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Late Permian palynoassemblage from Chalburdi area, Chandrapur District, Maharashtra

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ABSTRACT

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The study deals with the palynological dating and correlation of the sediments of Bore–hole No. CHB–5, Chalburdi area, Chandrapur District, Wardha Valley Coalfield, Maharashtra. Based upon the palynological studies, two distinct palynoassemblages have been identified; the first one at 57.00 m depth contains the dominance of an enveloping monosaccate genus *Densipollenites* along with striate bisaccate *Striatopodocarpites* and *Faunipollenites*. The stratigraphically significant palynotaxa include *Crescentipollenites, Corisaccites, Klausipollenites, Alisporites,* etc. The second palynoassemblage recorded at 51.00 m depth is characterised by the dominance of *Faunipollenites* followed by *Densipollenites, Striatopodocarpites, Arcuatipollenites, Striatites, Microbaculispora, Microfoveolatispora* and *Scheuringipollenites*. The recovered palynotaxa suggest that the sediments belong to the Late Permian Period.

Key–words—Palynology, Correlation, Chalburdi, Late Permian, Wardha Valley, Maharashtra.

चालबर्डी क्षेत्र, जिला चंद्रपुर से प्राप्त विलंबित पर्मियन परागाणुसमुच्चय

श्रीकांत मूर्ति एवं ओमप्रकाश एस. सराटे

सारांश

अध्ययन वेध–छिद्र संख्या सी एच बी–5, चालबर्डी क्षेत्र, जिला चंद्रपुर, महाराष्ट्र वर्धा घाटी कोयलाक्षेत्र, महाराष्ट्र के परागाणविक आयुनिर्धारण अवसादों के सहसंबंध से संबंधित है। परागाणविक अध्ययनों के आधार पर, दो भिन्न परागाणुसमुच्चयें अभिनिर्धारित की गई हैं; पहली *57.00* मीटर गहराई पर रेखित द्विसपुट *स्ट्रिएटोपोडोकार्पाइटिस* एवं *फॉनोपॉल्लेनाइटिस* के साथ अन्चालोपी (आवरण) एकलसपुट वंश *डेन्सीपॉल्लेनाइटिस* की प्रमुखता सन्निहित है। स्तरिक रूप से महत्वपूर्ण परागाणुटैक्सा *क्रेसेन्टीपॉल्लेनाइटिस, कोरीसेक्काइटिस, क्लॉसीपॉल्लेनाइटिस, एलीस्पोराइटिस* इत्यादि समावेशित है। दूसरी *51.00* मीटर गहराई पर परागाणुसमुच्चय *डेन्सीपॉल्लेनाइटिस, स्ट्रिएटोपोडोकार्पाइटिस, अर्कुएटिपॉल्लेनाइटिस, स्ट्रिएटाइटिस, माइक्रोबेकुलिस्पोरा, माइक्रोफोविओलेटिस्पोरा* एवं *स्यूरिंगीपॉल्लेनाइटिस* के अनुगामी *फॉनोपॉल्लेनाइटिस* की प्रमुखता से अभिलक्षणित है। प्राप्त परागाणुसमुच्चय सुझाते हैं कि अवसाद विलंबित पर्मियन काल के हैं।

सूचक शब्द—परागाणुविज्ञान, सहसंबंध, चालबर्डी, विलंबित पर्मियन, वर्धा घाटी, महाराष्ट्र।

INTRODUCTION

WARDHA Basin as such represents the north–western extension of the Godavari Valley and displays almost similar lithological as well as stratigraphic sequence. The information so far available regarding the palynological details of the Lower Gondwana succession of the Wradha Valley Coalfield is skimpy. The major contributors in the field of Lower Gondwana palaeopalynology include Agashe & Chitnis, 1970, 1972; Bhattacharrya, 1997; Bharadwaj & Anand–Prakash, 1974; Jha *et al.,* 2007, 2011; Pauline Sabina *et al.,* 2007, 2008; Mahesh *et al.,* 2011, 2014; Kalkar *et al.,* 2010). However, all these studies deal with the palynological dating of sediments, though a few cover

coal petrological study (Anand–Prakash & Khare, 1974) and palaeoenvironmental aspects as well (Mahesh *et al.,* 2008; Pauline Sabina *et al.,* 2010).

Palynological studies have been extensively utilized in the biostratigraphic delineation of the Lower Gondwana formations and in this regards several syntheses have been published during the last few decades (Bharadwaj, 1969, 1971, 1975; Bharadwaj & Srivastava, 1969; Tiwari & Tripathi, 1988, 1992) provided spore and pollen based zonation for the Permian sequence of the Indian peninsula.

The present study has been taken up from the sub–surface sediments collected from Bore–hole CHB–5 representing Chalburdi area in Chandrapur District of the Wardha Valley Coalfield, to palynologically date the sequence, prepare the biostratigaphic zonation and its correlation with the similar palynoassemblages known from other Gondwana basins of peninsular India.

GENERAL GEOLOGY

A major portion of the Wardha Valley Coalfield lies in Chandrapur District of Maharashtra, while a small extension of it occurs in Yeotmal District. This Coalfield covers an area of 4,130 km^2 which extends across the length of 116 km demarcated between latitudes 19º30' and 20º27' N and longitudes 78º50' and 79º45' E. Hughes (1877) conducted the first systematic geological mapping of the entire coalfield. The Wardha Valley Coalfield displays structure of a graben bound on either side by NW–SE trending faults. Raja Rao (1982) has provided the geological details of the coalfield.

