Palynological sequence and relationship of subsurface Permian-Triassic sediments in eastern Raniganj Coalfield, West Bengal, India*

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The Raniganj and Panchet palynoassemblages in subsurface sediments have been analysed for understanding their changing pattern through Permian-Triassic boundary in eastern part of Raniganj Coalfield. The quantitative analysis of palynotaxa in bore-holes RAD-6 and RAD-8 has revealed the presence of two assemblages in each bore-core, having *Striatopodocarpites-Densipollenites* in the older and *Lunatisporites- Verrucosisporites* in the younger phase. The known assemblages from other bore-holes in the East Raniganj Coalfield, have been correlated with those of RAD-6 and RAD-8. The palyno-compositions have detected local hiatuses in the area, but by-and-large the Raniganj-Panchet sequence is continuous. The climatic changes, lithological alterations and palynofloral modulations support for a P/Tr time boundary at the Raniganj-Panchet boundary.

Key-words - Palynology, Permian - Triassic boundary, Raniganj Coaldfield, India.

INTRODUCTION

The present investigation adds to the data generated earlier through the palynological investigations of the bore-core profiles in the East Ranigang Coalfield (see Tiwari & Singh, 1986), representing the Raniganj-Panchet transitional phase. The geological sequence in this area (Map 1) is known only through drill cores, as the Gondwana sediments are concealed under alluvium and laterite. So far, the presence of Raniganj, Panchet, Supra-Panchet and Tertiary sediments have been proved. Two bore-cores RAD-8 (500 m deep) and RAD-6 (455.10 m deep) studied here, pass through Lower Panchet and Raniganj formations. This data has been utilized for correlation with the previously investigated bore-cores in the same region. The derivations on palaeoclimate and palaeoecology, based on palynological findings have been added.

The material for the palynological study was procured from two bore-holes, RAD-6 and RAD-8, located in the easternmost part of the East Raniganj Coalfield, West Bengal (Map 1). The depth of productive samples are given in Histograms I & II. Out of 379 samples analysed, 90 have yielded palynomorphs.

PALYNOLOGICAL COMPOSITION

A check-list of palynotaxa found in the Upper Raniganj and Lower Panchet formations, in bore-holes RAD-6 and RAD-8 is given below. The distribution is indicated in parenthesis. Some of the important species are illustrated in plate 1.

Genus- *Callumispora* Bharadwaj & Srivastava 1969

C. gretensis (Balme & Hennelly) Bharadwaj & Srivastava 1969 (Upper Raniganj)
C. fungosa (Balme) emend. Bharadwaj & Tiwari, 1977 (Lower Panchet)

Genus- *Verrucosisporites* Ibrahim 1933 emend. Smith *et al.* 1964

V. protomulosus Reinhardt 1964 (Lower Panchet)
V. diversus Bharadwaj & Salujha 1964 (Upper Raniganj-Lower Panchet)
V. distinctus Tiwari 1965 (Lower Panchet)
V. ambiplicatus Kar 1967 (Lower Panchet)
V. surangei Maheshwari & Banerji 1975 (Upper Raniganj-Lower Panchet)
V. densus Bharadwaj & Tiwari ,1977 (Lower Panchet)

Genus- *Guttatisporites* Visscher 1966

G. microechinatus Visscher 1966 (Lower Panchet)
G. ambiguus Tiwari & Rana 1980 (Lower Panchet)

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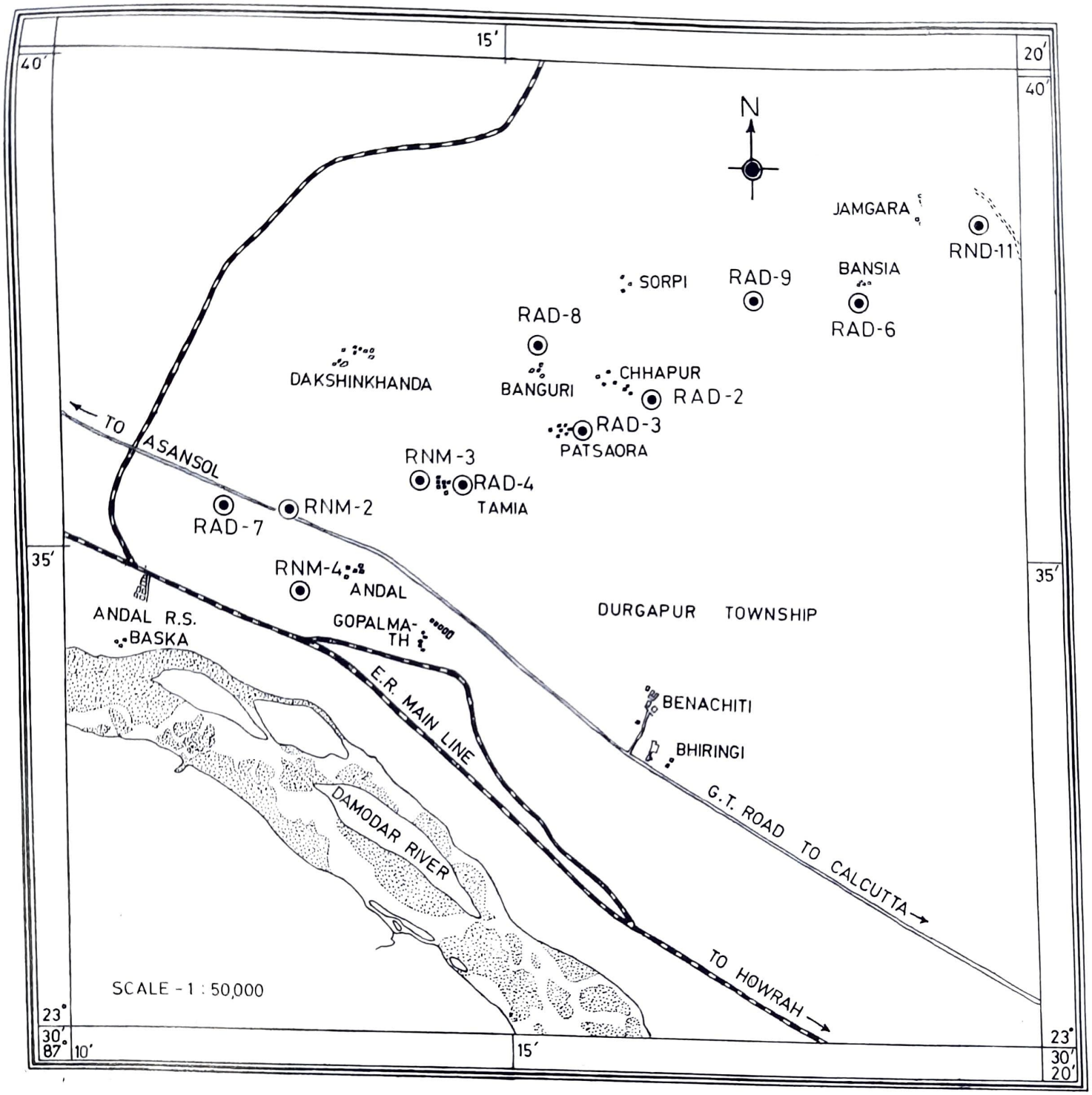


