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Petrified Neogene woods of Tripura

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ABSTRACT

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A large number of fossil woods were collected from three new fossiliferous localities situated in the South Tripura District, India where rocks of the Tipam Group (Late Miocene) are exposed. Three of these woods, namely *Bauhinia*, *Dipterocarpoxylon* and *Glutoxylon* have been described out of which first two are reported for the first time from this region. Their presence indicates the existence of tropical evergreen forests in the South Tripura District during the Late Miocene.

Key-words—Fossil woods, South Tripura District, Late Miocene, Palaeoecology

त्रिपुरा की अश्मीभूत नियोजीन काष्ठ

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सारांश

भारत के दक्षिणी त्रिपुरा जिले में स्थित तीन नई जीवाश्ममय संस्थितियों से जीवाश्म काँठों को प्रचुर मात्रा में एकत्र किया गया है जहाँ टीपम समूह (अंतिम मायोसीन) की चट्टाने अनावरित हैं। *बौहिनिआ, डिप्टेरोकार्पोक्सीलॉन* एवं *ग्लुटॉक्सीलॉन* नाम की तीन काँठें वर्णित हो चुकी हैं जिनमें से पहली दो इस क्षेत्र से प्रथम बार अभिलिखित हुई हैं। उनकी उपस्थिति से अंतिम मायोसीन के दौरान दक्षिणी त्रिपुरा जिले में उँणकटिबंधीय सदाहरित वनों की विद्यमानता इंगित होती है।

संकेत-शब्द—जीवाश्म काष्ठ, दक्षिणी त्रिपुरा जिला, अंतिम मायोसीन, पुरापारिस्थितिकी।

INTRODUCTION

TRIPURA, the second smallest state in India, lies geographically in the eastern part of India bordering Bangladesh in the west, south and north, Assam in the northeast and Mizoram in the east respectively (Fig. 1). The state is connected with the rest of India by only one road which runs through the hills of the Cachar District in Assam.

The geological study of Tripura dates back to 1908 when Dasgupta first classified the folded sedimentary rocks into the 'Coal Measures' and 'Tipam Group' (in Karunakaran, 1974). The rocks lying in this state range from the Early Tertiary (40 m.y.) to the Recent. As per the most accepted classification, the oldest sedimentary rocks exposed in the state belong to the Surma Group followed by the Tipam, Dupitila and Recent groups. The Tipam Group is further divided into two formations,

namely Champanagar and Manu Bazar of which the former generally contains fossil woods (Karunakaran, 1974).

Although a large number of fossil woods are found in the region, yet the area is not fully explored from the palaeobotanical point of view. In order to build up the palaeofloristics of the region for reconstruction of its palaeoenvironment, a large number of fossil woods were collected from Manughat, Mandoli Dak and Udaipur of South Tripura District. Udaipur (23° 32' N; 91° 30' E), the district headquarter of South Tripura, is approximately 35 km south east of Agartala, while Manughat and Mandoli Dak are situated near Manu Bazar (23° 04' N; 91° 37' E) at a distance of approximately 50 km south of Udaipur (Fig. 1). The woods are preserved *in situ* (Fig. 2) in the rocks of the Champanagar Formation of the Tipam Group which is considered Late Miocene in age (Karunakaran, 1974). So far only a few fossil woods have been recorded from Tripura especially from near Khowai bridge, Teliamura near Agartala in the West Tripura District and Dumbur Waterfall near Amarpur in the South Tripura District. The recorded taxa are *Afzelia-Intsia* (Ghosh & Kazmi, 1961), *Cassia*, *Millettia* (Acharya & Roy, 1986), *Cynometra* (Awasthi *et al.*, 1994) of Fabaceae and *Dipterocarpus* of Dipterocarpaceae (Mehrotra & Bhattacharyya, 2002). Besides, a badly preserved fossil wood of *Gluta* was also reported by Ghosh and Taneja (1961) but it was published without photographs/figures and detailed description.

