

Occurrence of Australian element in the Deccan Intertrappean flora of India

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Three new fossil woods, viz., *Eucalyptus dbarmendrae* sp. nov., *Tristania confertoides* sp. nov. and *Callistemonoxylon deccanensis* gen. et sp. nov. resembling the modern Myrtaceous taxa *Eucalyptus*, *Tristania conferta* and *Callistemon-Melaleuca* respectively and an infructescence *Callistemonites indicus*, also resembling *Callistemon-Melaleuca*, have been described from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. As all these genera are Australian, their presence in the Deccan Intertrappean flora is phytogeographically important.

Key-words—Xylotomy, *Eucalyptus*, *Tristania*, *Callistemon*, *Melaleuca*, Myrtaceae, Infructescence, Deccan Intertrappean beds (India).

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सारांश

भारत के दक्खिन अन्तर्द्वीपी वनस्पतिजात में ऑस्ट्रेलिया के अवयवों की उपस्थिति

मोहन बलवंत बाँडे, राकेश चन्द्र मेहरोत्रा एवं उत्तम प्रकाश

मध्य प्रदेश में मंडला जनपद के दक्खिन अन्तर्द्वीपी संस्तरो से वर्तमान मिर्सेसी कुल के क्रमशः यूकेलिप्टस, त्रिस्तानिया कनफर्टा एवं केलिस्टीमोन-मिलाल्यूका नामक वर्गकों से मिलते-जुलते तीन काष्ठाश्रमों अर्थात् यूकेलिप्टस धरमेन्दी नव जाति, त्रिस्तानिया कनफर्टायडिस नव जाति एवं केलिस्टीमोनॉक्सीलॉन दक्खिनेन्सिस नव प्रजाति व जाति तथा केलिस्टीमोनॉयटिस इन्डिकस नामक फलीय अक्ष जो कि केलिस्टीमोन-मिलाल्यूका से मिलता-जुलता है, वर्णित किये गये हैं। चूँकि ये सभी प्रजातियाँ ऑस्ट्रेलिया की हैं अतएव दक्खिन अन्तर्द्वीपी वनस्पतिजात में इनकी उपस्थिति पादप-भौगोलिक दृष्टि से महत्वपूर्ण है।

INTRODUCTION

THE fossil plants described from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh have added considerably to our knowledge about the early Tertiary flora of India. Their study during the last nearly 15 years has developed a better understanding of the vegetation, climate and phytogeography of Central India during the early Tertiary.

The fossil taxa described from Mandla District were listed by Bande and Prakash (1983) and Mehrotra, Prakash and Bande (1984). Since then three more records have been added. These are: (i) a palm peduncle *Palmostroboxylon arengoidum* Ambwani (1984a), (ii) a palm wood *Palmoxyylon dilacunosum*

Ambwani (1984b), and (iii) a dicot wood *Canarioxylon shahpuraensis* Trivedi & Srivastava (1985).

Recent investigations on plant fossils on these beds have revealed the occurrence of four characteristic Myrtaceous taxa representing Australian element. As the Australian element has so far not been reported from the early Tertiary beds of India, the present discovery is significant and is reported here. Out of these four new taxa, three are based on silicified woods and one on a petrified infructescence. They represent the taxa *Eucalyptus*, *Tristania*, *Melaleuca* and *Callistemon*.

Regarding the nomenclature of fossil woods the recommendations given by Lakhnupal and Prakash (1980) and further enumerated by Bande (1986) have been followed. Accordingly, two of the fossil woods,

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because of their close anatomical similarities with the modern genera, have been assigned modern generic names. The third wood shows affinities with two genera which can not be distinguished anatomically and hence has been assigned to an organ genus with the suffix *oxylon* added to one of them. As regards the fruiting axis, it has also been placed under an organ genus because more precise identification is not possible on the basis of available data.

SYSTEMATIC DESCRIPTION

Family—Myrtaceae

Genus—*Eucalyptus* L'Hérit

Eucalyptus dbarmendrae sp. nov.

Pl. 1, figs 1, 3, 4, 6, 7

Material—A single piece of well-preserved secondary wood measuring about 7 cm in length and 5 cm in width.

Description—Wood diffuse-porous (Pl. 1, fig. 1). *Growth rings* distinct, demarcated by crowding of vessels and thick-walled fibres. *Vessels* usually small to medium-sized, rarely very small, t.d. 47-137 μm , r.d. 51-185 μm , usually in definite echelon arrangement of 2-10 vessels, sometimes solitary and in clusters, evenly distributed, 13-21 per sq mm, usually circular to oval (Pl. 1, figs 1,3); vessel members 450-690 μm long with oblique to horizontal ends; perforations simple; vessel-tracheid pits usually 1-2 seriate, bordered, in vertical rows, small, about 4-6 μm in diameter, oval to circular in shape (Pl. 1, fig. 7); tyloses present. *Tracheids* vasicentric, associated with parenchyma forming a sheath of 2-5 cells around most of the vessels or vessel groups and joining the vessels radially and tangentially (Pl. 1, fig. 3). *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma occurring as few cells around the vessels; apotracheal parenchyma diffuse and sparse (Pl. 1, figs 1,3); parenchyma cells thin-walled, 13-17 μm in diameter and 20-26 μm in length. *Xylem rays* almost exclusively uniseriate, rarely biseriate, usually made up of

procumbent cells only, 13-25 μm in width and 4-36 cells or 90-600 μm in height, 13-18 per mm (Pl. 1, fig. 4); ray tissue mostly homogeneous to rarely weakly heterogeneous due to occasional presence of upright cells (Pl. 1, fig. 6); ray cells thin-walled, usually filled with dark-coloured deposits, 13-26 μm in tangential height and 34-52 μm in radial length. *Fibres* semi-libriform to libriform, circular to angular in cross section, septate, 12-20 μm in diameter and 390-900 μm in length (Pl. 1, figs 3,4).

Affinities—The important anatomical characters of the fossil wood, namely small to medium-sized vessels arranged in echelon pattern, both paratracheal and apotracheal type of parenchyma, narrow, homogeneous to weakly heterogeneous xylem rays and vasicentric tracheids, strongly indicate its affinities with the genus *Eucalyptus* L'Hérit of Myrtaceae (Metcalf & Chalk, 1950; Miles, 1978). For further comparison wood slides of 22 modern species of *Eucalyptus* were examined at the xylaria of the Forest Research Institute, Dehradun and the Birbal Sahni Institute of Palaeobotany, Lucknow. Besides, the photographs and published descriptions of a number of its species were also consulted (Greguss, 1945, p. 128, fig. 156; Kribs, 1959, pp. 122-126, figs 263-272, 439; Miles, 1978, pp. 153-158). It was found that although *Eucalyptus* has some characteristic anatomical features there is a lot of variation within its numerous species. Hence, it is very difficult to differentiate the species on the basis of wood anatomy. However, the fossil was found to have maximum similarity with *E. resinifera* Sm. (F.R.I. Slide no. F. 1236) in the shape, size and distribution of the vessels, structure of the xylem rays and fibres, parenchyma pattern and the presence of vasicentric tracheids and tyloses.

As far as we are aware this is the first record of a fossil wood of *Eucalyptus*. Therefore it has been described as a new species, *E. dbarmendrae*. The specific name is after Dr Dharmendra Prasad, who was of great help to us in the collection of this material.

