

Palaeontological Laboratory, Southern Region, GSI Complex, Hyderabad.

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Palynological evidence for Upper Permian Raniganj coals in western part of Talcher coal field, Orissa, India

R. S. Tiwari, Archana Tripathi and B. N. Jana

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India

The coal-bearing sediments exposed in Madalia river section near Patrapara village at the westernmost region of Talcher coal field, Orissa, have yielded four sequentially identifiable palynoassemblages. The Upper Permian Raniganj Formation has been identified in the area. This opens the possibility of coal deposits in the Supra Barakar sequence in western Talcher coal field.

THE Talcher coal field (20° 53'–21° 12' N, 84° 20'–85° 23' E) is the southeasternmost basinal region of Mahanadi graben. Regionally a northwesterly plunging synclinal structure is seen, with younger horizons outcropping progressively towards the west. The stratigraphic succession includes Talchir, Karharbari, Barakar and Kamthi formations¹. The major coal-seams occur in Karharbari and Barakar formations which are developed along the eastern and southern parts of the basin. In the central part, the subsurface data have revealed the presence of a thick coal sequence. In the westernmost region, a 2-m-thick coal seam is exposed in Madalia river, near Patrapara village, which was first described by Blanford *et al.*² under Lower Damuda Group (i.e. Barakar Formation). These beds were described to be unconformably overlain by Mahadeva Group (now classified as Kamthi). Fox³ opined that if there were no Upper Damuda and Panchet rocks in this field, a large stratigraphical break might separate the Lower coal-measures and the Mahadevas. In recent work of the Geological Survey of India¹ also, the coal exposures

near Patrapara village have been included in the Lower Damuda Group (i.e. Barakar Formation). However, the palynological analysis has revealed a Late Permian Raniganj affinity for the coal seam at Patrapara section (Figure 1), and indications are also recorded to suggest the occurrence of this horizon in the central part of the coal field.

Ten samples collected from sections exposed on both the banks of Madalia river (Figures 2 and 3a) were analysed. On the right bank, a 10-m-thick sequence includes coal, shale (compact whitish to blackish-grey, false-bedded) and clay (white to greyish and purple). A 2-m-thick pebbly sandstone rests on the highly denuded surface of the clay bed. On the left bank of the river, a 1.4-m-thick coal seam is exposed overlying a grey to bluish, compact shale. Above this coal seam a 0.5-m-thick coarse-grained sandstone and grey shale containing *Glossopteris* leaves are exposed.

Of the 10 samples, five yielded rich palynoflora which could be analysed quantitatively; one sample (PPD-6) was assessed only for its qualitative composition because of poor yield, while the remaining four samples were either barren or extremely poor in palynofossils. Four assemblages have been identified in the sequence exposed on the right bank of the river (Figure 2).

The Assemblage-I (sample no. PPD-1), the oldest in the profile, depicts abundance of striate disaccate (mainly *Striatopodocarpites* Sedova 1956 and *Faunipollenites* Bharadwaj 1962). The presence of *Microfoveolatispora* Bharadwaj 1962 (*M. raniganjensis* Bharadwaj 1962), *Horriditriteles* Bharadwaj and Salujha 1964, *Reticulatisporites* Ibrahim emend. Potonié and Kremp