Map 1. A portion of eastern extension of Raniganj Coalfield showing locations of bore-holes studied for palynological analysis.

Genus- *Cyclobaculisporites* Bharadwaj 1955

C. grandiverrucosus Bharadwaj 1955 (Upper Raniganj - Lower Panchet)

Genus- *Lophotriletes* (Naumova) Potonie & Kremp 1954

L. rarus Bharadwaj & Salijha 1964 (Upper Raniganj - Lower Panchet)

Genus- *Osmundacidites* Couper 1953

O. pilatus Tiwari & Rana 1981 (Lower Panchet)

Genus- *Microfoveolatispora* Bharadwaj 1962

M. raniganjensis Bharadwaj 1962 (Upper Raniganj).

Genus-*Gondisporites* Bharadwaj 1962

G. imbricatus Segroves 1970 (Upper Raniganj)

Genus- *Thymospora* Wilson & Venkatachala 1963

T. gondwanensis Bharadwaj & Salujha 1965 (Upper Raniganj)

Genus- *Lundbladispora* Balme emend. Playford 1965

L. brevicula Balme 1963 (Lower Panchet)
L. densispinosa Bharadwaj & Tiwari 1977 (Lower Panchet)
L. microconata Bharadwaj & Tiwari 1977 (Lower Panchet)
L. raniganjensis Tiwari & Rana 1981 (Lower Panchet)

Genus- *Densoisporites* Weyland & Krieger 1953

D. contactus Bharadwaj & Tiwari, 1977 (Lower Panchet)

Genus- *Parasaccites* Bharadwaj & Tiwari 1964

P. plicatus Lele & Makada 1972 (Upper Raniganj-Lower Panchet)

Genus- *Plicatipollenites* Lele 1964

P. gondwanensis (Balme & Henn.) Lele 1964 (Upper Raniganj)

Genus- *Densipollenites* Bharadwaj 1962

D. indicus Bharadwaj 1962 (Upper Raniganj-Lower Panchet)
D. densus Bharadwaj & Srivastava 1969 (Upper Raniganj)

Genus- *Playfordiaspora* Maheshwari & Banerji 1975

P. cancellosa (Playford & Dettmann) Maheshwari & Banerji 1975 (Lower Panchet)

Genus- *Ibisporites* Tiwari, 1968

I. diplosaccus Tiwari 1968 (Upper Raniganj)

Genus- *Striomonosaccites* Bharadwaj 1962

S. ovatus Bharadwaj 1962 (Upper Raniganj)

Genus- *Sahnites* Pant emend. Tiwari & Singh 1984

S. thomasii Pant emend. Tiwari & Singh 1984 (Upper Raniganj-Lower Panchet)

Genus- *Alisporites* Daugh. emend. Jansonius 1971

A. indicus Bharadwaj & Srivastava 1969 (Lower Panchet)

Genus- *Klausipollenites* Jansonius 1962

K. schaubergeri (Potonie & Klaus) Jansonius 1962
K. sp. (In Bharadwaj & Srivastava , 1969) (Lower Panchet)

Genus- *Straitopodocarpites* Sedova 1956

S. decorus Bharadwaj & Salujha *1964* (Upper Raniganj)
S. diffusus Bharadwaj & Salujha 1964 (Upper Raniganj)
S. venustus Bharadwaj & Salujha 1965 (Upper Raniganj)
S. ovatus (Maheshwari) Bharadwaj & Dwivedi 1981 (Upper Raniganj)
S. subcircularis Sinha 1972 (Upper Raniganj)

Genus- *Faunipollenites* Bharadwaj 1962

F. varius Bharadwaj 1962 (Upper Raniganj-Lower Panchet)
F. perexiguus Bharadwaj & Salujha 1965 (Upper Raniganj)

Genus- *Lahirites* Bharadwaj 1962

L. rarus Bharadwaj & Salujha 1964 (Upper Raniganj)

Genus- *Crescentipollenites* Bharadwaj, Tiwari & Kar 1974

C. amplus (Maithy) Bharadwaj, Tiwari & Kar 1974
C. karharbariensis (Maithy) Bharadwaj, Tiwari & Kar 1974
C. notabilis Tiwari) Bharadwaj, Tiwari & Kar 1974 (Upper Raniganj)

