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TWO NEW DIPTEROCARPACEOUS WOODS FROM THE MIDDLE SIWALIK OF KALAGARH, BIJNOR DISTRICT, INDIA

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ABSTRACT

Two new fossil woods described here were collected from near Kalagarh, Uttar Pradesh at the foot hills of the Himalayas which are reported to be of Mio-Pliocene age. Both these woods show closest resemblance with the genus *Vateria* of the family Dipterocarpaceae. However, there are differences between the two and therefore two species of the new genus *Vaterioxylon*, viz., *Vaterioxylon kalagarhense* sp. nov. and *Vaterioxylon miocenecum* sp. nov. have been created for these woods.

Key-words— *Vaterioxylon*, Middle Siwalik, Mio-Pliocene, Kalagarh (India).

साराँश

कालागढ़, बिजनौर जनपद, भारत के मध्य शिवालिक से डिप्टेरोकारपेसी कुल के दो नये काष्ठाश्म—
भीम शंकर त्रिवेदी एवं जगदीश्वर प्रसाद मिश्रा

उत्तर प्रदेश में कालागढ़ के निकटस्थ हिमालय के गिरिपादों से एकत्रित दो काष्ठाश्मों का यहाँ वर्णन किया गया है जो कि मायो-प्लायोसीन काल के माने गये हैं। ये दोनों काष्ठाश्म डिप्टेराकारपेसी कुल की **वैटेरिया** प्रजाति से घनिष्ठ अनुरूपता प्रदर्शित करते हैं तथापि इन दोनो में कुछ भिन्नताऐं हैं। अतएव इनके लिए **वैटेरियॉक्सोलॉन** न० प्रजाति की दो जातियाँ अर्थात् **वै० कालागढ़ेन्से** न० जा० तथा **वै० मियोसेनिकम्** न० जा० बनाई गई हैं।

INTRODUCTION

MANY silicified fossil woods were collected by one of us (JPM) from near Kalagarh (29′ 33″ N & 78′ 43″ E), Bijnor District, Uttar Pradesh. This locality is situated at the foot hills of Himalayas known as Siwalik ranges. The formations near Kalagarh belong to Middle Siwaliks (Mio-Pliocene) according to Middlemiss (1890), Auden (1937) and Krishnan (1960). Hills on the North-eastern boundary of the township are drained by small tributaries (rivulets & nalahs) of the Ramganga River. From the beds of these tributaries a large number of fossil woods have been recovered. Some of these are well-preserved and quite a few of them belong to the family Dipterocarpaceae. We are here describing one new genus, viz., *Vaterioxylon* with two new species *V. kalagarhense* and *V. miocenecum*.

The locality from which these woods are being described has been recently discovered and the woods have been reported for the first time from this area.

So far, only five fossil woods of this family have been described from several other places in the Siwalik range. *Dipterocarpoxylon* sp. was described by Rawat (1964) from Mohand near Dehra Dun, some 150 km west of Kalagarh. Ghosh and Ghosh (1958) described *Anisopteroxylon jawalamukhi* from the "Middle conglomerate zone" of the Middle Siwaliks near Jawalamukhi (Himachal Pradesh) and

Dipterocarpoxylon sivalicus, *D. nalagarhense* and *D. premacrocarpum* have been described by Prakash (1975) from the Lower Siwalik beds near Nalagarh in Himachal Pradesh.

SYSTEMATIC DESCRIPTION

FAMILY — DIPTEROCARPACEAE

***Vaterioxylon* gen. nov.**

Vaterioxylon kalagarhense sp. nov.

Pl. 1, figs 1-3

Material — Woods piece about 10 cm in length, 8 cm in diameter and greyish black in texture. Preservation is fairly good.

