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STUDIES ON SOME MORE CARBONISED WOODS FROM THE NEOGENE OF KERALA COAST, INDIA

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ABSTRACT

More carbonised woods from Varkala Cliff Section and Payangadi Clay Mine belonging to Warkalli beds (Miocene-Pliocene) have been investigated. These woods show close resemblance with the extant woods of *Leea*, *Gluta* and *Gonystylus* and have been named as *Leeoxylon cannanorense* sp. nov., *Glutoxylon burmense* (Hold.) Chowdhury, *Gonystyloxylon indicum* gen. et sp. nov. and *G. tertiarum* sp. nov. Almost all the modern taxa with which these carbonised woods show closest resemblance are confined to the tropical evergreen forests of Malayan and Indonesian archipelagoes.

Key-words — Xylotomy, Carbonised woods, *Leea*, *Gluta*, *Gonystylus* Miocene-Pliocene (India).

सारांश

केरल तट (भारत) के पश्च-तृतीयक कल्प से कुछ और कार्बनी काष्ठों का अध्ययन – नीलाम्बर अवस्थी एवं मधु पंजवानी

वरकली संस्तरों (मध्यनूतन-आदिनूतन) से सम्बद्ध वरकला क्लिफ़ खंड एवं पयाँगदी मृत्तिका खान से और एकत्र किये गये कार्बनी काष्ठों का इस शोध-पत्र में वर्णन किया गया है। ये काष्ठ लीआ, ग्लूटा एवं गोनीस्टाइलस की वर्तमान काष्ठों से घनिष्ठ सजातीयता प्रदर्शित करते हैं तथा इन्हें लीआॅक्सीलॉन कैन्नेनोरेन्से नव जाति, ग्लूटॉक्सीलॉन बर्मेन्से (होल्डन) चौधरी, गोनीस्टाइलॉक्सीलॉन इन्डिकम् नव वंश व नव जाति तथा गो० टर्शियेरम् नव जाति से नामांकित किया गया है। जिन वर्तमान वर्गकों से ये कार्बनी काष्ठ समानता प्रदर्शित करते हैं वे सभी प्रायः मलाया एवं इंडोनेशिया के प्रायद्वीपों के उष्णकटिबंधीय सदाहरित वनों में पाये जाते हैं।

INTRODUCTION

IN the Neogene rocks of Kerala Coast the megaplant remains chiefly occur in the form of carbonised (lignitised) woods associated with lignites and carbonaceous clays. The associated lignites and carbonaceous clays have been considerably analysed by various workers (Vimal, 1953; Ramanujam, 1960, 1972; Ramanujam & Rao, 1973a, 1973b, 1977, 1978; Ramanujam & Srisailam, 1980; Ramanujam, Srisailam & Reddy, 1981; Rao & Ramanujam, 1975, 1976, 1978; Jain & Gupta, 1972; Jain & Kar, 1979; Kar & Jain, 1981) and reported the occurrence of fungal remains, spores and pollen contents mainly for stratigraphical correlations. However, keeping in view the great significance of plant megafossils in deciphering the palaeo-ecology and palaeophytogeography the present authors have initiated the systematic study of carbonised woods from the Neogene deposits of Kerala Coast. Awasthi and Ahuja (1982) reported six dicotyledonous woods, viz., *Calophyllum*, *Dryobalanops*, *Swintonia*, *Cynometra*, *Terminalia*, *Diospyros* and a lauraceous member having close resemblance with some of the species of *Cinnamomum* — *Litsea* and anatomically allied genera from the Varkala Coast. The material investigated here is a part of collection made from the Varkala Cliff Section and from the Payangadi Super Clay Mine in Cannanore District. The Payangadi Super Clay Mine is considered to be the extension of Warkalli beds.

SYSTEMATIC DESCRIPTION

FAMILY — AMPELIDACEAE

Genus — *Leeoxylon* Prakash & Dayal, 1964

Leeoxylon cannanorense sp. nov.

Pl. 1, figs 1-6

Description — Wood diffuse-porous. *Growth rings* not observed. *Vessels* solitary and in radial multiples of 2-3 (Pl. 1, figs 1, 2), small to medium, round to oval, t.d. 96-160 μm, r.d. 114-192 μm, evenly distributed, 3-8 per sq mm; vessel-members 272-1,280 μm long with truncate to tailed ends; perforations simple; intervascular pitting scalariform (Pl. 1, figs 5, 6); pits leading to parenchyma cells and rays opposite, large, usually with long axis placed horizontally; tyloses not seen. *Parenchyma* paratracheal, scanty, a few cells occurring round the vessels (Pl. 1, fig. 2). *Rays* broad (Pl. 1, fig. 4), up to 12-seriate and up to 225 μm wide, very high, mostly of indeterminate height, heterocellular, consisting of upright and square cells (Pl. 1, fig. 3); upright cells 40-80 μm in vertical length, 32-40 μm in radial length; square cells 32-40 μm in vertical and radial length; uniseriate rays rare, composed wholly of upright cells. *Fibres* aligned in radial rows in crosssection, semilibriform, moderately thick-walled and septate.