There are not many references to the occurrence of *Eucalyptus* in fossil state. Berry (1915) had mentioned about 50 fossil records of *Eucalyptus* from the

PLATE 1

1. *Eucalyptus dbarmendrae* sp. nov.—Cross section of the fossil wood in low power showing shape, size and distribution of the vessels. $\times 30$; slide no. 35882-I.
2. *Eucalyptus paniculata*—Cross section of the modern wood showing similar shape, size and distribution of the vessels. $\times 30$.
3. *Eucalyptus dbarmendrae* sp. nov.—Magnified cross section of the fossil wood showing oblique pattern of the vessels and the parenchyma distribution. $\times 80$; slide no. 35882-I.
4. *Eucalyptus dbarmendrae* sp. nov.—Tangential longitudinal section of the fossil wood showing structure of xylem rays. $\times 80$; slide no. 35882-II.
5. *Eucalyptus paniculata*—Tangential longitudinal section of the modern wood showing similar structure of xylem rays. $\times 80$.
6. *Eucalyptus dbarmendrae* sp. nov.—Radial longitudinal section of the fossil wood showing homocellular xylem rays. $\times 160$; slide no. 35882-III.
7. *Eucalyptus dbarmendrae* sp. nov.—Magnified vasicentric tracheids of the fossil wood. $\times 325$; slide no. 35882-IV.
8. *Tristania confertoides* sp. nov.—Magnified vasicentric tracheids of the fossil wood. $\times 660$; slide no. 35883-II.

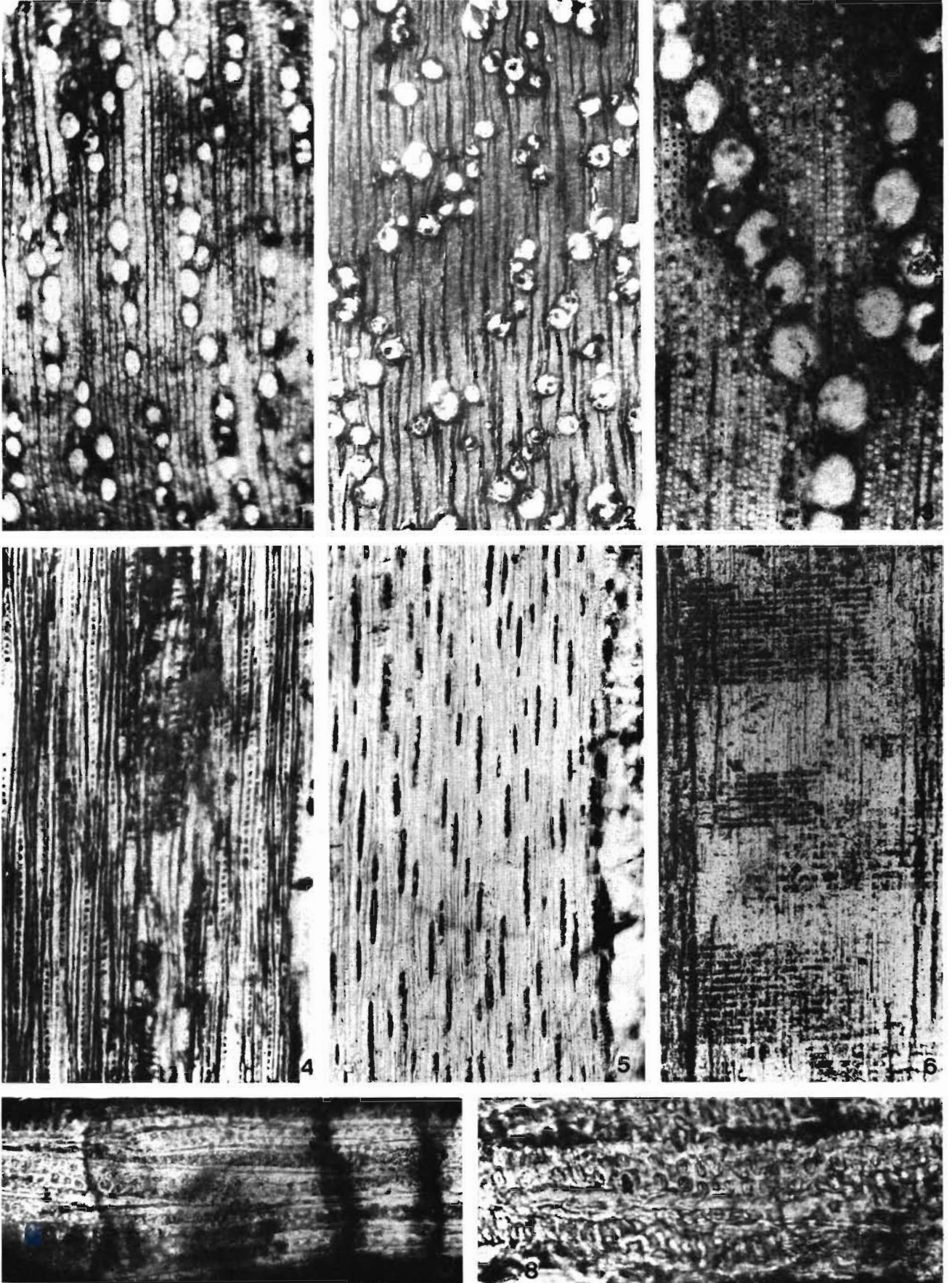


PLATE 1

Cretaceous and Tertiary deposits of North America, Europe and Asia. A leaf fragment showing affinities with *Eucalyptus* was described as *Eucalyptophyllum oblongifolium* from the Cretaceous of Virginia, U.S.A. (Fontaine, 1889). From India the only record is by Varma (1968) who described a leaf impression, *Eucalyptophyllum raoi*, from the Middle Siwalik beds of Hardwar. Awasthi (1982) considered this finding in the Tertiary of India as highly improbable. However, in the light of the present discovery, the occurrence of *Eucalyptus* in the Neogene flora of India should not be ruled out and deserves a verification.

Holotype—B.S.I.P. Museum specimen no. 35882.

Locality—Ghughua (23°7' N 80°37'E) near Shahpura, Madhya Pradesh.

Horizon—Deccan Intertrappean beds.

Age—Early Tertiary.

Genus—*Tristania* R. Br.

Tristania confertoides sp. nov.

Pl. 1, fig. 8; Pl. 2, figs 9, 11, 13

Material—A single piece of secondary wood measuring 12 cm in length and 8 cm in width.

Description—Wood diffuse-porous (Pl. 2, fig. 9). *Growth rings* absent. *Vessels* mostly medium-sized, occasionally small to large, t.d. 65-258 μm , r.d. 75-280 μm , almost exclusively solitary, rarely in radial pairs, evenly distributed, 8-16 per sq mm, usually circular to oval when solitary, with flat contact walls when in pairs (Pl. 2, fig. 9); vessel members 250-900 μm long with transverse to oblique ends; perforations simple; vessel-tracheid pits 1-2 seriate, bordered, opposite to alternate, small, about 4 μm in diameter, circular to oval in shape with linear apertures (Pl. 1, fig. 8); tyloses occasionally present. *Tracheids* vasicentric, forming a thin sheath around most of the vessels. *Parenchyma* apotracheal appearing scanty diffuse (Pl. 2, fig. 9); parenchyma cells thin-walled, 16-20 μm in diameter and 48-64 μm in length. *Xylem rays* closely spaced, 8-11 per mm, usually

uniseriate, sometimes biseriate, made up of procumbent cells only, 24-52 μm in width and 6-26 cells or 82-430 μm in height (Pl. 2, fig. 11); ray tissue homogeneous (Pl. 2, fig. 13); ray cells thin-walled, 34-56 μm in radial length and 12-20 μm in tangential height. *Fibres* semi-libriform with big lumen, polygonal in cross section, non-septate, 8-12 μm in diameter and 300-775 μm in length (Pl. 2, figs 9, 11).