Topography — Wood diffuse porous. *Growth rings* absent. *Vessels* medium to large, solitary, occasionally in radial group of two, distributed in oblique pattern (Pl. 1, fig. 1) and at places in tangential rows, some vessels are ocluded with gummy deposits, heavily tylosed, 8-12 per sq mm, either side of the vessel contiguous with xylem rays. *Vasicentric tracheids* present round the vessel which intermingle with parenchyma cells. *Parenchyma* paratracheal and apotracheal, paratracheal parenchyma vasicentric, 1-2 seriate sheath interrupted by vasicentric tracheids, apotracheal parenchyma sparsely diffuse and also 2-3 seriate round the gum canals (Pl. 1, fig. 1). *Xylem rays* 6-10 per mm, 1-6 seriate, ray tissue heterogeneous, uniseriate rays many, heterocellular, composed both of procumbent and upright cells, 5-14 cells (up to 220 μm) high, 20-26 μm wide, multiseriate rays heterocellular, 16-36 cells (up to 960 μm) high, up to 68 μm wide, 1-6 upright cells present at both the ends, sheath cells present either on one or both the flanks (Pl. 1, figs 2, 3). *Fibres* not aligned in radial rows, non-septate and non-libriform. *Gum canals* mostly solitary and scattered, sometimes in tangential rows of 2-4, enclosed by parenchymatous cells.

Elements — Vessels medium to large in size, t.d. 148-180 μm, r.d. 165-280 μm, round to oval in cross section, vessel segments 820-1200 μm long with truncate or slightly tailed end, perforation simple, pits leading to contiguous tracheids alternate, bordered with orbicular pore. *Parenchyma* cells circular to angular, 28-32 μm in diameter. *Tracheids* oval to polygonal in cross section, 18-23 μm in diameter. Upright cells 40-44 μm in tangential height, radial length 35-40 μm, procumbent cells 16-21 μm in tangential height, radial length 40-60 μm. *Fibres* angular in cross section and 16-19 μm in diameter. *Gum canals* 90-120 μm in diameter.

AFFINITIES

Comparison with Extant Members — In having such distinctive anatomical features as vertical gum canals, solitary vessels, vasicentric tracheids, multiseriate and heterogeneous xylem rays, the fossil shows undoubted affinities with the family Dipterocarpaceae. Metcalfe and Chalk (1950) divided the family into two groups on the basis of the arrangement of gum canals:

1. Gum canals in concentric rows occur in *Shorea*, *Doona*, *Hopea*, *Isoptera*, *Parashorea*, *Pentacme*, *Balanocarpus*, *Dryobalonops* and *Dioticarpus*.
2. Gum canals diffuse, solitary and also in short tangential rows occur in *Anisoptera*, *Dipterocarpus*, *Vateria*, *Vatica*, *Upuma*, *Cotylelobium* and *Monoporandra*. In *Monotes* and *Marquesia* the gum canals are absent.

In presence of diffuse, solitary, gum canals the fossil wood can be included in the second group. It comes closer to *Anisoptera*, *Vatica* and *Vateria* in having sheath cells on the flanks of rays and irregular and scattered distribution of vertical gum canals. *Anisoptera* differs from the fossil in having homocellular, uniseriate rays. There is marked difference in the size of vessels between *Vatica* and the fossil as the former has mostly small to occasionally medium sized vessels (75-150 μm), whereas the latter has generally large vessels (148-280 μm). The fossil wood closely resembles the wood of modern genus *Vateria* as both have heterocellular, uniseriate rays and oblique distribution of vessels as distinctive features. They also show other anatomical features. A comparison of the present fossil wood with all the three species of *Vateria* has been made. It shows closest similarity with *Vateria indica* L. (Pl. 1, figs 4, 5; Pl. 2, fig. 6), however, the fossil wood differs from the extant wood in the frequency and size of the

vessels (extant member has somewhat larger vessels — 250-330 μm in diameter).

