

FOSSIL DICOTYLEDONOUS WOODS FROM THE DECCAN INTERTRAPPEAN BEDS NEAR SHAHPURA, MANDLA DISTRICT, MADHYA PRADESH

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ABSTRACT

Four fossil dicotyledonous woods, viz., *Sterculioxylon shahpurensis* Bande & Prakash, *Burseroxylon preserratum* Prakash & Tripathi, *Heyneoxylon tertiarum* Bande & Prakash, and *Dracontomelumoxylon mangiferumoides* Ghosh & Roy have been described here from a recently discovered rich Deccan Intertrappean exposure near Shahpura in Mandla District of Madhya Pradesh. These fossil woods are closely comparable with the woods of *Sterculia* of Sterculiaceae, *Bursera* of Burseraceae, *Heynea* of Meliaceae and *Dracontomelum* of Anacardiaceae and suggest the presence of a rich forest flora in the Mandla region during the Early Tertiary times.

Key-words — Xylotomy, *Sterculioxylon*, *Burseroxylon*, *Heyneoxylon*, *Dracontomelumoxylon*, Deccan Intertrappean beds, Early Tertiary (India).

सारांश

मांडला जनपद (मध्य प्रदेश) में शाहपुरा के निकटस्थ दक्खिन अन्तर्द्वीपी संस्तरों से द्विबीजपत्रीय काष्ठाश्म — मोहन बलवंत बांडे एवं उत्तम प्रकाश

मध्य प्रदेश के मांडला जनपद में शाहपुरा के समीपस्थ हाल ही में अन्वेषित एक दक्खिन अन्तर्द्वीपी अनावरण से चार द्विबीजपत्रीय काष्ठाश्म — स्टरकुलिआक्सिलॉन शाहपुरेन्सिस बांडे व प्रकाश, बर्सेरोक्सिलॉन प्रीसेरेटम् प्रकाश व त्रिपाठी, हेनिआक्सिलॉन टर्शियेरम् बांडे व प्रकाश तथा ड्रेकॉन्टोमिलमॉक्सिलॉन मेंजिक्रेमॉयडिस घोष व रॉय — वर्णित किये गये हैं। ये काष्ठाश्म स्टरकुलिएसी कुल के स्टरकुलिआ, बर्सेरोसी कुल के बर्सेरा, मिलिएसी कुल के हेनिआ तथा ऐनाकाडिएसी कुल के ड्रेकॉन्टोमिलम् की वर्तमान काष्ठों से निकट तुलनीय हैं तथा मांडला क्षेत्र में प्रारम्भिक आदिनूतन युग में एक प्रचुर वन्य-वनस्पति की उपस्थिति इंगित करते हैं।

INTRODUCTION

ALTHOUGH the Deccan Traps cover an area not less than about 5,12,000 square kilometers, occupying about one-third of the Peninsular India (Krishnan, 1968), the palaeobotanical work on the Intertrappean flora has been confined mostly to the regions of Nagpur and Chhindwara. However, new areas have recently been explored in search of more fossiliferous exposures so as to have a better knowledge of this important flora of the Indian Palaeogene. One such area is Mandla District of Madhya Pradesh, which has turned out

to be quite rich in fossil woods. All the dicot woods so far described from this area have been listed in Table 1 and the relative positions of these different localities have been shown in Map 1. The assemblage includes 19 species of fossil dicotyledonous woods besides two species of *Palmoxyton* described by Lakhanpal, Prakash and Ambwani (1979). Besides the three fossiliferous localities previously known from this area, a fourth one has recently been discovered near Shahpura, a township 86 km east of Jabalpur. The actual locality is situated between the villages Ghughua and Katangi at a distance of 13 km from Shahpura on

TABLE 1 — FOSSIL DICOTYLEDONOUS WOODS FROM THE DECCAN INTERTRAPPEAN BEDS OF MANDLA DISTRICT

FOSSIL SPECIES	FAMILY	LIVING COMPARABLE SPECIES	LOCALITY	REFERENCE
1. <i>Vitexoxylon indicum</i>	?Verbenaceae	? <i>Vitex leucoxylo</i>	Mandla District	Ingle, 1972
2. <i>Polyalthioxylo</i> <i>parapaniense</i>	Anonaceae	<i>Polyalthia simiarum</i>	Parapani	Bande, 1973
3. <i>Syzygioxylo</i> <i>mandlaense</i>	Myrtaceae	<i>Syzigium cumini</i>	Mandla District	Ingle, 1973
4. <i>Homalioxylo</i> <i>mandlaense</i>	Flacourtiaceae	<i>Homalium tomentosum</i>	Parapani	Bande, 1974
5. <i>Bischofinium deccanii</i>	Euphorbiaceae	<i>Bischofia javanica</i>	Parapani	Bande, 1974
6. <i>Sterculioxylo</i> <i>deccanensis</i>	Sterculiaceae	<i>Sterculia foetida</i> , <i>S. angustifolia</i>	Mohgaon	Lakhanpal, Prakash & Bande, 1979
7. <i>Grewioxylo</i> sp.	Tiliaceae	<i>Grewia laevigata</i>	Mohgaon	Lakhanpal, Prakash & Bande, 1979
8. <i>Elaeocarpoxylo</i> <i>mandlaensis</i>	Elaeocarpaceae	<i>Elaeocarpus-Echinocarpus</i>	Mohgaon	Lakhanpal, Prakash & Bande, 1979
9. <i>Atalantioxylo</i> <i>indicum</i>	Rutaceae	<i>Atalantia monophylla</i> - <i>Limonia acidissima</i>	Mohgaon	Lakhanpal, Prakash & Bande, 1979
10. <i>Hydnocarpoxylo</i> <i>indicum</i>	Flacourtiaceae	<i>Hydnocarpus alpina</i> <i>Hydnocarpus wightiana</i>	Parapani	Bande & Khatri, 1980
11. <i>Garcinioxylo</i> <i>tertiarum</i>	Guttiferae	<i>Garcinia cowa</i> & <i>G. xanthochymus</i>	Parapani	Bande & Khatri, 1980
12. <i>Gomphandroxylo</i> <i>samnapurensis</i>	Icacinaceae	<i>Gomphandra tetrandra</i>	Samnapur	Bande & Khatri, 1980
13. <i>Dracontomelumboxylo</i> <i>mangiferumoides</i> syn. <i>Dracontomelumboxylo</i> <i>palaeomangiferum</i>	Anacardiaceae	<i>Dracontomelum mangiferum</i>	Parapani & Ghughua near Shahpura	Bande & Khatri, 1980
14. <i>Barringtonioxylo</i> <i>mandlaensis</i>	Lecythidiaceae	<i>Barringtonia acutangula</i> , <i>B. pterocarpa</i>	Parapani	Bande & Khatri, 1980
15. <i>Sterculioxylo</i> <i>shahpurensis</i>	Sterculiaceae	<i>Sterculia foetida</i> , <i>S. guttata</i> & <i>S. campanulata</i>	Ghughua near Shahpura	Bande & Prakash, 1980
16. <i>Calophylloxylo</i> <i>dharmandrae</i>	Guttiferae	<i>Calophyllum spectabile</i> <i>C. tomentosum</i>	Ghughua near Shahpura	Bande & Prakash, 1980
17. <i>Burseroxylo</i> <i>preservatum</i>	Burseraceae	<i>Bursera serrata</i>	Ghughua near Shahpura	
18. <i>Heyneoxylo</i> <i>tertiarum</i>	Meliaceae	<i>Heynea trijuga</i>	Ghughua near Shahpura	Bande & Prakash, 1980
19. <i>Laurinoxylo</i> <i>deccanensis</i>	Lauraceae		Ghughua near Shahpura	Bande & Prakash, 1980

Shahpura-Niwas Road (Map 2). This road is not shown in the map as the map has been prepared from the Survey of India Topo Sheet no. 64A/12 of an old date. Four fossil woods collected from this locality are described here. These are comparable with the modern woods of *Sterculia* of Sterculiaceae, *Bursera* of Burseraceae, *Heynea* of Meliaceae, and *Dracontomelum* of Anacardiaceae respectively. Of these, the fossil woods of *Sterculia*, and *Heynea* have been recently recorded by us from this locality (Bande & Prakash, 1980).

