The Palaeobotanist 62(2013): 65–70
0031–0174/2013

A fossil wood of *Gluta* L. (Anacardiaceae) from the Early Eocene sediments of Gujarat, western India

ANUMEHA SHUKLA*, R.C. MEHROTRA AND J.S. GULERIA

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.
**Corresponding author: anu_bsip@yahoo.co.in*

(Received 30 March, 2012; revised version accepted 7 November, 2012)

ABSTRACT

Shukla A, Mehrotra RC & Guleria JS 2013. A fossil wood of *Gluta* L. (Anacardiaceae) from the Early Eocene sediments of Gujarat, western India. The Palaeobotanist 62(1): 65–70.

A fossil wood showing resemblance with the modern genus *Gluta* L. is described from the Rajpardi Lignite Mine of Bharuch District, Gujarat. The age of this mine has been considered as Early Eocene. The modern comparable species of the fossil, *Gluta travancorica* Bedd., is an evergreen element and presently growing in wet evergreen forests of Western Ghats, India. An account of the present distribution of its modern analogue, along with previously described fossils from the same locality indicates the existence of humid conditions and evergreen forest in and around the fossil locality during the Eocene as compared to arid to semi–arid climate in the area today.

Key–words—*Gluta travancorica* Bedd., Evergreen forests, Rajpardi Lignite Mine, Palaeoclimate.

पश्चिम भारत में गुजरात के प्रारंभिक आदिनूतन अवसादों से प्राप्त *ग्लुटा* एल. (एनाकार्डिएसी) की जीवाश्म काष्ठ

अनुमेहा शुक्ला, आर.सी. मेहरोत्रा एवं जे.एस. गुलेरिया

सारांश

गुजरात में जिला भरूच के राजपर्दी भूराकोयला खान से प्राप्त आधुनिक वंश *ग्लुटा* एल. से सदृश्ता दर्शाती हुई एक जीवाश्म काष्ठ वर्णित की गई है। इस खान की आयु प्रारंभिक आदिनूतन के रूप में मानी गई है। जीवाश्म की आधुनिक तुलनीय जाति, *ग्लुटा ट्रावनकोरिका* बेड. एक सदाहरित तत्व है तथा वर्तमान में भारत, पश्चिमी घाटों के आर्द्र सदाहरित वनों में उग रहा है। उसी उपबस्ती से प्राप्त पहले वर्णित जीवाश्मों सहित इसके सदृशरूप के मौजूदा वितरण का विवरण क्षेत्र में आज शुष्क से अर्ध शुष्क जलवायु की तुलना में आदिनूतन के दौरान जीवाश्म उपबस्ती में व चहुंओर आर्द्र स्थितियां व सदाहरित वन की विद्यमानता इंगित करता है।

संकेत-शब्द—*ग्लुटा ट्रावनकोरिका* बेड., सदाहरित वन, राजपर्दी भूराकोयला खान, पुराजलवायु।

INTRODUCTION

The Rajpardi Lignite Mine is situated about 35 km south-east of Bharuch on Ankleshwar–Rajpipla Road towards south of the Rajpardi Village, Bharuch District, between Lat. 21°43'–21°40' and Long. 73°13'–73°15' (Fig. 1) and covers an area of about 3.5 sq km. The detailed geology of the area has been discussed by many workers (Chandra & Chowdhary, 1969; Kathiara, 1969; Kathiara & Bhatt, 1969; Sudhakar & Basu, 1973; Agarwal, 1986; Kumar, 1996) and on the basis of palynological assemblage the age of this mine is considered as Early Eocene (Koshal & Uniyal, 1986; Bhattacharya, 1987; Phadtare & Thakur, 1990; Guleria, 1991; Kar & Bhattacharya, 1992; Kumar, 1996). The lignite of the mine belongs to the Cambay Shale Formation of the Cambay Basin, south Gujarat (Agarwal, 1986) (Fig. 2). A meagre work has been done on the plant megafossils of this mine (Guleria, 1991, 1994) as only two taxa, namely *Sonneratia* L.f. and *Terminalia* L. of the families Sonneratiaceae and Combretaceae, respectively are known. The present work is very significant as it not only reports a typical wet evergreen element to reconstruct the palaeoclimate at the time of deposition of this huge lignite but also is the oldest record of the genus *Gluta* L.

