Palyno-dating of Nidpur beds, Son Graben, Madhya Pradesh

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The Nidpur beds, located in Gopad River section near Nidpur Village, Sidhi District, Madhya Pradesh, have proved to be a treasure of plant fossils—mainly fructifications and leaf-structures. The occurrence of *Dicroidium* rich pteridospermic megaflora provides the basis for dating these beds as Triassic. The present study reveals that the Nidpur beds are bracketed between two faults, as a result of which they escaped the erosion. The other underlying plant beds exposed in Gopad river and its tributaries (Mahan River and Sehra Nala) are older than Nidpur beds, as they yielded latest Permian palyno-assemblages. Lithologically the Nidpur beds are classified within the Upper Pali Member, and their palyno assemblage containing *Playfordiaspora, Lundbladispora, Densoisporites, Araucariacites, Goubinispora, Klausipollenites, Lunatisporites, Trabeculosporites*, indicates a Triassic affiliation. The trailing striate-disaccates are the remainié of the Upper Permian flora. On the basis of mega- and microfossils it is suggested that they are of the Early Triassic age.

Key-words—Palynology, Palyno-dating, Nidpur beds, Early Triassic (India)

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सारांश

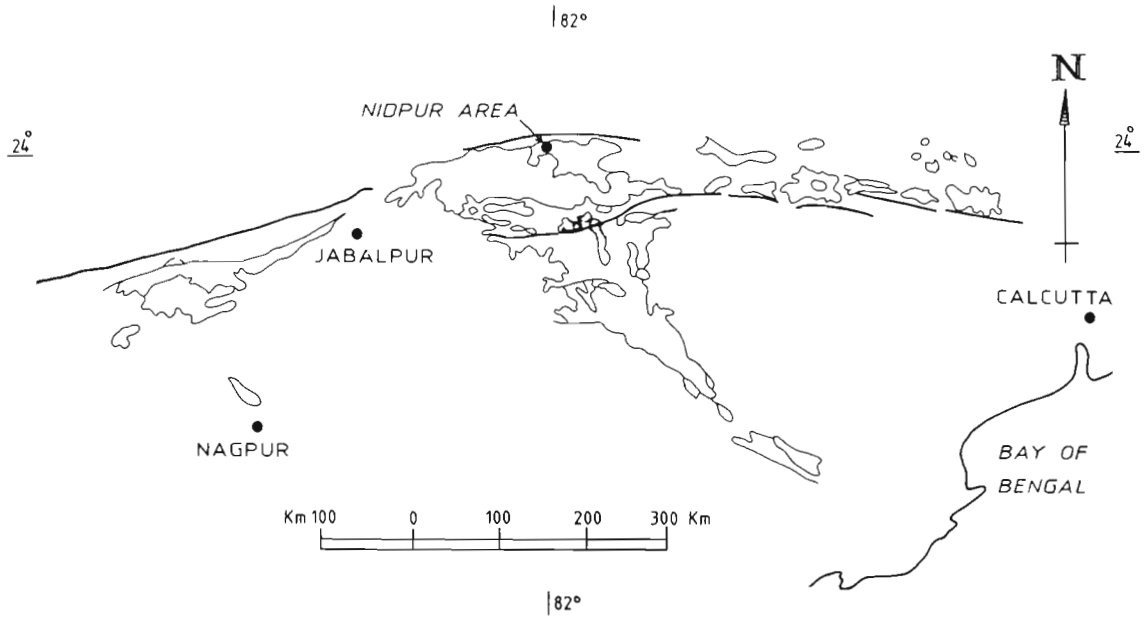
मध्य प्रदेश में सोन द्रोणिका में निदपुर संस्तरों का परागाणविक कालनिर्धारण

राम शंकर तिवारी एवं राम अवतार

मध्य प्रदेश में सिधी जनपद में निदपुर गाँव के समीप गोपद नदी खंड में विद्यमान निदपुर अश्मित पादप-धारक संस्तरों से प्रचुर मात्रा में पादपाश्म मिले हैं जिनमें मुख्यतया फलन एवं पत्ती-संरचनायें हैं। **डाइक्रोइडियम्** से भरपूर टेरिडोस्पर्मी गुरुवनस्पतिजात के आधार पर इन्हें त्रिसंधी कल्प का आँका गया है। प्रस्तुत अध्ययन व्यक्त करता है कि निदपुर संस्तर दो भ्रंशों के बीच स्थित हैं जिसके फलस्वरूप ये नष्ट होने से बचे रहे। गोपद नदी तथा इसकी सहायक नदियों (महान नदी व सेहरा नाला) में निदपुर संस्तरों के नीचे विगोपित संस्तर इनकी अपेक्षाकृत अधिक पुरानी हैं चूँकि इनसे अनंतिम परमी युगीन परागाणविक समुच्चय उपलब्ध हुई है। शैलविज्ञान की दृष्टि से, जिन्हें मध्य पाली सदस्य के अन्तर्गत वर्गीकृत किया गया है तथा जिनमें **प्लेफ़ोर्डियास्पोरा, लुन्ब्लाडिस्पोरा, डेन्सोइस्पोराइटिस, ऑराकेरियासाइटिस, गाउबिनिस्पोरा, क्लॉसिपोलिनाइटिस, ल्यूनाटिस्पोराइटिस, ट्रेबेकुलोस्पोराइटिस** नामक परागाणुवर्गक विद्यमान हैं, त्रिसंधी कल्प का होना इंगित करते हैं। रेखीय-द्विकोष्ठीय परागकण उपरि परमी वनस्पतिजात के अवशेष हैं। शैल-स्तरविन्यास के आधार पर ये संस्तर उपरि पाली सदस्य के अन्तर्गत आती हैं। परन्तु गुरु- एवं सूक्ष्मपादपाश्मों के आधार पर इन्हें प्रारम्भिक त्रिसंधी आयु का प्रस्तावित किया गया है।

NIDPUR beds were discovered by Satsangi (1964) in the Gopad River section, western part of Singrauli Coalfield (Map 1), Sidhi District, Madhya Pradesh. Since then, they have attracted the attention of palaeobotanists, particularly because of well-preserved, abundant megafossils with varied fructifications found in these beds (Srivastava, 1975; Srivastava & Maheshwari, 1975; Pant & Basu, 1977, 1979). Also, a few palynological assemblages are recorded from these fossiliferous beds as well as other outcrops in the area (Chandra & Satsangi, 1965; Maheshwari, 1967; Bharadwaj & Srivastava, 1969; Trivedi & Misra, 1970). The tectonic set-up and the relative position of these beds, with mega- and microfossils, are of much interest for the age relationship of these beds.

Palynological dating of these beds makes the focal theme of the present paper. The sediments exposed on the left bank of Gopad River, at about 2 km north-east of Nidpur Village (24° 7′ : 81° 53′), between two faults (F^2 and F^3, Map 2) adjacently south of Sehra Nala confluence with Gopad River



Map 1—Showing pivotal positioning of Nidpur area in Son Valley Graben (southern arm) in relation to Damodar Graben (eastern arm) and Satpura Graben (western arm).

have been exclusively considered here as "Nidpur beds" and the area of study has been termed as "Marhwas area" (24°0′-24°10′ : 81°50′-82°0′) named after the Marhwas Village. As an essential suppliment for finer palyno-dating of these beds, several exposures is this area along Gopad River, Mahan River and Sehra Nala were also studied. A comparative assessment of assemblages recovered from *Dicroidium*-rich and *Glossopteris*-rich strata has been made. The data have been interpreted against the back-drop of geology, lithology and stratigraphy of the Pali Formation to which these sediments belong.

GEOLOGY OF THE AREA

The Marhwas area is located in the Singrauli Basin, the extreme northern region of Son-Mahanadi Graben and the Nidpur beds are situated in the western most tongue of the Singrauli Basin. The situation of this part of the basin is very peculiar in that it occupies a point at the tri-junction of Damodar, Satpura and Son-Mahanadi grabens. Implicitly, the resemblance, in degrees, with these three grabens is expected in lithology and plant history (Map 1). In north, Pali Formation (Raniganj) and, at places, Parsora (Mahadeva) sediments are directly in contact with the Precambrian basement. The Gopad River traverses in south-north direction through this area. A shifting of basinal centre during sedimentation has been inferred with reference to the regional set-up of the basin (Raja Rao, 1983). The southern part of the area is bound by Parsora (Mahadeva) hillocks. The main country around Marhwas and Nidpur villages is a flat alluvial plain, excepting Gothra and Chakdahi hills, exposing mainly sediments of Pali Formation in river cuttings.

Majumdar (1981) gave a comprehensive account of the geological set-up of this area which has been modified as under on the basis of present palaeobotanical and palynological evidences.