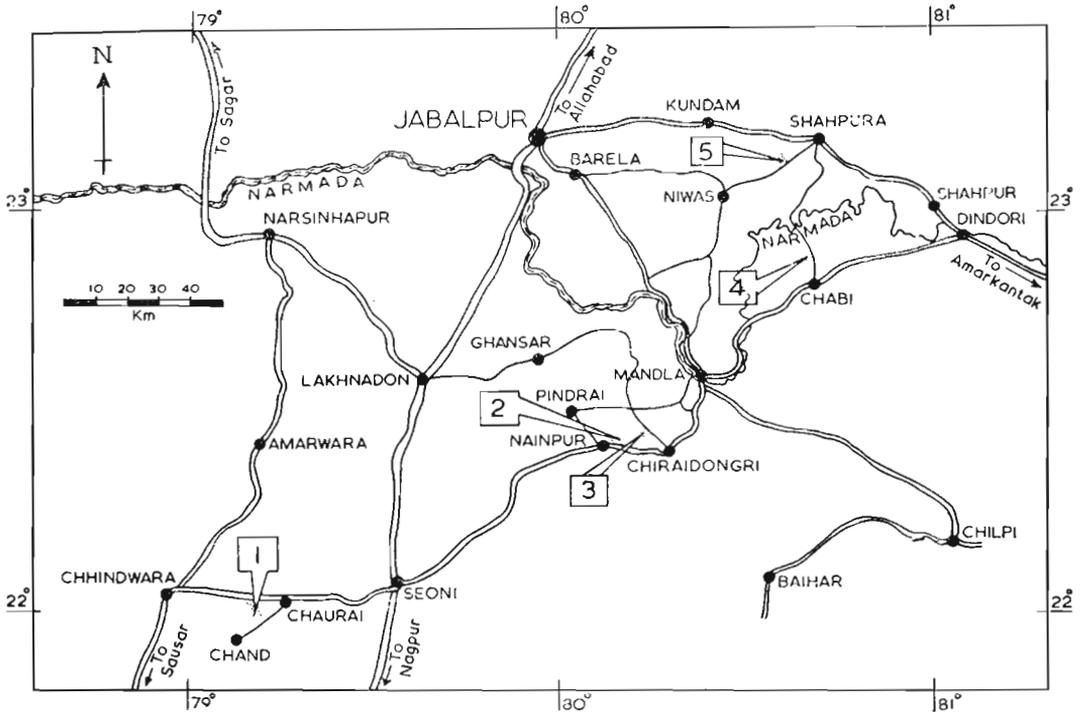
DESCRIPTION

FAMILY — STERCULIACEAE

Genus — *Sterculioxylo* Kräusel, 19391. *Sterculioxylo shahpurensis* Bande & Prakash, 1980

Pl. 1, figs 1-5; Text-fig. 1

Material — A well-preserved piece of secondary xylem detached from a big petrified log.



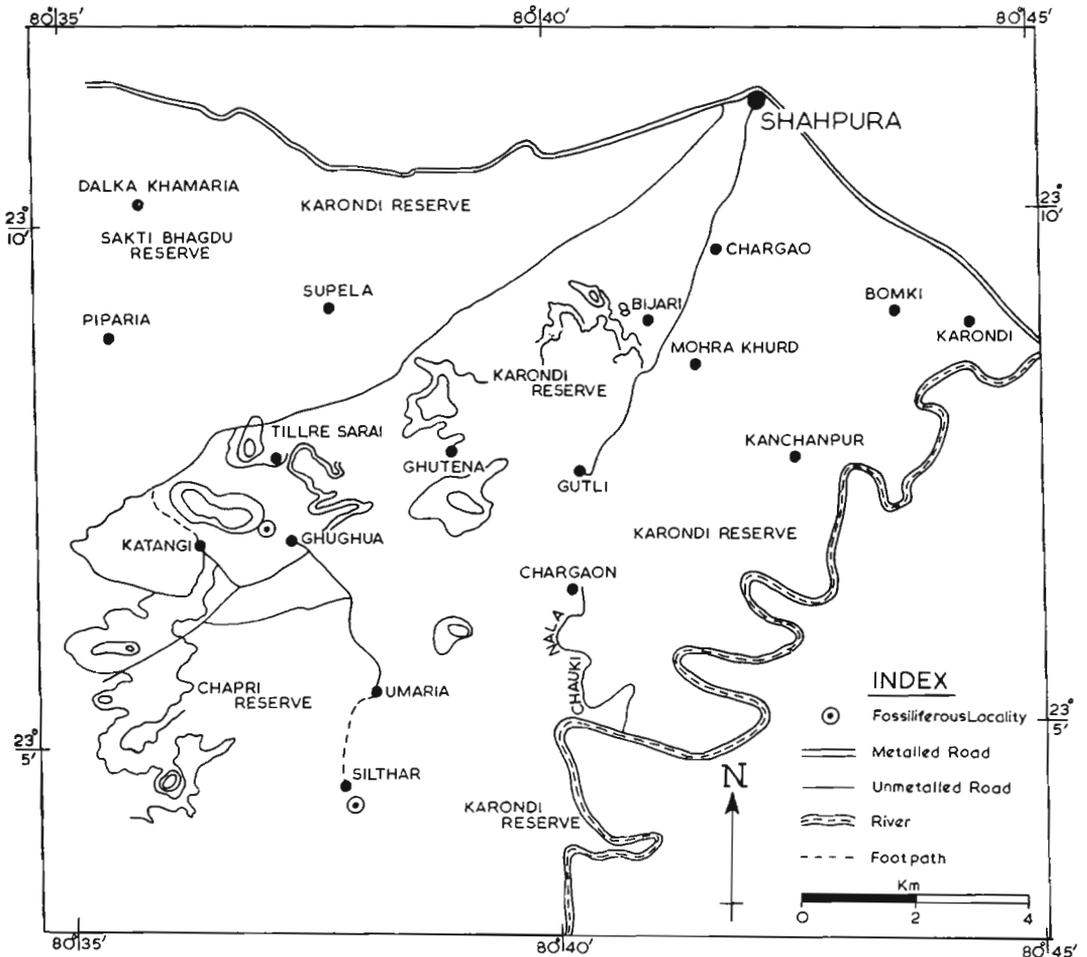
MAP 1 — Mandla and nearby areas showing various Deccan Intertrappean fossiliferous localities — (1) Mohgaon Kalan, (2) Samnapur, (3) Mohgaon, (4) Parapani, and (5) Ghughua.

Topography — Wood diffuse-porous (Pl. 1, fig. 1). *Growth rings* faintly demarcated by crowding of the vessels. *Vessels* small to large, mostly in radial multiples of 2-10, rarely solitary, frequently in clusters (Pl. 1, figs 1, 2; Text-fig. 1), uniformly distributed, 5-12 per sq mm. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming 1-2 seriate continuous or interrupted sheath around the vessels or vessel groups (Pl. 1, figs 1, 2; Text-fig. 1); apotracheal parenchyma abundant, diffuse-in-aggregate, forming 1-2 seriate, closely spaced, irregular, short tangential lines (Pl. 1, figs 1, 2; Text-fig. 1). *Xylem rays* evenly distributed, 4-5 per mm, homocellular to heterocellular, of two distinct types; uniseriate rays made up either of upright cells only or with some procumbent cells at places, 2-15 cells or 150-1000 μ m in height (Pl. 1, fig. 3); multiseriate rays made up of procumbent cells in the central portion and with uniseriate extensions of upright cells at the ends, 4-22 cells or 90-450 μ m in width and 15-200 cells or 600-8000

μ m in height (Pl. 1, fig. 3); sheath cells present, ray tissue heterogeneous. *Fibres* aligned in radial rows in between the rays.