Comparison with Fossil Wood — The genus *Dipterocarpoxylon* was instituted by Holden (1916) to include the fossil woods showing resemblance with those of Dipterocarpaceae; Den Berger (1927) emended the diagnosis of *Dipterocarpoxylon* retaining the generic name for the fossil woods resembling those of *Anisoptera* and *Dipterocarpus* of the Dipterocarpaceae. Ghosh and Kazmi (1958) instituted the genus *Anisopteroxylon* to accommodate the fossil woods resembling that of *Anisoptera*. In 1958, Sehweitzer instituted the genus *Vaticoxylon* in which he included the woods both of Vaticae (*Cotylelobium*, *Vatica*, *Pachynocarpus*) and Vateriae (*Stemonoporus*, *Monoporandra*, *Vateria*) though, he was somewhat diffident in including the last genus in his *Vaticoxylon*.

The woods of *Vatica* and *Vateria* differs from each other as in the former the vessels are generally smaller (75-150 μm) whereas in the latter they are larger (150-310 μm). Further, frequency and distribution pattern of the vessels in the two genera is quite different. *Vateria* is anatomically quite distinct from *Vatica* both in living as well as in fossil specimens as is evident from the present fossil. It is therefore proposed to institute a new genus *Vaterioxylon* to accommodate the woods which indicate the affinities with the genus *Vateria*.

Vateria with three Indian species extends to South India including Ceylon (Chowdhury & Ghosh, 1958). *Vateria indica* L., to which the present fossil wood shows closest resemblance, occurs presently in the evergreen forests at the foot of Western Ghats from Kanara to Travancore. However, the wood differs from this species in minor details and therefore named as *Vaterioxylon kalagarhense* sp. nov.

GENERIC DIAGNOSIS

Vaterioxylon gen. nov.

Wood diffuse porous. *Growth rings* absent. *Vessels* large to medium-sized, solitary or in pairs or sometimes in groups of 2-5, distribution in oblique pattern at places in tangential rows; perforation simple. *Vasicentric* tracheids present. *Parenchyma* vasicentric, sparsely diffuse, sometimes at places diffuse in aggregate and round the gum ducts. *Xylem rays* 1-6 seriate, heterogeneous, uniseriate, heterocellular, multiseriate, heterocellular having sheath cells on the flanks and marginal upright cells. *Fibres* non-septate and nonlibriform to libriform. *Gum canals* mostly solitary, scattered occasionally in tangential groups of 2-4.

Genotype — *Vaterioxylon kalagarhense* sp. nov.

SPECIFIC DIAGNOSIS

Vaterioxylon kalagarhense sp. nov.

Wood diffuse porous. *Growth rings* absent. *Vessels* large to medium-sized, t.d. 148-180 μm, r.d. 165-280 μm, solitary, occasionally in radial groups of two, distributed in oblique pattern and at places in tangential row, 8-12 per sq mm, tyloses present, vessel segments 820-1200 μm long with truncate to slightly tailed end, perforation simple; pits leading to contiguous tracheids, alternate, bordered with orbicular pore. *Vasicentric tracheids* present. *Parenchyma* paratracheal and apotracheal, paratracheal parenchyma scanty to vasicentric; apotracheal sparsely diffuse and 2-3 seriate round the gum canals. *Xylem rays* 1-6 seriate, uniseriate rays many, heterocellular, multiseriate rays heterocellular, 1-6 upright cells present at both the ends, sheath cells present either on one or both the flanks. *Fibres* not aligned in radial rows. *Gum canals* scattered, mostly solitary, some times in tangential groups of 2-4, 90-120 μm in diameter.

Holotype — B. S. Trivedi collection no. D.G. 23, Botany Department, Lucknow University, Lucknow.

Locality — 2-3 km east of Kalagarh town.

Age — Mio-Pliocene.

2. *Vaterioxylon miocenecum* sp. nov.

Pl. 2, figs 7-10

Material — Fossil wood piece 5 cm in length, 4 cm in diameter and yellowish in texture. Preservation is fairly good.