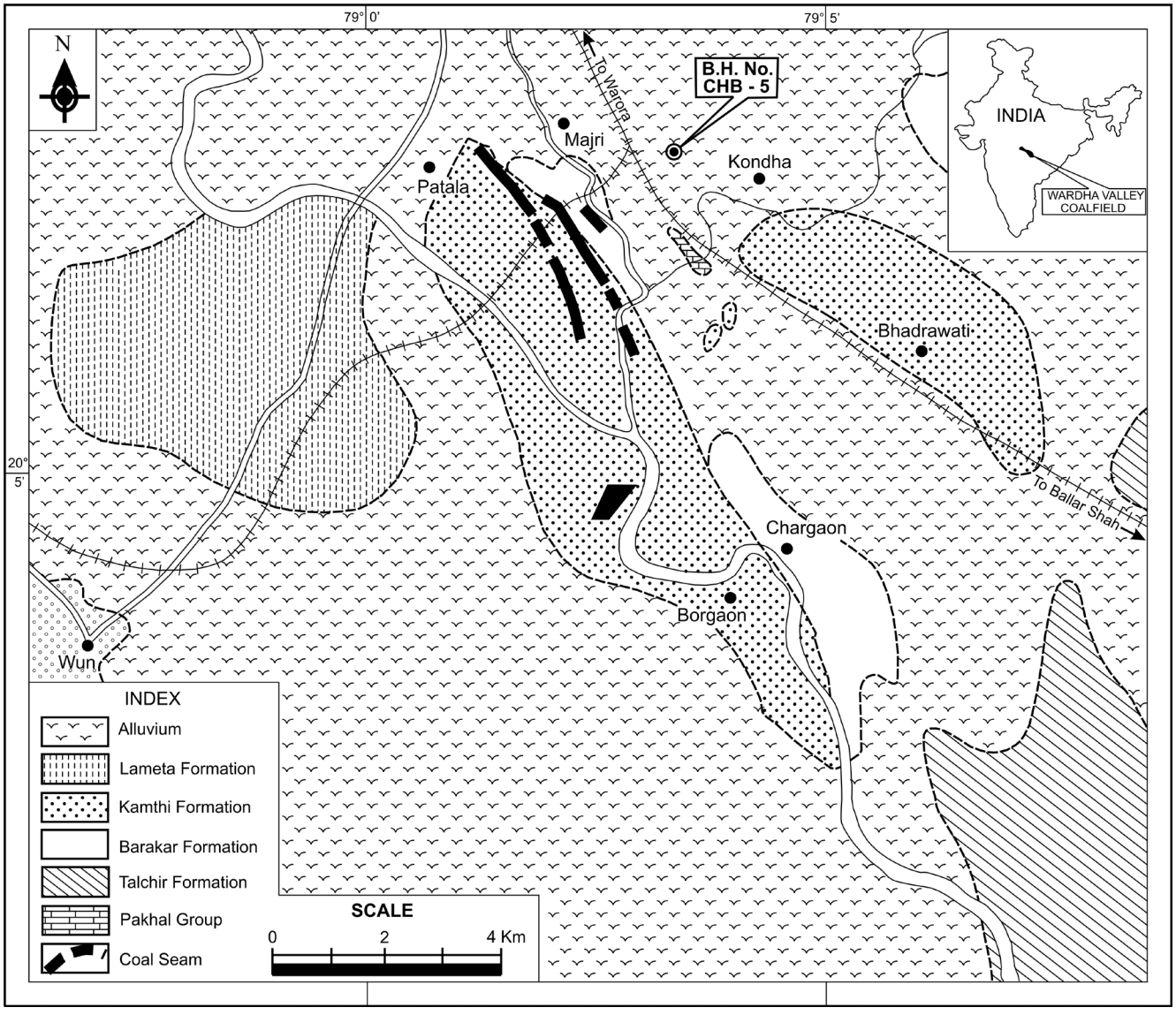

Fig. 1—Geological map of the Chalburdi area showing location of Bore–hole No. CHB–5, Wardha Valley Coalfield (after Raja Rao, 1982).

Archaean rocks mostly occupy the eastern extremity of the Wardha Basin, exist mostly in patches and includes granite gneisses in predominance along with impersistent quartzite bands. Pakhal limestone lies unconformably over the Archaeans and display wide range of colour variation, the most common and massive variety display, bluish hue with a characteristic elephant skin type of weathering however, the thin bands show pink coloration. Occasionally, limestones contain patches of breccia with angular fragments cemented in calcareous matrix.

The Sullavai Sandstone Sequence rests upon the Pakhal limestone which in turn is deposited on Archaeans gneisses. This sequence mainly includes white or light brown coloured, coarse–grained quartzite sandstones.

The outcrops of glacially influenced sediments of the Talchir Formation mostly cover areas near Wun in the northern part of the basin and are also exposed covering the western portion of Chandrapur and the sediments deposited along the course of Erai river, their continuity is also noticed in the south–westward direction right up to boundary between Maharashtra and Telangana State. Similarly, the Talchir exposures are known from northern part of the basin near Karmana Village near Wun and also in Penganga River Valley. The Talchir sequence displays the dominant association of cross bedded green shales having thin laminations besides medium–grained sandstones. An exposure of a complete Talchir sequence deposited over Pakhal limestones with thickness of about 235 m is seen at the confluence of Penganga and Wardha rivers. Fedden (1875) has recorded the existence of striated pavements, which proves the existence of glacial regime. Smith (1963) also studied the glacial striations, crecentric marks as well as plucking features from the Proterozoic rocks, which indicates the northward flow of ice.

Tillites represent the basal member of the Talchir Formation which are deposited on limestone rocks and comprise clasts of limestones, granites, jaspers and shale. At times rude cross–stratification and silt interbands, a few of which are stromatolitic in nature are also observed. The overlying sequence is represented by tabular cross bedded sandstones containing conglomerate lenses. The succeeding sandstone has graded beddings with sole marks and slump folds. Recurrence of tillite with dispersed clasts having maximum diameter of about 2 m is also observed. The topmost tillite is covered by clay with green coloration. Its overlying thin clay band contains varves, whereas the lower part is thick and also displays dark colour. The upper most Talchir unit contains coarse–grained cross bedded sandstones which gradually upgrades into Barakar Formation.

The Barakar sequence conformably overlies the Talchir Formation and covers vast area of the Wardha Valley. Generally these sediments exist in narrow, discontinuous patches and are rarely found as outcrop sections. They include feldspathic coarse–grained sandstone and occasionally display the existence of ferruginous nodules and a few carbonaceous shales bands. The single coal seam found in the Valley confined to Barakar Formation is referred as Main Seam with thickness variation between 17 m and 20 m. This seam is found sandwiched between 150 m thick fine– to coarse–grained Barakar Sandstone sequence at its top and 200 m sequence below it. At several places the Barakar sediments have been subjected to denudation.

The entire strata unconformably overlying the Barakar Formation with thickness range from 500 to 700 m is described under the name Kamthi Formation. However, the recent subsurface studies have proved the existence of the sediments sandwiched between the underlying Barakar and overlying Kamthi Formation and are described as Barren

