Stratigraphic status of coal horizon in Tatapani–Ramkola Coalfield, Chhattisgarh, India

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The palynostratigraphic data given here are based on the explored borecores (TRBD-2, TRBD-3 and TROD-1), by Geological Survey of India. The Permian strata worked-out is about 1174.00 m thick and comprises from base to top – Talchir, Barakar and Barren Measures formations. The palynological content enables delimitation of five palynological assemblages. (i) *Scheuringipollenites barakarensis*, (ii) *Faunipollenites varius*, (iii) *Gondisporites raniganjensis*, (iv) *Densipollenites magnicorpus*, and (v) *Krempipollenites indicus* in ascending order from the subsuface rock strata. The lithologically identified strata Talchir Formation in borecores TRBD-2 and TRBD-3 is palynologically dated late Early Permian in having the *Scheuringipollenites barakarensis* and the *Faunipollenites varius* palynozones. Subsequently, the part of Barakar strata in these borecores corroborates with Barakar Formation. In borecore TRBD-3, the Barren Measures rocks do not match with the palynological dates, and are affiliated with the palynoflora of the Raniganj Formation. In TROD-1, the strata identified as Barakar Formation is dated Late Permian in having *Gondisporites ranigangensis* Palynozone; while that of Barren Measures Formation is palynologically dated Early Triassic having *Krempipollenites indicus* Palynozone. The palynology has helped in the precise dating of the Lower Gondwana succession of Odari and Bartikhurd blocks in Tatapani–Ramkola Coalfield of South Rewa Gondwana Basin.

1. Introduction

The present study focuses on the palynostratigraphy of coal-bearing sedimentary rocks in the Tatapani–Ramkola Coalfield, Chattisgarh, India. The coal-bearing Lower Gondwana rocks are exposed along the peripheral region. The Gondwana sediments are represented by variable thickness of different formations starting from Talchir Formation at the base to Supra Panchet Formation at the highest stratigraphic level (Raja Rao 1983). Very little palaeobotanical work has been carried out in this area (Bose *et al* 1977; Srivastava *et al* 1997). The biostratigraphic knowledge is very limited (Srivastava and Kar 2001). Henceforth, the primary objective of the present study is to build-up the palynozonation to provide biostratigraphy in the study area.

2. General geology

The east-west trending Tatapani–Ramkola Coalfield is the eastern member of the south Rewa Basin of the Son–Mahanadi Valley Master Basin. In this coalfield, coal bearing Lower Gondwana sediments occurring in the north and east (Tatapani

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sector) are separated from those cropping-out in the south (Ramkola sector) by vast stretches of area occupied by the formational units of Upper Gondwana Group. The coal bearing Lower Gondwana sediments disposed in an arcuate pattern occur along the northern part of the coalfield and take a southerly turn from Pipra hill in the east and finally terminate against the east-west trending border fault (Tatapani fault?) passing north of Tatapani village. In the northern side, the Lower Gondwana rocks unconformably overlie Surguja Crystalline Complex in the east, while in west the boundary between the two is faulted. This forms the Tatapani sector (figure 1).

In the southern part, the coal bearing Lower Gondwanas are exposed in the east-west stretch extending from Duba in the east to Ramkola in the west, and are juxtaposed against Surguja Crystalline Complex along EW trending southern boundary fault. This southern strip of Lower Gondwana rocks comprises the Ramkola sector.

Odari block in the south-central part of the Tatapani–Ramkola Coalfield contains coal bearing Barakar Formation under the cover of Barren Measures. However, in Bartikhurd block occurring west of Odari block, the coal bearing Barakar Formation is intersected under Raniganj Formation and Barren Measures (table 1).

The generalized stratigraphic sequence in Tatapani–Ramkola Basin is given in table 1.

3. Materials and method

Total depth in the three borecores is approximately 38.45 m in TRBD-2, 496.00 m in TRBD-3 and 649.40 m depth in TROD-1. Sediments are processed by standard maceration technique, i.e., 50 gm of sediments taken and crushed, were first treated with 40% hydrofluoric acid for 3–4 days (to remove silica material), and then followed by Nitric acid for 5 days (digestion of humic matter). Further to this, it is treated with 10% potassium hydroxide to release the humus. The maceral were mounted in Polyvinyl alcohol and Canada balsam. Five slides from each sample were prepared and pollen-spores were observed under the binocular microscope.

4. Study material

For present palynological study, in all, the samples were collected from three borecores. The details are given on the next page.

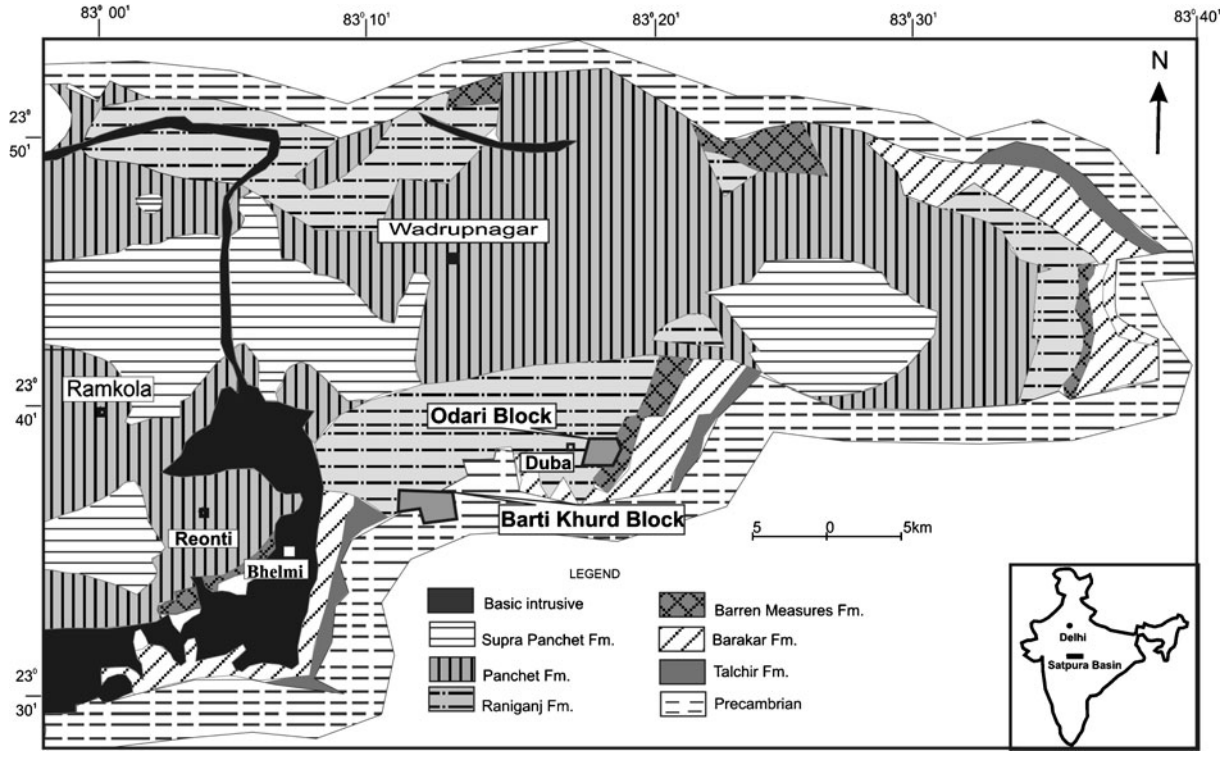

Figure 1. Tatapani–Ramkola Coalfield showing the trap blocks – Bartikhurd and Odari, from where the bore core material is obtained for the present study.

Table 1. *General stratigraphic succession of Tatapani–Ramkola Coalfield, Chhattisgarh.*

Age	Formation	Thickness	Lithology
Recent	Alluvium		Soil, sand, clay
Late Cretaceous to Palaeocene	Basic intrusive	100 m	Dolerite
Early Jurassic to Late Triassic	Supra–Panchet	200 m+	Dirty white to brick red, loose, medium- to coarse-grained arenites with ferruginous matrix and with profuse rounded, flat, medium-sized pebbles of quartz; thin oligomictic conglomerate.
	——————Low angular unconformity——————		
Middle to Early Triassic	Panchet		Mostly massive to cross-bedded sandstone, dirty white to red, and medium- to coarse-grained arenites with ferruginous matrix and occasional carbonate cement, rare oligomictic conglomerate and occasional red clay.
	i) Upper	550 m+	
	ii) Lower	250 m+	Dirty white to red, greenish white and mottled, medium- to coarse-grained subarkose to arenite with or without ferruginous matrix variegated clays.
Late Permian	Raniganj	420 m+	Fine- to medium-grained, micaceous feldspathic sandstone, dark grey to grey shale, intercalation of shale and sandstone, siltstone, impersistent coal seams.
Late Permian	Barren Measures	300 m+	Predominantly grey to black shale (at places carbonaceous) with minor fine-grained sandstone (occasionally greenish) and siltstone with very thin coal bands.
Early Permian	Barakar	468 m+	Conglomerate very coarse to pebbly sandstone, fine- to medium-grained sub-arkose, siltstone, vintercalation of shale and sandstone, carbonaceous shale and regional and local coal seams.
Early Permian to Late carboniferous	Talchir	160 m+	Diamictite, coarse- to fine-grained sub-arkose to arenite with conglomerate lenses, siltstones, variegated and green shale, limestone and very rare chart bands.
	——————Unconformity——————		
Precambrian	Surguja, crystalline, complex		Granites, gneisses, quartzite, mica-schist, phyllites, amphibolites.