Topography — *Wood* diffuse porous. *Growth rings* absent. *Vessels* solitary, occasionally radially or tangentially

paired, often contiguous to xylem rays either on one or both the sides (Pl. 2, figs 7, 8); tyloses present, 7-10 vessels per sq mm, distributed in oblique pattern and at places in tangential rows. *Vasicentric tracheids* scanty, only 2-3 round the vessels. *Parenchyma* paratracheal and apotracheal; paratracheal vasicentric 1-2 seriate, sheath interrupted by vasicentric tracheids; apotracheal parenchyma sparsely diffuse, occasionally at places diffuse in aggregate forming short net work with rays and also enclosing gum canals (Pl. 2, figs 7, 8). *Xylem rays* broad to fine, multiseriate rays are more common than uniseriate rays, ray tissue heterogeneous; uniseriate rays heterocellular, composed both of procumbent and upright cells, 5-11 cells (up to 590 μm) high, 39 μm wide, multiseriate rays heterocellular, 1-2 upright cells present at both the ends and sheath cells present at both the flanks, rays up to 89 μm wide, 24-36 cells (up to 1260 μm) high, 6-9 rays per mm (Pl. 2, figs 9, 10). *Fibres* 6-8, aligned in radial rows, libriform to semilibriform, non-septate. *Gum canals* scattered, mostly solitary, rarely in pairs, small, enclosed by parenchymatous cells.

Elements — Vessel, round to oval in cross section, r.d. 160-310 μm, t.d. 147-247 μm, common wall 5-6 μm thick, vessel members 800-1500 μm in length with truncate or slightly tailed end, perforation simple, pits leading to contiguous tracheids, alternate, bordered with orbicular pore. *Parenchyma* cells thin-walled, round to slightly angular, 33 μm in diameter. Upright cells 32-52 μm in tangential height, radial length 30-42 μm, procumbent cells 16-26 μm in tangential height, 40-45 μm in radial length. *Fibres* round to polygonal in cross section, 18 μm in diameter. *Gum canals* round, 35-56 μm in diameter.

Affinities — The present fossil wood shows some characteristic anatomical features, viz., diffuse vertical gum canals, solitary vessels, distributed in oblique pattern and at places in tangential rows, *xylem rays* are heterogeneous, uniseriate and multiseriate rays are heterocellular, the latter with upright cells at ends and sheath cells on the flanks. On the basis of these characters it becomes obvious that it shows affinities with the wood of modern genus *Vateria* of the family Dipterocarpaceae. A comparison with all the three species that grow in South India and Ceylon, viz., *Vateria indica* Linn., *V. macrocarpa* Gupta and *V. accuminata* Hayne establishes that the fossil closely resembles *V. macrocarpa*, although the other two differ in minor features in frequency, the size of the vessels and the size and frequency of rays.

However, the wood shows superficial similarity to *Vaterioxylon kalagarhense* but differs from it as the latter has comparatively lesser apotracheal parenchyma, smaller vessels, bigger gum canals 90-120 μm in diameter (in the fossil wood gum canals are 35-56 μm in diameter) and fibres are not aligned in radial rows. It is therefore assigned to a new species, viz., *Vaterioxylon miocenecum*. *Vateria macrocarpa*, with which it shows closest resemblance, occurs presently in the forests of Muthu Kalan, Ballan Patty range, Palaghat Division, Karnataka.

SPECIFIC DIAGNOSIS

Wood diffuse porous. *Growth rings* absent. Vessels large to medium sized, t.d. 140-247 μm, r.d. 160-310 μm, 7-10 vessels per sq mm, solitary, occasionally in tangential or in radial pairs, distributed in oblique pattern and at places in tangential rows, tyloses present, vessel segments 800-1500 μm in length with truncate or slightly tailed ends, perforations simple, pits leading to contiguous tracheids, alternate, bordered with orbicular pore. *Vasicentric tracheids* present. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric, apotracheal parenchyma sparsely diffuse, occasionally at places diffuse in aggregate forming short net work with rays and also enclosing gum canals. *Xylem rays* 1-6 seriate, uniseriate rays few, heterocellular, multicellular rays heterocellular with 1-2 upright cells present at both the ends and upright sheath cells present at the flanks, 6-9 rays per mm. *Fibres* 6-8 aligned in radial rows, libriform to semilibriform and nonseptate. *Gum canals* diffuse, small, solitary, rarely in pairs and 35-56 μm in diameter.