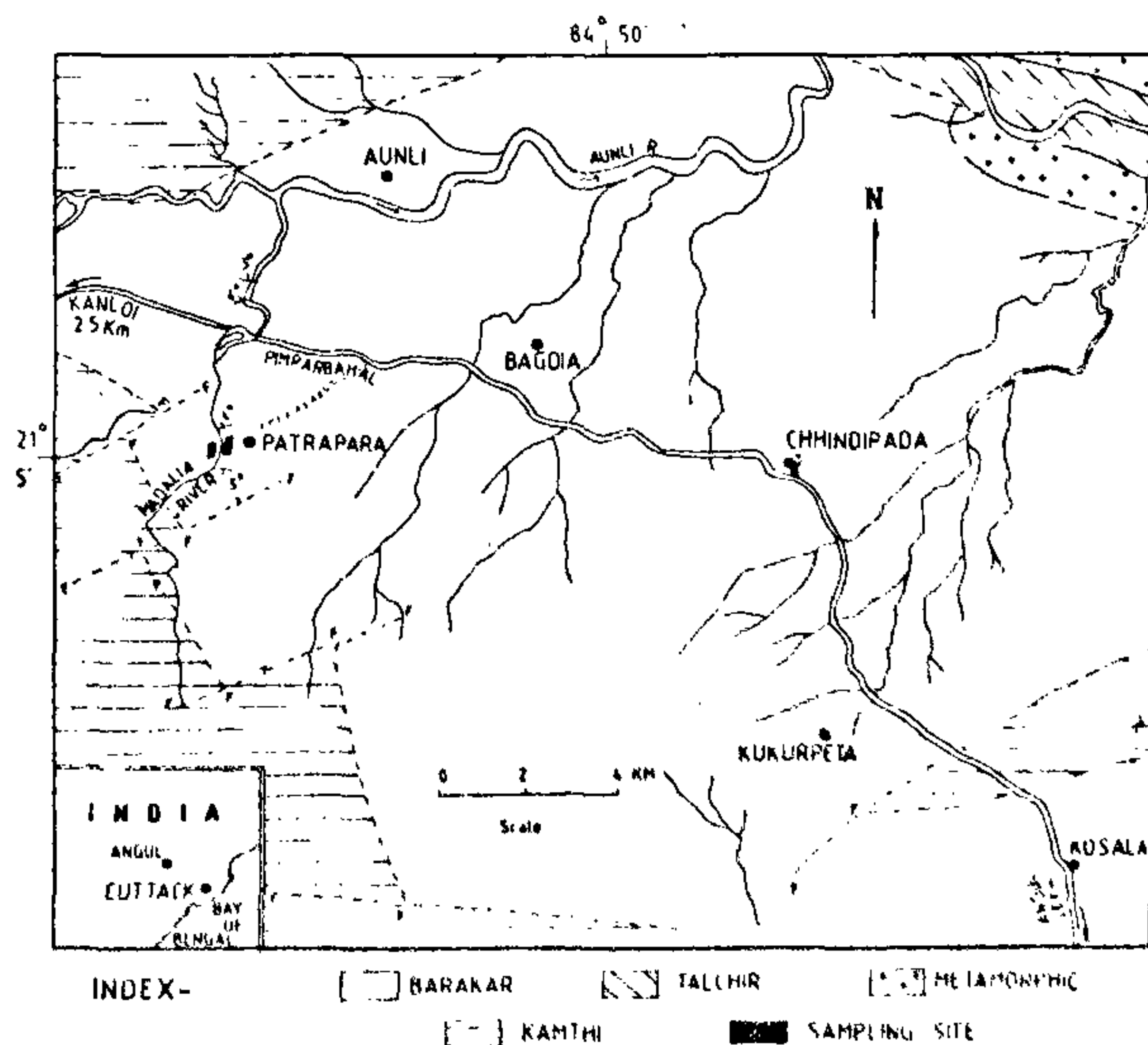


Figure 1. Geological map of central and western part of Talcher coal field, showing the location of outcrops in Madalia river at Patrapara village (after Raja Rao¹).

