FOSSIL WOODS RESEMBLING ELAEOCARPUS AND LEEA FROM THE DECCAN INTERTRAPPEAN BEDS OF MAHURZARI NEAR NAGPUR

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ABSTRACT
In this paper are described two new fossil woods from the Deccan Intertrappean Series at Mahurzari (21° 13' N; 79° 1' E) near Nagpur in Maharashtra state. These have been assigned to two new genera, Elaeocarpoxylon and Leeoxylon because of their strong resemblance with the modern woods of Elaeocarpus L. and Leea L. respectively.

INTRODUCTION
The present study is concerned with the description and interpretation of two fossil woods, one of Elaeocarpus and the other of Leea, from the Deccan Intertrappean beds of Mahurzari in Nagpur district. Both these genera are of interest anatomically and in their palaeogeographic distribution in the Tertiary of Deccan Plateau. The age of the Deccan Intertrappean beds, although a controversial matter, is now generally regarded as Early Tertiary, probably Eocene on the basis of plant remains found from the earliest Intertrappean beds of the series exposed in Nagpur and Chhindwara districts (CROOKSHANK et al., 1937; SAINI, 1940).

The fossiliferous locality of Mahurzari is rich in fossil woods which are being intensively studied with regard to their botanical identification. A correct interpretation of a number of plants discovered here is bound to throw much light in deciphering the age of the Intertrappean beds and also the palaeoclimate and palaeogeography of the region.

So far only a few fossil woods have been described from this area. The first one to be described was a dicotyledonous wood, without a name, showing affinities to Burseraceae and Anacardiaceae (SHALLOM, 1958). Prakash (1958) described another wood as Glochidioxylon sahnii resembling the genera Glochidion and Antidesma. It has recently been renamed Paraphyllanthoxylon sahnii by Mädel (1962). In 1959, Shallow briefly described a Simaroubaceous wood under a new generic name — Simarubaceoxylon (S. mahurzari*). However, later on she (SHALLOM, 1959a) transferred this wood to the genus Ailanthoxylon Prakash (1958). Shallow (1960) further described another wood as Barringtonioxyxylon deccanense resembling the modern genus Barringtonia of Lecythidaceae. Prakash (1962) has published a detailed account of a fossil wood of Aeschynomene. More recently Prakash and Dayal (1963) have described a fossil wood resembling Grewia Linn.

The preservation of structure of the fossil woods is unusually good although it has been generally seen that the percentage of organic matter retained in the Intertrappean silicifications is very low. Hence, it is apparent that the woods were mineralized at a stage when there was almost complete break down of the cellulosic component of the cell wall.

DESCRIPTION
Family — Elaeocarpaceae

Elaeocarpoxylon antiquum gen. et sp. nov.

The specimen described here consists of a piece of petrified secondary wood measuring about 6 cm. in length and 3.5 cm. in diameter. It is brown to rusty-brown in colour with good preservation.

Topography — Wood diffuse-porous (Pl. 1, Fig. 1). Growth rings indistinct. Vessels appearing as minute dots with the naked eye, the orifices not easily distinguishable without a hand lens, small to medium-sized, commonly in radial multiples of 2-9 (mostly 3-4) cells (Pl. 1, Figs. 1, 3), occasionally solitary and in short double rows or small clusters, 5-14 per sq. mm., distributed without any definite pattern, usually with

*Correct form is Simaroubaceoxylon mahurzariense.
rays contiguous on one or both the sides; tyloses present (Pt. 1, Fig. 7). Parenchyma paratracheal, limited to a few cells round the vessels, not easily recognized in the transverse sections, clearly seen in the tangential longitudinal sections. Xylem rays not visible with the naked eye, distinct with a hand lens, medium to fine, 1-3 cells and 12-80 μ broad, closely spaced, 12-18 per mm. (Pt. 1, Fig. 7); ray tissue markedly heterogeneous (Pt. 1, Figs. 5-7); rays divisible on the basis of size and composition into two types, (a) narrow rays homocellular, uniseriate, 12-20 μ in width, consisting of upright cells only (Pt. 1, Figs. 6, 7), very variable in height; (b) broader rays heterocellular, 2-3 (mostly 2) seriate throughout the median thickened portion, with long uniseriate marginal extensions of upright cells at one or both the ends (Pt. 1, Figs. 6, 7); median portion 52-80 μ wide consisting of all procumbent cells. Fibres not aligned in distinct radial rows, however, at some places there appears to be a tendency to align themselves in vertical rows (Pt. 1, Fig. 3). Intercellular canals vertical, traumatic, arranged in horizontal rows (Pt. 1, Fig. 4).