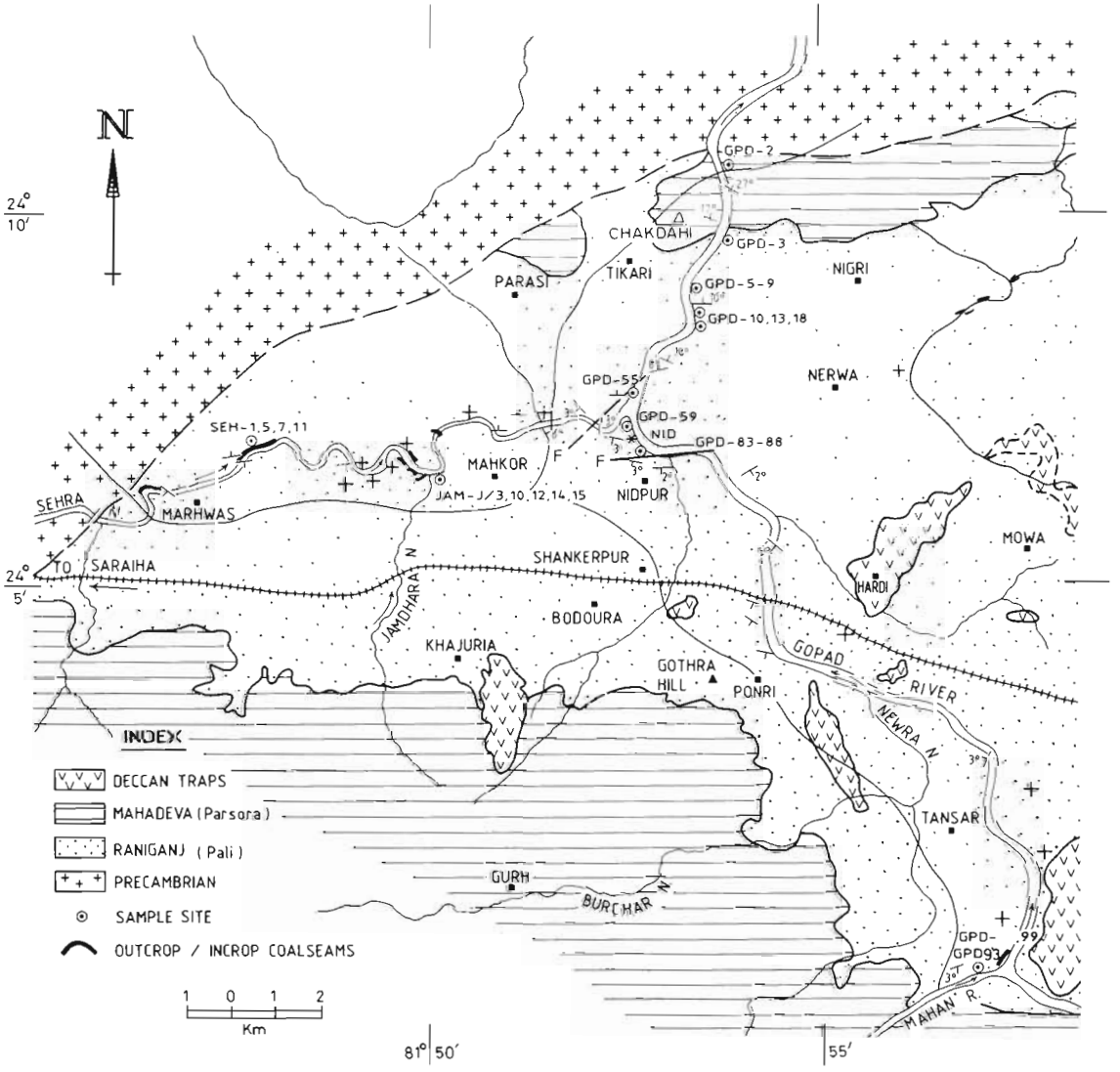
CRETACEOUS	DECCAN TRAP	DOLERITES AND BASALTS
Middle Triassic Upper Triassic?	Parsora	Grey coarse to medium-grained sandstone with red to lilac coloured sandstone
.....Unconformity/Overlap and fault.....		
Upper Permian to Lower Triassic	Middle and Upper Pali Formation	Grey feldspathic sandstone, shale, siltstone with carbonaceous shales, coal and siderite bands
.....Faulted.....		
Precambrian	Precambrian	Slates, quartzites and metabasic granite schists, gneisses and granulites

The Precambrian igneous- metamorphic complex forms a high scarp in the north and north-western part of the area. The younger sediments are separated from Precambrian by a prominent boundary fault.

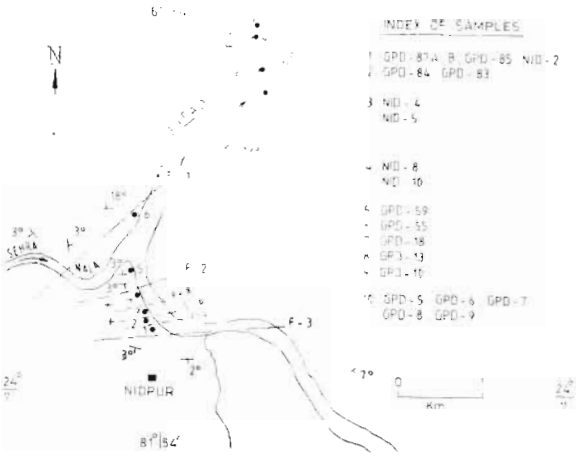
The Pali Formation is mainly composed of monotonous, multistoreyed arenaceous argillaceous rock assemblage and its lower contact faulted against the Precambrian complex. These suites of sediments are unconformably overlain by dominantly arenaceous beds with ferruginous violet-coloured, lilac-coloured sandstone, as seen in the Gopad River, north of Nidpur Village. Lithologically, the Pali Formation comprises sandstone, shale-siltstone, carbonaceous shale and coal sequence with minor calcareous intercalations and red shale-clay pockets. The Nidpur beds occupy the topmost part of the Pali sequence.

The Parsora Formation is exposed in the south and south-western part of the area (earlier marked as Mahadeva). Along the Gopad River, capping the Nidpur beds, coarse-grained sandstone with lilac colour intercalation have been noticed. In the northern-most region, the Parsora Formation is exposed in a overlap contact with the Pali Formation.

As is clear from the dip directions given in Map 2, a mild anticlinal structure trending east-west in the centre of the region is developed. Its axis runs along Marhwas-Nidpur alignment, more or less along the course of Sehra Nala which generally exposed horizontally along the strike. Near the confluence of Sehra nala with Gopad River, the situation has become complicated because of three faults (Map 2, 3). As defined above, the Nidpur beds exposed on the left bank of Gopad River, about 300 m south of Sehra-Gopad confluence, are bracketed between faults F-2 and F-3. In its turn, the sequence locked up between these two faults is also dissected by



Map 2—Geological map of north-west portion of Singrauli Coalfield showing Marhwas area where the Nidpur beds (asterisk) are situated. The yielding samples, marked by dot within a circle, are indicated along the traverses taken. NID (asterisk) indicates the position of sample nos. NID-4, 5, 8, 10, whose details are given in Map 3 (after Raja Rao, 1983).



Map 3—Gopad River section enlarged to show Nidpur beds—between Fault F2 and F3; location of yielding samples also depicted.

three minor faults, F-a, F-b and F-c, with 2 to 5 m differential down-throws. The Nidpur beds are more or less horizontally placed, and their displacements can be reconstructed on the basis of lateral extensions of lithological units.

Between faults F-1 and F-2, a distinct anticlinal fold structure is exposed in a faulted contact (F2) whose southern limb is dipping (6°) southwardly (Map 2, 4; Text-fig. 4). The sediments between faults F-1 and F-2 contain *Glossopteris-Vertebraria*-dominant magaflora and a typical Upper Permian palynoflora (present work); *per contra*, the Nidpur beds between faults F-2 and F-3 contain *Dicroidium*-bearing flora with distinctive palynofossils. The discontinuity of the Permian sequence with respect to Nidpur beds is thus evident The Permian sediments are exposed again at southern side of Nidpur beds with a faulted contact (Fault F-3)

PALYNOSTRATIGRAPHY

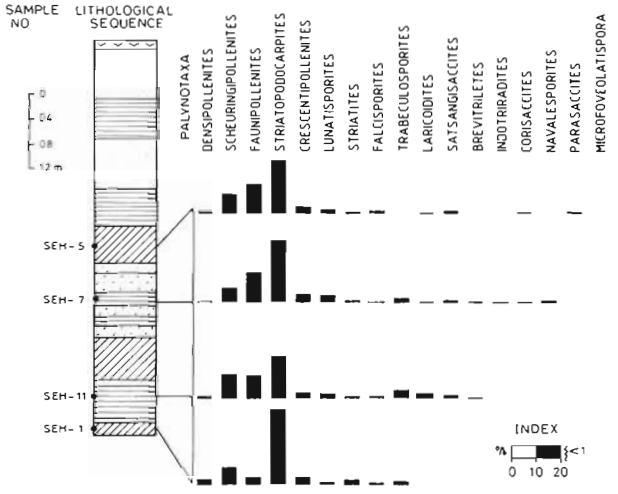
I. Sehra Nala Section

A traverse was taken from west of Marhwas Village along the course of Sehra nala eastwards up to its confluence with Gopad River. The main lithology of the exposed sediments exhibits sandstones, shales, rarely thin coalseams of dull coal, carbonaceous shales and thin bands of fine clays. The sandstones are ferruginous with brick-red colour near Mahkor Village. The beds are gently dipping northwards, or horizontal (Map 2). Plant megafossils seen during the collection of samples are mainly *Glossopteris* leaves, *Vertebraria* and few unidentifiable twigs, but no *Dicroidium* was found. In all, 47 samples were collected, out of which 11 have yielded palynomorphs (Map 2). The details of these samples are as follows :