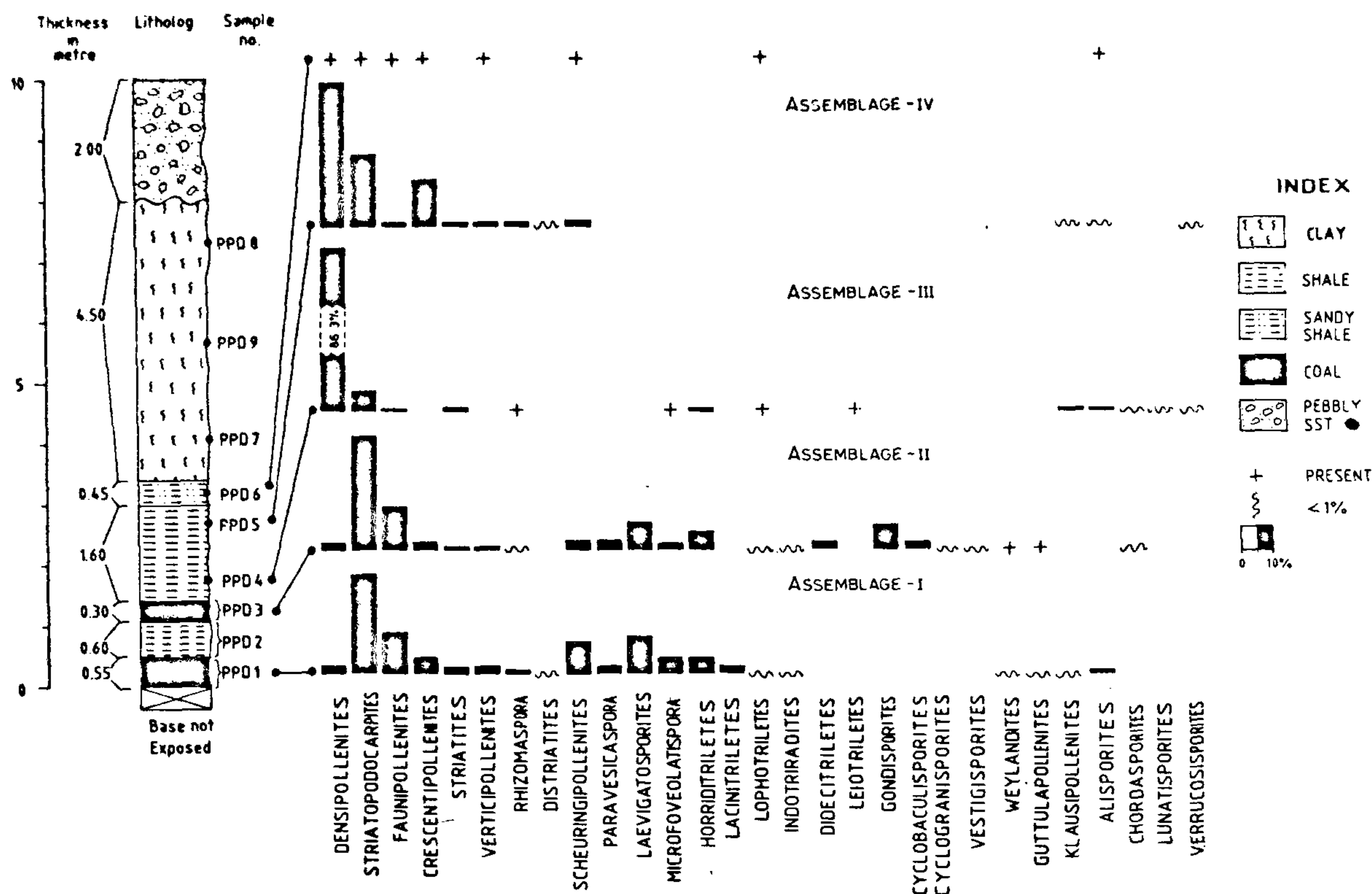


Figure 2. Litholog of section exposed on right bank of Madalia river near Patrapara village, showing sample location, thicknesses of lithounits and frequency (in per cent) of palynotaxa in yielding samples.

1954, *Weylandites* Bharadwaj and Srivastava 1969, and *Guttulapollenites* Goubin 1975 makes a characteristic association. The taxa *Hemisphaerium* Hemer and Nygreen 1967, *Leiosphaeridia* Eisenack emend. Downie and Sarjeant 1963 and *Mamealetus* Kar 1968, representing the alete spores could have a bearing on the ecological condition of deposition⁴.

Assemblage-II (sample no. PPD-3) is basically related to Assemblage-I but here the genus *Gondisporites* Bharadwaj 1962 appears in high frequency. In addition, *Didecitriletes* Venkatachala and Kar 1965, *Cyclobaculisporites* Bhardwaj 1955 ex Bharadwaj 1956, and *Cyclogranisporites* Potonié and Kremp 1954, are also present, and impart a qualitative distinction.

Assemblage-III (sample no. PPD-4) registers a sudden change in composition, with remarkable dominance of *Densipollenites* Bharadwaj 1962. Qualitatively the genera *Verrucosisporites* Ibrahim emend. Smith 1971 and *Lunatisporites* Leschik emend. Scheuring 1970 (cf. *L. pellucidus*) make their first appearance in the sequence.

In Assemblage-IV (sample no. PPD-5 and 6) the genus *Densipollenites* continues to remain as a domi-

nant component but increase in the frequency of *Crescentipollenites* Bharadwaj, Tiwari and Kar 1974 is recorded and hence a floral change is suggested.

The sample no. PPD-6 is poor in its palynomorph contents (Figure 2); nevertheless, qualitatively it resembles sample no. PPD-5. The palynological composition of coal seam exposed on the left bank of the river (sample no. PPD-10) resembles with that of the Lower coal seam (sample no. PPD-1, Assemblage-I) of the right bank in having comparable frequency of *Striatopodocarpites*, *Faunipollenites*, *Laevigatosporites*, *Microfoveolatispora*, *Scheuringipollenites*, etc.

The striate disaccate-rich assemblages are on record from Barakar, Kulti and Raniganj formations of Indian Lower Gondwana. The pattern of incidences of palynotaxa in Patrapara section shows a close similarity with the Late Permian Raniganj palynoflora⁵⁻¹².

