REVISION OF *HOPEOXYLON INDICUM* NAVALE AND *SHOREOXYLON SPECIOSUM* NAVALE FROM THE CUDDALORE SERIES NEAR PONDICHERRY

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ABSTRACT

The affinities of *Hopeoxylon indicum* and *Shoreoxylon speciosum*, described by Navale (1963) from near Pondicherry, have been revised. These have been found very similar to the woods of *Sindora* of the family Leguminosae. The diagnosis of *Hopeoxylon indicum* Navale has been emended and *Shoreoxylon speciosum* Navale has been placed under *Hopeoxylon* Navale emend. and named as *Hopeoxylon speciosum* (Navale) comb. nov. Besides, a new wood also resembling *Sindora*, collected from the same area, has been described as *Hopeoxylon arcotense* sp. nov.

INTRODUCTION

NAVALE (1963) created the genus *Hopeoxylon* to accommodate a fossil wood from the Cuddalore Series near Pondicherry, which he described very similar to the modern woods of the genus *Hopea* of the family Dipterocarpaceae. While investigating the fossil woods from the same locality the present author came across many woods having similar anatomical characters as present in *Hopeoxylon indicum* Navale. However, on comparing them with the modern woods of *Hopea* they appeared very much different from it. In the same paper Navale also described another wood, *Shoreoxylon speciosum* which he considers very similar to those of *Shorea*. On critical re-examination of their type slides as well as duplicate specimens, both these woods were found identical with those of *Sindora* of the family Leguminosae. A revised account of these and description of a new wood which also shows closest resemblance with *Sindora* is presented here.

REVISED AFFINITIES

FAMILY — LEGUMINOSAE

1. *Hopeoxylon indicum* Navale emend.

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

1963 — *Hopeoxylon indicum* Navale, p. 76, pl. 4, figs. 14-18, text-figs. 15-18.

Navale (1963) has shown the affinity of *Hopeoxylon indicum* with the woods of *Hopea* of Dipterocarpaceae on the basis of gross anatomical features, such as small to medium-sized vessels, concentric rings of vertical gum canals and 1-3 seriate xylem rays. In these features the fossil wood under revision no doubt resembles the woods of *Hopea* but largely differs from it in many other important characters.

In *Hopea* the vessels are small to medium-sized or large and show tendency towards oblique arrangement or grouping in the oblique radial lines. The parenchyma is apotracheal, mostly diffuse or in irregular lines or forming network apart from vasicentric to aliform and aliform-confluent. The xylem rays are mostly 1-7, seriate, heterocellular, consisting of 1—several rows of upright cells with crystalliferous upright cells often found on the flanks as well as scattered among procumbent cells, fibres mostly thick-walled. Moreover, the vasicentric tracheids are always present which is an important feature of the woods of this genus as well as other genera of the family Dipterocarpaceae. In *Hopeoxylon indicum* Navale the vessels are uniformly distributed and do not show any tendency towards oblique arrangement or grouping. The parenchyma is vasicentric to aliform and aliform-confluent; sometimes short, fine, apotracheal parenchyma lines are also present close to the concentric rings of gum canals; diffuse parenchyma is absent. Xylem rays 1-3 seriate, heterocellular, consisting of 1-2 marginal rows of upright cells at one or both the ends, crystals not seen. The fibres are moderately thick-walled and the vasicentric tracheids are absent.

Thus, it is evident that *Hopeoxylon indicum* Navale is quite different from that of *Hopea* and hence it should no more be considered as *Hopea*.

Besides Dipterocarpaceae there are a few genera of the families Connaraceae,

Cornaceae, Simaroubaceae and Leguminosae in which the normal vertical gum canals occur (Metcalfe & Chalk, 1950). However, considering the gross anatomical characters, *Hopeoxylon indicum* Navale can be compared with the following genera of the family Leguminosae having normal vertical gum canals:

Copaifera	*Kingiodendron*
Daniella	*Oxystigma*
Detarium	*Prioria*
Eperua	*Pterygopodium*
Gosweilerodendron	*Sindora*

Of these, in *Copaifera, Detarium, Eperua* and *Sindora* the gum canals are always in concentric rings while in rest of the above genera the gum canals are diffuse and solitary. So *Hopeoxylon indicum* Navale should be compared only with those of the above four genera having concentric rings of gum canals.