4.1 *Bartikhurd Block*

Borecore – TRBD-2 (table 2)
Depth – 315.00–353.45 m
Formational contact – Barakar/Talchir formations at 329.81 m
No. of samples – 17
Productive samples – 8

Borecore – TRBD-3 (table 3)
Depth – 19.00–515.20 m
Formational contact – Barakar/Talchir formations at 496.60 m; Barren Measures/Barakar at 211.86 m
No. of samples – 110
Productive samples – 72

4.2 *Odari Block*

Borecore – TROD-1 (table 4)
Depth – 5.66–645.15 m
Formational contact – Barren Measures/Barakar formations at 443.50 m
No. of samples – 144
Productive samples – 108

5. Palynological observations

The observations are based on total of ca 1174.10 m thick strata from all the three borecores. The palynoflora recovered in the productive samples consists of moderately well preserved spores and pollen (Plates 1, 2; tables 2, 3 and 4) derived from the terrestrial material with some acritarchs. The compositional variations among spores and pollens are considered for the identification of assemblages. The presently identified Assemblages I to VI in three borecores are compared with the scheme

Table 2. *Details of lithofacies and the recovery of yield of spore-pollen and Taphonomic remains at different depths in Borehole TRBD-2, Tatapani–Ramkola Coalfield, Chhattisgarh.*

Depth (m)	Lithology	Remarks
	Contact Talchir/Barakar	
315.60	Dark grey shale	Preservation good, spore-pollen rich, organic matter common to rich
316.46	Grey silty shale	Organic plant tissues and plant matter variedly represented
337.30	Boulder+sandstone matrix	Preservation bad–fair, spore-pollen rare, organic matter rare–common
338.15	Fine grained sandstone	Organic plant tissues and plant matter variedly represented
339.00	Fine grained sandstone	
343.25	Matrix sandstone+clast	
328.00	Coal	Preservation bad–fair, spore-pollen rare, organic matter rich
328.50	Silty sandstone	Preservation bad, spore-pollen rare, wood pieces rich
329.40	Cross coal	Organic plant tissues and plant matter variedly represented
330.10	Fine grained sandstone	Preservation fair, spore-pollen rare–common, unidentifiable matter rare−common
332.35	Fine grained matrix sandstone	
344.50	Finegrainedsandstone	Organic plant tissues and plant matter is variedly represented
347.65	Finegrainedsandstone	
348.30	Finegrainedsandstone	
352.25	Sandstone matrix	Preservation fair, spore-pollen rare–common, unidentifiable matter rare–common
355.70	Sandstone matrix	Organic plant tissues and plant matter variedly represented
356.45	Sandstone matrix	Preservation fair, spore-pollen rare–common, unidentifiable matter rare–common

proposed by Tiwari and Tripathi (1992). The vertical ranges of index species are considered as given by Vijaya *et al* (2001). The below given details of assemblages are borecore wise.

5.1 *Borecore-TRBD-2 (approx. 38.45 m)*

In the total run from 315.00–353.45 m depth, only one assemblage is identified.

5.1.1 *Assemblage-I (table 6)*

Depth: 315.00–337.30 m, 352.25–356.45 m
Dominant: *Parasaccites*, *Scheuringipollenites*
Associated taxa: *Dentatispora, Callumispora, Microbaculispora, Microfoveolatispora, Cyclogranisporites, Cyclobaculisporites, Verrucosisporites, Acanthotriletes, Leiotriletes, Jayantisporites, Laevigatosporites, Densipollenites, Faunipollenites, Circumstriatites, Striatopodocarpites, Crescentipollenites, Verticipollenites* and *Schizopollis* (table 5).
Index species: *Indotriradites sparsus, Rhizomaspora indica, Striatites communis, Verticipollenites gibbosus* and *Densipollenites indicus.*
Palynodating: The assemblage is rich in having simple as well as zonate trilete spores, their representation increases in the up-section. The composition of this assemblage is similar to that known from the lower part of the Barakar Formation in the Damodar Basin, in having abundance of *Parasaccites* and *Scheuringipollenites–Faunipollenites* along with the above-mentioned index species. Assemblage-I is placed in *Scheuringipollenites barakarensis* assemblage zone of Tiwari and Tripathi (1992). It is dated as late Early Permian.

5.2 *Borecore-TRBD-3 (approx. 496.00 m)*

In the total run from 19.00–515.20 m depth, three assemblage zones are identified.

Table 3. *Details of lithofacies and the recovery of spore-pollen and other associated plant-remains, at different depths in Borehole TRBD-3, Tatapani–Ramkola Coalfield, Chhattisgarh.*

Depth (m)	Lithology	Remarks
19.00	Laminated shale	Preservation bad, spore-pollen rare, organic matter rich
20.30	Laminated shale	Preservation good, spore-pollen rich, organic matter rich
22.00	Laminated shale	Organic plant tissues and plant matter variedly represented
26.30	Silty shale	Preservation fair, spore-pollen rich, organic plant tissue material bad–fair
29.60	Silty shale	Organic plant tissues and plant matter variedly represented
32.70	Micaceous grey shale	
35.80	Silty shale	
38.70	Dark grey shale	
44.40	Dark grey shale	
48.20	Grey laminated silty sandstone	Preservation fair, spore-pollen rich, other plant tissue common
52.00	Grey shale	Organic matter and other plant tissue variedly represented
54.80	Grey micaceous shale	
57.50	Grey shale	Preservation fair, spore-pollen rich, other plant tissue rare–common
61.00	Grey micaceous shale	Organic plant tissues and plant matter variedly represented
63.70	Grey micaceous shale	
69.90	Dark grey shale	Preservation good, spore-pollen rich, organic matter common
73.00	Laminated silty shale	Organic matter and plant tissue variedly represented
77.55	Micaceous grey shale	
80.40	Dark grey shale	
84.50	Coal	Preservation bad, spore-pollen rare, other plant tissue rich
88.30	Grey silty sandstone	Organic matter and other plant tissue variedly represented
92.10	Dark grey micaceous shale	
94.45	Dark grey micaceous shale	Preservation bad, spore-pollen rare, other plant material rich
101.00	Dark grey shale	Organic matter and plant tissue variedly represented
106.70	Dark grey shale	Preservation fair, spore-pollen common, other plant tissue common
110.00	Silt+sandstone cross	Organic matter and plant tissue variedly represented
113.10	Laminated dark grey shale	Preservation bad, spore-pollen rare, organic matter rich
116.00	Shale	Organic matter and plant tissue variedly represented
118.40	Shale+sandstone	
123.20	Grey shale cross laminated	Preservation good, spore-pollen rich, other plant tissue common
129.40	Grey shale micaceous	Organic matter and other plant tissue variedly represented
133.40	Carbonaceous shale	
137.35	Shale+sandstone	
141.80	Black shale micaceous	
144.90	Black shale micaceous	
150.00	Coal band in shale	Preservation fair, spore-pollen common, other plant tissue rich
154.20	Dark shale	Organic matter and other plant tissue variedly represented
157.30	Grey shale	
160.40	Black shale	Preservation good, spore-pollen rich, other plant tissue common
166.60	Black shale	Organic matter and plant tissue variedly represented
172.10	Black shale	
176.40	Grey silt shale	
179.50	Grey silt shale	
182.00	Black shale	
188.20	Black shale	
193.75	Black shale	
197.30	Black shale	
201.45	Black shale	
207.35	Black shale	Preservation good, spore-pollen rich, other plant tissue common

Table 3. *(Continued.)*

Depth (m)	Lithology	Remarks
210.45	Siltstone	Organic matter and plant tissue variedly represented
216.65	Siltstone	
219.75	Hard compact black shale	
222.85	Grey shale	
225.95	Black shale	Preservation bad–fair, spore-pollen rich but broken, organic matter rare
230.40	Black shale	Organic matter and plant tissue variedly represented
235.25	Shale	
238.50	Black shale	
244.70	Black shale	
247.80	Grey shale	Preservation bad, spore-pollen rare, organic matter rich
253.15	Grey shale	Organic matter and plant tissue variedly represented
256.25	Grey shale	
260.00	Grey shale	
262.40	Carbonaceous shale	Preservation fair, spore-pollen rare, other plant tissue rich
266.30	Coal	Organic matter and plant tissue variedly represented
270.70	Grey shale	
271.37 – 272.74	Coal	
273.20	Siltstone	
283.10	Grey shale	Preservation good, spore-pollen rich, other plant tissue rare
288.30	Shale	Organic matter and plant tissue variedly represented
288.48 – 289.52	Coal	
291.10	Black shale	
297.45	Grey shale	
300.40	Silt shale	
301.09 – 302.65	Coal	
322.10	Black shale	Preservation good, spore-pollen common, organic matter and wood rich
331.75	Fine grained sandstone	Organic matter and plant tissue variedly represented
361.00	Dark grey micaceous shale	
368.90	Thin coal in sandstone	
374.30	Thin coal in sandstone	
384.50	Siltstone	
393.25	Coal	Preservation bad, spore-pollen rare, organic matter common, blackish splintry wood rich
401.45	Shale+sandstone	Organic plant tissues and plant matter variedly represented
403.30	Coal 40 cm	
407.05	Silt shale in sandstone	
414.20	Medium fine grained sandstone	Preservation bad, spore-pollen rare, organic matter common
415.85	Medium fine grained sandstone	
424.40	Cross beded very fine grained sandstone	Organic matter and plant tissue variedly represented
434.96	Cross laminated shale+sandstone	
436.20	Cross laminated fine grained sandstone	
438.80	Coal band 35 cm	Preservation bad, spore-pollen rich, organic matter in lumps
442.40	Cross laminated	Organic plant tissues and plant matter variedly represented
450.55	Dark grey shale	
452.24	Dark grey shale	
462.69	Black shale	Preservation bad, spore-pollen very rare, blackish unidentified matter rich

