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Plant diversity in the Kamthi Formation of India: A Review

ARUN JOSHI*, RAJNI TEWARI AND DEEPA AGNIHOTRI

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.
**Corresponding author: arunjoshi119@gmail.com*

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ABSTRACT

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Plant megafossils recorded from the Kamthi Formation of India have been assessed in the present communication. The formation is mainly exposed in the Mahanadi, Godavari and Wardha basins and has been critically analysed on the basis of its megafloral and palynological contents, and the lithological aspects by earlier workers who variously assigned its age as late Permian, early and late Triassic. An endeavour has been made here to compile all the known plant fossil records from the Kamthi Formation for better understanding of its floral and biostratigraphical significance. Known records of the plant megafossils from the Kamthi Formation reveal dominance of the *Glossopteris* flora and paucity of the *Dicroidium* floral elements suggesting a transition between late Permian and early Triassic.

Key–words— Megafossils, Kamthi Formation, Permian, Triassic, Mahanadi Basin, Wardha Basin, Godavari Graben, India.

भारत के कामथी शैलसमूह में पादप विविधता पर एक समीक्षा

अरुण जोशी, रजनी तिवारी एवं दीपा अग्निहोत्री

सारांश

भारत के कामथी शैलसमूह से अभिलिखित पादप गुरुजीवाश्मों का वर्तमान संप्रेषण में मूल्यांकन किया गया है। यह शैलसमूह मुख्यतः महानदी, गोदावरी व वर्धा द्रोणियों में अनावरित है तथा इनके गुरूवनस्पति, परागाणविक पदार्थों एवं अश्मविज्ञान संबंधी पहलुओं के आधार पर आलोचनात्मक विश्लेषण पूर्व कार्मिकों द्वारा किए गए हैं जिन्होंने इसकी आयु अंतिम पर्मियन, प्रारंभिक व अंतिम ट्रायसिक निर्धारित की है। इसकी वनस्पति तथा जैवस्तरिकी महत्व को बेहतर समझने के लिए कामथी शैलसमूह से प्राप्त सभी ज्ञात पादप जीवाश्म अभिलेखों को यहां पर संकलित करने का प्रयास किया गया है। कामथी शैलसमूह से प्राप्त पादप गुरूजीवाश्मों के ज्ञात अभिलेखों से *ग्लॉसॉप्टेरिस* वनस्पति की प्रमुखता एवं *डाइक्रोइडियम* वनस्पति तत्वों का अभाव व्यक्त होता है जो कि अंतिम पर्मियन एवं प्रारंभिक ट्रायसिक के मध्य पारगमन प्रस्तावित करता है।

सूचक शब्द—गुरूजीवाश्म, कामथी शैलसमूह, पर्मियन, ट्रायसिक, महानदी द्रोणी, वर्धा द्रोणी, गोदावरी द्रोणिका, भारत।।

INTRODUCTION

THE name "Kamthi" was coined by Blanford in 1868 after the former military station 'Kamptee' near Nagpur city. The type area of the Kamthi Formation is the Kamptee Coalfield, Wardha Basin, Nagpur District, Maharashtra State. Other than the Wardha Basin, this formation is exposed in the Godavari and Mahanadi basins (Fig. 1). In the southeastern part of the Godavari Graben, the formation was previously recognised as the Chintalpudi sandstone, whereas, in the Mahanadi Basin, it was known as the Hingir Formation (Sastry *et al.*, 1979). The Kamthi Formation is non coaliferous and is represented by brown coloured, ferruginous fine- to coarse–grained, gritty sandstone and yellow clay sequences (Srivastava & Jha, 1997). On the basis of lithology, the Kamthi Formation is generally considered equivalent to the Bijori Formation of Satpura Basin, the Pali Formation of South–Rewa Basin and the Pachhwara Formation of Rajmahal Basin (Srivastava & Agnihotri, 2010).