Taking into consideration all the anatomical characters it shows closest resemblance with the woods of *Sindora*. However, it can be differentiated from *Copaifera, Detarium* and *Eperua* in having some important characters. In *Eperua* the uniseriate xylem rays are abundant and the multiseriate rays consist of 1-4 marginal rows of upright cells, whereas in *Hopeoxylon indicum* the uniseriate rays are few and the multiseriate rays consist of 1-2 marginal rows of upright cells. The wood of the genus *Detarium* differs from *Hopeoxylon indicum* in having vessels comparatively bigger in size. Besides, the parenchyma in *Detarium* is typically aliform and the uniseriate rays are more frequent. The genus *Copaifera* differs from *Hopeoxylon indicum* in possession of homocellular xylem rays which are composed wholly of procumbent cells.

Detailed comparison of the fossil wood was made with the thin-sections of the modern woods of *Sindora*, viz., *Sindora cochinchinensis* Baill., *S. coriacea* Prain, *S. echinocalyx* Benth., *S. intermedia* Baker, *S. irpicina* de Wit, *S. leiocarpa* Backer ex K. Heyne, *S. wallichii* Benth., *S. siamensis* Teysm. ex Miq., *S. supa* Merr. and *S. velutina* Baker. It was also compared with a few other species of *Sindora* described by Reyes (1938, pp. 149-152, pl. 22, figs. 2-3), Kanehira (1924, p. 30), Desch (1957, pp. 295-298), Moll and Janssonius (1914, pp. 142-149, fig. 163), Henderson (1953, fig. 234) and Kribs (1954, p. 100, figs. 226-424). From this it was found that the closest resemblance of *Hopeoxylon indicum* is with *Sindora supa, S. siamensis* and *S. velutina* which are anatomically very similar to each other.

Since the fossil wood described under *Hopeoxylon indicum* Navale shows closest resemblance with *Sindora* it should have been placed under a new genus created by adding suffix "*Oxylon*" to the extant genus *Sindora*. But according to the International Code of Botanical Nomenclature (1972) vide Article no. 62 "a legitimate name must not be rejected merely because it is inappropriate or disagreeable, or because another is preferable, or better known, or because it has lost its original meaning". Hence the generic name *Hopeoxylon* Navale, originally created for the fossil woods of *Hopea*, is considered for the fossil woods resembling *Sindora* of the family Leguminosae. The diagnosis of the genus *Hopeoxylon* Navale has been amended.

EMENDED GENERIC DIAGNOSIS

Hopeoxylon Navale emend.

Wood diffuse-porous. ***Growth rings*** indistinct, at places delimited by apotracheal parenchyma lines or bands consisting of vertical gum canals. ***Vessels*** small to medium, occasionally large, solitary as well as in radial multiples of mostly 2-4; perforations simple; intervessel-pits large, bordered, alternate, vestured. ***Parenchyma*** paratracheal, apotracheal; paratracheal parenchyma vasicentric, aliform to confluent apotracheal parenchyma associated with concentric rings of gum canals, thin apotracheal lines or bands also present simulating growth rings. ***Xylem rays*** 1-5 (mostly 2-3) seriate, ray tissue heterogeneous, rays heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells. ***Fibres*** nonseptate, thin to moderately thick-walled. ***Gum canals*** normal, vertical, in closely spaced concentric rings.

Hopeoxylon indicum Navale emend.

Wood diffuse-porous. ***Growth rings*** delimited by thin lines or bands of apotracheal parenchyma consisting of gum canals. ***Vessels*** small to medium, t.d. 60-165 μ,

r.d. 45-180 μ, evenly distributed, about 10-20 vessels per sq mm; perforations simple; intervessel pits large, 8-10 μ in diameter, alternate, bordered, vestured. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric to aliform, rarely aliform-confluent; apotracheal parenchyma confined to concentric rings of gum canals, thin or narrow, regular or irregular lines of apotracheal parenchyma also occur in close association of gum canals, probably stimulating growth rings. *Xylem rays* 1-3 (mostly 2) seriate, heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells at one or both the ends; rays 2-26 cells in height. *Fibres* nonseptate, thin to moderately thick-walled. *Gum canals* normal, vertical, in concentric rings, circular, 20-80 μ in diameter, about 8-12 rings per cm.

Holotype — B.S.I.P. Museum no. 26382.