Table 3. *(Continued.)*

Depth (m)	Lithology	Remarks
463.50	Laminated fine grained sandstone	Organic plant tissues and plant matter variedly represented
466.00	Laminated fine grained sandstone	
479.60	Coal	Preservation bad, spore-pollen very rare, rich in splintary wood matter
483.38	Grey fine grained sandstone	Preservation fair, spore-pollen common, organic plant tissue rich
484.51	Grey shale	
486.10	Grey shale	
489.40	Thin coal band	
492.50	Coal band 15 cm	
495.50	Coarse grained sandstone+coal	
496.60	Contact Barakar Talchir	Organic plant tissues and plant matter variedly represented
496.96	Green fine grained sandstone+shale	
497.50	Fine grained sandstone	
501.60	Green+grey silt stone	
507.80	Boulder bed matrix	Preservation bad, spore-pollen rare, organic matter common
510.50	Very fine grained green sandstone	Organic matter and plant tissue variedly represented
511.55	Calcareous shale in mg.	Preservation bad, spore-pollen rare, organic matter rare
512.15	Medium sandstone	Organic matter and plant tissue variedly represented
513.25	Fine grained sandstone	
515.20	Medium sandstone	

5.2.1 *Assemblage-II (table 7)*

Depth: 393.25–511.55 m
Dominant: *Striatopodocarpites, Faunipollenites, Scheuringipollenites*
Associated taxa: *Cyclogranisporites, Microbaculispora, Horriditriletes, Callumispora, Indotriradites, Dentatispora, Caheniasaccites, Parasaccites, Plicatipollenites, Densipollenites, Sahnites, Platysaccus, Scheuringipollenites, Striatites, Crescentipollenites, Verticipollenites, Schizopollis, Striasulcites, Tiwariasporis, Laevigatosporites, Weylandites* and *Ginkgocycadophytes* (table 5).
Index species: *Didecitriletes horridus, Densipollenites densus, Horriditriletes curvibaculosus, Cyclobaculisporites gondwanensis, Verticipollenites crassus, Striatopodocarpites ovatus.*
Palynodating: The composition of Assemblage-II is very similar to the palynoflora from the upper part of the Barakar Formation in the Damodar Basin, in having abundance of *Faunipollenites* and *Scheuringipollenites* along with above-mentioned index species. It is placed in the *Faunipollenites varius* assemblage zone of Tiwari and Tripathi (1992), and is dated late Early Permian in age.

5.2.2 *Assemblage-III (table 7)*

Depth: 57.30–283.10 m
Dominant: *Striatopodocarpites*
Associated taxa: *Cyclogranisporites, Cyclobaculisporites, Microbaculispora, Horriditriletes, Brevitriletes, Callumispora, Laevigatosporites, Thymospora, Parasaccites, Striamonosaccites, Barakarites, Scheuringipollenites, Sahnites, Vestigisporites, Platysaccus, Faunipollenites, Striatites, Crescentipollenites, Verticipollenites, Distriatites,Schizopollis, Striasulcites, Primuspollenites, Guttulapollenites, Densipollenites, Weylandites, Gondisporites* and *Welwitsciapites.*
Acritarch: *Leiosphaeridia* and *Quadrisporites* (table 5).
Index species: *Gondisporites reticulates, Distriomonosaccites ovalis, Distriatites bilateris, Verticipollenites oblongus.*
Palynodating: In Assemblage-III, variety of trilete spores continue from the older Assemblages I and II, but do not attain high frequency. This composition is very similar to the known palynoflora from lower part of the Raniganj Formation in Damodar Basin and having an abundance of *Striatopodocarpites, Funipollenites* and *Crescentipollenites.* Hence, it is placed in the *Gondisporites raniganjensis* assemblage zone of Tiwari and Tripathi (1992), and dated Late Permian in age. The presence of acritarch is noteworthy.

5.2.3 *Assemblage-IV (table 7)*

Depth: 19.00–54.80 m
Dominant: *Densipollenites*

Table 4. *Details of lithofacies and the recovery of spore-pollen and other associated remarks at different depths in Borehole TROD-1, Tatapani–Ramkola Coalfield, Chhattisgarh.*

Depth (m)	Lithology	Remarks
5.66	Buff silt sandstone	Unproductive
7.85	Brownish clay	Organic plant tissues and plant matter variedly represented
9.70	Brownish clay	
10.00	Brownish clay	Preservation fair, mixed black or yellow, organic matter poor, not much
10.60	Mudstone	Preservation fair, mixed black or yellow, organic matter poor, not much
11.65	Grey mudstone	Preservation fair, mixed black or yellow, organic matter poor, not much
11.75	Grey micaceous shale	Preservation fair, mixed black or yellow, organic matter poor, not much
12.50	Grey micaceous shale	Preservation fair, plant tissues or wood rare
13.75	Light grey shale	
14.40	Grey silt stone	Preservation fair, plant tissues or wood rare
14.90	Grey shale	
16.80	Dark grey mica shale	
19.10	Dark grey mica shale	Organic plant tissues and plant matter variedly represented
22.00	Light grey shale	
23.60	Light grey shale	
26.30	Grey shale+sandstone	Preservation fair, spore-pollen, other plant tissue rich
28.00	Grey shale+sandstone	Organic matter and plant tissue variedly represented
31.70	Grey shale	
33.90	Grey shale	Preservation fair, spore-pollen, other plant tissue rich
37.20	Medium grained sandstone	Organic matter and plant tissue variedly represented
40.00	Dark grey shale	Other plant tissue common, preservation fair
43.00	Dark grey shale	Organic matter and plant tissue variedly represented
46.00	Dark grey shale	Preservation bad, other plant tissue rare–common
50.40	Fine grained silt stone	Preservation fair, spore-pollen, and other plant tissue common
52.10	Sandy shale	Preservation bad, other plant tissue and wood rare
54.25	Micaceous sandy shale	Organic matter and plant tissue variedly represented
56.10	Grey shale	Preservation fair, other plant tissue rich
58.60	Grey shale	Preservation fair, other plant tissue common
62.25	Grey micaceous sandstone	Organic matter poor, fair–good, black wood present
63.90	Grey micaceous sandstone	Preservation bad, other plant tissue rich
65.50	Shale	Preservation bad, other plant tissue rich
67.15	Shale	Preservation bad, other plant tissue rich
71.55	Grey shale	Preservation bad, other plant tissue rich
75.00	Grey shale	Very good preservation, other plant tissue rare–common
79.00	Grey shale	Good preservation, other plant tissue rare–common
84.60	Grey shale	Fair preservation, other plant tissue rare–common
86.55	Silty sandstone	Preservation bad, organic matter rare
91.50	Grey shale	Good preservation, other plant tissue rare–common
95.30	Micaceous grey shale	Preservation bad–fair, other plant tissue rich
97.70	Grey shale in sandstone	Preservation bad–fair, other plant tissue rich
100.60	Grey shale	Preservation bad–fair, other plant tissue rich
103.80	Grey shale	Other plant tissue common
107.90	Fine-grained silty shale	Good preservation, other plant tissue common
110.20	Dark grey shale	Preservation fair, other plant tissue rich
113.90	Dark grey shale	Preservation bad, other plant tissue rich
118.15	Dark grey shale	Preservation good, other plant tissue common