Genus- *Distriatities* Bharadwaj 1962

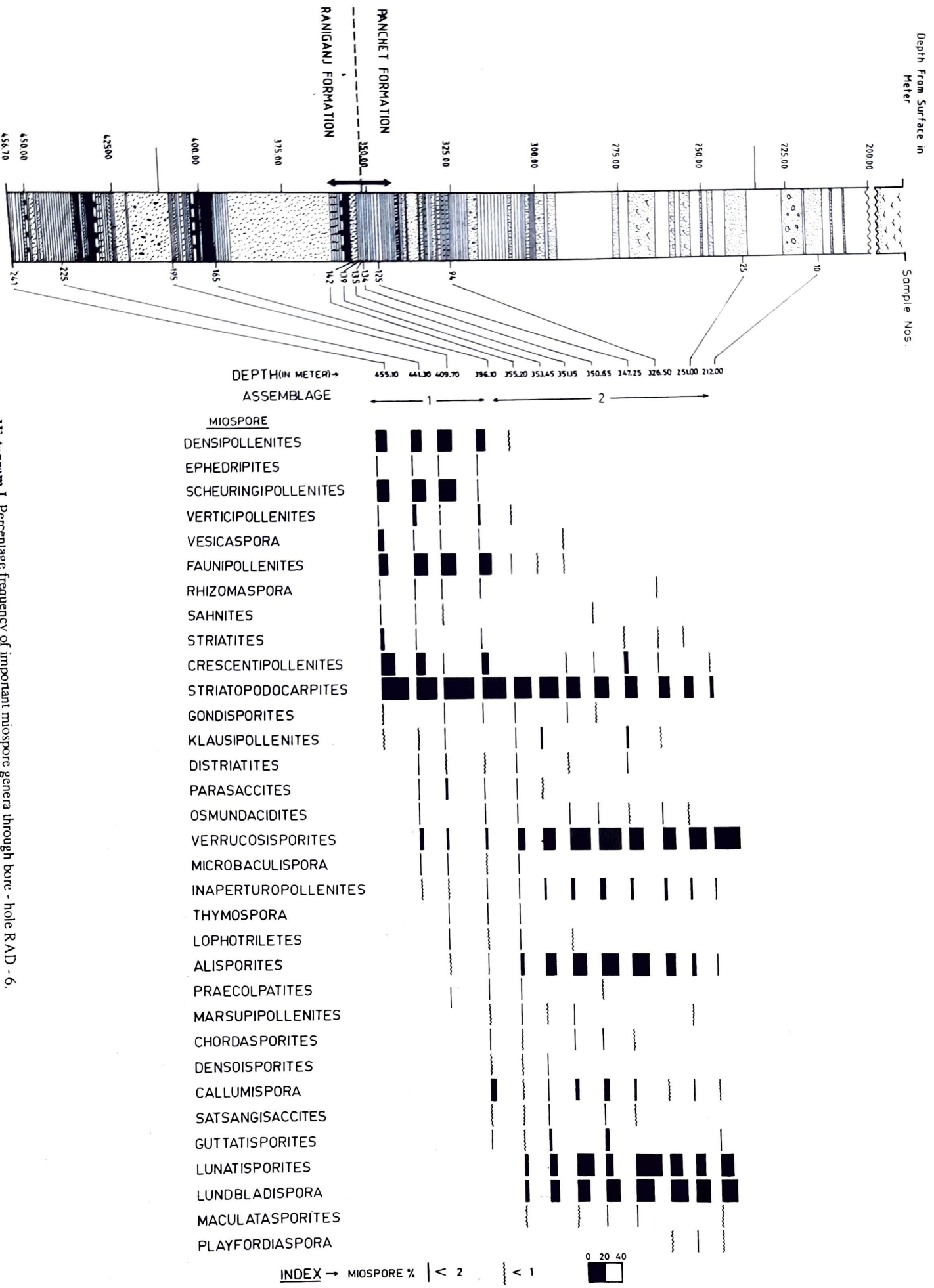
D. distinctus Sinha 1972 (Upper Raniganj)
D. indicus Sinha 1972 (Upper Raniganj)

Genus- *Lunatisporites* Leschik emend. Scheuring 1970

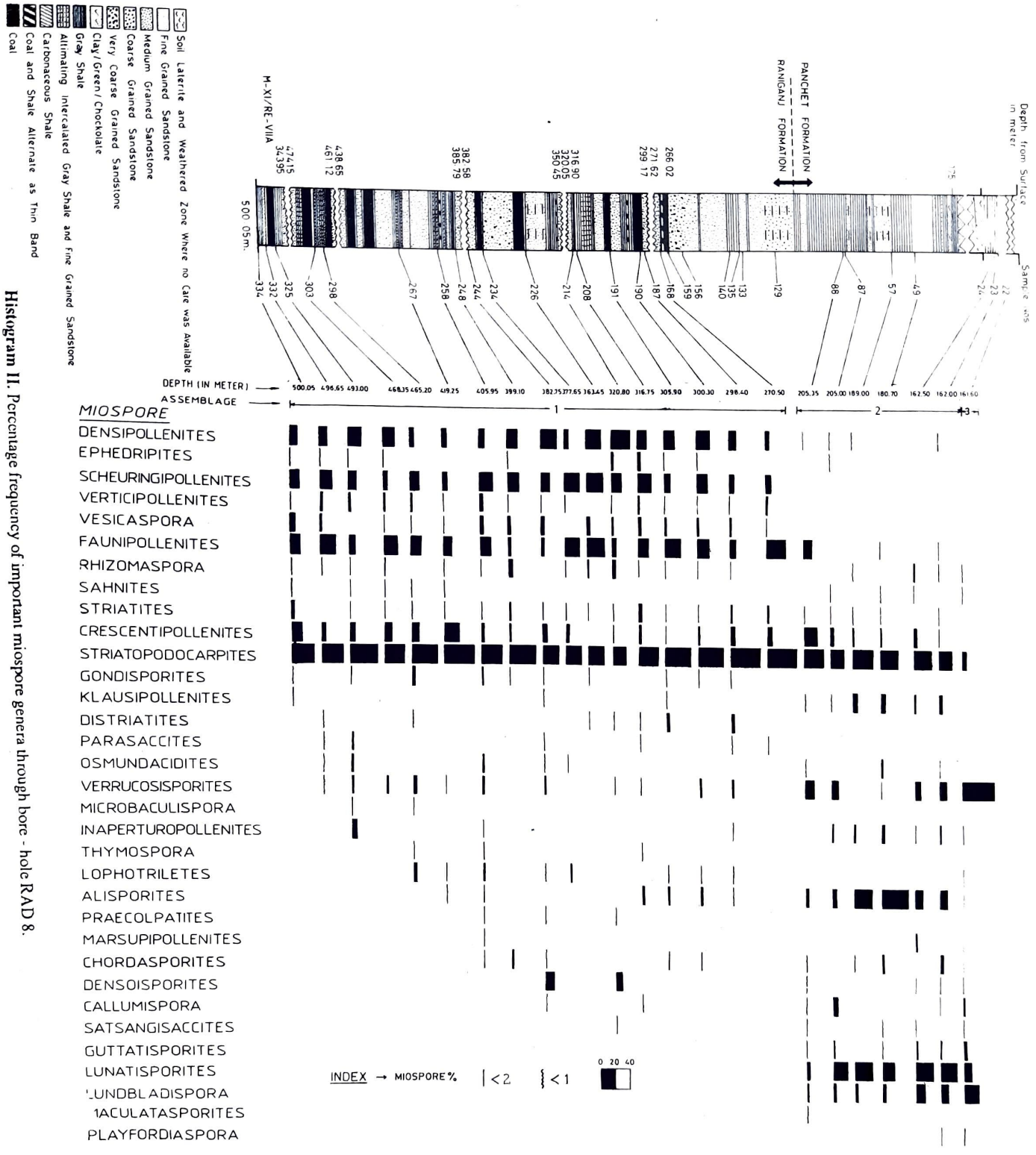
L. pellucidus (Goubin) Maheshwari & Banerji 1975 (Upper Raniganj-Lower Panchet)
L. ovatus (Goubin) Maheshwari & Banerji 1975 (Lower Panchet)
L. diffusus Bharadwaj & Tiwari 1977 (Lower Panchet)
Lunatisporites sp. cf. *L. diffusus* Bharadwaj & Tiwari 1977 (Lower Panchet)