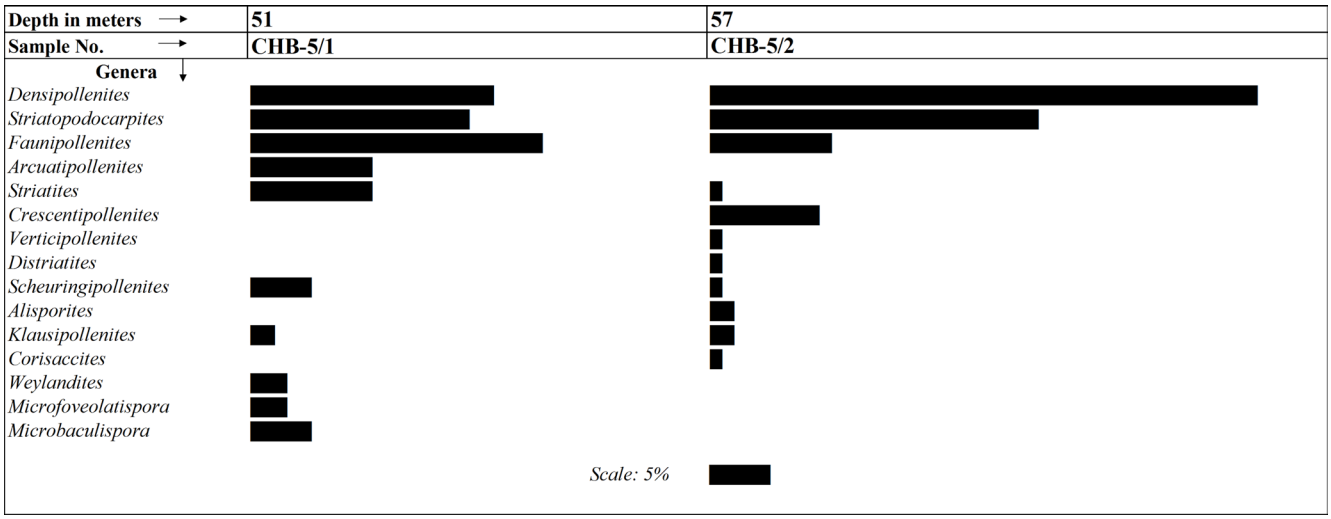

Fig. 2—Percentage frequency of various palynotaxa in Bore–hole CHB–5, Chalburdi area, Chandrapur District, Maharashtra.

Measures Formation. The Kamthi Formation mainly includes medium– to coarse–grained porous and friable brownish yellow to red coloured sandstones, interspersed with the granules and pebbles of quartz and quartzite, inter–bedded with shale bands of red, grey, cream and white coloration, sometimes the clay bands are silicified forming prominent ridges (Table 1). The lower part of the Kamthi Formation of Wardha, Godavari (Mukhopadhay *et al.,* 2010) and Mahanadi (Singh *et al.,* 2006) coalfields is considered as late Permian in age and equivalent to the Raniganj Formation of Damodar Basin and Bijori Formation of Satpura Basin.

MATERIAL AND METHOD

The sub–surface samples for palyno–dating have been collected from a Bore–hole No. CHB–5, drilled at a distance of approximately 2–2.5 km south–west of Majri Village (Fig. 1) in Chandrapur District of Maharashtra. The sedimentary sequence intersected between 51.00–295.00 m depth range from the sub–surface of Chalburdi area consists of green shales, red shales and red mudstones. The lithological details of the samples collected for palyno–dating has been given in Table 2.

Approximately 10–15 gm of each sample was taken and powdered. The samples having silica contents and those of shaly nature were treated with HF (40%) for about 3–4 days. However, the coaly samples have been directly treated with concentrated HNO_3. The HF as well as HNO_3 treated samples were made acid free by repeated dilution by addition of distilled water (3–4 times) and its removal, after allowing to settle for about 2 hours. The HF treated acid free samples were observed under microscope and if required were further treated with HNO_3 or KOH (10%). The macerate was passed through successively placed two sieves of 150 mesh and 400 mesh respectively, placing 150 mesh sieve on the top and 400 mesh sieve below it. The residue collected from the 400 mesh sieve has been used for palyno–dating. Five slides of each productive sample were prepared for pollen–spore study. The clean and dry slides were observed under the transmitted light microscope (Olympus 51) and selectively micro–photographed.

PALYNOLOGICAL ANALYSIS

Fifteen samples were analysed for the palynological studies, out of which only two shale samples, i.e. CHB5/1 (51.00 m depth) and CHB5/2 (57.00 m depth) were found productive enough to be used for palyno–dating. However, CHB5/14 (224.00 m depth) contains palynomorphs but their frequency distribution is very low. All the remaining samples are devoid of any spore and pollen grains; however, they have shown the existence of fairly well–preserved dark yellowish–dark brown coloured amorphous matter. For describing this palynoassemblage their existence is regarded as dominant (< 20%), subdominant (10–19%), fair (5–9%), common (2–4%) and poor (> 2%).

The palynoassemblage (Fig. 2) at the depth of 57.00 m has shown the dominance of *Densipollenites* (45%) and the sub–dominance of *Striatopodocarpites* (27%) followed by *Faunipollenites* (10%), *Crescentipollenites* (9%). The other commonly known components are *Striatites*, *Klausipollenites, Scheuringipollenites, Alisporites, Corisaccites, Verticipollenites* and *Distriatites* with a meagre distribution of 1–2 per cent. The other palynoassemblage recorded at 51.00 m shows the dominance of *Faunipollenites* (24%) with sub–dominance of *Densipollenites* (20%), besides, *Striatopodocarpites* (18%), *Arcuatipollenites* and *Striatites* 10% each, *Scheuringipollenites* and *Microbaculispora* both having equal distribution of 5%. *Microfoveolatispora*, *Weylandites* and *Klausipollenites* are recorded between 2–3% (Pl. 1.1–22).

PLATE 1

1. *Godavarisporites* sp. Slide No. 51/ 2, R67/1–2.
2. *Insignisporites barakarensis* Bharadwaj & Dwivedi, 1977; Slide No. 51/2, R68/3
3. *Microfoveolatispora foveolata* emend. Tiwari, 1965; Slide No. 57/ 1, T47.
4. *Microbaculispora gondwanensis* Bharadwaj, 1962; Slide No. 51/ 3, P38
5. *Densipollenites magnicorpus* Tiwari & Rana, 1981; Slide No. 57/1, J–K54
6. *Densipollenites indicus* Bharadwaj & Srivatsava, 1969; Slide No. 57/3, V41/1
7. *Densipollenites magnicorpus* Tiwari & Rana, 1981; Slide No. 57/ 4, Q36/1
8. *Scheuringipollenites barakarensis* (Tiwari) Tiwari, 1973; Slide No. 57/ 2, T64/2
9. *Faunipollenites varius* Bharadwaj emend. Tiwari *et al*., 1989; Slide No. 57/3, T45
10. *Striatopodocarpites globosus* Maheshwari, 1967a; Slide No. 57/3, R39/3–4
11. *Crescentipollenites fuscus* Bharadwaj *et al*., 1974; Slide No. 57/ 2, S31/2
12. *Striatites communis* Bharadwaj & Salujha, 1964; Slide No. 57/2, O36/1–2
13. *Verticipollenites crassus* Bharadwaj & Salujha, 1964; Slide No. 57/ 2, O33/1
14. *Distriatites bilateralis* Bharadwaj, 1962; Slide No. 57/2, F51/2–F52/1
15. *Arcuatipollenites ovatus* (Goubin) Tiwari & Vijaya, 1995; Slide No. 51/5, R31/1–3
16. *Arcuatipollenites pellucidus* (Goubin) Tiwari & Vijaya, 1995; Slide No. 51/3, K58/3–4
17. *Dicappipollenites crassus* (Sinha) Tiwari & Vijaya, 1995; Slide No. 57/ 4, U57/3–V57/1
18. *Corisaccites alutus* Venkatachala & Kar, 1966; Slide No. 57/ 4, R68/3
19. *Alisporites grobus* Bharadwaj & Tiwari, 1977; Slide No. 51/1, P30
20. *Klausipollenites* sp. Slide No. 57/ 6, R36/3
21. *Brachysaccus* sp. Slide No. 51/4, W51/1–3
22. *Weylandites minutus* Bharadwaj & Srivastava, 1969; Slide No. 51/1, M/33

