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Some more fossil woods from the Lower Siwalik sediments of Kalagarh, Uttar Pradesh and Nalagarh, Himachal Pradesh

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Seven fossil woods comparable with the woods of *Anisoptera oblonga* and *Dipterocarpus obtusifolius* of Dipterocarpaceae, *Aglaia edulis* of Meliaceae, *Acrocarpus fraxinifolius, Ormosia robusta, Koompassia malaccensis* and *Adenanthera pavonina* of Fabaceae are described from the Lower Siwaliks of Kalagarh, Uttar Pradesh and Nalagarh, Himachal Pradesh. Occurrence of these taxa is indicative of a warm and humid climate around Kalagarh and Nalagarh during the Lower Siwalik period.

Key-words—Fossil woods, Xylotomy, Dipterocarpaceae, Meliaceae, Fabaceae, Lower Siwaliks, Middle Miocene (India).

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सारांश

उत्तर प्रदेश में कालागढ़ तथा हिमाचल प्रदेश में नालागढ़ के अधरि शिवालिक अवसादों से प्राप्त कुछ और अश्मित काष्ठ

राम रतन यादव

उत्तर प्रदेश में कालागढ़ एवं हिमाचल प्रदेश में नालागढ़ के अधरि शिवालिक अवसादों से उपलब्ध अश्मित काष्ठों का वर्णन किया गया है। ये काष्ठ डिप्टेरोकार्पेसी कुल के **एँनाइसॉप्टेरा ओबलोंगा** एवं **डिप्टेरोकार्पस ऑबट्यूसीफ़ोलिया**, मिलियेसी के **एँग्लेआ एँड्यूलिस** तथा फैबेसी के **एँक्रोकार्पस फ्रेक्सिनिफ़ोलियस, ओर्मोसिआ रोबस्टा, कूम्पासिआ मलक्केन्सिस** एवं **एडिनेन्थीरा पवोनिया** की काष्ठों से तुलनीय हैं। इन वर्गकों की उपस्थिति से अधरि शिवालिक के समय कालागढ़ एवं नालागढ़ के आस-पास उष्ण एवं आर्द्र जलवायु का होना इंगित होता है।

THE Lower Siwalik sediments exposed in the foot-hills of Himalaya near Kalagarh, Uttar Pradesh and Nalagarh, Himachal Pradesh are rich in petrified woods. Earlier, Prakash (1978, 1981), Trivedi and Ahuja (1978a,b, 1979a,b, 1980), Trivedi and Misra (1978, 1979, 1980), and Prakash and Prasad (1984) described the fossil woods from Kalagarh. Some more fossil woods were also reported from the Lower Siwalik of Nalagarh, Himachal Pradesh (Prakash, 1975, 1979a,b). Further investigation of the petrified woods from the above localities has shown the presence of some new forms resembling species of *Anisoptera, Dipterocarpus, Aglaia, Acrocarpus, Ormosia, Koompassia* and *Adenanthera*.

SYSTEMATIC DESCRIPTION

Family—Dipterocarpaceae

Genus—*Anisopteroxylon* Ghosh & Kazmi 1958

Anisopteroxylon oblongoides sp. nov.
Pl. 1, figs 1, 3, 5

The fossil wood described here is a small piece of secondary xylem. *Wood* diffuse-porous. *Growth rings* absent. *Vessels* medium to large, mostly solitary, rarely in pairs, thick-walled, usually round to oval, 4-5 per sq mm, t.d 120-230 μm, r.d. 180-330 μm; vessel-members 180-375 μm long with truncate ends; perforations simple; inter-vessel pits not seen,

tyloses present. *Vasicentric tracheids* sparse, oval to peripherally flattened, intermingled with paratracheal parenchyma; 30-40 μm in diameter, vessel-tracheid pits numerous, bordered. *Parenchyma* both paratracheal as well as apotracheal; paratracheal parenchyma vasicentric, apotracheal parenchyma diffuse to diffuse-in-aggregate, often forming irregular lines, several rows of parenchyma cells usually surround the gum canals; cells thin-walled, 32-40 μm in diameter and 64-132 μm in length. *Xylem rays* usually broad, spindle-shaped, 1-9 (11) seriate, mostly 7-9 seriate and 20-180 μm wide, about 5-56 cells and 150-1080 μm high, 4-8 per mm; ray tissue heterogeneous with rays composed of both upright and procumbent cells; upright cells forming 1-2 or more marginal rows at one or both the ends and also present as sheath cells along the flanks of multiseriate rays, quite often forming a continuous sheath; procumbent cells 12-20 μm in vertical height and 60-80 μm in radial length; upright cells 40-52 μm in vertical height and 20-28 μm in radial length. *Fibres* polygonal in cross-section, 20-28 μm in diameter, thick-walled. *Gum canals* vertical, scanty, large, round to oval, encircled by parenchyma cells, usually in continuous tangential rows, occasionally solitary, 120-150 μm in diameter.

Affinities—The characters of the fossil wood indicate its affinity with the woods of *Anisoptera* Korth. A detailed comparative study of fossil with thin sections of modern woods of *Anisoptera* shows that the fossil wood resembles closely the wood of extant *Anisoptera oblonga* Dyer in all important characters, such as the size and distribution pattern of vessels and parenchyma, ray structure and in the type and distribution of vertical gum canals (F.R.I. slide no. 6887).

So far only six species of *Anisopteroxylon* are known from the Tertiary of India and Southeast Asia (Ghosh & Kazmi, 1958; Ghosh & Ghosh, 1958; Navale, 1963; Prakash & Tripathi, 1970; Prakash, 1978; Ghosh & Roy, 1980). All these species markedly differ from the present fossil wood especially in the absence of concentric rows of gum canals. Besides, the xylem rays are very broad and fusiform in the present fossil as compared to all the known species in which the xylem rays are narrower.

The genus *Anisoptera* consisting of about 30 species is widely distributed from Chittagong in Bangla Desh to New Guinea in the Pacific. The largest number of species, however, occur in the Malay Peninsula, Sumatra and Borneo. The nearest comparable species of the present fossil wood, *A. oblonga*, occurs in semi-evergreen and deciduous forests from Arakan to Mergui Victoria Point in Burma at low altitudes and also in Malay Peninsula (Chowdhury & Ghosh, 1958).