Elements — *Vessels* thick-walled, circular to oval when solitary, with flat contact walls when in groups, t.d. 45-255 μ m, r.d. 60-360 μ m (Pl. 1, figs 1, 2; Text-fig. 1), vessel-members 400-600 μ m long with truncate ends; perforations simple, intervessel pit-pairs 4-6 μ m in diameter, alternate, bordered, angular in shape with linear-lenticular apertures (Pl. 1, fig. 4). *Parenchyma cells* thin-walled, 15-30 μ m in width and 60-120 μ m in length, parenchyma strands as well as cells distinctly storied (Pl. 1, fig. 3). *Ray cells* thin-walled, procumbent cells 15-45 μ m in tangential height and 30-120 μ m in radial length; upright cells 60-120 μ m in tangential height and 30-60 μ m in radial length. *Fibres* libriform to semi-libriform (Pl. 1, fig. 2), non-septate, 30-40 μ m in diameter and 450-1000 μ m in length.

Affinities — Important anatomical characters of the present fossil such as small to large vessels with simple perforations, vasi-

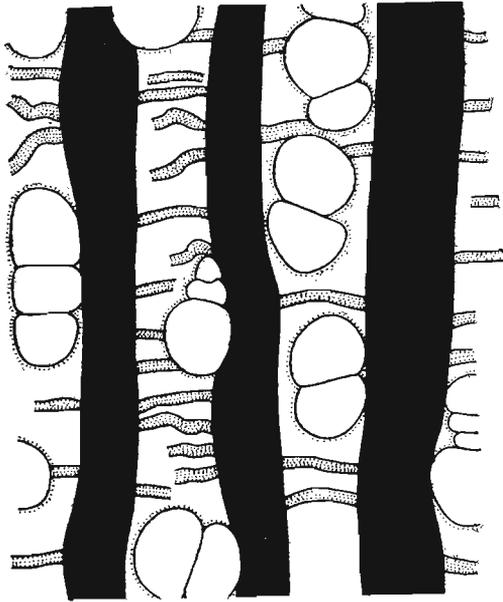


MAP 2 — Locality map of Ghughua and nearby area.

centric and diffuse-in-aggregate parenchyma forming 1-2 seriate tangential lines with storied strands, 1-22 seriate, usually heterocellular, long xylem rays and libriform to semi-libriform, non-septate fibres clearly indicate its affinities with the extant genus *Sterculia* of the family Sterculiaceae. The fossil wood was compared with the modern woods of 13 species of *Sterculia* available to us besides the published descriptions and photographs of these and some other species (Lecomte, 1926, pl. 21; Pearson & Brown, 1932, pp. 146-152, figs 52-55; Chattaway, 1937, pl. 4, figs 1, 2; 1937, pls 29-31; Metcalfe & Chalk, 1950, pp. 243-251, fig. 61J; Henderson, 1953, pl. 68, fig. 362; pl. 69,

fig. 364; Desch, 1954, pp. 581-583, pl. 114, fig. 2; Chowdhury & Ghosh, 1958, pp. 210-223, pls 27, 28, figs 160, 163, 164, 165; Brazier & Franklin, 1961, p. 79). The species which were studied from thin sections are *Sterculia alata* Roxb., *S. angustifolia* Roxb., *S. campanulata* Wallex Mast, *S. coccinia* Roxb., *S. colorata* Roxb., *S. foetida* L., *S. fulgens* Wall., *S. guttata* Roxb., *S. ornata* Wall., *S. populifolia* Roxb., *S. scaphigera* Wall., *S. urens* Roxb. and *S. villosa* Roxb.

Based on parenchyma distribution the species of *Sterculia* have been divided by Chattaway (1937) into two broad groups, viz., (i) in which apotracheal parenchyma



TEXT-FIG. 1 — *Sterculioxylon shahpurensis* sp. nov. — Cross section showing small to large vessels, broad xylem rays and tangential lines of parenchyma, $\times 55$. Slide no. 6139/35368.

is predominantly in lines of one cell width, and (ii) those in which apotracheal parenchyma is predominantly in broad bands of 3-4 cells width. Consequently, as the apotracheal parenchyma in the present fossil wood is in the form of 1-2 seriate tangential lines, the fossil wood is comparable with only those species of *Sterculia* which exhibit this character. Out of a long list of *Sterculia* species included under this group by Chatterway (1937), the wood slides of only six species, viz., *Sterculia campanulata*, *S. foetida*, *S. guttata*, *S. ornata*, *S. urens* and *S. villosa* were studied for a detailed comparison. However, besides parenchyma when other anatomical characters of the present fossil are also taken into consideration, it becomes clear that it does not agree totally with any one species. Its anatomical characters are distributed in more than one species of *Sterculia*, viz., *S. foetida*, *S. guttata* and *S. campanulata*. Thus shape, size and the distribution of vessels in the fossil is quite similar to that in *Sterculia guttata* but in this species some tangential bands of apotracheal parenchyma are also present in addition to the uniseriate lines; these are, however, not

seen in the present fossil. Apotracheal parenchyma very similar to that of the fossil wood is present in *S. foetida*, but in this species the xylem rays are much narrower than in the fossil, and the size and distribution pattern of the vessels also differ in the two. In its ray structure, the fossil is very closely comparable with *S. campanulata* in which up to 20 seriate, long, heterogeneous xylem rays are present. However, the vessels in this species are bigger than in the fossil and the parenchyma is also markedly different being vasicentric only.

Ten species of fossil woods said to be showing anatomical structures similar to those of extant genus *Sterculia* have so far been described from India and abroad under the generic name *Sterculioxylon* Kräusel (1939). Those described from outside the region of the Indian subcontinent are *Sterculioxylon aegyptiacum* (Unger) Kräusel (1939) from the Tertiary of Egypt and also from the Post Eocene of Tibesti in Sahara (Boureau, 1949), *S. giarabubense* (Chiarugi) Kräusel (1939) from the Lower Oligocene to Lower Miocene of North Africa, *S. rhenanum* Müller-Stoll (1949) from the Eocene of South West Germany and *S. freulonii* Boureau (1957) from the Post Eocene of Libya, Sahara. The species described from the various Tertiary localities of the Indian Subcontinent are *Sterculioxylon foetidense* Prakash (1973) from the Tertiary of Burma, *S. dattai* Prakash & Tripathi (1974) from the Tipam sandstones near Hailakandi, Assam, *S. kalagarhense* Trivedi and Ahuja (1978) from the Siwalik beds of Kalagarh, Uttar Pradesh, *S. deccanensis* Lakhanpal *et al.* (1978) from the Deccan Intertrappean beds near Mandla, Madhya Pradesh, *S. varmahii* Lakhanpal *et al.* (1981) from the Miocene-Pliocene of Deomali, Arunachal Pradesh and *S. pondicherriense* Awasthi (1981) from the Cuddalore Series near Pondicherry.