Affinities—Presence of almost exclusively solitary vessels, diffuse parenchyma, usually uniseriate xylem rays, non-septate fibres and vasicentric tracheids are the important anatomical characters of the fossil wood, which indicate its affinities with the family Myrtaceae (Pearson & Brown, 1932; Metcalfe & Chalk, 1950; Kribs, 1959; Normand, 1960; Miles, 1978). Amongst the various genera of Myrtaceae the fossil wood shows maximum resemblance with *Xanthostemon* F. Muell. and *Tristania* R. Br. in distribution of vessels, parenchyma pattern, structure of the fibres and presence of usually uniseriate xylem rays (Kribs, 1959; Miles, 1978). However, in *Xanthostemon* and some species of *Tristania*, the xylem rays are heterogeneous as against the homogeneous xylem rays of the present fossil wood (Metcalfe & Chalk, 1950, p. 627; Kribs, 1959, p. 127; Miles, 1978, p. 159). Consequently, the affinities of the fossil wood should be traced among those species of *Tristania* which possess homogeneous xylem rays. Three such species of *Tristania*, viz., *T. conferta* R. Br., *T. laurina* R. Br. and *T. suaveolens* Sm. were available for study. After a detailed comparison it was found that the fossil wood is very close to *T. conferta* (B. S. I. P. slide nos. 919, 1214, 762; Pl. 2, figs 10, 12) in almost all the anatomical characters.

This is the first record of a fossil wood of *Tristania* and hence has been placed under a new species, *T. confertoides*, indicating its close resemblance with modern *T. conferta*.

Fossil records of the genus *Tristania* are very few. *Tristania*-like fruits have been described as *Tristanites* by Saporta (1865) who described its infructescence as *T. cloeziaeformis* from the Tertiary of Armissan, France (Andrews, 1970). Fruits resembling *Tristania* are also

PLATE 2

9. *Tristania confertoides* sp. nov.—Cross section of the fossil wood showing shape, size and distribution of the vessels. $\times 30$; slide no. 35883-I.
10. *Tristania conferta*—Cross section of the modern wood in low power showing similar shape, size and distribution of the vessels. $\times 30$.
11. *Tristania confertoides* sp. nov.—Tangential longitudinal section of the fossil wood showing structure of the xylem rays and fibres. $\times 80$; slide no. 35883-II.
12. *Tristania conferta*—Tangential longitudinal section of the modern wood showing similar structure of the xylem rays and fibres. $\times 80$.
13. *Tristania confertoides* sp. nov.—Radial longitudinal section of the fossil wood showing homocellular xylem rays. $\times 125$; slide no. 35883-III.
14. *Callistemonoxylon deccanensis* gen. et sp. nov.—Cross section of the fossil wood showing shape, size and distribution of the vessels. $\times 40$; slide no. 35884-I.
15. *Melaleuca quinquenervia*—Cross section of the modern wood showing similar shape and distribution of the vessels. $\times 40$.
16. *Callistemonoxylon deccanensis* gen. et sp. nov.—Radial longitudinal section of the fossil wood showing heterocellular rays. $\times 80$; slide no. 35884-III.
17. *Callistemonoxylon deccanensis* gen. et sp. nov.—Magnified vasicentric tracheids of the fossil wood. $\times 325$; slide no. 35884-III.

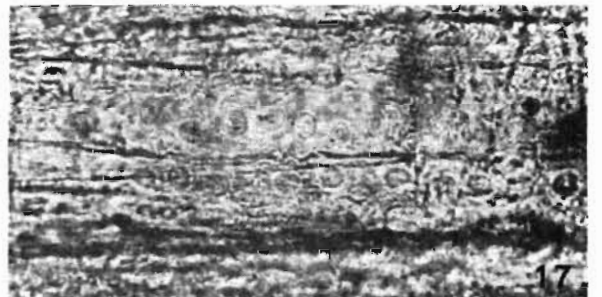
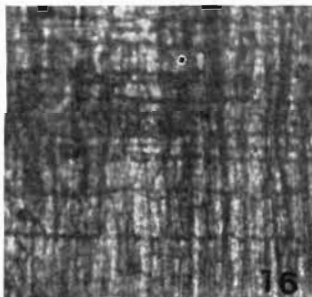
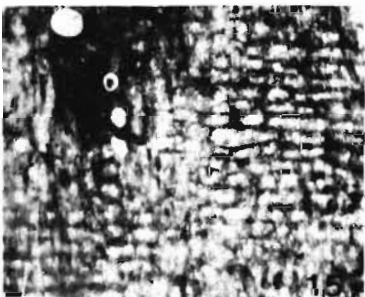
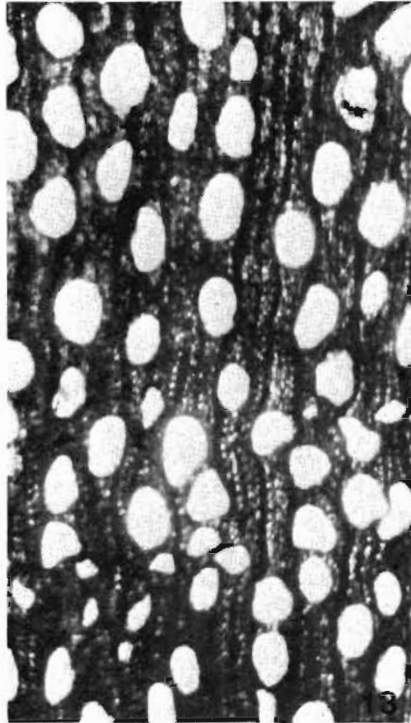
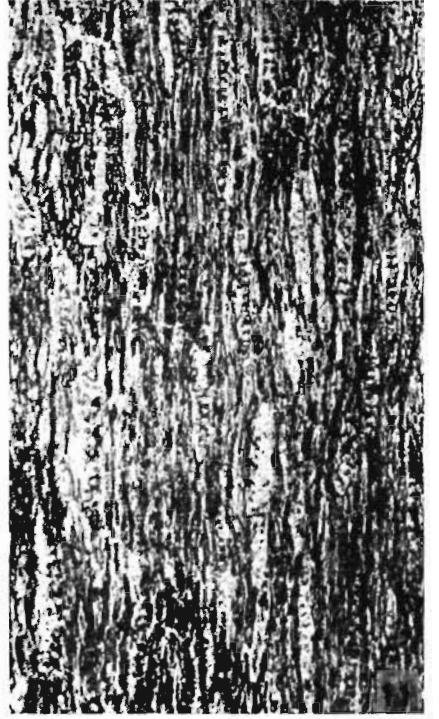
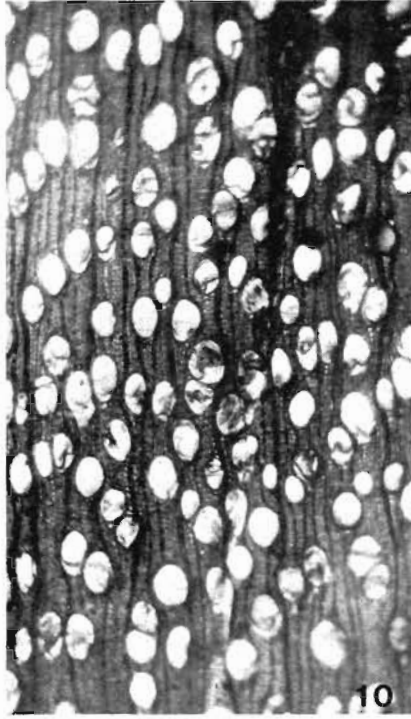
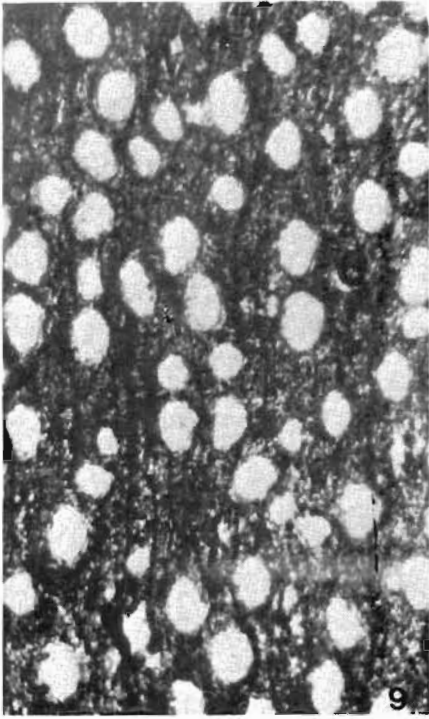


