OCCURRENCE OF *BOSWELLIA* IN THE DECCAN INTERTRAPPEAN BEDS OF KERIA, MADHYA PRADESH

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ABSTRACT

The present paper describes in detail the anatomy of a fossil dicotyledonous wood, *Boswellioxylon indicum* Dayal (1964), from the Deccan Intertrappean beds of Keria (21°59′40″ N; 79°10′15″ E) in Madhya Pradesh. In all anatomical details the fossil wood resembles the modern genus *Boswellia* Roxb. of the family Burseraceae.

INTRODUCTION

THE fossil flora of the Deccan Intertrappean beds possesses an abundance of silicified dicotyledonous woods. In recent years these woods are being studied intensively with regard to their botanical identification and interpretation. Although a number of dicotyledonous woods have been described from other localities of these beds, only *Bridelioxylon kraeuselii* (Prakash) Mädel (1962) and *Mallotoxylon keriense* Lakhanpal & Dayal (1964) are known from Keria.

The Intertrappean wood dealt with in the present paper was briefly described in a recent note (DAYAL, 1964). Its resemblance with the wood structure of the living *Boswellia* was shown and the name *Boswellioxylon indicum* was proposed for it. In the present paper it has been described in detail and compared anatomically with the wood of a large number of the extant dicotyledons.

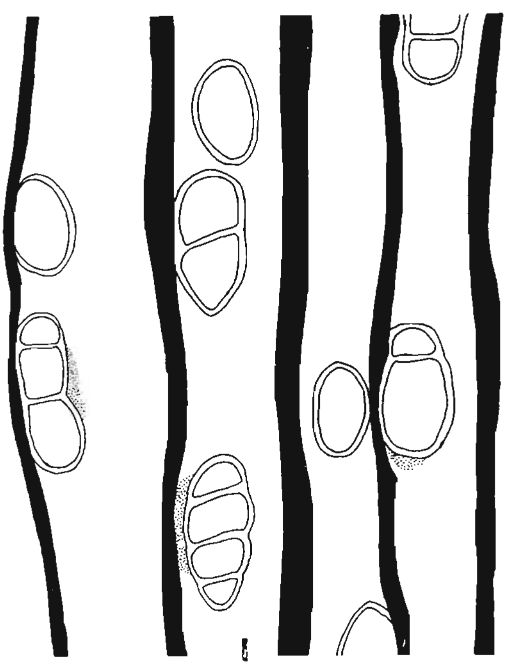
DESCRIPTION

FAMILY — BURSERACEAE

Boswellioxylon indicum Dayal

The material on which the present species is based, comprises two petrified pieces of decorticated secondary wood. The bigger specimen, about 7·5 cm. long and 8 cm. wide, is fairly well-preserved. The general appearance of the fossils suggests that they come from a large-sized trunk as they are not close to the pith.

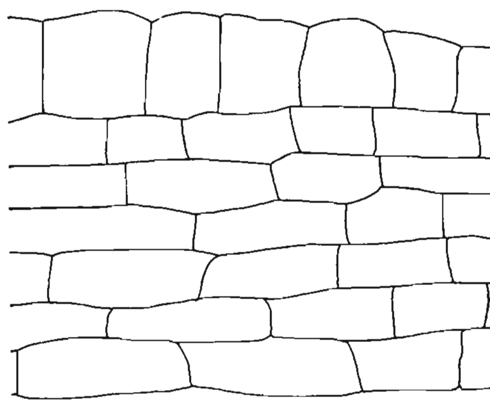
Topography — *Wood* diffuse-porous (PL. 1, FIG. 1). *Growth rings* indistinct (PL. 1, FIG. 1). *Vessels* appearing as minute dots to the naked eye, small to medium-sized, solitary and in radial multiples of 2-4 or more cells, sometimes in short double rows and small clusters (PL. 1, FIGS. 1 & 2; TEXT-FIG. 1), evenly distributed without any pattern, 10-22 per sq. mm., with rays contiguous on one or both the sides, profusely tylosed (PL. 1, FIGS. 2 & 3). *Parenchyma* scanty — paratracheal, not visible with a hand lens, difficult to locate even under the microscope, occurring as few cells about some vessels (PL. 1, FIG. 2; TEXT-FIG. 1). *Xylem rays* visible to the naked eye in the cross-section of the wood, fine to moderately broad, 1-6 (mostly 2-4) seriate (PL. 1, FIGS. 3, 5 & 7) and 16-90 μ wide, 8-13 per



