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Palynodating and correlation of subsurface sediments from bore-hole CMWY-95 of Wardha Valley Coalfield, Maharashtra, Central India

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ABSTRACT

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Palynological studies have been carried out in the subsurface sediments of borehole CMWY-95 drilled near Pisagaon in Chandrapur District of Maharashtra. The studies have been aimed to palynologically date and correlate the sediments. On the basis of the statistical analysis of the spores and pollen from the productive samples, two palynoassemblages have been demarcated: Assemblage I recognised at a depth of 149.00 m is characterised by the dominance of the monosaccate genus *Parasaccites* and subdominance of *Plicatipollenites* which is typical of the Early Permian Upper Talchir palynoflora and Assemblage II identified between the depths 147.00-133.00 m is characterised by the dominance of *Parasaccites* and subdominance of *Callumispora* which corresponds to the Early Permian Lower Karharbari palynoflora. Therefore, palynologically these sediments have been dated to be of Early Permian age.

Further, within India, an inter and intra basinal correlation has been attempted while with the continents of the Gondwanaland- Africa, Australia, Antarctica and South America, it is observed that the correlation with Antarctica is closest when compared to other continents suggesting a closer genetic relationship with Antarctica. A close similarity with the Early Permian palynosequences of Africa than that of Australia has also been noticed due to regional differences amongst eastern and western Australia, while in South America correlation was feasible only in broader pattern of group occurrences as the differences were pronounced at finer levels.

Key-words—Palynology, Gondwana, Karharbari, Barakar, Early Permian, Correlation, Wardha Valley Coalfield.

वर्धा घाटी कोयलाक्षेत्र, महाराष्ट्र, मध्य भारत के वेध-छिद्र सीएमडब्ल्यूवाई-95 से प्राप्त उपपृष्ठीय अवसादों की परागाणुआयुनिर्धारण एवं सहसंबंध

महेश एस., पॉलिन सबीना के. एवं एल. महेश बिल्वा

सारांश

महाराष्ट्र के चंद्रपुर जिले में पिसागाँव के नजदीक वेधे गए वेध-छिद्र सीएमडब्ल्यूवाई-95 के उपपृष्ठीय अवसादों का परागाणविक अध्ययन किया गया है। अध्ययनों का लक्ष्य अवसादों का परागाणविक रूप से आयुनिर्धारण एवं सहसंबंध रहा है। उत्पादी नमूनों से प्राप्त बीजाणु व पराग के सांख्यिकीय विश्लेषण के आधार पर दो परागाणुसमुच्चय पहचाने गए हैं: 149.00 मीटर गहराई पर पहचानी गई प्रथम समुच्चय एकलसपुट वंश *पैरासैकाइट्स* से प्रभावी और *प्लिकेटीपॉलेनाइट्स* से उप-प्रभावी द्वारा अभिलक्षणित है जो कि पूर्व पर्मियन ऊपर तल्चीर परागाणु पेड़-पौधों के प्रतिरूपी है तथा 147.00-133.00 मी. गहराई के मध्य पहचानी गई द्वितीय समुच्चय *पैरासैकाइट्स* से प्रभावी और *कल्लुमिस्पोरा* से उप-प्रभावी द्वारा अभिलक्षणित है जो कि पूर्व पर्मियन निम्न करहरबाड़ी परागाणु पेड़-पौधों के अनुरूपी है। अतः ये अवसाद परागाणविक रूप से पूर्व पर्मियन काल के निर्धारित किए गए हैं।

आगे भारत में अंतः एवं अंतद्रोणीय सहसंबंध प्रयत्न किया गया है जब कि गोंडवाना स्थल- अफ्रीका, आस्ट्रेलिया, दक्षिणध्रुवीय व दक्षिणी अफ्रीका के महाद्वीप सहसंबंध ने दर्शाया है कि दक्षिणध्रुवीय के साथ निकटतर आनुवंशिक संबंधता सुझाते हुए जब अन्य महाद्वीपों के साथ तुलना की गई तो दक्षिणध्रुवीय के साथ सहसंबंध निकटतम हैं। अफ्रीका के पूर्व पर्मियन परागाणुसमुच्चय के साथ निकट समानता जो आस्ट्रेलिया की थी, पूर्वी व पश्चिमी प्रादेशिक विभिन्नताओं के कारण भी पाई गई है, जबकि दक्षिण अमेरिका में समूह प्राप्तियों के विस्तृत होते हुए प्ररूप में ही सहसंबंध संभव था क्योंकि विभिन्नताएं शोधक स्तरों पर सुस्पष्ट थीं।