The presently described Assemblage-I is akin to the Assemblage-RII-A (ref. 11) representing the *Striatopodocarpites*-*Faunipollenites* dominance. The Assemblage-II is closely comparable to Assemblage-RII-B (ref. 11), which has *Striatopodocarpites*-*Gondisporites* association. The Assemblage-III of the present study, which

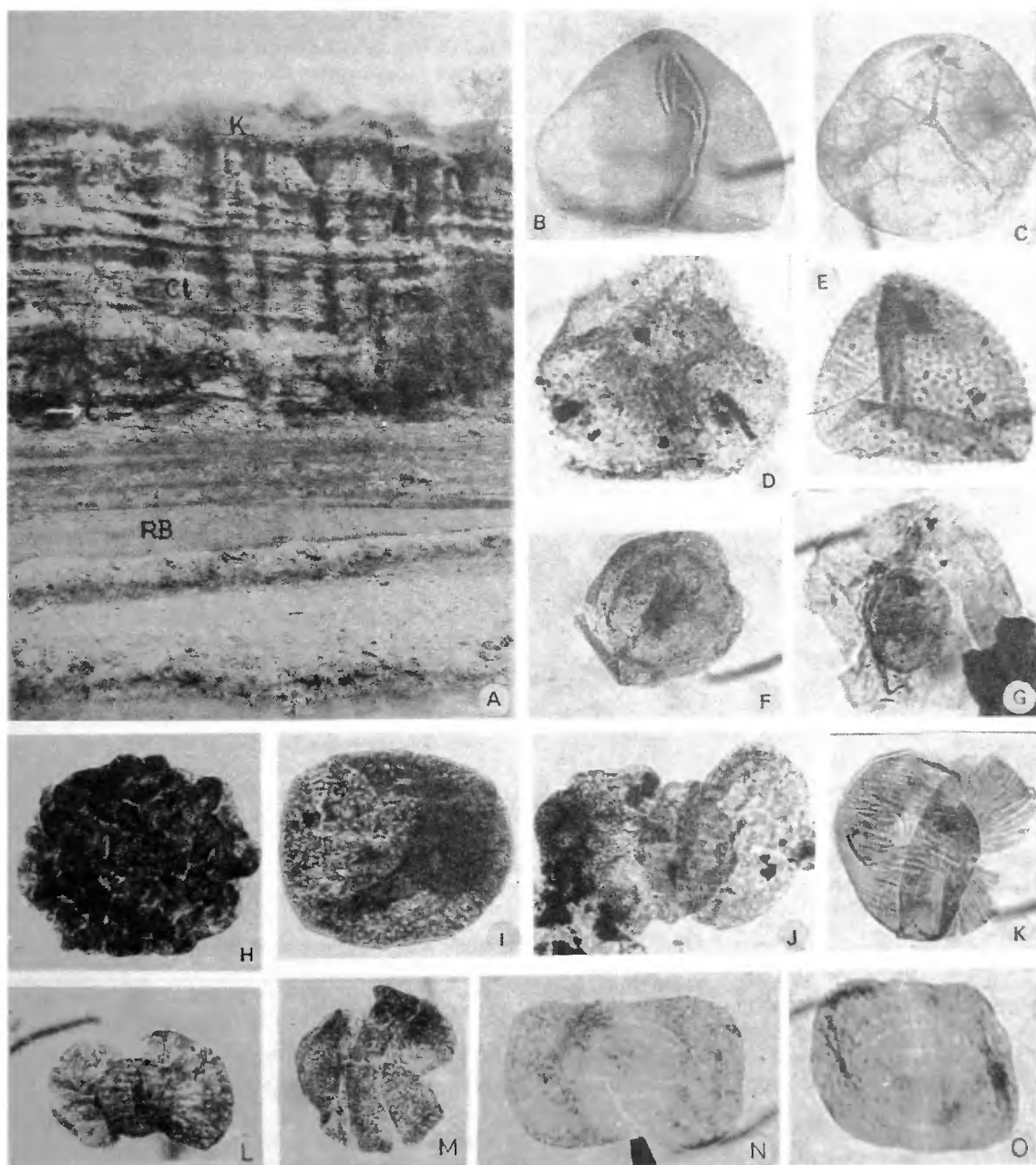


Figure 3. a, Photograph showing various lithounits in the section exposed in Madaha river near Patrapara village. Arrow indicates denuded surface of clay bed overlain by pebbly sandstone (C, coal. Sh. Shale; Cl, clay; K, Kamthi; RB, river bed). b-o, Palynofossils recovered from coal and shale samples exposed in Madaha river near Patrapara (all photomicrographs are X 500 unless otherwise stated). b, *Microcoleolatispora*, BSIP slide no. 10549, c, *Reticulatisporites*, BSIP slide no. 10550, d, *Gondisporites*, BSIP slide no. 10551; e, *Dicetriletes*, BSIP slide no. 10551; f, cf. *Lundbladispore*, BSIP slide no. 10549; g, cf. *Polyjordiaspora*, BSIP slide no. 10552; h, *Maniculus*, BSIP slide no. 10552, i, *Densipollenites*, BSIP slide no. 10555, X 450, j, *Hindipollenites*, BSIP slide no. 10553, X 450; k, *Weylandites*, BSIP slide no. 10554, l, *Verticillipollenites*, BSIP slide no. 10554; m, *Guttulapollenites*, BSIP slide no. 10552, n, cf. *Lunatisporites*, BSIP slide no. 10550, o, *Striatopodocarpites*, BSIP slide no. 10550

