absent. A detailed sporological study of the coal seams of this measure indicates a diversified assemblage with some characteristic dominance of triletes and monosaccate grains (Table 6). The miospores show a close resemblance with that of Karharbari Stage by the common presence of *Punctatisporites*, *Cyclogranisporites*, *Virkkipollenites*, *Plicatipollenites*, *Parasaccites*, *Crusisaccites*, *Potonieisporites*, *Vestigisporites*, *Rhizomaspora*, *Vesicaspora*, *Faunipollenites* and *Welwitschiapites*.

The dominant presence of monosaccates accompanied by *Punctatisporites* clearly suggests a Karharbari age. The presence of the genera *Lophotriletes*, *Lacinitriletes*, *Retusotriletes*, *Rhizomaspora* and *Vesicaspora* indicate an affinity of the assemblage with the

TABLE 8 — COMPARATIVE DISTRIBUTION PATTERN OF DIFFERENT SPORE GENERA IN THE PRESENT AREA AND THAT OF OTHER BARAKAR FORMATIONS OF INDIA

Spore Genera	Korba (Bharadwaj) 1966	Chirimiri (Bharadwaj) 1966	West Bokaro (Bharadwaj) 1966	South Karanpura Coalfield (Bharadwaj) 1966	Present area (N. Karanpura Coalfield) (Mukherjee & Ghosh) 1971
1. Leiotriletes	2·1	1·0	7·2	6·0	3·4
2. Retusotriletes	3·9	6·8	—	0·3	0·7
3. Punctatisporites	5·5	2·8	—	0·6	1·2
4. Verrucosisporites	0·2	2·6	—	0·8	0·45
5. Horriditriletes	2·5	1·5	9·1	9·9	7·1
6. Apiculatisporites	4·2	—	1·9	0·4	4·9
7. Lophotriletes	3·7	10·3	6·5	5·0	4·1
8. Cyclogranisporites	0·2	4·2	3·3	0·1	1·9
9. Cyclobaculisporites	0·1	3·5	5·0	17·4	2·4
10. Microbaculispora	4·9	13·7	0·3	5·5	3·6
11. Microfoveolatispora	1·9	0·5	2·0	0·6	6·4
12. Indotriradites	23·3	6·8	0·7	1·5	0·94
13. Dentatispora	18·7	0·2	0·1	2·5	0·65
14. Latosporites	0·1	3·6	—	1·9	3·1
15. Punctatosporites	—	0·7	—	0·6	1·7
16. Plicatipollenites	1·6	1·8	—	—	4·8
17. Virkkipollenites	0·2	0·7	—	0·1	4·9
18. Diverisaccus	—	—	—	—	0·98
19. Parasaccites	3·0	2·4	—	1·2	1·5
20. Rhizomaspora	0·6	0·8	3·5	1·0	2·8
21. Primuspollenites	0·3	—	1·0	0·1	0·67
22. Striatites	3·3	1·2	9·0	10·3	9·9
23. Verticipollenites	—	0·3	—	—	1·7
24. Faunipollenites	7·0	3·4	21·0	12·3	9·4
25. Schizopollis	—	—	—	—	2·1
26. Vittatina	0·2	0·6	—	0·3	0·68
27. Ginkgocycadophytus	0·9	2·2	0·1	—	0·55
28. Welwitschiapites	0·6	0·4	—	—	0·86
29. Sulcatisporites	4·4	10·0	18·0	14·9	13·92
30. Vestigisporites	—	—	—	—	2·8

Barakar Stage. The total absence of *Quadrisporites* and *Stellapollenites* (which strictly belong to Talchir Stage) indicates its remote connection with the Talchir Stage.

Thus from the above comparison and distribution pattern of the spores of the two coal seams (Table 6) along with that of Karharbari Stage of Giridih Coalfield (Maithy, 1965) suggest its assignment to Upper Karharbari Stage.

Upper Measure—The coals of this measure reveal 30 miospore genera out of which 13 genera belong to triletes, 2 genera belong to monoletes, 4 genera belong to monosaccates, 5 genera belong to striated disaccates, 4 genera belong to monostriated disaccates, 1 genus each to monocolpate and plicates.

From the foregoing account of the distribution pattern (Table 7) of the various spore genera, it appears that the trilete types along with disaccates and few monosaccates form the bulk of the assemblage. The index association of *Sulcatisporites*, *Indotriradites*, *Lophotriletes*, *Microbaculispora*, *Latosporites*, *Faunipollenites* and *Retusotriletes* suggests the assignment of this measure to Barakar Stage (Bharadwaj, 1966) and relatively high percentage of monosaccate pollen grains indicates its close relation with the underlying Karharbari Stage. Hence from the present analysis and comparative study of the distribution pattern of the present area and other Barakar stages of India (Table 8) this measure can be placed within Lower Barakar Stage.

