REVISION OF SOME DICOTYLEDONOUS WOODS FROM THE TERTIARY OF SOUTH INDIA

N. AWASTHI

Birbal Sahni Institute of Palaeobotany, Lucknow-226007

ABSTRACT

Five fossil dicotyledonous woods, namely *Guttiferoxylon indicum* Ramanujam (1960), *Celastrinoxylon dakshinense* Ramanujam (1960), *Ingoxylon sahnii* (Ramanujam) Müller-Stoll & Mädel (1967), *Dalbergioxylon antiquum* Ramanujam (1960) and *Dipterocarpoxylon cuddalorense* Navale (1963b) described from Murattandichavadi near Pondicherry have been reinvestigated. Of these, the first two species are identical with *Ailanthoxylon indicum* Prakash (1959) from the Deccan Intertrappean Series of Mahurzari near Nagpur. The occurrence of these two woods in the Cuddalore Series has been considered doubtful. The remaining three species show identity with the already known species *Pahudioxylon sahnii* Ghosh & Kazmi (1961) from the Tertiary of Tripura, *Euacacioxylon bharadwajii* (Navale) Müller-Stoll & Mädel (1967) and *Terminalioxylon grandiporosum* Ramanujam (1966) from the Cuddalore Series near Pondicherry respectively.

INTRODUCTION

THE petrified woody flora of the Cuddalore Series near Pondicherry is perhaps the best studied amongst the Tertiary floras of India. It consists of a variety of woods belonging to both Gymnosperms and Angiosperms. However, from the examination of a large number of modern woods and from an extensive study of fossil woods collected from the same area from time to time the present author has found that the identifications of some of the earlier described woods are incorrect. Such wrongly identified woods not only provide a false picture of the past flora of this region but also mislead the later investigators particularly in dealing with the palaeoecology and palaeophytogeography and other related aspects of this flora. In a previous paper, the author (Awasthi, 1971) revised the affinities of five fossil dipterocarpaceous woods described by earlier workers. In continuation, five more dicotyledonous woods have been reinvestigated and their revised account is given in the present paper. The revision is based on critical re-examination of type slides and specimens available at the Institute's museum. In some cases where the anatomical details were not seen clearly in the type slides, fresh sections were prepared from the type material as well as from their duplicate specimens. All the photographs exhibited there to illustrate the various anatomical details have been taken from the original type slides.

REVISED AFFINITIES

Family — SIMAROUBACEAE

1. Ailanthoxylon indicum Prakash

Pl. 1, figs. 1-7

1959 *Ailanthoxylon indicum* Prakash, p. 16, pl. 2, figs. 7-13, text-figs. 14-21.

1960–*Guttiferoxylon indicum* Ramanujam, p. 104, pl. 16, figs. 7-11, text-fig. 7.

1961–*Celastrinoxylon dakshinense* Ramanujam, p. 111, pl. 18, figs. 19-21, text-figs. 12-16.

In 1960 Ramanujam described a fossil wood as *Guttiferoxylon indicum*. According to him it possesses apotracheal parenchyma in the form of fine, closely or widely spaced tangential bands. On the basis of this particular feature he suggested its affinities with *Garcinia*. But, as seen in the photograph of the fossil wood showing cross-section (Ramanujam, *l.c.* figs. 8-9) the parenchyma is not of the same type; it is distinctly paratracheal, aliform-confluent. The lateral extensions of aliform parenchyma are quite prominent and often extending across several rays (Pl. 1, figs. 1-2) which Ramanujam interpreted as apotracheal bands and considered them to be similar to those of the woods of *Garcinia*. However, on re-examination of the type slides it was seen that not only the nature and distribution of parenchyma but the other anatomical features of this fossil wood are also different from those of *Garcinia*. In *Garcinia* as far as the nature

and distribution of xylem rays are concerned they are usually high with uniseriates, mostly heterogeneous, consisting of 1-3 or more uniseriate marginal rows of upright cells; whereas in *Guttiferoxylon indicum* the xylem rays are not so high, and are homocellular, consisting of procumbent cells only (Pl. 1, fig. 4). Besides, the fibres in *Garcinia* are comparatively thick-walled with narrow lumen than the fibres of *Guttiferoxylon indicum*. Thus from these important characters it is evident that *Guttiferoxylon indicum* can neither be *Garcinia* nor even any other guttiferous wood.