Genus- *Rhizomaspora* Wilson 1962

R. divaricata Wilson 1962 (Upper Raniganj)



Histogram I. Percentage frequency of important miospore genera through bore - hole RAD - 6.



Histogram II. Percentage frequency of important miospore genera through bore - hole RAD 8.

R. singula Tiwari 1968 (Upper Raniganj)
R. radiata Wilson 1962 (Upper Raniganj)

Genus- *Guttulapollenites* Goubin emend. Venkatachala, Goubin & Kar 1967

G. hannonicus (Goubin) Venkatachala, Goubin & Kar 1967 (Upper Raniganj - Lower Panchet)

Genus- *Praecolpatites* Bharadwaj & Srivastava 1969

P. nidpurensis Bharadwaj & Srivastava 1969 (Lower Panchet)

Genus- Marsupipollenites Balme & Hennely emend. Pocock & Jansonius 1969

M. triradiatus Balme & Hennelly 1956 (Upper Raniganj)

Genus- *Ephedripites* Bolkhovitina emend. Krutzsch 1961

E. corrugatus Wilson 1962 (Upper Raniganj)
E. ellipticus Kar 1968 (Upper Raniganj)
E. mesozoicus Maheshwari, Bose & Kumaran 1977 (Upper Panchet)

Genus- *Inaperturopollenites* Thomson & Pflug emend. Potonie 1958

I. dubius (Potonié) Pflug 1953 (Lower Panchet)
I. nebulosus Balme 1970 (Lower Panchet)

PALYNOLOGICAL SEQUENCE

The quantitative composition of the assemblages in bore-holes RAD-6 and RAD-8 has been determind after counting 200 specimens from each yielding sample.

Bore-hole RAD-6

In this hole, 45 samples were taken for analysis out of which 12 samples yielded the palynomorphs (Histohram-I). Two assemblages have been identified on the basis of percentage frequency.

Assemblage I- Depth in meters 455.10, 441.30, 409.70 & 396.10

A perusal of Histogram-I reveals the prominence of the genus *Striatopodocarpites* with significant association of *Faunipollenites, Densipollenites* and *Scheuringipollenites* as abundant taxa. At 396.10 m depth certain additional taxa are encountered, such as *Praecolpatites, Marsupipollenites, Satsangisaccites, Guttatisporites;* common to rare forms are *Gondisporites, Verrucosisporites, Inaperturopollenites, Rhizomaspora, Sahnites* and *Distriatites*. Apparently there is a fairly uniform pattern in the frequency of prominent taxa but the incoming of forms having an younger affinity gives a characteristic look to this assemblage of upper reaches of Raniganj Formation; it is comparable to the assemblage R-IA of Tiwari and Singh (1986).

Assemblage II - Depth in meters 355.20, 353.45, 351.15, 350.65. 347.25, 326.50, 251.00 & 212.00

In this zone, prominence of *Verrucosisporites* is observed in association with *Lunatisporites, Lundbladispora* and *Alisporites;* other significant taxa are *Callumispora, Guttatisporites,* and *Satsangisaccites*. Besides, some forms, although inconsistent in their incidence, are stratigraphically important, viz., *Densoisporites* and *Playfordiaspora*.

This pattern represents a clear palynofloral change-over at the level of Assemblage-I/Assemblage-II; absence of *Densipollenites* and meagre presence of striate bisaccate pollen suggest an alteration in the composition of this assemblage with respect to the Assemblage-I. A close resemblance with assemblage P-IIA of Tiwari and Singh (1986) is evident for this assemblage.

Bore-hole RAD-8

In this bore-hole 334 samples were macerated out of which 78 samples were proved to be productive (Histogram-II; only rich samples depicted). Three assemblages have been identified in this succession.