संकेत-शब्द—परागाणुविज्ञान गोंडवाना, करहरबारी, बराकर, पूर्व पर्मियन, सहसंबंध, वर्धा घाटी कोयला क्षेत्र।

INTRODUCTION

The Wardha Valley Coalfield is the north western extension of the Godavari Valley Coalfield. It is the biggest coalfield among the four coalfields in the Wardha Basin, viz. Wardha Valley Coalfield, Kamptee Coalfield, Bandar Coalfield and Umrer Coalfield. Coal exploration in the Wardha Valley Coalfield was initiated by Blanford (1868), followed by Oldham in the next year which has paved the way for the initiation of palynological investigation by various pioneering workers (Agashe & Chitnis, 1970, 1972; Anand-Prakash & Khare, 1974; Bharadwaj & Anand-Prakash, 1974) within the Wardha Basin. With the ever increasing target for coal production and demand for coal, palynological studies were later pursued by recent workers (Jha *et al.*, 2007; Pauline *et al.*, 2008; Mahesh *et al.*, 2008) who have significantly contributed in solving various biostratigraphic problems and thereby assisting in demarcating the potential coal horizons within the basin. Megafloral studies were also recorded from this basin (Agashe, 1979; Tewari *et al.*, 2004; Jha *et al.*, 2007). The present paper deals with the palynological dating and correlation of sub-surface sediments from bore-hole No.CMWY-95 from Wardha Valley Coalfield (Fig. 1). Statistical analysis of the palynomorphs recovered from these sediments has revealed the presence of two palynoassemblages, viz. *Parasaccites* + *Plicatipollenites* and *Parasaccites* + *Callumispora* palynoassemblage which are characteristic of Upper part of Talchir Formation and Lower Karharbari Formation respectively, thus suggesting an Early Permian age to these sediments.

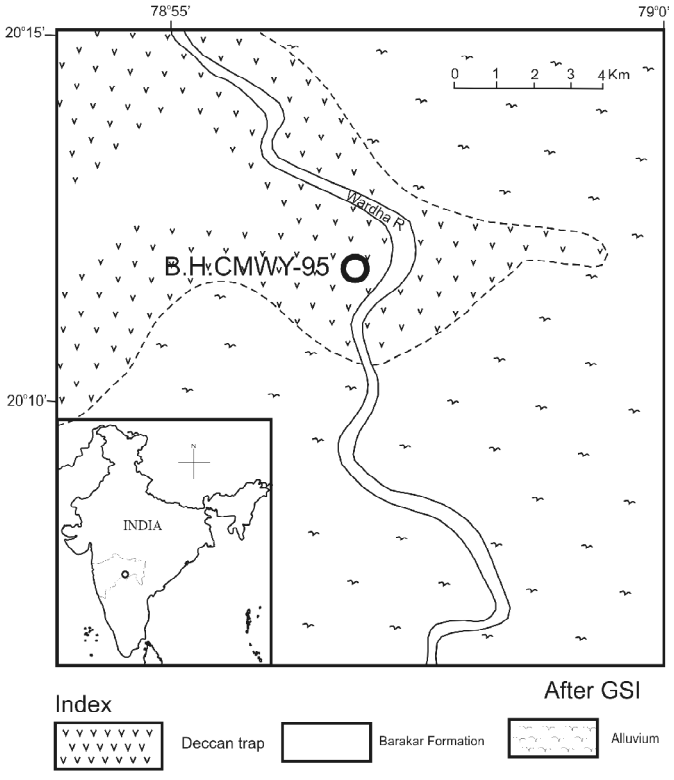

Fig. 1—Location map of B.H. CMWY-95 (after GSI).