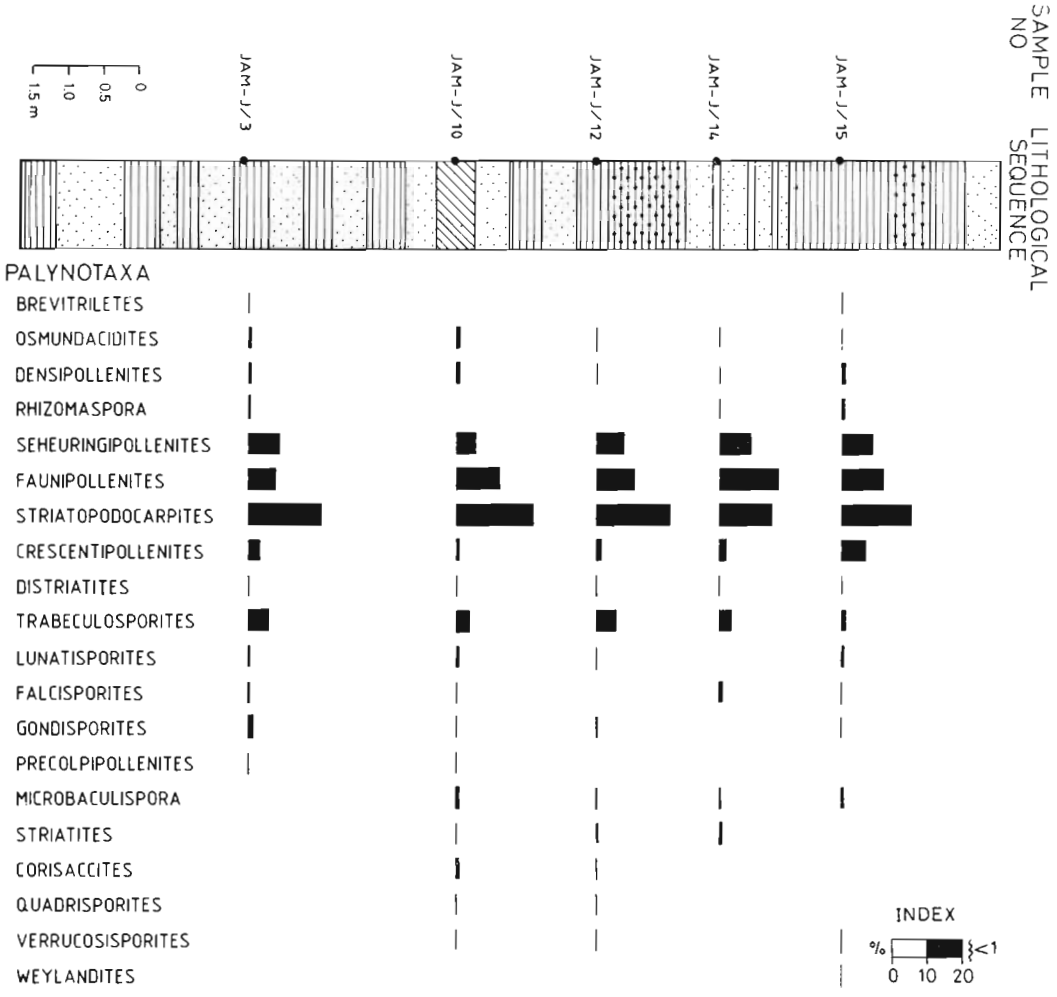
Sample No.	Lithology	Geological horizon	Flora
SEH-5	Black shale	Pali (Raniganj)	*Glossopteris* dominant
SEH-7	Grey shale		
SEH-11	Shale		
SEH-1	Carbonaceous shale		
JAM-J/3	Grey shale	Pali (Raniganj)	*Glossopteris* dominant
JAM-J/10	Black shale		
JAM-J/12	Black shale		
JAM-J/14	Ferruginous compact sandstone		
JAM-J/15	Ferruginous compact sandstone		

I-A. *Exposures near Marhwas Village*—About one kilometer north-east of Marhwas Village, a 6 m thick pile of horizontally placed black and grey shales and sandstones are exposed (Text-fig. 1) in the right bank of Sehra nala from where four samples proved to be rich in spores and pollen grains.

The assemblage is dominated by striate-disaccate genera : *Striatopodocarpites* and *Faunipollenites*, in association with non-striate genus *Scheuringipollenites*. Other taxa recorded are *Brevitriletes, Microfoveolatispora, Indotriradites, Guttulapollenites, Densipollenites, Crescentipollenites, Inaperturopollenites, Navalesporites* and *Striatites*. The genera—*Lunatisporites, Trabeculosporites* and the non-striate group consisting of *Satsangisaccites* and *Falcisporites* also



Text-figure 1—Frequency of palynotaxa in sequential samples collected from Sehra nala section (refer Map 2) near Marhwas.



Text-figure 2—Frequency of palynotaxa in sequential samples collected from Sehra nala section (refer Map 2) near Mahkor

appear inconsistently and sporadically in the assemblage.

No spore of *Lundbladispora-Densoisporites* group, or the genus *Weylandites* has been recorded. The overall composition indicates an uppermost Permian affinity for the assemblage. For such a conclusion, *Guttulapollenites* and *Navalesporites* have been taken into consideration with reference to the totality of assemblage.

I-B. *Exposures near Mahkor Village*—Thick exposures with low, northerly dips or horizontal strata are seen at the confluence of Jamdhara nala and Sehra nala. Further downstream of Sehra nala, near Mahkor Village massive deposits of compact, ferruginous, red sandstones are exposed. The intermittent shale bands within the sandstones, containing *Glossopteris* and *Vertebraria,* yielded spores and pollen.

Palynological assemblage recovered from this section (Map 2; Text-fig. 2) also resembles Marhwas assemblage in general, but the increased percentages of *Trabeculosporites* and occasional appearance of *Hamiapollenites, Weylandites* and *Osmundacidites* are indicative of changing trend towards a relatively younger aspect.

II. Gopad River Section

The river was traversed from northern boundary fault, upstream up to the Mahan River junction (Map 2). All the prospective lithologies represented in about 150 samples were collected systematically (Map 2). The whole stretch of the area along Gopad River has been divided into following three parts.

II-A. *Section north of Nidpur plant beds*—The extent of this part runs from northern basement line up to fault F-2; 66 samples were collected for palynoanalysis, out of which only eleven have yielded.

Adjacent to the south of metamorphics, massive, coarse, ferruginous, yellowish to reddish sandstone of Parsora (Mahadeva) Formation are exposed in the

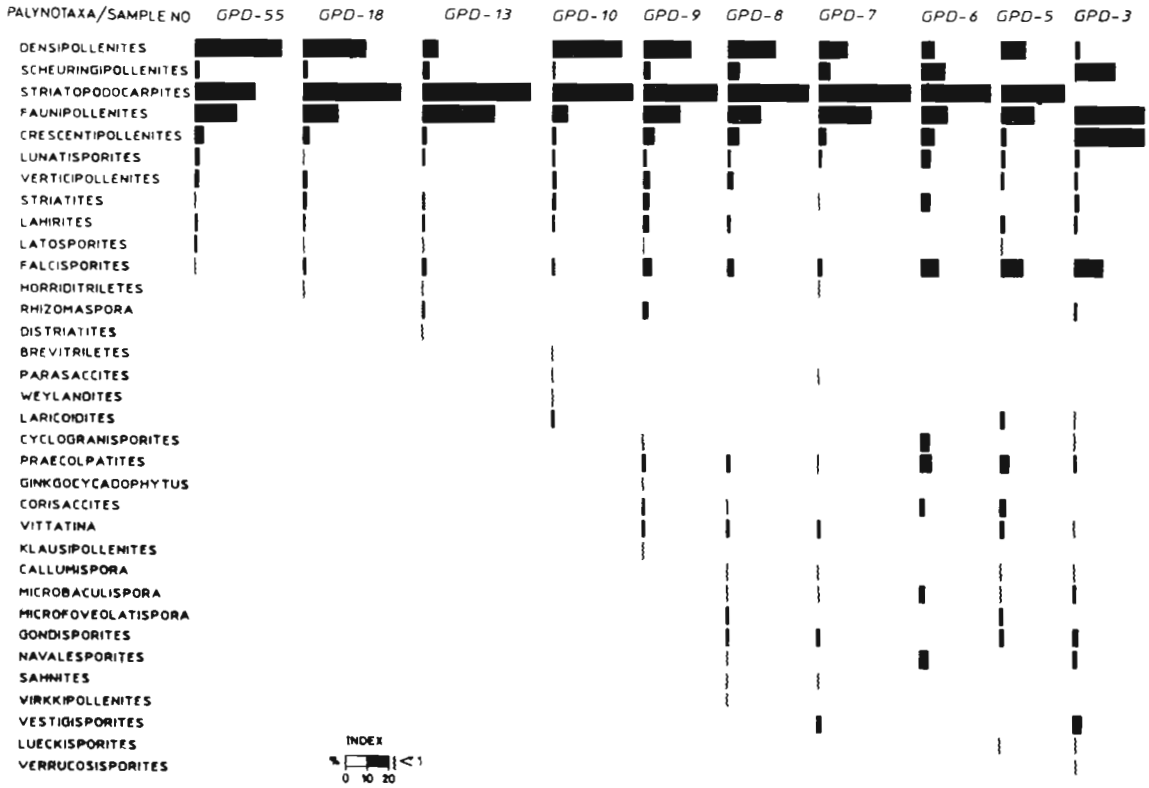
right bank of Gopad River. On the left bank, at this point, the Chakdahi Hill exposes a huge succession but none of the samples collected from scarpment proved to be positive.

Older to this strata, with a faulted contact, the Raniganj (Middle Pali) Formation is exposed; the main lithology of this sequence comprises fine-grained sandstones, siltstones, grey and black shales and rarely coaly-shale bands. Opposite to Bhumka Village, on the right bank of the river, a sequence of red ferruginous sandstone with large *Glossopteris* leaves is exposed. Even otherwise, the *Glossopteris, Vertebraria* and *Schizoneura* are commonly found The strata are low dipping towards north and north-east direction (Map 2).