Among the other modern dicotyledonous woods a combination of all anatomical details of *Guttiferoxylon indicum* is met with in the woods of *Ailanthus* of the Simaroubaceae. Hence it should be placed under the genus *Ailanthoxylon*.

Fossil woods resembling modern *Ailanthus* are already known from the same locality from where the wood under revision was collected, they are *Ailanthoxylon scantiporosum* Ramanujam and *A. pondicherriense* Navale (1964). Recently Prakash *et al.* (1967) have shown that these woods are identical with *Ailanthoxylon indicum* Prakash (1959) from the Deccan Intertrappean Series. Similarly *Guttiferoxylon indicum* Ramanujam is also identical with *Ailanthoxylon indicum* in all anatomical details. Therefore, *Guttiferoxylon indicum* Ramanujam is merged with *Ailanthoxylon indicum* Prakash.

In the same paper Ramanujam (1960) described another fossil wood as *Celastrinoxylon dakshinense* showing its closest resemblance with the wood structure of the family Celastraceae as a whole. The important anatomical characters of the fossil as described by him (Ramanujam, 1960, pp. 111-112) are: vessels small to medium, tylosed, perforations scalariform with 3-7 scalariform bars in addition to simple; parenchyma apotracheal, in short tangential strips (diffuse-aggregate), forming a sort of reticulum with fibre-tracheids, parenchyma strips 1-2 cells, forming fairly widely spaced; ground tissue composed of thick-walled fibre-tracheids with numerous bordered pits, pits circular with rounded apertures; xylem rays 1-4 seriate, short or long with 1-3 marginal rows of vertical (upright) cells which are sometimes placed on the outer fringes of the rays. These anatomical characters of the fossil do not tally with the characters exhibited by the photographs of the same wood (Ramanujam, 1960, pl. 18, figs. 19-21). After critical re-examination of the type slides it was confirmed that the fossil has been erroneously described and compared with those of Celastraceae. The fossil is very much different in its anatomy than what it has been described. The important anatomical characters of this fossil wood as observed by the present author are: vessels small to medium, the smaller being towards the centre (near the pith), solitary and in radial multiples of 2-4; parenchyma paratracheal, aliform to aliform-confluent, confluent bands fine, often extending beyond the proximate xylem rays (Pl. 1, figs. 6, 7); xylem rays 1-4 seriate, homogeneous, consisting of procumbent cells only, about or up to 80 cells in height (Pl. 1, fig. 5); fibres non-septate, bordered, pits not seen.

From the above revised description of the fossil it is evident that there are no scalariform perforations. The parenchyma is not apotracheal type and the ground tissue consists of only non-libriform fibres without bordered pits. In view of the above facts *Celastrinoxylon dakshinense* cannot be a celastraceous wood. The revised anatomical characters indicate its close similarity with *Ailanthoxylon indicum* Prakash. The only difference between *Celastrinoxylon dakshinense* and *Ailanthoxylon indicum* is that in the former the dimensions of the elements of various tissues are comparatively smaller than those of the latter. This is a common phenomenon among woods. The size, i.e. the diameter and length of various tissues vary from region to region of the same tree. Another minor difference which may also be pointed out here is that the xylem rays in *Celastrinoxylon dakshinense* are slightly higher and narrower than those of *Ailanthoxylon indicum*. This may be due to the fact that the wood consists of a small twig with 7×4 cm length and diameter, having pith in the centre. In young or immature woods (or the portion of wood close to the pith) the xylem rays in some cases are present as narrower and higher than the rays of mature wood of the same tree. Taking these size differences into consideration *Celastrinoxylon dakshinense* still shows a closer resemblance with *Ailanthoxylon indicum*. Therefore, it has also been merged with *Ailanthoxylon indicum*.