Table 4. *(Continued.)*

Depth (m)	Lithology	Remarks
121.80	Grey shale	Preservation fair, other plant tissue rare–common
125.05	Grey shale	Preservation fair, other plant tissue rare–common
129.35	Grey shale	Preservation fair, other plant tissue rare–common
131.90	Grey shale	Preservation bad, other plant tissue rare–common
136.00	Grey shale	Preservation good, other plant tissue rare–common
139.00	Grey shale	Preservation good, other plant tissue rare–common
142.60	Grey shale	Preservation good, other plant tissue rare–common
146.00	Grey shale	Preservation good, other plant tissue rare
148.35	Sandy grey shale	Preservation good, other plant tissue rare–common
153.00	Sandy grey shale	Preservation good, other plant tissue rare
156.45	Sandy grey shale	Preservation bad, other plant tissue rare–common
162.50	Sandy grey shale	Preservation fair, other plant tissue rich
168.75	Sandy grey shale	Preservation good, other plant tissue rare–common
171.25	Sandy grey shale	Preservation fair, other plant tissue rare–common
173.80	Grey shale	Preservation fair, other plant tissue rich
176.95	Grey shale	Preservation bad, other plant tissue rich
179.80	Brown silt stone	Preservation fair, black wood common
181.15	Grey shale	Preservation fair–good, other plant tissue rich
186.55	Grey fine grained sandstone	Preservation good, other plant tissue rare–common
189.75	Silt+sandstone	Preservation fair, other plant tissue common, light colour, black wood present
195.85	Grey shale in sandstone	Preservation fair, other plant tissue common, light colour, black wood present
198.85	Grey shale	Preservation bad, other plant tissue rich
208.00	Grey shale	Preservation bad, other plant tissue rich
212.55	Grey shale	Preservation bad, other plant tissue rich
219.30	Grey shale	Other plant tissue rare–common, light colour
225.50	Grey shale	Other plant tissue rich, light yellow, preservation fair
231.10	Grey shale	Other plant tissue common, fair–good
235.95	Grey shale	Preservation good, other plant tissue rich
240.70	Grey shale	Other plant tissue and big wood pieces common
246.80	Grey shale	Other plant tissue common, light colour
252.50	Grey shale	Preservation bad, other plant tissue common
258.50	Dark grey shale	Organic matter and plant tissue variedly represented
264.70	Dark grey shale	
273.95	Dark grey shale	
280.05	Dark grey shale	
285.50	Dark grey shale	Preservation fair, other plant tissue rich
290.45	Grey sandstone +shale	Organic matter and plant tissue variedly represented
293.45	Grey sandstone+shale	Preservation fair, other plant tissue rich
299.50	Grey sandstone+shale	Organic matter and plant tissue variedly represented
308.55	Grey sandstone+shale	
314.40	Fine-grained grey sandstone	Preservation fair, other plant tissue common
320.66	Intercalation sandstone+shale	Organic matter and plant tissue variedly represented
326.00	Intercalation sandstone+shale	Preservation bad, other plant tissue rich
332.50	Intercalation sandstone+shale	Organic matter and plant tissue variedly represented
339.40	Intercalation sandstone+shale	Other plant tissue rich, preservation bad–fair
348.10	Intercalation sandstone+shale	Organic matter and plant tissue variedly represented

Table 4. *(Continued.)*

Depth (m)	Lithology	Remarks
357.20	Intercalation sandstone+shale	Other plant tissue rich, preservation bad–fair
364.00	Intercalation sandstone+shale	Organic matter and plant tissue variedly represented
371.10	Shale	Other plant tissue common
377.10	Shale	Organic matter and plant tissue variedly represented
382.15	Dark grey shale	Other plant tissue rare–common
390.30	Dark grey shale	Organic matter and plant tissue variedly represented
396.00	Dark grey shale	Other plant tissue rich, preservation bad–fair
406.50	Grey shale	Organic matter and plant tissue variedly represented
409.80	Grey shale	Other plant tissue rich, bad
422.60 428.10	Micaceous grey shale Pebbles grey shale	Organic matter and plant tissue variedly represented
429.75 – 431.40	Carbonaceous shale with band of shale coal	Other plant tissue rich, preservation bad, not clear, black matter attached
435.80	Grey silt shale	Organic matter and plant tissue variedly represented
442.90	Grey silty shale	Other plant tissue rich, preservation bad
450.45	Coaly shale	Organic matter and plant tissue variedly represented
460.55	Carbonaceous shale	Preservation bad, other plant tissue common
471.00	Grey shale	Organic matter and plant tissue variedly represented
480.00	Black shale	Other plant tissue rich, yellow colour
486.65	Black shale	Organic matter and plant tissue variedly represented
495.70	Black shale	Other plant tissue rich, yellow colour
499.10	Black shale	Organic matter and plant tissue variedly represented
504.00	Black shale	Other plant tissue rich, preservation bad–fair
508.35	Intercalation grey shale	Organic matter and plant tissue variedly represented
513.00	Grey shale	Rich in black wood pieces, preservation fair
521.45	Black shale	Organic matter and plant tissue variedly represented
526.55	Black shale	Other plant tissue rich, preservation bad, light colour
531.55	Grey shale	Other plant tissue rich, preservation bad, light colour
535.35	Grey shale	Other plant tissue rich, preservation bad, light colour
539.00	Coal band	Other plant tissue rich, preservation bad, very light colour
545.60	Black shale	Organic matter and plant tissue variedly represented
554.55	Grey shale band in sandstone	Other plant tissue rare–common, preservation fair–good
562.25	Coal	Organic matter and plant tissue variedly represented
568.80	Dark grey shale	Other plant tissue rich, preservation bad–fair
574.30	Grey shale	Organic matter and plant tissue variedly represented

Table 4. *(Continued.)*

Depth (m)	Lithology	Remarks
577.50	Carbonaceous shale	Other plant tissue rich, preservation bad
586.20	Carbonaceous shale	Organic matter and plant tissue variedly represented
590.45	Carbonaceous shale	Other plant tissue rich, preservation bad, very light colour
594.45	Siltstone	Organic plant tissue and plant matter variedly represented
597.90	Grey shale	Other plant tissue rich, preservation bad–fair
601.40	Coal	Organic matter and plant tissue variedly represented
608.20	Grey shale	Other plant tissue rich, light colour
611.50	Grey shale	Organic matter and plant tissue variedly represented
616.45	Grey shale in sandstone	Other plant tissue, black wood light, preservation fair
621.15	Grey shale in sandstone	Organic matter and plant tissue variedly represented
624.80	Grey shale in sandstone	
629.15	Grey shale in sandstone	Black organic matter, unidentifiable
631.15	Grey shale in sandstone	Organic matter and plant tissue variedly represented
632.90	Grey shale in sandstone	
636.20	Grey shale in sandstone	Organic matter rich, preservation fair
640.60	Grey shale in sandstone	Organic matter and plant tissue variedly represented
642.10	Grey shale in sandstone	
645.15	Coaly shale	Other plant tissue rich, preservation bad–fair

Associated taxa: *Brevitriletes, Laevigatosporites, Scheuringipollenites, Striatopodocarpites, Faunipollenites, Striatites*, *Crescentipollenites, Verticipollenites, Distriatites* and *Vittatina* (table 5).
Index species: *Lundbladispora brevicula, L. microconata, Arcuatipollenites diffusus* and *Krempipollenites indicus*.
Palynodating: The composition of Assemblage-IV is similar to that of Assemblage-II. However, presence of taxa *Playfordiaspora* delineates the stratigraphic placement of this assemblage. It is equivalent to the palynoflora from uppermost Raniganj Formation of Damodar Basin in the dominance of *Striatopodocarpites, Densipollenites* and *Crescentipollenites*. It is placed in *Densipollenites magnicorpus* assemblage zone of Tiwari and Tripathi (1992), and is dated latest Permian in age.

5.3 *Borecore-TROD-1 (approx 649.40 m)*

In the total run of 5.66–645.15 m, two assemblages are identified.

5.3.1 *Assemblage-V (table 8)*

Depth: 460.50–645.15 m
Dominant: *Striatopodocarpites*
Associated taxa: *Cyclogranisporites, Microbaculispora, Horriditriletes, Brevitriletes, Indotriradites, Laevigatosporites, Densipollenites, Barakarites, Parasaccites, Plicatipollenites, Potonieisporites, Faunipollenites, Crescentipollenites, Verticipollenites, Distriatites, Striatites, Schizopollis, Scheuringipollenites, Primuspollenites, Arcuatipollenites, Playfordiaspora, Accintisporites* and *Weylandites* (table 5).
Index species: *Gondisporites reticulatus, Krempipollenites indicus, Arcuatipollenites diffusus, Gondisporites raniganjensis* and *Densipollenites magnicorpus*.
Palynodating: The overall composition of Assemblage-V is similar to that known from the upper part of the Raniganj Formation of Damodar Basin having dominance of *Striatopodocarpites, Crescentipollenites, Densipollenites* along with above-mentioned index species. But these two taxa, *Arcuatipollenites pellucidus* and *Playfordiaspora cancellosa* make their appearance at 645.15 m depth. Therefore, it is placed in the *Densipollenites magnicorpus* assemblage zone of Tiwari and Tripathi (1992), and is dated as latest Permian in age.