All the specimens and slides are preserved in the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

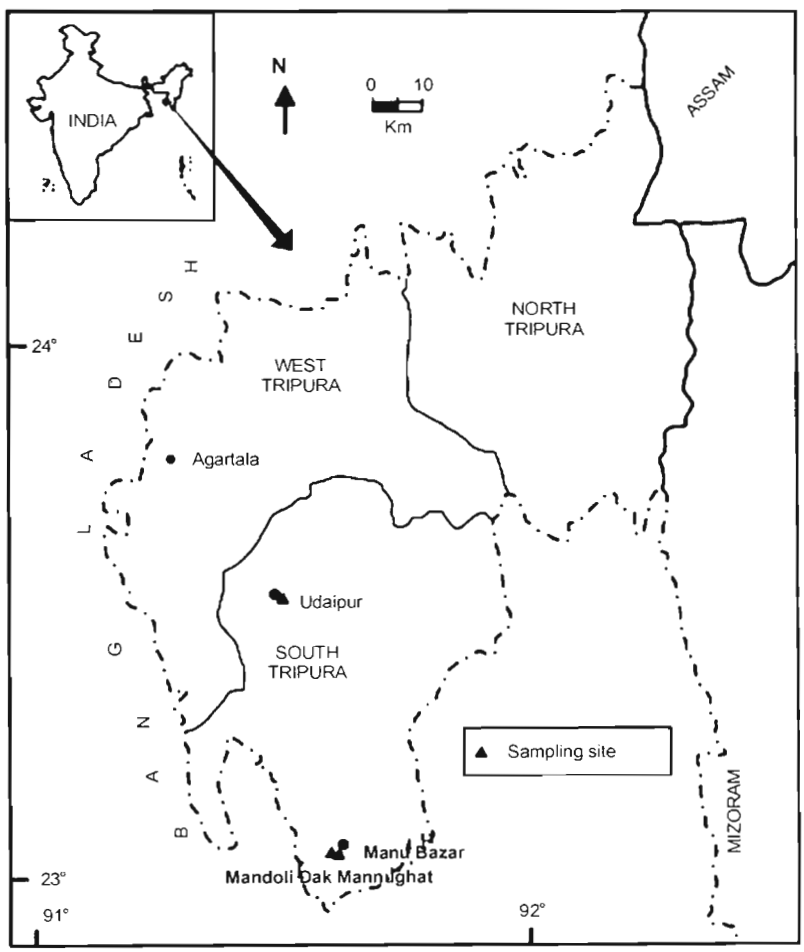

Fig. 1—Map of Tripura showing fossiliferous localities.

SYSTEMATICS

Family—DIPTEROCARPACEAE

Genus—DIPTEROCARPOXYLON Holden emend. Den Berger, 1927

Dipterocarpoxylon tertiarum Prakash, 1965

(Pl. 1.1-4)

Material—The study is based on a solitary piece of silicified wood measuring 8 cm in length and 5 cm in width.

Description—Wood diffuse porous. Growth rings absent. Vessels medium to large, t.d. 30-360 μm, r.d. 75-400 μm, almost exclusively solitary, rarely in radial pairs, circular to oval, sometimes deformed, evenly distributed, 3-6 per sq. mm, tylosed; vessel members 275-500 μm in height with oblique to horizontal ends; perforations simple; intervessel pits occasionally seen, bordered, alternate, large with lenticular apertures. Tracheids vasicentric, intermixed with parenchyma cells and forming a thin sheath around vessels. Parenchyma both paratracheal and apotracheal; paratracheal scanty to vasicentric forming a thin sheath around vessels; apotracheal diffuse and in the form of short broken tangential bands enclosing gum canals; cells 36-60 μm in width and 60-120 μm in length. Xylem rays 1-9 seriate, 3-5 per mm; ray tissue heterogeneous, uniseriate rays rare, made up of upright cells, 25-55 μm in width and 3-7 cells or 135-440 μm in height; multiseriate rays made up of procumbent cells in the central portion with a few upright cells at the margins, 70-154 μm in width and 6-51 cells or 330- 2035 μm in height; sheath cells occasionally observed in some of the rays; procumbent cells 75-105 μm in radial length and 18-30 μm in tangential height; upright cells about 30 μm in radial length and 30-45 μm in tangential height. Fibres moderately thick walled, polygonal in cross section, nonseptate, 15-18 μm in width. Gum canals normal, vertical, scattered, singly or in groups of 2-3, usually smaller than vessels, 75-180 μm in diameter, enclosed in parenchyma bands and circular in shape.

Figured Specimen—Specimen No. BSIP 39283.

Occurrence—Manughat near Manu Bazar, South Tripura District, Tripura; Tipam Group; Late Miocene.