Of the four species described from outside the Indian subcontinent, the parenchyma is vasicentric to aliform, confluent and banded in *Sterculioxylon rhenanum*, while in *S. aegyptiacum*, *S. giarabubense* and *S. freulonii* it is present in broad apotracheal bands. Thus, these can easily be distinguished from our fossil wood where the parenchyma is in 1-2 seriate tangential lines. Similarly, in *S. varmahii*, *S. pondicherriense* and *S. kalagarhense* also broad apotracheal bands

are present. Thus, in only three species, viz., *S. foetidense*, *S. dattai* and *S. deccanensis*, parenchyma similar to that of the present fossil is present. However, in the Burmese species, *Sterculioxylon foetidense*, the vessels are large to moderately large (t.d. 160-400 μm , r.d. 240-480 μm), solitary and in radial multiples of 2-4 and only 2-3 per sq mm, while in the present wood the vessels are small to large (t.d. 45-255 μm , r.d. 60-360 μm), rarely solitary, mostly in radial multiples of 2-10, frequently in clusters and with a frequency of 5-12 per sq mm. The xylem rays in *S. foetidense* are also quite different from those in the present fossil being only 1-8 seriate wide and 2700 μm high as against 1-22 seriate wide and up to 8000 μm high rays in the fossil wood under discussion. Similarly in *S. dattai* although the shape, size and the frequency of the vessels is somewhat similar as in the present fossil, but majority of the vessels are solitary, only occasionally in pairs. Also the xylem rays are only 1-10 seriate wide and up to 1500 μm high in this species. Lastly, *S. deccanensis*, the only species so far known from the Deccan Intertrappean beds, also differs distinctly from the present fossil in having smaller vessels (t.d. 50-120 μm , r.d. 70-180 μm), which are solitary and in radial multiples of 2-4 only. The xylem rays although somewhat similar to those of present fossil wood are only up to 4800 μm in height. As the fossil wood from near Shahpura is quite distinct from all the known species of *Sterculioxylon*, it has been placed under a new species, *Sterculioxylon shahpurensis*, the specific name indicating its occurrence near Shahpura.

The genus *Sterculia* Linn. consists of 300 species (Willis, 1973) distributed throughout the tropics and reaches its best development in tropical Asia (Pearson & Brown, 1932, p. 145). Twenty species are known from India (Chowdhury & Ghosh, 1958). Of the three extant species resembling the fossil wood, *Sterculia foetida* is a large tree found on the west coast at low elevation from Konkan southwards, Ceylon and Martaban and Upper Tenasserim in Burma. *Sterculia guttata* is a medium sized to large tree occurring in the evergreen forests of the Western Ghats from Konkan to Travancore, ascending up to 600 m in Assam and also in Tenasserim in Burma. *Sterculia campanulata* is a large tree found in Lower Burma

from Martaban to Mergui and Tenasserim and in the Andamans (Chowdhury & Ghosh, 1958, pp. 212-215).

SPECIFIC DIAGNOSIS

Sterculioxylon shahpurensis Bande & Prakash, 1980

Wood diffuse-porous. *Growth rings* faintly demarcated by crowding of vessels. *Vessels* small to large, t.d. 45-255 μm , r.d. 60-360 μm , rarely solitary, majority in radial multiples of 2-10, frequently in clusters, evenly distributed, 5-12 per sq mm; perforations simple; intervessel pit-pairs alternate, bordered, 4-6 μm in diameter with linear-lenticular apertures. *Parenchyma* paratracheal and apotracheal, paratracheal parenchyma vasicentric, forming 1-2 seriate sheath around vessels; apotracheal parenchyma diffuse-in-aggregate forming 1-2 seriate, tangential lines, cells storied. *Xylem rays* 4-5 per mm, heterogeneous, of two distinct types, 1-22 seriate, uniseriate rays made up of either upright cells only or both upright and procumbent cells, up to 15 cells or 1500 μm in height; multiseriate rays made up of procumbent cells in the middle part with uniseriate extensions of upright cells at the ends and sheath cells along the flanks, up to 22 seriate and 200 cells or 8000 μm in height. *Fibres* libriform to semi-libriform, non-septate, polygonal in cross section, 30-40 μm in diameter and 450-1000 μm in length.

Holotype — B.S.I.P. Museum specimen no. 35368.

Sterculioxylon sp. cf. *S. shahpurensis*
Bande & Prakash, 1980

Pl. 1, fig. 6; Pl. 2, fig. 8

Material — A well-preserved piece of secondary wood taken out from a large log of the fossil wood.

Description — *Wood* diffuse-porous. *Vessels* medium to large, mostly in radial multiples of 2-8 or in clusters (Pl. 1, fig. 6); rarely solitary; perforations simple; intervessel pit-pairs alternate, bordered, 4-6 μm in diameter with linear-lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric in 1-2 seriate sheath (Pl. 1, fig. 6); apotracheal parenchyma diffuse-in-aggregate forming 1-2

seriate tangential lines (Pl. 1, fig. 6); parenchyma cells storied (Pl. 2, fig. 8). Xylem rays heterogeneous, 1-40 seriate, of two distinct types; uniseriate rays made up of upright cells only or both upright and procumbent cells, up to 15 cells or 1500 μm in height, multiseriate rays made up of procumbent cells in the middle part with extensions of upright cells at the ends and sheath cells on the flanks, up to 40 seriate in width and more than 200 cells or 11,000 μm in height (Pl. 2, fig. 8). *Fibres* libriform, non-septate.

Specimen — B.S.I.P. Museum no. 35369.

Affinities — The structural features of the present fossil wood also indicate its closest affinities with the genus *Sterculia* although such broad rays have not been seen in the modern woods of *Sterculia* so far examined. Besides, during the present study some more fossil woods have been examined from the same locality which exhibit a wide range in the width and height of the xylem rays showing intermediate stages between this fossil wood and that of *Sterculioxylon shahpurensis*. In the fossil wood no. 35372 which exhibits similar structural features like that of *Sterculioxylon shahpurensis*, the xylem rays are much narrower, up to 7 cells in width and 225 cells or 11,000 μm in height and the solitary vessels are quite frequent (Pl. 2, figs 12, 13). In another specimen no. 35371, the xylem rays are more broad, up to 11 cells in width and 200 cells or 9000 μm in height (Pl. 2, figs 10, 11). Further, in specimen no. 35370, even broader, spindle-shaped xylem rays with 23 cells width and 150 cells or 4500 μm in height are seen which exhibit a stage nearer to this fossil wood (Pl. 2, fig. 9). Consequently, all this indicates that there is a series of anatomical structures exhibited by the specimens 35369, 35370, 35371 and 35372 which show variable stages of ray width ranging from narrow, 1-7 seriate to broad, 1-40 seriate condition. Somewhat similar variations in the width of the xylem rays have also been observed in different wood specimens of *Sterculia alata*, *S. campanulata* and *S. urens*. In wood specimen no. F.R.I. 43768/B 6441 of *Sterculia alata*, the xylem rays are 1-9 (mostly up to 6) seriate, while in wood specimen no. F.R.I. 462/06205 of this species the xylem rays are 1-15 seriate. In *Sterculia campanulata* the xylem rays,

which are only 1-10 seriate in wood specimen no. F.R.I. A935/B6547, are 20 seriate in wood specimen no. F.R.I. A1825/B6083. Similarly, in *Sterculia urens* the xylem rays also show variation in their width. While in wood specimen no. F.R.I. A3057/C11027, the xylem rays are 1-13 seriate, they are 1-25 seriate in another wood specimen no. F.R.I. A3059/D64027. This suggests that the fossil wood specimens described above, exhibiting a wide range of variation in ray width, might belong to a single species of *Sterculia* and may represent different parts of the stem and the root; the broader rays being usually present in the root wood. The possibility of their belonging to one and the same species is strengthened by the fact that all these fossil woods have been collected from a small area of the same locality. However, in spite of all this, it would be better to refer them to *Sterculioxylon* sp. cf. *S. shahpurensis* till further evidences are forthcoming either to separate them or put them definitely under this species. It may be further said that this study also emphasizes the necessity of a cautious approach in creating new species of fossil woods based on variable characters.

FAMILY — BURSERACEAE

Genus — *Burseroxylon* Prakash & Tripathi emend. Lakhanpal, Prakash & Awasthi, 1981

2. *Burseroxylon preserratum* Prakash & Tripathi, 1975

Pl. 3, figs 14-17

Material — A single piece of well-preserved secondary wood 25 cm in length and 10 cm in diameter.