5.3.2 *Assemblage-VI (table 8)*

Depth: 12.50–442.90 m
Dominant: *Striatopodocarpites*
Associated taxa: *Microbaculispora, Horriditriletes, Cyclobaculisporites, Camptotriletes,*

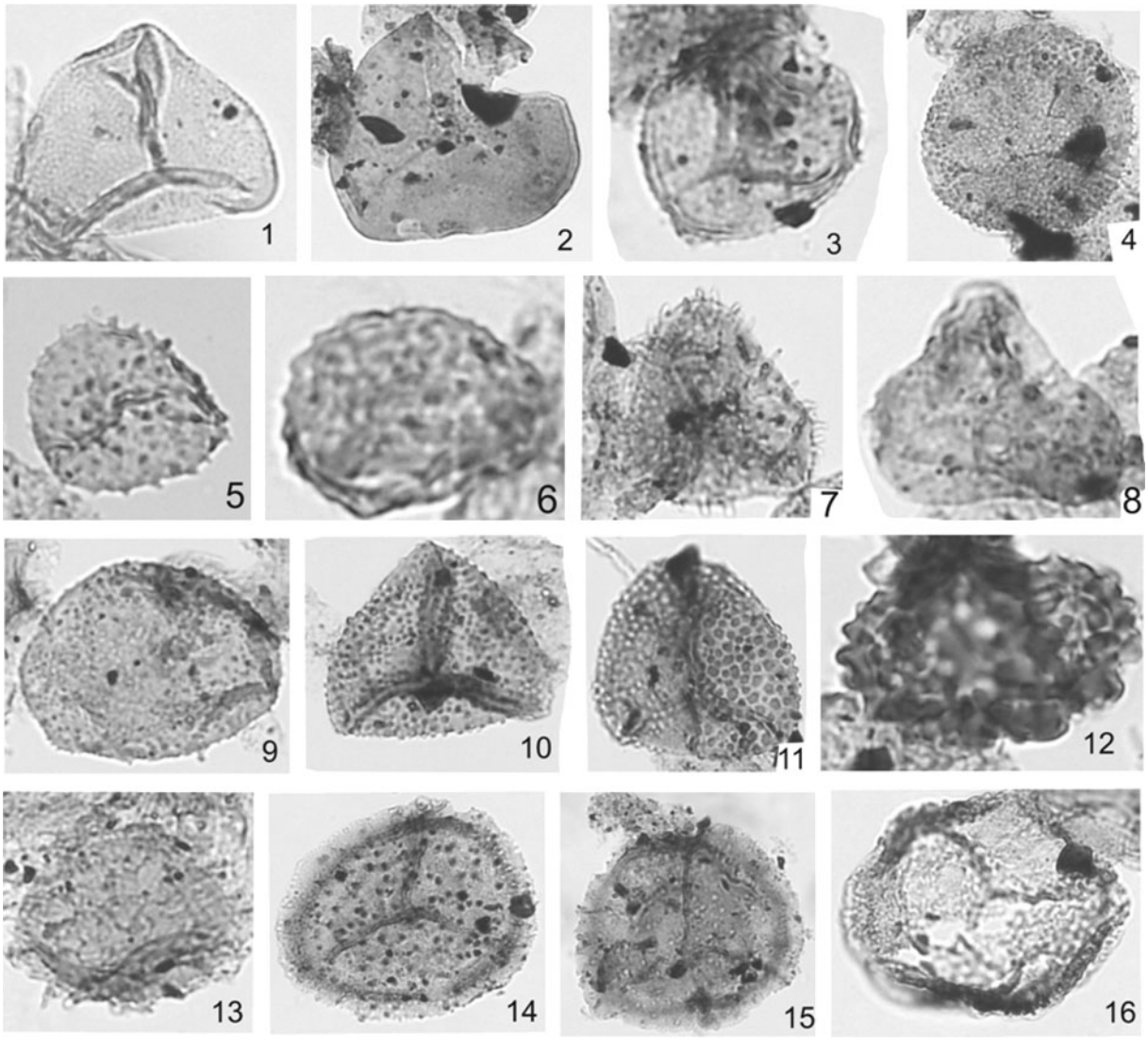

Plate 1. 1. *Microfoveolatispora foveolata* Tiwari (1965); 2. *Microfoveolatispora bokaroensis* Tiwari (1965); 3. *Cyclogranisporites triletus* Kar (1970); 4. *Microbaculispora tentulu* Tiwari (1965); 5. *Brevitriletes unicus* Bharadwaj and Srivastava (1969); 6. *Thymospora thiessnii* Willson and Venkatachala (1963); 7. *Horriditriletes curvibaculosus* Bharadwaj and Salujha (1964); 8. *Horriditriletes* sp.; 9. *Cyclogranisporites distinctus* Kumaran and Maheshwari (1980); 10. *Microbaculispora indica* (Tiwari) emend. Tiwari and Singh (1981); 11. *Microbaculispora barakarensis* Tiwari (1965); 12. *Verrucosisporites triassicus* Bharadwaj and Tiwari (1977); 13. *Indotriradites cuspidus* (Balme) Bharadwaj and Tiwari (1977); 14. *Gondisporites raniganjensis* Bharadwaj (1962); 15. *Lundbladispora raniganjensis* Tiwari and Rana (1981); 16. *Ringosporites fossulatus* (Balme) Tiwari and Rana (1981).

Osmundacidites, Acanthotriletes, Lophotriletes, Indotriradites, Striamonosaccites, Distriamonosaccites, Krempipollenites, Faunipollenites, Crescentipollenites, Verticipollenites, Distriatites, Striatites, Schizopollis, Striapollenites, Striasulcites, Distriatites, Guttulapollenites, Trabeculisporites, Protoeusaccites, Caytonipollenites, Accintisporites, Alisporites, Weylandites and *Tiwariasporis* (table 5).

Acritarch: *Peltacystia* and *Quadrisporites.*

Index species: *Playfordiaspora cancellosa*, *Satsangisaccites nidpurensis, Plicatisaccus, Brachysaccus, Minutosaccus, Lundbladispora baculata* and *Densoisporites* sp.

Palynodating: The overall qualitative composition along with index species of this assemblage is akin to the palynoflora recovered from the Lower Triassic succession Panchet Formation of Damodar Basin. Here, the first occurrence of *Minutosaccus* sp. at 442.90 m, *Plicatisaccus* sp. and *Brachysaccus* sp. at 409.80 m depth is noteworthy. Proliferation of *Playfordiaspora cancellosa* is noticed at 65.00 m depth. Considering all these characteristics, the assemblage is placed in the *Krempipollenites indicus*

