The Palaeobotanist, **26**(3): 248-256, 1980.

TWO NEW DIPTEROCARPACEOUS WOODS FROM THE CUDDALORE SERIES NEAR PONDICHERRY

N. AWASTHI

Birbal Sahni Institute of Palaeobotany, Lucknow-226 007, India

ABSTRACT

Two new fossil dipterocarpaceous woods have been described from Murattandichavadi near Pondicherry. These show close resemblance with those of *Dipterocarpus* and *Hopea* and hence named as *Dipteroca rpoxylon arcotense* sp. nov. and *Hopenium pondicherriense* gen. et sp. nov. respectively.

Key-words — Dipterocarpaceous woods, Cuddalore Series, Mio-Pliocene, Pondicherry (India).

सारॉंश

पांडिचेरी के समीप कुडलोर श्रेणी से डिप्टेरोकारपेसी कुल के दो नये काष्ठाश्म — नीलाम्बर अवस्थी

पांडिचेरी के समीप मुरातंडिचावड़ी से डिप्टेरोकारपेसी कुल के दो नये काष्ठाश्मों का वर्णन किया गया है। ये **डिप्टेरोकारपस** तथा **होपिया** से घनिष्ठ समानता प्रदर्शित करते हैं अतएव इनको क्रमशः **डिप्टेरोकारपॉक्सीलॉन आरकोटेन्से** न० जा० तथा **होपीनियम पांडिचेरियेन्से** न० प्रजाति व न० जाति से नामांकित किया गया है।

INTRODUCTION

IN the Indian Neogene deposits the dipterocarpaceous woods are found in abundance. The richest among them is the Cuddalore Series. So far seven species, belonging to the genera *Anisopteroxylon*, *Dipterocarpoxylon*, *Dryobalanoxylon* and *Anisopteroxylon*, are known from the beds exposed around the village Murattandichavadi near Pondicherry (Awasthi, 1971, 1974a, 1974b; Navale, 1963; Ramanujam & Rao, 1969).

Investigations of more petrified woods from the same locality have further yielded some new taxa belonging to the family Dipterocarpaceae. Two of them show closest resemblance with the woods of *Dipterocarpus* and *Hopea* respectively and are described here in detail.

DESCRIPTION AND AFFINITIES

FAMILY — DIPTEROCARPACEAE

Genus — *Dipterocarpoxylon* Hold. emend. Den Berger, 1927

1. *Dipterocarpoxylon arcotense* sp. nov.

Pl. 1, figs 1-4, 6

Material — Two small pieces of fairly well-preserved petrified wood measuring about 8 cm in length and 4 cm in width.

Topography — Wood diffuse-porous. *Growth rings* not seen. *Vessels* visible to the naked eye as dark as well as white dots against the light, medium to mostly large, rarely small, forming vessel lines along the grain, exclusively solitary (Pl. 1, figs 1-3), fairly close, evenly distributed, about 6-15

per sq mm, mostly occluded with tyloses (Pl. 1, fig. 3). *Vasicentric tracheids* present in the immediate vicinity of vessels, intermingled with paratracheal parenchyma. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming sheath of 1-3 cells wide around vessels, intermingled with vasicentric tracheids, occasionally aliform; apotracheal parenchyma fairly abundant, diffuse, diffuse-in-aggregate, often forming irregularly spaced uniseriate lines (Pl. 1, figs 1-3), at places quite close, up to 18 lines per mm, parenchyma occurring around gum canals 1-3 seriate (Pl. 1, figs 1-3). *Rays* 1-7 (mostly 4-5) seriate (Pl. 1, fig. 6), about 5-55 cells in height and 5-8 per mm in cross section; ray tissue heterogeneous; uniseriate rays few, short, homocellular to heterocellular, consisting of upright cells or both procumbent as well as upright cells; multiseriate rays heterocellular (Pl. 1, fig. 4), consisting of 1-3 or rarely more uniseriate marginal rows of upright cells and procumbent cells through the median portion; sheath cells also present (Pl. 1, fig. 6). *Fibres* aligned in radial rows between two consecutive rays. *Gum canals* normal, vertical, solitary or in pairs and also in short tangential rows of 2-6, occasionally up to 8, usually bigger than the vessels, about 5-12 per sq mm in cross section.

