

Text-figure 1—A, Multiseriate ray with one radial gum canal. $\times 80$; B, Multiseriate ray with two radial gum canals. $\times 80$.

Vessels small to medium, t.d. 50-170 μm , r.d. 60-210 μm , solitary and in radial multiples of 2-3, solitary vessels circular to oval, multiple vessels flattened at the places of contact, 11-18 vessels per sq mm; tyloses present; vessel-members 320-480 μm in length with truncate ends; perforations simple; inter-vessel pits alternate, angular, 8-10 μm in

diameter with linear apertures (Pl. 1, fig. 4). *Parenchyma* scanty, a few cells associated with vessels (Pl. 1, fig. 2), rarely forming uniseriate sheath around vessels. *Rays* fine to broad, 1-7 (mostly 1-4) seriate, uniseriate rays frequent, ray tissue heterogeneous; rays heterocellular, consisting of procumbent cells and 1-2 or sometimes more marginal rows of upright cells at both the ends, up to 30 cells high; broad rays usually consisting of 1-2 radial gum ducts, fusiform, up to 40 cells high; cells crystalliferous; upright cells 48 μm in tangential height, 32 μm in radial length, procumbent cells 20 μm in tangential height, 64 μm in radial length. *Fibres* aligned in radial rows, 20-28 μm in diameter, semilibriform, moderately thick-walled, septate. *Gum canals* radial, 1-2, occurring in multiseriate rays (Pl. 1, figs 6, 8; Text-figs 1, 2), about 48-96 μm in diameter.

Affinities—Such important anatomical features as heavily tylosed small to medium-sized vessels with inter-vessel pits having linear apertures, scanty paratracheal parenchyma, 1-7 (mostly 1-4) seriate xylem rays consisting of 1-2 gum canals in some multiseriate rays and septate fibres, strongly suggest the affinity of the carbonised wood with the family Burseraceae.

Although the presence of radial gum canals in rays does suggest its affinities with some of the woods of Anacardiaceae, the absence of characteristic features of this family such as usually large amount of parenchyma, lenticular apertures of inter-vessel pits and the fibres being mostly non-septate (except in a few genera such as *Lansea*, *Odina*, *Spondias*) easily rules out this possibility.

All the available literature on the xylotomy of Burseraceae (Anonymous, 1963; Desch, 1957; Henderson, 1953; Kribs, 1958; Metcalfe & Chalk, 1950; Miles, 1978; Moll & Janssonius, 1908; Pearson & Brown, 1932; Normand, 1960) and critical examination of thin sections of the woods of several

PLATE 1



Canarium palaeoluzonicum sp. nov.

- 1 Cross-section showing nature and distribution of vessels. $\times 35$; Slide no. BSIP 36221/I.
- 2 Cross-section magnified to show vessels and scanty paratracheal parenchyma. $\times 80$; Slide no. BSIP 36221/I.
- 3 Radial longitudinal section showing heterocellular ray. $\times 80$; Slide no. BSIP 36221/III.
- 4 Intervessel pits showing linear apertures. $\times 700$; Slide no. BSIP 36221/IV.

Canarium luzonicum (Bl.) A. Gray

- 5 Tangential longitudinal section showing multiseriate rays with single radial gum canals. $\times 80$; Slide no. BSIP Xylarium (BSIPw) 1711.

Canarium palaeoluzonicum sp. nov.

- 6 Tangential longitudinal section showing similar radial gum canals in the multiseriate rays as in *Canarium luzonicum* shown in (fig. 5) $\times 80$; Slide no. BSIP 36221/II.

Canarium luzonicum

- 7 Tangential longitudinal section showing multiseriate ray with two radial gum canals $\times 80$; Slide no. BSIP Xylarium (BSIPw) 1711

Canarium palaeoluzonicum sp. nov.

- 8 Tangential longitudinal section showing multiseriate ray with two radial gum canals as in *Canarium luzonicum* shown in fig. 7 $\times 80$; Slide no. BSIP 36221/II.

burseraceous genera and species clearly indicate that this family is homogeneous in wood structure. Consequently, it is usually not possible to differentiate its members on the basis of wood

anatomy except in some rare cases where some uncommon and characteristic features are noticeable. The Varkala carbonised wood has all the usual anatomical characters of Burseraceae including