Specific Diagnosis

Anisopteroxylon oblongoides sp. nov.

Wood diffuse-porous. *Growth rings* absent. *Vessels* large to medium, t.d. 120-230 μm, r.d. 180-330 μm, mostly solitary, 4-5 per sq mm, usually tylosed; vessel-tracheid pits bordered, numerous. *Vasicentric tracheids* sparse, 30-40 μm in diameter. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric; apotracheal parenchyma diffuse to diffuse-in-aggregate forming uniseriate tangential lines; several rows of cells also surround the gum canals. *Xylem rays* 1-9 (11) seriate, mostly 7-9 seriate, 5-56 cells in height, 4-8 per mm; ray tissue heterogeneous, rays heterocellular; multiseriate rays with continuous row of sheath cells on the flanks. *Fibres* libriform, 20-28 μm in diameter, nonseptate. *Gum canals* vertical, scanty, usually in long tangential rows, occasionally solitary, 120-150 μm in diameter.

Holotype—Museum specimen no. BSIP 35754.

Locality—Kalagarh, Tehri Garhwal District, Uttar Pradesh.

Genus—*Dipterocarpoxylon* Holden emend. Den Berger 1927

Dipterocarpoxylon kalagarhensis sp. nov.
Pl. 1, figs 6, 8, 10

The description of the fossil wood is based on a small piece of secondary xylem. *Wood* diffuse-porous. *Growth rings* absent. *Vessels* visible to the naked eye, medium to large, mostly solitary, rarely in pairs, round to oval or elliptical, 4-6 per sq mm, heavily tylosed, thin-walled, t.d. 116-224 μm, r.d. 184-320 μm; vessel-members 240-480 μm long with truncate ends; perforations simple, vessel tracheid pits bordered. *Vasicentric tracheids* sparse, associated with the vessels, tracheidal cells oval to peripherally flattened, 25-40 μm in diameter, bordered pits present in rows. *Parenchyma* mostly apotracheal, the paratracheal being scanty, present around some of the vessels, apotracheal parenchyma diffuse to diffuse-in-aggregate forming uniseriate lines and surrounding the gum canals and forming 2-4 seriate sheath, t.d. 18-24 μm, length 68-240 μm. *Xylem rays* fine to broad, 1-6 seriate, usually 4-5 seriate, 20-112 μm wide and 5-40 cells or about 120-1540 μm high, closely spaced, 5-8 per mm, ray tissue heterogeneous, rays heterocellular, uniseriate rays composed of upright and procumbent cells while the broad rays with upright or square cells at one or

both the ends and procumbent cells in the middle, sometimes with sheath cells on the flanks, procumbent cells with vertical height 12-20 μm, radial length 28-68 μm; upright cells with vertical height 36-60 μm, radial length 24-35 μm. *Fibres* polygonal in cross section, 12-20 μm in diameter, moderately thick-walled, inter-fibre pits bordered. *Gum canals* vertical, moderately small to medium, abundant, single or usually in pairs, sometimes in tangential rows of 3-4 and occasionally in continuous trangential rows, 88-180 μm in diameter, round to oval, encircled by parenchyma.

Affinities—In having solitary vessels, vasicentric tracheids, heterogeneous xylem rays with some sheath cells on the flanks and axial gum canals which are mostly in tangential pairs some times in tangential rows of 3-4 or even more and occasionally in continuous rows the fossil wood is very similar to that of *Dipterocarpus*. A detailed comparison of the fossil with available thin sections of wood of several species of *Dipterocarpus* as well as descriptions and photographs of about 26 species of *Dipterocarpus* (Moll & Janssonius, 1906; Kanehira, 1924 a, b; Pearson & Brown, 1932; Desch, 1957; Chowdhury & Ghosh, 1958; Kribs, 1959; Miles, 1978) shows its close resemblance with that of *Dipterocarpus obtusifolius* (F.R.I. Slide no. A 5964) except that the parenchyma is not so profuse in the latter.

A large number of fossil woods resembling to *Dipterocarpus* are known from India and abroad, most of which were earlier listed by Prakash (1973) and Awasthi (1974) and subsequently few more species of *Dipterocarpoxylon* were described (Awasthi, 1974, 1980; Prakash, 1975, 1978, 1979b, 1980; Ghosh & Roy, 1979; Trivedi & Ahuja, 1980). *Dipterocarpoxylon kalaicharparense* Eyde shows some similarity with the present fossil wood but differs in having abundant apotracheal parenchyma forming patches in the ground tissue and comparatively narrower xylem rays as compared to the present fossil. As the present fossil wood is different from all the known species of *Dipterocarpoxylon*, it is described as a new species, *Dipterocarpoxylon kalagarhensis*.

The genus *Dipterocarpus* includes about 80 species which grow mainly in the Indo-Malayan region having maximum development in Borneo, Malay Peninsula and Sumatra. *Dipterocarpus obtusifolius* with which the fossil is comparable, grows in Burma up to 900 m above sea level and also in Cochin-China, Thailand and Malay Peninsula (Chowdhury & Ghosh, 1958).

Specific Diagnosis

Dipterocarpoxylon kalagarhensis sp. nov.

Wood diffuse-porous. *Growth rings* absent. *Vessels* medium-sized to large, t.d. 116-224 μm, r.d. 184-320 μm, 4-6 per sq mm and tylosed; vessel members 240-480 μm. *Vasicentric tracheids* sparse, 25-40 μm in diameter. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma scanty, often partly encircling the vessels; apotracheal parenchyma associated with gum canals and diffuse to diffuse-in-aggregate forming uniseriate lines. *Xylem rays* 1-6 (mostly 4-5) seriate, 5-8 per mm; rays heterocellular; sheath cells quite common. *Fibres* thick-walled, non-septate, 12-20 μm in diameter. *Gum canals* vertical, abundant, solitary or usually in pairs, sometimes in tangential rows of 3-4 and occasionally in continuous tangential rows, 88-180 μm in diameter, round to oval in shape.

Holotype—Museum specimen no. BSIP 35755.