Holotype — B. S. Trivedi collection no. L.G. 6, Botany Department, Lucknow University, Lucknow.

Locality — About 8 km east of Kalagarh town.

Age — Mio-Pliocene.

Discussion — The Middle Siwalik beds in Kalagarh have revealed a rich assemblage of woods belonging to the family Dipterocarpaceae including a new genus *Vaterioxylon* which is described here for the first time from this locality. It appears that in Mio-Pliocene times this part was probably warmer than what it is today. This created more congenial climate for the dipterocarps to flourish. It seems that the third and final upthrust of the Himalayas by the end of Tertiary times resulted in raising the Himalayas higher, thus ushering in colder climate. This cooling was probably responsible for making this area inhospitable to the dipterocarps which prefer warm and humid climate. Thus the changed ecological conditions made their continued growth difficult.

In the present time most of the members of Dipterocarpaceae (about 350 spp.) are distributed in tropical Asia, viz., India, Ceylon, Burma, Malaya Peninsula, Philippines and New Guinea. Beyond this region the family is represented by one species *Vateriopsis seychellarum* in Seychells and by two tropical African genera *Monotes* and *Marquesia* (Merrill, 1923). All the places where these plants at present grow are well-drained and have warm humid climate.

While studying the migration and distribution of the dipterocarps, Bancroft (1933), Chowdhury (1966) and Lakhanpal (1970) contend that they extended from Malaya to India and Africa in the west and Philippines in the east during late Tertiary times along the regions of heavy precipitation with warm climate. Their extinction from certain areas in the present times according to these authors is mainly attributed to lesser precipitation. No mention, however, has been made about the effects of temperature which might have dropped due to topographical changes because of geological upheavels occurred. Kalagarh, situated in the Siwalik ranges (the latter were being probably formed by the denudation of inner Himalayas and gradual deposition of this debris during late Tertiary), is certainly in a more elevated and northern position at present then it would have been during Mio-Pliocene times when it must have been at a lower elevation and more southwards. Therefore, it may safely be deduced that the factors indicated above contributed to the lowering of temperature which in its turn every thing else remaining unchanged proved fatal for the survival of these plants.

This area has enough precipitation and is well-drained by various nalas and tributaries of the Ramganga River fulfilling the conditions in which the dipterocarps would otherwise flourish except the lowering of temperature. It is therefore probable that extinction of genera like *Vatica* and *Vateria* from this area could be ascribed to the lowering of temperature of this area. Probably, lowering of temperature played a very important role in the extinction of a majority of dipterocarps from this area and not the precipitation.

Our findings show for the first time that *Vateria* was growing in the Siwalik during Mio-Pliocene times, though it has disappeared from this area now. *Vateria* with three Indian species is at present confined exclusively to South India, Kanara, Travancore and Ceylon. The occurrence of these two species of *Vaterioxylon* from Kalagarh extends its distribution to northern India during Mio-Pliocene times.

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EXPLANATION OF PLATES

PLATE 1

Vaterioxylon kalagarhense gen. et sp. nov.

1. Cross section of the fossil wood showing type and distribution of vessels and parenchyma. × 60 (slide no. D.G. 23).
2. Tangential longitudinal section of the fossil wood showing xylem rays. × 100 (slide no. D.G. 23).
3. Radial longitudinal section of the fossil wood showing heterocellular xylem rays. × 100 (slide no. D.G. 23).

Vateria indica Linn.

4. Cross section of the extant wood showing type and distribution of vessels and parenchyma. × 40.
5. Radial longitudinal section of the extant wood showing heterocellular xylem rays. × 100.

PLATE 2

Vateria indica Linn.

6. Tangential longitudinal section of the extant wood showing xylem rays. × 100.

Vaterioxylon miocenecum n. sp.

7. Cross section of the fossil wood showing type and distribution of vessels and parenchyma. × 50 (slide no. L.G. 6).
8. Another cross section of the fossil wood in different plane showing vessels and parenchyma. × 60 (slide no. L.G. 6).
9. Radial longitudinal section of the fossil wood showing heterocellular xylem rays. × 100 (slide no. L.G. 6).
10. Tangential longitudinal section of fossil wood showing xylem rays. × 100. (slide no. L.G. 6).