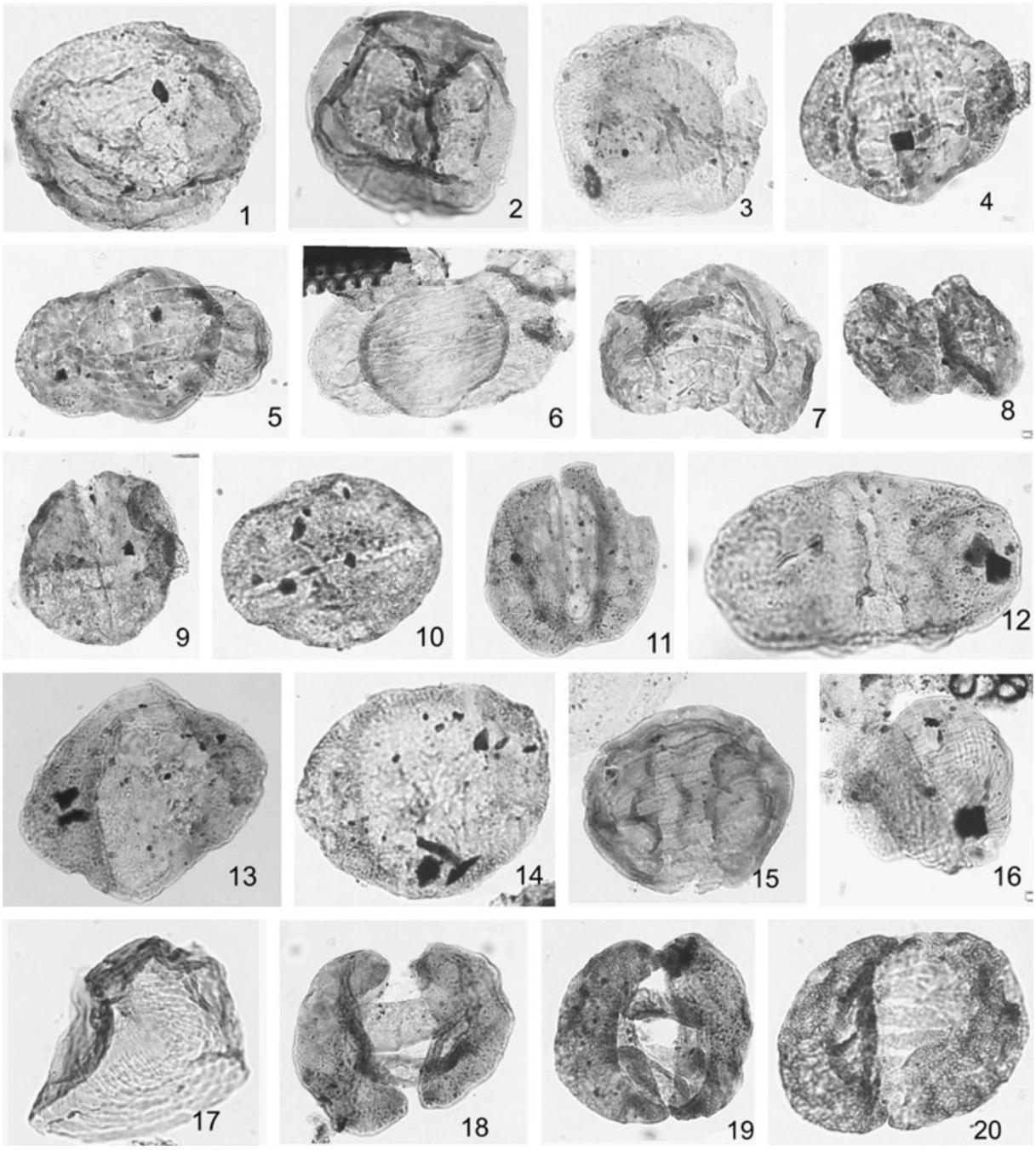

Plate 2. 1. *Densipollenites invisus* Bharadwaj and Salujha (1964); 2. *Densipollenites magnicorpus* Tiwari and Rana (1981); 3. *Densipollenites indicus* Bharadwaj (1962); 4. *Distriatites bilateris* Bharadwaj (1962); 5. *Hamiapollenites* sp.; 6. *Striatopodocarpites magnificus* Bharadwaj and Salujha (1964); 7. *Striatites communis* Bharadwaj and Salujha (1964); 8. *Verticipollenites oblongus* Bharadwaj (1962); 9. *Scheuringipollenites tentulus* (Tiwari) Tiwari (1973); 10. *Faunipollenites prexiguus* Bharadwaj and Salujha (1965); 11. *Alisporites ovalis* Kumar (1973); 12. *Satsangisaccites nidpurensis* Bharadwaj and Srivastava (1969); 13. *Falcisporites minutosaccus* Kumaran and Maheshwari (1980); 14. *Alisporites damudicus* Tiwari and Rana (1981); 15. *Schzopollis distinctus* Sinha (1972); 16. *Weylandites minutus* Bharadwaj and Srivastava (1969); 17. *Weylandites irregularis* Bharadwaj and Srivastava (1969); 18. *Arcuatipollenites asansoliensis* (Tiwari and Rana) Tiwari and Vijaya (1995); 19. *Arcuatipollenites paliensis* (Tiwari and Ram-Awatar) Tiwari and Vijaya (1995); 20. *Arcuatipollenites pellucidus* (Goubin) Tiwari and Vijaya (1995).

assemblage zone of Tiwari and Tripathi (1992), and dated as Early Triassic in age. The presence of acritarch is noteworthy. The nonproductive strata (442.90–460.50 m in Borecore TROD-1), might represent the Raniganj–Panchet formational transition in this area.

Table 5. *List of the palynomorph taxa identified in present study, arranged under probable plant groups.*

Probable affinity	Palynotaxa
Sphenopsida	*Calamospora* Schopf, Wilson and Bentall (1944)
	Calamospora sp.
	Laevigatosporites Ibrahim (1933)
	Laevigatosporites vulgaris Balme and Hennelly (1956)
Lycopsida	*Indotriradites* Tiwari (1964)
	Indotriradites korbaensis Tiwari (1964)
	Indotriradites sparsus Tiwari (1965)
	Indotriradites surangei Tiwari (1965)
	Dentatispora Tiwari (1964)
	Dentatispora crassus Tiwari (1965)
	Dentatispora lacunata Tiwari (1965)
	Didecitriletes Venkatachala and Kar (1965)
	Didecitriletes horridus Venkatachala and Kar (1965)
	Densoisporites Weyland and Krieger emend. Dettman (1963)
	Densoisporites sp.
	Jayantisporites Lele and Makada (1972)
	Jayantisporites sp.
	Gondisporites Bharadwaj (1962)
	Gondisporites reticulates Tiwari and Ram-Awtar (1989)
	Gondisporites raniganjensis Bharadwaj (1962)
	Lundbladispora Balme and Playford (1965)
	Lundbladispora brevicula Balme (1963)
	Lundbladispora raniganjensis Tiwari and Rana (1981)
	Lundbladispora baculata Bharadwaj and Tiwari (1977)
	Lundbladispora microconata Bharadwaj and Tiwari (1977)
	Ringosporites Tiwari and Rana (1981)
	Ringospotites fossulatus (Balme) Tiwari and Rana (1981)
Filicopsida	*Apiculatisporis* Potonie and Kremp (1956)
	Apiculatisporis sp.
	Brevitriletes Bharadwaj and Srivastava (1969)
	Brevitriletes unicus Bharadwaj and Srivastava (1969)
	Callumispora Bharadwaj and Srivastava emend. Tiwari *et al* (1989)
	Callumispora gretensis (Balme and Hennelly) Bharadwaj and Srivastava emend. Tiwari *et al* (1989)
	Camptotriletes Naumova (1937)
	Camptotriletes sp.
	Cyclogranisporites Potonie and Kremp (1954)
	Cyclogranisporites distinctus Kumaran and Maheshwari (1980)
	Cyclogranisporites gondwanensis Bharadwaj and Salujha (1964)
	Cyclogranisporites barakarensis Srivastva (1970)
	Cyclogranisporites triletus Kar (1970)
	Cyclobaculisporites Bharadwaj (1955)
	Cyclobaculisporites bharadwajii Salujha (1965)
	Cyclobaculisporites minutus Bharadwaj and Salujha (1964)
	Didecitriletes Venkatachala and Kar (1965)
	Didecitriletes horridus Venkatachala and Kar (1965)
	Horriditriletes Bharadwaj (1962)
	Horriditriletes curvibaculosus Bharadwaj and Salujha (1964)
	Horriditriletes rampurensis Tiwari (1968)
	Horriditriletes sp.
	Indospora Bharadwaj (1962)
	Indospora clara Bharadwaj (1962)
	Lophotriletes (Naumova) Potonie and Kremp (1954)
	Lophotriletes frequenssus Tiwari (1969)

Table 5. *(Continued.)*

	Microbaculispora Bharadwaj (1962)
	Microbaculispora barakarensis Tiwari (1965)
	Microbaculispora indica (Tiwari) emend. Tiwari and Singh (1981)
	Microbaculispora tentula Tiwari (1965)
	Microfoveolatispora Bharadwaj (1962)
	Microfoveolatispora bokaroensis Tiwari (1965)
	Microfoveolatispora foveolata Tiwari (1965)
	Osmundacidites Couper (1953)
	Osmundacidites wellmanni Couper (1953)
	Thymospora Wilson and Venkatachala (1963)
	Thymospora thessnii Wilson and Venkatachala (1963)
	Verrucosisporites Ibrahim emend. Smith (1971)
	Verrucosisporites distinctus Tiwari (1965)
	Verrucosisporites triassicus Bharadwaj and Tiwari (1977)
Gymnosperms	
Cycado-ginkgopsida	*Ginkgocycadophytus* Samoilovich (1953)
	Ginkgocycadophytus novus Srivastava (1970)
	Praecolpatites Bharadwaj and Srivastava (1969)
	Praecolpatites sp.
	Tiwariasporis Maheshwari and Kar (1967)
	Tiwariasporis flavatus Maheshwari and Kar (1967)
	Vittatina (Luber) Wilson (1962)
	Vittatina sp.
	Welwitschiapites Bolchowitina (1953)
	Welwitschiapites tenuis Bharadwaj and Salujha (1964)
	Weylandites Bharadwaj and Srivastava (1969)
	Weylandites circularis Bharadwaj and Srivastava (1969)
	Weylandites indicus Bharadwaj and Srivastava (1969)
	Weylandites irregularis Bharadwaj and Srivastava (1969)
	Weylandites minutes Bharadwaj and Srivastava (1969)
Coniferopsida	
Monosaccate	*Barakarites* Bharadwaj and Tiwari (1964)
	Barakarites implicatus Tiwari (1965)
	Caheniasaccites Lele and Makada (1972)
	Caheniasaccites decorus Lele and Makada (1972)
	Densipollenites Bharadwaj (1962)
	Densipollenites densus Bharadwaj (1962)
	Densipollenites indicus Bharadwaj (1962)
	Densipollenites invisus Bharadwaj and Salujha (1964)
	Densipollenites magnicorpus Tiwari and Rana (1981)
	Distriamonosaccites Bharadwaj (1962)
	Distriamonosaccites ovalis Bharadwaj and Salujha (1964)
	Parasaccites Bharadwaj and Tiwari (1964)
	Parasaccites bilateralis Tiwari (1965)
	Parasaccites korbaensis Bharadwaj and Tiwari (1964)
	Playfordiaspora Maheshwari and Banerji emend. Vijaya (1995)
	Playfordiaspora cancellosa Maheshwari and Banerji emend. Vijaya (1995)
	Plicatipollenites Lele (1964)
	Plicatipollenites indicus Lele (1964)
	Potonieisporites Maheshwari (1967)
	Potonieisporites lelei Maheshwari (1967)
	Striamonosaccites Bharadwaj (1962)
	Striamonosaccites circularis Bharadwaj and Salujha (1964)
Nonstriate Bisaccate	*Accintisporites* Leschik (1955)
	Accintisporites sp.
	Alisporites Daugherty emend. Jansonius (1971)
	Alisporites damudicus Tiwari and Rana (1981)