TEXT-FIG. 1 — Cross-section showing the shape, size and distribution of the vessels and the parenchyma (stippled). × 220.

mm.; ray tissue heterogeneous; uniseriate rays very few, 4-6 cells and up to 100 μ high, often composed of upright cells only, sometimes of both procumbent and upright cells (TEXT-FIGS. 2-4); multiseriate rays 2-5 cells and 20-90 μ broad, 90-675 μ high, often with intercellular canals (PL. 1, FIGS. 3, 5 & 7), heterocellular consisting of procumbent cells with 1-2 marginal rows of upright cells (PL. 1, FIG. 4; TEXT-FIG. 5). *Fibres* aligned in more or less distinct radial rows between the two consecutive xylem rays (PL. 1, FIG. 2). *Intercellular canals* of radial type (PL. 1, FIGS. 3, 5 & 7).

Elements — *Vessels* thinwalled, the common wall about 8 μ thick; the solitary vessels circular or oval in cross-section, sometimes slightly angular, those in radial multiples flattened at the places of contact, t.d. 60-150 μ, r.d. 75-165 μ in fossil specimen No. 32781; t.d. 75-180 μ, r.d. 90-210 μ in fossil specimen No. 32782; vessel-members with truncate or slightly tapered ends (TEXT-FIG. 6); perforations simple (TEXT-FIG. 7); intervessel pit-pairs large, 8-10 μ in diameter, bordered, alternate, border hexagonal due to crowding, aperture linear and horizontal (PL. 1, FIG. 6); vessel-ray and vessel-parenchyma pits not preserved. *Parenchyma cells* thinwalled, circular or oval in cross-section. *Ray cells* thin to slightly thickwalled; procumbent cells round-oval or slightly angular as seen in the tangential longitudinal section, radial length 24-40 μ, vertical height 16-20 μ, with infiltration; upright cells without any crystals, radial length 20-28 μ, vertical height 32-36 μ; pits of the ray cells not observed. *Fibres* typically septate (PL. 1, FIGS. 3 & 5), moderately thickwalled, the



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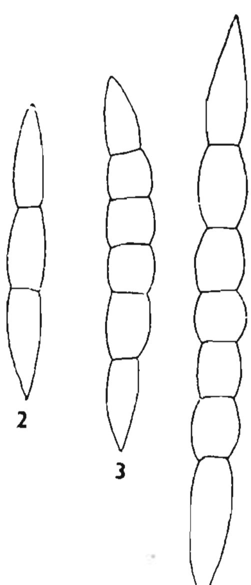

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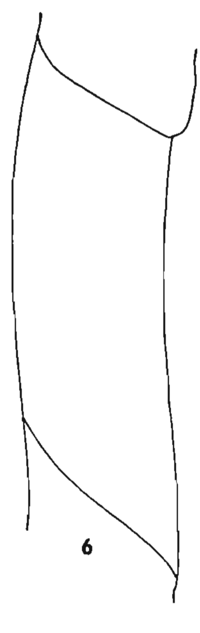
TEXT-FIGS. 2-4 — 2. Uniseriate xylem ray consisting of upright cells only. × 350. 3, 4 — Uniseriate xylem rays consisting of procumbent cells with marginal upright cells. × 350.



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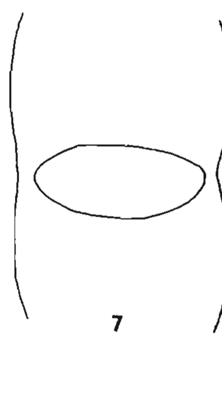

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TEXT-FIGS. 5-7. Radial longitudinal section showing procumbent cells and single row of upright cells. × 350. 6. Vessel-member. × 220. 7. Simple perforation. × 350.

walls about 4-8 μ thick, circular or angular in the cross-section; t.d. 4-16 μ, r.d. 8-20 μ; interfibre pits not observed. *Intercellular radial canals* 0-10 per sq. mm., usually 1-2 in a ray, rarely more than two, commonly roundish to broadly elliptic in tangential longitudinal sections; t.d. of the canal orifice 45-105 μ in fossil specimen No. 32782 (PL. 1, FIG. 7), and 20-75 μ in fossil specimen No. 32781 (PL. 1, FIG. 5); usually bordered by one to several layers of cells which are smaller in tangential section than the ordinary ray cells.