Description — Wood diffuse-porous. *Growth rings* indistinct, faintly demarcated by crowding of vessels. *Vessels* small to medium-sized, t.d. 30-150 μm , r.d. 30-200 μm (Pl. 3, fig. 14) solitary and in radial multiples of 2-4 (the multiples become longer in the region of the growth ring), almost uniformly distributed, 10-30 per sq mm (may be more near the region of the growth ring), tyloses present (Pl. 3, fig. 14); vessel members 200-450 μm long with truncate to tailed ends; perforations simple; intervessel pit-pairs alternate,

bordered, polygonal with lenticular apertures, 8-10 μm in diameter (Pl. 3, fig. 17). *Parenchyma* scanty paratracheal vasicentric forming 1-2 seriate sheath around the vessels (Pl. 3, fig. 17). *Xylem rays* 8-12 per mm, 1-3 (mostly 2) seriate, uniseriate rays sparse, made up of upright cells only or both upright and procumbent cells, multiseriate rays made up of procumbent cells in the centre and 1-3 seriate extensions of upright cells at one or both the ends (Pl. 3, fig. 15), the end cell usually enlarged and crystalliferous, the rays 2-12 cells or 40-225 μm in height; ray tissue heterogeneous. *Fibres* moderately thick-walled with big lumen, angular in cross section, septate and 400-800 μm long.

The fossil is almost identical to the known fossil species *Burseroxylon preserratum* Prakash & Tripathi (1975) described from the Tipam sandstones near Hailakandi in Assam showing close resemblance with the modern wood of *Bursera serrata* Wall. ex Coleb. Consequently, it is assigned to it. The minor anatomical differences observed in the fossil wood from the Deccan and that from Assam are due to the absence of growth rings in the latter and in the size of the vessels which are somewhat smaller in the former. However, these differences have been found to occur in different modern wood specimens of *Bursera serrata* (Prakash & Tripathi, 1975, p. 59). In addition to the variations observed by these authors it was also observed that there is a variation in the frequency of enlarged crystalliferous cells in the rays of *Bursera serrata*. In some of the specimens of this species studied at the Forest Research Institute, Dehradun (slide nos. 355/E6013 & A264/B6438), the crystalliferous cells are not frequent, whereas in other specimens (slide nos. 289/05507 & 1983/E6073) the crystalliferous cells are abundant. Similar variations were also observed in different fossil wood specimens collected along with the fossil described above. Thus in the above specimen, the crystalliferous cells in the rays are not very frequent but in another specimen no. 35375 they are abundant (Pl. 3, fig. 16).

The genus *Bursera* Linn. consists of 80 species widely distributed in tropical America especially in the West Indies, northern South America, Central America and Mexico, and two species extend north-

ward into the United States. *Bursera serrata* Wall. ex Coleb. with which the present fossil wood resembles closely is the sole Indian species extending from eastern moist zone of Bengal, Assam, Orissa, Chittagong to tropical forests of Upper and Lower Burma. It also occurs in Rajmahal hills, extending to eastern Ghats, especially in the valley and along water courses (Pearson & Brown, 1932, p. 224; Ghosh, Purkayastha & Rawat, 1963, p. 71; Willis, 1973). The present finding thus records *Bursera serrata* in the Deccan Plateau and extends the antiquity of this genus in the Palaeogene of India. The other fossil records of Burseraceae from the Deccan Intertrappean beds of India are *Boswellioxylon indicum* Dayal (1964, 1966) said to be similar to the modern genus *Boswellia* and one more fossil wood, tentatively assigned to this family by Shallom (1958).

Specimen — B.S.I.P. Museum no. 35374.

FAMILY — ANACARDIACEAE

Genus — *Dracontomelumoxylon* Ghosh & Roy, 1979

3. *Dracontomelumoxylon mangiferumoides* Ghosh & Roy, 1979

Pl. 3, figs 18-20

Material — A silicified piece of mature secondary wood, 10 cm in length and 6 cm in diameter.

Description — *Wood* diffuse-porous. *Growth rings* absent. *Vessels* small to large, t.d. 60-225 μm , r.d. 60-300 μm , solitary and in radial multiples of 2-4, rarely in small clusters (Pl. 3, fig. 19), 9-12 per sq mm; tyloses present; perforations simple; inter-vessel pit-pairs alternate, bordered, 8-12 μm in diameter, polygonal in shape with lenticular apertures (Pl. 3, fig. 18). *Parenchyma* paratracheal vasicentric to aliform, sometimes aliform-confluent (Pl. 3, fig. 19). *Xylem rays* 1-4 seriate, up to 30 cells high and 5-7 per mm; uniseriate rays made up of upright cells only, multiseriate rays made up of procumbent cells in the centre with uniseriate extensions of upright cells at the ends (Pl. 3, fig. 20); ray tissue heterogeneous. *Fibres* moderately thick-walled, rarely septate, polygonal in cross section.

The fossil wood is almost identical to the known species *Dracontomelumoxylon mangiferumoides* Ghosh & Roy (1979) recently described from the Tertiary deposits of Labpur, District Birbhum, West Bengal and resembles the modern wood of *Dracontomelum mangiferum*. The only difference observed between the two fossil woods is that in the wood described from West Bengal the parenchyma is only 2-4 seriate vasicentric but in the present fossil wood from Deccan it is vasicentric to aliform, sometimes aliform confluent. However, similar variation in parenchyma distribution has also been observed in different modern wood samples of *Dracontomelum mangiferum*. Consequently, the present fossil wood has been referred to this species.

Besides, two more fossil woods resembling *Dracontomelum mangiferum* have recently been described under the name *Dracontomeloxylon palaeomangiferum* by Prakash (1979) and by Bande and Khatri (1980) from the Lower Siwalik beds of Himachal Pradesh and the Deccan Intertrappean beds of Parapani in Madhya Pradesh respectively. All these fossil woods are almost identical to each other except in possessing some minor variations. Under the circumstances, *Dracontomeloxylon palaeomangiferum* Prakash (1979) becomes synonym to *Dracontomelumoxylon mangiferumoides* Ghosh & Roy (1979) which has the priority.

Dracontomelum mangiferum Blume is a tree by habit growing wild in damp places along the streams in Andaman and Nicobar islands. In Burma, it is found in Myitkyiana, Katha and Mergui. It also occurs in Malaya Peninsula (Ghosh & Purkayastha, 1963, p. 275).

Specimen — B.S.I.P. Museum no. 35376.

FAMILY — MELIACEAE

Genus — *Heyneoxylon* Bande & Prakash, 1980

4. *Heyneoxylon tertiarum* Bande & Prakash, 1980

Pl. 4, figs 21-25; Text-fig. 2

Material — A piece of secondary wood 8 cm in length and 5 cm in diameter.

Topography — Wood diffuse-porous. *Growth rings* indistinct demarcated by fine



TEXT-FIG. 2 — *Heyneoxylon tertiarum* gen. et sp. nov.— Cross section showing small vessels, xylem rays and alternating bands of parenchyma and fibres, $\times 40$. Slide no. 6158/35377.

bands of terminal parenchyma. *Vessels* mostly small, rarely medium-sized, solitary and in radial rows of 2-6, also in clusters (Pl. 4, figs 21, 22; Text-fig. 2), evenly distributed, 6-13 per sq mm. *Parenchyma* terminal and paratracheal forming 3-10 seriate continuous or interrupted tangential bands alternating with similar bands of the fibres. The bands bifurcating at places and joining similar bands on upper and lower side (Pl. 4, figs 21, 22; Text-fig. 2). *Xylem rays* fine to medium, 6-9 per mm, 1-6 (mostly 2-4) seriate or 15-90 μm in width and 1-42 cells or 30-900 μm in height; uniseriate rays either made up of upright cells only or both upright and procumbent cells, multiseriate rays made up of procumbent cells in the central portion with 1-5 cells high uniseriate extensions similar to uniseriate rays at one or both the ends, ray tissue heterogeneous. *Fibres* arranged in tangential bands alternating with similar bands of parenchyma (Pl. 4, figs 21, 22).