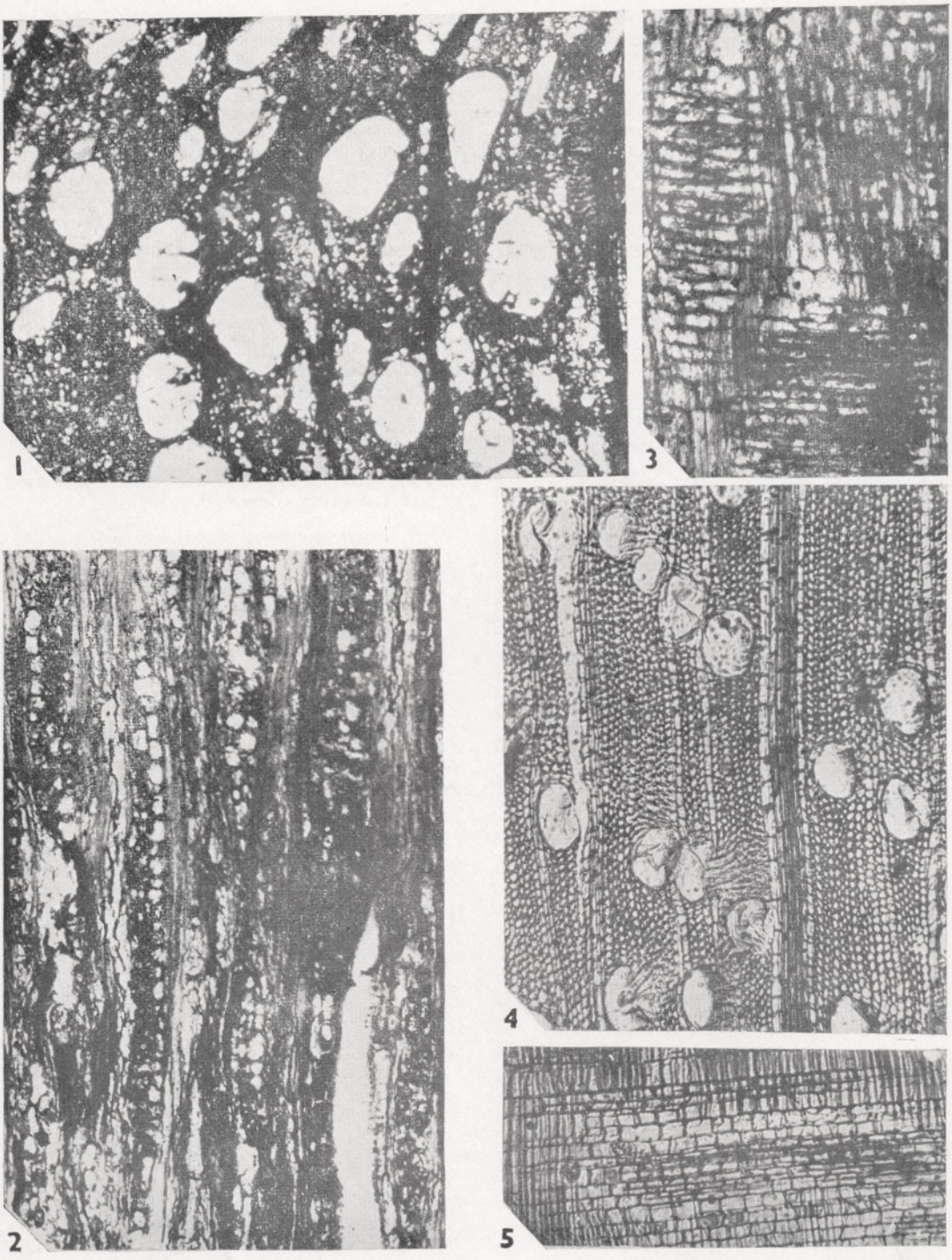

PLATE 1