Locality—Kalagarh, Tehri Garhwal District, Uttar Pradesh.

PLATE 1 →

1. *Anisopteroxylon oblongoides* sp. nov.—Cross section showing type and distribution of the vessels and parenchyma. × 35; Slide no. BSIP 35754-1.
2. *Anisoptera oblonga*—Cross section showing similar type and distribution of vessels and parenchyma. × 35.
3. *Anisopteroxylon oblongoides* sp. nov.—Tangential longitudinal section showing type and distribution of the xylem rays. × 50; Slide no. BSIP 35754-2.
4. *Anisoptera oblonga*—Tangential longitudinal section showing similar type and distribution of xylem rays. × 50.
5. *Anisopteroxylon oblongoides* sp. nov.—Cross section under low power showing the distribution of vessels and gum canals. × 15; Slide no. BSIP 35754-1
6. *Dipterocarpoxylon kalagarhensis* sp. nov.—Cross section showing distribution of vessels, parenchyma and gum canals. × 30; Slide no. BSIP 35755-1.
7. *Dipterocarpus obtusifolius*—Cross section showing similar type and distribution of vessels, parenchyma and gum canals. × 30.
8. *Dipterocarpoxylon kalagarhensis* sp. nov.—Tangential longitudinal section showing type and distribution of the xylem rays. × 50; Slide no. BSIP 35755-2.
9. *Dipterocarpus obtusifolius*—Tangential longitudinal section showing similar type of xylem rays. × 50.
10. *Dipterocarpoxylon kalagarhensis* sp. nov.—Cross section under low power showing the distribution of vessels and gum canals. × 15; Slide no. BSIP 35755-1

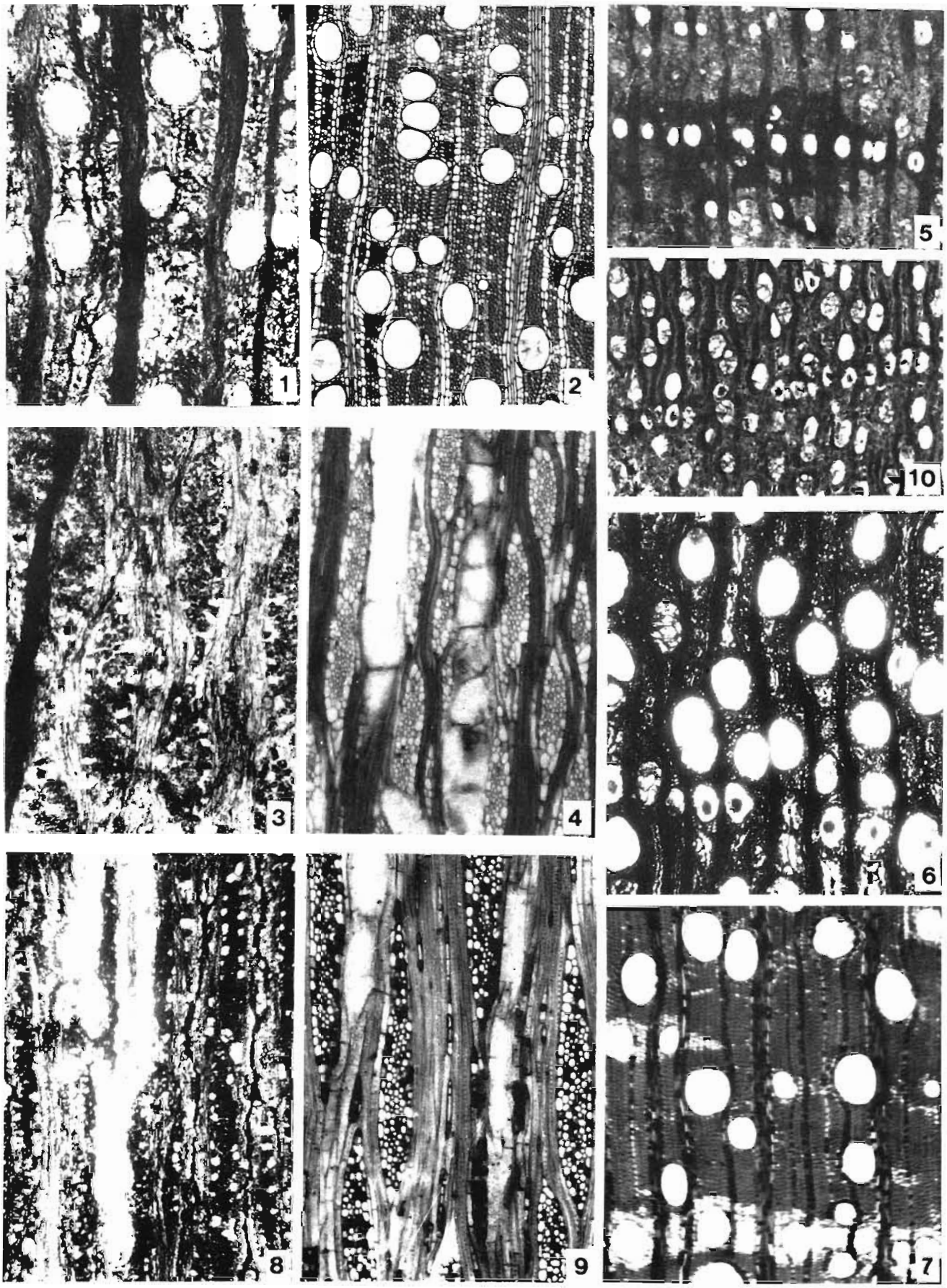

PLATE 1

Family—Meliaceae

Genus—*Aglaia* Laour.

Aglaia nahanensis (Prakash) comb. nov.
Pl. 2, figs 1, 3, 4

1975 *Dryoxylon nahanai* Prakash, pp. 206, 208, pl. 5, figs 23, 24.

Prakash (1975) described the wood as *Dryoxylon nahanai* since its affinity with any extant taxon could not be ascertained. The present description is based on the critical re-examination of type slides as well as thin sections prepared from the type specimen.