Elements — *Vessels* circular to oval when solitary, with flat contact walls when in groups, t.d. 30-90 μm , r.d. 20-135 μm , vessel members 100-300 μm long with truncate to tailed ends; perforations simple; intervessel pit-pairs alternate to opposite, bordered, minute, about 4 μm in diameter with lenticular sometimes coalescent apertures (Pl. 4, fig. 25). *Parenchyma cells* very variable in size, thin-walled, 20-50 μm in diameter and 30-120 μm in length, sometimes fusiform and quite similar to the smaller vessels, vessel parenchyma pits similar to intervessel pits. *Ray cells* thin-walled, procumbent cells 15-20 μm in tangential height and 20-90 μm in radial length; upright cells 30-40 μm in tangential height and 20-25 μm in radial length (Pl. 4, fig. 24). *Fibres* moderately thick-walled to thick-walled, angular in cross-section, rarely septate, 15-30 μm in diameter and 400-600 μm in length

Affinities — The important anatomical characters of the fossil wood namely mostly small vessels with simple perforations, broad bands of paratracheal parenchyma, 1-6 seriate heterocellular xylem rays and thick-walled, mostly nonseptate fibres indicate its affinities with the modern woods of Meliaceae (Kribs, 1930; Panshin, 1933; Pearson & Brown, 1932, pp. 234-274; Metcalfe & Chalk, 1950, pp. 349-359; Ghosh, Purkayastha & Krishna Lal, 1963, pp. 81-159). Besides, a near resemblance was also observed with the wood of *Mappia foetida* Miers. of Icacinaceae. However, in *Mappia foetida* the percentage of uniseriate xylem rays is much more than in the present fossil, the multiseriate rays are usually separated by a number of uniseriate rays. Among the various genera of Meliaceae the present fossil is very closely comparable with the modern wood of *Heynea trijuga* Roxb., the only species of the genus *Heynea* Roxb. represented in India. This comparison included a detailed examination of a number of thin sections from wood samples of this species besides studying its photographs and description (Ghosh, Purkayastha & Krishna Lal, 1963, pp. 130-132, pl. 44, figs 259, 260). It indicates that both in *Heynea trijuga* as well as in the present fossil, the wood is diffuse-porous, growth rings indistinct, vessels small to very small, solitary and in radial multiples of 2-4 and in short clusters, perforations simple and

the inter-vessel pit-pairs are bordered, alternate and minute. Parenchyma in *H. trijuga* is quite similar to that in the fossil wood. It is aliform to aliform-confluent and forms wavy, continuous tangential bands. The thickness of these bands also varies at different places and quite frequently they are as thick as the alternating fibre bands like those of the present fossil. The xylem rays of *H. trijuga* are also quite similar to those of the present fossil being 1-5 seriate, heterocellular, made up of both procumbent and upright cells and are up to 35 cells in height. Further, the fibres in both the extant species and the fossil wood are moderately thick-walled to thick-walled and rarely septate.

As the fossil is closely comparable to the modern wood of *Heynea trijuga* in its anatomical characters, it has been placed under the genus *Heyneoxylon* instituted to include the fossil woods of *Heynea* Roxb. of the family Meliaceae. The specific name *Heyneoxylon tertiarum* indicates its occurrence in the Tertiary period. Although this is the first record of a fossil wood of *Heynea* from the Deccan Intertrappean beds, a fossil wood showing similarity with the genus *Amoora* Roxb., also belonging to Meliaceae, has recently been described from the Deccan Intertrappean beds near Nawargaon in Wardha District of Maharashtra (Bande & Prakash, 1983).

The family Meliaceae consists of 50 genera and 1400 species of trees and shrubs growing in warm climate (Willis, 1973). In India, the family is represented by 19 genera. *Heynea* Roxb. is a small genus of trees or shrubs confined to the Indo-Malayan region. The only Indian species, *Heynea trijuga* Roxb., is a small tree, 6-12 m in height, widely distributed in India. It grows in the sub-Himalayan tract up to 1500 m elevation from Kumaon eastwards to North Bengal. It also occurs in the plain and hill forests of Assam ascending to 600 m, Chota Nagpur, in the Eastern Ghats up to 1400 m and in the Western Ghats where it is common from Mysore to Travancore up to 1800 m. In Burma, it occurs in the hill forests at an elevation of about 600-1200 m. It is also found in southern China, Thailand, the Malaya Peninsula and Sumatra (Ghosh, Purkayastha & Krishna Lal, 1963, p. 131).

GENERIC DIAGNOSIS

Heyneoxyton Bande & Prakash, 1980

Wood diffuse-porous. *Growth rings* faint, demarcated by fine bands of parenchyma. *Vessels* very small to medium, solitary and in short radial multiples; perforations simple; intervessel pit-pairs bordered, alternate to opposite, and minute. *Parenchyma* aliform confluent frequently forming wavy bands and also thin lines at the growth rings. *Xylem rays* fine to medium, ray tissue heterogeneous. *Fibres* moderately thick-walled to thick-walled, septate or nonseptate. *Gum canals* vertical, traumatic, present or absent.

Genotype — *Heyneoxyton tertiarum* Bande & Prakash, 1980.

members 100-300 μm long with truncate to tailed ends; perforations simple; intervessel pit-pairs bordered, alternate to opposite, about 4 μm in diameter with lenticular, sometime coalescent apertures, *Parenchyma* terminal and paratracheal, forming 3-10 seriate, continuous or interrupted, tangential bands; cells very variable in length and width. *Xylem rays* 1-6 (mostly 2-4) seriate, homocellular to heterocellular, made up of both procumbent and upright cells, 1-42 cells or 30-900 μm in height and 6-9 per mm. *Fibres* moderately thick-walled to thick-walled, arranged in tangential bands alternating with similar bands of parenchyma, rarely septate, 15-30 μm in diameter and 400-600 μm in length.

Holotype — B.S.I.P. Museum no. 35377.

SPECIFIC DIAGNOSIS

Heyneoxyton tertiarum Bande & Prakash, 1980

Wood diffuse-porous. *Growth rings* indistinct, demarcated by terminal parenchyma. *Vessels* mostly small, rarely medium-sized, t.d. 30-90 μm , r.d. 20-135 μm , solitary and in radial rows of 2-6, also in clusters, 6-13 per sq mm; vessel

ACKNOWLEDGEMENTS

The authors express their sincere thanks to Dr Dharmendra Prasad, Secretary, District Archaeological Association, Mandla, for his kind help during the search of this locality. They are also thankful to the authorities of the Forest Research Institute, Dehradun for permission to consult the modern wood slides at the Wood Anatomy Branch of the Institute.

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EXPLANATION OF PLATES

PLATE 1

- Sterculioxylon shahpurensis* — Cross section showing shape, size and distribution of vessels, broad xylem rays and parenchyma. $\times 35$. Slide no. 6139/35368.
- S. shahpurensis* — Cross section enlarged to show vessels, broad xylem rays, tangential lines of parenchyma and thick-walled fibres. $\times 55$. Slide no. 6139/35368.
- S. shahpurensis* — Tangential longitudinal section showing uniseriate and broad multiseriate xylem rays and storied parenchyma. $\times 30$. Slide no. 6140/35368.
- S. shahpurensis* — Intervessel pit-pairs. $\times 110$. Slide no. 6140/35368.
- S. shahpurensis* — Radial longitudinal section showing heterocellular xylem rays. $\times 110$. Slide no. 6141/35368.
- Sterculioxylon* sp. cf. *S. shahpurensis* — Cross section showing vessels, broad xylem rays and parenchyma. $\times 25$. Slide no. 6142/35369.
- Sterculioxylon* sp. cf. *S. shahpurensis* — Cross section showing vessels, xylem rays and tangential lines of parenchyma. $\times 25$. Slide no. 6144/35370.