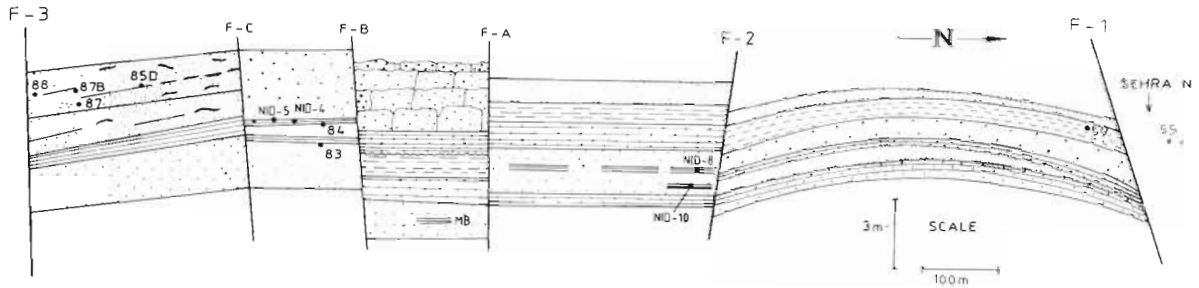
Sample no. GPD-2, a sandy shale-lense within the Mahadeva Sandstone, contains several dark brown taeniate-bisaccate pollen grains. Sample no. GPD-3, grey shale-band of 0.5 m thickness belonging to Raniganj (Pali) sequence, exposed just below Mahadeva sandstone contains a well preserved, diversified assemblage; it is in contrast with sample no. GPD-2 of Mahadeva Formation. Lithologically there is an abrupt change between GPD-3 and GPD-2 which is also reflected by palynofossils. This could represent a hiatus between Raniganj (Pali) and Mahadeva (Parsora). Sequential placement of yielding samples depicts a pattern of quantitative occurrence of various taxa, in Gopad River section, north of Nidpur fossiliferous beds (Text-fig.3).

Striatopodocarpites, Faunipollenites and *Densipollenites* are quantitatively important genera. Other characteristic forms are *Callumispora, Cyclobaculisporites, Microbaculispora, Crescenti-pollenites, Gondisporites, Lunatisporites, Falcisporites, Guttulapollenites, Verticipollenites* and *Navalesporites*. Absence of *Playfordiaspora, Trabeculosporites, Satsangisaccites, Weylandites* and *Goubinispora* is noteworthy as it reflects an older aspect of these beds than that of the palynoflora in the Nidpur beds discussed below. It is evident that the strata, exposed in Gopad River in the north of Nidpur beds, have an Upper Raniganj affinity.

II-B. *Section of Nidpur beds*—Fifty-two samples were collected from the bed exposed between fault F-2 and F-3 (Map 3), out of which 11 yielded pollen and spores. The yield was fairly rich in *Dicroidium*-bearing shales as well as in the carbonaceous bands in one of the sectors. Text-figure 4 depicts the section of this bed alongwith the location of yielding samples and Text-figure 5 gives the log of the sequence in this locality.

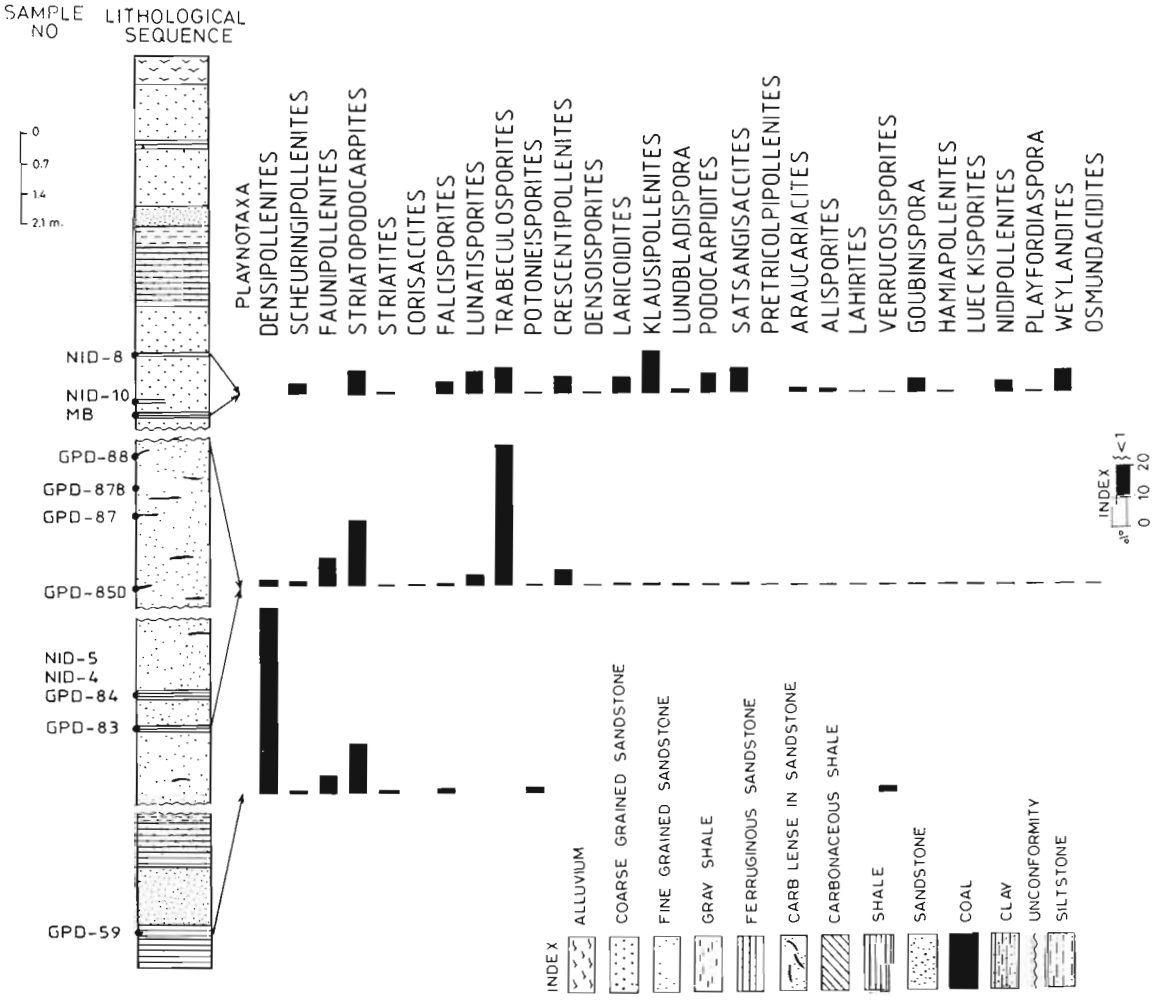


Text-figure 3—Percentage frequency of palynotaxa recovered from samples collected from north of Nidpur beds, in Gopad river (refer Map 2).



Text-figure 4—Generalised section of the Nidpur beds and associated sequence along Gopad River with location of palynologically productive samples (refer Map 3), F-1, F 2, F-3 major faults, F-A, F-B, F C faults represented by minor dislocation (for Index see Text-fig 5).

The oldest strata in Nidpur beds are situated between fault F-c and F-3. This patch has distinctive lithology having dominantly coarse-grained sandstones with whitish greyish colour in the older level and ferruginous, pinkish-redish tint in the younger level. There are several carbonaceous shales, lenses and bands in sandstone units containing few fragments of *Glossopteris* leaves and unidentifiable dispersed plant remains. A number of samples (GPD-83, 84, 85D, 87, 87B, NID-4) have



Text-figure 5—Resolved super imposition of productive samples from Nidpur beds (between Faults F-1 and F-3, refer Map 2), and the percentage frequency of palynotaxa in productive samples. Similar assemblages have been clubed together, i.e., GPD-83 to GPD-88, and MB to NID-8.

yielded a taeniate disaccate (*Lunatisporites, Trabeculosporites*) dominating assemblage. Forms assignable to *Densipollenites* having diffused body are present (Type-A; Pl. 1, fig. 13) but species with distinct body are absent.

The *Dicroidium*-bearing shales of classical important beds are exposed just above the described carbonaceous-lense-bearing sandstone unit. This sequence is located between faults F-2 and F-c in which the general sequence, from bottom to top, starts with a grey, micaceous siltstone and grey shale which is full of carbonaceous matter comprising fructifications and profused *Dicroidium* leaves with allied forms, such as *Pteruchus, Savitrispermum* and *Lepidopteris*; fragmentary and rare *Glossopteris* leaves could be seen in some layers (see Srivastava, 1969). The thickness of this siltstone bed varies from 10 to 40 cm and, at places, because of the down thrusting, it remains submerged in the Gopad stream for most of the time during the year, except summer.

Above this *Dicroidium*-rich shale layer, a 1.5 m thick sandstone unit is present being fine to medium coarse grained in texture. It contains thin, 2-10 cm, lenses of grey, silty shale as well as siltstone, having imprints of *Dicroidium*. Palynology of the sample (MB, NID-8, NID-10) from this second horizon of *Dicroidium* shows an abrupt change in palynoflora where taeniate forms decline considerably.

Younger to the sandstone unit described above, there is another sandstone bed (1-2 m) containing thin layers of silty shale as well as siltstone but no mega-or microfossils have been found in them. This sandstone is capped by generally weathered, massive, red ferruginous sandstone of about 2 m thickness. Between these two sandstone layers a chocolate colour shale band (20-30 cm) is present which did not yield any microfossils.

The details of sequential set-up, thus, clearly reveal that the beds exposed between faults F-2 and F-a are horizontally placed exhibiting *Dicroidium*-bearing shales in the lower sandstone. The slice between faults F-a and F-b has suffered a subsidence so that the layers rich in *Dicroidium* have submerged in water. Sediments between faults F-b and F-c are again down-thrusted. The beds between fault F-c and F-2 represent more or less similar lithology, but those between F-c and F-3 are different, where the dips turn southwardly. No sediments are exposed after fault F-3 for quite some distance, beyond which the Pali (Raniganj) sediments are again exposed.