Affinities—The important features of the fossil, viz., diffuse porous wood, presence of vertical gum canals, vasicentric tracheids, almost exclusively solitary vessels, non septate fibres and broad xylem rays with heterogeneous ray tissue strongly indicate its affinity with Dipterocarpaceae (Ilic, 1991; Kribs, 1959; Metcalfe & Chalk, 1950; Miles, 1978; Pearson & Brown, 1932). The family can be divided into two groups (Ghosh, 1958) on the basis of the arrangement of gum canals: (i) gum canals always in concentric rings (e.g., *Shorea*, *Doona*, *Hopea*, *Parashorea*, *Pentacme*, *Balanocarpus* and *Dryobalanops*) and (ii) gum canals diffuse, solitary and in short tangential rows (e.g., *Anisoptera*, *Dipterocarpus*, *Vatica*, *Vateria* and *Cotylelobium*). As gum ducts in the present fossil wood are of diffuse type, it can be compared with the genera of second group. Ghosh (1958) has further given a key to distinguish these genera. According to this key our fossil shows maximum resemblance with *Dipterocarpus* Gaertner.

The fossil woods resembling *Dipterocarpus* are generally described under the genus *Dipterocarpoxylon* Holden emend. Den Berger (1927). A number of fossil species belonging to the genus are known and listed by Prakash (1973) and Awasthi (1974, 1980). Since then many species have been described from several Neogene localities of India

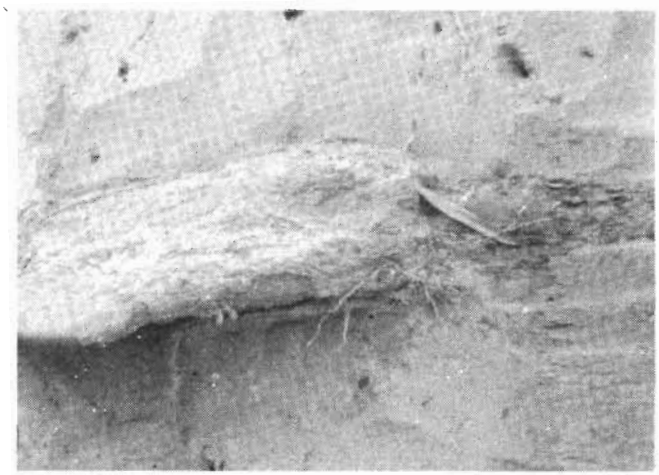

Fig. 2—Mandoli Dak fossil locality showing *in situ* fossil wood in the sandstone.

(Awasthi & Mehrotra, 1993, 1997; Bera & Banerjee, 2001; Guleria, 1983, 1996; Guleria *et al.*, 2001; Mehrotra & Bhattacharyya, 2002; Prakash, 1981; Prakash *et al.*, 1994; Srivastava, 2001; Tiwari & Mehrotra, 2000; Trivedi & Ahuja, 1980; Yadav, 1989). Besides, two fossil woods have been assigned to the natural genus *Dipterocarpus* (Antal *et al.*, 1999; Prasad & Khare, 1994). After a detailed comparison with the recorded species, our fossil shows near resemblance with *D. tertiarum* Prakash (1965) and *D. nalagarhense* (Prakash, 1975) especially in having broader rays (up to 9 seriate). However, the latter slightly differs in having smaller vessels (up to 360 μm in diameter). As the present fossil is almost identical with the former species, it has been assigned to *D. tertiarum*. Further, *Dipterocarpoxylon bolpurense* Ghosh and Roy (1979) from the Champanagar Formation of Tripura (Mehrotra & Bhattacharyya, 2002) differs in having narrower (1-4 seriate) as well as shorter (up to 20 cells high) xylem rays and smaller vessels (up to 330 μm in diameter).

The genus *Dipterocarpus* Gaertner (Hindi name *Gurjun*) consists of about 69 species confined mainly to the Indo-Malayan region (Mabberley, 1997). In India it is represented by 13 species found in Assam, the Andamans and the Western Ghats (Ghosh, 1958; Santapau & Henry, 1973). All of them are large to very large trees found in the tropical evergreen forests of the country.

Family—ANACARDIACEAE

Genus—GLUTOXYLON Chowdhury, 1934

Glutoxylon burmense (Holden) Chowdhury, 1952

(Pl. 1.5-6, 2.1-2)

Material—The study is based on three silicified woods measuring maximum 12 cm in length and 9 cm in width.