Revised description—*Wood* diffuse porous. *Growth rings* indistinct. *Vessels* small to medium, solitary and in radial multiples of 2-3, mostly 2, oval to irregular in shape owing to pressure during fossilization, 6-9 per sq mm, sometimes plugged with gummy deposits, thin-walled, t.d. 50-150 μm, r.d. 75-190 μm, vessel members 400-500 μm long with truncate ends, perforations simple, intervessel pits minute, 3-4 μm in diameter with linear to lenticular apertures. *Parenchyma* paratracheal, vasicentric to aliform confluent, usually forming short, irregular, undulating bands, cells thin-walled with t.d. 8-10 μm and 40-80 μm in length. *Xylem rays* 1-4 (mostly 3) seriate, 15-70 μm wide and 5-34 cells or 120-600 μm high, 8-15 per mm, ray tissue heterogeneous with rays composed either of procumbent cells only or sometimes with single marginal row of square or upright cells, ray cells thin-walled, procumbent cells 15-18 μm in tangential height and 25-70 μm in radial length, upright cells 20-24 μm in radial length and 28-30 μm in tangential height. *Fibres* irregularly arranged in between the consecutive xylem rays, thick-walled, polygonal in cross section, septate, 5-12 μm in diameter and 600-1100 μm in length; interfibre pits not seen.

Affinities—Small to medium sized, solitary vessels and in radial multiples of 2-3 (mostly 2), with gum plugs and minute inter-vessel pits; 1-4 seriate and weakly heterocellular xylem rays; vasicentric to aliform-confluent parenchyma, usually forming short, undulating bands and septate fibres indicate a close affinity with the *Aglaia edulis* A. Gray of Meliaceae (Slide no. BSIP 7535).

The fossil woods of Meliaceae, so far known, are many though no definite record of *Aglaia* as known. *Aglaioxylon mandlaense* from the Deccan Intertrappean beds of Mandla District (Trivedi & Srivastava, 1982) does not appear to show any affinity with the genus *Aglaia* as the xylem rays described as homocellular, are always heterocellular in *Aglaia*. However, to ascertain the indentification of *A. mandlaense* Trivedi & Srivastava, the original specimens need to be restudied. In view of the doubtful affinity of *Aglaioxylon mandlaense*, the present fossil wood is described as *Aglaia nahanensis* (Prakash) comb. nov.

Aglaia is a large genus consisting of small to moderate sized tree distributed in the Indo-Malayan region and southern China. About 20 species are reported to occur in India and Burma. *Aglaia edulis* with which the present fossil resembles grows in Sibsagar, Mikir Hills, North Cachar Hills and Khasi Hills in Assam up to 600 m elevation (Anonymous, 1963, p. 89).

Holotype—Museum specimen no. BSIP 7/1014.

Locality—Nalagarh, Solan District, Himachal Pradesh.

PLATE 2 →

1. *Aglaia nahanensis* (Prakash) comb. nov.—Cross section showing the vessel and parenchyma distribution × 40; Slide no. BSIP 4739.
2. *Aglaia edulis*—Cross section showing similar type of vessels and parenchyma. × 40.
3. *Aglaia nahanensis* (Prakash) comb. nov.—Tangential longitudinal section showing type and distribution of xylem rays and septate fibres. × 100; Slide no. BSIP 4740.
4. *Aglaia nahanensis* (Prakash) comb. nov.—Magnified intervessel pit-pairs. × 500; Slide no. BSIP 4740.
5. *Aglaia edulis*—Tangential longitudinal section showing similar type of xylem rays and fibres. × 100.
6. *Acrocarpus siwalicus* sp. nov.—Cross section showing type and distribution of the vessels and parenchyma. × 30.
7. *Acrocarpus fraxinifolius*—Cross section showing similar type of vessels and parenchyma. × 30.
8. *Acrocarpus siwalicus* sp. nov.—Tangential longitudinal section showing type and distribution of xylem rays. × 50; Slide no. BSIP 35756-2.
9. *Acrocarpus fraxinifolius*—Tangential longitudinal section showing similar type and distribution of xylem rays. × 50.
10. *Acrocarpus siwalicus* sp. nov.—Radial longitudinal section showing heterocellular xylem rays. × 120; Slide no. BSIP 35756-3.
11. *Acrocarpus siwalicus* sp. nov.—Magnified intervessel pit-pairs. × 400; Slide no. BSIP 35756-2.