Affinities with modern woods — The salient features of the present fossil wood are small to medium vessels, scanty paratracheal parenchyma, broad, and very tall, multiseriate rays with a few homocellular uniseriate rays and scalariform intervessel pitting. These may be considered as cogent features in bringing the present fossil wood closer to the genus *Leea* Royen ex Linn. of the family Ampelidaceae (Hess, 1936; Dadswell & Record, 1936; Metcalfe & Chalk, 1950). Thin sections of the woods of seven species of *Leea*, viz., *L. sambucina* Willd., *L. philippinensis* Merill, *L. indica* Merill, *L. alata* Edgew, *L. brunoniana* C. B. Clarke, *L. angulata* Korth. and the descriptions and illustrations of the woods of *Leea quineense* Don. (Metcalfe & Chalk, 1950, p. 417, fig. 956), *L. sundaica* Miq., *L. javanica* Bl. (Moll & Janssonius, 1908, pp. 314, 315), *L. gigantea* Griff. (Desch, 1954, p. 5) were examined in order to find out the nearest living counter part of the present fossil wood. This thorough task enabled us to put our fossil wood more closer to *Leea angulata* and *L. philippinensis*. The former shows similarity in the nature and distribution of vessels, parenchyma and fibres while the latter has similar xylem rays. But none of the above species of *Leea* seems to be exactly identical to our fossil.

Affinities with fossil species — As the fossil shows closest resemblance with the modern wood of *Leea* of the family Ampelidaceae, it has been placed under the genus *Leeoxylon* Prakash & Dayal (1964). So far only four fossil woods having close resemblance with *Leea* are known. They are *Leeoxylon multiseriatum* Prakash & Dayal (1964) from the Deccan Intertrappean beds of Mahurzari near Nagpur, India *Leeoxylon eojaponicum* (Watari) Kramer (1974) (*Leea eojaponica* Watari, 1951) from the Lower Miocene of Simane, Japan, *Leeoxylon altiradiatum* Kramer (1974) from the Tertiary of Java and *Leeoxylon* sp. Lemoigne (1978) from the Pliocene-Pleistocene of Omo Basin, Ethiopia. Our fossil though resembles these species in the nature and distribution of vessels, parenchyma, xylem rays and scalariform intervessel pitting, yet it can easily be differentiated in the size and frequency of vessels, height and width of xylem rays. In *Leeoxylon multiseriatum* the vessels are relatively smaller in size, i.e. up to 120 μm in diameter and their frequency is 8-15 per sq mm; the xylem rays are up to 18 cells wide and 375-2775 μm high; whereas in the present fossil the vessels are less frequent, i.e. 3-8 per sq mm and relatively bigger, up to 192 μm in diameter and the xylem rays are up to 12 cells wide and extremely tall, so much so that the height of most of the rays is indeterminable. *Leeoxylon eojaponicum* shows considerable differences from the present species particularly in the absence of uniseriate rays, presence of raphids in ray cells, relatively larger vessels and complete sheath of paratracheal parenchyma around the vessels. The broad xylem rays in *Leeoxylon eojoponicum* are 2-10 (mostly 7-8) seriate and are still higher than in the present fossil. Lastly, *Leeoxylon* sp. Lemoigne also differs in having diffuse parenchyma. Therefore, the present fossil is named as *Leeoxylon cannanorense* sp. nov.; the specific name is after Cannanore District.

SPECIFIC DIAGNOSIS

Lecoxylon cannorense sp. nov.

Wood diffuse-porous. *Growth rings* not observed. *Vessels* solitary and in radial multiples of 2-3, small to medium, t.d. 96-160 μm, r.d. 144-192 μm; vessel-members 272-1280 μm long with truncate to tailed ends; perfora ions simple; intervess.l pitting scalariform. *Parenchyma* scanty paratracheal, only a few cells associated with vessels. *Rays* 1-12 seriate, heterocellular, consisting of mostly upright and square cells, very tall; uniseriate rays occasionally present, homocellular, consisting of only upright cells. *Fibres* semilibriform and septate.

Holotype — B.S.I.P. Specimen no. 35529.

Locality — China Clay Mine, Payangadi, district Cannanore, Kerala.

FAMILY — THYMELAEACEAE

Genus — *Gonystyloxylon* gen. nov.

Gonystyloxylon indicum sp. nov.