PLATE 2

known from the Miocene of Australia (Berry, 1915, p. 490). Deane (1902, 1923) has also described *Tristanites angustifolia* as well as leaves resembling *Tristania* from the Tertiary of Australia (Andrews, 1970).

Holotype—B. S. I. P. Museum specimen no. 35883.

Locality—Umari (23° 6' N 80° 38' E) near Shahpura, Madhya Pradesh.

Horizon—Deccan Intertrappean beds.

Age—Early Tertiary.

Genus—*Callistemonoxylon* gen. nov.

Callistemonoxylon deccanensis sp. nov.

Pl. 2, figs 14, 16, 17; Pl. 3, fig. 18

Material—A piece of secondary wood measuring about 10 cm in length and 6 cm in width.

Description—Wood diffuse-porous (Pl. 2, fig. 14). *Growth rings* absent. *Vessels* small to large-sized, t.d. 60-250 μm , r.d. 80-215 μm , almost always solitary, very rarely in radial and tangential pairs, evenly distributed, 15-25 per sq mm, circular to oval, sometimes variously shaped (Pl. 2, fig. 14); vessel members 190-525 μm long with oblique to transverse ends; perforations simple; vessel tracheid pits 1-2 seriate, bordered, alternate, about 6-8 μm in diameter, circular to oval in shape (Pl. 2, fig. 17); tyloses rarely present. *Tracheids* vasicentric forming a thin sheath around the vessels. *Parenchyma* scanty paratracheal (Pl. 2, fig. 14); parenchyma cells thin walled, 50-84 μm in length and 16-25 μm in diameter. *Xylem rays* 1-3 (rarely 4) seriate, 7-10 per mm; ray tissue heterogeneous (Pl. 2, fig. 16); rays of two types, (a) uniseriate rays made up of upright cells only, 8-12 μm in width and 1-8 cells or 45-290 μm in height, (b) multiseriate rays made up of procumbent cells in the central portion and 1-4 rows of upright cells at one or both the ends, 16-34 μm in width and 8-24 cells or 240-856 μm in height (Pl. 3, fig. 18); sheath cells occasionally present; ray to ray fusion observed; ray cells thin-walled, procumbent cells 28-64 μm in radial length and 12-21 μm in tangential height; upright cells 16-30 μm in radial length and 54-85 μm in tangential height (Pl. 2, fig. 16). *Fibres* semi-libriform, oval to angular in cross section,

usually non-septate, occasionally septate, 12-20 μm in diameter and 425-935 μm in length (Pl. 2, fig. 14; Pl. 3, fig. 18).

Affinities—The important anatomical characters of the fossil wood, viz., almost exclusively solitary vessels, vasicentric tracheids, scanty paratracheal parenchyma and narrow to moderately broad, heterogeneous xylem rays, indicate its affinities with the family Myrtaceae (Pearson & Brown, 1932; Metcalfe & Chalk, 1950; Kribs, 1959; Miles, 1978; Purkayastha, Shahi & Taneja, 1982). A detailed comparison of the present fossil with various genera of Myrtaceae from their wood slides, published descriptions and figures (Metcalfe & Chalk, 1950, pp. 624-628, figs 140-141; Kribs, 1959, pp. 122-127, figs 263-275, 439; Miles, 1978, pp. 153-159; Purkayastha, Shahi & Taneja, 1982, pp. 1-17, figs 559-584) indicates that its affinities should be traced amongst various species of *Callistemon* R. Brown and *Melaleuca* L.

Thin sections of eight species of *Callistemon* and 16 species of *Melaleuca* were studied and it was found that it is not possible to distinguish these two genera anatomically. A detailed comparison of the fossil wood with all the available species of both these genera indicates that its closest affinities are with two species of *Melaleuca*, *M. quinquenervia* (Cav.) S. T. Blake and *M. linariifolia* Sm. However, our fossil differs from *M. quinquenervia* in the structure of xylem rays which are comparatively narrower in the modern species. On the other hand *Melaleuca linariifolia* shows closer proximity in having similar rays but it differs from the fossil in having apotracheal parenchyma and comparatively smaller vessels.

As it is not possible to differentiate the genera *Callistemon* and *Melaleuca* on the basis of wood anatomy, a new organ genus *Callistemonoxylon* has been constituted to include fossil woods of both these genera and the fossil has been assigned to it. Its specific name *C. deccanensis* indicates its occurrence in the Deccan Intertrappean flora.

PLATE 3

18. *Callistemonoxylon deccanensis* gen. et sp. nov.—Tangential longitudinal section of the fossil wood showing structure of the xylem rays and fibres. $\times 90$; slide no. 35884-II.
19. *Melaleuca quinquenervia*—Tangential longitudinal section of the modern wood showing similar structure of the xylem rays and fibres. $\times 90$.
20. *Callistemonites indicus* gen. et sp. nov.—Fossil infructescence-1 under reflected light showing shape, size and arrangement of the fruits. $\times 1$; specimen no. 35885.
21. *Callistemonites indicus* gen. et sp. nov.—Fossil infructescence-2

under reflected light showing shape, size and arrangement of the fruits. $\times 1$; specimen no. 35885.

22. *Callistemonites indicus* gen. et sp. nov.—Fossil infructescence-3 under reflected light showing shape, size and arrangement of the fruits. $\times 1$; specimen no. 35885.
23. *Melaleuca leucadendron*—Infructescence of the modern plant showing similar shape, size and arrangement of the fruits. $\times 1$.
24. *Callistemon lanceolatus*—Infructescence of the modern plant showing similar shape, size and distribution of the fruits. $\times 1$.