The occurrence of the above two revised woods as well as of those which were originally described as *Ailanthoxylon scantiporosum* Ramanujam (1960) and *Ailanthoxylon pondicherriense* Navale (1964) and later merged with *Ailanthoxylon indicum* by Prakash *et al.* (1966), in the Cuddalore Series is doubtful. It has been shown that all these four species now placed under *Ailanthoxylon indicum* Prakash (1959) are identical in all anatomical details. Not only this, even their colour, general appearance of the material and the preservation of tissues is so similar as if they have been derived from the same horizon. The woods having so much of identity in all respects cannot be found in two different horizons, i.e. the Deccan Intertrappean Series and the Cuddalore Series, in which there is perhaps a gap of about 35 million years in their age. It is to be mentioned here that in an extensive survey of fossil locality made from where the above woods are claimed to have been described, the present author collected large number of duplicate pieces of all the woods so far described excepting the above woods and those placed under the family Euphorbiaceae by the earlier workers. This also leads us to conclude that these woods do not belong to the Cuddalore Series. The *Ailanthus* type of woods are very common in the Deccan Intertrappean beds. A large number of them are still stored in the Institute's museum. There are every chances that the wood pieces upon which the above species were based some how got mixed with the collection of the woods belonging to the Cuddalore Series. Unless it is proved otherwise by the chemical analysis their occurrence in the Cuddalore Series should be regarded as doubtful.

Family — LEGUMINOSAE

2. *Pahudioxylon sahnii* Ghosh & Kazmi

Pl. 1, fig. 8; Pl. 2, fig. 10

1961-*Pahudioxylon sahnii* Ghosh & Kazmi, p. 96, figs. 1-2.
1960-*Albizzioxylon sahnii* Ramanujam, p. 118, pl. 21, figs. 33-36, text-fig. 25.
1967-*Ingoxylon sahnii* (Ramanujam) Müller-Stoll & Mädel, p. 112.

Critical re-examination of the type slides of *Albizzioxylon sahnii* Ramanujam as well as several thin sections from the duplicate specimens of this wood collected from the same locality has created doubts about its affinities with the modern woods of *Albizzia*. Because some of the important anatomical characters which are characteristic of *Albizzia* are not present in it. One of them is the nature of fibres, which are described as septate but they have been found to be nonseptate. The other feature is the nature and distribution of apotracheal (terminal) parenchyma which Ramanujam described as very scanty and constituted by diffuse cells or cell group which are distinguished with difficulty from the surrounding fibres in transverse section. However, the apotracheal parenchyma is present in this fossil as fine or narrow, regular lines or bands of 2-4 cells wide, delimiting the growth rings (Pl. 2, fig. 10). This is a very important character of most of the leguminous woods. As there are no septa in the fibres it cannot be an *Albizzia*. Besides, this wood appears in general to be quite different from those of the modern *Albizzia* spp.

Recently, based on the description and figures of *Albizzioxylon sahnii* Müller-Stoll & Mädel (1967) re-assigned it to *Ingoxylon* and named *Ingoxylon sahnii* (Ramanujam) considering it closer to *Inga* than to *Albizzia*. Since they had not examined the type material or type slides they were not aware of the fact that it has nonseptate fibres. Like *Albizzia*, *Inga* also possesses septate fibres and therefore it cannot be an *Inga*. Hence the name *Ingoxylon sahnii* cannot be retained.