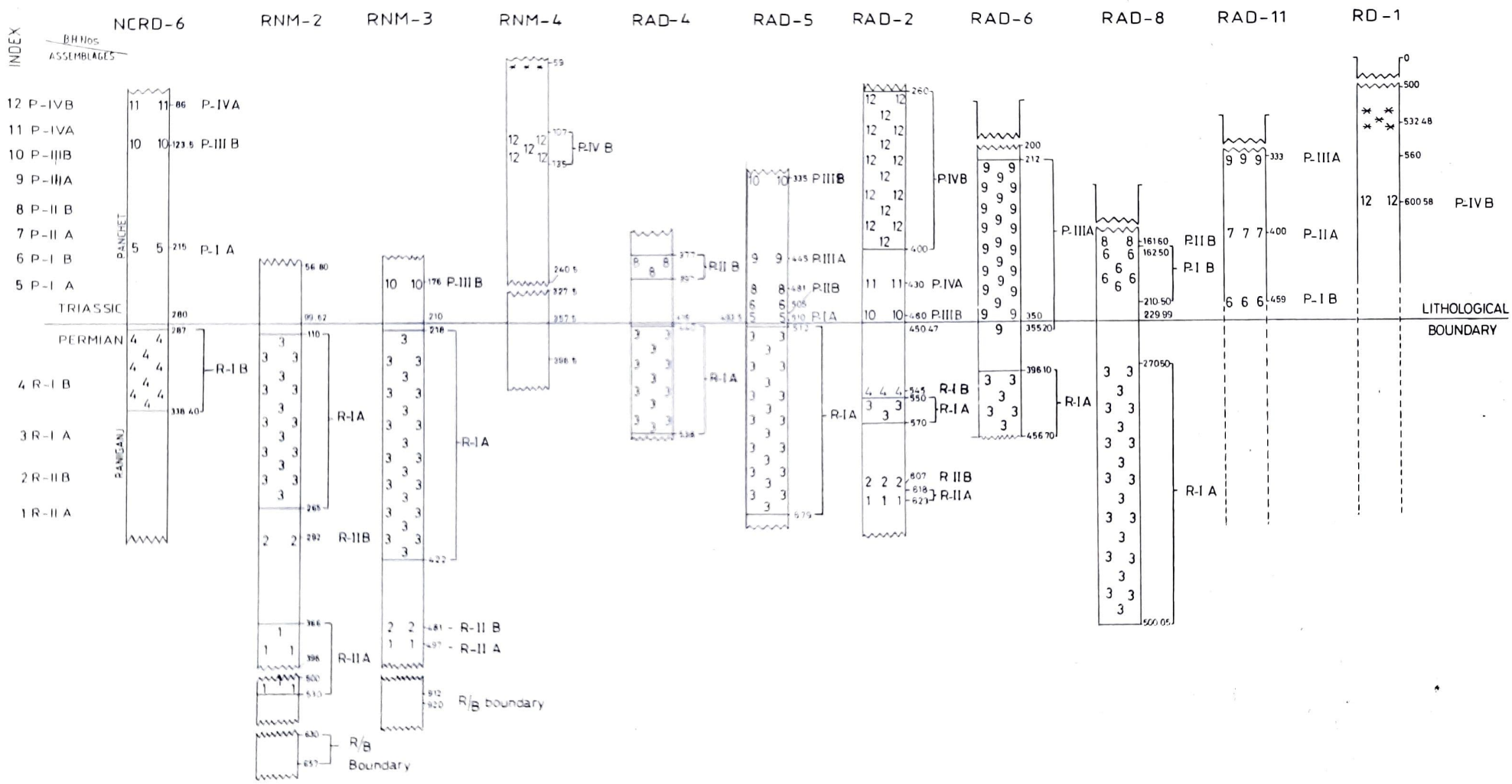
Assemblage I - Depth in meters 500.00, 495.65, 493.00, 468.45, 465.20, 419.25, 405.25, 399.10, 382.75, 377.65, 363.45, 320.80, 316.75, 300.00, 298.40, 270.50

This assemblage exhibits the dominance of *Striatopodocarpites* along with *Densipollenites;* other taxa in fair representation are *Scheuringipollenites, Faunipollenites* and *Crescentipollenites*. The rare but significant ones are : *Rhizomaspora, Sahnites, Gondisporites, Distriatites, Osmundacidites, Praecolpatites, Marsupipollenites* and *Playfordiaspora*. Absence of *Indospora* is noteworthy; however, trilete spores, as such, are meagre. This assemblage closely resembles R-1A of Tiwari and Singh (1986) in the preponderance of striate disaccates (Text- fig. 1)

Assemblage II - Depth in meters 210.05, 205.35, 205.00, 189.20, 181.00, 162.50, 162.00

The qualitatively significant taxe are *Satsangisaccites,* and *Callumispora* , other forms are *Alisporites, Lunatisporties, Lundbladispora, Verrucosisporites* which dominate the overall scene. Inconsistency of *Densoisporites, Playfordiaspora* and *Guttatisporites* has been noted.

The overall composition of Assemblage-II differs from that of the Assemblage-I in the declining frequency of some



Text-figure 1. Composite diagramme to show palynological correlation at the passage of Raniganj - Panchet formations. The assemblages - R = Raniganj, P = Panchet and their subdivisions (adapted after Tiwari & Singh, 1986). The ordinal numbers 1-12 given in bore-holes correspond with those as Index.

genera which have been prominent in the latter one, e.g. *Densoisporites, Faunipollenites, Scheuringipollenites, Verticipollenites* and *Praecolpatites.*

The significant change-over from Assemblage-I to Assemblage-II, is noted in the outstanding rise of the genera *Alisporites* and *Lunatisporites.* Thus, inspite of a basic continuity of elements, at the level of Assemblage-I/Assemblage-II, the alteration is distinct, which has comparability with P-IB of Tiwari and Singh (1986) illustrated here in Text-fig.3.

Assemblage III - Depth in meters 161.60; Histogram-I.