GEOLOGICAL SETUP

The Wardha Valley Coalfield lies in the Chandrapur District of Maharashtra between the latitudes 19º30' and 20º27' and longitudes 78º50' and 79º45'. Hughes (1877) conducted the first systematic geological mapping of the entire coalfield which has revealed that the Gondwana sediments in this coalfield are thickly overlain by alluvium and trap. In the eastern part of the coalfield the Kamthis form a blanket over the Talchirs and Barakars as they were deposited after some tectonic deformation and erosion of the underlying rocks but in the western part they have been exposed revealing the structure of the Wardha Valley Coalfield. The generalized stratigraphic sequence in the Wardha Valley Coalfield is given below in Fig. 2.

MATERIAL AND METHODS

The standard maceration technique has been adopted for the recovery of palynomorphs involving cleaning and crushing of 5-10 gm of sample followed by demineralization, which involves removal of carbonates by 10% HCl, removal of silicates by 40% HF, oxidation of organic matter with conc. HNO_3 and removal of humic matter by 10% KOH. Sequel to chemical methods for release of microfossils some non-chemical techniques like sieving and swirling were used to achieve maximum concentration of palynomorphs. Later the macerates were mounted in Canada Balsam and slides were prepared for observation. The slides have been deposited in the Repository of the Museum of Department of Geology, University of Mysore, Mysore.

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——
Late Triassic	Maleri Formation	Fine to medium grained sandstone and red shale
Late Permian to Early Triassic	Kamthi Formation	Red, brown and variegated sandstones, reddish siltstones and variegated shales to Early
Early Permian	Barakar Formation	Light grey to white sandstones, shales and coal seams
Early Permian	Talchir Formation	Tillites, turbidites, varves, needle shales and sandstones
		——Unconformity——
Precambrian	Sullavai Group	White to brown quartzitic sandstones, conglomerates, blue pink limestones and cherts
Archaean	Pakhal Group	Quartzites, granite, gneisses, etc.

Fig. 2—Generalized stratigraphic sequence at Wardha Valley Coalfield (after Raja Rao, 1982).

PALYNOLOGY

Approximately, 10 samples were macerated of which five samples yielded spores and pollen but quantitative analysis could be done only for two samples as they were productive. The other samples were very poor in their yield; however, they were also examined in order to assess the presence of various taxa. Fig. 3 depicts the litholog along with the quantitative representation of various palynomorphs in the sequence studied here and stratigraphically significant taxa are illustrated in Pl. 1. A detailed analysis of relative frequencies of palynotaxa reveals the presence of two palynoassemblages. The quantitative categories defined here are: abundant->10%, common-5-10%, rare-1-4% and sporadic-<1%.

Assemblage I: This assemblage is recorded at a depth of 149.00 m and is lithologically constituted of green shale. The assemblage shows dominance of the monosaccate genus *Parasaccites* (29%) and subdominance of the genus *Plicatipollenites* (20%); *Virkkipollenites* (13%) is also abundant. The taxa in common occurrence are *Potonieisporites* (9%), *Callumispora* (9%) and *Jayantisporites* (5%). The taxa of rare occurrence are *Vesicaspora* (3%), *Crescentipollenites* (2%) and *Sahnites* (2%).

Assembalge II: This assemblage is recognised at a depth of 147.00 -133.00 m, represented lithologically by coarse grained sandstone and shale with coal bands. The assemblage is characterised by the dominance of monosaccate genus *Parasaccites* (19%) and subdominance of *Callumispora* (15%) along with *Plicatipollenites* (13%). The taxa in common occurrence are *Jayantisporites* (10%), *Sahnites* (9%), *Scheuringipollenites* (9%), *Vesicaspora* (5%), *Horriditriletes* (5%) and *Virkkipollenites* (5%); while *Crescentipollenites* (1%), *Dentatispora* (1%), *Divarisaccus* (2%), *Caheniasaccites* (2.5%), *Lophotriletes* (1%) and *Microbaculispora* (1%) are of rare occurrence.