Description—Wood diffuse porous. Growth rings present delimited by bands of parenchyma. Vessels mostly medium to large, t.d. 75-315 μm, r.d. 60-270 μm, solitary and in radial multiples of 2-6 (mostly 2-3), circular to oval when solitary, with flat contact walls when in multiples, evenly distributed, 3-10 per sq. mm, profusely tylosed; vessel members 495-990 μm long with truncate ends; perforations simple; intervessel pits not preserved due to heavy tyloses. Parenchyma distinctly apotracheal banded, bands 1-2 celled thick, broken to continuous, 1-4 bands per mm (Pl. 2.2), distance between two bands variable, sometimes bands distantly placed (2.5 mm apart) and terminal (Pl. 2.1); paratracheal parenchyma not clearly observed; cells 17-22 μm in width and 27-66 μm in length. Xylem rays 11-14 per mm; divisible into two types- simple and fusiform; simple rays uniseriate, made up of procumbent cells; fusiform rays made up of procumbent cells in the central portion with 1-2 upright cells at the margins and having solitary gum ducts in the centre, 22-99 μm in width and 3-20 cells or 140- 660 μm in height; ray tissue heterogeneous, ray cells sometimes crystalliferous, procumbent cells 30-54 μm in radial length and 15-30 μm in tangential height; upright cells about 20-40 μm in radial length and 45-175 μm in tangential height. Fibres aligned in radial rows, semilibriform, polygonal in cross section, nonseptate, 11-22 μm in diameter and 440-660 μm in length.

PLATE 1 →

Dipterocarpoxylon tertiarum Prakash, 1965

1. Cross section showing shape, size and distribution of vessels and gum canals. x 40; Slide No. BSIP 39283-I.
2. Tangential longitudinal section showing structure of the xylem rays. x 40; Slide No. BSIP 39283-II.
3. Radial longitudinal section showing nature of the ray tissue. x 100; Slide No. BSIP 39283-III.
4. Tangential longitudinal section magnified to show the presence of vasicentric tracheids. x 400; Slide No. BSIP 39283-II.

Glutoxylon burmense (Holden) Chowdhury, 1952

5. Tangential longitudinal section showing predominantly uniseriate xylem rays. x 40; Slide No. BSIP 39284-II.
6. Tangential longitudinal section magnified to show the occurrence of fusiform rays having radial gum canals. x 100; Slide No. BSIP 39284-II.