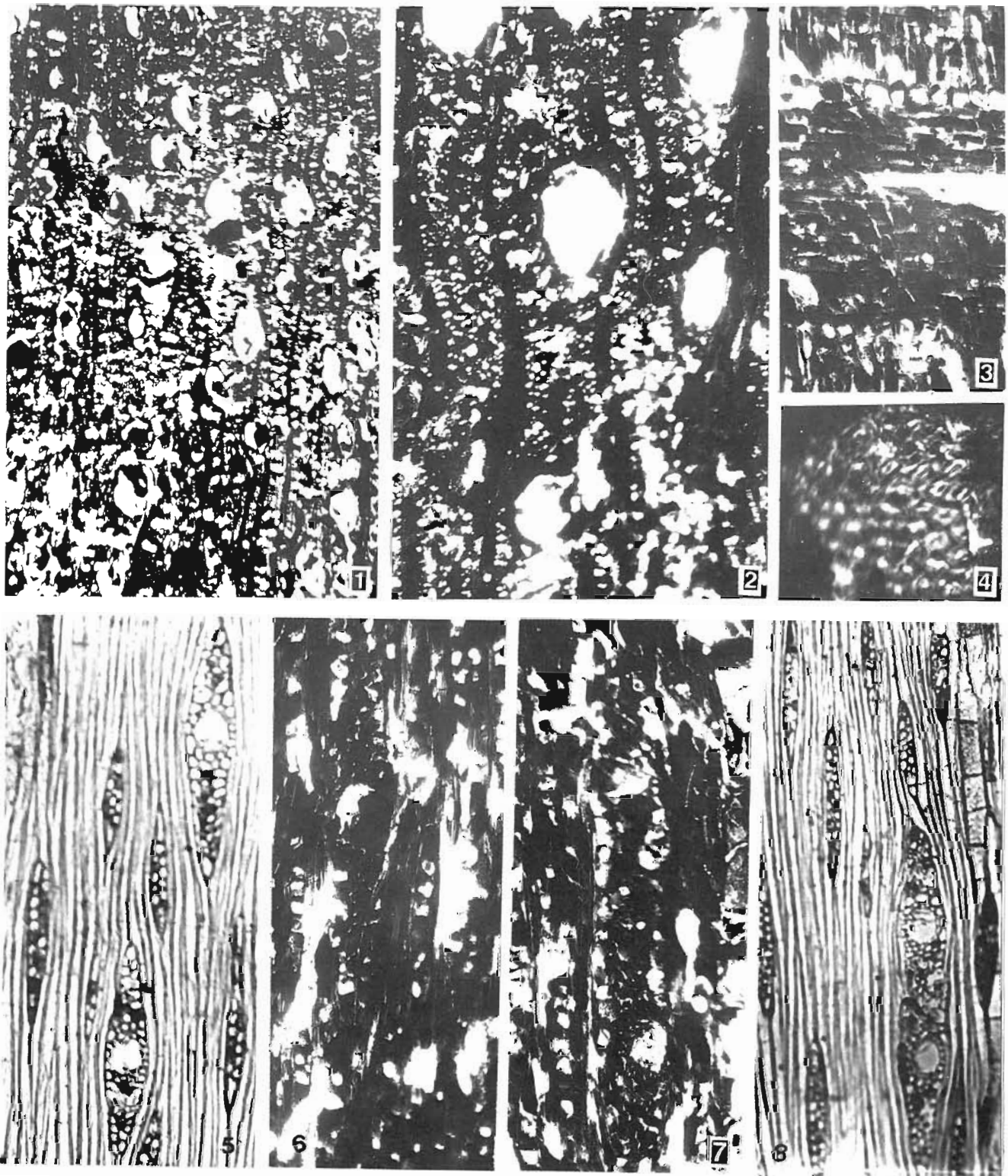


PLATE 1

one horizontal gum canal in its multiseriate rays. Some of these rays possess two gum canals, which is a unique feature so far found only in the modern wood of *C. luzonicum* (Bl.) A. Gray. Except uniseriate rays which are crystalliferous and more frequent, our carbonised wood and the wood of *C. luzonicum* are very similar in all the structural details such as shape, size and frequency of vessels;

amount of vasicentric parenchyma; height of xylem rays and the frequency of multiseriate rays with 1-2 horizontal gum canals.