Elements — Vessels circular to oval in cross section (Pl. 1, figs 1-3), t.d. 100-320 μ, r.d. 100-360 μ, walls 8-12 μ; perforations simple, nearly horizontal to oblique; vessel-members about 250-800 μ in height, with truncated ends; pits leading to contiguous tracheids arranged in vertical rows, medium to large, about 8-10 μ in diameter, vestured; vessel-parenchyma and vessel-ray pits similar to vessel-tracheid pits in nature but slightly bigger and horizontally oriented, occasionally confluent with wide apertures. *Vasicentric tracheids* oval to orbicular, diameter nearly same as of parenchyma; length almost same as of fibres. *Parenchyma cells* tangentially elongated, 20-36 μ in diameter; infiltration dark. *Fibre-tracheids* angular, 12-28 μ in diameter, non-septate, thick-walled, walls 4-10 μ; pits arranged in a vertical row, small, about 4-5 μ in diameter, vestured, with small slit-like apertures. *Gum canals* circular to oval, t.d. 100-280 μ, r.d. 160-320 μ, mostly empty, sometimes with contents (Pl. 1, figs 1-3).

Comparison with the Modern Woods — Presence of vertical gum canals as diffuse or usually aligned in short tangential rows, exclusively solitary vessels, vasicentric tracheids and fibre-tracheids, vasicentric as well as diffuse parenchyma and 1-7 seriate heterogeneous rays obviously suggest that it is a *Dipterocarpus*. In order to find out its nearest modern equivalent, thin sections of about 16 species of *Dipterocarpus* were examined critically and the descriptions and illustrations of many other species of this genus were also consulted (Chowdhury & Ghosh, 1958, p. 114, pls 16-18, figs 93-105; Desch, 1957, pp. 105-106; Kribs, 1959, p. 33, figs 115-116; Lecomte, 1926, pls 34-36; Moll & Janssonius, 1906, pp. 348-360; Pearson & Brown, 1932, pp. 68-91, figs 26-33; Reyes, 1938, pp. 280-296, figs 49-54).

Out of all those species consulted, *Dipterocarpus pilosus* Roxb., *D. tuberculatus* Roxb., *D. grandiflorus* Wall., *D. obtusifolius* Teysm., *D. chartaceous* Sym. and *D. concavus* Foxw. show similarity with the present fossil. Further, considering the size and frequency of gum canals and the frequency of diffuse parenchyma it was found that the fossil shows closest resemblance with *Dipterocarpus tuberculatus* Roxb. (specimen nos A-1062, 662, 616, 328 and F-90) housed in the Wood Anatomy Branch, F.R.I., Dehra Dun. In both, the present fossil and *D. tuberculatus* Roxb., the size of the vessels and gum canals is nearly same, vessels are tylosed and the parenchyma is diffuse or diffuse-in-aggregate as well forming uniseriate lines.

Comparison with the Fossil Species — A large number of fossil woods of *Dipterocarpus* are already known from the Neogene of India and abroad as listed by Awasthi (1974a, p. 343). In addition, recently Prakash (1975) described 3 species of *Dipterocarpoxylon*, viz., *Dipterocarpoxylon sivalicus*, *D. nalagarhense* and *D. premacrocarpum* from the Lower Siwalik beds of Khokhra near Nalagarh in Himachal Pradesh. The fossil wood shows general similarity with all the species of *Dipterocarpoxylon*. However, taking into consideration a combination of some important characters, such as medium to large-sized vessels, diffuse, diffuse-in-aggregate or uniseriate lines of parenchyma, 1-7 seriate, heterocellular rays, large-sized gum canals which are almost equal to or even bigger

than the vessels, the present fossil is quite different from all the species of *Dipterocarpoxylon*. Hence it is named as *Dipterocarpoxylon arcotense* sp. nov.

Diagnosis

Dipterocarpoxylon arcotense sp. nov.