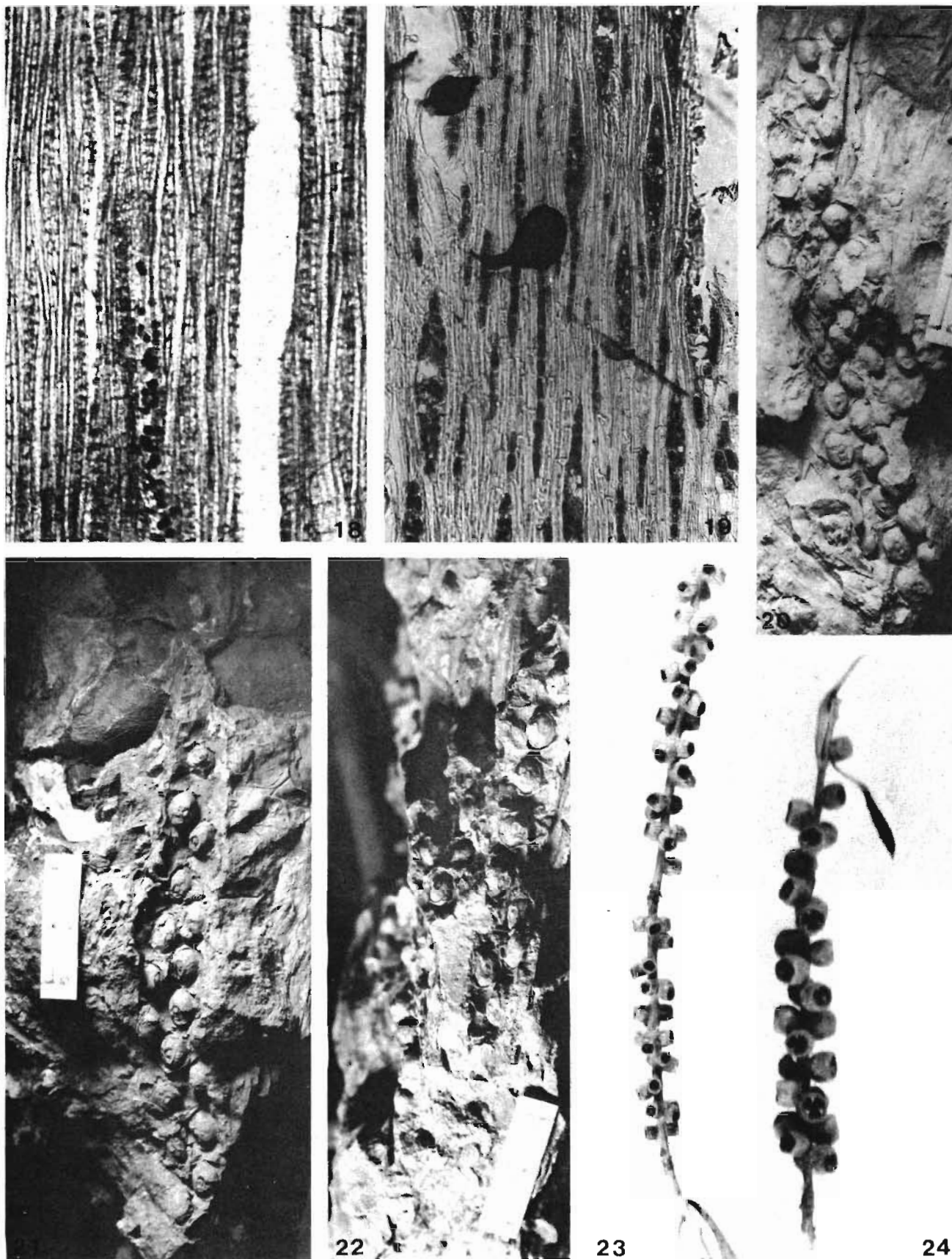


PLATE 3

GENERIC DIAGNOSIS***Callistemonoxylon* gen. nov.**

Wood diffuse-porous. *Growth rings* usually absent or indistinct, demarcated by denser zone of fibres. *Vessels* small to large-sized, usually exclusively solitary, very rarely in radial or tangential pairs; perforations simple. *Tracheids* vasicentric. *Parenchyma* scanty paratracheal. *Xylem rays* 1-4 seriate; ray tissue heterogeneous. *Fibres* libriform to non-libriform, septate or non-septate.

Genotype—*Callistemonoxylon deccanensis* sp. nov.

SPECIFIC DIAGNOSIS***Callistemonoxylon deccanensis* sp. nov.**

Wood diffuse-porous. *Growth rings* absent. *Vessels* small to large-sized, t.d. 60-250 μm , r.d. 80-215 μm , usually exclusively solitary, rarely in radial or tangential pairs, 15-25 per sq mm; tyloses rarely present; vessel members 190-525 μm long with oblique to transverse ends; perforations simple; vessel-tracheid pits 1-2 seriate, bordered, alternate, about 6-8 μm in diameter, circular to oval in shape. *Parenchyma* scanty paratracheal. *Xylem rays* 1-3 (rarely 4) seriate, 7-10 per mm; ray tissue heterogeneous, uniseriate rays made up of upright cells, multiseriate rays made up of procumbent cells in the central portion and 1-4 rows of upright cells at one or both the ends. *Fibres* semi-libriform, oval to angular in cross section, mostly non-septate, occasionally septate, 12-20 μm in diameter and 425-935 μm in length; interfibre pits could not be seen.

Holotype—B. S. I. P. Museum specimen no. 35884.

Locality—Ghughua (23°7'N 80°37'E) near Shahpura, Madhya Pradesh.

Horizon—Deccan Intertrappean beds.

Age—Early Tertiary.

Genus—*Callistemonites* gen. nov.***Callistemonites indicus* gen. et sp. nov.**

Pl. 3, figs 20-22

Material—The material consists of two chert pieces, one of them bearing two and the other with three incomplete infructescences. Transverse and longitudinal sections of some of the fruits were prepared to study their internal structure but due to poor preservation no anatomical details were available. This study is, therefore, based only on the external morphological characters.

Description—The infructescences are 4-12 cm in length and 1-2 cm in diameter, made up of 6-34 small fruits (Pl. 3, figs 20-22). The fruits are sessile and usually spirally arranged giving the appearance of a spike. They are mostly ovoid, measuring 8/4 mm in size. A cup-shaped perianth encloses each fruit to most of its length

with a circular to truncate opening about 2-3 mm in diameter near the apex.