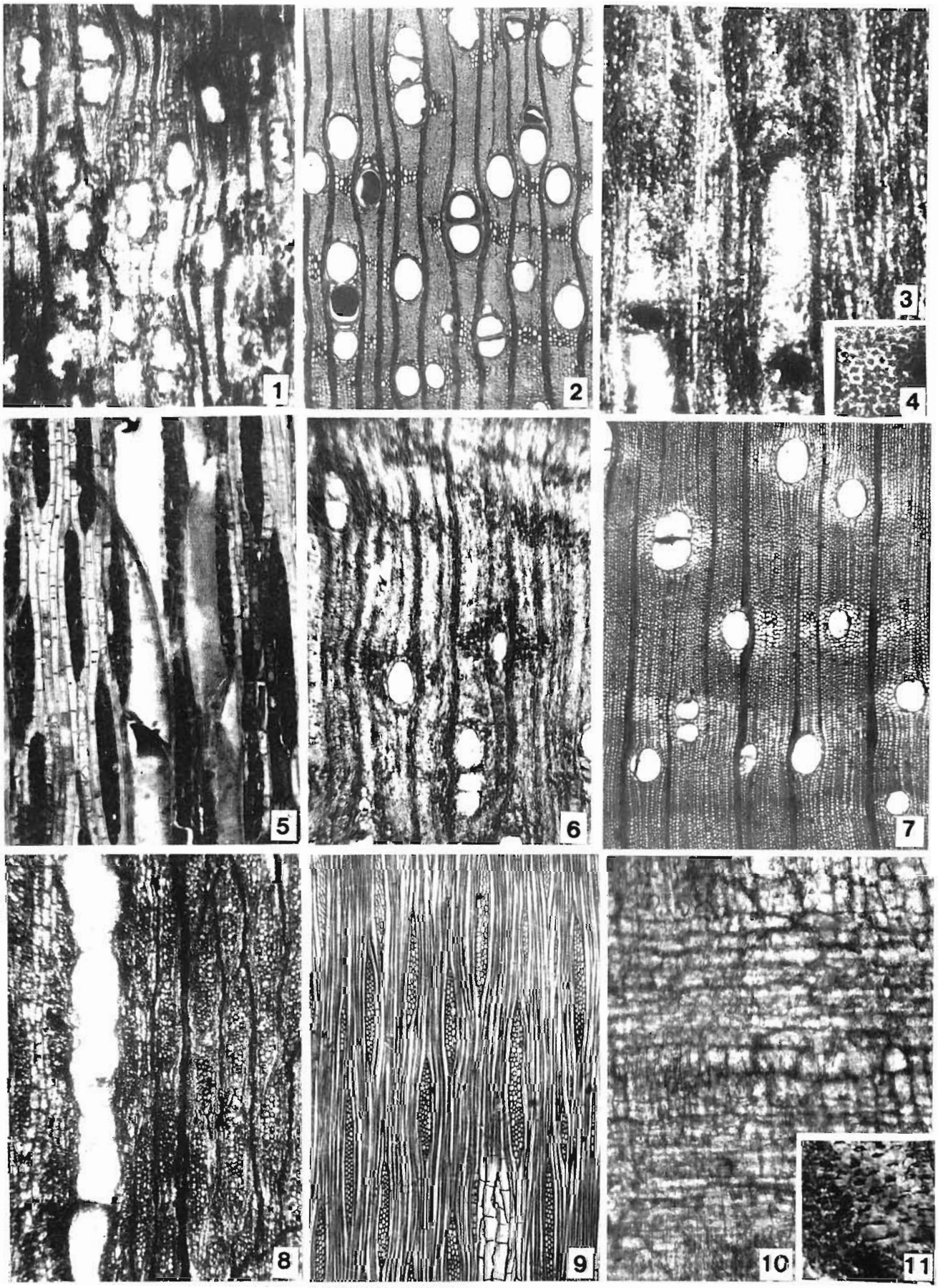

PLATE 2

Family—Fabaceae

Genus—*Acrocarpus* Wight ex Arn.

Acrocarpus siwalicus sp. nov.
Pl. 2, figs 6, 8, 10, 11

The present species is based on a piece of secondary wood measuring about 12 cm in length and 8 cm in diameter.

Wood diffuse-porous. *Growth rings* present, delimited by thin lines of parenchyma. *Vessels* medium-to large, solitary and in radial multiples of 2-5, circular to oval when solitary and with flat contact walls when in groups, evenly distributed, 12-14 per sq mm, tyloses absent, thin-walled, t.d. 100-250 μm, r.d. 110-260 μm, perforations simple, vessel members 100-640 μm long with truncate ends, intervessel pits alternate, vestured, small, 5-7 μm in diameter with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma aliform to aliform-confluent; apotracheal parenchyma terminal and forming short 4-10 seriate tangential bands in the ground tissue; parenchyma cells 30-40 μm in diameter, 80-100 μm in length; crystals present in parenchyma strands. *Xylem rays* 1-5 seriate or 12-100 μm wide and 5-35 cells or 90-560 μm high, 6-8 per mm, ray tissue heterogeneous with rays either composed of procumbent cells only or with 1-2 marginal rows of upright cells, ray cells thick-walled, procumbent cells 20-30 μm in tangential height and 25-75 μm in radial length, upright cells 50-55 μm in tangential height and 30-40 μm in radial length, crystals usually present in upright cells. *Fibres* aligned in radial rows in between the xylem rays, thick-walled, polygonal in cross section, septate, 12-18 μm in diameter and 480-1200 μm in length, interfibre pits not seen.

Affinities—The important anatomical diagnostic features of the present fossil wood such as typically aliform to aliform-confluent parenchyma along with apotracheal bands separating the growth zones, vestured intervessel pits, crystalliferous parenchyma strands, weakly heterogeneous xylem rays and septate fibres indicate that it belongs to the family Fabaceae. Predominance of aliform parenchyma and heterogeneous xylem rays are characteristic of *Acrocarpus fraxinifolius* Wight and *Saraca indica* L. But *Saraca indica* L. differs in having very fine (1-2 seriate) xylem rays as against 1-5 seriate in the fossil. The fossil shows its close resemblance with the wood of *Acrocarpus fraxinifolius* in having aliform to aliform-confluent and terminal parenchyma separating the growth zones, 1-5 seriate, weakly heterocellular xylem rays with crystals in the marginal upright cells, crystalliferous parenchyma strands, vestured pits, and thick-walled, septate fibres.

In view of its close resemblance with the woods of *Acrocarpus*, the fossil wood is assigned to *Acrocarpus* and is named as *A. siwalicus* sp. nov.

The genus *Acrocarpus* consists of three species confined to Southeast Asia and India. In India it is represented by *Acrocarpus fraxinifolius* only in the evergreen forests of Western Ghats from south Kanara southwards up to an elevation of 1,200 m and in the eastern Himalaya in Sikkim and hills of Assam, Chittagong, and Burma (Ramesh Rao & Purkayastha, 1972, p. 61).

Specific Diagnosis

Acrocarpus siwalicus sp. nov.

Wood diffuse porous. *Growth rings* present, demarcated by bands of terminal parenchyma. *Vessels* medium to large, t.d. 100-250 μm, r.d. 110-260 μm, solitary and in radial multiples of 2-5, 12-14 per sq mm; vessel members 100-640 μm long with truncate ends; perforations simple; intervessel pits bordered, vestured, alternate, 5-7 μm in diameter