Taking into consideration the important characters of this wood such as the presence of terminal parenchyma, non-septate fibres, medium to moderately large vessels, aliform to aliform-confluent parenchyma, vestured inter-vessel pits, 2-3 seriate homogeneous xylem rays, it shows closest resemblance with those of *Afzelia* and *Intsia* (both being identical in wood structure). Therefore *Albizzioxylon sahnii* is transferred to the genus *Pahudioxylon* Chowdhury *et al.* (1960) which stands for the fossil woods resembling those of *Afzelia*, *Intsia* (*Pahudia*) (see Prakash, 1966). Among the species of *Pahudioxylon bankurensis* Chowdhury *et al.* (1960) from Bankura, West Bengal, *P. sahnii* Ghosh & Kazmi (1961) from Tripura and *P. deomaliense* Prakash (1965) from Deomali, Arunachal Pradesh, it shows similar

structure as present in *Pahudioxylon sahnii* Ghosh & Kazmi. There is hardly any difference between the two and therefore *Ingoxylon sahnii* (Ramanujam) Müller-Stoll & Mädel syn. *Albizzioxylon sahnii* Ramanujam is merged with *Pahudioxylon sahnii* Ghosh & Kazmi.

3. *Euacacioxylon bharadwajii* (Navale) Müller-Stoll & Mädel

Pl. 2, figs. 12-13

1963a—*Acacioxylon bharadwajii* Navale, p. 54, pl. 1, figs. 1-4, text-figs. 1-4.
1960—*Dalbergioxylon antiquum* Ramanujam, p. 125, pl. 24, figs. 47-48, pl. 25, figs. 49-51, text-figs. 32-35.

Ramanujam (1960) described another leguminuous wood as *Dalbergioxylon antiquum* suggesting it to be very similar to that of modern *Dalbergia*. The description and figures of this fossil wood also created doubts about its affinities with *Dalbergia*. On critical re-examination of the type slides as well as the section prepared from the type material it was found quite different from *Dalbergia*. The nature and distribution of the vessels, parenchyma and fibres as described and figured by him (Ramanujam, 1961, pp. 125-126, pl. 24, figs. 46-49, text-fig- 32) based on the type slides are no doubt correct but are different from those of *Dalbergia*. While the author has described and illustrated the xylem rays as 1-3 mostly (2-3) seriate, 8-22 cells high, spindle-shaped, storied (Ramanujam, *l.c.* pp. 126-127, pl. 25, figs. 50-51, text-figs. 34-35), in the type slides (tangential longitudinal section) which belong to the same type material from which the other tissues have been described, the xylem rays are entirely different, i.e. they are 3-8 seriate, 10-70 cells and up to 900 μ in height, non-storied (Pl. 2, fig. 13). When the type material of the wood does not possess that type of xylem rays as described by Ramanujam, the question arises as to how they have been described and illustrated as such. In the same paper Ramanujam also described another leguminous wood as *Pterocarpoxylon arcotense* which has similar xylem rays (Ramanujam, 1960, pl. 26, figs. 55-57) as described for *Dalbergioxylon antiquum*. It is, therefore, presumed that the author happend inadvertently to take the photomicrograph and the observation of the tangential section showing xylem rays of *Pterocarpoxylon arcotense*. As it has been shown above that the wood does not have storied xylem rays, it cannot be *Dalbergia*.

Among the fossil legumes an identical wood has been described by Navale (1964) as *Acacioxylon bharadwajii* resembling some of the acacias from the same area from where the wood under revision was described. Later Müller-Stoll and Mädel (1967) transferred it to the genus *Euacacioxylon* and named *Euacacioxylon bharadwajii* (Navale). They created this genus for those acacias which have non-septate fibres. Since *Dalbergioxylon antiquum* is identical to *Euacacioxylon bharadwajii* (Navale), it is being merged with the latter.

Family — COMBRETACEAE

4. *Terminalioxylon grandiporosum* Ramanujam

Pl. 2, figs. 14-15

1966—*Terminalioxylon grandiporosum* Ramanujam, p. 246, pl. 1, figs. 1-5, text-figs. 1-5.
1963b—*Dipterocarpoxylon cuddalorense* Navale, p. 66, pl. 1, figs. 1-4, text-figs. 1-4.