MATERIAL AND METHODS

The present fossil material was collected from lignite bands and lenses alternating with carbonaceous clay. The fossil woods were highly carbonized and brown in colour. After studying a large number of fossil woods a single specimen was found satisfactorily preserved. To study the xylotomical characters this fossil was cut into thin sections, viz. transverse, tangential and radial longitudinal and its slides were prepared by the usual method of cutting, grinding and polishing. The thin sections were examined under the high power light microscope. The identification of the fossil was made after its comparison with a large number of modern woods, both from thin sections and published literature. The anatomical terms used in describing it are those adopted by Wheeler *et al.* (1986) and International Association of Wood Anatomists (1989). The figured slides are housed in the museum of the Birbal Sahni Institute of Palaeobotany, Lucknow.

SYSTEMATICS

Family—ANACARDIACEAE

Genus—GLUTOXYLON (Chowdhury) Prakash & Tripathi, 1976

Glutoxylon burmense (Holden) Chowdhury, 1952

(Pl. 1.1–6)

Description—Wood diffuse porous. Growth rings present. Vessels mostly medium to large, sometimes small, t.d. 88–225 µm and r.d. 120–267 µm, solitary to radial multiples of 2–3, rarely 4 (Pl. 1.2–3), round to oval in shape, with flattened walls when in radial multiples, 3–8 per sq mm, profusely tylosed (Pl. 1.2); vessel elements 282–678 µm in length; perforations simple; intervessel pits alternate. Axial parenchyma paratracheal and apotracheal; paratracheal parenchyma scanty, few cells attached with vessels (Pl. 1.2–3), apotracheal parenchyma in the form of tangential bands at irregular intervals, bands 1–3 cells in thickness (Pl. 1.1–2) and 1–4 per mm; cells thin walled, 25–60 µm in length and 15–20 µm in width. Rays two types, simple and fusiform, about 83–484 µm in height and 11–37 µm in width; ray tissue heterogeneous; simple rays 1–2 (mostly 1) seriate (Pl. 1.4), homocellular (Pl. 1.6), consisting of procumbent cells only,