Pl. 2, figs 7-11

Description — *Wood* diffuse-porous. *Growth rings* indistinct (Pl. 2, fig. 7) though at places narrow zones of relatively small-sized fibres indicate the annual growth marks. *Vessels* solitary and in radial multiples of 2-3, sometimes in tangential groups of 2-3, small to medium, somewhat angular in shape, t.d. 80-90 μm, r.d. 60-120 μm, 3-9 per sq mm; vessel-members short, up to 352 μm high with truncate or slightly tailed-ends; perforations simple; intervascular pitting small, alternate, bordered (Pl. 2, fig. 9). *Parenchyma* abundant, paratracheal, forming 2-3 seriate, incomplete or mostly complete sheath around vessels, and frequently extending laterally across several rays forming fine tangential lines of usually 1-2 cells in width, sometimes aliform parenchyma bifurcating into fine lines (Pl. 2, fig. 7); lines about 4-5 per mm; parenchyma cells 20-42 μm in tangential diameter and up to 16 μm in radial diameter. *Rays* predominantly uniseriate (Pl. 2, fig. 8), occasionally biseriate due to pairing of procumbent cells through the median portion, homogeneous to weakly heterogeneous (Pl. 2, fig. 10), 15-17 cells and 88-640 μm high, 16-32 μm wide, about 10-12 per mm; solitary crystal sometimes present in ray cells. *Fibres* aligned in radial rows, angular to mostly hexagonal in shape (Pl. 2, fig. 7), t.d. up to 36 μm, bigger than parenchyma cells, short, somewhat fusiform, thin-walled with numerous simple as well as bordered pits on both radial and tangential walls (Pl. 2, figs 8, 9), nonlibriform, non-septate. *Included phloem* absent.

Affinities with modern woods — The salient anatomical features of the present carbonised wood are: vessels solitary and in short radial multiples of 2-3, sometimes in groups of double rows, parenchyma paratracheal, vasicentric and confluent, forming narrow tangential lines, rays uniseriate to biseriate and fibres frequently pitted. These features strongly suggest the affinities of our fossil with the woods of the genus *Gonystylus* of the family Thymelaeaceae. The other genera of this family which have uniseriate to bi-celled rays are *Aquilaria*, *Daphne*, *Gyrinops* and *Passerina*. However, comparatively long radial multiples of vessels and abundant patches of included phloem in *Aquilaria* distinguish it from the present fossil. Extremely small vessels and scanty paratracheal parenchyma limited to the vessels in *Passerina*, *Daphne* and *Gyrinops* are the anatomical characters different from our specimen. So *Gonystylus* is the only genus which comes closer to the present fossil wood in almost all its anatomical characters.

The taxonomic position of the genus *Gonystylus* is controversial. This genus is referred to Thymelaeaceae by some botanists (Janssonius, 1930; Willis, 1972; Desch, 1954) while others have placed it under a separate family Gonystylaceae (Hutchinson, 1926; Metcalfe & Chalk, 1950; Miles, 1978). According to Metcalfe and Chalk (1950) "the lack of intraxylary phloem serves to distinguish *Gonystylus* from most of the Thymelaeaceae, although it should be noted that this is also absent from *Lagetta*, *Microsenima* and *Solusia*, and the rather specialized *Drapets*". In this connection the authors examined thin sections of the woods of *Gonystylus*, viz., *G. bancanus* Gilg., *G. macrophyllus* (Miq.) Airy Shaw and *Gonystylus* sp. and found that a few patches of intraxylary phloem are present in one of the species of *Gonystylus*, viz., *G. macro-*

phyllus, although no where in the literature there is any report about the presence of the intraxylary phloem in this genus. So this character seems to be a variable one and it is a matter of opinion whether *Gonystylus* be treated in a distinct family or be retained in Thymelaeaceae.

The fossil wood was also compared with the published literature of *G. bancanus* Gilg and *G. miquelianus* Teijsm et Binn. (Metcalfe & Chalk, 1950, pp. 1178-1181, fig. 283A-B), *G. warburgianus* Gilg (Desh, 1954, pp. 208, 209). *G. macrophyllus* (Miq.) Airy Shaw [(syn. *G. bancanus* (Miq.) Kurz], Miles, 1978, p. 66) and it was found that the fossil wood resembles all the above mentioned species in the distribution pattern of vessels, parenchyma, fibres and rays. However, it differs in having smaller vessels. Besides, the fossil can be further differentiated from *G. macrophyllus* in the absence of intraxylary phloem.

Since the fossil woods shows resemblance with the woods of *Gonystylus*, it is placed under a new genus *Gonystyloxylon*, instituted to include all the fossil woods having close similarity with the woods of *Gonystylus* of the family Thymelaeaceae. It is specifically named as *Gonystyloxylon indicum* sp. nov.

With regard to other fossil records of Thymelaeaceae, Ramanujam (1966) recovered the pollen grains of this family from the Neyveli Lignite and placed them under the artificial genus *Clavatiperiporites* and named *C. jacobi*. He has shown their affinities with the pollen grains of *Wikstroemia*. This also confirms that the family Thymelaeaceae had existed in South India in the geological past.