A fossil wood from near Murattandichavadi, exhibiting solitary as well as multiple vessels, paratracheal parenchyma and exclusively uniseriate xylem rays is described as *Dipterocarpoxylon cuddalorense* by Navale (1964). He suggested its close affinity with the modern *Dipterocarpus*, particularly with *D. tuberculatus*, *D. pilosus* and *D. obtusifolius*. According to him the most distinctive features of this fossil wood are the presence of vertical diffuse gum ducts and uniseriate xylem rays. In this connection it is important to mention here that a combination of these two important characters is found neither in *Dipterocarpus* nor in any other genus of the Dipterocarpaceae. Thus it is obvious that the identification of this fossil wood as *Dipterocarpus* is wrong. From a critical survey of the type slides and duplicate pieces of this species, it is revealed that there are no diffuse gum ducts. However, there are a few smaller vessels, as seen in the cross-

section, which are often filled with dark contents which Navale mistook for diffuse gum canals or ducts.

Among the modern woods it shows close resemblance with the woods of *Terminalia* of the Combretaceae. In 1966 Ramanujam in a study of some more combretaceous fossil woods described a wood as *Terminalioxylon grandiporosum* resembling that of *Terminalia* from the same locality. It possesses the important characters, such as large to very large, mostly solitary vessels (Pl. 2, fig. 15), large vestured inter-vessel pits; vasicentric and terminal parenchyma (Pl. 2, fig. 15); non-septate fibres; uniseriate homogeneous xylem rays with cells containing solitary crystal (Pl. 2, fig. 14). The fossil wood under revision, apart from these important characters, possesses all the minute anatomical details of *Terminalioxylon grandiporosum* Ramanujam. So it would not be misleading to regard the wood, upon which *Dipterocarpoxylon cuddalorense* is based, as a duplicate piece of *Terminalioxylon grandiporosum*. In view of this *Dipterocarpoxylon cuddalorense* Navale is merged with *Terminalioxylon grandiporosum* Ramanujam.

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EXPLANATION OF PLATES

PLATE 1

Ailanthoxylon indicum Prakash
Syn.
Guttiferoxylon indicum Ramanujam

1. Cross-section showing type and distribution of vessels and parenchyma. × 15.
2. Magnified cross-section showing vessels, parenchyma and fibres. × 50.
3. Intervessel pits. × 400.
4. Tangential longitudinal section showing xylem rays and fibres. × 50.

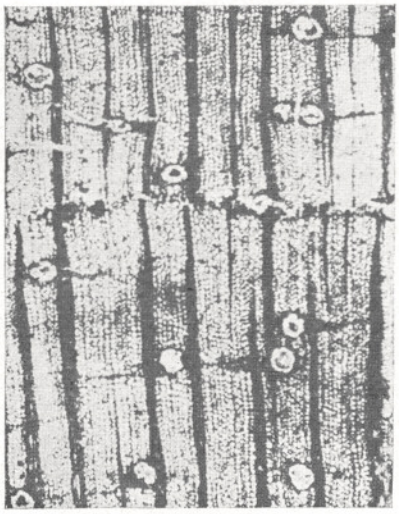
Ailanthoxylon indicum Prakash
Syn.
Celastrinoxylon dakshinense Ramanujam

5. Tangential longitudinal section showing xylem rays and vessel-members. × 50.
6. Complete cross-section under low magnification showing pith and the type and distribution of vessels. × 3.
7. Magnified cross-section showing type and distribution of vessels and parenchyma. × 50.

Pahudioxylon sahnii Ghosh & Kazmi
Syns.
Albizzioxylon sahnii Ramanujam

Ingoxylon sahnii (Ramanujam) Müller-Stoll & Mädel

8. Tangential longitudinal section showing rays. × 68.
9. Tangential longitudinal section of *Intsia palambengense* showing similar type of rays. × 68.