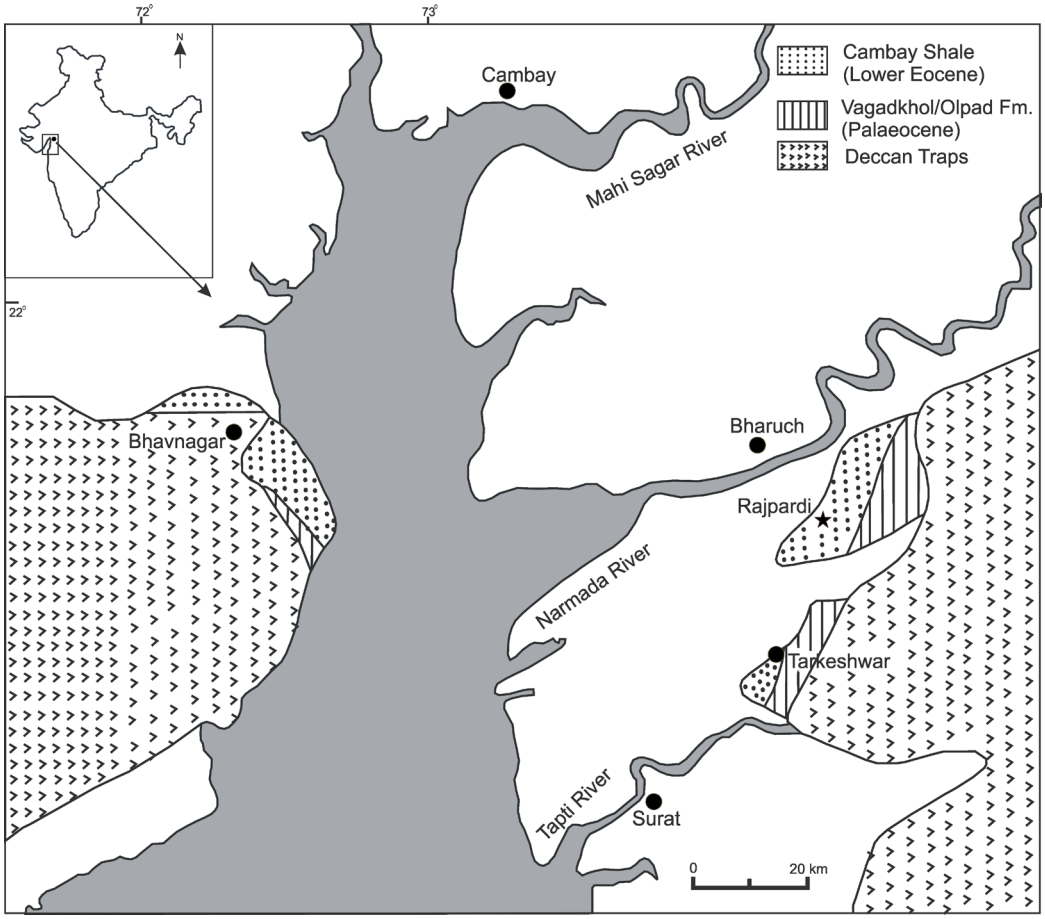

Fig. 1—Geological map showing Rajpardi Lignite Mine (marked by star).

Age	Formations (Sub–surface)	Lithology
Pleistocene	Jambusar	Sandstone, silt, clays and gravels
Pliocene	Broach (300 m)	Sandstone, gritstone, conglomerate, breccias, clays, silt
	Jhagadia (200 m)	
Miocene	Kand (400 m)	Conglomerate, fossil, limestone, calcareous sandstone and gravelly clay
	Babaguru (300 m)	Conglomerate, sandstone, clays–cherry red and highly ferruginous
Oligocene	Tarkeshwar (175 m)	Grey, yellow and brown friable sandstone with lenses of bentonitic clays
Eocene	U Ankleshwar/Dinod (500 m)	Fossiliferous limestone and marl
	L Cambay Shale (430 m)	Dark grey to black carbonaceous and pyritic shales, lignite
Palaeocene	Vagadkhol (520 m)	Conglomerate, grit, sandstone, variegated clays and siltstone
Cretaceous	Deccan Trap	Basalt, trachyte, etc.

Fig. 2—A generalized stratigraphic table of the Cambay Basin (Agarwal, 1986).

fusiform rays 3–4 seriate with horizontal gum canal in the centre (Pl. 1.5), made up of procumbent cells in the middle portion and 1–2 marginal rows of upright cells at the one or both the ends. Fibres rectangular to polygonal in shape as seen in the cross section, non septate, moderately thin walled, 570–879 µm in length and 15–23 µm in width.

Figured specimen—Specimen No. BSIP 39994.

Horizon & Locality—Cambay Shale Formation; Rajpardi Lignite Mine, Bharuch District, Gujarat.

Age—Early Eocene.

Affinities—The characteristic anatomical features of the fossil wood are: diffuse porous wood, simple perforation plates, apotracheal parenchyma bands at irregular intervals, fusiform rays with gum canal, heterogeneous ray tissue and non septate fibres. All these features of the fossil show its close resemblance with the modern woods of the family Anacardiaceae, in particular with *Gluta* Linn. (=*Melanorrhoea* Wall.). Earlier *Gluta* and *Melanorrhoea* were considered as two separate genera but now these are considered as a single genus (Hou, 1978). Wood anatomy also supports this view as woods of these genera show similar or overlapping characters. For further identification the fossil was compared with the thin sections of various species of *Gluta* and found close to *G. travancorica* Bedd. (Wood Slide No. BSIP 643) (Pearson & Brown, 1932; Metcalfe & Chalk, 1950; Miles, 1978; Ilic, 1991).

Chowdhury (1934, 1936) instituted the genus *Glutoxylon* for the fossil woods resembling both *Gluta* and *Melanorrhoea* and described a fossil wood as *Glutoxylon assamicum* from the Tertiary of Assam. Later on, he merged *G. assamicum* to *G. burmense* (Holden) Chowdhury, along with many other genera and species (Chowdhury, 1952). Prakash and Tripathi (1969) emended the diagnosis of *Glutoxylon* while reporting *G. burmense* from Hailakandi, Assam. They observed that the two genera, i.e. *Gluta* and *Melanorrhoea* can be placed into two groups on the basis of differentiation in their parenchyma bands and created a new genus *Melanorrhoeoxylon* Prakash & Tripathi to accommodate fossil woods resembling *Melanorrhoea* (Prakash & Tripathi, 1976). However, Hou (1978) merged *Melanorrhoea* into *Gluta* in his work on the family Anacardiaceae. As the two genera are taxonomically and anatomically very similar, *Gluta* has the priority over *Melanorrhoea*. Therefore, the organ genus *Melanorrhoeoxylon* Prakash & Tripathi (1976) became synonym to the earlier known genus *Glutoxylon* (Chowdhury) Prakash & Tripathi (1969). Consequently, the two known species of *Melanorrhoeoxylon*, *M. cacharense* Prakash & Tripathi (1976) and *M. garbetanse* Roy & Ghosh (1981) were renamed as *Glutoxylon cacharense* (Prakash & Tripathi) and *G. garbetanse* (Roy & Ghosh) by Guleria (1984). So far six species of *Glutoxylon* namely, *G. burmense* (Holden) Chowdhury (1952), *G. cuddalorense* Awasthi (1966), *G. symphonoides* Lemoigne (1978), *G. kalagarhense* Trivedi & Ahuja (1978), *G. cacharense* (Prakash & Tripathi) Guleria and *G. garbetanse* (Roy & Ghosh) Guleria (1984) are known from various Tertiary exposures of India. The present fossil was compared with all these species and found very similar to *G. burmense* (Holden) Chowdhury (1952) and hence, it is placed under the same specific epithet. This fossil species is widely distributed in India and Southeast Asia during the Neogene (Guleria, 1984, 1992; Awasthi & Mehrotra, 1997; Mehrotra *et al*., 1999; Kar *et al*., 2004).