Elements — Vessels thin-walled, the walls about 4 μ thick, t.d. 60-150 μ, r.d. 30-145 μ; circular to elliptical when solitary, those in radial multiples generally flattened at the places of contact (Pt. 1, Figs. 1, 3), their outline being irregular at a number of places due to compression during fossilization; vessel-members short to medium-sized, 280-630 μ long with tapered ends; perforations simple, perforation plates horizontal or slightly oblique; intervascular pit-pairs large, 8-12 μ in diameter, bordered, usually alternate, round to oval sometimes hexagonal due to crowding with lenticular, horizontal apertures (Pt. 1, Fig. 2); vessel-parenchyma pits larger than the intervascular pits, several to each cell, with large horizontal apertures and distinct borders; vessel-ray pits not observed. Parenchyma cells thin-walled, t.d. 16-28 μ, height 40-68 μ. Ray cells thin-walled with infiltration, the walls about 4 μ thick; procumbent cells vacuously shaped, t.d. 16-20 μ, r.d. 24-36 μ; upright cells with t.d. 12-20 μ, r.d. 44-92 μ; crystals appear to be present in some ray cells. Fibres thin-walled, the walls 3-4 μ thick, septate, angular in the cross-section (Pt. 1, Figs. 3, 6); t.d. 12-32 μ, r.d. 12-28 μ; interfibre pits not observed.

Affinities and Discussion

Structural features of the fossil wood indicate, after extensive comparison, that its closest affinity is with the modern genus Elaeocarpus L. The fossil wood also shows a somewhat near resemblance to the mature secondary xylem of Echinocarpus Bl. However, the presence of a somewhat continuous line of parenchyma, delimiting the growth rings in many specimens of Elaeocarpus, serves to distinguish them from Echinocarpus, in which the parenchyma is diffuse, confluent and in narrow sheaths round the vessels (KUKACHKA & REES, 1943, p. 53; METCALFE & CHALK, 1950, p. 265; CHOWDHURY & GHOSH, 1958, p. 241). Besides, the intercellular canals of the vertical traumatic type have also been reported in Echinocarpus (RECORD, 1925; DESCH, 1941, p. 154) but not found in Echinocarpus.


The size and distribution of vessels in Elaeocarpoxylon antiquum nearly agrees with the distributional pattern in Elaeocarpus ferrugineus. Both in E. ferrugineus and the fossil the perforations are simple and the intervascular pit-pairs are usually alternate, bordered and the tyloses are present in the
vessels. However, the solitary vessels are more frequent in the modern species than in the fossil wood. Also the intervacular pit-pairs are separated and possess linear apertures in *E. ferrugineus* as against contiguous pit-pairs with lenticular apertures in the fossil wood which thus resembles the intervacular pit-pairs of *Elaeocarpus robustus*. Also in *E. ganitrus* the intervacular pit-pairs are contiguous and the apertures are linear to lenticular.

Although the distribution of parenchyma is different in the fossil and the modern wood of *E. ferrugineus*, the ray and fibre structure are basically similar in both. In *E. ferrugineus* the parenchyma is terminal forming faint lines at the rings but absent from many of them, whereas in the present fossil wood it is only scanty-paratracheal, somewhat similar to that of *E. floribundus* (Metcalfe & Chalk, 1950, p. 264, Fig. 64 D) minus the terminal parenchyma. Pearson and Brown (1932) also report the absence of terminal parenchyma in *E. lanceaefolius*.

Although the fibre structure is almost identical in both, the fibres are rarely septate in *E. ferrugineus* but commonly septate in the fossil wood as is also known in *Elaeocarpus robustus* and *E. lanceaefolius* (Pearson & Brown, 1932, pp. 183-185).

The vertical intercellular canals of traumatic type are present both in the Intercarpean fossil wood, and the modern wood of *Elaeocarpus* (Record, 1925; Desch, 1941, p. 154) although the authors have not been able to see these canals in the small specimens of the modern wood of *Elaeocarpus* available to them.

Thus it is evident from the above comparison that the fossil wood shows the closest resemblance in structural features with the modern wood of *Elaeocarpus* with a near approach to the species *E. ferrugineus*. Consequently, the present fossil wood has been named, *Elaeocarpxylon gen. nov.* The specific name, *Elaeocarpxylon antiquum* indicates its geological antiquity.