Floristically, the Kamthi Formation was considered equivalent to the Raniganj Formation of Damodar Basin and was assigned a late Permian age on account of the presence of a rich *Glossopteris* floral assemblage by Chandra (1992), Singh and Chandra (1996), Singh *et al.* (2006), Tewari (2007, 2008) and Tiwari *et al*. (2009). On the basis of the occurrence of the genera *Dicroidium*, *Lepidopteris*, *Yabiella* and *Desmiophyllum* in the Talcher Coalfield, Mahanadi Basin, Pal *et al.* (1991) and Pal and Ghosh (1997) assigned a late Triassic age to the Kamthi Formation. Srivastava and Jha (1997) discussed the status of this formation in detail and classified the Kamthi sediments of Godavari Graben into Barren Measures, Raniganj and Kamthi formations on the basis of lithology, mineralogy and palynology. They further divided the Kamthi Formation into Lower and Upper members considering them equivalent to the Panchet and Supra–Panchet Mahadeva formations, respectively. To address the problem of Gondwana stratigraphy, Mukhopadhyay *et al*. (2010) formulated a scheme for correlation of Indian Gondwana formations on the basis of geological events like marine flooding surfaces, large scale tectonism and changes in depositional environment (Fig. 2). On account of these geological events, the total time span of deposition of Gondwana basins has been divided into seven time slots. As a consequence, the Kamthi Formation in Godavari Graben is divided into Lower Kamthi equivalent to the Raniganj and Bijori (Bijuri in Mukhopadhyay *et al.,* 2010) formations of Damodar and Satpura basins, respectively; Middle Kamthi is equivalent to Panchet, Lower Kamthi, Pali and Lower Panchmarhi of Damodar, southern Mahanadi, Son and Satpura basins, respectively, and the Upper Kamthi is considered equivalent to Supra Panchet, Dubrajpur, Upper Kamthi, Bandhavgarh/ Parsora and Upper Panchmarhi/ Upper Bagra of Damodar, Rajmahal, southern Mahanadi, Son and Satpura basins, respectively. Accordingly, Lower Kamthi is late Permian (Lopingian), Middle Kamthi is early Triassic and Upper Kamthi is early Jurassic in age and are allotted the time slots III, IV and VI, respectively. Mukherjee *et al*. (2012), on the basis of lithological attributes have considered Kamthi Formation as early Triassic in age and correlated it with Panchet, Pali and Panchmarhi formations of Damodar, South Rewa and Satpura basins, respectively. Goswami and Singh (2013) divided the Formation into Lower and Upper Kamthi formations on the basis of megafloral records from the Mahanadi Basin. However, since a formation is a lithological unit we refrain to use the term formation for Lower and Upper Kamthi divisions based on flora as suggested by Goswami and Singh (2013). Accordingly, the Lower Kamthi has been assigned a late Permian age on the basis of presence of a rich *Glossopteris* flora recorded by Goswami *et al.* (2006a, b) and the Upper Kamthi is considered Triassic in age on account of presence of *Dicroidium* floral elements reported by Pal and Ghosh (1997). The Upper Kamthi is again divided into lower and upper beds which were assigned early and late Triassic ages, respectively. The criteria for this division of the Kamthi Formation was completely based on the presence of different kinds of plant fossils like *Dicroidium* sp. and *Lepidopteris* sp. (early Triassic), and *Dicroidium zuberi*, *D. superbum*, *D. giarensis*, *Lepidopteris* sp. cf. *L. stormbergensis*, *Elatocladus* sp., *Yabiella* sp. and *Desmiophyllum* sp. (late Triassic).

Fig. 1—Map of India showing occurrence of plant fossils in the Kamthi Formation of Mahanadi, Godavari and Wardha basins.

