

# A *Teredolites* infested fossil wood from the Lower Eocene sediments of the Vastan Lignite Mine of Gujarat, western India

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## ABSTRACT

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The Vastan Lignite Mine, situated about 30 km northeast of Surat in Gujarat, preserves a fairly continuous record of near shore lignites interbedded with lagoonal and open marine sediments bearing foraminifera and molluscs. This paper reports a teredo-infested fossil dicotyledonous wood belonging to Family Meliaceae from the carbonaceous shale sequence near the top of the Lower Eocene section. The wood is well preserved and shows resemblance with the extant woods of the genus *Aglaia* Lour. The presence of wood suggests a fluvial transport from its natural habitat of an inland moist tropical forest to a nearby coastal region. The profuse infestation of the wood by teredos further indicates considerable exposure before burial probably in a near shore lagoon or tidal flat area where it was bored by *Teredolites*.

**Key-words**—Fossil wood, *Aglaia*, Meliaceae, *Teredolites* (Ichnofossil), Eocene, Gujarat.

पश्चिमी भारत में गुजरात की वास्तन लिग्नाइट खदान के निम्न ईओसीन अवसादों से प्राप्त  
*टेरेडोलाइटीज* - ग्रसित अशिमत काष्ठ

जे.एस. गुलेरिया, अशोक साहनी, अनुमेहा शुक्ला एवं हुकम सिंह

## सारांश

गुजरात में सूरत के 30 किमी. पूर्वोत्तर में स्थित वास्तन लिग्नाइट खदान फोरैमिनिफेरा एवं मोलस्क धारी अनूपीय व खुले समुद्री अवसादों से अंतरास्तरित तट समीप लिग्नाइटों के सतत् अभिलेख बनाए रखती है। इस शोध-पत्र में निम्न ईओसीन अनुभाग के उपरीय कार्बनमय शेल अनुक्रम से प्राप्त टेरेडो (जंतु वंश) से ग्रसित मिलिएसी कुल के द्विबीजपत्री अशिमत काष्ठ का वर्णन किया गया है। यह काष्ठ सुपरिंक्षित है तथा *एग्लेया* लौर. वंश की मौजूद काष्ठों से समानता प्रदर्शित करता है। काष्ठ की उपस्थिति अंतर्देशीय आर्द्र उष्णकटिबंधीय वनों को इसके प्राकृतिक आवास से समुद्रीय क्षेत्र के निकट तक से नदीय वाहन प्रस्तावित करती है। टेरेडोज द्वारा काष्ठ का प्रचुर ग्रसन संभवतः समुद्र तट के निकट या ज्वारीय समतल क्षेत्र में दफन होने से पूर्व महत्वपूर्ण अनावरण के संकेत करता है जहाँ यह *टेरेडोलाइटीज* द्वारा दफन हुआ था।

**संकेत-शब्द**—अशिमत काष्ठ, *एग्लेया*, मिलिएसी, *टेरेडोलाइटीज* (इक्नोफॉसिल), ईओसीन, गुजरात।

## INTRODUCTION

A large number of fossils including amber have been reported from the Vastan Lignite Mine (Fig. 1) situated about 30 km north-east of Surat (Alimohammadian *et al.*, 2005; Mandal & Guleria 2006; Sahni *et al.*, 2006; Sahni *et al.*, 2007; Kraemer & Evenhuis 2008; Garg *et al.*, 2008; Mallick *et al.*, 2009). It is apparent from the available data that no plant megafossil has been described systematically from the mine until now although their occurrence has been reported (*op. cit.*). In the present communication a carbonised wood sample eaten by wood borers

(endoxylic bivalves) is being described for the first time from the carbonaceous shale sequence near the top of lignite seam I (Fig. 2). Occurrence of the carbonised wood was reported recently in a conference (Guleria *et al.*, 2008). The Vastan Lignite has been considered to be Early Eocene in age (Bajpai & Kapur 2004; Sahni *et al.*, 2006). However, Garg *et al.*, 2008 have assigned Late Palaeocene-Early Eocene (55-52 Ma) age to the Vastan Lignite based on dinoflagellate study.

## SYSTEMATICS

*Family*—MELIACEAE

*Genus*—AGLAIA LOUR.