MIOFLORISTICS

From the present stage of knowledge about the affinity of the miospore genera, a close relation between the stated stages is apparent. The Gangamopterids and Glossopterids assemblages suggest a close association of the two stages with distinct variation. Cycadoginkgopsids are low in representation but percentage is little higher in Barakar Stage. Cryptogams are lower in proportion in Karharbaris than Barakar and gymnosperms are higher in Karharbaris. The floral characteristics of the two stages are clear from the table (Table 9), which have been deduced from the present knowledge of the affinity of the '*sporae dispersae*'

TABLE 9 — SUMMARY OF MIOFLORISTICS OF THE PRESENT AREA WITH THAT OF GENERALIZED DISTRIBUTION OF BARAKAR AND KARHARBARI FORMATIONS OF INDIA

Stage	Cryptogams		Cordaitales		Gangamopterids		Glossopterids		Conifers		Cycadoginkgops	
	Authors	Bharadwaj 1966	Authors	Bharadwaj 1966	Authors	Bharadwaj 1966	Authors	Bharadwaj 1966	Authors	Bharadwaj 1966	Authors	Bharadwaj 1966
Barakar	45·72	56·4	—	0·9	12·18	3·5	24·09	19·5	15·7	16·8	1·41	2·0
Karharbari	28·2	11·3	—	0·2	39·0	37·0	11·8	32·1	19·8	18·3	1·2	1·4

with the palaeobotanical entities (Bharadwaj, 1964).

A richer vegetation during Barakar time is clearly indicated by rich coal deposits (11 coal seams with thickness ranging 3 m to 20 metres) of the upper measure than the lower measure (Karharbari) which contains only 2 coal seams of 0·4 m to 7·8 metre thickness. This is also supported by the amount and types of spores between the stages.

The present study reveals that the two measures do not have very wide floral differences in the case of generalized data given by Bharadwaj (1964) and rather a strong floral affinity is apparent (Table 9). The geological features like continuity in sedimentation, lithological similarities etc. of the two stages under consideration also suggest a gradual passage of Karharbari Stage to Barakar Stage in the area.

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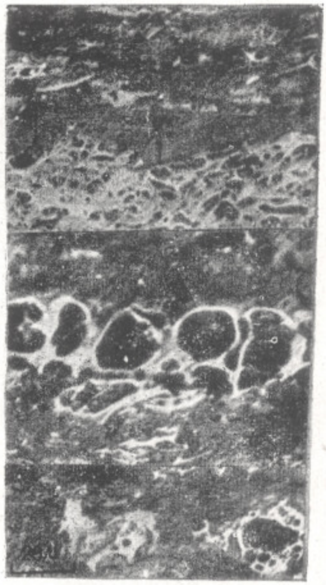

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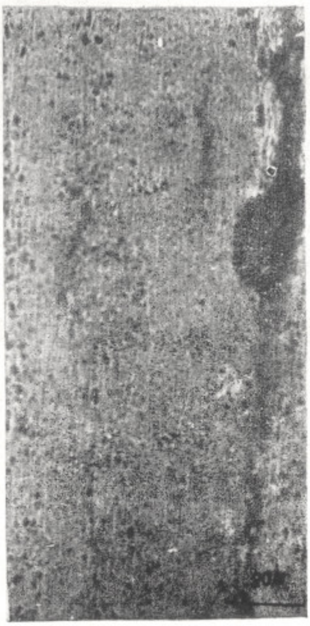

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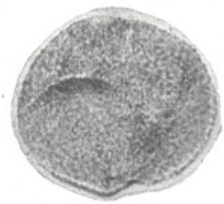

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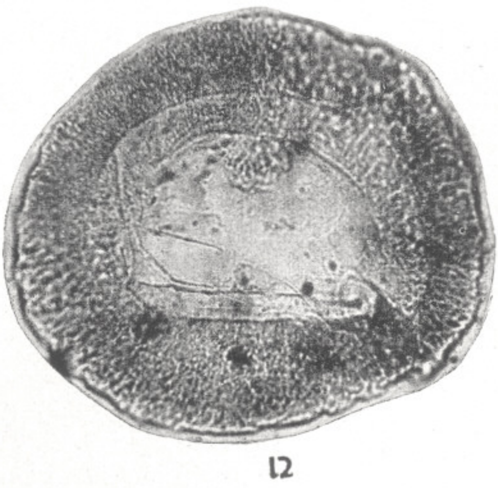