DISCUSSION

Comparison with the Living Species — The important structural features of the fossil wood are: (1) small to medium-sized vessels which are solitary and in radial multiples of 2-4 or more cells; (2) very sparse paratracheal parenchyma occurring as few cells about the vessels; (3) intervessel pit-pairs which are large, bordered and alternate; (4) heterogeneous ray tissue; (5) septate fibres; and (6) the presence of intercellular radial canals. The last feature is diagnostically valuable in the identification of the dicotyledonous woods. Occurrence of intercellular radial canals has been reported (RECORD, 1925) in a number of woody genera belonging to about a dozon families of the modern dicotyledons. However, considering all the features collectively some genera of the Anacardiaceae and Burseraceae show greater resemblance with the present fossil wood. Therefore, a detailed comparison with these two families is made below:

The Anacardiaceae (RECORD, 1925, 1939; MOLL & JANSSONIUS, 1908, pp. 438-512; PEARSON & BROWN, 1932, pp. 309-347; HEIMSCH, 1942, pp. 136-144; METCALFE & CHALK, 1965, p. 459) has a number of genera which are characterized by the presence of radial canals. Of these the wood structure of *Lannea* A. Rich. shows many similarities in gross features with the present fossil. Thin sections of about fifteen samples of *Lannea coromandelica* (Houtt.) Merrill [Syn. *Lannea grandis* (Dennst.) Engler, *Odina wodier* Roxb., *Lannea wodier* (Roxb.) Adelb.] (RAIZADA, 1958) were available for examination. It has, however, been observed that there are some important anatomical details which distinguish the Intertrappean fossil wood from *Lannea*. In the modern species examined (*L. coromandelica*) the radial canals are occasional, so much so that in many of the samples examined the canals are rare or absent; their frequency is very low (0-2 per sq. mm.); and the marginal upright cells of the rays are crystalliferous and conspicuous in the tangential longitudinal sections.

Other genera of the Anacardiaceae, although possessing radial canals, differ markedly from the Intertrappean fossil in one or the other anatomical details. Thus, *Melanorrhoea* Wall., *Gluta* Linn., *Swintonia* Griff. and *Bouea* Meisen. can be easily distinguished by the abundant apotracheal parenchyma which occurs as thin or thick tangential bands. Similarly *Schinopsis* Engl., with aliform of locally confluent parenchyma and *Buchanania* Roxb., with abundant paratracheal parenchyma forming one to several seriate sheath round the vessels and sometimes becoming confluent, show little similarity with the fossil. In *Schinus* Linn. the vessels are very small and arranged in ulmiform pattern. Various species of *Rhus* Linn. and *Pistacia* Linn. are distinctly ring-porous. Moreover, in *Pistacia* the vessels are commonly grouped in nests and arranged in oblique pattern. In *Parishia* Hook. f. the vessels are large to medium-sized and the fibres are non-septate. In *Spondias* Linn. the vessels are very large to medium-sized, the parenchyma is paratracheal as one to several seriate sheath round the vessels, rarely confluent with some scattered cells (diffuse). The fossil, therefore, cannot possibly be any of these genera.

Among the modern Burseraceae (MOLL & JANSSONIUS, 1908, pp. 87-109; PEARSON & BROWN, 1932, pp. 217-233; WEBBER, 1941, pp. 441-465; HEIMSCH, 1942, pp. 122-124; METCALFE & CHALK, 1950, pp. 345-347) there are only a few genera with radial canals (RECORD, 1925). Of these only three genera, viz., *Canarium* (Rumph.) Linn., *Garuga* Roxb. and *Boswellia* Roxb. ex Colebr. are worth comparing. Thin sections of a number of species of *Canarium*, viz., *C. bengalense* Roxb., *C. strictum* Roxb. and *C. euphyllum* Kurz from India, *C. zeylanicum* Bl. from Ceylon and *C. villosum* Hook.f. from Manila, Philippine Islands, were examined for comparison. A detailed microscopic examination has, however, shown that none of these species except *C. zeylanicum* possesses the intercellular radial canals. Moreover, in the genus *Canarium* the vessels are mostly large to very large with a maximum tangential diameter of up to 350 μ, the paratracheal parenchyma is abundant and the marginal upright cells of the rays are usually large and crystalliferous (METCALFE & CHALK, 1950, p. 345; PEARSON & BROWN, 1932, pp. 217-233; WEBBER, 1941).

Similarly, the genus *Garuga* is also distinguished from the present fossil wood by its vessels which are always large and the marginal upright cells of the rays are crystalliferous and conspicuous in the tangential longitudinal sections (METCALFE & CHALK, 1950, p. 345; PEARSON & BROWN, 1932, pp. 221-223; WEBBER, 1941). The frequency of the radial canals, as has been examined in *Garuga pinnata*, is very low (0-2 per sq. mm.). It is important in this connection to mention that in *G. floribunda* Decne. described and figured by Reyes (1938, pp. 164-165, PL. 25, FIG. 2) the intercellular radial canals are absent and the rays have oil cells.