Srivastava and Agnihotri (2010) compared the assemblage of the Bijori Formation with the plant fossil assemblages of the non–coaliferous Kamthi Formation of Mahanadi and Wardha basins and Pachhwara Formation of the Rajmahal Basin. They have considered the Bijori, Kamthi and Pachhwara formations younger than the Raniganj Formation on the basis of flora. According to these authors the plant fossils of the Raniganj Formation are represented by large sized species of *Glossopteris* with fair representation of arthophytes and ferns whereas, Bijori Formation contains narrow and small sized *Glossopteris* species and shows impoverished occurrence of pteridophytes. However, the *Glossopteris* leaves recorded from Handapa (Chandra & Singh, 1992; Singh & Chandra, 1987), and Madhupur (Singh & Chandra, 2000) beds, Mahanadi Basin, Odisha and from Kamptee Coalfield, Wardha Basin, Maharashtra (Tewari, 2007) are considerably large in size.

PALAEOFLORISTICS OF KAMTHI FORMATION

The fossil flora of the Kamthi Formation is heterogeneous and abundant. Well preserved plant fossils are recorded from

the Kamthi Formation of Wardha, Godavari and Mahanadi basins by several workers.

Plant fossils from Wardha Basin

The plant megafossils belonging to the orders Equisetales, Filicales, Glossopteridales, Cordaitales, Ginkgoales besides gymnospermous woods are reported from the Kamthi Formation of Kamptee Coalfield, Nagpur District and Wardha Valley Coalfield, Chandrapur District, Wardha Basin, Maharashtra by Bunbury (1861), Blanford (1872), Hughes (1877), Oldham (1880), Feistmantel (1880, 1881), Agashe *et al.* (1971), Vagyani and Mahabale (1974), Varadpande (1977), Agashe and Gowda (1978), Prasad and Chandra (1978, 1981), Biradar and Bonde (1981), Chitnis and Vagyani (1979), Vagyani and Raju (1981), Chandra and Prasad (1980, 1981), Prasad (1982, 1986), Agashe and Prasad (1989), Agashe and Shashi Kumar (1996, 2001), Tewari and Rajnikanth (2001), Agarwal *et al.* (2007) and Tewari (2007, 2008).

Plant fossils from Mahanadi Basin

Diversified and well preserved plant fossils from the Kamthi Formation of Talcher Coalfield, Anugul and Sambalpur districts and Ib–River Coalfield, Jharsuguda, Sundergarh and Sambalpur districts, Odisha are recorded by Ball (1877), Feistmantel (1880, 1881), Subramanian and Rao (1960), Khan (1969), Surange and Maheshwari (1970), Surange and Chandra (1973a, b, c, 1974), Chandra and Rigby (1981, 1983), Chandra (1984), Singh and Chandra (1987, 1996, 2000), Chandra and Singh (1986, 1988, 1989, 1992), Pal *et al.* (1991), Pal and Ghosh (1997), Singh (2000), Bhattacharya *et al.* (2001), Goswami (2006), Goswami *et al.* (2006a, b), Singh *et al.* (2006), Tiwari *et al.* (2009),