ASSESSMENT OF AGE

In the Indian Gondwana sequence, the Talchir palynoflora is defined by the prominence of radial monosaccate pollen. It is a sequence of three zones (Tiwari & Tripathi, 1992). Assemblage Zone I, is highly impoverished due to the impact of the glacial environment which hampered the growth of vegetation and also due the fact that the Early Permian flora was at the early stage of evolution. Therefore, this zone is characterised by least diversified flora represented by mainly girdling and radial monosaccate pollen, viz. *Parasaccites*, *Plicatipollenites* and *Potonieisporites*. Later progressive evolutionary diversification and a gradual withdrawal of glaciers led to the amelioration of climate which caused the proliferation of vegetation and thus diversification of palynotaxa in the successive Zones II and III. The palynoflora is represented by a variety of monosaccates and striate disaccates *Crescentipollenites fuscus*, appearance of laevigate triletes- *Callumispora gretensis* and pteridophytic apiculate spores, viz. *Jayantisporites* and lycopsid spores, viz. *Microbaculispora* and *Microfoveolatispora* in Zone II and III.

The Karharbari palynoflora is closely related to the underlying Talchir palynoflora by virtue of the continuing dominance of monosaccate pollen, *Parasaccites* and trilete genus *Callumispora*. But the appearance and proliferation of some disaccate pollen and apiculate trilete species suggest amelioration in climate from an adverse to moderate, comparatively less harsher climate than during the Talchir, which favoured the formation of coal deposits. The Karharbari palynoflora is characterised by the dominance of *Parasaccites* and *Callumispora* (Zone IV of Tiwari & Tripathi, 1992).