Eight fossil woods, referred so far to Burseraceae, are known from the different Tertiary localities of the world. Their important features are furnished below in a comparative form:

Table 1

NAME OF SPECIES	GROWTH RINGS	VESSELS	PARENCHYMA	XYLEM RAYS	GUM CANAL	FIBRES	LOCALITY AND AGE
<i>Boswellioxylon indicum</i> Dayal 1964	Absent	Small to medium, sometimes large, t.d. 60-180 μm , r.d. 75-210 μm , solitary and in multiples of 2-4	Paratracheal, scanty, occurring as few cells around some of the vessels	1-6 (mostly 2-4) seriate, heterocellular, uniseriate less frequent, upright cells non-crystalliferous	Present	Thick-walled	Keria, Chhindwara District, M.P., India; Early Tertiary
<i>Burseroxylon preserratum</i> Prakash & Tripathi 1975; Bande & Prakash, 1983	Indistinct	Small to large, t.d. 80-200 μm , r.d. 160-280 μm , solitary and in radial multiples of 2-4, 12-18 per sq mm, tylosed; pits 8-10 μm	Paratracheal, scanty to (mostly 1) celled vasicentric sheath	1-4 (mostly 2-3) seriate, heterocellular, crystalliferous	Absent	Non-libri-form, septate	Near Hailakandi Assam (Miocene); Mandla District, M.P., India; (Early Tertiary)
<i>Burseroxylon garugoides</i> Lakhanpal, Prakash & Awasthi 1981	Indistinct	Mostly large to very large, sometimes medium, t.d. 105-345 μm , r.d. 75-420 μm , solitary and in radial multiples of 2-4, 5-10 vessels per sq mm, tylosed; pits 8-12 μm	Paratracheal, scanty to narrow vasicentric, forming 1-2 celled sheath around vessels	1-5 (mostly 2-4) seriate, heterocellular, 6-28 cells in height, crystalliferous	Absent	Thick-walled, septate	Deomali, Arunachal Pradesh, India; Miocene-Pliocene
<i>Canarioxylon ceskobudjovicense</i> Prakash, Brezinova & Awasthi 1974	Indistinct	Large to medium or small, t.d. up to 225 μm , r.d. up to 230 μm , solitary and in radial multiples of 2-3, tylosed; pits 8-12 μm	Paratracheal, scanty, a few cells associated with vessels	1-4 (mostly 2-3) seriate, heterocellular, ray cells occasionally crystalliferous	Absent	Semi-libri-form, septate	Bohemia, Czechoslovakia; Oligocene
<i>C. indicum</i> Ghosh & Roy 1978	Absent	Small to moderately large, t.d. 133-266 μm , solitary and in radial multiples of 2-5, tylosed; pits large	Paratracheal, scanty, forming narrow vasicentric sheath	1-3 (mostly 2) seriate, heterocellular	Absent	Thick-walled, septate	Birbhum, West Bengal, India; Miocene-Pliocene

Contd.

<i>C. shahpuraensis</i> Trivedi & Srivastava 1985	Absent	Small to large, Paratracheal, t.d. 75-250 μm , scanty, 1-2 r.d. 75-295 μm , celled sheath mostly solitary around vessels and in radial multiples of 2-4 with a ten- dency to an oblique pattern, 12-25 per sq mm	1-4 (mostly 2-3) seriate, heterocellular	Absent	Non-libriform to semilibri- form, septate	Near Mandla, M.P., India; Early Tertiary	
<i>Sumatroxylon molli</i> (Kräusel) Den Berger Syn. <i>Anacardioxylon molli</i> (Kräusel) Den Berger, 1923	Present	Small to medium, t.d. 50-155 μm , r.d. 80-200 μm , around vessels solitary and in 2-3, 8-12 per sq mm	Paratracheal, scanty, 1-2 celled sheath around vessels	4-6 seriate, heterocellu- lar, marginal cells crysta- lliferous	Present	Septate	Sumatra; Miocene
**Wood of Burseraceae	Present	Small to medium, mostly solitary and in multi- ples of 2-3, 5-6 per sq mm	Paratracheal, scanty	1-4 seriate, heterocellular	Absent	Septate	Mohgaonkalan, M.P., India; Early Tertiary

**This wood does not seem to belong to the family Burseraceae.

From a perusal of the anatomical features of all these fossil woods it is evident that the present carbonised wood is quite different in having 1-2 gu canals in multiseriate rays though in other characters it shows general resemblance with them. Hence, it is being assigned to a new species. In view of its close similarity with the wood of *Canarium luzonicum*, this fossil wood is being named as *Canarium palaeoluzonicum* sp. nov.

Holotype—Specimen no. BSIP 36221; Varkala Coast, Kerala; Mio-Pliocene.