Vessels medium to large, t.d. 100-320 μ, r.d. 100-360 μ, exclusively solitary, evenly distributed, 6-15 vessels per sq mm, tylosed; pits leading to contiguous vasicentric tracheids large, 8-10 μ in diameter, vestured. *Vasicentric tracheids* present, intermingled with parenchyma. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming narrow sheath around the vessels, intermingled with tracheids; apotracheal parenchyma diffuse, diffuse-in-aggregate or in uniseriate lines, up to 18 lines per mm, irregularly spaced; parenchyma around gum canals 1-3 seriate, forming short tangential lines. *Rays* 1-7 (mostly 4-5) seriate, 5-55 cells in height, 5-8 per mm; ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells through the median portion and a few marginal rows of upright cells; sheath cells often present. *Fibre-tracheids* nonseptate, thick-walled, with small vestured pits. *Gum canals* solitary or in pairs and also in tangential rows of 2-6, occasionally up to 8, circular to oval, t.d. 100-280 μ, r.d. 160-320 μ.

Holotype — B.S.I.P. Museum no. 35308.

Locality — Murattandichavadi near Pondicherry.

Horizon & Age — Cuddalore Series; Miocene-Pliocene.

Hopenium gen. nov.

2. *Hopenium pondicherriense* sp. nov.

Pl. 1, fig. 5; Pl. 2, figs 7, 9-12

Material — A small piece of fairly well preserved silicified wood, measuring about 6 cm in length and 4 cm in width.

Topography — Wood diffuse-porous. *Growth-rings* seen at places, delimited by zone of thick-walled fibres having few vessels and also by narrow parenchyma lines (Pl. 1, fig. 5; Pl. 2, figs 7-9). *Vessels* hardly visible to the naked eye, small to medium, mostly small, majority solitary, rarely in radial multiples of 2-3, numerous, occurring mostly in groups, consisting of several vessels, showing tendency to arrange in oblique radial lines (Pl. 1, fig. 5; Pl. 2, fig. 7), about 25-75 vessels per sq mm; tyloses present, vessels completely filled with tyloses and dark contents (Pl. 2, figs 7, 9). *Vasicentric tracheids* present, but difficult to distinguish in cross section from parenchyma. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma intermingled with vasicentric tracheids, forming thin layers around the vessels or vessel groups, sometimes appearing as aliform to confluent; apotracheal parenchyma rarely forming thin to moderately broad, wavy, irregular tangential bands, at places diffuse or diffuse-in-aggregate, sometimes forming uniseriate lines, thin bands also associated with gum canals (Pl. 2, figs 7, 8-10). *Rays* 1-4 seriate, rarely up to 5-seriate, about 6-80 cells in height, 7-10 per mm in cross section; ray tissue heterogeneous; rays heterocellular (Pl. 2, fig. 11), consisting of 1-5 marginal rows of upright to square and procumbent cells through the median portion, interspersed with crystalliferous upright to square cells appearing as darker and bigger than procumbent cells (Pl. 2, fig. 12). *Fibres* aligned in radial rows between two consecutive xylem rays. *Gum canals* vertical, in tangential rows, embedded in narrow to moderately broad parenchyma bands (Pl. 2, fig. 10).

Elements — Vessels circular to oval, t.d. 30-140 μ, r.d. 30-150 μ, thick-walled, walls 8-12 μ; perforations simple, horizontal to oblique; vessel-members truncate or tailed, about 150-450 μ in height; intervessel pits and pits leading to contiguous vasicentric tracheids and parenchyma medium sized, about 6-8 μ in diameter, vestured. *Vasicentric tracheids* angular to oval or orbicular, diameter almost same as of parenchyma cells. *Parenchyma cells* angular, about 20-28 μ in diameter; infiltration dark. *Ray cells* upright to square and procumbent; upright or square cells 30-64 μ in vertical height, 20-64 μ in radial length; procumbent cells 16-20 μ in vertical height, 40-160 μ in radial length; solitary crystals present in upright or square cells. *Fibres* angular, 12-20 μ in diameter, nonseptate, thick-walled, walls 4-8 μ in thickness; pits

not seen. *Gum canals* circular, about 40-100 μ in diameter.