Affinities—The important morphological characters of the fossil are spike-like infructescence consisting of a number of fruits enclosed by persistent, cup-shaped perianth. These features are found in both the monocotyledons and dicotyledons and show affinities of the fossil with the families Bromeliaceae and Burmanniaceae of monocotyledons and Phytolaccaceae, Basellaceae, Lauraceae, Lythraceae, Myrtaceae, Plumbaginaceae, Symplocaceae and Plantaginaceae amongst the dicotyledons (Hooker, 1872-1897; Lawrence, 1964; Hutchinson, 1979). After going through the various genera belonging to these families at the Herbaria of the Forest Research Institute, Dehradun and National Botanical Research Institute, Lucknow, it was found that the fossil infructescence shows close resemblance with that of *Callistemon* R. Br. and *Melaleuca* L. of Myrtaceae. Ten species of *Callistemon* and 17 species of *Melaleuca* were examined in detail and it was found that fruits of both *Callistemon* and *Melaleuca* are almost identical and it is not possible to separate them from each other (N. B. R. I. Herbarium Sheet nos. 41318, 20258, 72405, 72452) on the basis of external morphology. However, the present fossil shows maximum similarities with the infructescences of *Callistemon brachyandrus* Lindl., *C. lanceolatus* DC., *C. pahudosa* R. Br., *C. salignus* DC., *Melaleuca gibbosa* Labill., *M. glomerata* F. Muell., *M. leucadendron* Linn., *M. styphelioides* Sm. and *M. uncinata* R. Br. especially in shape, size and arrangement of the fruits (Pl. 3, figs 23, 24).

As the present fossil shows close affinities with *Callistemon* and *Melaleuca* whose infructescences can not be differentiated, it has been placed under a new organ genus *Callistemonites* which stands for the fossil infructescences of both *Callistemon* and *Melaleuca*. The species has been named as *Callistemonites indicus* indicating its occurrence in the Indian strata.

As far as the authors are aware, *Melaleuca* is not known in the fossil state, whereas *Callistemon* has been identified in both the Upper Cretaceous and the Tertiary of Europe. According to Berry (1915) not less than 25 fossil species have been referred to the genus *Callistemophyllum* Ettingshausen. These include Upper Cretaceous forms in both America and Europe, Eocene or Oligocene forms from Greenland, and numerous Oligocene and Miocene species in Europe and Australia.

GENERIC DIAGNOSIS***Callistemonites* gen. nov.**

Spike-like infructescence made up of a number of ovoid, small fruits enclosed by persistent, cup-shaped perianth.

Genotype—*Callistemonites indicus* sp. nov.

SPECIFIC DIAGNOSIS

Callistemonites indicus sp. nov.

Incomplete spike-like infructescence, 4-12 cm in length and 1-2 cm in diameter, made up of 6-34, small fruits. Fruits spirally arranged, ovoid in shape measuring 8/4 mm in size and enclosed by persistent, cup-shaped perianth. Each fruit has a circular to truncate opening at the apex measuring 2-3 mm in diameter.

Holotype—B. S. I. P. Museum specimen no. 35885.

Paratype—B. S. I. P. Museum specimen no. 35886.

Locality—Ghughua (23°7'N 80°37'E) near Shahpura, Madhya Pradesh.

Horizon—Deccan Intertrappean beds.

Age—Early Tertiary.

DISCUSSION

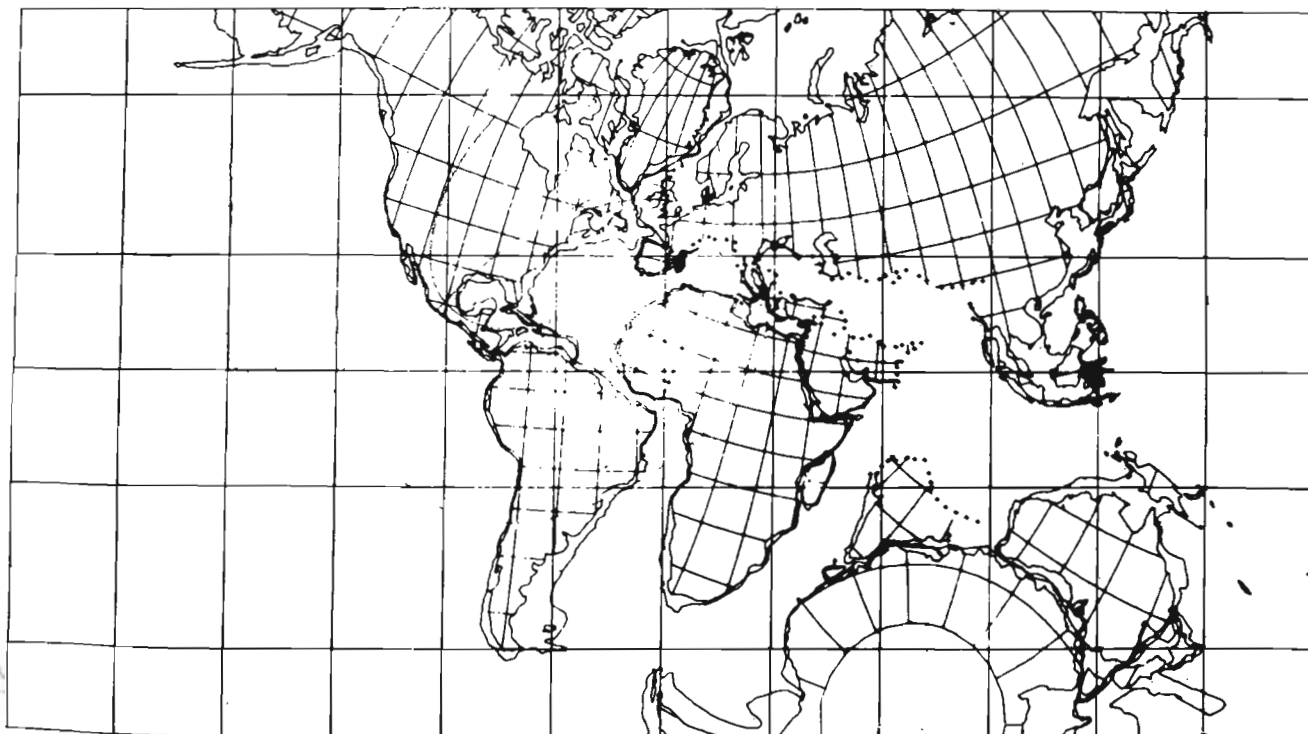
Ever since the discovery of *Rodeites dakshini* Sahni (1943) and *Cyclanthodendron sabnii* (Rode) Sahni & Surange (1944, 1953) the possible occurrence of plant taxa belonging to the Gondwanaland continents other than India, has been suspected in the Deccan Intertrappean flora. While *Rodeites* shows affinities with *Regnellidium*, a water fern of Brazil, *Cyclanthodendron* has been said to possess affinities with the tropical American family Cyclanthaceae. Like the Central and South American forms, the presence of tropical African element in the Deccan Intertrappean flora is evidenced

by a fossil fruit comparable with the branched palm *Hypphaene* from Ghughua (Bande, Prakash & Ambwani, 1982). Although one species of this palm *Hypphaene indica*, does grow along the western coast in India, all the other 40 species of this genus are distributed in tropical and subtropical Africa and Arabia. Similarly, the occurrence of a palm wood (from the same locality—Ghughua) resembling *Chrysalidocarpus*, a genus presently growing in Madagascar is a further evidence in the same direction (Ambwani & Prakash, 1983).

Araucariaceae is supposed to be a southern hemisphere family (Sporne, 1971). It is represented in the Deccan Intertrappean flora as a cone as well as a petrified wood (Prakash, 1957, 1962; Lakhanpal, Prakash & Bande, 1977). This is yet another evidence of the occurrence of some common plant taxa in India and other Gondwanaland continents during the Early Tertiary.

With this background it should not be surprising to find in the Deccan Intertrappean flora also an element from Australia, an another continent belonging to the Gondwanaland. However, its occurrence in these beds deserves a critical analysis.