DISCUSSION

Gluta Linn. consists of about 30 species of trees, rarely shrubs, often reaching up to a height of 30–55 m (Chowdhury, 1952). *Gluta travancorica*, the modern analogue of the fossil, is a large tree, mainly distributed in the wet evergreen forests of Western Ghats, south India (Ghosh & Purkayastha, 1963). In addition to this, two more genera, i.e. *Terminalia* and *Sonneratia* were described from the same locality (Guleria, 1991, 1994). Following the concept of NLR (Nearest Living Relative), which believes that the climatic requirement of a fossil must be the same as of its modern counterpart (Bamford, 2011; Mehrotra *et al*., 2011), a tropical environment with evergreen forests could be interpreted at the time of deposition of the sediments. As the area today is arid to semi–arid, the climatic condition at the time of deposition was much better for the growth of evergreen elements like *Gluta*. Further, the recovered microfossil remains from the area also support the above view (Bhattacharya, 1987; Kar & Bhattacharya, 1992; Kumar, 1996). Moreover, the presence of *Sonneratia* indicates the occurrence of sea in nearby areas (Lakhanpal, 1970; Guleria, 1991, 1994). This drastic change in the climate of Gujarat might be due to the northward movement of the Indian Plate and uplifting of the Himalayas.

Acknowledgement*—The authors are thankful to the Director, Birbal Sahni Institute of Palaeobotany, Lucknow for constant encouragement, infrastructure facilities and permission to publish this work.*

REFERENCES

Agrawal GC 1986. Structure and tectonics of exposed Tertiary rocks between Narmada and Kim rivers in south Gujarat. Journal of Geological Society of India 27: 531–542.

Awasthi N 1966. Fossil woods of Anacardiaceae from the Tertiary of south India. Palaeobotanist 14: 131–143.

Awasthi N & Mehrotra RC 1997. Some fossil dicotyledonous woods from the Neogene of Arunachal Pradesh, India. Palaeontographica 245 B: 109–121.

Bamford MK 2011. Late Pliocene woody vegetation of Area 41, Koobi Fora, East Turkana Basin, Kenya. Review of Palaeobotany & Palynology 164: 191–210.

Bhattacharya M 1987. Fungal remains from the Rajpardi Lignite, Broach District, Gujarat. Geophytology 17: 120.

Chandra PK & Chowdhary LR 1969. Stratigraphy of the Cambay Basin. Bulletin of Oil & Natural Gas Commission 6: 37–50.

Chowdhury KA 1934. A fossil dicotyledonous wood from Assam. Current Science 3: 255–256.

Chowdhury KA 1936. A fossil dicotyledonous wood from Assam. Annals of Botany London 50: 501–510.

Chowdhury KA 1952. Some more fossil woods of *Glutoxylon* from South–east Asia. Annals of Botany London New Series 16: 373–378.

Ghosh SS & Purkayastha SK 1963. Family Anacardiaceae. *In:* Ghosh SS *et al.* (Editors)—Indian Woods 2: 264–323. Manager of Publications, Delhi.

Guleria JS 1984. Occurrence of anacardiaceous woods in the Tertiary of western India. Palaeobotanist 32: 35–43.