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PLATE 3 →

1. *Ormosioxylon bengalensis* Bande & Prakash—Cross section showing type and distribution of vessels and parenchyma. × 30; Slide no. BSIP 35757-1.
2. *Ormosia robusta*—Cross section showing similar type of vessels and parenchyma. × 30
3. *Ormosioxylon bengalensis* Bande & Prakash—Tangential longitudinal section showing type and distribution of xylem rays. × 50; Slide no. BSIP 35757-2.
4. *Ormosia robusta*—Tangential longitudinal section showing similar type of xylem rays. × 50.
5. *Koompassioxylon elegans* Kramer—Cross section showing type and distribution of vessels and parenchyma. × 30; Slide no. BSIP 35758-1.
6. *Koompassia malaccensis*—Cross section showing similar type and distribution of vessels and parenchyma. × 30.
7. *Koompassioxylon elegans* Kramer—Tangential longitudinal section showing storied xylem rays. × 50. Slide no. BSIP 35758-2.
8. *Koompassia malaccensis*—Tangential longitudinal section showing similar type and arrangement of xylem rays. × 50
9. *Adenantheroxylon pavoninium* Prakash & Tripathi—Cross section showing type and distribution of vessels and parenchyma. × 30, Slide no. BSIP 35759-1.
10. *Adenantheroxylon pavoninium* Prakash & Tripathi—Tangential longitudinal section showing type and distribution of xylem rays. × 100. Slide no. BSIP 35759-2

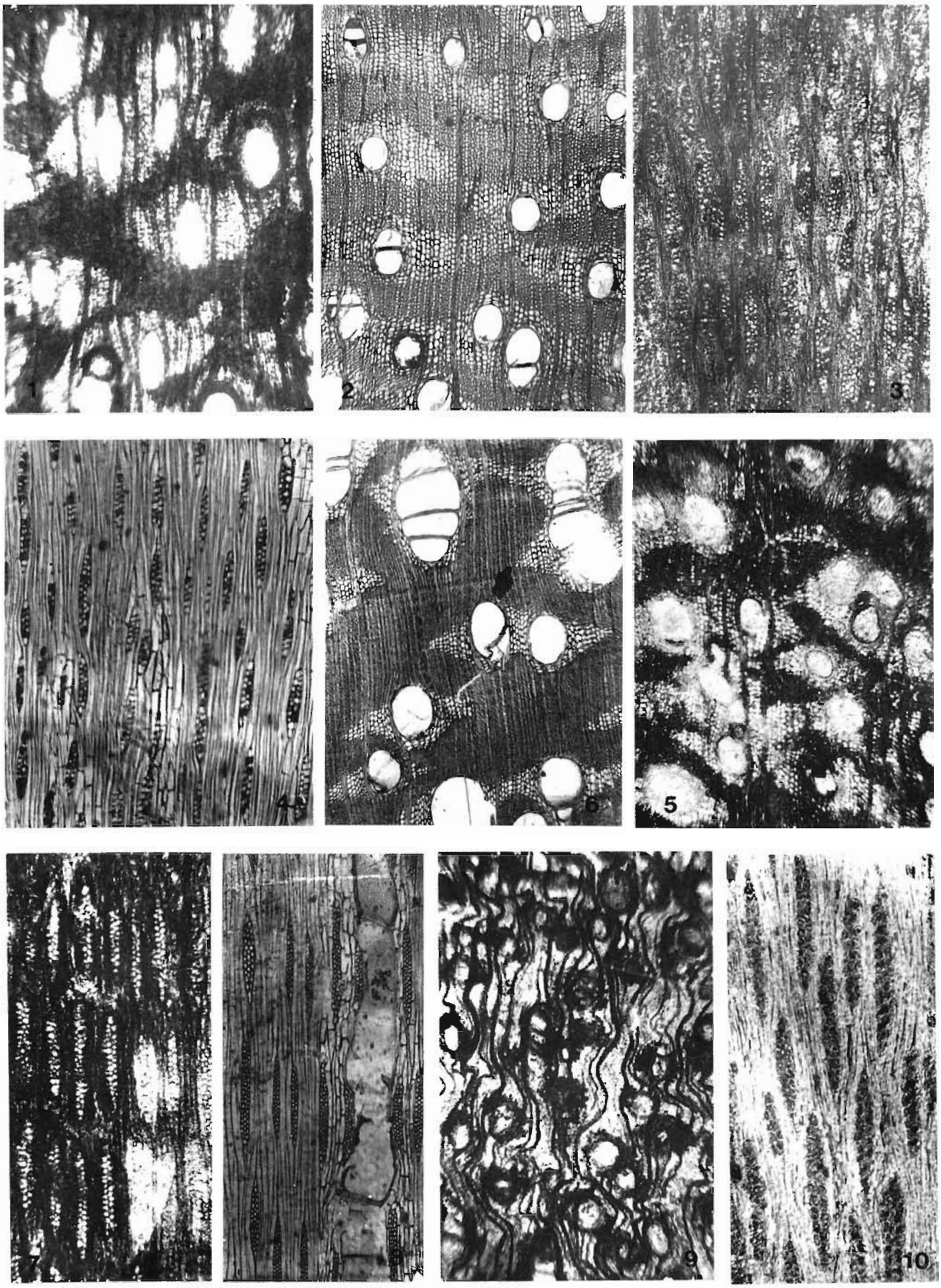

PLATE 3

with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma aliform to aliform confluent; apotracheal parenchyma demarcating the growth rings as well as forming short, 4-10 seriate bands in the ground tissue. *Xylem rays* 1-5 seriate or 12-100 μm wide and 5-35 cells or 90-560 μm high, ray tissue weakly heterogeneous, composed either of procumbent cells only or with one to two rows of marginal upright cells. *Fibres* thick-walled, septate, 12-18 μm in diameter and 480-1200 μm in length, inter-fibre pits not seen.

Holotype—Museum specimen no. BSIP 35756.

Locality—Nalagarh, Solan District, Himachal Pradesh.

Genus—*Ormosioxylon* Bande & Prakash 1980

Ormosioxylon bengalensis Bande & Prakash 1980
Pl. 3, figs 1, 3

The description of the present fossil wood is based on a well-preserved small piece of secondary xylem.