DIAGNOSIS

Gonystyloxylon gen. nov.

Wood diffuse-porous. *Growth rings* present or absent. *Vessels* small to medium, solitary and in radial multiples of 2-4 or more, cells sometimes in double rows, vessel-members usually short in height; perforations simple; intervessel pitting alternate, small to medium, bordered. *Parenchyma* abundant, paratracheal, forming 2-3 seriate complete or incomplete sheath around the vessels, often extending tangentially forming narrow lines. *Rays* 1-2 seriate, almost homogeneous to weakly heterogeneous; crystals present in ray cells. *Fibres* nonlibriform, non-septate with simple or bordered pits on radial and tangential walls. *Included phloem* present or absent.

Genotype — Gonystyloxylon indicum sp. nov.

Gonystyloxylon indicum sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* solitary and also in radial multiples of 2-3, small to medium, t.d. 80-100 μm, r.d. 60-120 μm, somewhat angular in shape; vessel-members up to 352 μm long with truncate or slightly tailed ends; perforations simple; intervessel pitting alternate, small, 4-6 μm, bordered. *Parenchyma* abundant, paratracheal, forming 2-3 seriate complete or incomplete sheath around vessels and extending laterally across several rays forming fine tangential lines of 2-4 cells in thickness, about 4-5 lines per mm. *Rays* predominantly uniseriate, occasionally bi-celled, homogeneous to weakly heterogeneous, 5-17 (88-640 μm) cells high, 16-32 μm wide, about 10-12 per mm; solitary crystal sometimes present in ray cells. *Fibres* aligned in radial rows, hexagonal to elongated, t.d. up to 36 μm, r.d. 32-60 μm, bigger than parenchyma cells, thin-walled with numerous simple as well as bordered pits on both radial and tangential walls, nonlibriform, non-septate. *Included phloem* absent.

Holotype — B.S.I.P. no. 35530.

Locality — Varkala Cliff Section, Varkala, Kerala.

Gonystyloxylon tertiarum sp. nov.

Pl. 2, figs 13, 15, 16; Pl. 3, figs 17, 19, 21

Description — Wood diffuse-porous. *Growth rings* present, delimited by narrow zone of thick-walled fibres (Pl. 2, fig. 12). *Vessels* solitary and also in radial multiples of 2-4 as well as in double rows (Pl. 2, fig. 12), occasionally in clusters of small vessels, almost uniformly distributed, circular to oval, t.d. 40-160 μm, r.d. 50-160 μm, small to medium, 3-13 per sq mm; vessel-members 180-600 μm long with truncate to slightly inclined ends; intervascular pitting alternate, small or minute, bordered, crowded, pits 4-5 μm in diameter with circular to lenticular aperture (Pl. 2, fig. 15). *Parenchyma*

paratracheal, completely enclosing vessels and extending laterally forming 1-2 seriate fine lines (Pl. 2, figs 12, 13; Pl. 3, fig. 17), about 8 lines per mm; parenchyma cells oval to elongated, 16-32 μm in diameter, those occurring around vessels peripherally flattened. *Rays* very fine, uniseriate to rarely biseriate (Pl. 3, fig. 19), 12-18 per mm in cross-section, 4-24 cells high; ray tissue homogeneous to weakly heterogeneous (Pl. 3, fig. 21), consisting of procumbent cells, sometimes with one squarish cell; vertical height of procumbent cells 20-32 μm, radial length 40-80 μm; vertical height of squarish cells 48-52 μm, radial length 36-40 μm; crystals present in almost all the cells (Pl. 3, fig. 21). *Fibres* aligned in radial rows, circular to oval in cross section, about 8-30 μm in diameter, moderately thick-walled, thicker and narrower towards the close of the ring (Pl. 2, fig. 12), nonlibriform, with numerous bordered pits on the radial as well as tangential walls (Pl. 2, fig. 16). *Included phloem* present, cells thin-walled, irregular in shape and size. These anatomical features of the fossil wood are more or less similar as shown by the previous fossil and hence it is also being placed under the genus *Gonystyloxylon*.

On the basis of the studies of modern species of *Gonystylus*, it was found that the present fossil closely resembles *G. macrophyllus* in having intraxylary phloem which is absent in *Gonystyloxylon indicum*. However, in almost all other characters, such as distribution of vessels, parenchyma lines, rays, crystals, thickness of fibres the fossil wood is more closer to *Gonystylus* sp. (B.S.I.P. slide no. 1472).

The present fossil wood differs from *Gonystyloxylon indicum* in having interxylary phloem, relatively bigger vessels and greater frequency of xylem rays and presence of crystals in almost all ray cells. Hence it is being described here as *Gonystyloxylon tertiarum* sp. nov.

Specific Diagnosis

Gonystyloxylon tertiarum sp. nov.