Locality — Kashikoppam (Kasipalaiyam) and Murattandichavadi, near Pondicherry, South Arcot District, Tamil Nadu.

2. *Hopeoxylon speciosum* (Navale) comb. nov.

1963 — *Shoreoxylon speciosum* Navale, p. 73, pl. 3, figs. 9-13; text-figs. 10-14.

Critical re-examination of the type slides of *Shoreoxylon speciosum* has also shown that the anatomical characters of this wood are quite different from those of *Shorea*, although the concentric rings of gum canals, type and distribution of vessels and rays indicate its similarity to some extent with the woods of *Shorea*. However, it does not possess the important features characteristic of *Shorea*. In *Shorea* the vasicentric tracheids are always present intermingled with vasicentric parenchyma, the parenchyma is also diffuse or forming loose bands in addition to paratracheal, ray cells are often crystalliferous and the tyloses are usually present. On the contrary, in *Shoreoxylon speciosum* Navale the vasicentric tracheids are absent, the parenchyma is typically vasicentric to aliform besides occurring in association with concentric rings of vertical gum canals, and the tyloses are absent. Thus it is evident that *Shoreoxylon speciosum* does not belong to *Shorea* but shows close resemblance with the woods of the genus *Sindora*.

Detailed comparison of *Shoreoxylon speciosum* was made with those of modern *Sindora*. Out of the species examined for comparison as mentioned in the preceding pages *Sindora siamensis* appears to be the nearest to the fossil. Their similarity can be seen in shape, size and distribution of vessels and gum canals, and the type and distribution of parenchyma and xylem rays. However, the only difference between the two is that the xylem rays in the fossil are 3-6 seriate, while in *Sindora siamensis* they are mostly 3-seriate, occasionally 4-seriate.

It differs from *Hopeoxylon indicum* Navale emend. in having vessels comparatively bigger in size (Pl. 2, figs. 9-10) and the xylem rays broader, being up to 6-seriate (Pl. 1, fig. 8), while in *Hopeoxylon indicum* the vessels are small to medium (Pl. 1, fig. 1) and the xylem rays are 2-3 seriate (Pl. 1, fig. 4). Moreover, the paratracheal parenchyma is less in it than in *Hopeoxylon indicum*. Hence, *Shoreoxylon speciosum* is placed under *Hopeoxylon* Navale emend. and named as *Hopeoxylon speciosum* (Navale) comb. nov.

EMENDED SPECIFIC DIAGNOSIS

Hopeoxylon speciosum (Navale) comb. nov.

Wood diffuse-porous. *Growth rings* delimited by apotracheal parenchyma, consisting of gum canals *Vessels* medium to large, solitary and mostly in radial multiples of 2-5, mostly 2-3, about 75-300 μ in diameter; perforations simple; intervessel pits large, 8-10 μ in diameter, alternate, bordered, vestured. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, aliform to aliform-confluent; apotracheal parenchyma occurring in concentric rings, completely enclosing gum canals, 6-7 cells wide, crystalliferous strands present. *Xylem rays* 3-6 seriate, heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells, up to 40 cells in height; 1-2 seriate rays rare. *Fibres* semilibriform, non-septate, moderately thick-walled. *Gum canals* normal, vertical, in concentric rings, embedded within apotracheal parenchyma bands, 75-255 μ in diameter, 4-5 rings per cm.

Holotype — B.S.I.P. Museum no. 26372.
Locality — Bangalamode, near Pondicherry, South Arcot District, Tamil Nadu.
Horizon & Age — Cuddalore Series; Miocene-Pliocene.

3. *Hopeoxylon arcotense* sp. nov.

Pl. 2, figs. 13-17

This species is based on two well-preserved pieces of petrified wood.

Topography — *Wood* diffuse-porous. *Growth rings* not clearly seen, however, at places thin apotracheal parenchyma lines or concentric rings of gum canals probably indicate the presence of growth rings (Pl. 2, fig. 14). *Vessels* medium to large, solitary as well as in radial multiples of 2-4 (mostly 2-3), majority solitary, evenly distributed (Pl. 2, figs. 14, 15), about 8-18 vessels per sq mm; tyloses absent. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric to aliform, aliform parenchyma narrowing into fine lines extending beyond several rays and running parallel to concentric rings of gum canals; short or incomplete apotracheal bands also occur frequently; apotracheal parenchyma associated with concentric rings of gum ducts, 6-9 parenchyma lines per mm (Pl. 2, figs. 14, 15). *Xylem rays* moderately broad, 1-5 seriate, mostly 3-seriate (Pl. 2, fig. 17), rarely 4-5 seriate, rays heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells at one or both the ends (Pl. 2, fig. 16), 1-45 cells in height, about 8-13 per mm. *Fibres* aligned in radial rows between two consecutive xylem rays. *Gum canals* normal, vertical in concentric rings, embedded within apotracheal parenchyma bands or lines (Pl. 2, figs. 14, 15), 3-5 rings per cm.