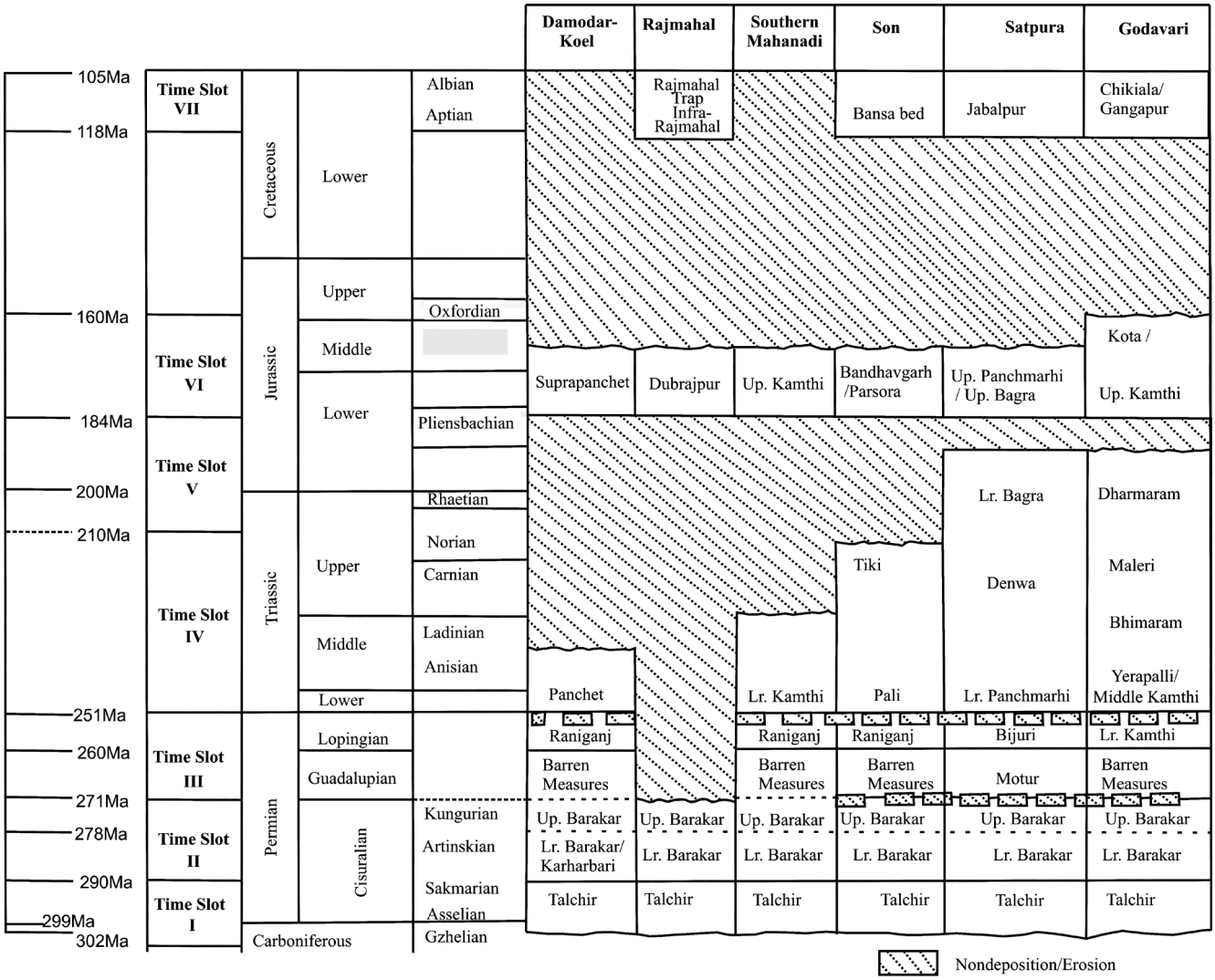

Fig. 2— Stratigraphic correlation of different Gondwana formations (after Mukhopadhyay *et al.*, 2010).

Goswami and Singh (2010, 2013), Tiwari and Chauhan (2013). The flora is represented by plant groups Lycopodiales, Equisetales, Sphenophyllales, Filicales, Glossopteridales, Corystospermales, Peltaspermales, Pinales, dispersed seeds and plant fossil of uncertain affinity.

Plant fossils from Godavari Graben

The records of plant megafossils from Godavari Graben are scarce in comparison to the Wardha and Mahanadi basins. The palaeobotanical studies from the Kamthi Formation of this graben have been carried out by King (1881) from Kunlacheru locality and by Lakshminarayana and Murty (1990) from Sattupalli area, Chintalpudi sub–basin, Khammam District, and by Varma (1963) from the Chintalpudi Sandstone, West Godavari District, Andhra Pradesh State. The assemblage includes the plants belonging to the orders Equisetales, Filicales, Glossopteridales and Cycadales.