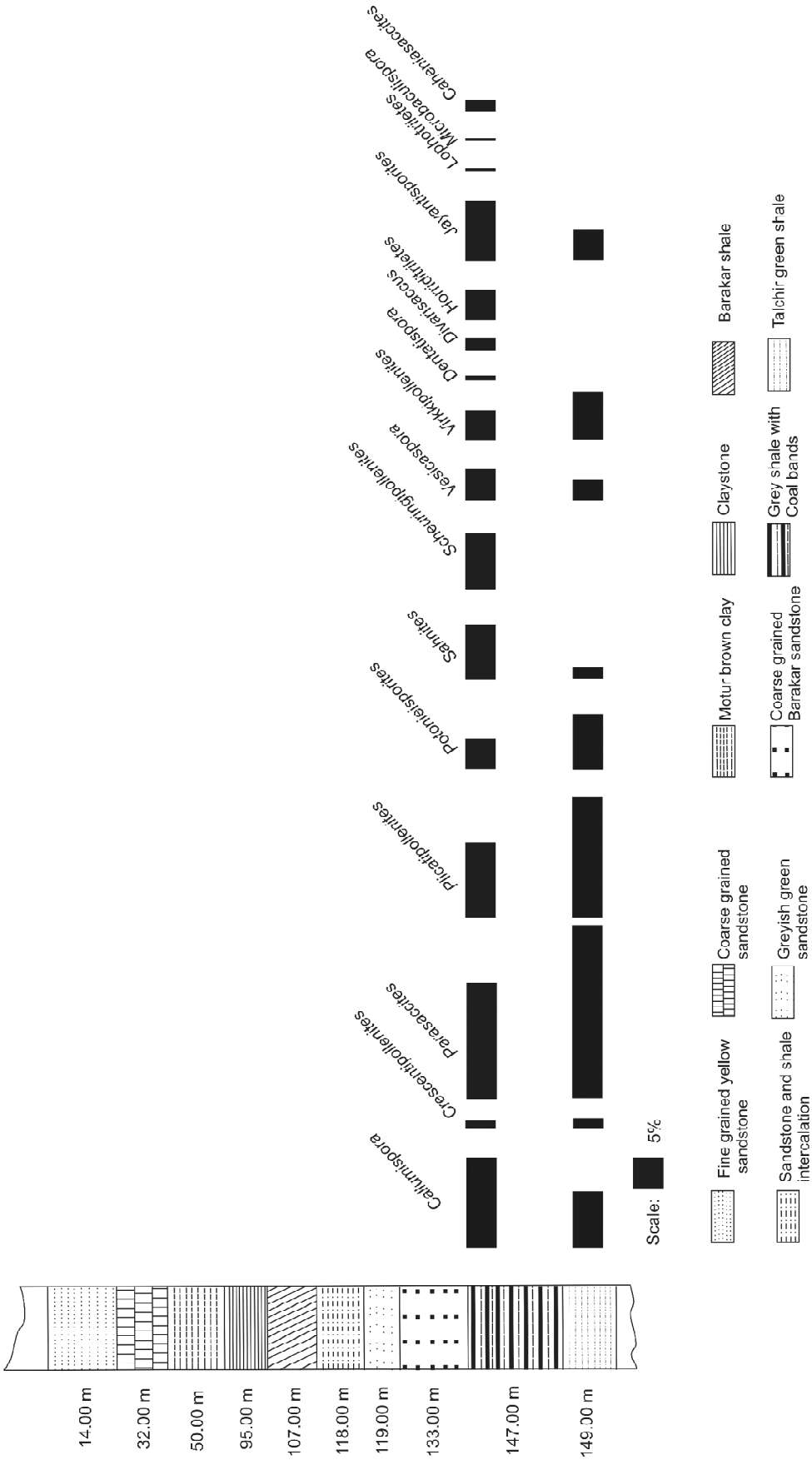

Fig. 3—Histogram showing the percentage frequency of spores and pollen.

The Assemblage I of the present study is characterised by the dominance of *Parasaccites* and subdominance of *Plicatipollenites* and corresponds to the *Parasaccites korbaensis* zone (Zone III) of Tiwari and Tripathi (1992) which is equivalent to the palynoflora of the Upper Talchir Formation. Therefore, on the basis of the characteristics of Assemblage I the sediments at 149.00 m in the bore hole CMWY-95 are palynologically dated to belong to the Upper Talchir Formation of Early Permian age. It is indeed younger than the older Talchir Formation due to the diversification of palynomorphs indicated by the presence of striate disaccates-*Crescentipollenites fuscus* and appearance of laevigate triletes-*Callumispora gretensis* and pteridophytic apiculate spores, viz. *Jayantisporites* and lycopsid spores, viz. *Microbaculispora* and *Microfoveolatispora* which are absent in the Zone I of Tiwari and Tripathi (1992).

The Assemblage II is characterised by the dominance of *Parasaccites* and subdominance of *Callumispora* and corresponds to the lower part of Zone IV of Tiwari and Tripathi (1992) which is equivalent to the palynoflora of the Lower Karharbari Formation. Therefore, the sediments from 147.00 m to 133.00 m are palynologically dated to belong to the Lower Karharbari Formation of Early Permian age.

The sediments at the depth of 119.00 m to 118.00 m were very poor in their yield and quantitatively significant palynomorphs could, therefore, not be retrieved but qualitative analysis of these sediments revealed the appearance or presence of non-striate disaccates like *Scheuringipollenites* in association with striate disaccates like *Faunipollenites*, which is typical of Lower Barakar palynofloral composition (*Scheuringipollenites barakarensis* Zone of Tiwari & Tripathi, 1992). Thus, these sediments may probably be of Barakar affinity of Early Permian age but due to paucity of yield it cannot be ascertained.

CORRELATION AND DISCUSSION

In India, the *Parasaccites+Plicatipollenites* palynoassemblage from the present study is correlatable with the *Parasaccites+Plicatipollenites* palynoassemblages from Godavari Basin (Srivastava & Jha, 1989), South Rewa Gondwana Basin (Potonie & Lele, 1961), Jayanti Coalfield (Lele & Makada, 1972), Korba Coalfield (Bharadwaj & Srivastava, 1973), West Bokaro Coalfield (Lele, 1975), Giridih Coalfield (Srivastava, 1973) and Manendragarh Coalfield (Bharadwaj & Srivastava, 1979), which are characteristic of Upper Talchir palynoflora. While the *Parasaccites+Callumispora* palynoassemblage from the present study is correlatable with the palynoassemblages SC-I and SC-II of the lower most workable Saharjuri coal horizon (Hait & Banerjee, 1994); the palynoassemblage from North Karanpura Coalfield of Damodar Basin (Mukherjee & Ghosh, 1972); Zone -2 of Pusai Shampur area, of Raniganj Coalfield of Damodar Basin (Tiwari, 1973); palynoassemblage from the Jharia Coalfield of Damodar Basin (Tiwari *et al.*, 1981); the microfloral Zone-2 of Umaria Coalfield of South Rewa Basin (Srivastava & Anand Prakash, 1984) and Zone-1 of Tatapani-Ramkola Coalfield of Koel-Damodar Basin (Kar & Srivastava, 2003) in having dominance of *Parasaccites* and subdominance of *Callumispora*, typical of the Lower Karharbari palynoflora.