A solitary sample contains abundant *Verrucosisporties;* other forms are *Lunatisporites* and *Lundbladispora;* the rare but qualitatively important taxa are *Playfordiaspora, Guttatisporites* and *Callumispora.* This compares well with Assemblage P-II B of Tiwari and Singh (1986).

RANIGANJ-PANCHET PASSAGE

In bore-hole RAD-8 three distinct assemblages have been identified. Assemblage-I is indicative of the Late Permian age by virtue of the presence of striate disaccates, enveloping monosaccates, and cavate spores with narrow-zona. Moreover, appearance of some of Early Triassic forms demonstrates the proximity, in time, of Permo-Triassic boundary at the level near 270 meter depth. This conclusion corroborates the results derived by Singh and Tiwari (1982) and Tiwari and Singh (1983,1986). The apparent line of demarcation between Assemblage-I and Assemblage-II lies after the sample no. 168 (depth 270.50 m) and sample no. 88 (depth 205.35 m) corresponding to a change from Raniganj to Panchet palynoflora (Histogram-II). However, the gap between these two samples can be narrowed down if we also take into account those samples which yield very few specimens but can be qualitatively assessed for their affinities with either of the assemblages; such samples, viz., no 163 (depth 267.30m), 159 (265.80 m), 158 (260.00 m), 154 (253.65 m), 140 (241.00 m), 135 (237.70 m) and 129 (228.55 m) have not been included in the Histogram-II because of the poor palynological contents in them. Considering these samples also, the P/Tr boundary can be placed between sample nos. 135 (depth 237.70 m), and 140 (241.00 m). The rest of the run of the bore core has not yielded any palynofossil.

Thus, the Early Triassic palynoflora foreshadows its signature right at the top of the Raniganj Formation by rare and inconsistent incidences of the genera *Lundbladispora, Densoisporites, Playfordiaspora, Klausipollenites, Satsangisaccites, Praecolpatites, Lunatisporites* and *Inaperturopollenites.* The alteration in the qualitative composition through this level is definite and suggestive of the change coinciding the Permo-Triassic transition phase (Tiwari & Singh, 1983; Tiwari & Vijaya, 1992).

The Assemblage-II has different quality of constituents. The taeniate disaccate, non-striate disaccate and the cavate forms are the major elements, while the forms typical of Raniganj palynoflora decline significantly. This assemblage is not the oldest assemblage of the Panchet Formation (Tiwari & Singh, 1986) but represents the next younger assemblage in the sequence with respect to the oldest Panchet assemblage.

The solitary sample at 161.60 m has yielded a still younger palynological association; it is rich in *Lundbladispora, Lunatisporites* and *Verrucosisporites.*

In bore-hole RAD-6 two assemblages have been recognised. Assemblage-I is of Late Permian age by virtue of *Densipollenites, Crescentipollenites, Striatopodocarpites, Verticipollenites* etc. In bore-hole RAD-8 similar assemblages are present which correspond to the palynoflora of Late Permian (Text-fig.3).

Assemblage-II of RAD-6 is strikingly different from the Assemblage-I of RAD-8, the older one, in showing a gradual disappearance of the genera characteristic of the latter. The positive evidence of the change in the composition of Assemblage-II is revealed by the dominance of *Verrucosisporites, Alisporites, Lunatisporites, Lundbladispora* and *Inaperturopollenites.* It is interesting to note that *Callumispora* appears in a significant way at the topmost reaches of Assembles-I (Raniganj) and continues into the Assemblage-II (Panchet). Here again, this assemblage does not represent the oldest composition of the Panchet palynoflora; it equates with P-II A Zone of Tiwari and Singh (1986).

Lithologically the Raniganj-Panchet boundry has been demarcated at the advent of khaki-green shales at 355.00 metre. Palynologically the change must lie between 355.20 to 396.10 meter, although a precise line could not be drawn because of the non-yielding nature of samples between two levels.

PALYNOFLORISTICS

The diversification of striate disaccate and variation in the trilete as well as monolete genera are the characteristics of Raniganj palynoflora. The diversity in the nature of spore-pollen assemblage indicates luxuriant vegetation.

Among the trilete spores, the record of the genus *Callumispora* in Raniganj assemblage is noteworthy because it is a remainic of the assemblage of Talchir Formation. It either inconsistently persists or vanishes from the scence but reappears in the Early Triassic. What made this form to continue through a period of 65 million years ? Apparently its parent plants were cold-loving and had a capacity to tolerate near-glacial conditions and as the climate ameliorated they survived through migration, probably to uplands.

The diversity in trilete spores is further evident from the species of *Thymospora*, *Verrucosisporites*, *Cyclobaculisporites*, *Lophotriletes*, *Microfoveolatispora* and *Microbaculispora*. Among the zonate form, *Gondisporites* is a good marker of the Raniganj assemblage. *Distriatites* and *Striomonosaccites* are clear evidences of the multiplication of striate character, adding to the complexity of this group. It appears that the stability of amicable climate was responsible for the diversification of plant groups which produced varied kinds of striate pollen.

Among the monosaccate pollen, *Densipollenites* is singled out for its organization, (saccus enveloping the body) and restricted distribution in time. Two species of the genus have been identified during the present study in the uppermost Raniganj.

The genera *Guttatisporites*, *Osmundacidites*, *Klausipollenites*, *Satsangisaccites*, *Praecolpatites*, *Alisporites* and *Inaperturopollenites* are characteristic elements of the Panchet palynoflora. The cavate forms, such as *Lundbladispora*, *Densoisporites* and *Playfordiaspora* and the taeniate disaccate *Lunatisporites* are recorded in traces from the uppermost Raniganj but make their significant presence only in the Panchet.

Thus, qualitatively the palynological assemblgaes of Raniganj and Panchet formations are two distinct populations with a backdrop continuity depicted by certain forms. The appearance of a new set of organization in the Panchet palynoflora certainly indicates a change in vegetation. There is no sharp break or a drastic change between the two assemblages under discussion.