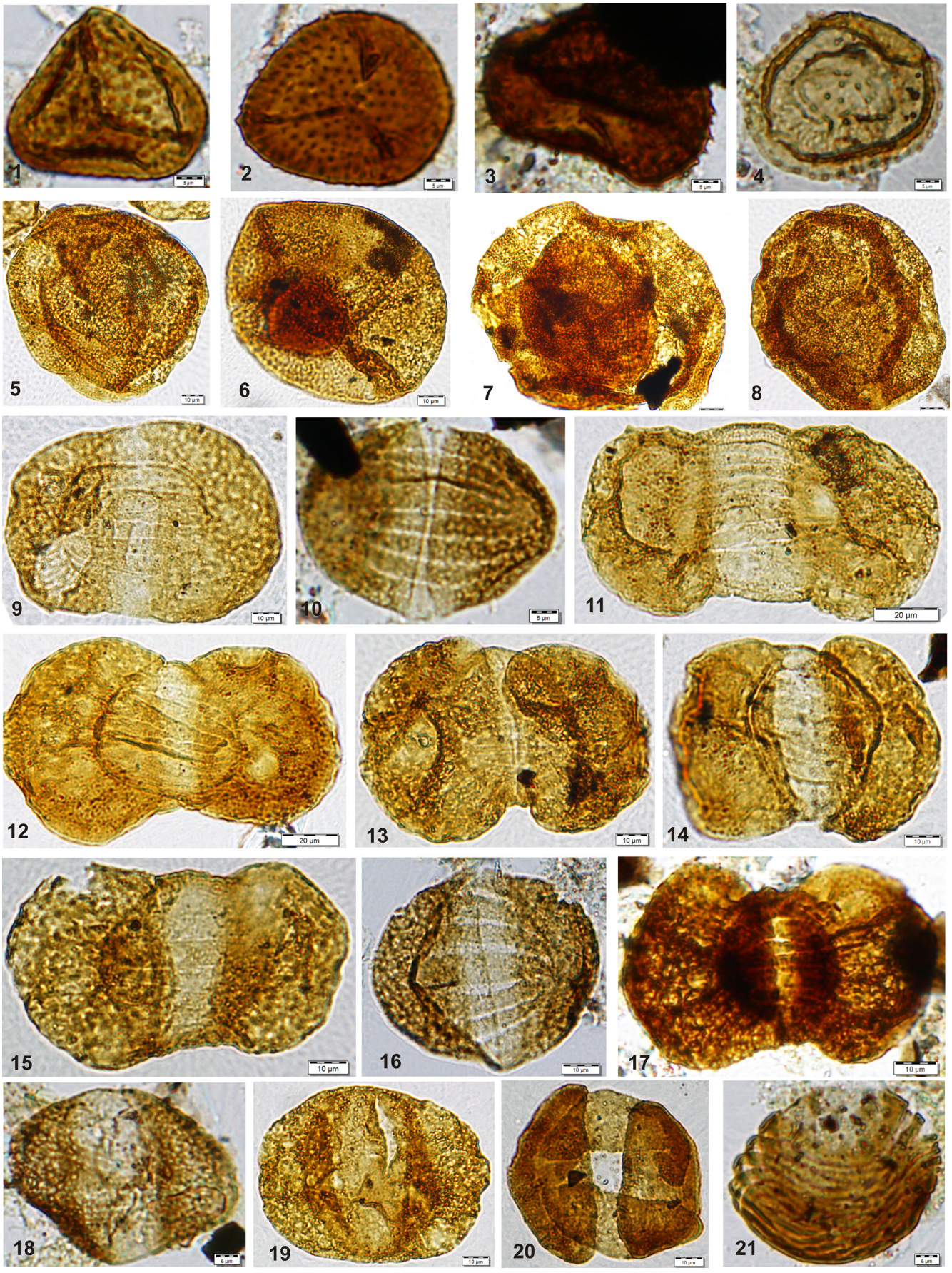

PLATE 1

Table 1—The geological succession recorded from Chalburdi area of Chandrapur District, Maharashtra (after Raja Rao, 1982).

Age	Group/Formation	Lithology
Recent	–	Alluvial gravel beds, black cotton soil
? Eocene	Deccan Trap	Basalts
——————Unconformity——————		
Cretaceous	Lameta Formation	Limestones, cherts and silicified sandstones
——————Unconformity——————		
Upper Triassic	Maleri Formation (only in the south eastern extremity)	Fine– to medium–grained sandstone and red shales
Upper Permian–Lower Triassic	Kamthi Formation	Red, brown and variegated sandstones, reddish siltstones and variegated shales
——————Unconformity——————		
Lower Permian	Barakar Formation	Light grey to white sandstones, shales and coal seams
? Upper Carboniferous–Lower Permian	Talchir Formation	Tillites, turbidites, varves, needle shales and sandstones
——————Unconformity——————		
Precambrian	Sullavai sandstones	White to light brown quartzitic sandstones, conglomerates
——————Overlap——————		
	Pakhal Limestone	Grey bluish or pinkish limestones and cherts
——————Unconformity——————		
Archaean		Quartzites, granite gneisses, etc.

CORRELATION WITH THE GONDWANA BASINS IN INDIA

DAMODAR BASIN

The present assemblage compares well with latest Permian, *Densipollenites magnicorpus* dominant assemblage recorded from the Raniganj Formation of Damodar Basin (Tiwari & Tripathi, 1992).

The *Striatopodocarpites–Faunipollenites* assemblage in association with high incidence of *Densipollenites* recorded from the Chalburdi area closely corresponds with Late Permian assemblages recorded from several areas of Raniganj Coalfield, viz. {Srikanta Murthy (2010); Srikanta Murthy *et al.,* (2010); Vijaya (2011); Vijaya & Tiwari (1987); Bharadwaj & Tiwari (1977); Tiwari & Singh (1983); Singh & Tiwari (1982); Rana & Tiwari (1980) and Tiwari *et al.,* (1992)}.