In the global context, although, there is a high degree of similarity amongst various palynofloras through the Gondwana sequences of the continents of the Gondwanaland, dominance datum of a particular genus or taxon are not very useful in close correlation because of their ecological bias. Besides, first appearance datum cannot be taken into consideration as they may not be synchronous in an area as vast as the Gondwanaland. Therefore, correlation has been attempted in a rather broader pattern of group occurrences.

In Africa, the Assemblages I and II of the present study are correlatable with the *Cordaitina* Zone from Ketewaka Coalfield, Tanzania (Manum & Tien, 1973); the Assemblage II of Witbank Coalfield of South Africa (Tiwari, 1974); the Assemblage Zone from Luwumbu Coal Formation, North Luangwa Valley of Zambia (Utting, 1976); the palynozone from Siankondoba Sandstone Formation (Utting, 1978) from Mid Zambesi Basin and with the Karroo Zone 3 of Middle Ecca Series (Anderson, 1977) of South Africa, all of which are characterised by the dominance of monosaccate pollen and common occurrence of *Callumispora* and some apiculate trilete groups.

In Australia, the Early Permian palynoflora of the Talchir and Karharbari formations of India are similar to the Stage 2 and Stage 3 of Eastern Australia (Evans, 1969) and *Pseudoreticulatispora confluence* palynozone of Western Australia (Backhouse, 1991). However, the Australian palynofloras are more diversified and therefore, the Assemblages I and II of the present study can be qualitatively correlatable with the Australian Early Permian palynoflora. It has also been observed that several diagnostic species, typically apiculate trilete spores, *Microbaculispora tentula*, appeared at the base of the Stage 2 while they started appearing at younger levels of the Talchir Formation suggesting that the Gondwana floral succession is older in Australia (Pennsylvanian) with migration to India during the Asselian-Sakmarian.

Within Antarctica, the Early Permian palynoflora, especially the palynoflora of the Talchir Formation and Karharbari Formation in India, is closely correlatable with the *Parasaccites*-zone of the Victoria Group of Trans-Antarctic mountains (Kyle, 1977) and with the Early Permian palynoflora from Milorgfjella, Droning Maud Land (Larson *et al.*, 1990), which is characterised by the dominance of monosaccate pollen, predominantly *Parasaccites* in association with *Plicatipollenites* and trilete genera, viz. *Callumispora* and *Microbaculispora*. Therefore, the Assemblages I and II from

bore hole CMWY-95 which are also characterised by similar palynoflora can be correlated with the *Parasaccites*-zone of Kyle (1977) and with that of Larson *et al.* (1990).

Qualitatively, the Assemblages I and II can also be correlated with the assemblages from Locality A in Milorgfjella and Lidkvarvet in Sivorgfjella, Droning Maud Land (Lindstrom, 1995), Antarctica in having many typical Early Permian Gondwana taxa such as gymnospermous grains *Parasaccites* sp., *Plicatipollenites*, *Scheuringipollenites* sp., *Faunipollenites* sp. and *Sahnites* and Lycopod spores *Jayantisporites pseudozonatus*, Pteridophyte spores *Leiotriletes* sp., *Horriditriletes* sp. and *Callumispora gretensis*.