Comparison with the Modern Woods— Presence of vertical gum canals, vasicentric tracheids, vestured intervessel pits and heterocellular xylem rays indicates that the fossil is a dipterocarpaceous wood. Since the gum canals are present in tangential rows and the fibres are without bordered pits, it can be compared with those of *Shorea*, *Parashorea*, *Pentacme*, *Hopea* and *Balanocarpus*. In addition to the above mentioned features, the fossil is further characterized in having vessels small to medium, mostly solitary, tylosed, tending to arrange in small groups along oblique radial lines, parenchyma vasicentric and diffuse, rays heterocellular with upright to square cells at one or both the ends and interspersed among procumbent cells in the median portion. These features collectively indicate its similarity with most of the species of *Hopea* including a few *Balanocarpus* and distinguish it from *Shorea*, *Parashorea* and *Pentacme*. However, *Balanocarpus heimii* King also differs from the present fossil in having storied rays.

Detailed comparison of the present fossil wood was made with the large number of woods of modern species of *Hopea* from their thin sections as well as published anatomical descriptions and figures. From this it was found that the fossil shows closest resemblance with *Hopea utilis*, *H. wightianum*, *H. glabra* and *H. parviflora*, all occurring presently in South India. It is difficult to suggest which of these is the nearest to the present fossil, since there are hardly any special anatomical features by which they can be differentiated from each other.

The present fossil is the first record showing closest resemblance with that of *Hopea* from India and abroad. Earlier, in 1963, Navale described a wood as *Hopeoxylon indicum* from the same area indicating it closest resemblance with the woods of *Hopea*. Recently Awasthi (1977) critically re-examined the type slides of this wood and found it very similar to that of the Malayan genus *Sindora* of the family Leguminosae. Therefore, he transferred it to the family Leguminosae retaining the existing name of the fossil.

In order to accommodate the present fossil wood, a new genus *Hopenium* has been created. This genus is considered to include the fossil woods resembling those species of *Hopea* which can be distinguished from *Shorea* and also those species of *Balanocarpus* which are very similar to *Hopea*. The present fossil is named as *Hopenium pondicherriense* sp. nov.

Generic Diagnosis

Hopenium gen. nov.

Wood diffuse-porous. *Growth rings* present, sometimes inconspicuous, delimited by zone of thick-walled fibres having few vessels and also by parenchyma lines. *Vessels* small to medium, occasionally large, mostly solitary, seldom in radial lines, tylosed. *Vasicentric tracheids* present, intermingled with paratracheal parenchyma; pits leading to vessels medium sized, vestured. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, forming sheath around vessels and vessel groups, aliform-confluent; apotracheal parenchyma diffuse-in-aggregate and also forming uniseriate lines. *Rays* fine to moderately broad, heterocellular, consisting of upright to square cells at both the ends and interspersed among procumbent cells in median portion. *Fibres* thick-walled, nonseptate. *Gum canals* vertical, in concentric rings.

Genotype — *Hopenium pondicherriense* sp. nov.

Specific Diagnosis

Hopenium pondicherriense sp. nov.

Vessels small to medium, 30-150 μ in diameter, mostly solitary, occasionally in radial multiples or in clusters, mostly grouped or showing tendency to arrange in oblique radial lines, profusely tylosed. *Vasicentric tracheids* intermingled with paratracheal parenchyma. *Parenchyma* paratracheal, vasicentric, forming thin, loose sheath around vessels or vessel groups, occasionally aliform to confluent, apotracheal parenchyma diffuse or diffuse-in-aggregate and sometimes forming 1-seriate lines. *Rays* 1-5 (mostly 1-4) seriate, up to