Elements — *Vessels* circular to oval, those in radial multiples flattened at places of contact, t.d. 120-270 μ, r.d. 75-270 μ, walls 6-10 μ in thickness; perforations simple; vessel-members short, 150-400 μ in height with truncated or slightly inclined ends, infiltration dark; intervessel pits large, 8-12 μ in diameter, alternate, vestured (Pl. 2, fig. 13). *Parenchyma cells* 3-5 per strand, up to 40 μ in diameter; crystalliferous cells present. *Ray cells* upright and procumbent, upright cells up to 100 μ in vertical height, 32 μ in radial length, procumbent cells up to 32 μ in tangential height, 160 μ in radial length. *Fibres* angular or squarish, up to 28 μ in diameter, moderately thick-walled, 2-4 μ in thickness, nonseptate, pits not seen. *Gum canals* circular (Pl. 2, fig. 15), 50-300 μ in diameter.

Affinities — The above anatomical features of the fossil wood indicate its affinities with those of *Sindora*. Out of the species of *Sindora* mentioned in the preceding pages almost all show resemblance with it in having similar nature and distribution of vessels, xylem rays and gum canals. However, it differs from them in the nature and distribution of parenchyma. In the present fossil wood the parenchyma is abundant, the paratracheal parenchyma is completely enclosing the vessels and forming aliform to confluent lines extending beyond several rays without uniting with those of other confluent parenchyma. Besides, some apotracheal parenchyma lines also commonly occur in between such parenchyma which is a characteristic feature of the present fossil wood. Among the modern woods of *Sindora* available for comparison, so much parenchyma is not present in any of the species. In this feature it also differs from *Hopeoxylon indicum* Navale emend. and *H. speciosum* (Navale) comb. nov.

Since the present fossil wood shows anatomical characters of *Sindora*, it is placed under the genus *Hopeoxylon* Navale emend. and named as *Hopeoxylon arcotense* sp. nov.

The genus *Sindora* consists of about 21 species (Willis, 1973, p. 1069). Only one species is found in tropical Africa and the rest are confined to south-east Asia, Hainan, West Malaysia, Celebes and Moluccas. None of its species is found in India, Burma and Sri Lanka.

SPECIFIC DIAGNOSIS

Hopeoxylon arcotense sp. nov.

Wood diffuse-porous. *Growth rings* probably delimited by thin lines of apotracheal parenchyma or by concentric bands of parenchyma consisting of vertical gum

canals. *Vessels* medium to large, t.d. 120-270 μ, r.d. 75-270 μ; perforations simple; intervessel pits large, alternate, vestured. *Parenchyma* paratracheal, apotracheal; paratracheal parenchyma vasicentric to aliform and aliform-confluent; confluent parenchyma narrowing into thin concentric lines, in between of which short lines also frequently occur, apotracheal parenchyma also associated with gum canals; crystalliferous strands present. *Xylem rays* 1-4 (mostly 3) seriate, heterocellular, consisting of procumbent cells and 1-2 marginal rows of upright cells at one or both the ends, 1-45 cells in height. *Fibres* semilibriform, nonseptate, moderately thick-walled, walls about 2-4 μ thick. *Gum canals* vertical, occurring in concentric tangential lines, embedded within parenchyma bands, circular, 50-300 μ in diameter.

Holotype — B.S.I.P. Museum no. 43/686.

Locality — Murattandichavadi, near Pondicherry, South Arcot District, Tamil Nadu.

Horizon & Age — Cuddalore Series; Miocene-Pliocene.

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EXPLANATION OF PLATES

Plate 1

Hopeoxylon indicum Navale emend.

1. Cross section showing nature and distribution of vessels, parenchyma and gum canals. × 35. B.S.I.P. Museum slide no. 1530.

Sindora supa Merr.