Presently, two diagnostic features are identified in certain spore-pollen in bore-holes RAD-6 and RAD-8 : *(i)* Secondary features of exine in pollen and spores, *(ii)* Tetrads of spores in dispersed conditions.

The sexinal abnormalities including scattered aggregated coarse foveolae or reticulum-like structures have been observed irregularly on the spore surface. They are not the product of biological degradation because their shapes and sizes are very regular. These features are the product of pyrite crystals which is indicative of high sulpher contents in the medium where such forms were preserved (Tiwari, Misra & Meena, 1990).

The occurrence of tetrads in dispersed condition in a large number has been identified as a significant incidence at the Permo-Triassic boundary (Tiwari & Meena, 1989). The changing conditions of climate resulted into the non-separation of the tetrad units and consequently an array of tetrads has been found in dispersed condition. This change appears to be crucial, and incoming of new elements corroborated this observation.

CORRELATION PARADIGM

So far, several bore holes in the area of present study have been analysed for palynological zonations (Bharadwaj & Tiwari, 1977; Tiwari & Singh, 1986). The addition of the presently studied data makes a total number of ten bore-holes, which represent the unequivocal Upper Permian - Lower Panchet sequence in the area. A composite figure of equations amongst different assemblages encountered in these bore-holes has been prepared (Text-fig. 3). The lithological demarcation between Raniganj and Panchet

PLATE 1

1. *Lunatisporites pellucidus* (Goubin) Maheshwari & Banerji 1975; BSIP slide no. 10559, EF 016/2.
2. *Ibisporites diplosaccus* Tiwari 1968; BSIP slide no. 10565, EF X 31.
3. *Praecolpatites sinuous* Bharadwaj & Srivastava 1969; BSIP slide no. 10562, EF W 5/4.
4. *Callumispora fungosa* (Balme) Bharadwaj & Srivastava 1977; BSIP slide no. 10568 ; EF M 24.
5. *Lophotriletes rarus* Bharadwaj & Salujha 1964; BSIP slide no. 10556; EF N 26/1.
6. *Playfordiaspora cancellosa* (Playford & Dettmann) Maheshwari & Banerji 1975; BSIP slide no. 9312, EF W 27/1
7. *Ephedripites mesozoicus* Maheshwari, Bose & Kumaran 1977; BSIP slide no. 10566, EF W 27/3.
8. *Lundbladispora brevicula* Balme 1963; BSIP slide no. 9313 W 24.
9. *Lunatisporites ovatus* (Goubin) Maheshwari & Banerji 1975; BSIP slide no. 10557, EF M 41.
10. *Osmundacidites pilatus* Tiwari & Rana, 1981; BSIP slide no. 10556, EF J 36/2.
11. *Alisporites indicus* Bharadwaj & Srivastava 1969; BSIP slide no. 10563, EF X 30/3.
12. *Marsupipollenites triradiatus* Balme & Hennelly 1956, BSIP slide no. 10571, EF Q 26.
13. *Crescentipollenites amplus* (Maithy) Bharadwaj, Tiwari & Kar, 1974; BSIP slide no. 10567, EF Q 31/2.
14. *Satsangisaccites triassicus* Bharadwaj & Srivastava 1969; BSIP slide no. 10556, EF M 19/2.
15. *Sahnites thomasii* Pant emend. Tiwari & Singh 1984; BSIP slide no. 10559, EF S 23/4.
16. *Densoisporites contactus* Bharadwaj & Tiwari 1977; BSIP slide no. 9314, EF W 25.
17. *Verrucosisporites protomulosus* Reinhardt 1964; BSIP slide no. 10564, EF O 16/4.
18. *Inaperturopollenites nebulosus* Balme 1970; BSIP slide no. 9313, EF X 21.
19.. *Striapollenites obliquus* Bharadwaj & Salujha 1964; BSIP slide no. 10559, EF T 16/2.
20. *Densipollenites invisus* Bharadwaj & Salujha 1964; BSIP slide no. 10561, EF R 36.
21. *Guttatisporites microechinatus* Visscher 1966; BSIP slide no. 10558, EF X 21.
22. *Lundbladispora* (Tetrad) - A tetrad bearing 1-2 mm long coni; BSIP slide no. 9313, EF N 17/1.