In this succession two palynological zones have been delimited between faults F-2 and F-3. The productive samples are grouped in sequential order as under·

SAMPLE NO.	LITHOLOGY	REMARKS
ZONE II		
NID-8	Greenish shale	Faint prints of fossils
NID-10	Grey siltstone	*Dicroidium* present
M.B.	Grey shale	(Master bed) Rich in fructifications *Dicroidium*; poor *Glossopteris*
ZONE I		
GPD-88	Carbonaceous shale	Fragmentary fossils; *Glossopteris*
GPD-87B	Grey micaceous shale	Fragmentary fossils
GPD-87	Grey silty shale	*Glossopteris* poor ?*Dicroidium* Poor
NID-5	Carbonaceous shale	Specks of plant material

Contd.

→

PLATE 1

(All photomicrographs are enlarged, × 500; orthoplan microscope no. 851393)

1. *Navalesporites spinosus* Sarate & Ram-Awatar 1984; Slide no. BSIP 10237, Coordinate 7 × 97.
2. *Scheuringipollenites maximus* (Hart) Tiwari 1973; Slide no. BSIP 10240A, Coordinate 22 × 98 (Leitz No. 512794/067053).
3. *Trabeculosporites* (Trivedi & Misra 1970); Slide no. BSIP 10243B, Coordinate 30 × 105.
4. *Tiwariasporis indicus* Srivastava, 1970; Slide no. BSIP 10240, Coordinate 9 × 93.
5. *Striatopodocarpites* Soritsch & Sedova emend. Bharadwaj 1962; Slide no. BSIP 10244, Coordinate 25 × 105.
6. *Labirites raniganjensis* Bharadwaj 1962; Slide no. BSIP 10245, Coordinate 28 × 105.
7. *Labirites* sp. (Tiwari 1965); Slide no. BSIP 10240A, Coordinate 6 × 112 (Leitz. no. 512794/067053).
8. *Densipollenites invisus* Bharadwaj & Salujha 1964; Slide no. BSIP 10240A, Coordinate 10 × 95 (Leitz. no. 512794/067053).
9. *Gondisporites raniganjensis* Bharadwaj 1962; Slide no. BSIP 10245, Coordinate 30 × 105.
10. *Striatites sewardii* (Virkki) Bharadwaj 1962; Slide no. BSIP 10237A, Coordinate 19 × 99.
11. *Lunatisporites* sp. (Goubin in: Maheshwari & Banerji 1975); Slide no. BSIP 10247; Coordinate 33 × 93.
12. *Densipollenites indicus* Bharadwaj 1962; Slide no. BSIP 10239, Coordinate 7 × 103.
13. Alete type-A; Slide no. BSIP 10241, Coordinate 38 × 107.
14. *Verticipollenites secretus* Bharadwaj 1962; Slide no. BSIP 10239, Coordinate 34 × 105.
15. *Corisaccites alutas* Venkatachala & Kar 1966; Slide no. BSIP 10243A, Coordinate 12 × 116.
16. *Crescentipollenites fuscus* (Bharadwaj) Bharadwaj, Tiwari & Kar 1974; Slide no. BSIP 10238, Coordinate 13 × 105.

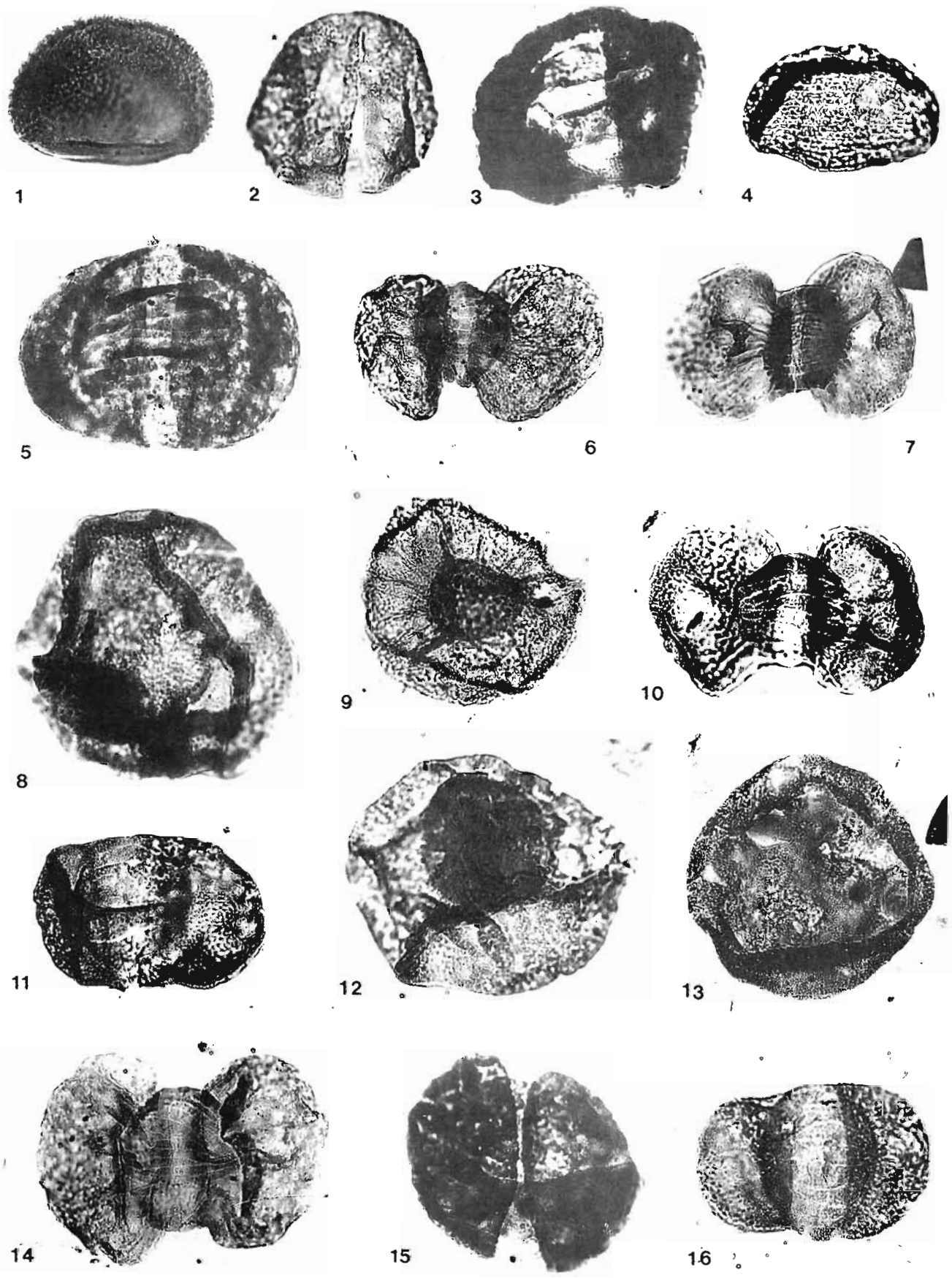


PLATE 1

NID-4	Carbonaceous shale	
GPD-85 D	Carbonaceous, shale lenses in coarse grained sandstone	Fragmentary fossils; dispersed plant matter
GPD-84	Sandstone	
GPD-83	Grey shale	

Zone I : Palyno-assemblage

The genus *Trabeculosporites* dominates in this zone. The genera *Striatopodocarpites, Faunipollenites, Scheuringipollenites, Crescentipollenites* and *Guttulapollenites* are also significant.

The suite of qualitatively important taxa include *Callumispora, Verrucosisporites, Densoisporites, Lundbladispora, Alisporites, Klausipollenites, Falcisporites, Lunatisporites, Goubinispora, Inaperturopollenites, Playfordiaspora, Vitreisporites, Araucariacites, Satsangisaccites, Nidipollenites, Weylandites*, etc.

The Permian striate pollen enlisted above are the significant remains of the lot and stradded into this level, but the suite of qualitatively important taxa, however, confirms a major change at this level.

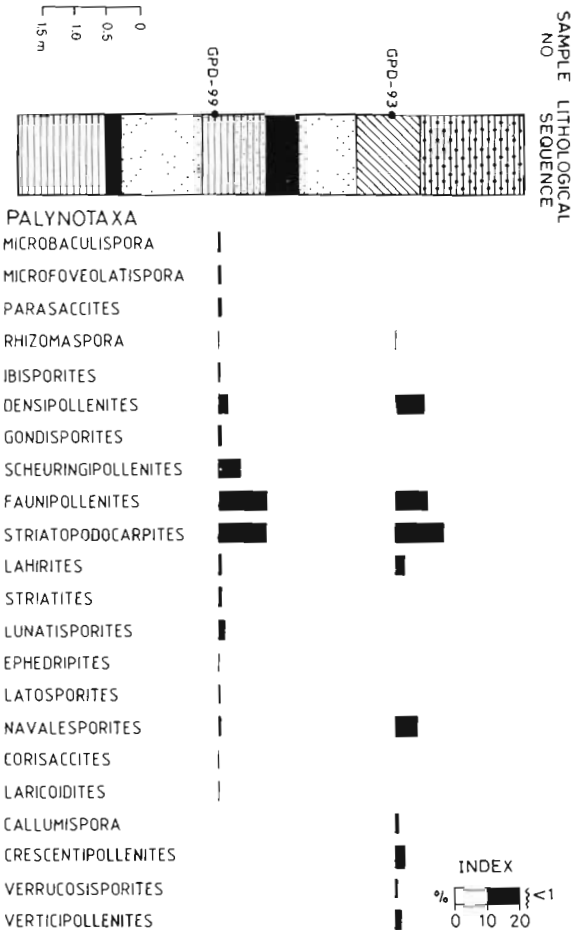
Zone II : Palyno-assemblage

This zone is younger to Zone I. The palynoflora remarkably changes at this level. The taeniate pollen suddenly decline in Zone II, and the remanant of Permian genera (e.g. *Striatopodocarpites, Faunipollenites, Scheuringipollenites*) are at their low ebb. A better representation of *Nidipollenites, Satsangisaccites, Weylandites, Goubinispora, Densoisporites, Klausipollenites, Falcisporites, Podocarpidites* and *Alisporites* is depicted in this zone as compared to Zone I.