Wood diffuse-porous. *Growth rings* present. *Vessels* solitary and also in radial multiples of 2-4, as well as in double rows, circular to oval, t.d. 40-160 μm, r.d. 50-150 μm, small to medium, 3-13 per sq mm, vessel-members 180-600 μm long with truncate to slightly tailed ends, intervessel pitting alternate, minute, bordered, pits 4-5 μm in diameter with circular to lenticular aperture. *Parenchyma* paratracheal completely enclosing the vessels and extending laterally forming 1-2 seriate lines, about 8 lines per mm. *Rays* uniseriate to rarely biseriate; ray tissue homogeneous to weakly heterogeneous, solitary crystals frequent in ray cells. *Fibres* circular to oval in cross section, moderately thick-walled, thicker and narrower towards the close of the ring, nonlibriform with numerous bordered pits on the radial walls. *Included phloem* present, thin-walled, cells irregular in shape and size.

Holotype — B.S.I.P. specimen no. 35531.

Locality — China Clay Mine, Payangadi, Cannanore District, Kerala.

Family — Anacardiaceae

Genus — *Glutoxylon* Chowdhury, 1934

Glutoxylon burmense (Hold.) Chowdhury, 1952

Pl. 3, figs 23, 24

Description — *Wood* diffuse porous. *Growth rings* not seen. *Vessels* small to large in size, t.d. 80-160 μm, r.d. 144-240 μm, oval in shape, solitary and also in radial multiples of 2-5 (mostly 2-3), 2-8 per sq mm, heavily tylosed (Pl. 3, fig. 23); perforations simple; intervessel pits bordered, large, alternate, orbicular with lenticular aperture. *Parenchyma* both paratracheal and apotracheal; paratracheal parenchyma scanty; apotracheal in the form of 2-4 (rarely up to 5) cells wide incomplete bands (Pl. 3, fig. 23), 2-4 per mm. *Xylem rays* simple and fusiform (Pl. 3, fig. 24), simple rays fine, 1-2 (mostly 1) seriate, homocellular, consisting of procumbent cells, up to 11 cells in height; fusiform rays 2-5 seriate with single radial gum duct in the centre (Pl. 3, fig. 24), homocellular, consisting of procumbent cells; gum ducts lined with single row of epithelial cells; rays 8-10 per mm. *Fibres* semilibriform, non-septate, thick-walled.

Affinities — In all its anatomical features the present carbonised wood shows closest resemblance with the woods of *Gluta*, and

hence placed under the genus *Glutoxylon* Chowdhury, 1934. This genus was created by Chowdhury (1934) for the fossil woods of *Gluta* and those melanorrhoeas which have thin apotracheal parenchyma lines or bands. Since then a large number of fossil woods have been described by several workers from various Neogene deposits of India and Burma and all of them have been placed under this fossil genus. However, to accommodate those fossils having broad parenchyma lines or bands as seen in a few species of *Malanorrhoea*, Prakash and Tripathi (1969) proposed a new genus *Melanorrhoeoxylon*. Ghosh and Roy (1980) described a fossil wood under this genus as *Melanorrhoeoxylon garbetaense* from the Tertiary of West Bengal.

Recently Ding Hou (1978), who made taxonomic study of the Malesian Anacardiaceae, has merged all the species of *Melanorrhoea* to the genus *Gluta*. As a consequence the genus *Melanorrhoeoxylon* Prakash & Tripathi becomes superfluous and hence merged with *Glutoxylon* (Hold.) Chowdhury. Among the fossil woods referred to the genus *Glutoxylon* our carbonised wood shows the structural details similar to *Glutoxylon burmense* (Hold.) Chowdhury. It is, therefore, placed under the same species.

Specimen — B.S.I.P. specimen no. 35532.

DISCUSSION

The carbonised woods identified as *Leea*, *Gonystylus* and *Gluta* are quite significant from the ecological and phytogeographical point of view. The genus *Leea* Royen ex L. consists of 70 species of climbers, climbing shrubs or small trees, distributed in palaeotropical regions (Willis, 1973, p. 643). In India, the species of *Leea* are generally found in the under-growth of the forest and one or two also in open grasslands like *Leea macrophylla* Roxb. and *L. alata* Edgw. Among the forest ones *L. aspera* Wall. is very common in deciduous forest all over India. *Leea crispa* Willd. and *L. sambucina* Willd. are common in the Darjeeling Terai. *Leea umbraculifera* C. B. Clarke and *L. robusta* Roxb. are found in the forests of the Sikkim-Himalaya, Terai up to 1,000 m in the undergrowth forests, and also in North Kanara, West coast (Gamble, 1972, p. 191). Of the species comparable to the present carbonised wood, *Leea angulata* is distributed in the evergreen forests of Malay peninsula, while *L. philippinensis* is known to occur in similar forest of Philippines.