DISCUSSION

An analysis of plant taxa in the Kamthi Formation of Mahanadi, Godavari and Wardha basins (Table 1) reveals the presence of a rich and heterogeneous megafloral assemblage in this Formation comprising both pteridophytes and gymnosperms. The pteridophytes include the plants belonging to the orders Lycopodiales, Equisetales, Sphenophyllales and Filicales, whereas, the gymnosperms comprise the orders Glossopteridales, Cordaitales, Cycadales, Corystospermales, Ginkgoales and Pinales (Fig. 3). Besides, dispersed seeds, gymnospermous woods and a taxon of uncertain affinity are also recorded. The Glossopteridales dominate the assemblage followed by gymnospermous woods, Filicales and Equisetales; Cycadales, Corystospermales and dispersed seeds in equal numbers; Sphenophyllales; Ginkgoales; Cordaitales, Pinales and Peltaspermales with two taxa each, and Lycopodiales. The Glossopteridales are reported from all the three basins, namely, Mahanadi, Wardha and Godavari. Lycopodiales, Sphenophyllales, Cycadales, Corystospermales and Ginkgoales are recorded from the Mahanadi Basin. The sole record of Cordaitales is from the Wardha Basin. Equisetales and Filicales are reported from the Mahanadi, Godavari and Wardha basins and the order Pinales is known from Mahanadi and Wardha basins. Till date, gymnospermous woods are reported only from the Wardha Basin. One genus of uncertain affinity namely, *Yabiella* sp. is reported from the Mahanadi Basin.

A review of the investigations carried out by earlier workers indicates that the Lower Kamthi of Goswami and Singh (2013) is qualitatively and quantitatively rich in glossopterid megafossils and equivalent to late Permian in age, and hence can be correlated with the lower part of the Kamthi Formation (sensu stricto Mukhopadhyay *et al.*, 2010). Similarly, the Middle Kamthi of Mukhopadhyay *et al.* (2010) which has been assigned an early Triassic age is comparable with the lower part of the Upper Kamthi division of Goswami and Singh (2013) with typical *Dicroidium* floral assemblage. The rich *Glossopteris* flora points towards extremely conducive climatic conditions, i.e. warm and humid with enough precipitation during the late Permian. The beginning of Triassic is marked by an arid climate in most of the basins as is evinced by the presence of thick cuticles on