East Bokaro Coalfield

The Chalburdi palynoflora is also comparable with the latest Permian palynoassemblage retrieved at the depth interval of 13.00–91.00 m from Bore–hole EBM–1 (Vijaya *et al.,* 2012a) from East Bokaro Coalfield of the Damodar Basin, as it contains the prevalence of *Densipollenites* and *Striatopodocarpites* along with *Faunipollenites, Crescentipollenites*, *Verticipollenites, Arcuatipollenites*, *Rhizomaspora* and *Playfordiaspora.*

North Karanpura Coalfield

Kar (1968) reported a palynoassemblage from Bore–hole K–3 from North Karanpura Coalfield, having the dominance of striate bisaccates *Strotersporites* and *Striatopodcarpites* and sub–dominance of *Densipollenites*. This assemblage may be compared with the present finding with respect to the sub–dominance of *Densipollenites*. A similar palynoassemblage has also been recorded from the south Karanpura Coalfield by Srikanta Murthy *et al.* (2014) having dominance of striate bisaccates chiefly *Striatopodocarpites* besides, *Crescentipollenites, Klausipollenites, Falcisporites, Krempipollenites* and *Arcuatipollenite*s. However, the genus *Densipollenites* is absent in the latter and therefore, the assemblage of South Karanpura Coalfield is comparatively older than the present findings.

Table 2—Showing the details of the lithological succession intersected in the Bore–hole CHB–5 from Chalburdi area, Chandrapur District, Maharashtra.

Sample No.	Depth (in meter)	Lithology	Remarks
1	51.00	Greenish clay	Productive
2	57.00	Green shale	Productive
3	66.00	Green shale	Non productive
4	72.10	Red shale	Non productive
5	78.00	Red shale	Non productive
6	84.00	Red shale	Non productive
7	87.00	Red shale	Non productive
8	93.00	Red shale	Non productive
9	108.00	Red mudstone	Non productive
10	117.00	Red mudstone	Non productive
11	126.00	Red mudstone	Non productive
12	207.00	Red mudstone	Non productive
13	213.00	Green shale	Non productive
14	224.00	Red mudstone	Non productive
15	295.00	Greenish shale	Non productive

RAJMAHAL BASIN

The palynoassemblage VIII recovered from Pachami area, (Vijaya, 2006) correlates well with the Chalburdi palynoassemblage in view of dominance of *Striatopodocarpites* followed by *Densipollenites*. It also compares well with palynoassemblage VIII recovered from Deocha–Pachami area of the Birbhum Coalfield (Vijaya, 2009) in having dominance of *Densipollenites* and sub–dominance of *Striatopodocarpites* along with *Crescentipollenites* and *Faunipollenites*. Palynological studies carried out by Tripathi (1986, 1989) from Rajmahal Basin has shown the abundance of *Striatopodocarpites* followed by *Faunipollenites*, *Crescentipollenites*, *Alisporites Verticipollenites*, *Striatites*, *Rhizomaspora* and *Lunatisporites* and is broadly comparable with the present study. However, it differs from the present assemblage as it has shown absence of genus *Densipollenites,* thus, the Rajmahal palynoflora is comparatively older in age than the present assemblage.

SATPURA BASIN

The palynoflora recorded from the sediments exposed in Sukh Tawa Nala section of Bijori Formation from the Satpura Basin (Bharadwaj *et al.,* 1978), Tamia Ghat Road, Chhindwara District, Madhya Pradesh (Kumar, 1996) and palynoassemblage IV recovered from the area of Parasia, Pench Valley Coalfield (Srikanta Murthy *et al.,* 2013) has shown the dominance of *Striatopodocarpites* associated with *Faunipollenites, Densipollenites, Playfordiaspora*, *Corisaccites, Guttulapollenites*, *Crescentipollenites, Arcuatipollenites, Alisporites* and *Klausipollenites* which corresponds closely with the present palynofloral assemblage.

SON–MAHANADI BASIN

The palynoassemblages of Chalburdi area is also comparable with that of Singrauli Coalfield (Vijaya *et al.,* 2012b), Assemblage B from Middle Pali out–crop exposed near Dargaon and Salaia villages (Ram–Awatar, 1987; Tiwari & Ram–Awatar, 1986), Gopat River bed, east of Nidpur bed (Maheshwari, 1967b), Jeer–Daser Road, Son Valley (Tiwari & Anand–Prakash, 1974), and Bore–hole JHL 24 of Johilla Coalfield (Tiwari & Ram–Awatar, 1987, 1989) with regards to the abundance of *Densipollenites* along with *Striatopodocarpites* and *Faunipollenites*. The other taxa of significance, viz. *Crescentipollenites* sp., *Weylandites* sp., *Guttulapollenites hannonicus* and *Arcuatipollenites pellucidus* are found in relatively fair quantity.

Similarly, the palynoassemblage–II of Bore–hole SKM–6 from Mithauri–Kelmania Sector, Sohagpur Coalfield (Ram–Awatar *et al.,* 2004) has indicated the presence of *Striatopodocarpites, Faunipollenites*, *Crescentipollenites*, *Rhizomaspora*, *Arcuatipollenites* and *Alisporites*. However, the present assemblage lacks the existence of *Densipollenites* and therefore appears to be older than the assemblage recorded from Chalburdi area.

The assemblages known from the sediments exposed in Madalia River Section and representing the westernmost part of Talcher Coalfield (Tiwari *et al.,* 1991) and several sub–surface sediments collected from different bore–holes from same area by Tripathi and Bhattacharya (2001) also

compare well with the present finds in having dominance of *Densipollenites*, *Striatopodocarpites*, *Faunipollenites*, *Crescentipollenites*, *Verticipollenites* and *Rhizomaspora*.

WARDHA–GODAVARI BASIN

The comparable palyno–assemblages displaying the existence of *Striatopodocarpites–Faunipollenites* complex along with high frequency of *Densipollenites* are also known from Mailaram area (Jha & Aggarwal, 2012), Budharam area (Srivastava & Jha, 1995), Sattupalli area (Srivastava & Jha, 1994), Gattugudem area (Jha, 2002), Bottapagudem area (Jha, 2004), Gauridevpet area (Jha *et al.,* 2014), Manuguru area (Srivastava & Jha, 1992) of the Godavari Basin and palynoassemblage I of Bore–hole DGW–6 from Bazargaon area of Kamptee Coalfield (Srivastava & Bhattacharyya, 1996) .

DISCUSSION AND AGE

The Gondwana sediments of peninsular India display dissimilarities in the sedimentation patterns in individual basins and therefore, are described under varied names, e.g. the sequence described as Motur and Bijori formations in Satpura Gondwana Basin, is believed to be the time equivalent of Barren Measures Formation and the Raniganj Formation of the Damodar Basin respectively. Similarly, the lower part of the Kamthi Formation of the Godavari Valley Coalfield (Mukhopadhyay *et al.,* 2010) also correlated with that of the Raniganj Formation of Damodar Basin. However, these sediments display broad palynofloral similarities which suggest that there existed almost similar vegetational pattern in different Indian Gondwana basins.

Tiwari and Tripathi (1992) have recorded three palynoassemblage zones for the late Permian sediments of Damodar Basin. (1) *Densipollenites densus* assemblage or zone VII, (2) *Gondisporites raniganjensis* assemblage or zone VIII and (3) the youngest *Densipollenites magnicorpus* assemblage or zone IX. The zone VII belongs to Barren Measures Formation (early late Permian), while zone VII and IX are assigned to Raniganj Formation (late Permian).