As regards the modern genus *Boswellia* Roxb., thin sections of about ten samples of *Boswellia serrata* Roxb. were available for study. Wood structure of this genus has also been described and figured by Chowdhury (1945, p. 35, PL. 22), Gamble (1902, p. 137, PL. 3, FIG. 1), Heimsch (1942, pp. 122-124, PL. 8, FIG. 46), Kanehira (1924, p. 5), Metcalfe & Chalk (1950, pp. 345-347, FIG. 79G), Pearson & Brown (1932, pp. 218-219, FIG. 81) and Webber (1941, pp. 441-465). A detailed examination of the modern wood as well as the published literature has revealed that the present fossil wood is closely allied to the modern genus *Boswellia* especially *B. serrata* Roxb. (F.R.I. Slide No. A 1741).

The size, shape and distribution of vessels in the present fossil wood is similar to the distributional pattern in *Boswellia serrata* (F.R.I. Slide No. A 1741). Both in the fossil and the living species the perforations are simple and the intervessel pit-pairs are large, alternate and bordered with usually hexagonal borders and linear and horizontal apertures. Tyloses have also been observed in some samples of *Boswellia serrata*. Occurrence of tyloses has also been reported by Chowdhury (1945, p. 35).

The amount and distribution of the parenchyma, as also the nature and distribution of the xylem rays, the radial canals and the fibres is basically similar both in the fossil and the modern wood. It is important at this place to mention that the marginal upright cells of the rays are non-crystalliferous and not conspicuous in the tangential longitudinal sections both in the fossil wood and the wood of the modern *Boswellia* (METCALFE & CHALK, 1950, p. 345; WEBBER, 1941). The crystals have also not been observed in the samples of *B. serrata* examined.

Comparison with the Fossil Species — As far as known the present find forms the first record of the fossil wood resembling the modern *Boswellia* from India and abroad. However, there are two other fossil dicotyledonous woods which have been referred to the Burseraceae. The first one was described by Shallom (1958), without a name, showing affinity to Burseraceae from the Deccan Intertrappean beds of Mahurzari, India. This fossil wood, however, does not possess intercellular radial canals, a character by which alone it can be distinguished from the present fossil. The second is *Sumatroxylon mollii* (Kräusel) Berger (1923) from the Tertiary of South Sumatra. This wood was first described by Kräusel (1922) as *Anacardioxylon mollii* showing resemblance with the modern genus *Lannea* of Anacardiaceae. Later on Berger (*l. c.*) found that the wood shows near resemblance to Burseraceae, and he gave it a non-committal name, i.e., *Sumatroxylon mollii*. However, in this wood the marginal upright cells of the rays are very conspicuous, i.e., they are large and crystalliferous a character not seen in the modern wood of *Boswellia* (METCALFE & CHALK, 1950, p. 345; WEBBER, 1941), with which the present fossil shows its closest resemblance. Moreover, in *Sumatroxylon mollii* the radial canals are smaller, only 15-30 μ in diameter.

The genus *Boswellia* Roxb. consists of 10 species of small, medium-sized, or large deciduous trees. Nine species occur in north-eastern tropical Africa and the tenth species, *B. serrata* Roxb., has a wide distribution in India. It is a moderate to large tree common and usually gregarious in dry forests throughout India; not found in Bengal, Assam and Burma. It is very common in most parts of Madhya Pradesh, Maharashtra, Bihar and Orissa. It is equally common in Rajasthan, Central India and north Gujrat (PEARSON & BROWN, 1932, p. 218). It is interesting to note that

Boswellia serrata grows very near the fossil locality.

In the drier parts of Maharashtra, Madhya Pradesh and Berar it generally occupies the hotter slopes and ridges of hills, usually on trap and sometimes on gneiss and schist. In its natural habitat the absolute maximum shade temperature varies from 110° to 120° F, the absolute minimum from 30° to 45° F, and the normal rainfall from 20-50 inches (TROUP, 1921, p. 175).