Guleria JS 1991. On the occurrence of carbonized woods resembling *Terminalia* and *Sonneratia* in Palaeogene deposits of Gujarat, western India. Palaeobotanist 39: 1–8.

Guleria JS 1992. Neogene vegetation of peninsular India. Palaeobotanist 40: 285–311.

Guleria JS 1994. Fossil leaf of *Terminalia* from the Rajpardi Lignite mine, district Bharuch, Gujarat, India. Geophytology 24: 55–58.

Hou D 1978. Florae Malesianae praecursores LVI. Anacardiaceae. Blumea 24: 1–41.

Ilic J 1991. CSIRO Atlas of Hardwoods. Springer, Berlin.

International Association of Wood Anatomists 1989. IAWA list of microscopic features for hardwood identification. International Association of Wood Anatomists Bulletin New Series 10: 219–332.

Kar RK, Ambwani A, Agarwal A & Saha SK 2004. Remarks on *Glutoxylon burmense* (Holden) Chowdhury from Lal Mai hills, Comilla District, Bangladesh. Palaeobotanist 53: 137–141.

Kar RK & Bhattacharya M 1992. Palynology of Rajpardi Lignite, Cambay Basin, Gujra Dam and Akli Lignite, Kutch Basin. Palaeobotanist 39: 250–263.

Kathiara RS 1969. Lignite deposit in Bhuri area, Broach District, Gujarat. Mineral Wealth 4: 1–5.

Kathiara RS & Bhatt BK 1969. Sedimentology of Bhuri Lignite area, Broach District, Gujarat. Mineral Wealth 4: 12–16.

Koshal VN & Uniyal SN 1986. Palynostratigraphy of the Cenozoic succession of Cambay Basin, Gujarat. Bulletin of Geological Mining & Metallargical Society of India 54: 208–226.

Kumar M 1996. Palynostratigraphy and palaeoecology of Early Eocene palynoflora of Rajpardi Lignite, Bharuch District, Gujarat. Palaeobotanist 43: 110–121.

Lakhanpal RN 1970. Tertiary flora of India and their bearing on the historical geology of the region. Taxon 19: 675–694.

Lemoigne Y 1978. Flores tertiaires de la haute vallée de l' Omo (Ethiopie). Palaeontographica 165 B: 89–157.

Mehrotra RC, Awasthi N & Dutta SK 1999. Study on fossil wood from the upper Tertiary sediments (Siwalik) of Arunachal Pradesh, India and its implication in palaeoecological and phytogeographical interpretations. Review of Palaeobotany & Palynology 107: 223–247.

Mehrotra RC, Bera SK, Basumatary SK & Srivastava G 2011. Study of fossil wood from the Middle–Late Miocene sediments of Dhemaji and Lakhimpur districts of Assam, India and its palaeoecological and palaeophytogeographical implications. Journal of Earth System Science 120: 681–701.

Metcalfe CR & Chalk L 1950. Anatomy of the dicotyledons. 1 & 2. Clarendon Press, Oxford.

Miles A 1978. Photomicrographs of world woods. Department of the Environment Building Research Establishment, London.

Pearson RS & Brown HP 1932. Commercial timbers of India. 1 & 2. Government of India, Central Publication Branch, Calcutta.

PLATE 1

Glutoxylon burmense (Holden) Chowdhury, 1952

1–2. Transverse sections of the fossil showing vessel distribution and parenchyma bands (TV= Tylosed Vessels).

3. Enlarged transverse section of the fossil showing shape, size and distribution of vessels.

4. Tangential longitudinal section of the fossil showing uniseriate rays (marked by arrows).

5. Tangential longitudinal section of the fossil showing multiseriate rays with gum canal in the centre (marked by arrows).