The palynocomposition recorded from Chalburdi area equates well with the *Densipollenites magnicorpus* assemblage or zone IX of Damodar Basin (Tiwari & Tripathi, 1992) with respect to the dominance of *Densipollenites* in association with subdominance of striate bisaccate such as *Striatopodocarpites* and *Faunipollenites*. Other significant palynomorphs includes *Crescentipollenites, Striatites, Distriatites, Corisaccites, Arcuatipollenites, Alisporites* and *Klausipollenites*. In view of this, the palynoassemblage described herein, has been assigned a late Permian age. The present palynoassemblage also compares with the late Permian palynoassemblage recorded form other Gondwana basins of peninsular India.

Although minor discrepancies in the palyno–composition may be noticed between the palynoassemblages of the Godavari Graben and those of Chalburdi area, still a broad correlation is feasible. The taxa similar to and shared between the two include *Densipollenites* and *Striatopodocarpites* along with *Faunipollenites, Crescentipollenites*, *Verticipollenites, Corisaccites*, *Arcuatipollenites*, *Alisporites* and *Klausipollenites.*

The age control for the present sequence from Chalburdi area is ascertained from its comparison with previously known similar palyno–assemblages from several other Gondwana basins of the peninsular India (Table 3). Comparison and tentative correlation with similar zones has been erected in the region. However, considering the limiting factors, such as the disparity in the frequency and distribution of palynotaxa in different Gondwana basins of peninsular India, some local variations might exist in the area.

CONCLUSIONS

Based upon the palynological studies, it is inferred that late Permian (Lower Kamthi) Sequence has been deposited in Chalburdi area, Chandrapur District, Wardha Valley Coalfield Maharashtra. This palynoassemblage has displayed closer degree of similarity with the Late Permian palynoassemblages recorded from the Damodar, Son–Mahanadi and Rajmahal basins in having the dominance of *Densipollenites* followed by *Striatopodocarpites* palynomorphs. It also resembles closely with the late Permian palynoassemblage of Wardha–Godavari and Satpura basins as it contains sub–dominance of *Striatopodocarpites* and *Faunipollenites* and shows presence of *Densipollenites*. However, minor differences have been noticed between the palynoassemblages of Godavari and Satpura basins and the assemblage recorded from Chalburdi area which suggests that almost similar Glossopteris rich floral elements proliferated with existence of warm and humid climatic conditions prevailed in these different basins with sufficient water availability.

Tiwari and Singh (1986) based upon their palynological studies from Johilla Coalfield, South Rewa Gondwana Basin Madhya Pradesh have noticed that the genus *Densipollenites* exhibits maximum diversity in Raniganj Formation. The species recorded include *Densipollenites indicus, D. invisus, D. densus,* and *D. magnicorpus* in assemblage. It is further inferred that the species *Densipollenites magnicorpus* is recorded from the uppermost part of the Raniganj Formation. In present palynoassemblage of Chalburdi area the dominance of *Densipollenites magnicorpus* has been observed which justifies the inference that these sediments represent the Lower part of the Kamthi Formation equivalent to the Raniganj Formation of Damodar Basin indicating a late Permian age.

Table 3—Latest Permian palynoassemblage known from the Indian Peninsula.

Gondwana Basins	Coalfields/Area	References
Damodar Basin	Raniganj Coalfield	Srikanta Murthy *et al.,* 2010; Vijaya, 2011; Vijaya & Tiwari, 1987; Bharadwaj & Tiwari, 1977; Tiwari & Singh, 1983; Singh & Tiwari, 1982; Rana & Tiwari, 1980; Tiwari *et al.,*1992
	East Bokaro Coalfield	Vijaya *et al.*, 2012a
	Karanpura Coalfield	Kar, 1968; Srikanta Murthy *et al.,* 2014
Rajmahal Basin	Birbhum Coalfield	Vijaya, 2006, 2009; Tripathi, 1986, 1989
Son–Mahanadi Basin	Singrauli Coalfield	Vijaya *et al.,* 2012b
	Talchir Coalfield	Tiwari *et al.,* 1991; Tripathi & Bhattacharya, 2001
	Johilla Coalfield	Tiwari & Ram–Awatar, 1987; Tiwari & Ram–Awatar, 1989
	Sohagpur Coalfield	Ram–Awatar *et al.,* 2004
	Dargaon and Salaia village	Ram–Awatar, 1987
	Gopat River Bed	Maheswari, 1967b
	Jeer–Daser Road	Tiwari & Anand–Prakash, 1974
Satpura Basin	Shivapura Coal Mine	Srikanta Murthy *et al.,* 2013
	Tamia Ghat Road	Kumar, 1996
	Near Sukh Tawa Nala	Bharadwaj *et al.,* 1978
Wardha–Godavari Basin	Kamptee Coalfield	Srivastava & Bhattacharyya, 1996
	Mailaram area	Jha & Aggarwal, 2012
	Budharam area	Srivastava & Jha, 1995
	Sattupalli area	Srivastava & Jha ,1994
	Gattugudem area	Jha, 2002
	Bottapagudem area	Jha, 2004
	Gauridevpet area	Jha *et al.,* 2014
	Manuguru area	Srivastava & Jha, 1992
	Chalburdi area	Present study

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REFERENCES

Agashe SN & Chitnis SR 1970. Palynological investigation of coal seams of Lower Gondwana strata from Maharashtra, India–A preliminary report. Palynological Bulletin 4: 6–8.

Agashe SN & Chitnis SR 1972. Palaeopalynology of a Permian coal seam from the Hindustan Lalpeth Colliery, Chandrapur District, Maharashtra, India. Seminar on Palaeopalynology and Indian Stratigraphy: 21–29.

Anand–Prakash & Khare RC 1974. Petrology and Palynostratigraphy of some Wardha Valley coal, Maharashtra, India. Palaeobotanist 23: 124–138.

Bharadwaj DC 1962. Miospore genera in the coals of Raniganj Stage (Upper Permian) India. Palaeobotanist 9: 68–106.

Bharadwaj DC 1969. Lower Gondwana Formations. 6th International Congress on Carbonaceous Geology and Stratigraphy, Sheffield. Compte Rendu 1: 255–274.

Bharadwaj DC 1971. Palynological subdivision of the Gondwana Sequence in India. *In*: Haughtan SH *et al.* (Editors)–Proceedings of the 2nd International Gondwana Symposium, Pretoria, University of Cape Town: 531–536.

Bharadwaj DC 1975. Palynology in biostratigraphy and palaeoecology of Indian Lower Gondwana formations. Palaeobotanist 22: 150–157.

Bharadwaj DC & Anand–Prakash 1974. Palynostratigraphy of Lower Gondwana sediments from Umrer Quarry, Nagpur, Maharashtra, India. Geophytology 4: 130–134.