TABLE 1 — DISTRIBUTION OF DIPTEROCARPS IN SOUTH INDIA

1. *Dipterocarpus bourdilloni* Bedd.	Evergreen forests of Western Ghats, Malabar, North and South Travancore at low elevation.
2. *D. indicus* Bedd.	Evergreen rain forests of Western coast and Western Ghats from South Kanara to Travancore and Tinnevelly up to 900 m.
3. *Hopea glabra* W. & A.	Evergreen forests of South Kanara, Travancore and Tinnevelly up to 1,200 m altitude, often growing along banks.
4. *H. parviflora* Bedd.	Evergreen moist forests of Western Ghats, South Kanara southwards up to 1,100 m altitude, common in both the moist and dry forests in the Malabar and Travancore up to an elevation of 900 m.
5. *H. racophloea* Dyer	Western Ghats in the forests of South Kanara, Wynaad and Travancore.
6. *H. utilis* (Bedd.) Bole	Evergreen forests of Tinnevelly 300-580 m elevation and also in Travancore.
7. *H. wightiana* Wall.	Semi-evergreen to deciduous forests of Western Ghats from North to South Kanara, Coorg, Malabar and Travancore up to an altitude of 450 m.
8. *Shorea tumbuggaia* Roxb.	Eastern Ghats, forests of the Cuddapah, North Arcot and Chingleput Hills up to 270 m.
9. *S. talura* Roxb.	Forests of the Eastern Ghats and Deccan in Cuddapah, North Arcot, Anantapur, Mysore and Salem, up to 270 m, Western Ghats in Malabar, Coimbatore and Madurai.
10. *Vatica roxburghiana* Bl.	Evergreen forests of Western Coast and Western Ghats, South Kanara and Mysore to Travancore at low elevation especially on the banks of rivers.
11. *Vateria indica* L.	Evergreen forests of the Western Ghats from South Kanara to Tinnevelly at low elevation up to 750 m.
12. *V. macrocarpa* Gupta	Forests of Muthu Kalam, Bolampatty range Palghat Division, Karnataka.

TABLE 2 — FOSSIL DIPTEROCARPS FROM THE CUDDALORE SERIES NEAR PONDICHERRY

NAME OF FOSSIL	AFFINITIES WITH MODERN GENERA/SPECIES	DISTRIBUTION
1. *Anisopteroxylon coromandelense* Navale, 1963	? *Anisoptera*	Evergreen forests of upper Burma, Tenasserim in Bangladesh and Malayan region
2. *Dipterocarpoxylon pondicherriense* Awasthi, 1974	*Dipterocarpus indicus* Bedd.	See Table 1
3. *D. arcotense* sp. nov.	*Dipterocarpus tuberculatus* Roxb.	Evergreen forests of Burma, Cochin, China, Thailand, Chittagong hill tracts in Bangladesh
4. *Dryobalanoxylon indicum* (Ramanujam) Awasthi, 1971	*Dryobalanops*	Tropical rain forests of western Malaya, Sumatra and Borneo
5. *D. holdeni* (Ramanujam) Awasthi, 1971	,,	,,
6. *Hopenium pondicherriense* sp. nov.	*Hopea glabra* W. & A. *H. utilis* Bedd. *H. wightiana* Wall. *H. parviflora* Bedd.	See Table 1
7. *Shoreoxylon arcotense* Awasthi, 1974	*Shorea acuminata* Dyer and allied species	Malayan region
8. *S. indicum* Awasthi, 1974	*Shorea obtusa* Wall. *Parashorea stellata* Kurz. *Pentacme sauvis* A. Dc.	Burma Tropical evergreen forests of Peguyama and Martaban, Burma
9. *S. kraeuseli* Ramanujam & Rao, 1969	? *S. talura* Roxb. ? *S. tumbuggaia* Roxb.	See Table 1

80 cells in height, heterocellular, consisting of procumbent cells through the median portion and crystalliferous upright to square cells at both the ends as well as interspersed among procumbent cells. *Fibres* thick-walled, nonseptate. *Gum canals* about 40-100 μ in diameter.

Holotype — B.S.I.P. Museum no. 35309.

Locality — Murattandichavadi near Pondicherry.

Horizon & Age — Cuddalore Series; Miocene-Pliocene.

DISCUSSION

With the addition of two new woods described in this paper the number of dipterocarpaceous species in the flora of the Cuddalore Series goes up to 9 belonging to 5 genera (see Table 2). These dipterocarps represent the genera and species presently growing either in the evergreen forests of Western Ghats of South India or in the evergreen forests of Chittagong in Bangladesh, Burma and Malaysia. Since most of these are inhabitants of the tropical evergreen rain forests having excessive humid conditions, it is further envisaged that similar climatic conditions prevailed in the eastern region of South India throughout the Coromandel coast during Miocene-Pliocene period. At present only 12 species of dipterocarps occur in South India, most of which are distributed in the evergreen forests of Western Ghats.