Although plantations of *Eucalyptus* are a common sight at present in various parts of the country, phytogeographically the genus is not indigenous to India. It was introduced in this country in the late 18th Century (Gamble, 1972). The genus consisting of about 500 species is mainly distributed in Australia.



Map 1—Position of the Indian Plate 100 million years ago (after Smith & Briden, 1979).

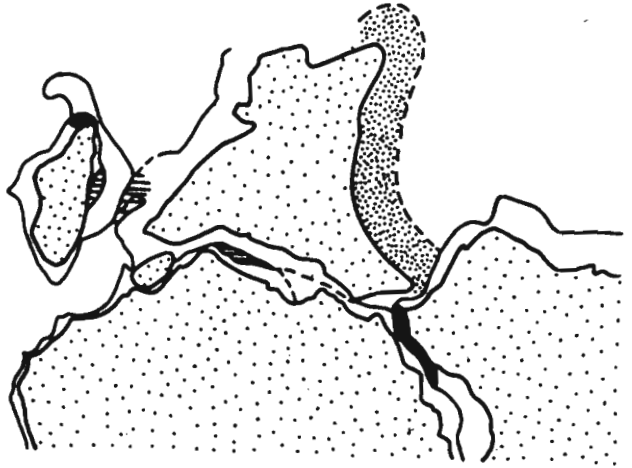
The other genus *Tristania* comprises trees or tall shrubs, of which about 50 species are distributed in Malaysia, Queensland, New Caledonia, Australia, Fiji, Burma and India. However, *Tristania conferta* with which the fossil wood described in this paper shows affinity is found in North Australia, Queensland and New South Wales (Bentham, 1866; Santapau & Henry, 1973; Willis, 1973).

The third genus, *Melaleuca* is also a tropical form consisting of about 100 species of trees and shrubs which occur in Australia and the Pacific (Bentham, 1866; Willis, 1973). Only one species *M. leucadendron* is found in the Indian subcontinent. However, *M. linariifolia* and *M. quinquenervia*, with which the fossil wood described here shows close resemblance, are confined to Australia.

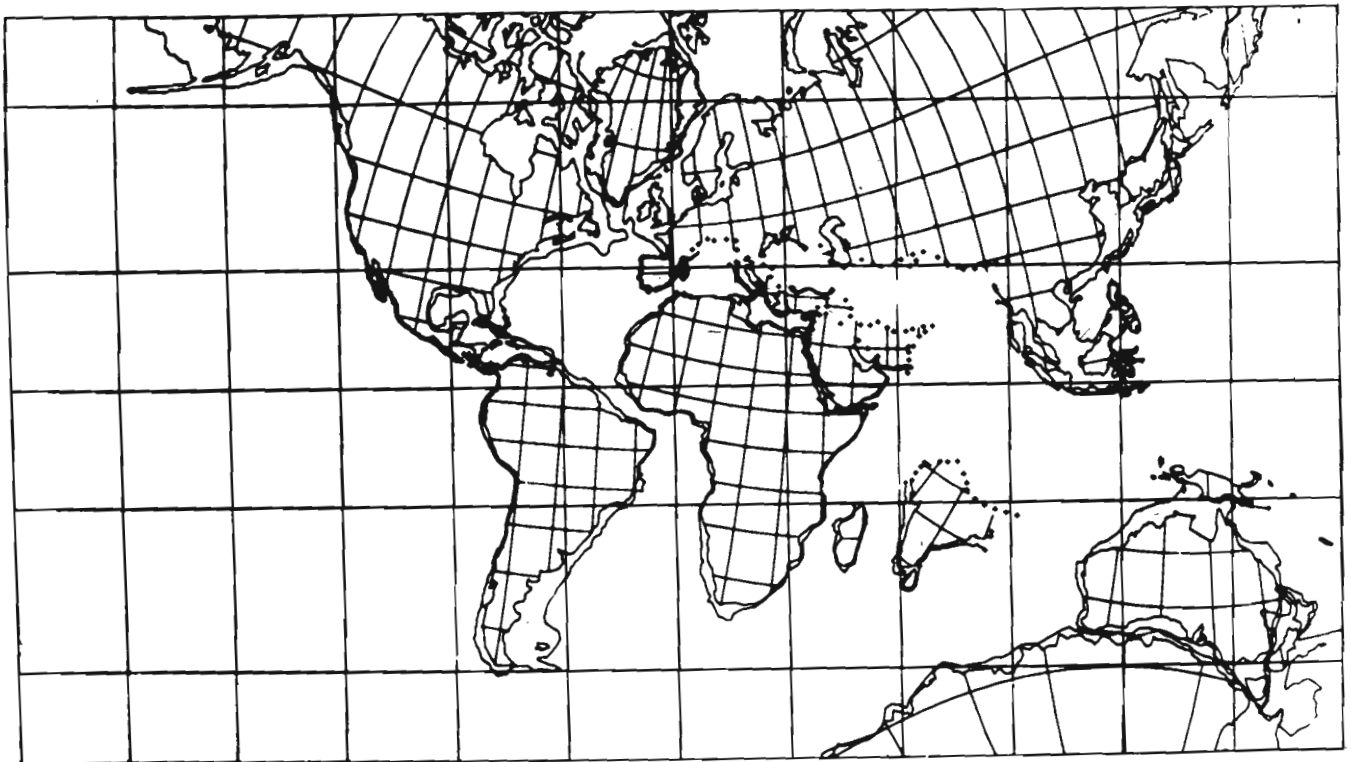
Lastly, the genus *Callistemon* with which the fruiting axis described in the previous pages shows resemblance is also a tropical genus of about 25 species of tall shrubs or small trees distributed in Australia and New Caledonia (Bentham, 1866; Willis, 1973). Thus the finding of all these Australian taxa in the Deccan Intertrappean beds of Mandla District furnishes a definite evidence for the occurrence of some common plants in India and Australia during the early Tertiary times when these beds were deposited.

The study of the Mesozoic and Cenozoic palaeocontinental maps given by Smith and Briden

(1979) indicates that as late as mid-Cretaceous (100 million years back) India and Australia were situated roughly at the same latitudes and interconnected through Antarctica (Map 1). In their revised reconstruction of the southern continents Barron, Harrison and Hay (1978) have even suggested that the north eastern tip of India lay in direct contact with Australia (Map 2).



Map 2—Position of India, Antarctica and Australia showing direct connections of the Indian Plate with the Australian Plate (after Barron, Harrison & Hay, 1978).



Map 3—Position of the Indian Plate 80 million years ago (after Smith & Briden, 1979).

Whether we accept the position of India, Australia and Antarctica as suggested by Smith and Briden or by Barron, Harrison and Hay, it is apparent that during the Late Cretaceous or even a little later India and Australia must have enjoyed a similar type of climate permitting the existence of some common plant taxa. A study of the palaeocontinental maps of successive ages shows that Late Cretaceous onwards India started its northward journey towards Asia. Subsequently, this resulted in an entirely different latitudinal position for India in comparison to Australia, and a consequent change of climatic conditions ultimately leading to the extinction of Australian taxa from India.

The occurrence of Myrtaceous genera in the Deccan Intertrappean flora raises another point which needs consideration. Myrtaceae is considered to be one of the most primitive families of the dicotyledons with an advancement index of 27 (Spome, 1977). Long ago, Berry (1915) suggested that America was the original home of the family. However, in the light of present finding Berry's statement needs critical analysis. Obviously, further studies are needed to throw more light on the origin and diversification of this family.