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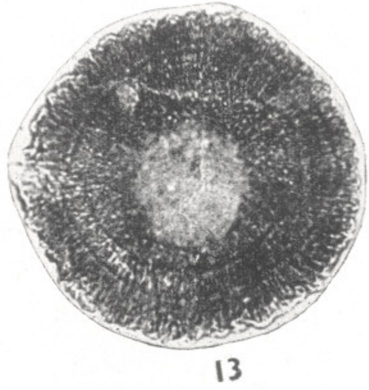

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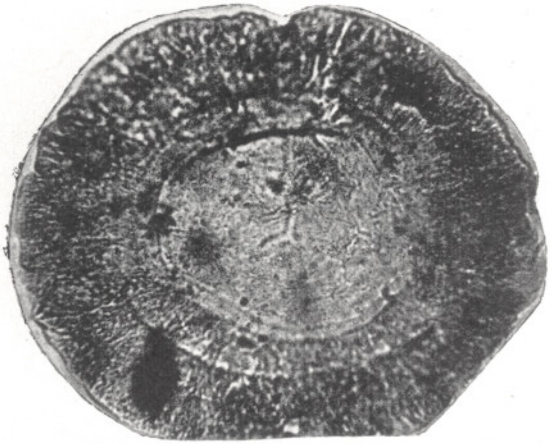

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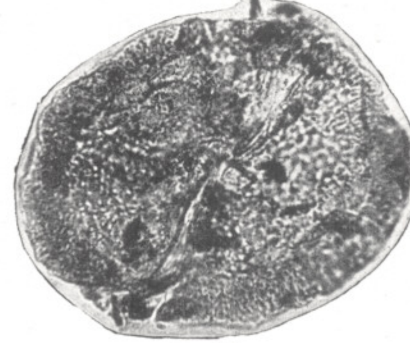

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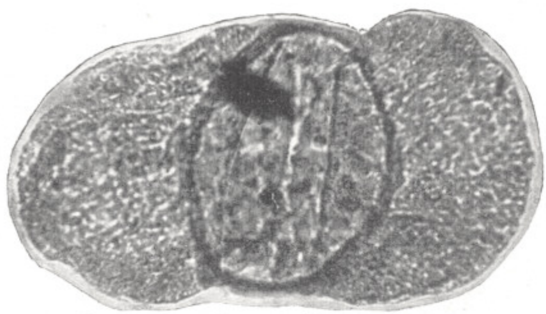