In South America, Marques Toigo (1991) described palynomorph assemblages from the Permian sediments of the Parana Basin in Southern Brazil. He proposed the *Cannanoropollis korbaensis* zone defined by the stratigraphical range of *Cannanoropollis korbaensis* (Bharadwaj & Tiwari) Foster 1975. This zone is characterized by the dominance of monosaccate pollen over non-striate bisaccate pollen in its lower most part and by an increase in trilete spores in the middle part and is therefore broadly correlatable with the Assemblages I and II of borehole CMWY-95 of Wardha Valley Coalfield.

CONCLUSION

In the Wardha Valley Coalfield the Lower Gondwana sediments are mostly confined to the Chandrapur District of Maharashtra, represented by three main formations. The Talchir Formation is the oldest formation represented by boulder beds, green needle shales and sandstones. This is overlain by the Barakar Formation comprising of a thick series of fluviatile or lacustrine deposits of sandstones, shales and coalseams and it is the main Coal bearing group. This is overlain by the Kamthi Formation which comprises of sandstones, shales and clays.

The present study deals with the palynological analysis of the samples from borehole CMWY-95 which was drilled near Pisagaon on the northern bank of the Wardha River. The borehole was drilled to a depth of approximately 150.00 m and is lithologically constituted of green shales, sandstones, coal and claystones. Statistical analysis of the productive samples enabled the recognition of two palynoassemblages. Assemblage I (Depth: 149.00 m) is characterised by the dominance of the monosaccate genus *Parasaccites* and subdominance of *Plicatipollenites* which is typical of the Early Permian Upper Talchir palynoflora. It is further lithologically substantiated by the presence of green shales which is characteristic of the Talchir Formation. Assemblage II (Depth: 147.00-133.00 m) is characterised by the dominance of *Parasaccites* and subdominance of *Callumispora* which corresponds to the Early Permian Lower Karharbari Formation. Further, an intra and interbasinal correlation of these assemblages have been done with the known Early Permian palynoassemblages of India. With other Gondwana continents, viz. Africa, Australia, Antarctica and South America, correlation has been attempted in a rather broader pattern of group occurrences without taking into consideration the first appearance datums as they may not be synchronous in an area as vast as the Gondwanaland. This has shown that the correlation with Antarctica is closest, when compared to other continents, suggesting a closer genetic relationship with Antarctica (Mitra *et al.*, 1979). A close similarity with the Early Permian palynosequences of Africa (Jha, 2006) than that of Australia has also been noticed due to regional differences (Truswell, 1980) amongst eastern and western Australia. In South America, correlation was feasible only in broader pattern of group occurrences as the differences were pronounced at finer levels.

It is inferred that the climate played a decisive role in controlling the evolution of the morphographic characters of the pollen and spores (Tiwari & Tripathi, 1988; Venkatachala *et al.*, 1995). As glaciers prevailed at the advent of the Permian, as is evidenced by the lithological features such as boulder beds, varves and diamictites, it hampered the growth of vegetation resulting in impoverished and less diversified flora during the Lower Talchir Formation, represented mainly by girdling and radial monosaccate pollen with huge massive leathery saccus as an adaptation to withstand the frigid climate that prevailed during that time. But the progressive diversification in the Upper Talchir palynotaxa (Assemblage I

PLATE 1 →

1. *Callumispora barakarensis*
2. *Callumispora gretensis*
3. *Jayantisporites conatus*
4. *Horriditriletes bulbosus*
5. *Horriditriletes curvibaculosus*
6. *Lophotriletes rectus*
7. *Microbaculispora barakarensis*
8. *Parasaccites korbaensis*
9. *Parasaccites korbaensis*
10. *Plicatipollenites gondwanensis*
11. *Plicatipollenites densus*
12. *Jayantisporites pseudozonatus*
13. *Parasaccites bilateralis*
14. *Potoneiesporites neglectus*
15. *Faunipollenites varius*
16. *Crescentipollenites talchirensis*
17. *Crescentipollenites fuscus*
18. *Divarisaccus lelei*
19. *Caheniasaccites indicus*
20. *Sahnites thomasii*
21. *Sahnites barrelis*