Wood diffuse porous. *Growth-rings* indistinct. *Vessels* small to moderately large, mostly solitary, sometimes in radial multiples of 2-5, evenly distributed, round to oval when solitary, with flat contact walls when in groups, 8-12 per sq mm, tyloses absent, thin-walled, t.d. 105-210 μm, r.d. 150-270 μm; vessel members 96-420 μm long with truncate ends; perforations simple, inter-vessel pit pairs vestured, alternate, 6-10 μm in size, with linear to lenticular apertures. *Parenchyma* paratracheal, aliform with blunt ends to aliform-confluent; cells thin-walled, 13-24 μm in diameter and 30-70 μm in length, parenchyma strands 2-4 celled, sometimes crystalliferous. *Xylem rays* 1-4 (mostly 3) seriate, 6-40 μm wide and 4-45 cells or 30-500 μm high, closely spaced, 5-8 per mm, ray tissue weakly heterogeneous, rays composed either of procumbent cells only or with 1-2 rows of upright cells at one or both the ends, ray cells thin-walled, procumbent cells 16-24 μm in tangential height and 70-95 μm in radial length, upright cells 60-72 μm in tangential height and 25-37 μm in radial length; rays with storied tendency. *Fibres* non-septate, 8-12 μm in diameter and 450-800 μm in length, interfibre pits not preserved.

Affinities—The present wood specimen is quite similar to *Ormosioxylon bengalensis* Bande & Prakash 1980 and therefore is assigned to the same species.

Specimen—Museum specimen no. BSIP 35757.

Locality—Nalagarh, Solan District, Himachal Pradesh.

Genus—*Koompassioxylon* Kramer 1974

Koompassioxylon elegans Kramer 1974
Pl. 3, figs 5, 7

The description of the present fossil wood is based on a single piece of petrified secondary xylem. *Wood* diffuse-porous. *Growth-rings* distinct, delimited by thin lines of terminal parenchyma and smaller vessels. Vessels medium-sized to moderately large, mostly solitary, sometimes in radial multiples of 2-4 or more, rarely in tangential pairs, 2-4 per sq mm, mostly open, thin-walled, solitary vessels round to oval in shape, t.d. 112-320 μm, r.d. 120-326 μm, vessel members 160-592 μm long with truncate ends, storied, perforations simple, intervessel pits alternate, 5-8 μm in diameter, vestured with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma aliform, usually with pointed wings on both the sides, sometimes confluent, apotracheal parenchyma terminal, forming 2-3 seriate lines delimiting the growth rings, parenchyma cells thin-walled, 24-42 μm in diameter and 40-50 μm in height, showing storied tendency, parenchyma strands 7-8 celled and crystalliferous. *Xylem rays* fine to very fine and low, 1-3 (mostly 2) seriate, 7-13 per mm and storied, 12-60 μm wide and 8-25 cells or 80-450 μm high; ray tissue heterogeneous, rays weakly heterocellular consisting of 1-2 rows of marginal upright cells at one or both the ends, ray cells thin-walled, procumbent cells 18-25 μm in tangential height and 42-72 μm in radial length; upright cells 40-55 μm in tangential height and 30-40 μm in radial length. *Fibres* polygonal in cross section, libriform, nonseptate, 14-17 μm in diameter and 650-800 μm in length, interfibre pits not seen. *Ripple marks* present due to storied arrangement of vessel members and xylem rays.

Affinities—The fossil wood shows close resemblance with the wood of *Koompassia* especially to *K. malaccensis* Maing. ex Benth. of Fabaceae in having aliform sometimes confluent parenchyma with crystalliferous and storied parenchyma strands, vestured intervessel pits, 1-3 seriate, weekly heterogeneous and storied xylem rays, similar vessel distribution with storied vessel elements and in the nature of fibres. Fossil wood resembling *Koompassia malaccensis* Maing. ex Benth. is described as *Koompassioxylon elegans* (Kramer, 1974; Bande & Prakash, 1980). The present fossil wood too is identical to this species except some minor differences.

Specimen—Museum specimen no. BSIP 35758.

Locality—Nalagarh, Solan District, Himachal Pradesh.

Genus—*Adenantheroxylon* Prakash & Tripathi 1968

Adenantheroxylon pavoninium
Prakash & Tripathi 1968
Pl. 3, figs 9, 10

The material consists of a single piece of decorticated secondary xylem measuring 8 cm in length and 5 cm in diameter.

Wood diffuse porous. *Growth-rings* present, demarcated by smaller vessels. *Vessels* small to medium sized, solitary and in radial multiples of 2-5, numerous, 9-13 per sq mm, open, sometimes filled with dark contents, thin-walled, t.d. 80-176 μm, r.d 85-190 μm; vessel members 64-320 μm in length with truncate or slightly tapered ends, perforations simple, intervessel pits very small, alternate, vestured, measuring 3-4 μm in diameter with linear to lenticular apertures. *Parenchyma* paratracheal and apotracheal; paratracheal parenchyma vasicentric to aliform, sometimes joining adjacent vessels, apotracheal parenchyma present as diffuse cells, parenchyma cells filled with dark contents, cells thin-walled, 12-15 μm in diameter and 20-30 μm in length; crystalliferous strands present. *Xylem rays* narrow, 1-2 (3) mostly 2 seriate, 12-25 per mm, ray tissue homogeneous, rays homocellular; composed entirely of procumbent cells, measuring 8-15 μm in tangential height and 20-30 μm in radial length. *Fibres* libriform, non-septate, 12-16 μm in diameter, 520-900 μm in length; inter-fibre pits not seen.

Affinities—The fossil wood resembles the modern wood of the genus *Adenanthera* in general and *A. pavonina* in particular (F.R.I. Slide no. 3657). Prakash and Tripathi (1968, 1969) described a fossil wood of *Adenanthera pavonina* L. from the Tertiary of Assam as *Adenantheroxylon pavoninium*. The present fossil wood is quite similar to it except the frequency of vessels.

Specimen—Museum specimen no. BSIP 35759.

Locality—Nalagarh, Solan District, Himachal Pradesh.

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REFERENCES

Anonymous 1963. *Indian woods : Their identification, properties and uses* 2. Delhi.

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

Awasthi, N. 1980. Two new dipterocarpaceous woods from the Cuddalore Series near Pondicherry. *Palaeobotanist* **26**(3) : 248-256.

Bande, M. B. & Prakash, U. 1980. Fossil woods from the Tertiary of West Bengal, India. *Geophytology* **10**(2) : 146-157.

Chowdhury, K. A. & Ghosh, S. S. 1958. *Indian woods; Their identification, properties and uses* **1**. Delhi.