shows an abundance of *Densipollenites* and *Striatopodocarpites* is akin to Assemblage-RI-A (ref. 11), and the youngest assemblage in Patrapara, Assemblage-IV, is comparable to the Assemblage-RI-B (ref. 11), which represents *Striatopodocarpites* and *Crescentipollenites* prominence.

Besides the above-described quantitative structure, some forms which are qualitatively good age indicators are also present in these assemblages (Figure 3, b-o), viz. *Microfoveolatispora*, *Didecitriletes*, *Gondisporites*, *Densipollenites* spp., *Guttulapollenites*, *Mamealetus*, cf. *Playfordiaspora*, *Chordasporites* Klaus 1960 cf. *Lundbladisporea*, cf. *Lunatisporites* and *Klausipollenites* Janssonius 1962. Cumulatively they confirm a late Late Permian age for these beds having equatability with Raniganj Formation.

Blanford *et al.*² recognized Talchir, Damudas and Mahadevas in the Talcher coal field. Their Damuda series included Barakar coal-measures which were supposed to be underlain by the strata referred to as Mahadevas, having a large stratigraphic break between the two³. Recently, Raja Rao¹ classified the litho-stratigraphic sequence in Talcher coal field into Talchir, Karharbari and Barakar formations as Lower Permian and Kamthi Formation as Upper Permian-Triassic. The presence of Upper Permian Raniganj sequence in the area was also suggested by the megafossil findings of Subramanian (in Raja Rao¹). The sediments of Kamthi Formation include fine- to medium-grained sandstone, carbonaceous shale, coal bands, greenish sandstone, pink clays and pebbly sandstone at the top (total thickness 250 m). The section exposed at Patrapara fits in the circumscription of the coal-shale-clay package of Kamthi Formation given by Raja Rao¹, although in the map he included this part of the area in the Barakar Formation.

In addition to the Patrapara section, a preliminary palynological study of the uppermost coal-shale sequence in bore hole TCW-6 drilled in the central part of the field between Kosala and Kukurpeta reveals a correlation between the Patrapara section and the depth levels 290.92 m and 303.72 m. The palynozone recognized at the latter depths contains, besides striate pollen, *Klausipollenites*, *Crescentipollenites* and *Densipollenites* in frequency comparable with that in the Patrapara assemblages. Additionally, the most revealing support for a Late Permian age of the TCW-6 palynozone under consideration is the presence of the taxa *Guttulapollenites*, *Satsangisaccites*, *Chordasporites*, *Alisporites* and *Osmundacidites*. In view of this the presence of latest Permian sediments can be envisaged in a wider extent of the western part of the Talcher coal field.

In the Patrapara section the coal-shale-clay beds—having a latest Permian age affinity—and the gritty coarse-grained sandstone resting on its highly denuded

surface suggest a considerable gap between the coal-bearing strata and the Mahadevas. The presence of Lower Triassic Panchet Formation is indicated in bore hole TCW-6 where a thick profile of green and chocolate facies overlies the coal-shale facies; the latter contains Upper Raniganj palynoflora. Thus the presence of Raniganj, Panchet and Mahadeva formations *sensu* Subramanian and Chakraborty and Das and Banerjee (in Raja Rao¹)—combinedly designated as Kamthi Formation by Raja Rao¹—is corroborated by identifying the uppermost Permian sequence on the basis of palynology.

The western part of the Talcher coal field is thus a highly promising area for exploring the subsurface Upper Permian coals.

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The crystal and molecular structure of putrescine-DL-glutamic acid complex

S. Ramaswamy and M. R. N. Murthy
Molecular Biophysics Unit, Indian Institute of Science,
Bangalore 560 012

The polyamines spermine, spermidine, putrescine, cadaverine, etc. have been implicated in a variety of cellular functions. However, details of their mode of interaction with other ubiquitous biomolecules is not known. We have solved a few structures of polyamine-amino acid complexes to understand the nature and mode of their interactions. Here we report the structure of a complex