2. Cross section showing vessels, parenchyma and gum canals similar in nature and distribution as in fossil shown in fig. 1. × 35.

Hopeoxylon indicum Navale emend.

3. Radial longitudinal section showing heterocellular xylem rays. × 125. B.S.I.P. Museum slide no. 1532.

4. Tangential longitudinal section showing 1-3 seriate heterocellular xylem rays. × 70. B.S.I.P. Museum slide no. 1531.

Sindora supa Merr.

5. Tangential longitudinal section showing similar xylem rays as in fig. 4. × 70.

Hopeoxylon indicum Navale emend.

6. Intervessel pits. × 500. B.S.I.P. Museum slide no. 1531.

Sindora supa Merr.

7. Intervessel pits to show similarity in shape, size and distribution with those of fossil shown in fig. 6. × 500.

Hopeoxylon speciosum (Navale) comb. nov.

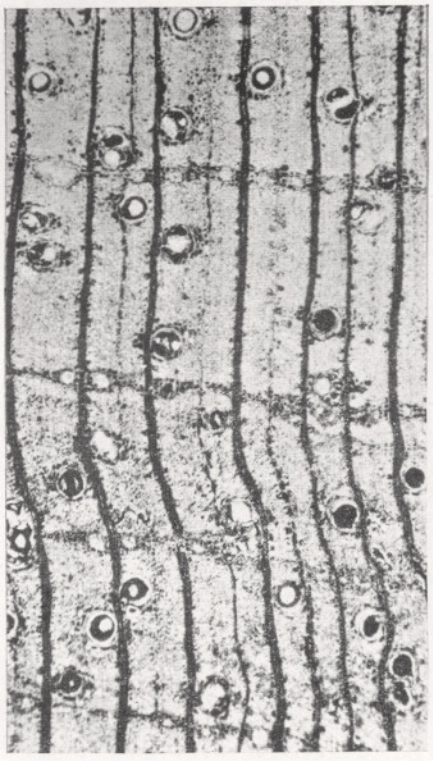
8. Tangential longitudinal section showing xylem rays. × 60. B.S.I.P. Museum slide no. 1527.

Plate 2

Hopeoxylon speciosum (Navale) comb. nov.

9. Cross section showing vessels, parenchyma and gum canals. × 30. B.S.I.P. Museum slide no. 1526.

10. Another cross section showing vessels, gum canals and aliform confluent parenchyma. × 30. B.S.I.P. Museum slide no. 1526.



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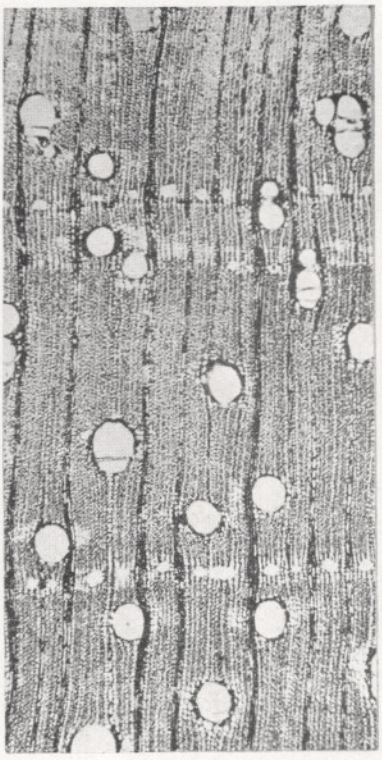

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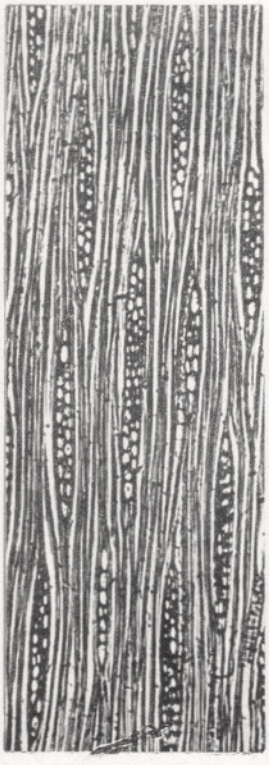

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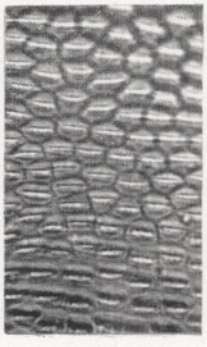