The other genus *Gluta* consists of about 30 species as a consequence of the reduction of *Melanorrhoea* to *Gluta*. It is distributed in Madagascar, India, Burma, Thailand, Indochina, China and throughout Malaysia (Ding Hou, 1978). In India this genus is represented by *Gluta travancorica*, occurring in dense moist forests on the hills of Travancore and Tinnevelly. The genus *Gonystylus* which is totally absent from the Indian subcontinent, consists of about 30 species (Willis, 1973) confined to the evergreen forests of Malayan and Indonesian archipelagoes.

Since the modern equivalents of the present fossil woods are the important elements of the tropical evergreen forests, it is thus envisaged that somewhat similar climatic conditions prevailed during Neogene times all along the Kerala Coast.

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EXPLANATION OF PLATES

PLATE 1

Leeoxylon cannanorense sp. nov.

1. Cross section showing gross features. × 40; B.S.I.P. slide no. 7016.
2. Cross section at higher magnification showing vessels and scanty paratrachael parenchyma. × 100; B.S.I.P. slide no. 7016.
3. Radial longitudinal section showing heterocellular xylem rays made up of upright and square cells. × 100; B.S.I.P. slide no. 7017.
4. Tangential longitudinal section showing broad rays of indeterminate height. × 100; B.S.I.P. slide no. 7018.
5. Tangential longitudinal section showing scalariform intervessel pitting. × 100; B. S. I. P. slide no. 7018.
6. Tangential longitudinal section magnified to show bars of scalariform intervessel pitting. × 400; B.S.I.P. slide no. 7019.

PLATE 2

Gonystyloxylon indicum gen. et sp. nov.

7. Cross section showing shape, size and distribution of vessels, parenchyma and fibres. × 40; B.S.I.P. slide no. 7020.
8. Tangential longitudinal section showing homocellular to weakly heterocellular xylem rays. × 100; B.S.I.P. slide no. 7021.
9. Tangential longitudinal section showing intervessel pits. × 400; B.S.I.P. slide no. 7021.
10. Radial longitudinal section showing crystals in ray cells. × 400; B.S.I.P. slide no. 7022.

11. Bordered pits on the radial walls of fibres. × 400; B.S.I.P. slide no. 7022.

Gonystyloxylon tertiarum sp. nov.

12. Cross section showing growth rings and distribution of vessels and parenchyma. × 100; B.S.I.P. slide no. 7023.
13. Cross section showing nature and distribution of vessels, parenchyma and fibres. × 40; B.S.I.P. slide no. 7023.

Gonystylus sp.

14. Cross section showing similar type and distribution of vessels and parenchyma as in fossil. × 40.
15. *Gonystyloxylon tertiarum* sp. nov. showing intervessel pitting. × 400; B.S.I.P. slide no. 7024.
16. *G. tertiarum* sp. nov. showing fibre pits. × 400; B.S.I.P. slide no. 7025.

PLATE 3

17. *Gonystyloxylon tertiarum* sp. nov.: Cross section showing vessels, parenchyma and included phloem. × 40; B.S.I.P. slide no. 7023.
18. *Gonystylus macrophyllus*: Cross section showing similar included (interxylary) phloem, vessels and parenchyma. × 40.
19. *Gonystyloxylon tertiarum* sp. nov.: Tangential longitudinal section showing homocellular to weakly heterocelluar xylem rays. × 100; B.S.I.P. slide no. 7024.
20. *Gonystylus* sp.: Tangential longitudinal section showing similar type of rays. × 100.
21. *Gonystyloxylon tertiarum* sp. nov.: Radial longitudinal section showing ray cells with crystals. × 100; B.S.I.P. slide no. 7025.
22. *Gonystylus* sp.: Radial longitudinal section showing similar type of ray cells with crystals as in fossil. × 100.

Glutoxylon burmense (Hold.) Chowdhury

23. Cross section showing distribution of vessels (with tyloses) and apotracheal parenchyma (dark bands or lines). × 40; B.S.I.P. slide no. 7026.
24. Tangential longitudinal section showing simple uniseriate xylem rays and a fusiform ray with gum canal. × 120; B.S.I.P. slide no. 7027.