A broader aspect of continuity of Zone I and Zone II palyno-assemblages is evident from this analysis, but a floral change is well marked and significant because lithological changes are also distinct between these strata.

II-C. Section south of Nidpur beds—After the fault F-3, the strata are mostly covered under alluvium. Several samples were collected from the exposures near the railway bridge (Map 2), but none of them yielded microfossils. Only two samples (GPD-99 and GPD-93) collected from the confluence of Mahan and Gopad rivers were found to be productive. Thin coal seam with prominent shale layers is also exposed in this region.

The succession at Mahan-Gopad meeting point, on the left bank, exposes mainly micaceous, fine-grained sandstone, siltstone, grey shale, coaly shale and coal (Text-fig. 6). This bed contains distinct *Glossopteris* leaves and few needle-shaped indistinct



Text-figure 6—Frequency of important genera in two samples at Mahan-Gopad confluence (refer Map 2).

plant debris. No *Dicroidium* has been seen in this section.

Sample no. GPD-99 exhibits the prominence of *Striatopodocarpites, Faunipollenites* and *Scheuringipollenites*. Other rare but qualitatively important genera are: *Cyclobaculisporites, Indotriradites, Microbaculispora, Microfoveolatispora, Densipollenites, Gondisporites, Lahirites, Lunatisporites, Navalesporites, Guttulapollenites*, etc. The other sample GPD-93 is younger to GPD-99 in the sequence; there is a subtle change in the assemblage of this sample when compared to the latter. Striate-disaccate pollen are in prominence, but two genera, i.e., *Densipollenites* and *Navalesporites*, increase considerably; *Crescentipollenites* is also present in this assemblage.

A clear Upper Raniganj affinity for these two assemblages is depicted. Quantitative differences are, however, evident amongst these two shale horizons.

RELATIONSHIP OF NIDPUR BEDS

The sediments exposed in Gopad River and Sehra nala sections have been mapped earlier as Raniganj (Hughes, 1881). Recently, Raja Rao (1983), although delimited the area as Raniganj on the base map, commented that the Nidpur beds are of Triassic age. Tripathi (1963) reported the presence of *Rhinesuchus wadiai*—a labyrinthodont remain, from near Marhwas Village, indicating the age of sediments as Late Permian. The present palynological results from the same region (Marhwas assemblage) also support this conclusion.

Sequel to the report of *Dicroidium* by Satsangi (1964) from Nidpur, continuous efforts to analyse the flora of the area have resulted in the wealthy record of cuticles, fructifications and *in situ* pollen from this bed (Srivastava, 1975). Besides, reports of rich floral elements by Bose and Srivastava (1970, 1971, 1972, 1973), Pant and Basu (1973, 1977, 1979), Srivastava and Maheshwari (1975), and Pant and Pant (1987) made this bed a classical example of preservation and diversification. Because of the presence of characteristic *Dicroidium*-rich flora with other pteridospermic, ginkgoalean and coniferalean groups of plants, the assignment of Triassic age has been supported by these workers for the Nidpur beds.

In 1965, Chandra and Satsangi in a preliminary report of spores and pollen illustrated non-striate and taeniate disaccate pollen and few pteridophytic spores; the trisaccate pollen documented are referable to *Goubinispora* and the 'pteridophytic spores having ribs or striations belonging probably to Schizaeaceae' (Chandra & Satsangi, 1965) could be the specimens of the genus *Weylandites*. Although this bed bears *Dicroidium* imprints (Chandra & Satsangi, 1965), its stratigraphic position with reference to different units of this section, as known now, is not certain. However, in all probability, it belongs to the bed designated here as Master Bed (MB).

Maheshwari (1967) enlisted a palynoflora recovered from a shale, about 2 km south-east of Nidpur in Gopad River, near the railway bridge (Map 2). Although the stratigraphic location of this shale is not controlled, the prominence of striate-disaccates, *Densipollenites* and *Scheuringipollenites* suggests an Upper Permian affinity. This shale contained *Glossopteris* leaves but no *Dicroidium* is known from this locality.

Probably unaware of the detailed palynological studies of 'Nidpur plant beds' by Bharadwaj and Srivastava (1969), Trivedi and Misra (1970, pp. 14, 15) published an assemblage from the same area comprising the abundance of taeniate, striate pollen and *Weylandites*. Presence of few cingulate, monocolpate and *Falcisporites, Satsangisaccites* complex is also noticed.

Bharadwaj and Srivastava (1969) found a rich palynoflora in a "6 inch thick bed of highly carbonaceous shale which overlies the basal fine grey sandstone" The positioning of these shales has been determined now to be between faults F-2 and F-3 as numbered in the present work (Srivastava *pers. comm.*, 1986), and stratigraphically, this shale lies below the grey siltstone facies. It is not carbonaceous but contains rich carbonised plant matter as well as *Dicroidium* fossils. We have also recovered a comparable palynoassemblage in the grey siltstone facies younger to (i.e. 1.5 m above) the shale analysed by Bharadwaj and Srivastava (1969), however, the taxa, viz., *Densipollenites densus* and *D. indicus* with clearly defined central body, and some of the striate-disaccate species are not found in our assemblage. Except for this, the whole flora has been reproduced in the grey shale and siltstone which bear *Dicroidium*. The lithological observations as well as palynological contents indicate that the palynoflora described by Bharadwaj and Srivastava (1969) was obtained from a relatively older shale bed from inside the pit, with carbonaceous rich contents. The presently analysed grey siltstone also contains *Dicroidium* but has no *Densipollenites* with well-defined body. A fresh set of slides recently given to us by Srivastava (*pers. comm.*, 1988) made from *Dicroidium*-bearing grey siltstone and grey shale also contains an assemblage which does not have *Densipollenites* species with sharply defined central body.

AGE CONNOTATION

The Upper Permian and Lower Triassic palynofloral sequences are well understood for Damodar Valley basins (Bharadwaj & Tiwari, 1977; Bharadwaj, Tiwari & Anand-Prakash, 1979; Tiwari & Rana, 1984; Tiwari & Singh, 1983, 1986; Vijaya & Tiwari, 1988). Tagged with lithological changes from Raniganj to Panchet formations in the Raniganj Coalfield, the assemblage R-I and P-I respectively qualify for the latest Permian and earliest Triassic (Tiwari & Singh, 1986). When compared with this model of Damodar Graben, the palynoassemblages recovered from the Sehra nala section and north as well as south of Nidpur beds in Gopad River (Text-figs 1, 2, 3, 6) match with the R-I and R-II assemblages of Late Permian (Tiwari & Singh, 1986). On the basis of the occurrence of *Corisaccites* and *Navalesporites* it can be compared with Sukhtawa

assemblage in Satpura Basin (Bharadwaj, Tiwari & Anand-Prakash, 1978) which is considered to be latest Permian in age. Besides, the palynofossils from Gopad River, Mahan River and Sehra nala (except Nidpur beds) have also an akinness with the assemblages known from Middle Member of Pali Formation in Birsinghpur Pali Coalfield (Tiwari & Ram-Awatar, 1986, 1987b).

As discussed above, the palynoflora in the Nidpur beds contains *Lunatisporites, Trabeculosporites* (taeniate-complex), *Playfordiaspora, Densoisporites, Lundbladispora, Klausipollenites, Falcisporites, Araucariacites* and *Goubinispora* as the basic components indicating a Triassic age affiliation of these beds.

No Permian palynoflora in the peninsular India is known to possess such a composition of taxa, while the established Triassic palynofloras exhibit closely comparable trends in fundamental elements (Vijaya & Tiwari, 1988).

In Damodar Basin, the assemblage from Panchet Formation is mainly associated with high percentage of cavate spore genera *Lundbladispora* and *Densoisporites*, while these forms are rare in the Nidpur beds. In Zone-1, there are fairly large number of specimens assignable to the genus *Densipollenites* (Type-A, Pl. 1, fig. 13; Pl. 2, fig. 14) but none of them possesses a sharply defined central body. However, species with or without distinct body have been recorded from Upper Raniganj as well as Lower Panchet palynofloras of the Raniganj Coalfied (Vijaya & Tiwari, 1988).

When compared with the Australian Permian-Triassic assemblages (Helby *et al.*, 1987), there seems to be a factor of provinciality which plays a vital role in shaping the Triassic palynofloras of two regions. Thus, *Aratrisporites, Triplexisporites, Duplexisporites, Crateriporites*, etc., are some of the forms which are not well-represented in the so far known Indian assemblages. On the basis of taeniate dominance, the Nidpur assemblages are comparable with *Protohaploxypinus samoilovichii* Zone (in *Falcisporites* Super Zone : Helby *et al.*, 1987) but in other components the comparisons are not befitting. The genus *Trabeculosporites*, characteristic of the Nidpur fossiliferous bed, does not appear in any of the zones in Australia; it seems most plausible that *Trabeculosporites*-complex is related with *Infernopollenites* type of pollen having Anisian age aspect.