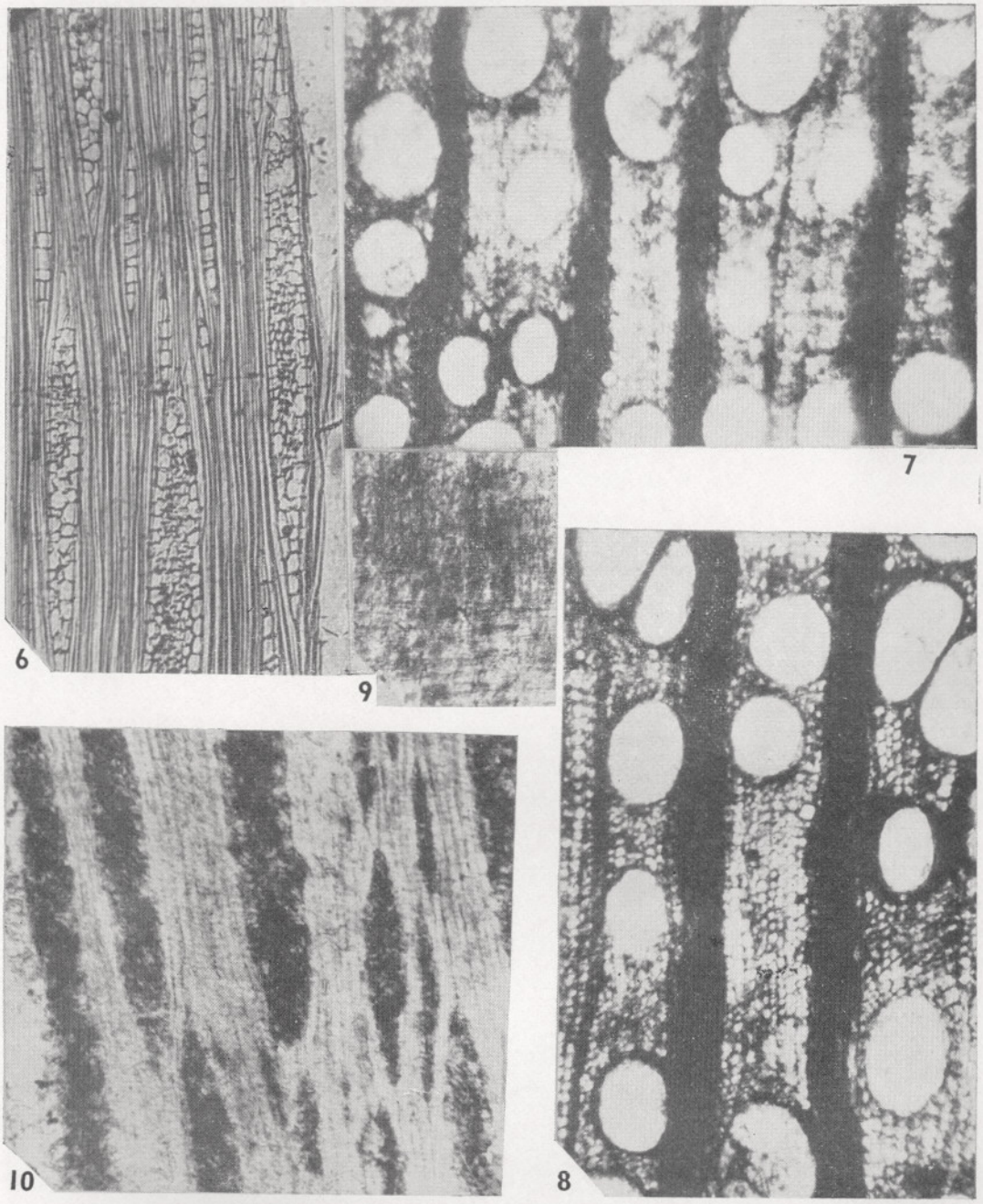

PLATE 2