As far as known, the present finding forms the first record of the fossil wood of *Elaeocarpus* from India and abroad. Fruit remains of the genus are, however, known from the Tertiary of Australia as *Elaeocarpus mackayi* (F.v.M.) Kirchheimer (1935, p. 179). According to him (Kirchheimer, loc. cit.) fossil remains from the European Tertiary, which were compared with *Elaeocarpus*, belonged to the family Cornaceae (see also Gothan & Weyland, 1954, p. 415) and those from the Tertiary of Japan (Nathorst, 1883, in Kirchheimer, 1935) do not show any definite characters which indicate their unquestioned similarity with *Elaeocarpus*.

*Elaeocarpus* is a large genus of trees consisting of over a hundred species spread over a wide area, the majority being found in the Indo-Malayan region. It is also represented in Madagascar, Socotra, Cochin-China, the Philippines, Formosa, the Pacific islands, Australia and New Zealand. About 25 species occur in Indian region. The species *Elaeocarpus ferrugineus*, with which the fossil wood resembles most, occurs in the forests of Western Ghats, in the Nilgiris, Anamalais, Pulney hills as well as the high hills of Travancore (Chowdhury & Ghosh, 1958).

**Diagnoses**

*Elaeocarpxylon antiquum* sp. nov.

Wood diffuse-porous. Vessels small to medium-sized, solitary and in radial multiples of 2-4 or more cells, open or sparsely plugged with tyloses; vessel-members short to medium-sized or long; perforations simple; intervacular pit-pairs large, bordered, alternate and opposite; vessel-parenchyma pits larger than the intervacular pits. Parenchyma paratracheal, limited to a few cells associated with the vessels, terminal parenchyma absent or present. Xylem rays medium to fine, divisible on the basis of size and composition into two types; ray tissue markedly heterogeneous. Fibres non-libriform, septate, thin-walled. Intercellular canals traumatic, vertical.

*Elaeocarpxylon antiquum* gen. nov.

Vessels small to medium-sized, t.d. 60-150 μ, r.d. 30-145 μ, commonly in radial multiples of 3-4, sometimes up to 9 cells, thin-walled, sparsely tylosed, 5-14 per sq. mm.; vessel-members short to medium-sized, 280-630 μ long with tapered ends; perforations simple, perforation plates horizontal to slightly oblique; intervacular pit-pairs usually alternate, occasionally opposite, with round to oval borders sometimes hexagonal due to crowding with lenticular, horizontal apertures. Parenchyma as few cells associated with the vessels; terminal parenchyma absent; cells thin-walled. Xylem
rays 1-3 cells and 12-80 μ broad, 12-18 per
mm.; uniseriate rays homocellular, of upright
cells only; multiseriate rays heterocellular
consisting of procumbent cells throughout
the median thickened portion, with long
uniseriate marginal extensions of upright cells
at one or both the ends. Fibres non-libriform,
commonly septate, thin-walled, angular in the
cross-section, t.d. 12-32 μ, r.d. 12-28 μ.
*Intercellular canals* traumatic, vertical.

_Holotype_ — B.S.I.P. Museum No. 32734.

_Locality — Mahurzari, Nagpur district,
Maharashtra, India.

_Horizon — Deccan Intertrappean series.

_Age — Early Tertiary (probably Eocene)._  

**Family — Vitaceae**

*Leeoxylon multiseriatum* gen. et sp. nov.

The following description is based on a
piece of a petrified wood measuring about
4 cm. in length and 4-4.5 cm. in diameter.
The present specimen is fairly well-preserved
and consists of secondary xylem only. The
general appearance of the fossil suggests
that either it comes from a small branch
of a tree or belongs to a shrub. The fossil
wood shows considerable distortion of the
tissues which commonly occurs where a branch
is being given off. This is also associated
with the climbing nature of the plant.

**Topography —** Wood diffuse-porous, coarse­
textured. _Growth rings_ not observed either
with a hand lens or under the microscope
(Pl. 2, Figs. 11, 15). _Vessels_ visible as small
dots with the naked eye against the ground
mass of the wood, small to medium-sized,
mostly moderately small, solitary and in
radial multiples of 2-3 or more cells (Pl. 2,
Figs. 11, 15), occasionally in clusters, 8-15
per sq. mm., evenly distributed, sometimes
contiguous to the rays; tyloses present
(Pl. 2, Fig. 13). _Parenchyma_ present in
limited amount as few cells associated with
some vessels (entirely absent from others),
recognizable in the radial longitudinal sec­
tions only. _Xylem rays_ quite prominent as
broad lines on the cross-surface of the wood
(Pl. 2, Figs. 11, 15), 1-18 cells and up to
525 μ broad, closely spaced, 2-3 per mm.
(Pl. 2, Figs. 12, 14); ray tissue markedly
heterogeneous (Pl. 2, Figs. 12, 14, 17);
uniseriate rays rare, homocellular, consisting
wholly of upright cells, up to 6 cells and
192 μ high; multiseriate rays 4-18 cells and
120-525 μ wide and 375-2775 μ high, often
showing various stages of dissection into
smaller units (Pl. 2, Fig. 14), often very
much inflated near the knot (Pl. 1, Fig. 8;
Pl. 2, Fig. 14); heterocellular, consisting of
1-3 marginal rows of upright cells and
multiseriate part of mixed procumbent and
square cells, with sheath cells at the flanks
(Pl. 2, Figs. 12, 14). Fibres not well pre­served,
aligned in distinct radial rows between the
two consecutive xylem rays (Pl. 2, Fig. 9).
Almost in all the cells secondary wall not preserved, only primary wall
giving the shape of the fibre in cross-section.