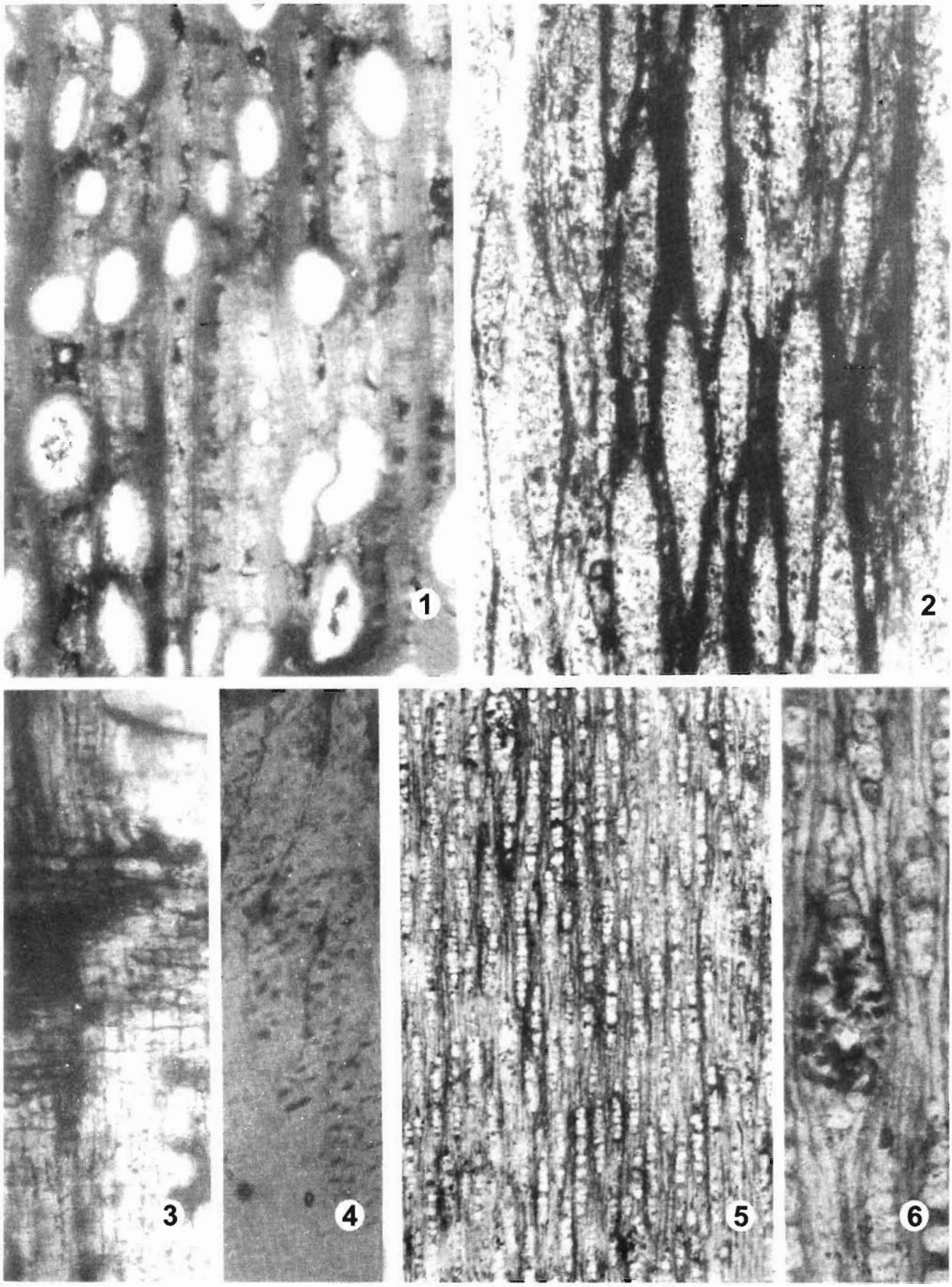

PLATE 1

Figured Specimens—Specimen Nos. BSIP 39284-86.

Occurrence—Mandoli Dak near Manu Bazar, South Tripura District, Tripura; Tipam Group; Late Miocene.

Affinities—The diagnostic characters of the fossil, viz., diffuse porous wood, large profusely tylosed vessels, simple perforation plates, thin broken to continuous apotracheal parenchyma bands, simple uniseriate xylem rays with occasional presence of fusiform rays having gum canals and non septate fibres strongly indicate its affinities with extant genus *Gluta* Linnaeus of Anacardiaceae (Ilic, 1991; Kribs, 1959; Metcalfe & Chalk, 1950; Miles, 1978; Pearson & Brown, 1932).

Chowdhury (1934) instituted the genus *Glutoxylon* (Guleria, 1984; Prakash & Tripathi, 1969) for the fossil woods resembling *Gluta*. So far five species of the genus, namely *Glutoxylon burmense* (Holden) Chowdhury (1952), *G. cuddalorense* Awasthi (1966), *G. cacharense* (Prakash & Tripathi) Guleria (1984), *G. garbetaense* (Ghosh & Roy) Guleria (1984) and *G. symphonoides* Lemoigne (1978) are known from various Tertiary localities of the world. As our fossil is identical to *G. burmense* (Holden) Chowdhury, it has been placed under the same species. This species was widely distributed in India and Southeast Asia during the late Tertiary (Awasthi, 1992; Awasthi & Mehrotra, 1997; Dutta Choudhury *et al.*, 1997; Guleria, 1984, 1992; Kar *et al.*, 2004; Mehrotra *et al.*, 1999; Poole & Davies, 2001).

The genus *Gluta* consists of about 30 species confined to tropical evergreen to coastal forests of India, Madagascar, Myanmar, Thailand, Indo-China and throughout Malaysia (Ghosh & Purkayastha, 1963; Hou, 1978).

Family—FABACEAE

Genus—BAUHINIA Linnaeus

Bauhinia deomalica Awasthi & Prakash, 1987

(Pl. 2.3-5)

Material—The study is based on a well preserved piece of petrified wood measuring 9 cm in length and 4 cm in width.