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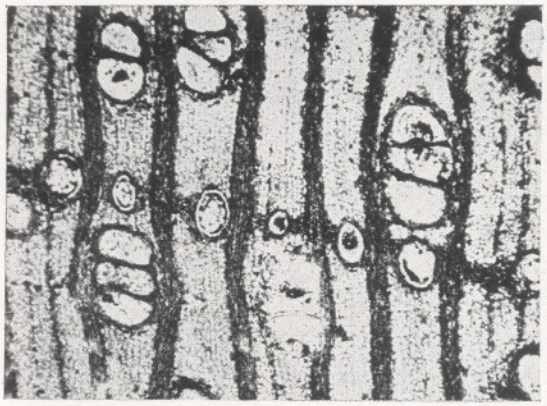

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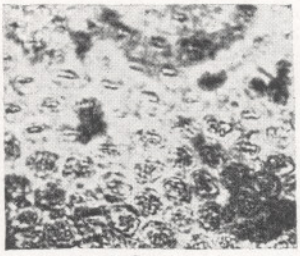

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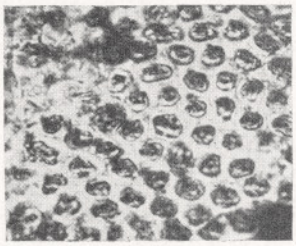

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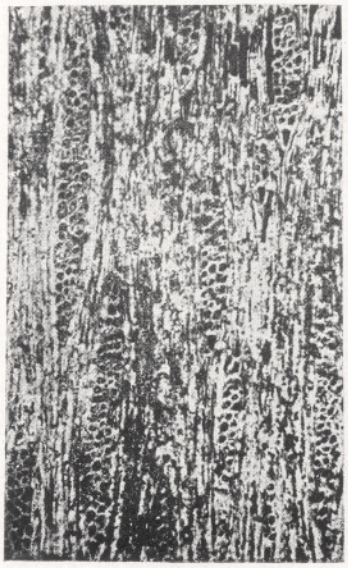

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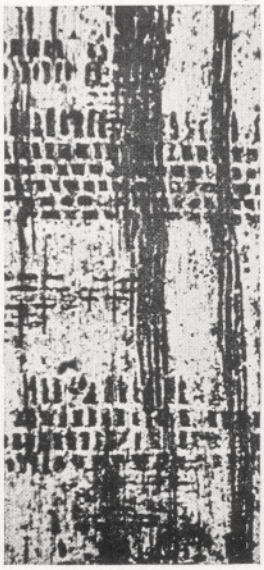

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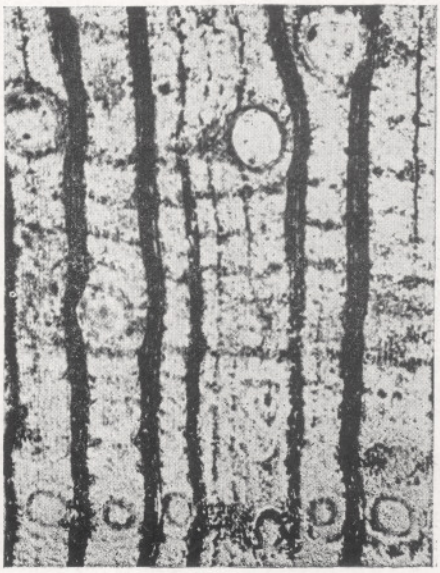

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11. Radial longitudinal section showing heterocellular xylem rays. × 37. B.S.I.P. Museum slide no. 1529.

12. Intervessel pits. × 550. B.S.I.P. Museum slide no. 1527.

Hopeoxylon arcotense sp. nov.

13. Intervessel pits. × 550. B.S.I.P. Museum slide no. 5027.

14. Cross section showing nature and distribution of vessels, parenchyma and concentric rings of gum canals. × 10. B.S.I.P. Museum slide no. 5026.

15. Cross section magnified to show the ring of gum canals, vessels and confluent lines of parenchyma. × 30. B.S.I.P. Museum slide no. 5026.

16. Radial longitudinal section showing heterocellular xylem rays. × 45. B.S.I.P. Museum slide no. 5028.

17. Tangential longitudinal section showing xylem rays. × 60. B.S.I.P. Museum slide no. 5027.