DISCUSSION

Distribution of living and fossil Burseraceae

The family Burseraceae consists of 16 genera and about 500 species distributed in the tropical region (Willis, 1973, p. 172). In India, this family is represented by 5 genera, viz., *Boswellia*, *Canarium*, *Commiphora*, *Garuga* and *Protium*. The genus *Canarium* includes 75 species, widely distributed in the tropical regions of India, Sri Lanka, Mascarene, Madagascar, Africa, North Australia, Micronesia, Malaysia to Fiji Island. About 7 species are known to occur in India, mostly in the tropical evergreen forests of Assam, Kerala and Andaman Island. *Canarium luzonicum*, whose wood structure shows closest resemblance with the present carbonised wood from Varkala, commonly occurs in the Philippine Islands (Mindoro, Luzon, Alabat Island, Masbate, Tiaco Island and Bohol) in primary rain

forest at low and medium altitudes (Leenhouts, 1955, p. 270).

Besides petrified woods described from the Tertiary of Czechoslovakia, Sumatra and India fossil leaves and fruits of Burseraceae are also known from several parts of the world. They are (i) *Burserites venezuelana* Berry 1921 from the Tertiary of Betijoque, Trujillo, Venezuela, (ii) *B. fayettensis* Berry 1924 from the Eocene of Fayette Sandstone, Louisiana, U.S.A., (iii) *Bursera inequilateralis* (Lesquereux) Mac Ginitie 1969 from the Eocene of Green River Formation, North-western Colorado and Wyoming, U.S.A., (iv) *Canarium californicum* Mac Ginitie 1941 from the Middle Eocene of Central Siera Nevada, Western U.S.A., and (v) *Icica pichileufuana* Berry 1938 from the Tertiary of Rio Pichileufu, Argentina. Leaflets comparable to *Canarium californicum* Mac Ginitie have been described by Tanai (1970) as *Canarium ezoanum* from the Kushiro Coalfield (Oligocene), Hokkaido, Japan. From the Upper Miocene of Western Honshu, Japan, Kakawa (1955) reported seeds of *Canarium album*.

A number of fruits and a carpel have been described in the Eocene flora of southern England by Reid and Chandler (1933), Chandler (1961, 1962, 1963) and Collinson (1983) under the genera *Tricarpellites*, *Protocommiphora*, *Bursericarpum* and *Palaebursera*.

From the above records it is evident that the family Burseraceae was quite well established during Early Tertiary in the warmer regions of the old as well as the new world. In India, fossil plants of

Burseraceae have been found in Early Eocene Deccan Intertrappean beds as well as in various Neogene deposits of southern and eastern parts of the country. The occurrence of *C. palaeoluzonicum*, a species closely resembling *C. luzonicum* of Philippines, has interesting phytogeographical significance. Its presence along with some other Malayasian elements, viz., *Dryobalanops*, *Swintonia*, *Gonystylus* and *Leea* in the Neogene of Kerala Coast suggests a phytogeographical link of the Indian sub-continent with Southeast Asia during Mio-Pliocene

Nomenclature of the fossil woods of Burseraceae

So far the known records of fossil woods of Burseraceae have been described under four genera, viz., (i) *Boswellioxylon* Dayal 1964, (ii) *Burseroxylon* Prakash & Tripathi 1975, (iii) *Canarioxylon* Prakash *et al.* 1974, and (iv) *Sumatroxylon* Den Berger 1923. Of these, the first three are obviously for the fossil woods supposedly resembling those of *Boswellia*, *Bursera-Garuga* and *Canarium* respectively and the fourth is for those showing affinities with burseraceous woods in general. As already pointed out, the generic and specific differentiation among the woods of Burseraceae is usually not possible because of the homogeneity in their anatomical characters. Unfortunately, while creating the fossil genera, their respective authors did not give due consideration to this fact. Bearing separate generic names, these fossil genera are supposed to be distinct from each other in their anatomical features, but critically looking at the diagnoses of these four genera one can hardly find any difference between them. Thus, these different genera having hardly any structural differentiation are unwarranted. In this context Lakhanpal and Prakash (1980) have suggested that in cases where it is not possible to identify the fossil woods beyond the family level, new genera should be created by adding *oxylon* to the name of the family. Accordingly we propose that all the fossil woods of Burseraceae listed in Table 1 should be placed under the form genus *Burseraceoxylon*. This genus would include all fossil woods of Burseraceae which possess the following general anatomical features of this family

Wood diffuse-porous. *Growth rings* distinct or indistinct. *Vessels* small to large, solitary as well as in radial multiples of usually 2-5, tylosed; perforation simple. *intervessel pits* large, bordered, alternate, with linear to lenticular (mostly linear) apertures. *Parenchyma* paratracheal, scanty to narrow vasicentric. *Rays* fine to broad, 1-6 seriate, heterogeneous, multiseriate rays with or without radial gum canals; cells often crystalliferous. *Fibres*

thin to moderately thick-walled, septate. Horizontal (Radial) *Gum canals* present or absent, when present solitary, occurring in multiseriate rays.

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