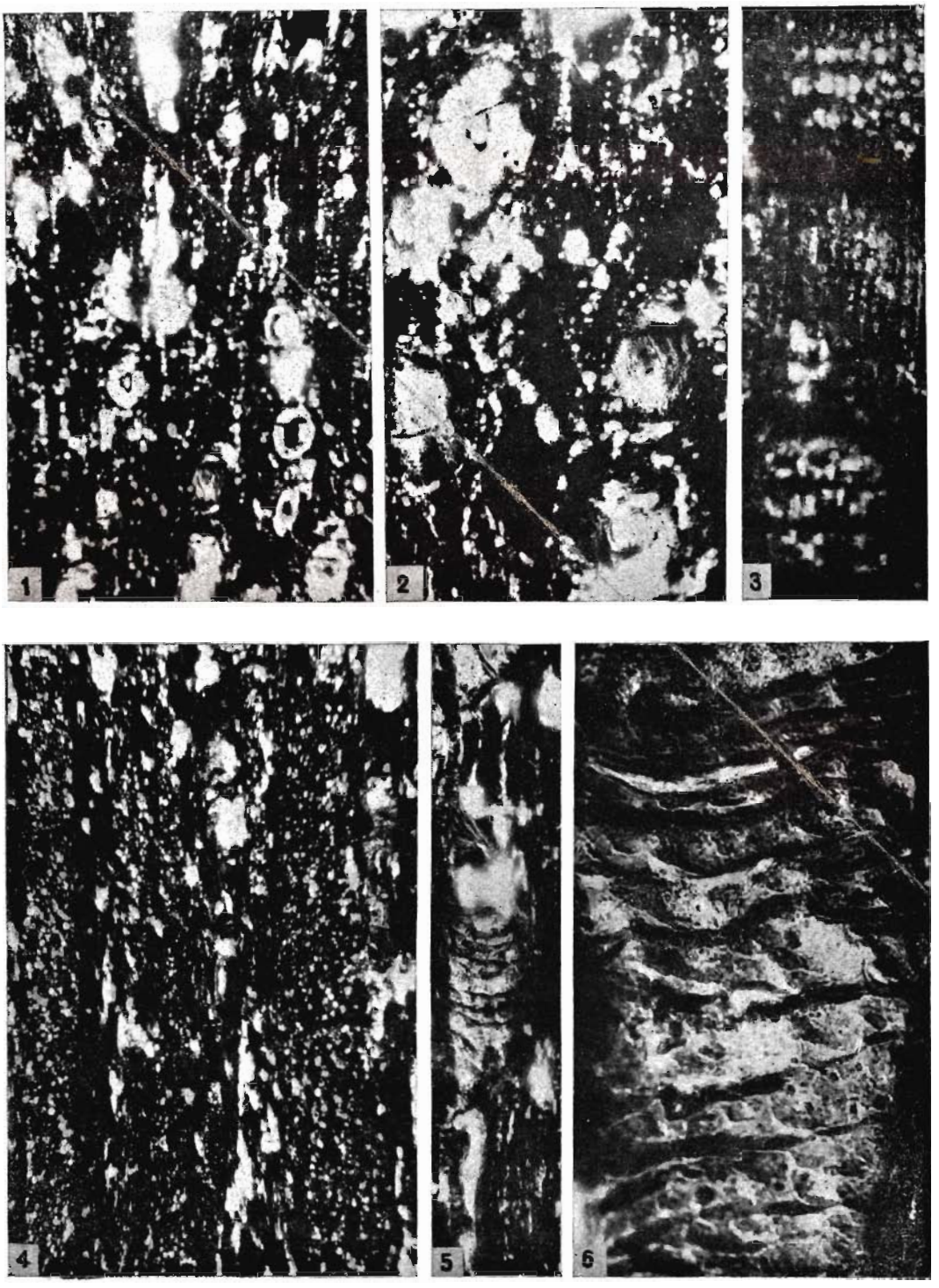


PLATE 1

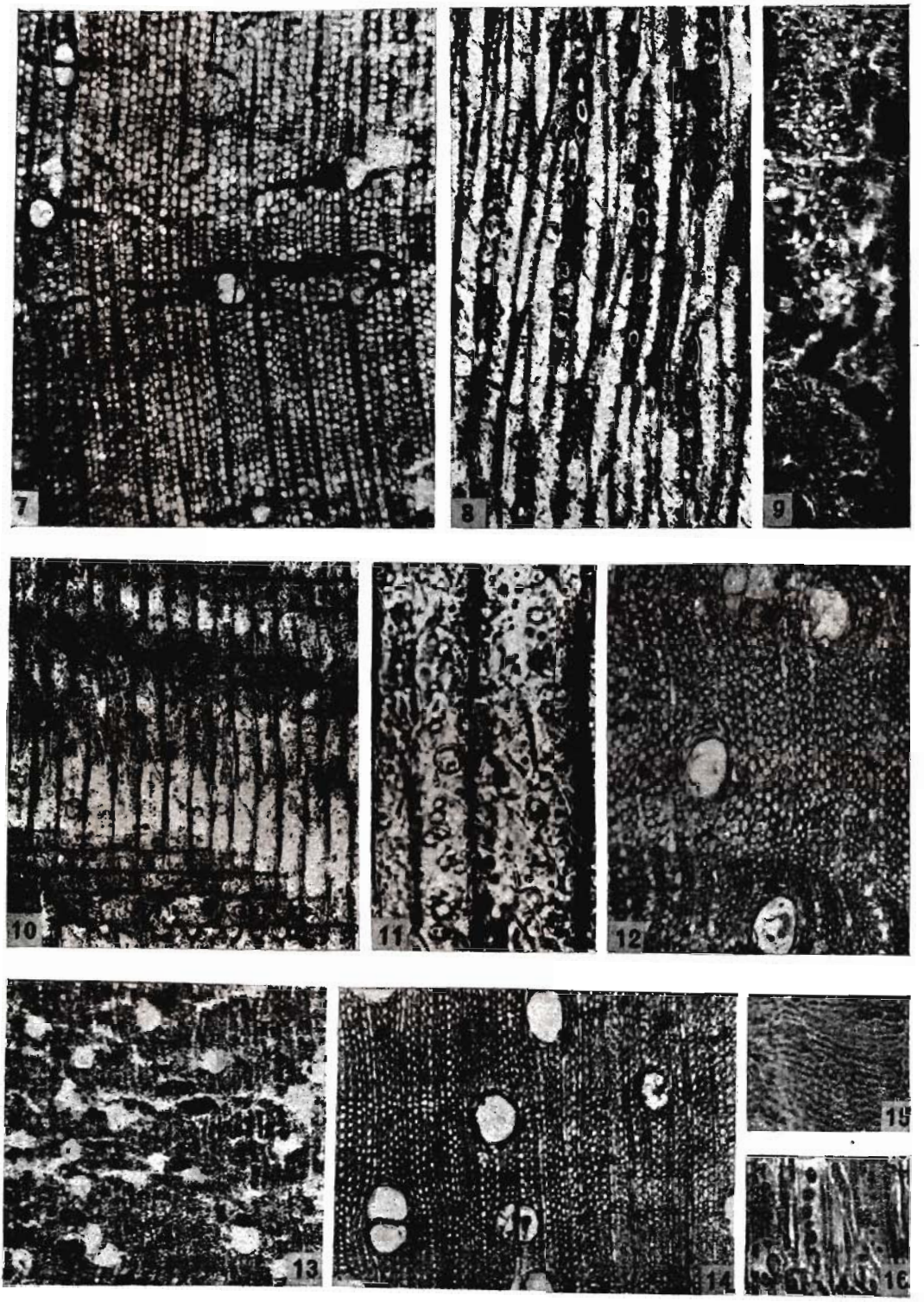
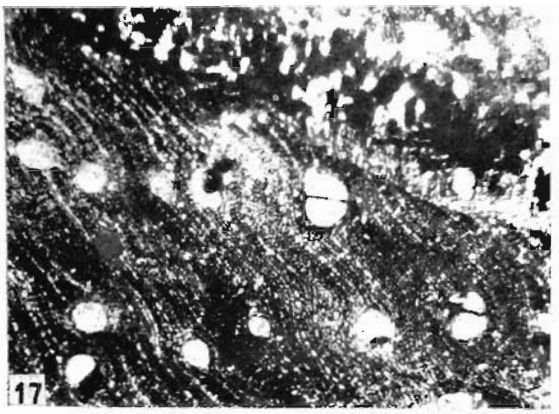