.Elements —** Vessels** thin-walled, the walls
about 4 μ thick; t.d. 45-120 μ, r.d. 60-120 μ;
round to oval in cross-section, those in radial
groups flattened at the place of contact
(Pl. 2, Fig. 9); vessel-members of medium­
size, 495-600 μ long with tapered ends;
perforations simple (Pl. 2, Fig. 16), per­
foration plates slightly horizontal to oblique;
intervascular pitting scalariform (Pl. 2,
Fig. 10) rarely opposite, bars often branched;
vessel-ray and vessel-parenchyma pits similar
to the intervascular pitting. _Parenchyma_
cells thin-walled, t.d. 20-24 μ, height 44­
56 μ. _Ray cells_ thin to slightly thick-walled;
cells of various shapes and sizes ranging from
very small to large and elongated as seen
in the tangential longitudinal sections (Pl. 2,
Figs. 12, 14); procumbent cells circular or
angular, t.d. 12-32 μ, r.d. 16-48 μ; marginal
upright cells t.d. 32 μ, r.d. 40 μ; sheath
cells t.d. 20-45 μ, r.d. 72-80 μ; pits of the
ray cells not observed. Fibres septate,
thin to slightly thick-walled with large
lumina (Pl. 2, Figs. 9, 12, 14), circular or
angled in the cross-section; t.d. 20-36 μ,
r.d. 16-36 μ; interfibre pits not observed.

**AFFINITIES AND DISCUSSION**

Most of the anatomical features of the
present fossil wood are limited to only a few
families of the modern dicotyledons. The
two important characters of the present
fossil, viz., the scalariform intervascular
pitting and conspicuously broad rays, are
so limited in distribution that most of the
dicotyledonous families are eliminated and
the comparison of the fossil wood is restrict­
ed only to the following (Record, 1936,
p. 16, 23; Tupper, 1927; Dadswell &
Record, 1936).

Aquifoliaceae

Araliaceae

Chloranthaceae

Monimiaceae

Rhizophoraceae

Symlocaceae
Cornaceae Vacciniaceae
Fagaceae Violaceae
Flacourtianae Vitaceae
Greyiaceae

On a closer anatomical comparison between the present fossil wood and the above families it has been found that the fossil exhibits its nearest approach to the members of the family Vitaceae (AmpeUidaceae), where it shows the closest resemblance with the genus Leea L. (Hess, 1936, p. 30; DADSWELL & RECORD, 1936, pp. 29, 30, Pl. 2, Fig. 5; METCALFE & CHALK, 1950, pp. 414-418; ADKINSON, 1913). Although with the available material, the authors have not been able to find any modern species of Leoa resembling very closely or identical with the fossil wood, the general agreement in, as well as the numerous microscopic details of, anatomical structure provide sufficient evidence to identify the present Intertrappean fossil wood as a species of Leoa. Our survey included the study of thin sections of Leoa angulata Korth., L. sambucina Wild., L. alata Edgew., L. brunniania C.B. Clarke, L. philippinensis Merrill, L. indica Merrill, and Leoa sp. (from Madagascar) and published descriptions of Leoa sundaca Miq., L. javanica Bl. (MOLL & JANSSONIUS, 1908, p. 314, 315), L. gigantea Griff. (DESH, 1941, p. 5) and L. guineense Don. (METCALFE & CHALK, 1950, p. 414, Fig. 95C).

The present fossil wood combines the specific characters of Leoa indica and L. angulata, resembling L. indica in parenchyma distribution, fibre structure and in vessel size and their distribution and L. angulata in the type of rays with a somewhat similar composition and dissection. However, the rays of L. angulata are not so wide as those of the present fossil wood which approaches in ray width to a species of Leoa from Madagascar. Raphides, although commonly seen in the ray cells of a number of species of Leoa (Hess, 1936, p. 30), are absent from the present fossil wood and also in the extant wood of Leoa alata examined by the authors. MOLL and JANSSONIUS (1908, pp. 314, 315) also report the absence of raphides from Leoa javanica and L. sundaca.