Bharadwaj DC & Dwivedi A 1977. *Insignisporites* gen. nov. A new cavate miospore genus from Barakar Stage (Lower Gondwana) of India. Geophytology 7: 113–120.

Bharadwaj DC & Salujha SK 1964. Sporological study of seam VIII in Raniganj Coalfield, Bihar (India). Part II–Distribution of *Sporae dispersae* and correlation. Palaeobotanist 13: 57–73.

Bharadwaj DC & Srivastava SC 1969. Some new miospores from Barakar Stage Lower Gondwana, India. Palaeobotanist 17: 220–229.

Bharadwaj DC & Tiwari RS 1977. Permian–Triassic miofloras from the Raniganj Coalfield, India. Palaeobotanist 24: 26–49.

Bharadwaj DC, Tiwari RS & Anand–Prakash 1978. Palynology of Bijori Formation (Upper Permian) in Satpura Gondwana Basin, India. Palaeobotanist 25: 72–78.

Bharadwaj DC, Tiwari RS & Kar RK 1974. *Crescentipollenites* gen. nov.:

a new name for hitheno known *Lunatisporites* leschik from the Lower Gondwanas. *Geophytology* 4: 141·146.

Bhattacharrya AP 1997. Palynological recognition of the Karharbari–Barakar formations in the sub–surface sediments of Wardha Coalfield, Maharashtra, India. Palaeobotanist 46: 217–219.

Fedden F 1875. On the evidence of "ground–ice" in the tropical India during the Talchir period. Record of the Geological Survey of India VIII (Part I): 16–18.

Hughes TWH 1877. The Wardha Valley Coalfield. Memoirs of the Geological Survey of India 13: 1–154.

Jha N 2002. Palynological dating of sediments from Gattugudem area, Chintalapudi sub–basin, Andhra Pradesh. Geophytology 30: 85–89.

Jha N 2004. Palynodating of coal bearing sediments from the Bottapagudem area, Chintalapudi sub–basin, Andhra Pradesh. Palaeobotanist 53: 43–55.

Jha N & Aggarwal N 2012. Permian–Triassic palynostratigraphy in Mailaram area, Godavari Graben, Andhra Pradesh, India. Journal of Earth System Science 12: 1257–1285.

Jha N, Pauline Sabina K, Aggarwal N & Mahesh S 2014. Late Permian Palynology and depositional environment of Chintalapudi sub–basin, Pranhita–Godavari Basin, Andhra Pradesh, India. Journal of Asian Earth Sciences 79: 382–399.

Jha N, Pauline Sabina K, Tewari R & Mehrotra 2011. Palynological dating and correlation of surface and subsurface sediments from Wardha Valley Coalfield, Maharashtra. Journal of Geological Society of India 77: 137–148.

Jha N, Rajni Tewari & Rajnikanth A 2007. Palynology of Permian Gondwana Sequence of Umrer Coalfield, Maharashtra. Journal of the Geological Society of India 69: 851–857.

Kalkar SA, Bhute SD & Sarate OS 2010. Palynoflora recorded from Makardhokada area, Nagpur District, Maharashtra. Palaeobotanist 59: 63–70.

Kar RK 1968. Palynology of North Karanpura Basin, Bihar, India–3. Raniganj exposure near Lungatoo, Hazaribagh District. Palaeobotanist 16: 273–282.

Kumar P 1996. Permo–Triassic palynofossils and depositional environment in Satpura Basin, Madhya Pradesh. Geophytology 25: 47–54.

Mahesh S, Pauline Sabina K & Mahesh Bilwa L 2008. Permian sediments from the subsurface sediments of Lower Gondwana of Wardha Valley Coalfield, Maharashtra, India. Gondwana Geological Magazine. 23: 63–67.

Mahesh S, Pauline Sabina K & Mahesh Bilwa L 2011. Palynodating and correlation of subsurface sediments from Bore–hole CMWY–95 of Wardha Valley Coalfield, Maharashtra, central India. Palaeobotanist 60: 299–307.

Mahesh S, Pauline Sabina K & Mahesh Bilwa L 2014. Palynology and depositional facet of Lower Permian (Artinskian) sediments from New Majri Opencast Mine, Wardha Basin, India. Journal of the Geological Society of India 83: 697–708.

Maheshwari HK 1967a. Studies in the Glossopteris flora of India· 29. Miospore assemblage from the Lower Gondwana exposures along Bansoli River in Rajmahal Hills, Bihar. Palaeobotanist 15: 258·280.

Maheshwari HK 1967b. Note on a miospore assemblage from Gopat River Valley, M.P. Current Science 36: 181.

Mukhopadhyay G, Mukhopadhyay SK, Roychowdhury M & Puri PK 2010. Stratigraphic correlation between different Gondwana basins of India. Journal of Geological Society of India 76: 251–266.

Pauline Sabina K, Mahesh Bilwa L & Mahesh S 2007. A palynostratigraphic study of Lower Gondwana sediments from Bandar Coalfield, Nagpur District, Maharashtra. Journal of the Geological Society of India 69: 834–840.

Pauline Sabina K, Mahesh Bilwa L & Mahesh S 2008. A palynological study of the Lower Gondwana sediments of Umrer Coalfield of Wardha Basin, central India. Proceedings of the V International Conference on Environmental Micropalaeontology, Microbiology and Meiobenthology. University of Madras 239–244.

Pauline Sabina K, Mahesh Bilwa L & Mahesh S 2010. Palaeoenvironmental implications of the Umrer Coalfield, Wardha Basin, Central India, through palynological studies. Gondwana Geological Magazine 25: 175–180.

Raja Rao CS 1982. Coal resources of Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra. Bulletins of the Geological Survey of India. Series A. 45: 85–87.

Ram–Awatar 1987. Palynological dating of Supra–Barakar Formation in Son Valley Graben. Palaeobotanist 36: 133–137.

Ram–Awatar, Mukhopadhyay A & Adhikari S 2004. Palynostratigraphy of sub–surface Lower Gondwana, Pali sediments, Sohagpur Coalfield, M.P., India. Palaeobotanist 53: 51–59.

Rana V & Tiwari RS 1980. Palynological succession in Permian–Triassic sediments in Bore–hole RNM–3, East Raniganj Coalfield, West Bengal. Geophytology 10: 180–124.

Singh, KJ, Goswami S & Chandra S 2006. Megafloral assemblage similar to Karharbari biozone from Talchir Coalfield of Mahanadi Basin, Orissa. Journal of the Geological Society of India 68: 277–287.

Singh V & Tiwari RS 1982. Patterns of miofloras through Permo–Triassic transition in Bore–hole RAD–2, East Raniganj Coalfield, West Bengal. Geophytology 12: 181–186.

Smith AJ 1963. Evidences for Talchir (Lower Gondwana glaciations): Striated pavements of boulder bed at Irai, central India. Journal Sedimentology Petrology 33: 739–750.