An analysis of all the dipterocarpaceous woods, studied so far, has revealed that about 98 per cent belong to the genus *Dryobalanops*. This genus is presently confined to the tropical rain forests of West Malaya, Sumatra and Borneo. Thus, abundance of *Dryobalanops* in the Cuddalore flora suggests that during Miocene-Pliocene excessive humid conditions prevailed around Pondicherry due to high precipitation. Furthermore, it is pointed out that the absolute humidity during the past was much higher than what it actually exists today in the Western Coast of South India. However, it is concluded that the climatic conditions in the Coromandel coast during Miocene-Pliocene were similar to those existing today in Malaysia and Indonesia.

On account of the excessive humidity which is most suited to the dipterocarps, the Malayan dipterocarps along with other dicotyledonous species associated with them migrated into India via Burma and further extended into Eastern Coast of South India and then finally reached to Western Cost and Sri Lanka during or just before the Miocene. This view is also supported by the occurrence of pollen grains of Dipterocarpaceae in the Miocene lignites of Quilon, Kerala Coast (Rao & Ramanujam, 1975).

The occurrence of Malayan dipterocarps, viz., *Dryobalanops*, *Anisoptera* and a few species of *Dipterocarpus* and *Shorea* (see Table 2) in the Cuddalore flora and their absence in the modern evergreen forests of Western Ghats can be interpreted two-fold that during their extension into South India all the dipterocarps including those found in the Cuddalore flora reached to the Western Coast during the Miocene. By the end of Pliocene or the beginning of Pleistocene there had been a drastic change in the climate from humid to dry, particularly on the eastern coast of South India, resulting in the total disappearance of the evergreen forests from this region. This change must have also affected considerably the humidity of the Western Coast. As a result these Malayan dipterocarps along with other plants, being most sensitive to the changed environments, failed to survive thereafter. The other plausible explanation for this is that the present climatic conditions along the Western Coast prevailed since Miocene and remained almost unaffected by the change in the conditions of the Eastern Coast, which might have not been conducive for these dipterocarps to flourish, and thus prevented them to extend further into the Western Coast. Before any definite conclusions could be drawn about this fact, it is necessary to undertake the systematic study of the pollen grains and carbonized woods abundantly found in the lignites of Kerala Coast which might yield the dipterocarps.

ACKNOWLEDGEMENT

The author is grateful to the authorities of the Forest Research Institute Dehra Dun, for all facilities to consult their Xylarium.

REFERENCES

AWASTHI, N. (1971). Revision of some dipterocarpaceous woods previously described from the Tertiary of South India. *Palaeobotanist*, **18** (3): 226-233.

AWASTHI, N. (1974a). Occurrence of some dipterocarpaceous woods in the Cuddalore Series of South India. *Palaeobotanist*, **21** (3): 339-351.

AWASTHI, N. (1974b). Neogene angiospermous woods, pp. 341-358 in Surange, K. R. *et al.* (Eds)—*Aspects and Appraisal of Indian Palaeobotany*. Birbal Sahni Institute of Palaeobotany, Lucknow.

AWASTHI, N. (1977). Revision of *Hopeoxylon indicum* Navale and *Shoreoxylon speciosum* Navale from the Cuddalore Series near Pondicherry. *Palaeobotanist*, **24** (2): 102-107.

CHOWDHURY, K. A. & GHOSH, S. S. (1958). *Indian woods*. **1**. Dehra Dun.

DESCH, H. E. (1957). Manual of Malayan timbers 1. *Malay For. Rec.*, **15**: 1-338.

KRIBS, D. A. (1959). *Commercial Foreign Woods on the American Market*. Pennsylvania.

LECOMTE, H. (1926). *Les bois de l'Indochine Atlas*. Paris.