PLATE 2

- Sterculioxylon* sp. cf. *S. shahpurensis* — Tangential longitudinal section showing up to 40 seriate

- xylem rays and storied parenchyma. $\times 30$. Slide no. 6143/35369.
9. *Sterculioxylon* sp. cf. *S. shahpurensis* — Tangential longitudinal section showing spindle-shaped, up to 20 seriate xylem rays and storied parenchyma. $\times 30$. Slide no. 6145/35370.
 10. *Sterculioxylon* sp. cf. *S. shahpurensis* — Cross section showing vessels, xylem rays and parenchyma. $\times 25$. Slide no. 6146/35371.
 11. *Sterculioxylon* sp. cf. *S. shahpurensis* — Tangential longitudinal section showing up to 10 seriate heterocellular xylem rays and storied parenchyma. $\times 25$. Slide no. 6147/35371.
 12. *Sterculioxylon* sp. cf. *S. shahpurensis* — Cross section showing vessels, xylem rays and parenchyma. $\times 25$. Slide no. 6148/35372.
 13. *Sterculioxylon* sp. cf. *S. shahpurensis* — Tangential longitudinal section showing up to 6 seriate xylem rays and storied parenchyma. $\times 40$. Slide no. 6149/35372.
- PLATE 3
14. *Burseroxylon preserratum* — Cross section showing solitary and paired vessels with tyloses, vasicentric parenchyma and xylem rays. $\times 105$. Slide no. 6153/35374.
 15. *B. preserratum* — Tangential longitudinal section showing 1-2 seriate, xylem rays with enlarged crystalliferous cells in some of the rays and septate fibres. $\times 105$. Slide no. 6154/35374.
 16. *B. preserratum* — Tangential longitudinal section from another specimen showing xylem rays with abundant crystalliferous cells. $\times 135$. Slide no. 6155/35375.
 17. *B. preserratum* — Intervessel pit-pairs. $\times 250$. Slide no. 6154/35374.
 18. *Dracontomelumoxylon mangiferumoides* — Intervessel pit-pairs. $\times 250$. Slide no. 6156/35376.
 19. *D. mangiferumoides* — Cross section showing shape, size and distribution of vessels, paratracheal aliform to confluent parenchyma and xylem rays. $\times 30$. Slide no. 6157/35376.
 20. *D. mangiferumoides* — Tangential longitudinal section showing heterocellular xylem rays. $\times 55$. Slide no. 6156/35376.
- PLATE 4
21. *Heyneoxyton tertiarum* — Cross section showing shape, size and distribution of vessels, alternating bands of parenchyma and fibres and xylem rays. $\times 40$. Slide no. 6158/35377.
 22. *H. tertiarum* — Cross section enlarged to show alternating bands of parenchyma and fibres. $\times 65$. Slide no. 6158/35377.
 23. *H. tertiarum* — Tangential longitudinal section showing heterocellular xylem rays, parenchyma and fibres. $\times 100$. Slide no. 6159/35377.
 24. *H. tertiarum* — Radial longitudinal section showing heterocellular xylem rays. $\times 40$. Slide no. 6160/35377.
 25. *H. tertiarum* — Intervessel pit-pairs. $\times 250$. Slide no. 6159/35377.