Den Berger, L. G. 1927. Unterscheidungs merkmale von rezenten und fossilen Dipterocarpaceen gattungen. *Bull. Jand. bot. Buitenzorkg.* **3**(8) : 495-498.

Desch, H. E. 1957. Manual of Malayan timbers, I. *Malayan Forest Rec.* **15** : 1-328.

Ghosh, P. K. & Roy, S. K. 1978. *Dipterocarpoxylon bolpurense* sp. nov., a new fossil wood of Dipterocarpaceae from the Tertiary of West Bengal, India. *Curr. Sci.* **48** : 495-496.

Ghosh, P. K. & Roy, S. K. 1980. Fossil wood of *Anisoptera* from the Miocene beds, Birbhum District, West Bengal. *Curr. Sci.* **49** : 665-666.

Ghosh, S. S. & Ghosh, A. K. 1958. *Anisopteroxylon jawalamukhi* sp. nov., a new fossil record from the Siwaliks. *Sci. Cult.* **24** : 238-241.

Ghosh, S. S. & Kazmi, M. H. 1958. *Anisopteroxylon bengalensis* gen. et sp. nov., a new fossil wood from microlithic site of West Bengal. *Sci. Cult.* **23**(9) : 485-487.

Kanehira, R. 1924a. *Identification of Philippine woods by anatomical characters : Supplement of the anatomical characters and identification of Formosan woods, etc.* Govt. Res. Inst., Taihoku.

Kanehira, R. 1924b. Anatomical notes on Indian Woods. *Bull. Govt. Res. Inst., Taihoku* **4** : 1-40.

Kramer, K. 1974. The Tertiary woods of Southeast Asia (Dipterocarpaceae excluded). *Palaeontographica* **144B** : 45-181.

Kribs, D. A. 1959. *Commercial foreign woods on the American market.* Pennsylvania.

Miles, A. 1978. *Photomicrographs of world woods.* Garston-Watford.

Möll, J. W. & Janssonius, H. H. 1906. *Mikrographie des Holzes der auf Java Vorkammenden Baumarten*, **1** : Leiden.

Navale, G. K. B. 1963. Some silicified dipterocarpaceous woods from the Tertiary beds of Cuddalore Series near Pondicherry, India. *Palaeobotanist* **11**(1,2) : 66-81.

Pearson, R. S. & Brown, H. P. 1932. *Commercial timbers of India.* **1**. Calcutta.

Prakash, U. 1973. Fossil woods from Tertiary of Burma. *Palaeobotanist* **20**(1) : 48-70.

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

Prakash, U. 1978. Fossil woods from the Lower Siwalik beds of Uttar Pradesh, India. *Palaeobotanist* **25** : 376-392.

Prakash, U. 1979a. Fossil wood of *Dracontomelum* from the Lower Siwalik beds of Himachal Pradesh, India. *Geophytology* **8**(2) : 251.

Prakash, U. 1979b. Some more fossil woods from Lower Siwalik beds of Himachal Pradesh. *Himal. Geol.* **8** : 61-81

Prakash, U. 1981 Further occurrence of fossil woods from the Lower Siwalik beds of Uttar Pradesh, India. *Palaeobotanist* **28-29** : 374-388.

Prakash, U. & Prasad, M. 1984. Wood of *Bauhinia* from the Siwalik beds of Uttar Pradesh, India. *Palaeobotanist* **32**(2) : 140-145.

Prakash, U. & Tripathi, P. P. 1968. Fossil woods of *Adenanthera* and *Swintonia* from the Tertiary of Assam. *Curr. Sci.* **37**(4) : 115-116.

Prakash, U. & Tripathi, P. P. 1969. Fossil woods of Leguminosae

and Anacardiaceae from the Tertiary of Assam. *Palaeobotanist* **17**(1) : 22-32.

Prakash, U. & Tripathi, P. P. 1970. Fossil woods from the Tertiary of Hailakandi, Assam. *Palaeobotanist* **18**(1) : 20-31.

Ramesh Rao, K. & Purkayastha, S. K. 1972. *Indian woods : Their identification, properties and uses.* **3**. Dehradun.

Trivedi, B. S. & Ahuja, M. 1978a. *Sterculioxylon kalagarhense* sp. nov. from Kalagarh (Bijnor District), U.P., India. *Curr. Sci.* **47**(1) : 24-25.

Trivedi, B. S. & Ahuja, M. 1978b. *Glutoxylon kalagarhense* sp. nov. from Kalagarh. *Curr. Sci.* **47**(4) : 135.

Trivedi, B. S. & Ahuja, M. 1979a. *Pentacmeoxylon ornatum* gen. et sp. nov. from the Siwaliks of Kalagarh. *Curr. Sci.* **48**(14) : 646-647

Trivedi, B. S. & Ahuja, M. 1979b. *Parinarioxylon splendidum* sp. nov. from Kalagarh. *Curr. Sci.* **48**(2) : 75-76.

Trivedi, B. S. & Ahuja, M. 1980. *Dipterocarpoxylon nungarhense* n. sp. from Kalagarh, Bijnor District, India. *Palaeobotanist* **36**(3) : 221-225.

Trivedi, B. S. & Misra, J. P. 1978. *Dialiumoxylon kalagarhense* n. sp. from Mio-Pliocene of Kalagarh, U.P., India. *Indian J. Bot.* **1**(1&2) : 57-60.

Trivedi, B. S. & Misra, J. P. 1979. *Dysodendron kalagarhense* sp. nov. from Mio-Pliocene of Kalagarh, U.P., India. *J. Indian bot. Soc.* **58** : 90-94.

Trivedi, B. S. & Misra, J. P. 1980. Two new dipterocarpaceous woods from the Middle Siwalik of Kalagarh, Bijnor District, India. *Palaeobotanist* **26**(3) : 314-321.

Trivedi, B. S. & Srivastava, K. 1982. *Aglaioxylon mandlaense* gen. et sp. nov. from the Deccan Intertrappean beds of Mandla District (M.P.), India, pp. 255-258 *in*: Nautiyal, D. D. (Ed.)—*Phyta (D.D. Pant Commem. Vol.)*.