MOLL, J. W. & JANSSONIUS, H. H. (1906). *Mikrographie des holzer der auf Java Vorkommenden Baumarten*, **1**. Leiden.

NAVALE, G. K. B. (1963). Some silicified dipterocarpaceous woods from Tertiary beds of the Cuddalore Series near Pondicherry, India. *Palaeobotanist*, **1** (1 & 2): 66-81.

PEARSON, R. S. & BROWN, H. P. (1932). *Commercial Timbers of India*, **1** & **2**. Calcutta.

PRAKASH, U. (1975). Fossil woods from the Lower Siwalik beds of Himachal Pradesh, India. *Palaeobotanist*, **22** (3): 192-210.

RAMANUJAM, C. G. K. (1975). A palynological approach to the study of Quilon beds of Kerala State in South India. *Curr. Sci.*, **44** (20): 730-732.

RAMANUJAM, C. G. K. & RAO, M. R. R. (1969). *Shoreoxylon krauseli* sp. nov., a new dipterocarpaceous wood from the Cuddalore Series of South India: pp. 253 in Santapau, H. *et al.* (Eds)—*J. Sen Memorial Volume*. Bot. Soc. Bengal, Calcutta.

REYES, L. J. (1923). Woods of the Philippine dipterocarps. *Philipp. Jl Sci.*, **22** (3): 291-344.

EXPLANATION OF PLATES

PLATE 1

Dipterocarpoxylon arcotense sp. nov.

1. Cross section showing nature and distribution of vessels, parenchyma and gum canals (bigger and empty ones). × 16. B.S.I.P. Museum slide no. 5737.
2. Cross section magnified to show diffuse parenchyma, vessels and gum canals (bigger ones). × 32. B.S.I.P. Museum slide no. 5737.
3. Another cross section slightly magnified to show vessels (with tyloses) and gum canals (empty ones). × 30. B.S.I.P. Museum slide no. 5738.
6. Tangential longitudinal section showing rays. × 60. B.S.I.P. Museum slide no. 5739.
4. Radial longitudinal section showing heterocellular rays. × 60. B.S.I.P. Museum slide no. 5740.

Hopenium pondicherriense gen. et sp. nov.

5. Cross section showing nature and distribution of vessels and parenchyma. × 16. B.S.I.P. Museum slide no. 5741.

PLATE 2

Hopenium pondicherriense gen. et sp. nov.

7. Cross section slightly magnified to show the shape, size and distribution of vessels and type and distribution of parenchyma. × 32. B.S.I.P. Museum side no. 5747.

Hopea parviflora Bedd.

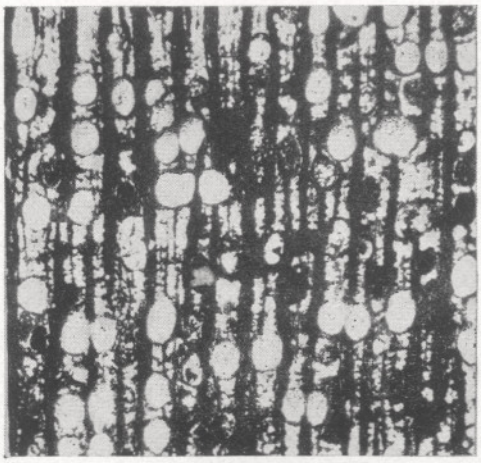
8. Cross section showing shape, size and distribution of vessels similar to those of fossil. × 32.

Hopenium pondicherriense gen. et sp. nov.