Table 5. *(Continued.)*

	Alisporites ovalis Kumar (1973)
	Brachysaccus Madler (1964)
	Brachysaccus sp.
	Caytonipollenites Couper (1953)
	Caytonipollenites sp.
	Cuneatisporites Leschik (1955)
	Cuneatisporites sp.
	Falcisporites Leschik emend. Klaus (1963)
	Falcisporites minutosaccus Kumaran and Maheshwari (1980)
	Krempipollenites Tiwari and Vijaya (1995)
	Krempipollenites indicus Tiwari and Vijaya (1995)
	Minutosaccus Madler (1964)
	Minutosaccus sp.
	Nidipolllenites Bharadwaj and Srivastava (1969)
	Nidipolllenite sp. Bharadwaj and Srivastava (1969)
	Platysaccus Naumova emend. Potonie and Klaus (1954)
	Platysaccus sp.
	Plicatisaccus Pautsch (1971)
	Plicatisaccus sp.
	Protoeusaccites Tiwari, Ram-Awatar and Vijaya (1995)
	Protoeusaccites sp.
	Sahnites Pant emend. Tiwari and Singh(1984)
	Sahnites sp.
	Satsangisaccites Bharadwaj and Srivastava (1969)
	Satsangisaccites nidpurensis Bharadwaj and Srivastava (1969)
	Scheuringipollenites Tiwari (1973)
	Scheuringipollenites tentulus (Tiwari) Tiwari (1973)
	Vestigisporites Balme and Hennelly emend. Tiwari and Singh (1984)
Striate Bisaccate	*Circumstriatites* Lele and Makada (1972)
	Circumstriatites obscurus Lele and Makada (1972)
	Crescentipollenites Bhardwaj, Tiwari and Kar (1974)
	Crescentipollenites amplus (Balme and Hennely) Tiwari and Rana (1980)
	Crescentipollenites sp.
	Crescentipollenites fuscus (Baradwaj) Bhardwaj, Tiwari and Kar (1974)
	Distriatites Bharadwaj (1962)
	Distriatites bilateris Bharadwaj (1962)
	Distriatites insolitus Bhardwaj and Salujha (1964)
	Faunipollenites Bharadwaj (1962)
	Faunipollenites varius Bharadwaj (1962)
	Faunipollenites perexiguus Bharadwaj emend Tiwari *et al* (1989)
	Primuspollenites Tiwari (1964)
	Primuspollenites dicavus Tiwari (1965)
	Rhizomaspora Wilson (1962)
	Rhizomaspora indica Tiwari (1965)
	Schizopollis Venkatachala and Kar (1964)
	Schizopollis distinctus Sinha (1972)
	Striasulcites Venkatachala and Kar (1968)
	Striasulcites tectus Venkatachala and Kar (1968)
	Striapollenites Bharadwaj (1962)
	Striapollenites obliquus Bharadwaj and Salujha (1964)
	Striatites Pant emend. Bharadwaj (1962)
	Satriatites communis Bharadwaj and Salujha (1964)
	Striatites gopalensis Srivastava (1970)
	Striatites levistriatus Bharadwaj and Tiwari (1977)
	Striatites ornatus Venkatachala and Kar (1968)
	Striatites reticuloides Tiwari (1964)

Table 5. *(Continued.)*

	Striatites tectus Venkatachala and Kar (1968)
	Striatites varius Kar (1968)
	Striatopodocarpites Soritsch and Sedova emend. Bharadwaj (1962)
	Striatopodocarpites ovatus (Maheshwari) Bharadwaj and Dwivedi (1981)
	Striatopodocarpites magnjficus Bharadwaj and Salujha (1964)
	Verticipollenites Bharadwaj (1962)
	Verticipollenites crassus Bharadwaj and Salujha (1964)
	Verticipollenites debilis Venkatachala and Kar (1968)
	Verticipollenites gibbosus Bharadwaj (1962)
	Verticipollenites oblongus Bharadwaj (1962)
Taeniate Bisaccate	*Arcuatipollenites* Tiwari and Vijaya (1995)
	Arcuatipollenites asansoliensis (Tiwari and Rana) Tiwari and Vijaya (1995)
	Arcuatipollenites diffusus (Tiwari and Rana) Tiwari and Vijaya (1995)
	Arcuatipollenites paliensis (Tiwari and Ram-Awtar) Tiwari and Vijaya (1995)
	Arcuatipollenites pellucidus (Goubin) Tiwari and Vijaya (1995)
	Guttulapollenites Goubin (1965)
	Guttulapollenites hannonicus Goubin (1965)
	Trabeculosporites Trivedi and Misra emend. Tiwari and Ram-Awtar (1992)
	Trabeculosporites sp.
Algae and probable algae	*Leiosphaeridia* Eisanach emend. Downie and Sarjeant (1963)
	Peltacystia Balme and Segroves (1966)
	Quadrisporites Hennelly emend. Potonie (1961)
	Tetraporina Naumova ex. Naumova emend. Kar and Bose (1976)
	Tetraporina sp. Banerjee and D'Rozrio (1988)

Table 6. *Palynodating of Borehole TRBD-2 (315.00–356.45 m depth), Tatapani–Ramkola Coalfield (Tiwari and Tripathi 1992, Vijaya et al 2001).*

Formation	Depth	Characteristics key taxa		Assemblage identified	Age affiliation
Barakar	315.00 315.60 to 337.30	Dominant– *Parasaccites* Other taxa– *Scheuringipollenites* *Callumispora* *Faunipollenites* *Sahnites* Trilete rich	*Indotriradites* *Dentatispora* *Jayantisporites*		
329.81				*Scheuringipollenites barakarensis*	**Early Permian Lower Barakar**
Talchir	338.15 to 348.30 352.25 to 356.45	Unproductive strata *Scheuringipollenites* *Faunipollenites* *Striatopodocarpites* Trilete rich			

Table 7. *Palynodating in Borehole TRBD-3 (19.00–515.20 m depth) Tatapani–Ramkola Coalfield (Tiwari and Tripathi 1992, Vijaya et al 2001).*

Formation	Depth	Characteristic key taxa		Assemblages identified	Age affiliation
Barren Measures	19.00 54.80 57.50 to 283.10 246.46	Dominant– *Densipollenites* Dominant– *Striatopodocarpites* *+Faunipollenites* Subdominant– *Scheuringipollenites* Other taxa– *Verticipollenites* *Distriatites* *Striamonosaccites* Many trilete spore	*Playfordiaspora* *Gondisporites* *Densipollenites* *Guttulapollenites*	*Densipollenites* *magnicorpus* *Gondisporites* *raniganjensis*	**Latest Permian** **Late Permian**
Barakar	393.25 to 438.80 462.69 to 496.60 496.60	Dominant– *Striatopodocarpites* Subdominant– *Scheuringipollenites* Other taxa– *Striasulcites* *Schizopollis* *Weylandites* Trilete spores rich Poor yield	*Indotriradites* *Striasulcites* *Densipollenites*	*Faunipollenites* *varius*	**Late Early Permian**
Talchir	507.80 to 511.55	Dominant– *Scheuringipollenites* Other taxa– *Sahnites* *Striasulcites* *Crescentipollenites* *Weylandites*			

6. Discussion

Here, in Tatapani–Ramkola Coalfield, the lithological units are typified with characteristic lithofacies. The argillaceous component includes clay, carbonaceous shales, black shales, silty shales, laminated shales along with micaceous content. The arenaceous component is mainly medium- to fine-grained sandstone. Lithologically, the strata are delineated into Talchir, Barakar and Barren Measures formations. The palynological findings differ at places in the three borecores – TRBD-2, TRBD-3 and TROD-1, which are located in the nearby blocks (figures 1–3), needed to be defined in timespan. The strata lithologically identified as of Talchir Formation in borecores TRBD-2 and TRBD-3 is equated with the Lower Barakar Formation of Damodar Basin (tables 6 and 7). Palynologically the strata pertaining to Barakar Formation in borecores TRBD-2, TRBD-3 conform the lithological demarcation (tables 6 and 7). However, in the Borecore TROD-1, the strata lithologically identified as Barakar Formation is palynologically dated as Late Permian and equated with the Raniganj Formation of Damodar Basin (table 8). In the up-section, the changing patterns observed in the palynoassemblages in the Barren Measures Formation in borecores TRBD-3 and TROD-1 have led in the identification of strata equivalent to the Raniganj and Lower Panchet formations of that in the Damodar Basin (figure 4).

The yield of spore-pollen, other plant tissues and organic matter is intermittently rare to rich.