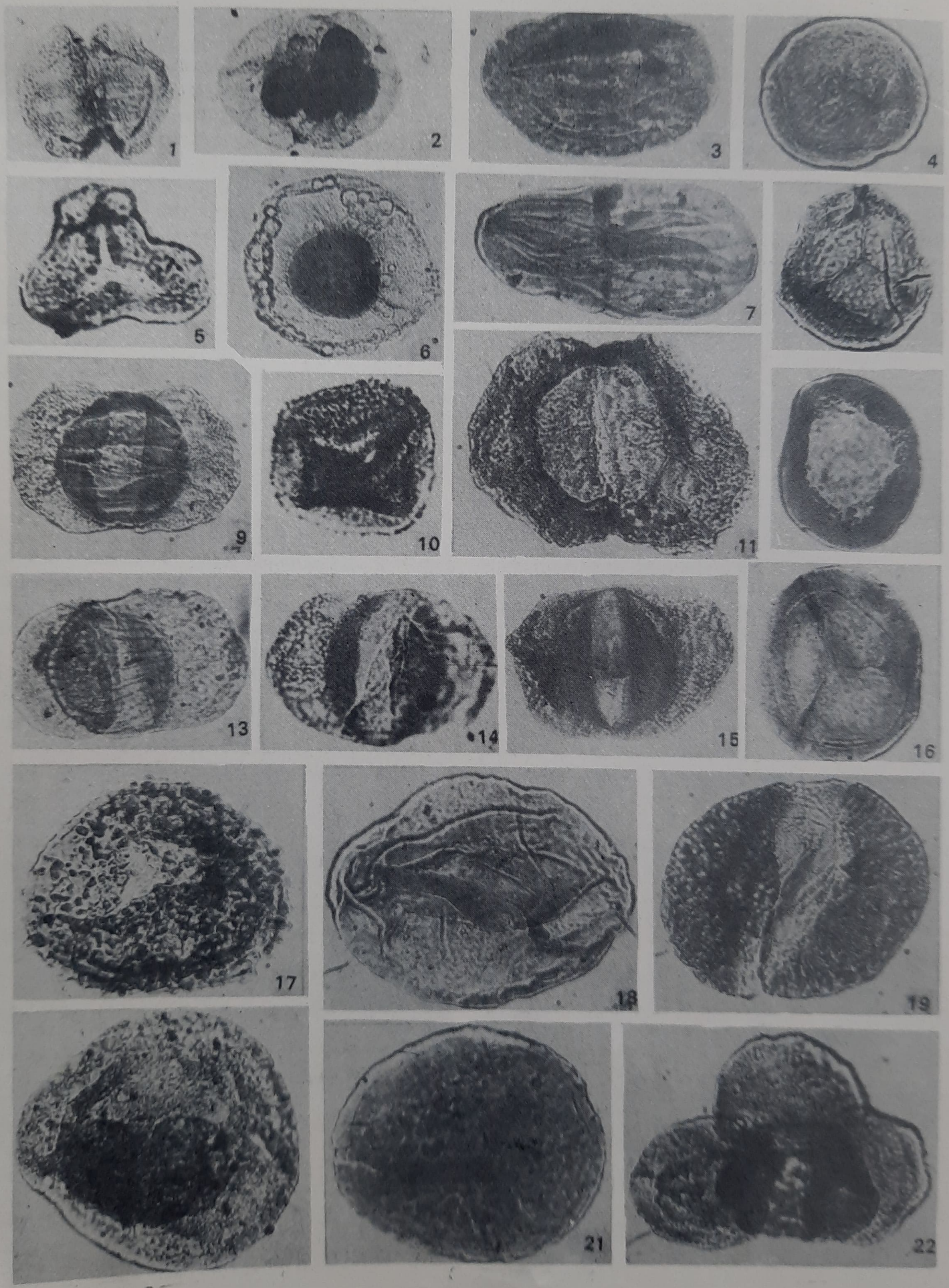


PLATE 1

formations in the Damodar Graben is very distinct. The Raniganj contains coal, grey and carbonaceous shale and sandstone units while the Panchet possesses khaki-green shales and sandstones followed by chocolate shales, sandstone package in the sequence.

The model of palyno- succession evolved by Tiwari and Singh (1986, fig. 1) for seven bore-holes in the Raniganj Coalfield, is taken here as the basis for further interpretation. To this figure, the presently studied two bore-holes, i.e. RAD-6 and RAD-8, and the data of bore-holes RAD-11 and RD-1 are added (Text-fig. 1). A persual of the correlated zones reveals that in NCRD-6 (near Asansol, 22° 42'N; 86^0 59' E : Bharadwaj & Tiwari, 1977) a regular and gradually smooth change in composition had occurred, which indicates a continuity in Raniganj-Panchet sedimentary suites. However, in other cases there are some gaps in palyno-assemblages at the transition from carbonaceous facies to the khaki green-shale facies. This has resulted due to either non-yielding nature of the samples or non-availability of the same, or could be discontinuity in deposition in some instances. Taking these three factors into account, the super-imposition of palynological assemblages, including their divisions, were made on the basis of relatively older or younger aspects of the taxa (Tiwari & Singh, 1986). The assemblage R-I definitely qualifies for the youngest levels of the Raniganj Formation; similary assemblage P-I is the marker of the oldest Panchet Formation.

It may be that the subdivisions of these assemblages, viz., R-IA and R-IB; P-IA and P-IB, are not represented in all the bore holes because of the reasons stated above. It will not be out of place to mention here that the changes in the nature of assemblages are much quicker along the temporal scale within the Lower Panchet as compared to their behavior in the Raniganj (Vijaya & Tiwari, 1987; present data). This means that chances of missing a subdivision of an assemblage are greater in the Panchet.

In two bore-holes (RAD-2, RAD-6) apparent anomaly seems to exist where Panchet palynofloras were recovered from the coarse gritty sandstone units which appears to lie below the lithological boundary. Very obviously this sandstone being gritty represents a time-lag as also indicated by spore-pollen content; hence the lithological boundary should be drawn below this unit in these bore holes.

Except for bore-holes RAD-2 and RAD-6, there appears to be no hiatus of greater magnitude in the sequence. The spore-pollen sequences in bore-holes NCRD-6, RNM-2, RNM-3 and RAD-8, very well fits into the pattern.

The palynology reveals that the breaks in deposition at Raniganj/Panchet boundary are not regional or of wider extent. However, in a river fan system and braided channel depositional model, such non-depositional loci do occur. They are represented by gritty sandstone unit and could be located by the composition of palynoassemblages. The shallowing of the basin, which was the scene during post-coal formation period, could have resulted into such a situation of local non-representation of the sediments in Panchet.

The change in lithology and palynology demarcates the line of major alteration at the Raniganj-Panchet boundary and, hence the existence of the Permian/Triassic boundary at this level is supported (Tiwari & Vijaya, 1992).

In sequal to palynozone P-IV, the *Lunatisporites* and cavate trilete phase is replaced by *Lunatisporites* - *Goubinispora* association identified in bore holes RD-1 and RNM-4. Such a change by the dominance of *Goubinispora* characterizes a new composition (Tiwari & Rana, 1984).

CONCLUSIONS

Additional evidences for palynofloral change at Raniganj-Panchet boundary are available which indicate substantial climatic and environmental modulation. The occurrence of unusually large number of tetrads of spores and rampant pyritic degradation of sexine are signals of such an episode. In the eastern part of Raniganj Coalfield the deposition through Raniganj/Panchet boundary is uniformly continuous but with local non-depositional phase. The discrete abreviations of sedimentation, however, appear to be the result of shallow basinal situation and channel depository system.

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