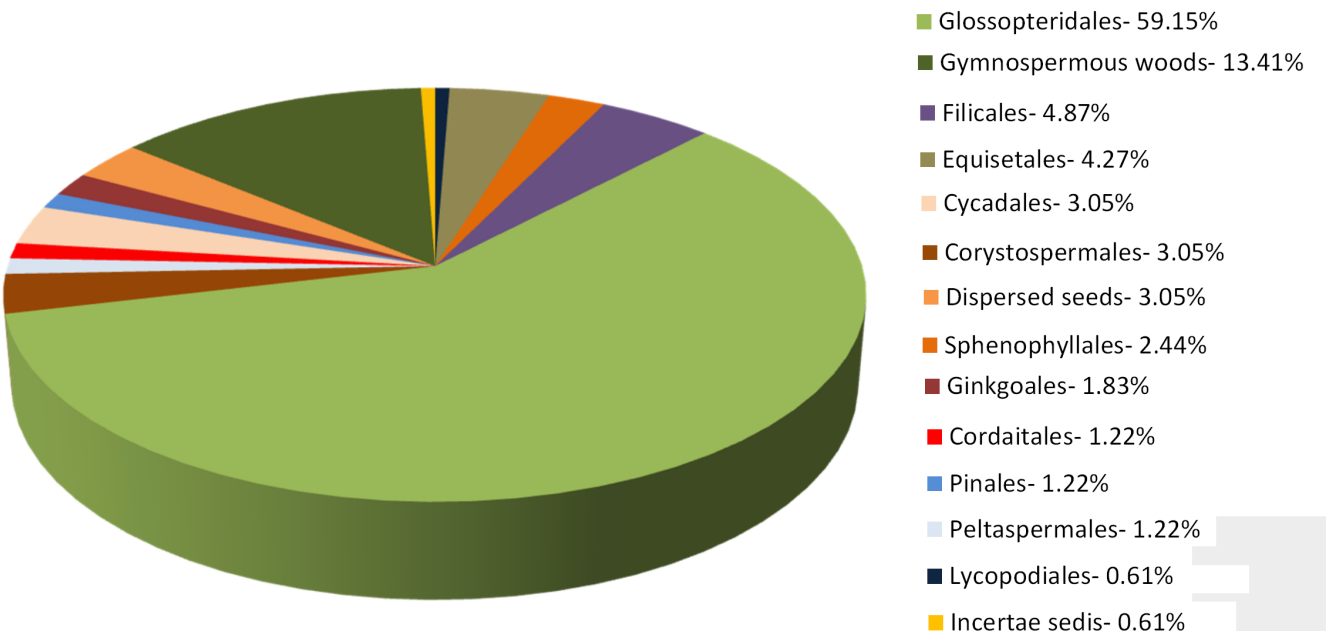

Fig. 3—Pie diagram showing the distribution of different plant groups in Kamthi Formation, India.

Plant taxa	Mahanadi Basin		Wardha Basin		Godavari Graben
	Ib–River Coalfield	Talcher Coalfield	Kamptee Coalfield	Wardha Valley Coalfield	
Lycopodiales					
Cyclodendron leslii		+			
Equisetales					
Equisetalean axes	+		+	+	
Lelstotheca robusta		+			
Phyllotheca indica		+	+		
Phyllotheca sp.					+
Raniganjia bengalensis		+			
R. etheridgei		+			
Schizoneura gondwanensis	+	+	+	+	
Sphenophyllales					
Sphenophyllum churulianum		+			
S. crenulatum		+			
S. utkalensis		+			
Trizygia speciosa		+	+	+	
Filicales					
Alethopteris sp.					+
Damudopteris bengalensis		+			
Dizeugotheca phegopteroides (Asansolia cf. *phegopteroides)*		+	+		
Neomariopteris hughesii	+	+	+	+	
N. khanii		+		+	
N. lobifolia		+			
N. polymorpha		+	+		
Pantopteris gracilis		+			
Glossopteridales					
Glossopteris acuminata		+			
G. angusta		+			
G. angustifolia	+	+	+	+	
G. arberi		+	+	+	
G. barakarensis		+			
G. bosei		+		+	
G. browniana	+	+	+	+	+
G. churiensis	+				
G. communis	+	+	+	+	+
G. conspicua	+	+	+	+	
G. cordatifolia (=*G. feistmantelii*)		+	+		
G. damudica	+	+			
G. danae			+		
G. decipiens	+		+		+
G. dhenkanalensis		+			
G. divergens		+			
G. emarginata			+		
G. fluctuosa		+			
G. gigas	+	+	+		
G. gondwanensis		+			

G. gopadensis		+			
G. hinjridaensis		+			
G. indica	+	+	+	+	+
G. inaequalis		+			
G. intermedia	+	+			
G. intermittens	+		+		
G. Kamthiensis		+			
G. lanceolatus		+		+	
G. leptoneura		+	+	+	
G. longicaulis				+	
G. major	+				
G. maheshwarii		+		+	
G. mohudaensis		+	+	+	
G. musaefolia			+	+	
G. nautiyalii		+			
G. nimishea		+			
G. obscura		+			
G. oldhamii		+			
G. pandurata		+			
G. rhabdotaenioides				+	
G. radiata		+			
G. raniganjensis	+			+	
G. retifera	+	+	+	+	+
G. rewaensis	+				
G. sastrii		+			
G. spathulata	+	+	+		
G. stenoneura	+	+	+	+	
G. stricta		+	+	+	
G. subtilis	+	+	+	+	
G. syaldiensis		+	+		
G. taeniensis		+	+		
G. tenuifolia	+	+	+	+	
G. tenuinervis	+	+			
G. tortuosa		+			
G. utkalensis		+			
G. varia		+			
G. vulgaris		+			
G. zeilleri	+	+			
Glossopteris sp.			+		
Palaeovittaria kurzii		+			
Rhabdotaenia danaeoides			+		
Senia reticulata		+			
Surangephyllum elongatum		+			
Vertebraria indica	+	+			
Vertebraria sp.					+
Fructifications					
Plumsteadia ovata (*Cistella ovata)*		+			
Plumsteadia sp. (=*Cistella*) sp.		+			
Denkania indica		+			
Dictyopteridium sporiferum		+	+		
Eretmonia hinjridaensis		+			