Table 8. *Palynodating in Borehole TROD-1 (5.66–645.15 m depth), Tatapani–Ramkola Coalfield (Tiwari and Tripathi 1992, Vijaya et al 2001).*

Formation	Depth	Characteristics key taxa		Assemblage identified	Age affiliation
Barren Measures	12.50 to 442.90	Dominant– *Striatopodocarpites* Other taxa– *Satsangisaccites* *Nidipollenites* *Alisporites* *Protoeusaccites* *Striatites* *Guttulapollenites* *Crescentipollenites* *Densipollenites* Trilete in low frequency	Proliferation of *Playfordiaspora* at 65.00 m First occurrences of *Plicatisaccus* *Brachysaccus* at 409.80 m, and *Minutosaccus* at 442.90 m	*Krempipollenites indicus*	**Early Triassic**
443.50					
Barakar	460.50 to 645.15	Dominant– *Striatopodocarpites* Other taxa– *Densipollenites* *Guttulapollenites* *Crescentipollenites* *Distriatites* *Accintisporites* *Barakarites* Varied trilete but low frequency	*Playfordiaspora* *Arcuatipollenites* at 616.45 m	*Densipollenites magnicorpus*	**Latest Permian**

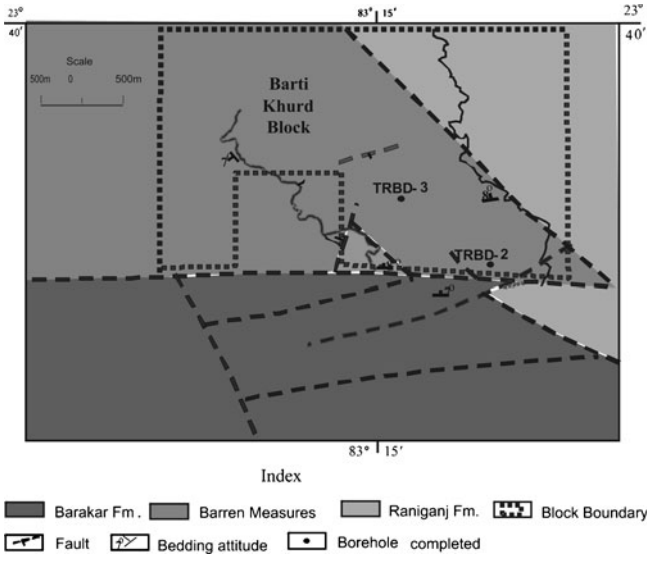

Figure 2. Geological map of Bartikhurd block, Tatapani–Ramkola Coalfield, Surguja district, Chhattisgarh.

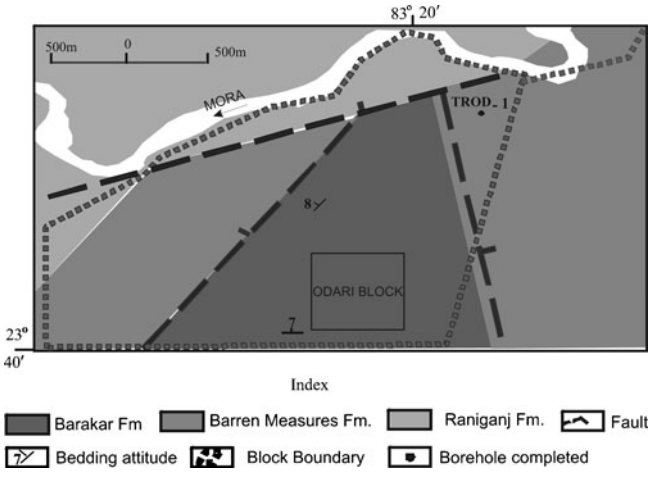

Figure 3. Geological map of Odari block, Tatapani–Ramkola Coalfield, Surguja district, Chhattisgarh.

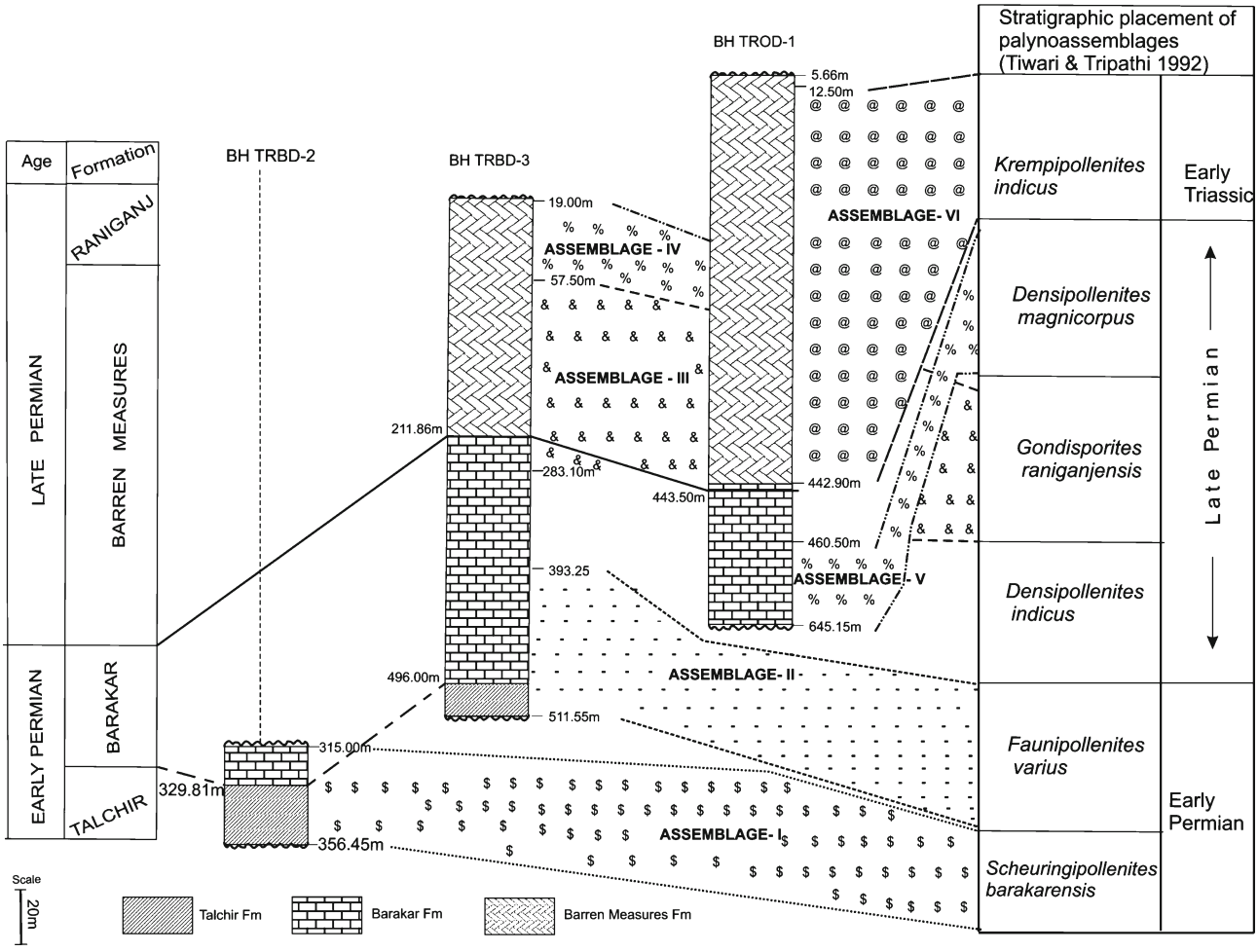

Figure 4. Biostratigraphic status of the palynoassemblages identified in the Talchir, Barakar and Barren Measures formations from the boreholes – TRBD-2, TRBD-3 in Bartikhurd block, and TROD-1 in Odari block, Tatapani–Ramkola Coalfield, Chhattisgarh.

The preservation in general is fair-to-good, but at various depths it is poor (tables 2–4). This observation that the energy was low to medium during the deposition of these sediments which corresponds with the lithofacies, more of argellacious component than arenaceous in the strata studied here.

7. Conclusions

The palynological studies done in approximately 1174.00 m thick Gondwana strata intersected through Barren Measures, Barakar and Talchir formations in the three borecores in Tatapani–Ramkola Coalfield, infers (figure 4):

- The strata lithologically demarcated as Talchir Formation (329.81–353.45 m, Borecore TRBD-2), is here palynologically equated with the basal part of Lower Barakar Formation and dated Early Permian.
- The Barakar and Talchir formational contact lies at 329.81 m, and the strata (352.25–356.45 m) overlying to this contains *Scheuringipollenites barakarensis* Palynozone equitable with the Lower Barakar Formation.
- However, strata in between 338.15 and 348.30 m is unproductive.
- In approximately 493.00 m thick strata comprising Barren Measures and Barakar formations in Borecore TRBD-3, only 72.00 m of the Barakar Formation has yielded the *Faunipollenites varius* Palynozone, which conforms lithological delimitation that is Barakar Formation.
- Other two assemblages recovered in the Barren Measures Formation (57.50–283.10 m and 19.00–57.50 m in Borecore TRBD-3) compare with the Late Permian palynoflora known from

Raniganj Formation (figure 4). This implies a younger status to the studied strata.

- Palynological dating of the 460.50–645.15 m depth in Borecore TROD-1, the Barakar Formation contains *Densipollenites magnicorpus* Palynozone that equates this part with the upper part of Raniganj Formation, Late Permian.
- Strata identified as the Barren Measures (12.50–442.90 m depth in Borecore TROD-1) has yielded *Krempipollenites indicus* Palynozone, which suggests an affiliation with Lower Panchet Formation of Early Triassic in age.
- Here, the non-productive strata (442.90–460.50 m in Borecore TROD-1), might represent the Raniganj–Panchet formational transition (P/Tr transition).

In Tatapani–Ramkola Coalfield, the strata of Talchir Formation are palynologically equated with the Barakar Formation Early Permian. While in the Barakar and Barren Measures formations, existence of the Raniganj Formation Late Permian is identified, of that in Damodar Basin. In Barren Measures Formation, it also encompasses a part deposited during the Early Triassic time.

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