Srikanta Murthy 2010. Palynostratigraphy of the Permian succession in Bore–hole RJS–2, Raniganj Coalfield, Damodar Basin, West Bengal. Journal of Indian Geological Congress 2: 83–90.

Srikanta Murthy, Chakraborthi B & Roy MD 2010. Palynodating of subsurface sediments, Raniganj Coalfield, Damodar Basin, West Bengal. Journal of Earth System Science 119: 701–710.

Srikanta Murthy, Tripathi A, Chakraborti B & Singh UP 2014. Palynostratigraphy of Permian succession from Binja Block, South Karanpura Coalfield, Jharkhand, India. Journal of Earth System Science 123: 1895–1906.

Srikanta Murthy, Vijaya & Vethanayagam SM 2013. Palynostratigraphy of Permian succession in the Pench Valley Coalfield, Satpura Basin, Madhya Pradesh, India. Journal of the Palaeontological Society of India 58: 241–250.

Srivastava SC & Bhattacharyya AP 1996. Permian–Triassic palynofloral succession in subsurface from Bazargaon, Nagpur District, Maharashtra. Palaeobotanist 43: 10–15.

Srivastava SC & Jha N 1992. Palynostratigraphy of Permian sediments in Manuguru area, Godavari Graben, Andhra Pradesh. Geophytology 22: 102–110.

Srivastava SC & Jha N 1994. Palynological dating of Lower Gondwana sediments in Sattupalli area, Chintalapudi sub–basin, Andhra Pradesh, India. Palaeobotanist 42: 169–173.

Srivastava SC & Jha N 1995. Palynostratigraphy and correlation of Permian–Triassic sediment in Budharam area, Godavari Graben, India. Journal of Geological Society of India 46: 647–653.

Tiwari RS 1965. Miospore assemblage in some coals of Barakar Stage (Lower Gondwana) of India. Palaeobotanist 13: 168–214.

Tiwari RS 1973. *Scheuringipollenites,* a new name for the Gondwana sporomorphs so far assigned to *"Sulcatisporites* Leschik 1955" *Senckenb. Leth.* 54: 105·117.

Tiwari RS & Anand–Prakash 1974. A miofloral assemblage in some Lower Gondwana sediments between Jeer and Daser, Son–Valley, MP, India. Geophytology 4: 135–140.

Tiwari RS & Ram–Awatar 1986. Late Permian palynofossils from the Pali Formation, South Rewa Basin, Madhya Pradesh. Bulletin of Geological, Mining and Metallurgical Society of India 54: 250–255.

Tiwari RS & Ram–Awatar 1987. A palynological assemblage from Parsora Formation, Johilla Coalfield, South Rewa Gondwana Basin, Madhya Pradesh. Geophytology 17: 104–109.

Tiwari RS & Ram–Awatar 1989. Sporae–dispersae and correlation of Gondwana sediments in Johilla Coalfield, Son Valley Graben, Madhya Pradesh. Palaeobotanist 37: 94–114.

Tiwari RS & Rana V 1981. *Sporae dispersae* of some Early and Middle Triassic sediments from Damodar Basin, India. Palaeobotanist 27: 190–220.

Tiwari RS & Singh V 1983. Miofloral transition at Raniganj–Panchet boundary in East Raniganj Coalfield and its implication on Permian–

Triassic time boundary. Geophytology 13: 227–234.

Tiwari RS & Singh V 1986. Palynological evidences from Permo–Triassic Gondwana sediments in Johilla Coalfield, Son Valley graben, M.P., India. Palaeobotanist 37: 94–114.

Tiwari RS & Tripathi A 1988. Palynological zones and their climatic inference in the coal–bearing Gondwana of Peninsular India. Palaeobotanist 36: 87–101

Tiwari RS & Tripathi A 1992. Marker assemblage zones and their spore and pollen species through Gondwana Palaeozoic and Mesozoic sequence in India. Palaeobotanist 40: 194–236.

Tiwari RS, Tripathi A & Jana BN 1991. Palynological evidences for upper Permian Raniganj coals in western of Talchir Coalfield, Orissa, India. Current Science 61: 407–410.

Tiwari RS & Vijaya 1995. Differential morphographic identity of Gondwana palynomorphs. Palaeobotanist 44: 62–115.

Tiwari RS, Vijaya & Meena KL 1992. Palynological sequence and relationship of subsurface Permian–Triassic sediments in eastern Raniganj Coalfield, West Bengal, India. Geophytology 21: 21–32.

Tiwari RS, Srivastava SC, Tripathi A & Vijaya 1989. Morphographic study of Permian palynomorphs: *Callumispora, Parasaccites, Crucisaccites* and *Faunipollenites*. Palaeobotanist 37: 215–266.

Tripathi A 1986. Upper Permian palynofossils from the Rajmahal Basin, Bihar. Bulletin of the Geological, Mining and Metallurgical Society of India 54: 265–271.

Tripathi A 1989. Palynological evidence for the presence of Upper Permian sediments in northern part of Rajmahal Basin. Journal of Geological Society of India 34: 198–207.

Tripathi A & Bhattacharya D 2001. Palynological resolution of upper Permian sequence in Talchir Coalfield, Orissa, India. Proceedings of the National Seminar on Recent Advance in Geology of Coal and Lignite basins of India, Calcutta, 1997. Geological Survey of India Special Publication 54: 59–68.

Venkatachala BS & Kar RK 1966. *Corisaccites* gen. nov., A new saccate pollen genus from the Permian of salt range, West Pakistan. Palaeobotanist 15: 107–109.

Vijaya 2006. Permian to Jurassic palynoflora in subsurface strata, Pachami area, West Bengal, India. Gondwana Geology Magazine 21: 13–26.

Vijaya 2009. Palynofloral changes in the Upper Palaeozoic and Mesozoic of the Deocha–Pachami area, Birbhum Coalfield, West Bengal, India. Science in China, Series D: Earth Sciences 52: 1932–1952.

Vijaya 2011. Palynostratigraphy of subsurface Upper Permian and Mesozoic Succession, Rakshitpur area, Raniganj Coalfield, West Bengal. Palaeoworld 20: 61–74.

Vijaya, Srikanta Murthy, Chakraborty B & Joyti SR 2012a. Palynological dating of subsurface coal bearing horizon in East Bokaro Coalfield, Damodar Basin, Jharkhand. Palaeontographica 288: 41–63.

Vijaya & Tiwari RS 1987. Role of spore–pollen species in demarcating the Permian Triassic boundary in Raniganj Coalfield, West Bengal. Palaeobotanist 35: 242–248.

Vijaya, Tripathi A, Roy A & Mitra S 2012b. Palynostratigraphy and age correlation of subsurface strata within the sub–basins in Singrauli Gondwana Basin, India. Journal of Earth System Science 121: 1071–1092.