6. Radial longitudinal section of the fossil showing weakly heterogeneous ray tissue.

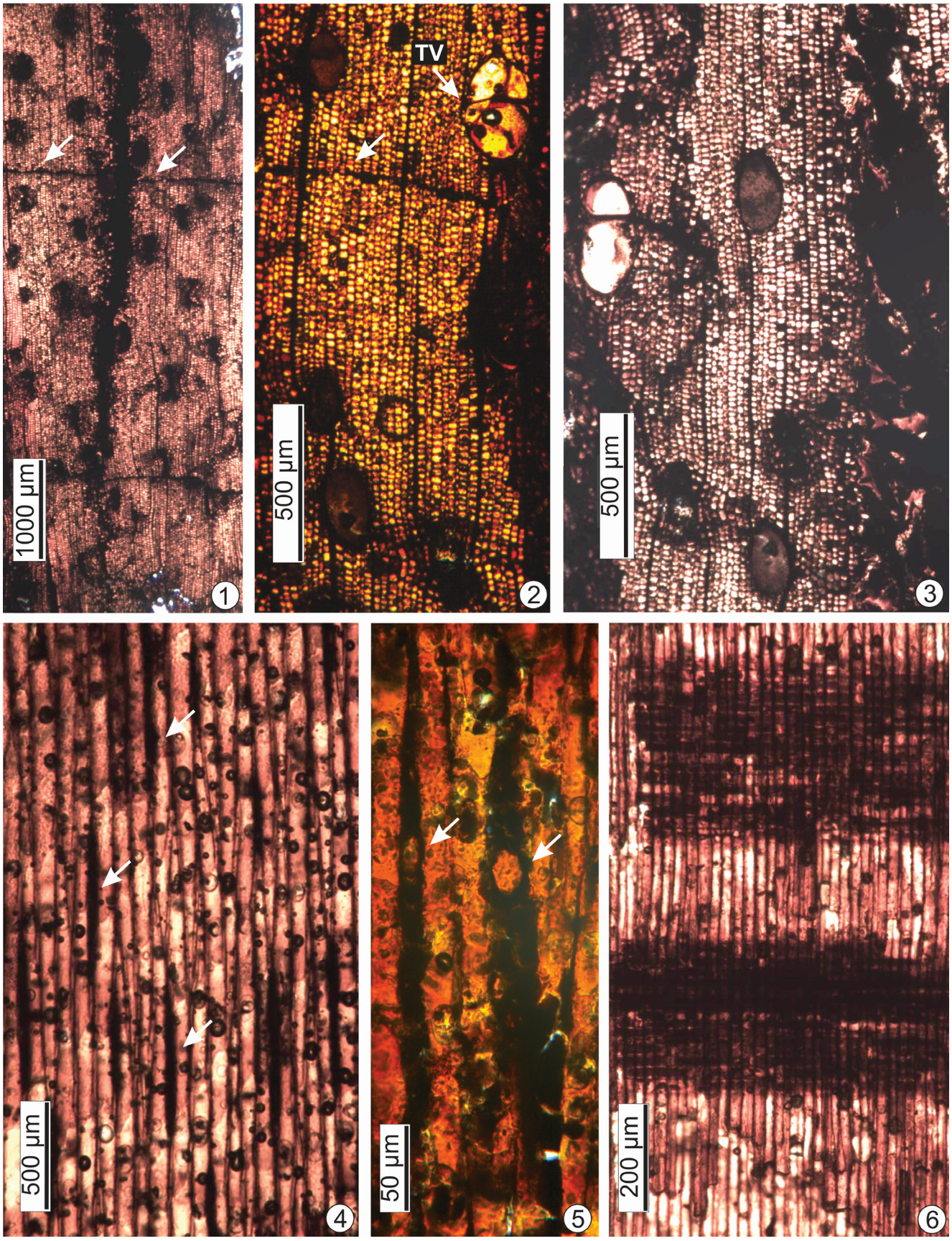

PLATE 1

Phadtare NR & Thakur B 1990. Fossil pollen of *Alangium* from the Eocene lignite of Gujarat, India with comments on its stratigraphic antiquity. Review of Palaeobotany & Palynology 63: 281–297.

Prakash U & Tripathi PP 1969. On *Glutoxylon burmense* from Hailakandi in Assam with critical remarks on the fossil woods of *Glutoxylon* Chowdhury. Palaeobotanist 17: 59–64.

Prakash U & Tripathi PP 1976. Fossil dicot woods from the Tertiary of Assam. Palaeobotanist 23: 82–88.

Roy SK & Ghosh PK 1981. Fossil woods of Anacardiaceae from the Tertiary of West Bengal, India. Palaeobotanist 28–29: 338–352.

Sudhakar R & Basu DN 1973. A reappraisal of the Palaeocene stratigraphy of the southern Cambay Basin. Bulletin of Oil & Natural Gas Commission 10: 55–76.

Trivedi BS & Ahuja M 1978. *Glutoxylon kalagarhense* sp. nov. from Kalagarh. Current Science 47: 135.

Wheeler EA, Pearson RG, La Pasha CA, Zack T & Hatley W 1986. Computer–aided wood identification: References manual. North Carolina Agricultural Research Service Bulletin 474: 1–96.