Description—Wood diffuse porous. Growth rings observed at one spot only. Vessels small to large, t.d. 36-300 µm, r.d. 90-330 µm, solitary as well as in radial multiples of 2-3 or rarely 4, mostly oval in shape when solitary, with flat contact walls when in multiples, evenly distributed, 3-6 per sq. mm, tyloses observed in some of the vessels; vessel members up to 360 µm long with oblique to horizontal ends, storeying tendency not clearly visible; perforations simple; intervessel pits bordered, alternate, 8-10 µm in diameter, circular to oval in shape with lenticular apertures. Parenchyma aliform, confluent and confluent banded, bands generally 4-6 celled thick; cells 27-55 µm in width and 22-44 µm in length. Xylem rays almost exclusively uniseriate, 12-17 per mm, made up of procumbent cells only, rarely with square or upright cells at the ends, storied tendency seen at places; ray tissue weakly heterogeneous, rays 15-55 µm in width and 3-16 cells or 80-550 µm in

PLATE 2 →

Glutoxylon burmense (Holden) Chowdhury, 1952

1. Cross section showing shape, size and distribution of vessels and a single terminal parenchyma band. x 40; Slide No. BSIP 39285-I.
2. Cross section of another specimen showing many parenchyma bands. x 40; Slide No. BSIP 39284-I.

Bauhinia deomalica Awasthi & Prakash, 1987

3. Cross section showing shape, size and distribution of vessels and aliform to confluent parenchyma bands. x 40; Slide No. BSIP 39287-I.
4. Tangential longitudinal section in low power showing the distribution and structure of uniseriate xylem rays. x 40; Slide No. BSIP 39287-II.
5. Tangential longitudinal section in high power showing the storied tendency of uniseriate xylem rays. x 100; Slide No. BSIP 39287-II.