Thus it is evident that the present fossil wood, although showing features of the genus Leoa, does not match exactly with any of the species so far examined by us. As the fossil wood shows anatomical characters of the genus Leoa it has been assigned to a new genus Leoxylon. The specific name, Leoxylon multisieratium, is after the broad rays seen in the fossil wood.

Not many fossil woods of the family Vitaceae are so far known. The four species known from Europe are Ampeloxylon cineritatum Fliche (1899) from Pliocene of Cantal, France; Vitoxylon cohenii Schuster (1911) from the Lower Eocene of south-east Rügen, Prussia; Vitis sp. Kräusel (1920) from the Miocene of Opplen, Silesia and Vitoxylon ampe10psoides Schönfeld (1930) from the Miocene of south-west Germany, agreeing most closely with the genus Ampelopsis. Edwards (1931) suggested synonymy of Vitoxylon Schuster with Ampeloxylon Fliche on grounds that the latter genus had priority over Vitoxylon. From United States of America, Brown (1942) described Vitoxylon opalinum from the Upper Miocene of Virgin Valley beds in Northwestern Nevada indicating its resemblance with Vitis. Watari (1951) described a fossil wood, Leoa coajponica from the Lower Miocene of Simane, Japan. This is the only record of a fossil wood of Leoa known to the authors. This Japanese fossil wood although resembling slightly with Leoxylon multisieratium, differs from it in having large vessels which are up to 220 µ in tangential diameter, in vasicentric parenchyma forming a layer of nearly complete sheath and in possessing less broad, only 4-10 seriate, xylem rays with the cells containing raphides. However, in L. multisieratium the rays are more wider, 1-18 cells broad and the raphides are absent from the ray cells.

The genus Leoa includes about 60 species (WILLIS, 1957) of small trees, herbs or shrubs, most abundant in the tropics of Asia and Africa and rare in Australia. Of the 22 species native to India nine are shrubs or small trees. L. aspera Wall. is very common in deciduous forests all over India; L. sambucina Wild. is common in Darjeeling Terai and throughout the hotter parts of India; L. robusta Roxb. a large shrub in Sikkim Himalayas and Khasia Hills, Northern Circars and West Coast; L. umbraclisera C. B. Clarke, a small tree grows in forests of Sikkim Himalayas, Terai and also perhaps in N. Circars (GAMBLE, 1902); L. alata Edgew. occurs in tropical Himalayas from Garhwal to Sikkim; L. integrijolia Willd. occurs in Western Peninsula (moist valleys in the Circars); L. hirta Roxb. occurs in Sikkim Himalayas, Assam, Silhet, the Khasia hills,
East Bengal, Chittagaon, Pegu and Andaman islands; *L. bracteata* C. B. Clarke, occurs in Sikkim and is very common in Oudh Terai areas and *L. indica* Merrill, is common throughout the hotter parts of India (Hooker 1872; Gamble, 1902; Duthie, 1911).

**DIAGNOSES**

*Leeoxylon* gen. novo.

Wood diffuse-porous. Vessels mostly moderately small, solitary and in radial multiples of 2-3 or more cells; vessel-members of medium-size; perforations simple; intervacular pitting opposite and scalariform. Parenchyma scanty paratracheal. Xylem rays 1-18 cells wide; ray tissue markedly heterogeneous. Fibres septate, thin to slightly thick-walled.

*Leeoxylon* multiseriatum sp. nov.

Vessels moderately small, t.d. 45-120 µ, r.d. 60-120 µ, thin-walled, 8-15 per sq. mm.; tyloses present; vessel-members of medium size, 495-600 µ long with tapered ends; perforations simple, perforation plates slightly horizontal to oblique; intervacular pitting opposite and scalariform. Parenchyma scanty-paratracheal; parenchyma cells thin-walled, t.d. 20-24 µ, height 44-56 µ. Xylem rays 1-18 cells and up to 525 µ wide; uniseriate rays rare; multiseriate rays common, heterocellular, consisting of 1-3 marginal rows of upright cells and multiseriate part of mixed procumbent and square cells, with sheath cells at the flanks. Fibres septate, thin to slightly thick-walled with large lumina; t.d. 20-36 µ, r.d. 16-26 µ.

**Horotype** — B.S.I.P. Museum No. 10392. **Locality** — Mahurzari, Nagpur district, Maharashtra, India. **Horizon** — Deccan Intertrappean series. **Age** — Early Tertiary (probably Eocene).

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**REFERENCES**


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