The evidences are accumulating to suggest strongly that the Son Valley basins have distinctive vegetational as well as depositional history during Permian and Triassic time (Raja Rao, 1983). A fairly marked deviation of palynological succession between Damodar River Basin and South Rewa Basin is also evident (Tiwari & Rana, 1980; Tiwari & Singh, 1986; Tiwari & Ram-Awatar, 1986, 1987 a, b) which reflects the influence of different floral components.

In South Rewa Basin, the Barakar Formation was overlain by uninterrupted deposition of thick sequence of Pali Formation, which is divisible into three units—Lower, Middle and Upper. The Lower Pali Member is equated with Barren Measures. The Middle Pali Member contains coal seams and carbonaceous layers with rich floral assemblage of Upper Permian affinity. The palynoflora of this horizon has been described by Tiwari and Ram-Awatar (1986) from Johilla Coalfield. In this assemblage, beside typical Upper Permian components, some forms such as taeniate genera *Trabeculosporites* and *Haemiapollenites* start appearing, which further increase in Nidpur beds. There is a fair degree of resemblance between the

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PLATE 2 →

1. *Crescentipollenites* Bharadwaj, Tiwari & Kar 1974; Slide no. BSIP 10248, Coordinate 31.5 × 96.5.
2,13. *Trabeculosporites* Trivedi & Misra 1970; Slide nos. BSIP 10248, 10246A, Coordinates 47 × 101.5 & 41 × 103.
3. *Lunatisporites pellucidus* (Goubin) Maheshwari & Banerji 1975; Slide no. BSIP 10248, Coordinate 43 × 91.5.
4. *Distriatites bilateralis* Bharadwaj 1962; Slide no. BSIP 10246A, Coordinate 40 × 97
5. *Satsangisaccites nidpurensis* Bharadwaj & Srivastava 1969; Slide no. BSIP 10248, Coordinate 15.5 × 104.
6. *Araucariacites* (Cookson, 1947 ex Couper 1953); Slide no BSIP 10246A, Coordinate 41 × 103.
7, 8. *Playfordiaspora* Maheshwari & Banerji 1975; Slide nos. BSIP 10246, 10242; Coordinates 35 × 110 & 22 × 92.
9. *Falcisporites* Leschik emend. Klaus 1963; Slide no. BSIP 10248, Coordinate 22 × 108.
10. *Klausipollenites* Jansonius 1962; Slide no. BSIP 10244A, Coordinate 22 × 94 (Leitz. no. 512794/067053).
11. *Lundbladispora brevicula* Balme 1970; Slide no. BSIP 10245, Coordinate 21 × 109 (Leitz. no. 512794/067053).
12. *Densoisporites* Weyland. & Krieg. emend. Dettmann 1963; Slide no. BSIP 10244B, Coordinate 32 × 98.
14. Alete Type-A, Slide no. BSIP 10243, Coordinate 25 × 102.
15. *Goubinispora morondavensis* Tiwari & Rana 1980; Slide no. BSIP 10242, Coordinate 32.5 × 91.
16. *Weylandites indicus* Bharadwaj & Srivastava 1969; Slide no BSIP 10247A, Coordinate 13 × 102.

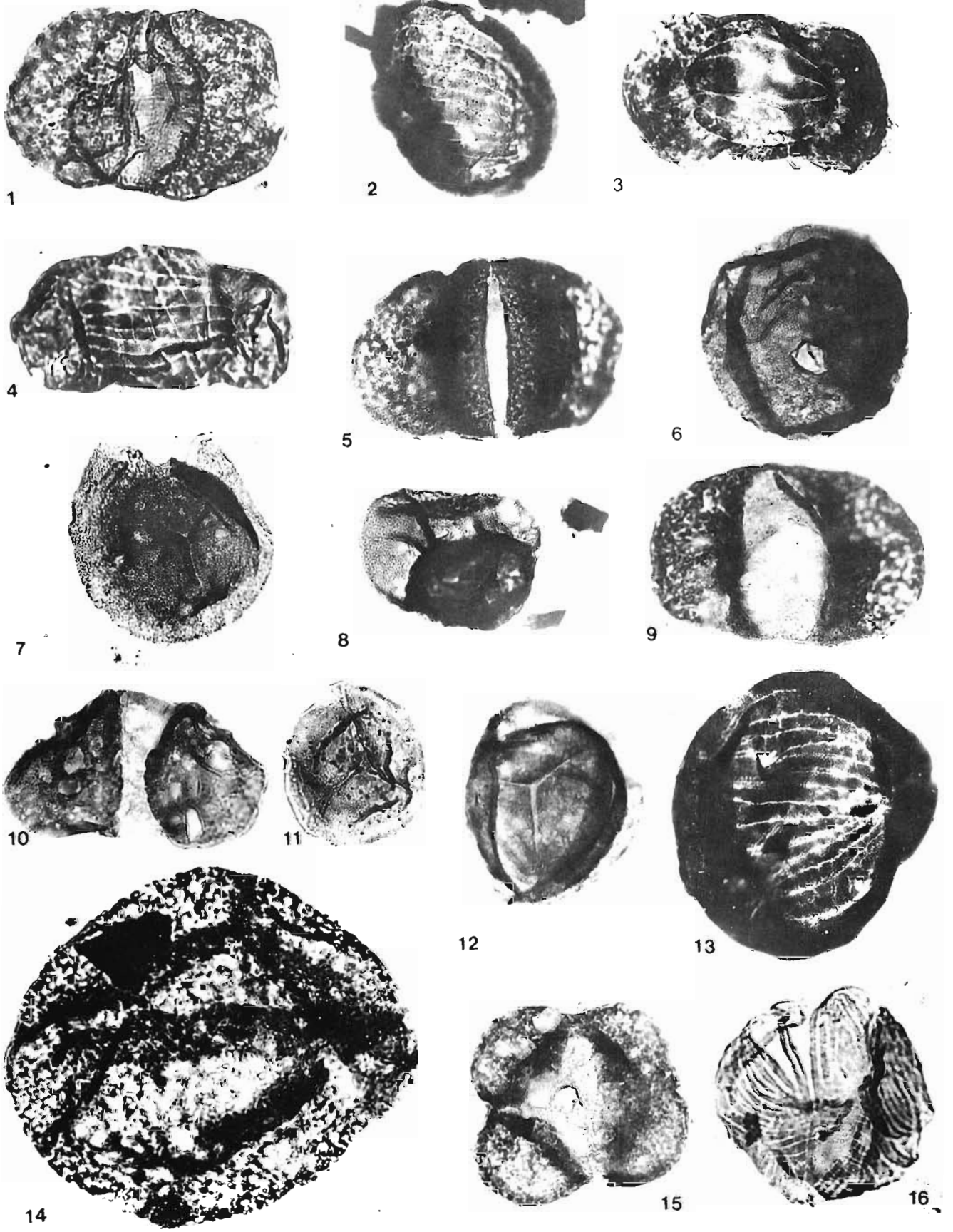
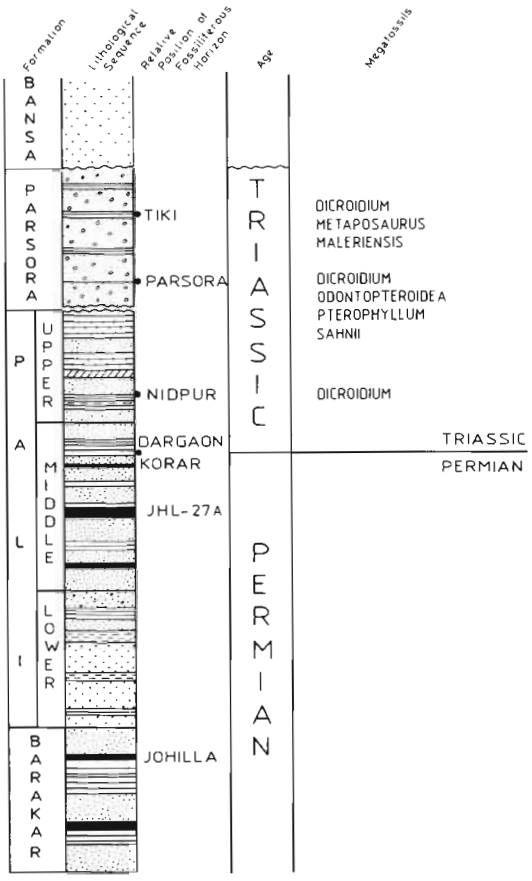


PLATE 2

Middle Pali palynoflora described by Tiwari and Ram-Awatar (1986) and those recovered in the assemblages from Gopad River Section (except Nidpur beds), Mahan River and Sehra nala studied here. Lithologically too, the latter sediments contain coal bands, grey shales and red facies with *Glossopteris* and *Vertebraria* fossils; therefore, they exhibit a relationship with Middle Pali. On the basis of mega- and microflora studied here. A latest Permian age is assigned to these beds. It is remarkable that the palynofloras in these beds are relatively younger to the assemblage described from bore-hole JHL-27A (Tiwari & Ram-Awatar, 1986). Besides, two assemblages from Korar Coalfield (in bore-hole UKD-8) are also recorded (Tiwari & Ram-Awatar, 1987b) ranging from Upper Permian to Lower Triassic. A still younger aspect has been noticed in the assemblage from beds exposed in Johilla River Section between Dargaon and Salaia villages (Tiwari & Ram-Awatar, 1987a). Earlier this portion was mapped in the Parsora Formation but now it is considered as a part of Pali Formation (Ram-Awatar, 1988). The sediments outcroping at Dargaon-Salaia villages have a well-preserved Late Permian/Early Triassic palynoflora. The palynoflora recovered from Nidpur bed is still younger than the Dargaon-Salaia assemblage of Johilla River having the predominance of taeniate pollen, and the *Playfordiaspora-Lundbladispora* components.