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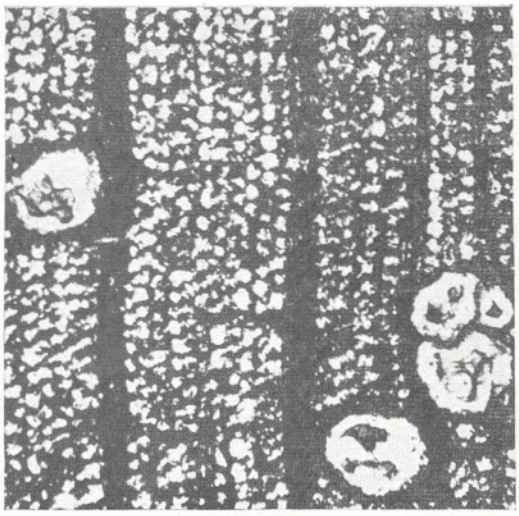

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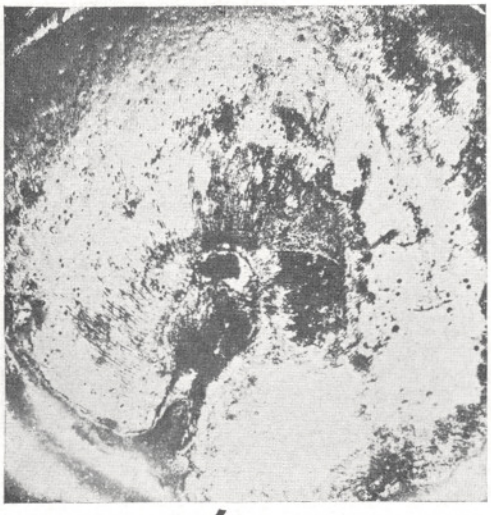

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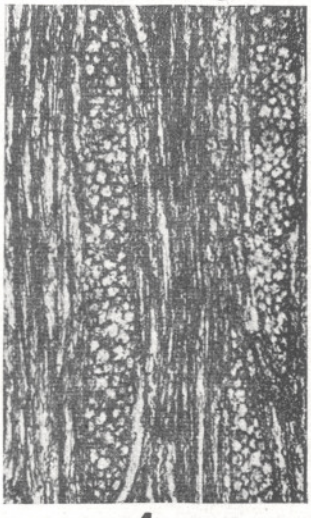

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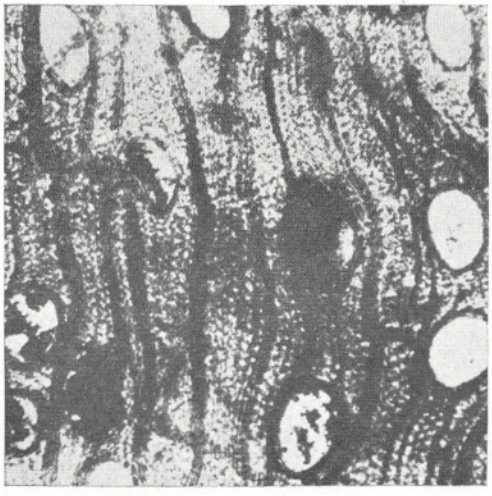

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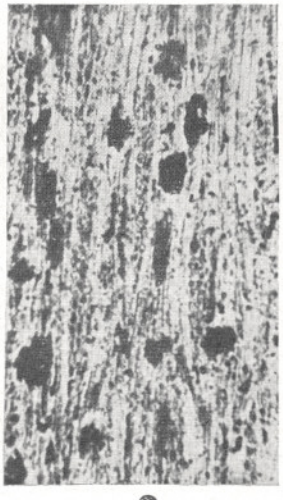

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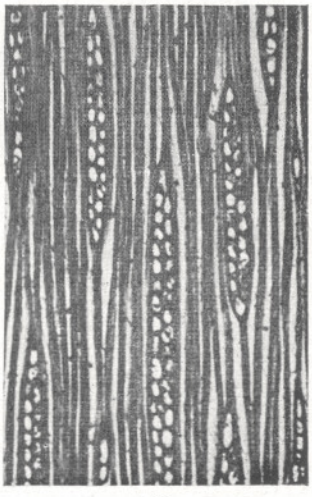