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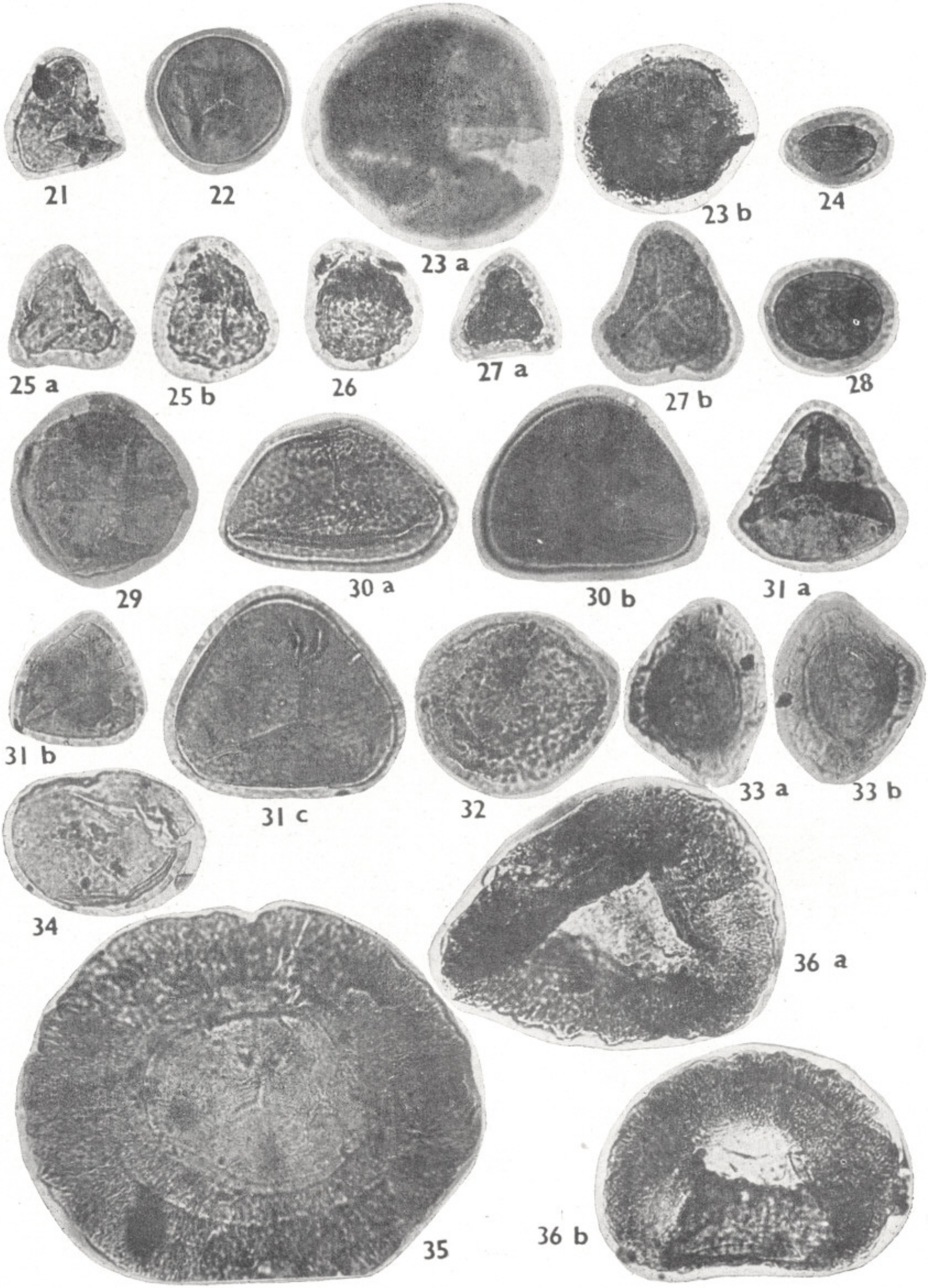
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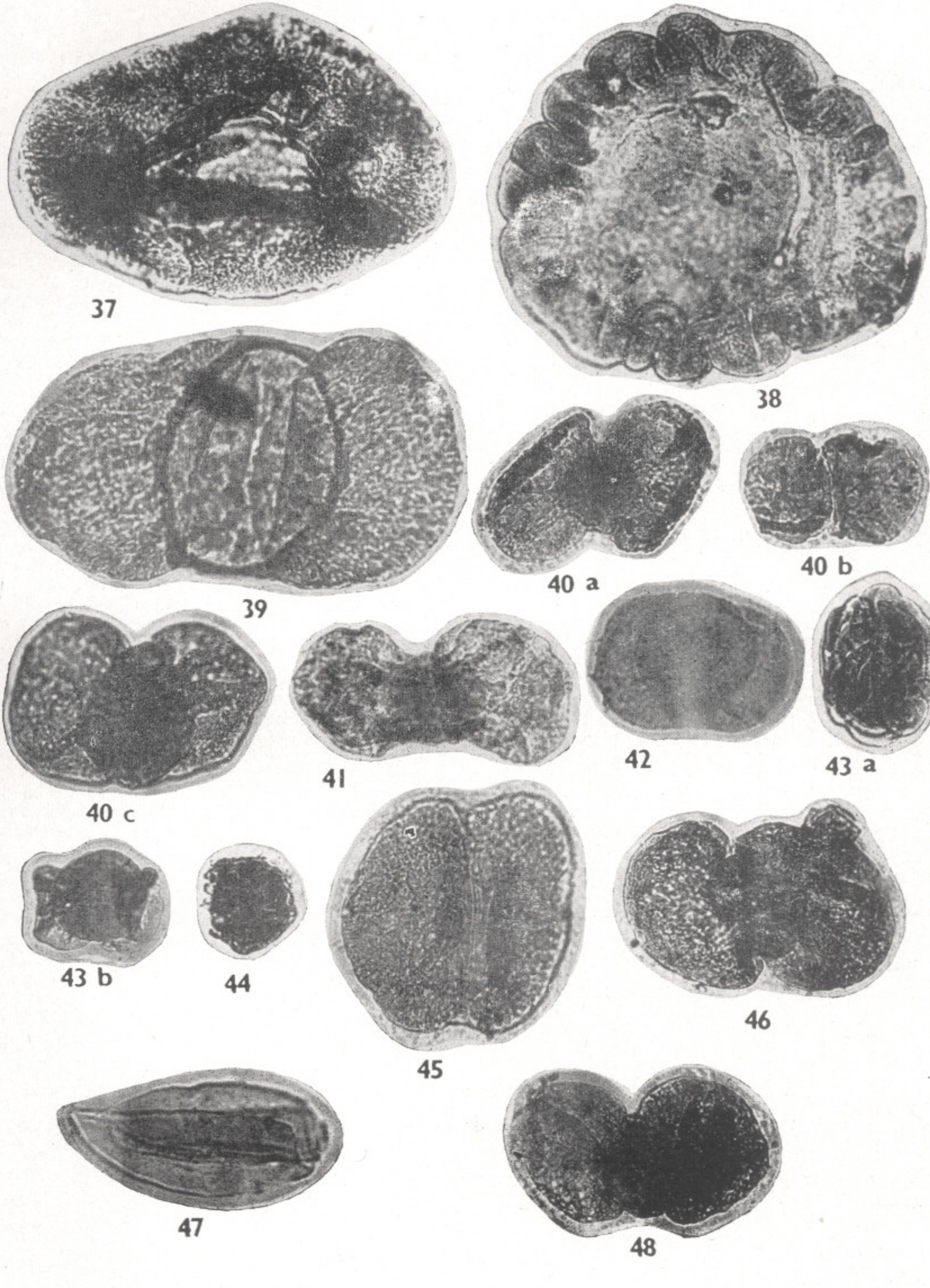
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EXPLANATION OF PLATES