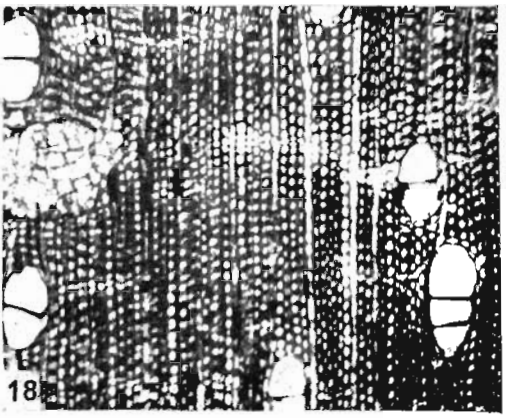
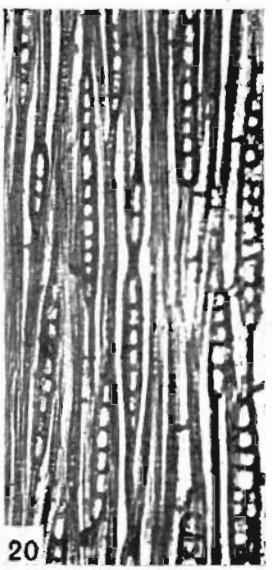


PLATE 2







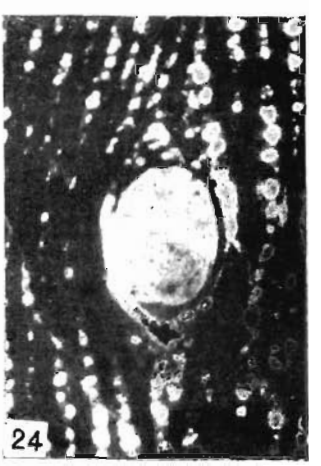


PLATE 3