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REFERENCES

- Ambwani, K. 1984a. *Palmostroboxylon arengoidum* sp. nov.—A fossil palm peduncle resembling *Arenga* from the Deccan Intertrappean beds of Shahpura, Madhya Pradesh. *Palaeobotanist* **32**(2): 134-139.
- Ambwani, K. 1984b. *Palmoxydon dilacunosum* sp. nov. from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. *Palaeobotanist* **32**(3): 211-216.
- Ambwani, K. & Prakash, U. 1983. *Palmoxydon ghuagensis* sp. nov. resembling *Chrysalidocarpus* from the Deccan Intertrappean beds of Mandla District in Madhya Pradesh. *Palaeobotanist* **31**(1): 76-81.
- Andrews, H. N. 1970. Index of generic names of fossil plants 1820-1965. *Bull. U. S. geol. Surv.* **1300**: 1-354.
- Awasthi, N. 1982. Tertiary plant megafossils from the Himalaya: A review. *Palaeobotanist* **30**(3): 254-267.
- Bande, M. B. 1986. Fossil wood of *Gmelina* Linn. (Verbenaceae) from the Deccan Intertrappean beds of Nawargaon with comments on the nomenclature of Tertiary fossil woods. *Palaeobotanist* (in press).
- Bande, M. B. & Prakash, U. 1983. Fossil dicotyledonous wood from the Deccan Intertrappean beds near Shahpura, Mandla District, Madhya Pradesh. *Palaeobotanist* **31**(1): 13-29.
- Bande, M. B., Prakash, U. & Ambwani, K. 1982. A fossil palm fruit *Hypbaeneocarpus indicum* gen. et sp. nov. from the Deccan Intertrappean beds, India. *Palaeobotanist* **30**(3): 303-309.
- Barron, E. J., Harrison, C. G. A. & Hay, W. W. 1978. A revised reconstruction of the southern continents. *B S* **59**(5): 436-449.
- Bentham, G. 1866. *Flora Australiensis: A Description of the Plants of the Australian Territory*. 3. Lovell Reeve & Co., London.
- Berry, E. W. 1915. The origin and distribution of the family Myrtaceae. *Bot. Gaz.* **59**(6): 484-490.
- Deane, H. 1902. Notes on the fossil flora of Berwick, Victoria. *Rec. geol. Surv. Victoria* **1**: 21-32.
- Deane, H. 1923. Fossil leaves from the open cut, State Brown Coal Mine, Morewell. *Rec.* **4**: 492-498.
- Gamble, J. S. 1972. *A Manual of Indian Timbers*. Bishen Singh Mahendra Pal Singh, Dehradun.
- Greguss, P. 1945. *I. Bestimmung der Mitteleuropäischen Laubhölzer und Sträucher auf Xylotomischer Grundlage*. Hungarian Museum of Natural History, Budapest.
- Hooker, J. D. 1872-1897. *The Flora of British India*. 1-7. L. Reeve & Co., Kent.
- Hutchinson, J. 1979. *The Families of Flowering Plants*. Clarendon Press, Koenigstein.
- Kribs, D. A. 1959. *Commercial Foreign Woods on the American Market*. The Pennsylvania State University, University Park, Pennsylvania.
- Lakhanpal, R. N. & Prakash, U. 1980. Suggestions regarding the nomenclature of fossil dicotyledonous woods, pp. 199-208 in: P. K. K. Nair (ed.)—*Glimpses in Plant Research*. 5. *Modern Trends in Plant Taxonomy*. New Delhi.
- Lakhanpal, R. N., Prakash, U. & Bande, M. B. 1977. An araucarian fossil wood from the Deccan Intertrappean beds of Mohgaonkalan. *Palaeobotanist* **24**(2): 125-131.
- Lawrence, G. H. M. 1964. *Taxonomy of Vascular Plants*. Mohan Primalani, Oxford & IBH Publishers Co., Calcutta, Bombay, New Delhi.
- Mehrotra, R. C., Prakash, U. & Bande, M. B. 1984. Fossil woods of *Lobpopetalum* and *Artocarpus* from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh, India. *Palaeobotanist* **32**(3): 310-320.
- Metcalf, C. R. & Chalk, L. 1950. *Anatomy of the Dicotyledons*. 1 & 2. Clarendon Press, Oxford.
- Miles, A. 1978. *Photomicrographs of World Woods*. Building Research Establishment, London.
- Normand, D. 1960. *Atlas des Bois de la Cote d'ivoire*. 3. Nogent Sur Mame (Seine), France.
- Pearson, R. S. & Brown, H. P. 1932. *Commercial Timbers of India*. 1 & 2. Government of India, Central Publication Branch, Calcutta.
- Prakash, U. 1957. Studies in the Deccan Intertrappean flora-1. On a petrified ovuliferous cone from Mohgaon cherts in the Deccan. *Palaeobotanist* **5**(2): 91-94.
- Prakash, U. 1962. Further observations on a petrified ovuliferous cone (*Mohgaostrobus sabnii* gen. et sp. nov.) from Mohgaon cherts in the Deccan. *Palaeobotanist* **10**(1&2): 1-5.
- Purkayastha, S. K., Shahi, R. & Taneja, K. 1982. Family Myrtaceae, pp. 1-18 in: *Indian Woods*-4. Controller of Publications, Delhi.

- Sahni, B. 1943. Palaeobotany in India-IV. *J. Indian bot. Soc.* **22** (2, 3 & 4) : 179-181.
- Sahni, B. & Surange, K. R. 1944. A silicified member of the Cyclantaceae from the Tertiary of the Deccan. *Nature* **154** (3899) : 114-115.
- Sahni, B. & Surange, K. R. 1953. On the structure and affinities of *Cyclantobodendron sahnii* (Rode) Sahni & Surange from the Deccan Intertrappean Series. *Palaeobotanist* **2** : 93-100.
- Santapau, H. & Henry, A. N. 1973. *A Dictionary of the Flowering Plants in India*. Publication and Information Directorate, New Delhi.
- Saporta, G. 1865. Etudes sur la végétation due sud-est de la France à l' époque Tertiaire. *Annales Sci. Nat. Botanique*, 5th Ser. **4** : 5-264.
- Smith, A. G. & Briden J. C. 1979. *Mesozoic and Cenozoic Palaeocontinental Maps*. Cambridge University Press, Cambridge, London, New York, Melbourne.
- Spome K. R. 1971. *The Morphology of Gymnosperms* Hutchinson & Co., London.
- Spome, K. R. 1977. *The Morphology of Angiosperms* B. I. Publication, Bombay, Calcutta, Madras, Delhi.
- Trivedi, B. S. & Srivastava, K. 1985. *Canarioxylon shahpuraensis* from the Deccan Intertrappean beds of Shahpura, District Mandla (M.P.), India. *Geophytology* **15**(1) : 27-32.
- Varma, C. P. 1968. On a collection of leaf impressions from Hardwar beds (Shivalik Formation) near Hardwar, Uttar Pradesh. *J. palaeont. Soc. India* **5-9** : 83-88.
- Willis, J. C. *A Dictionary of the Flowering Plants and Ferns* (8th edition). Cambridge Univ. Press, Cambridge.