GENERIC DIAGNOSIS

Boswellioxylon Dayal, 1964

Wood diffuse-porous. *Growth-rings* distinct or indistinct. *Vessels* small to medium-sized (sometimes large), solitary and in radial multiples of 2-4 or more cells, sometimes in short double rows or small clusters; vessel-members small to medium-sized; perforations simple; intervessel pit-pairs large, bordered, alternate with usually hexagonal border and linear aperture. *Parenchyma* scanty-paratracheal. *Xylem rays* 1-6 seriate; uniseriate rays very few; multiseriate rays with radial canals; ray tissue heterogeneous; crystals in the marginal upright cells absent. *Fibres* moderately thick-walled, typically septate. *Intercellular canals* of radial type, 0-10 per sq. mm., tangential diameter, of the canal orifice 20-105 μ.

Genotype — *Boswellioxylon indicum* Dayal, 1964

SPECIFIC DIAGNOSIS

Boswellioxylon indicum Dayal, 1964

Growth rings indistinct. *Vessels* moderately small to medium-sized, t.d. 60-180 μ, r.d. 75-210 μ, solitary and in radial multiples of 2-4 cells, sometimes in short double rows and small clusters; tyloses present; intervessel pit-pairs large, 8-10 μ, bordered, alternate, with hexagonal borders due to crowding and usually linear aperture. *Parenchyma* occurring as few cells about some vessels. *Xylem rays* 1-6 cells and 16-90 μ wide; uniseriate rays very few; multiseriate rays consisting of procumbent cells in the thickened portion with 1-2 marginal upright cells, upright cells without crystals; ray tissue heterogeneous. *Fibres* moderately, thick-walled, septate. *Intercellular canals* present, of radial type, 0-10 per sq. mm.; the canal orifice t.d. 20-105 μ, commonly roundish to broadly elliptic in tangential longitudinal sections, usually bordered by several layers of cells which are smaller in tangential longitudinal section than the ordinary ray cells.

Syntypes — B.S.I.P. Museum Nos. 32781 and 32782.

Locality — Keria, district Chhindwara, Madhya Pradesh.

Horizon — Deccan Intertrappean Series.

Age — Early Tertiary (probably Eocene).

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EXPLANATION OF PLATE

PLATE 1

1. Cross-section at low magnification showing distribution of the vessels and indistinctly seen growth rings. × 15.

2. Cross-section magnified to show the shape and size of the vessels and some parenchyma cells about the vessels. × 100.

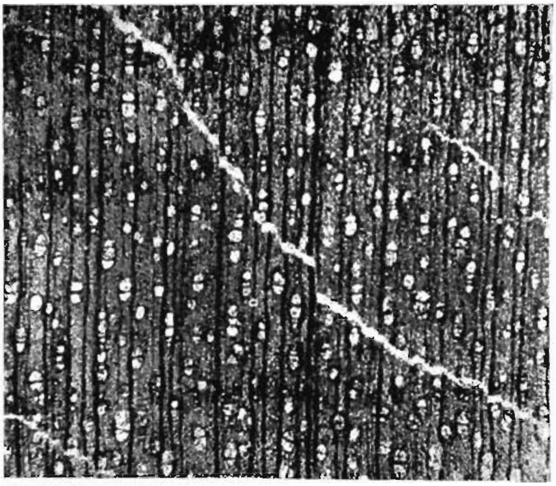
3. Tangential longitudinal section showing tyloses, distribution of the xylem rays and the intercellular canals. (Fossil Specimen No. 32781). × 100.

4. Radial longitudinal section showing procumbent cells and a row of upright cells. × 170.

5. Tangential longitudinal section magnified to show the xylem rays and the septate fibres. × 200.

6. Intervessel pit-pairs. × 440.

7. Tangential longitudinal section showing intercellular radial canals, tyloses and the septate fibres (Fossil Specimen No. 32782). × 50.



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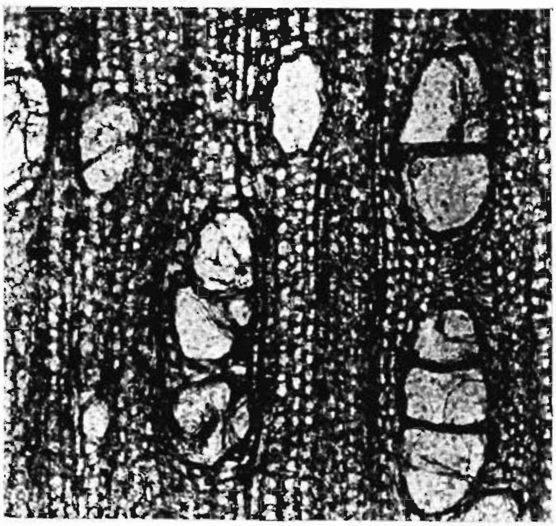

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