E. karanpuraensis		+				
E. ovata		+				
E. utkalensis		+				
Glossotheca immanis		+				
G. orissiana		+				
G. utkalensis		+				
Hirsutum dutoilides						+
Indocarpus elongatus		+				
Khania dhenkanalensis		+				
Lidgettonia indica		+				
L. mucronata		+				
Lidgettonia sp.		+				
Nesowalesia pantii		+				
Nupuria indica		+				
Partha indica		+				
P. spathulata		+				
Scutum elongatum		+				
S. indicum		+				
S. leslium						+
S. sahnii		+				
Scutum sp.		+				
Utkalia dichotoma		+				
Scale leaves						
Handapiolepis parijaii		+				
Nautiyalolepis lanceolata		+				
Utkaliolepis indica		+				
Scale leaf a (Tewari 2007)			+			
Scale leaf b (Tewari 2007)			+			
Corystospermales						
Dicroidium giarensis		+				
D. hughesii		+				
D. superbum		+				
D. zuberi		+				
Dicroidium sp.		+				
Peltaspermales						
Lepidopteris sp. cf. *L. stormbergensis*		+				
Lepidopteris sp.		+				
Cordaitales						
Noeggerathiopsis hislopii			+	+		
Noeggerathiopsis sp.				+		
Cycadales						
Macrotaeniopteris wianamattae	+					
M. feddeni	+	+				
Pseudoctenis balli		+				
Pterophyllum sp.						+
Fragmentary fossils resembling *Ptilophyllum*						+
Pinales						
Desmiophyllum sp.		+				
Elatocladus sp.		+				
Ginkgoales						
Handapaphyllum indicum		+				

Rhipidopsis densinervis				+	
R. gondwanensis				+	
Dispersed seeds					
Cordaicarpus utkalensis			+		
Samaropsis ganjrensis				+	
S. handapaensis			+		
S. raniganjensis			+		
Samaropsis sp.		+	+		
Gymnospermous woods					
Araucarioxylon loharense					+
Australoxylon kanhargaoense					+
A. longicellularis					+
Baieroxylon multiseriata					+
Dadoxylon adhaeriense					+
D. maharashtraensis					+
D. chandrapuraensis					+
Kamthioxylon adhariense					+
Kaokoxylon pseudotrimedullaris					+
Nandorioxylon saksenae					+
Planoxylon indicum					+
Prototaxoxylon mahabalei					+
P. maithyi					+
P. multiseriate					+
P. uniseriate					+
Polysolenoxylon sitholeyii					
Sclerospiroxylon marguerierae					+
Taxopitys indica					+
T. surangei					+
Trigonomyelon kamthiensis					+
Zalesskioxylon lepekhinae					+
Z. simplexum					+
Incertae sedis					
Yabiella sp.			+		

Table 1–Distribution of plant taxa in the Kamthi Formation of Mahanadi, Godavari and Wardha basins of India.

Dicroidium leaves. The absence of *Dicroidium* floral elements in Wardha and Godavari basins and their paucity in the Mahanadi Basin clearly indicates that the Kamthi Formation is a transition between late Permian and early Triassic and witnessed a change in climatic condition with a decrease in the precipitation .

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