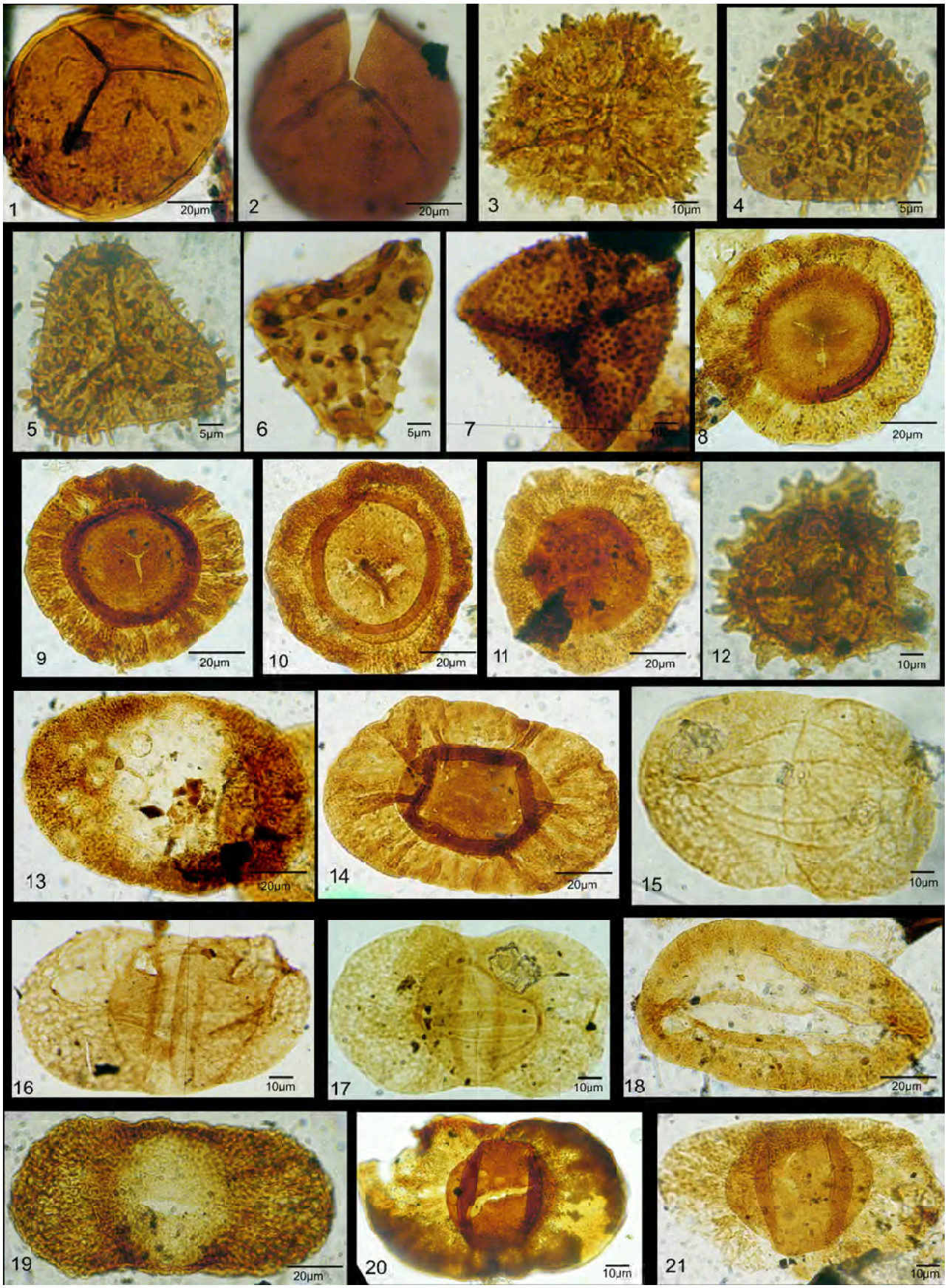
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PLATE 1

of the present study), Karharbari palynoflora (Assemblage II) and onwards, reveal that there was an amelioration in climate from the frigid to comparatively favourable one due to the retreat of glaciers resulting in the proliferation of vegetation which favoured the formation of coal during the Karharbari and Barakar formations of Early Permian Period.

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