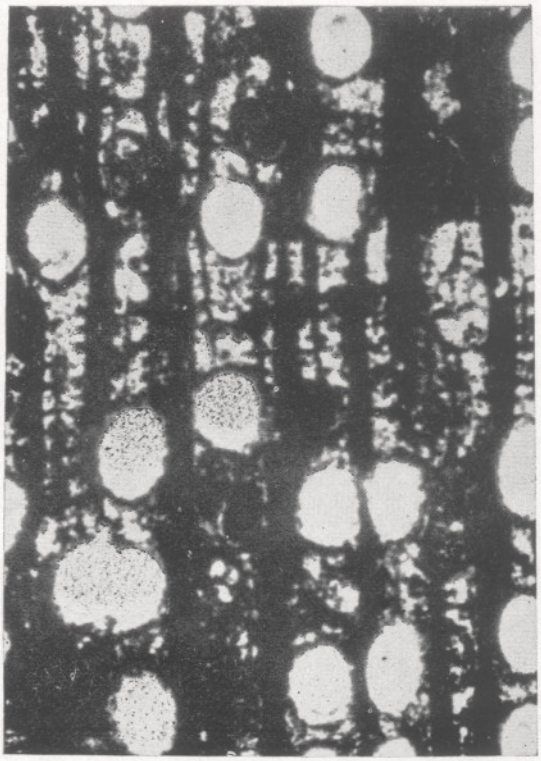
9. A portion of cross section magnified to show diffuse parenchyma. × 6. B.S.I.P. Museum slide no. 5741.
10. Cross section showing gum canals occurring in a tangential row. × 32. B.S.I.P. Museum slide no. 5741.
11. Radial longitudinal section showing heterocellular rays. × 120. B.S.I.P. Museum slide no. 5742.
12. Tangential longitudinal section showing rays. × 50. B.S.I.P. Museum slide no. 5743.

Hopea parviflora Bedd.

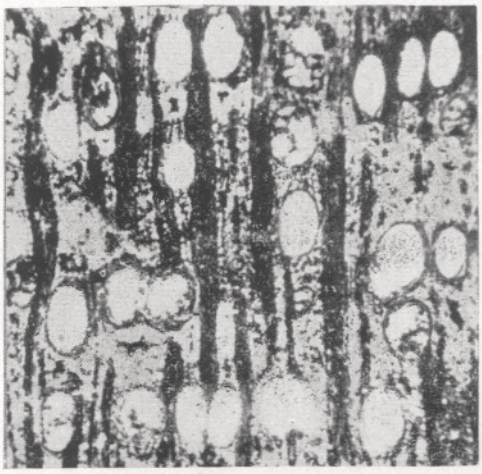
13. Tangential longitudinal section showing rays similar to those of fossil. × 50.



1



2



3

4

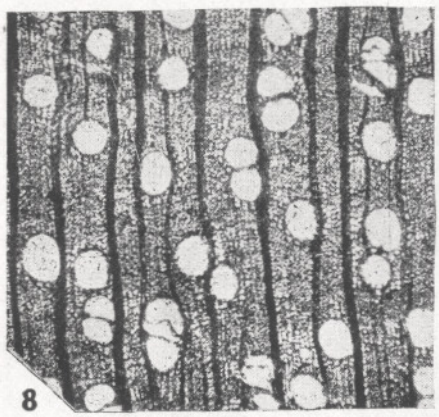
5

6

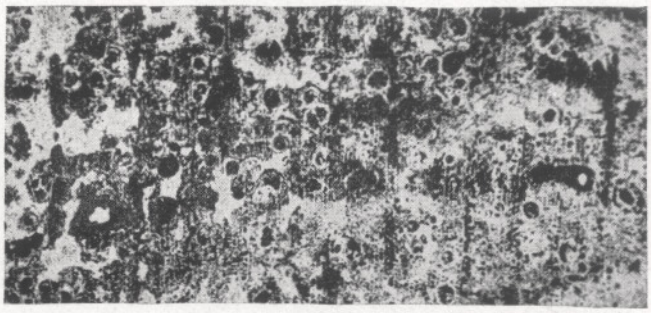
PLATE 1

7

9



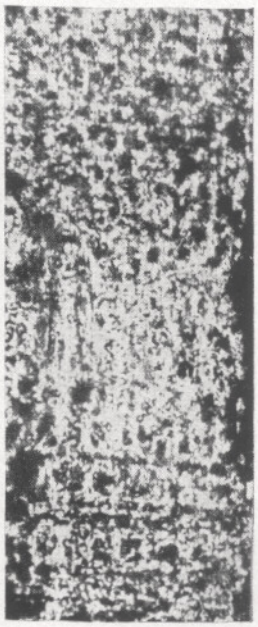
8



10

13

12



11

PLATE 2