There is a continuity of some forms in all the four assemblages discussed above (Text- fig. 7), but the Nidpur assemblage is distinctive as well as younger than the remaining three. Lithologically, the sediments containing the palynological Zone I in 'Nidpur plant beds' show affinity with the Middle Pali Member in having carbonaceous layers in sandstone, but the palynological Zone II comes from a distinct suite of rocks where grey shale and siltstone are interbedded in sandstone which passes on to chocolate, red shale facies and lilac-coloured massive sandstone. The latter suite of lithology does not belong to Middle Pali Member; on the otherhand, it has a trend of similarity with the Upper Pali and Parsora Formation. Since both the palynological zones of Nidpur beds, i.e., Zone I and Zone II, have Triassic affinity, it becomes evident that the P/T boundary lies in the upper part of the Middle Pali Member but not at the Middle/Upper Pali level. Thus the lithology continues to transgress the P/T boundary.

Palynofloristically, Nidpur beds are older than the Tiki Bed (Kumaran & Maheshwari, 1980; Maheshwari & Kumaran, 1979), and much younger than the beds exposed in Johilla River between Dargaon and Salaia (Tiwari & Ram Awatar, 1987a).



Text-figure 7—Generalized sequence of sediments of Barakar, Pali and Parsora formations in Son Valley. Relative positioning of various fossiliferous horizons and their age relationship. Palynofossils known from all the beds marked except Parsora.

The Tiki beds are dated as Carnian to Early Norian on the basis of animal remains, such as *Metaposaurua maleriensis, Pachygonia incurvata* (amphibian), and *Phytosaurus maleriensis* (reptilean), etc. (Chatterjee & Roy Chowdhury, 1974). The Dargaon-Salaia Bed do not contain animal fossils, but palynologically it represents a P/T boundary zone (Tiwari & Ram-Awatar, 1987a). The Parsora Formation, exposed near Parsora Village, overlies the Upper Pali Formation and considered here older to the Tiki Bed. Lithologically, the Parsora Formation includes medium to coarse-grained sandstone, pebbly intercalations, violet to lilac-coloured shales and massive sandstones. The strata capping the *Dicroidium*-bearing beds near Nidpur show resemblance with Parsora-type of lithology. The plant megafossils found in the Parsora Formation include *Dicroidium odontopteroidea, Pterophyllum sahnii* and *Marattiopsis* sp. (Lele, 1955, 1961, 1962); the age of this formation is considered to be Late Triassic.

DISCUSSION

The Nidpur fossiliferous beds are trapped between two faults at the anticlinal axis zone of the Middle Pali beds, and they have been down thrusted resulting into an escape from erosion. There is no continuity of sequence between the *Glossopteris*-dominant beds and the *Dicroidium*- dominant bed in the Gopad River.

The fragmentary glossopterid remains may occur sporadically in the Nidpur plant beds but overwhelming number of *Dicroidium* leaves and varied fructifications of pteridospermic affinity strongly suggest a major floral break at this level, with relation to other plant beds in Gopad River. The scope of this paper does not permit a discussion whether the *Dicroidium* leaves found in Nidpur beds are "true" *Dicroidium*, as they do not possess a forked rachis (cf. Townrow, 1957). Notwithstanding, it is certain that such leaves and other pteridospermic remains have never been reported from Sehra nala, Mahan River, Gopad River or any of the Upper Permian strata in peninsular India, including the type area of Raniganj Formation; obviously they do not indicate a Permian relationship. On the contrary, several reports of the occurrence of *dicroidium* are on record from the post-Permian horizon of India (Lele, 1962; Saksena, 1962; Bose & Banerji, 1976; Banerji & Bose, 1977; Pal, 1984). It could be that the forked and unforked rachis-bearing leaves were the constituents of the closely related population of plants. Nevertheless, it seems more probable that this leaf-taxon is an organ of the plant which thrived in the Triassic time rather than the Permian, because not a single specimen has been recorded so far from the rich megafossil zone of well-established Upper Permian in India.

Palynologically, the high incidence of taeniate pollen and variable representation of the genera *Playfordiaspora, Lundbladispora, Densoisporites, Klausipollenites, Goubinispora, Falcisporites, Araucariacites, Alisporites, Podocarpidites*, etc., directly corroborate with the Triassic palynofloras known from the Indian Gondwana. It may be that several Permian pollen continue to occur in the Nidpur beds, but this phenomenon is true for other Lower Triassic strata also. The remainié of Permian have always stradded up into the Triassic. It may be mentioned here that there are certain common species between Nidpur beds and the marine controlled Lower and Middle Triassic or even younger strata of Madagascar, e.g., *Striomonosaccites morondavensis, Protohaploxipinus ovatus, Vitreisporites pallidus, Cuneatisporites radialis, Platysaccus* cf. *leschiki, Sulcatisporites prolatus, Araucariacites australis* (original names after Goubin, 1965). A degree of close similarity between the two may be drawn from this observation.

As mentioned earlier, a sample (Sample no. GPD-2) collected from a shale in Mahadeva sandstone exposed in the Gopad River near northern boundary fault, yielded several taeniate-disaccate pollen. This is an important control-point because the Mahadeva are Triassic in age; it strongly suggests a Triassic affinity for Nidpur plant beds which also have abundant taeniate pollen.

From amongst the known assemblages of Tethys Himalayan sequence, the Kalapani Limestone and Kuti Shale (Anisian to Norian) have several elements of pollen which are common with the palynoflora of Nidpur beds (Tiwari *et al.*, 1984; Vijaya *et al.*, 1988). The Kalapani assemblage, in particular, possesses *Lundbladispora brevicula, Playfordiaspora cancellosa, Klausipollenites schaubergerii, Satsangisaccites nidpurensis, Alisporites landianus, Falcisporites stabilis, Nidipollenites monoletus*; these species are on record from the Nidpur beds.

The Permian and Triassic palynofloras from Salt Range are well known (Balme, 1970) but their comparison with that of Nidpur Bed is restricted as well as qualified because of the variance in diversity and regional influences on the former. Amongst the important taxa—*Navalesporites (Polypodiidites)* sp. and *Corisaccites-Guttulapollenites*-complex characterise the Permian formations of the Salt Range. These two genera are absent from the Nidpur beds but they are recorded in the *Glossopteris*-bearing sediments exposed in Sehra nala, Gopad River and Mahan River, which have been dated here as latest Permian. The taxa *Playfordiaspora (Guthoerlisporites) cancellosa, Lundbladispora brevicula* and *Falcisporites stabilis* (resembling *Satsangisaccites*), *Alisporites* spp. and *Densoisporites* spp. mainly qualify the late Lower and Middle Triassic of the Salt Range. Thus, their occurrence in Nidpur palynoflora is an indicator of Triassic relationship.

The *Paravittatina lucifer* in the Permian of Salt Range and *Weylandites indicus* in Nidpur palynoflora are different specific groups, hence their matching for dating cannot be done. So also the specimens referred to *Falcisporites nuthallensis* characterise the Permian of salt Range, but they are not comparable with the types found in Nidpur.

CONCLUSIONS

The possibility of Nidpur fossiliferous beds being of Permian age is ruled out because:

1. they contain fossils of *Dicroidium, Pteruchus, Lepidopteris,* etc;

2. *Dicroidium*, even it is mostly of unforked-rachis-type, is not found in any of the well-established Upper Permian of India; on the other hand, it is frequent in the Triassic sequence;

3. a feeble continuation of the occurrence of *Glossopteris* in the Nidpur beds is not abnormal because such reports are on record from the Panchet Formation of the Raniganj Coalfield also. Remainié of the dominant plant group in Permian always stradded accross the P/T boundary;

4. Nidpur beds occur in a down-thrusted block as a result of which they escaped erosion. They are the youngest beds in the sequence of Pali Formation exposed in Gopad River;

5. they are capped by a lilac-coloured shale, clays and pinkish coarse-grained sandstones which resemble the litho-suite of Parsora Formation;

6. Nidpur beds are in faulted contact, to the north and south, with the Upper Permian strata which bear profused glossopterid plant fossils, but no *Dicroidium.*

Palynologically, it resembles the Lower Panchet Formation. The fair and consistent presence of *Falcisporites, Lunatisporites* (and taeniate complex), *Densoisporites, Laricoidites, Klausipollenites, Lundbladispora, Satsangisaccites, Araucariacites, Goubinispora, Nidipollenites, Playfordiaspora, Weylandites* and *Alisporites* brings the Nidpur beds very close to the palynological zone P-I of the Panchet in the type area (table 1 in: Tiwari & Singh, 1986).

The R-I and R-II palynozones belonging to uppermost Raniganj Formation (Tiwari & Singh, 1986) record the presence of *Gondisporites, Striatosporites, Indospora, Ephidripites, Verticipollenites, Thymospora, Hindipollenites, Welwitschiapites*, etc., which are not present in the Nidpur beds. Although an inconsistent and highly sporadic occurrence of some of the elements of P-I zone is recorded in R-I and R-II zones of the Upper Raniganj Formation (Tiwari & Singh, 1986) but their presence only suggests of foreshadow of the floral change. In totality of generic prominence and that of the fairly high incidence of the marker palynotaxa of Panchet (i.e. P-I to P-IV assemblage; Tiwari & Singh, 1986) the palynoflora of the Nidpur beds ascertains an Early Triassic age for the *Dicroidium*-rich horizon.

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