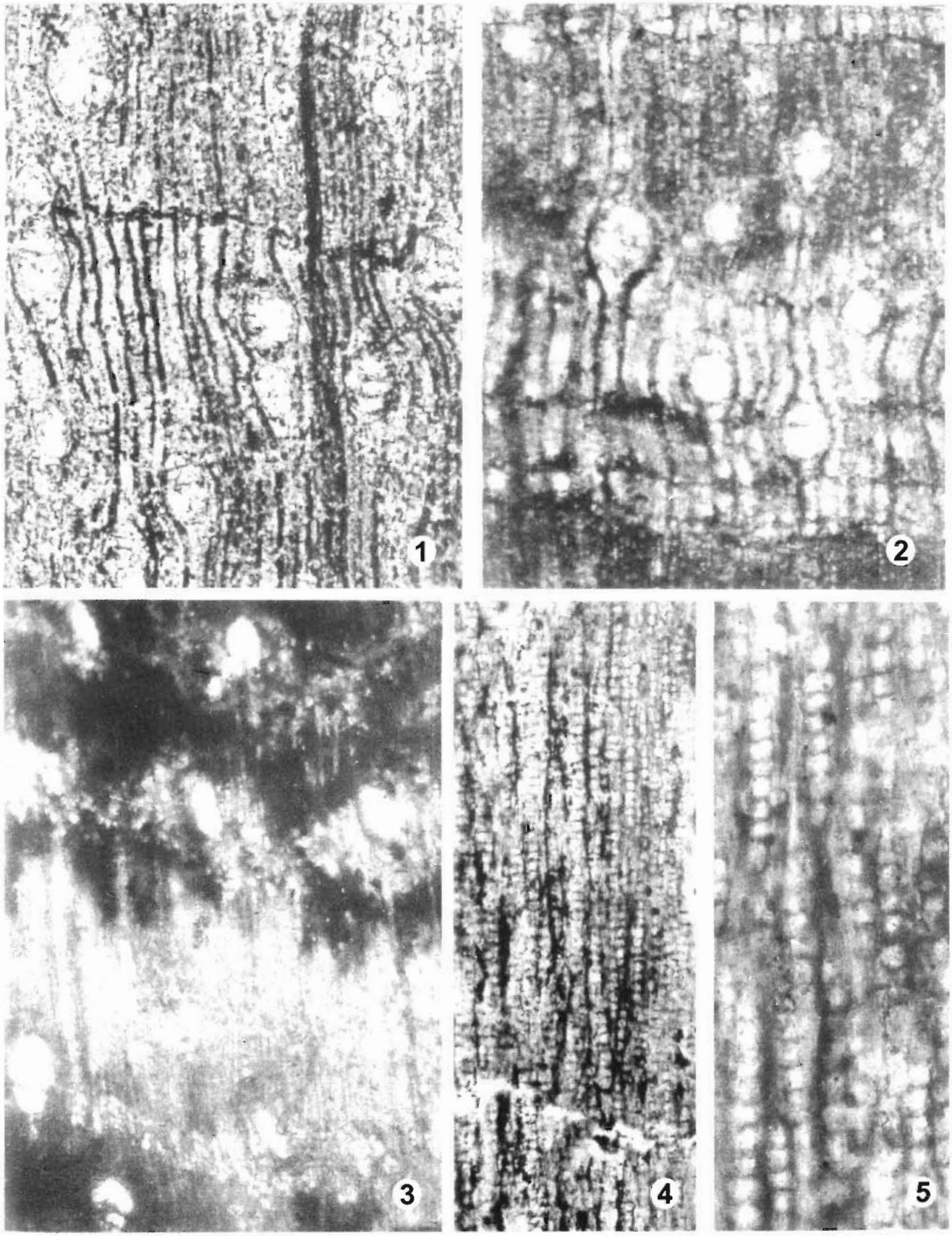

PLATE 2

height; ray cells 30-60 μm in radial length and 30-45 μm in tangential height. Fibres aligned in radial rows, semilibriform, polygonal in cross section, non septate, 11-22 μm in diameter and more than 100 μm in length, storied at places.

Figured Specimen—Specimen No. BSIP 39287.

Occurrence—Udaipur, South Tripura District, Tripura; Tipam Group; Late Miocene.

Affinities—The diagnostic features of the fossil, viz., diffuse porous wood, tylosed vessels, simple perforation plates, aliform to confluent banded parenchyma, almost exclusively uniseriate xylem rays with storied arrangement and non septate fibres indicate its affinities with *Bauhinia* Linnaeus of Fabaceae (Ilic, 1991; Kribs, 1959; Metcalfe & Chalk, 1950; Miles, 1978; Pearson & Brown, 1932). According to Ramesh Rao *et al.* (1972) about six Indian species of *Bauhinia,* namely *B. foveolata* Dalzell, *B. malabarica* Roxburgh, *B. purpurea* Linnaeus, *B. racemosa* Lamarck , *B. retusa* Hamann and *B. variegata* Lamarck attain tree size and all are anatomically similar except *Bauhinia purpurea* and *B. variegata* where ripple marks are absent.

Trivedi and Panjwani (1986) instituted the genus *Bauhinium* to include the fossil woods showing resemblance with extant *Bauhinia.* However, Awasthi and Prakash (1987) directly placed their fossil wood into the modern genus *Bauhinia.* So far there are many reports of this wood from India, viz., *Bauhinium miocenicum* Trivedi & Panjwani (1986), *B. palaeomalabaricum* Prakash & Prasad (1984), *Bauhinia deomalica* Awasthi & Prakash (1987) and *B. tertiara* Awasthi & Mehrotra (1990). Of these our fossil is more or less identical to *B. deomalica* Awasthi & Prakash (1987) and therefore, has been placed under the same taxon. *Bauhinium miocenicum* and *Bauhinia tertiara* differ from our fossil in having slightly broader rays (1-2 seriate), while *Bauhinium palaeomalabaricum* differs in having broader (3-9 celled thick) parenchyma bands.

Bauhinia is a large genus comprising about 300 species distributed throughout the tropics of the world. However, about 30 species grow in India of which only six attain tree size. The genus occurs as trees, shrubs, vines and gigantic lianas which are widely distributed in deciduous forests in all the states of India (Ramesh Rao *et al.*, 1972).

DISCUSSION

Fossil woods are very reliable indicator of the past climate especially when they are comparable to the modern taxa. The modern comparable genera of the present fossil assemblage of Tripura are *Dipterocarpus, Gluta, Bauhinia, Afzelia-Intsia, Cassia, Millettia* and *Cynometra.* The distribution pattern of these taxa collectively indicates that tropical wet evergreen to semievergreen forests (Champion & Seth, 1968) existed in the South Tripura District during the Late Miocene, denoting the prevalence of warm and humid climate. The flora must have experienced a heavy rainfall throughout the year.

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