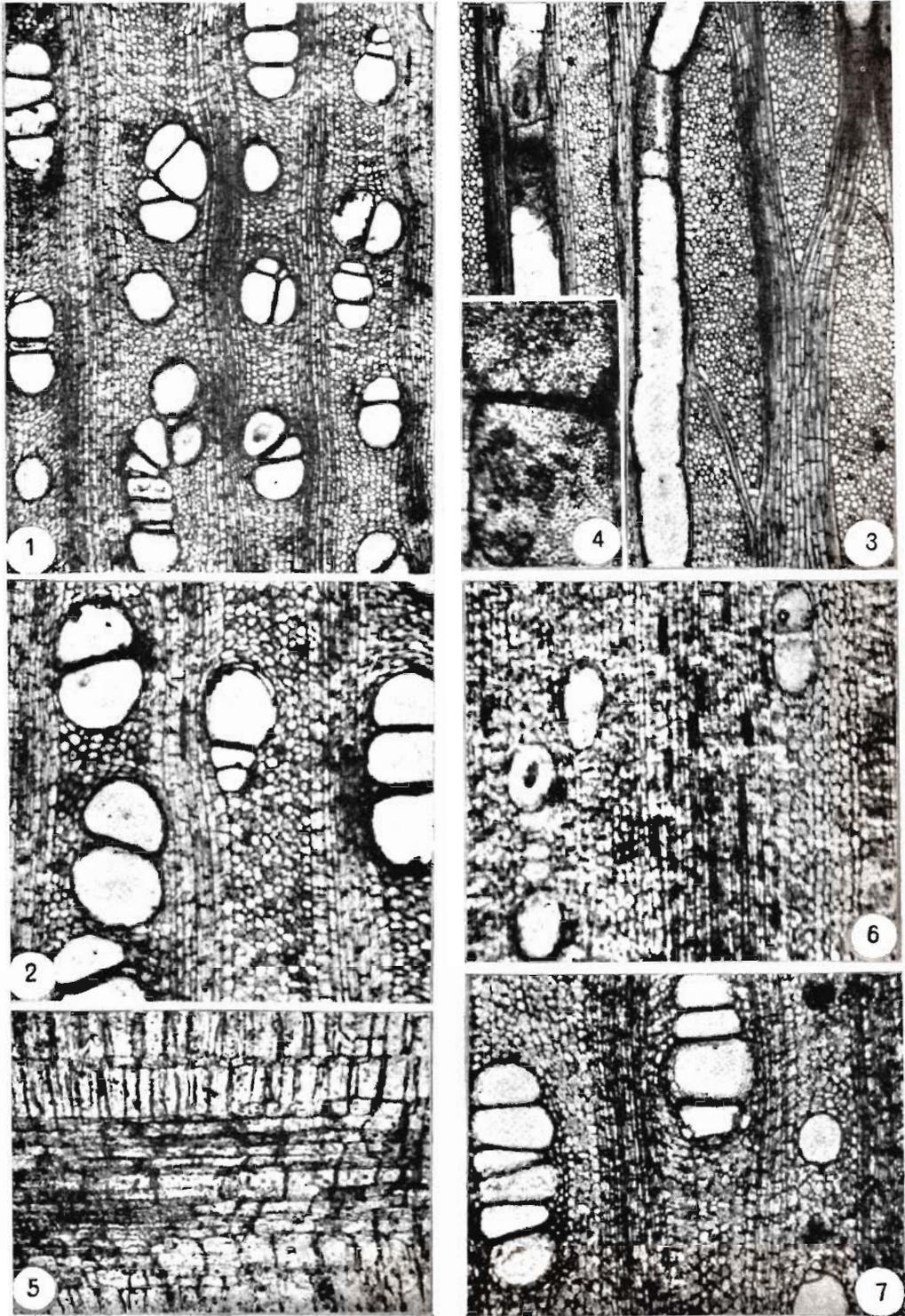


PLATE 1

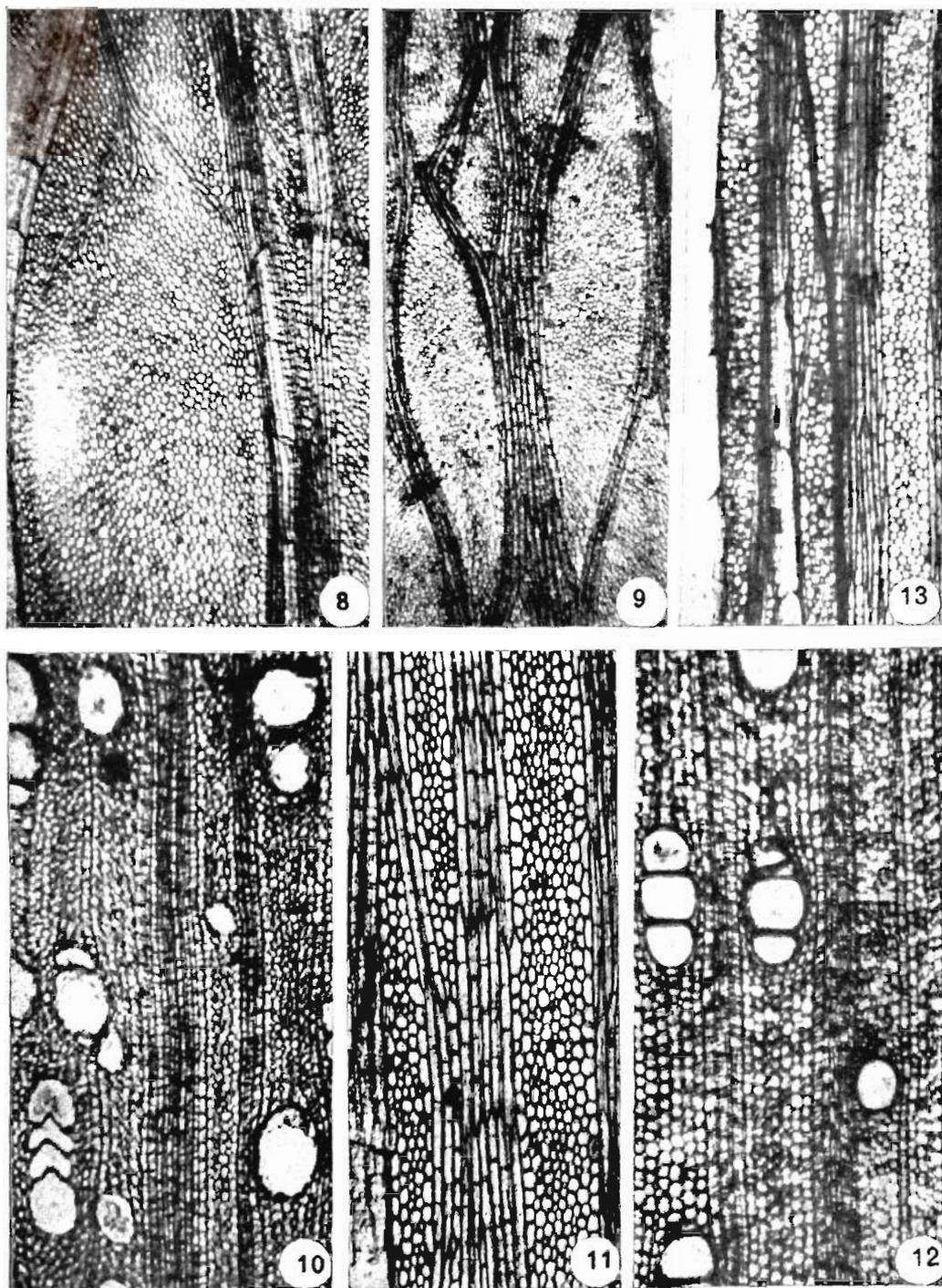
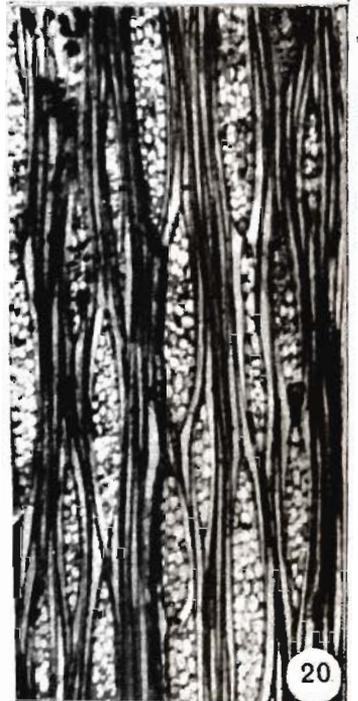
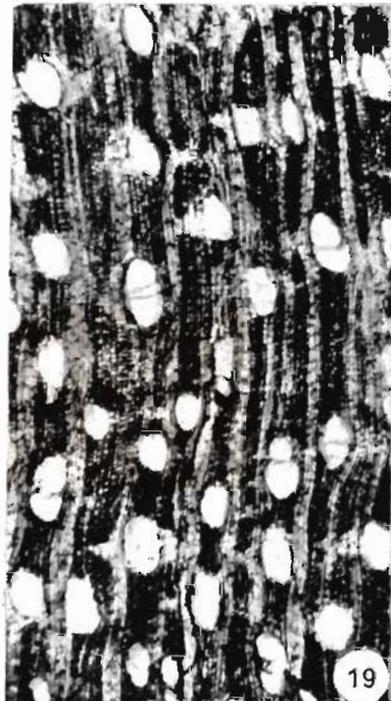
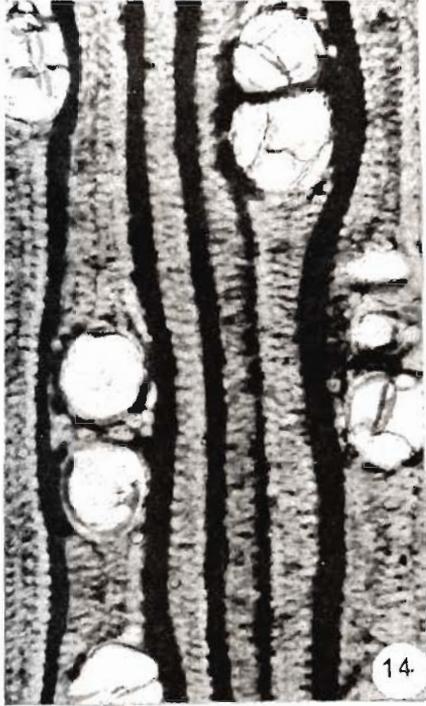


PLATE 2



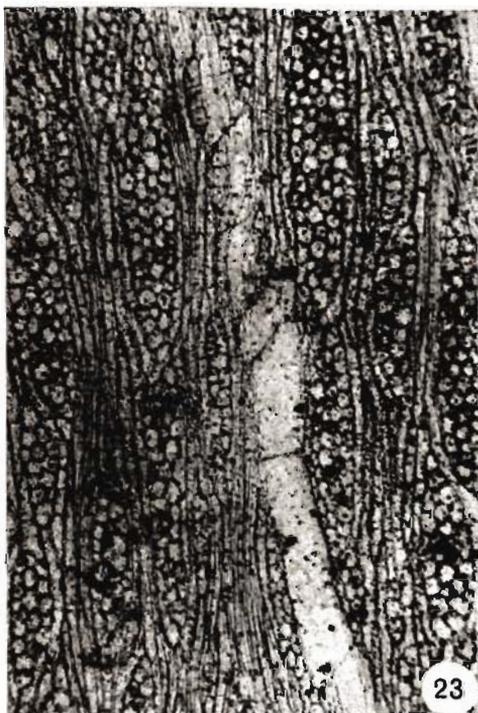
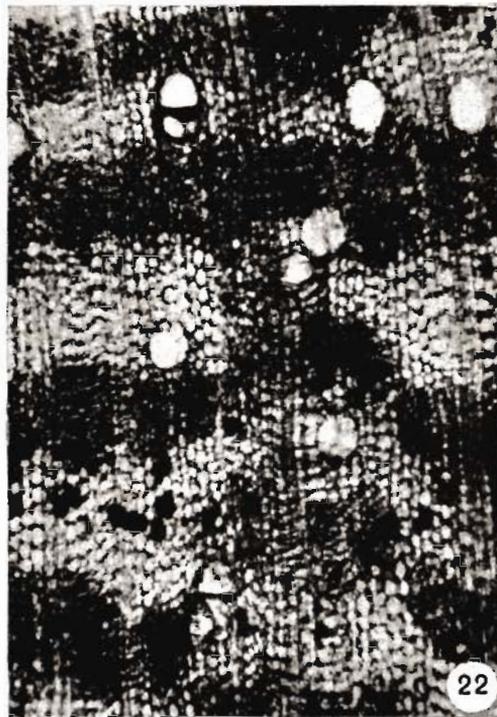


PLATE 4