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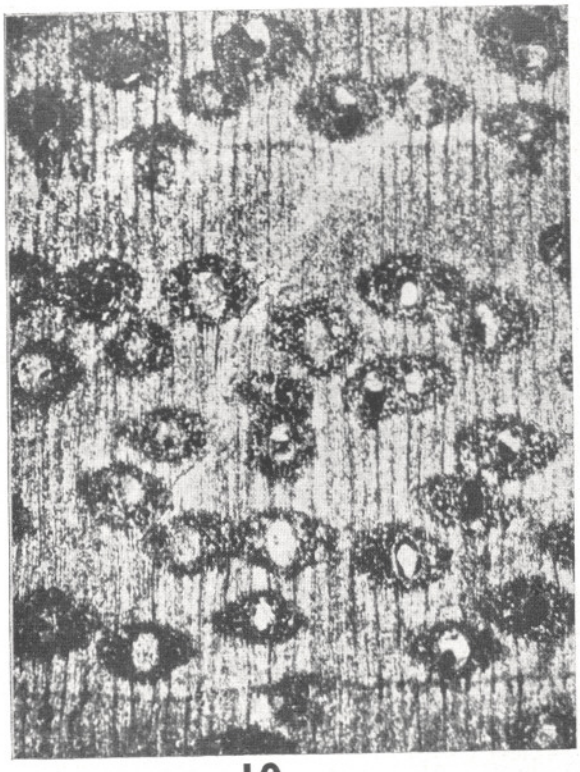

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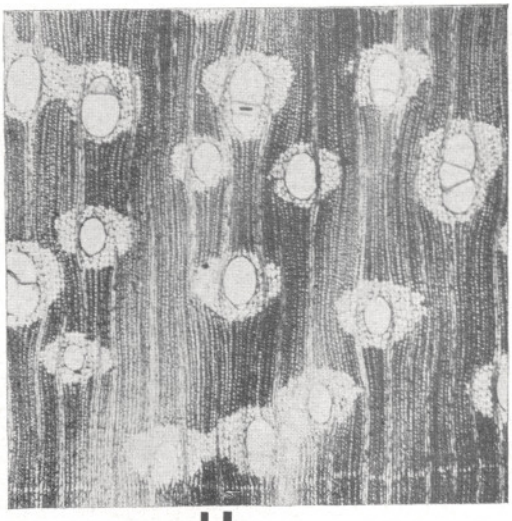

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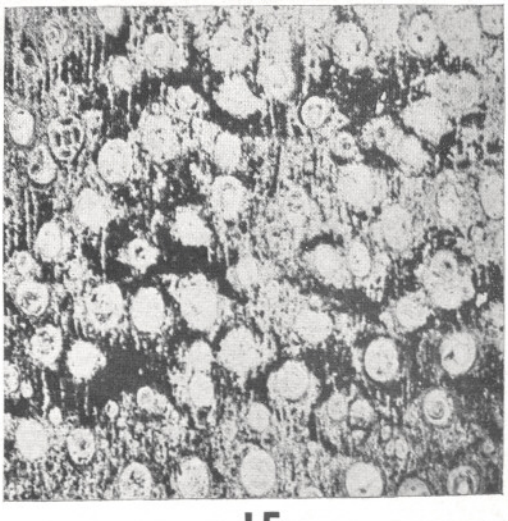

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PLATE 2

Pahudioxylon sahnii Ghosh & Kazmi
Syns.
Albizzioxylon sahnii Ramanujam

Ingoxylon sahnii (Ramanujam) Müller-Stoll & Mädel

10. Cross-section showing the type and distribution of vessels and parenchyma. × 15.
11. Cross-section of *Intsia palambengense* showing similar type of vessels and parenchyma. ×15.

Acacioxylon bharadwajii Navale
Syn.

Dalbergioxylon antiquum Ramanujam

12. Cross-section showing type and distribution of vessels and parenchyma. × 15.
13. Tangential longitudinal section showing xylem rays. × 68.

Terminalioxylon grandiporosum Ramanujam
Syn.
Dipterocarpoxylon cuddalorense Navale

14. Tangential longitudinal section showing xylem rays. × 68.
15. Cross-section showing nature and distribution of vessels and parenchyma. × 15.