[*Photo-micrograph of lower measure* (*Karharbari*) *and upper measure* (*Barakar*) *coals.* (*magnification:* × 400)]

PLATE 1

1. Typical lower measure coal showing thinly banded nature of the different components.
2. Lower measure coal showing different types of fusinitic cell structures.
3. Several types of sclerotinites in lower measure coals.
4. A representative of upper measure coal showing thickly banded nature.
5. A thick band of exinite showing impregnation of spores and cuticles in vitrinitic groundmass.
6. Upper measure coal showing banding of vitrinite and cutinite.

PLATE 2

7. *Punctatisporites gretensis* (Magnification: × 400)

8a, b. *Punctatisporites mukherjii* sp. nov. (Magnification: × 400)

9. *Retusotriletes diversiformis* (Magnification: × 400)
10. *Apiculatisporites levis* (Magnification: × 400)
11. *Cyclogranisporites* sp. (Magnification: × 400)
12. *Virkkipollenites triangularis* (Magnification: × 400)
13. *Virkkipollenites obscurus* (Magnification: × 400)
14. *Plicatipollenites indicus* (Magnification: × 400)
15. *Vesicaspora* sp. (Magnification: × 400)
16. *Potonieisporites neglectus* (Magnification: × 400)
17. *Rhizomaspora reticulata* sp. nov. (Magnification: × 400)
18. *Vestigisporites diffusus* (Magnification: × 400)
19. *Faunipollenites goraiensis* (Magnification: × 400)
20. *Lacinitriletes* sp. (Magnification: × 400)

PLATE 4

21. *Leiotriletes* sp. (Magnification: × 400)
22. *Retusotriletes* sp. ,, ,,
23. *Punctatisporites* sp. ,, ,,
24. *Verrucosisporites* sp. ,, ,,
25. *Horriditriletes* sp. ,, ,,
26. *Apiculatisporites* sp. ,, ,,
27. *Lophotriletes* sp. ,, ,,
28. *Cyclogranisporites* sp. ,, ,,
29. *Cyclobaculisporites* sp. ,, ,,
30. *Microbaculispora* sp. ,, ,,
31. *Microfoveolatisporites* sp. (Magnification: × 400)
32. *Dentatispora* sp. ,, ,,
33. *Indotriradites* sp. ,, ,,
34. *Latosporites* sp. ,, ,,
35. *Plicatipollenites* sp. ,, ,,
36. *Virkkipollenites* sp. ,, ,,

PLATE 5

37. *Divarisaccus* sp. (Magnification: × 400)
38. *Parasaccites* sp. ,, ,,
39. *Rhizomaspora* sp. ,, ,,
40. *Striatites* sp. ,, ,,
41. *Verticipollenites* sp. ,, ,,
42. *Faunipollenites* sp. ,, ,,
43. *Schizopollis* sp. ,, ,,
44. *Vittatina* sp. ,, ,,
45. *Sulcatisporites* sp. ,, ,,
46. *Vestigisporites* sp. ,, ,,
47. *Welwitschiapites* sp. ,, ,,
48. *Primuspollenites* sp. ,, ,,