*Aglaia vastanensis* sp. nov.

(Figs 3, 4; Pl. 1.1-3, 5, 7-9)

*Material*—The material consists of a single piece of carbonized wood 25 cm long, 7 cm in width and at one place 35 cm in circumference. The material is bored and eaten up by the wood borers (Figs 3, 4).

*Description*—Wood diffuse-porous (Pl. 1.1-3). Growth rings not seen. Vessels small to medium, solitary and in radial multiple of 2-5, round to oval in shape, 6-8 vessels per sq. mm, plugged with gummy and frothy material, the later gives an impression of tylosis (Pl. 1.3), thin walled, t.d. 81-139  $\mu$ m, r.d. 121-222  $\mu$ m, vessel members 315-401  $\mu$ m long with truncate ends, perforations simple, intervessel pits minute. Parenchyma paratracheal, vascentric to aliform, usually forming short, irregular, undulating bands 5-8 cells wide (Pl. 1.1-3), cells thin walled, t.d. 12-21  $\mu$ m, 38-75  $\mu$ m in length, crystalliferous strands present. Xylem rays 1-3, mostly 2 seriate, 10-44  $\mu$ m wide, 3-22 cells or 52-349  $\mu$ m high, 7-15 per sq. mm, ray tissue heterogeneous, uniseriate rays made up of procumbent or upright cell only (Pl. 1.5, 7). Fibres irregularly arranged in between consecutive xylem rays, thick walled, polygonal in cross section (Pl. 1.1-3), and 7-18  $\mu$ m in diameter, septate (Pl. 1.5). The sample is bored by wood borers, showing profuse elongate and subparallel borings.

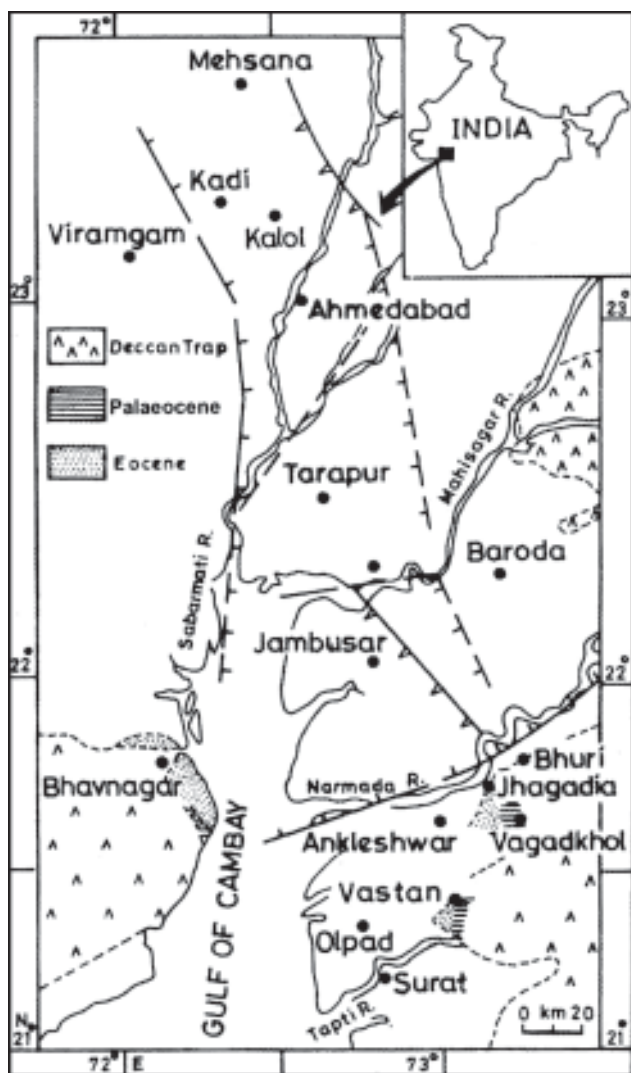


Fig. 1—Geological map showing location of Vastan (after Chandra & Chowdhury, 1969).

The characteristic features of the wood are as follows—*Wood* diffuse porous. *Growth rings* not clear. *Vessels* small to medium, solitary or in multiples of 2-5, plugged with gummy deposits, perforations simple, intervessel pits minute. *Parenchyma* paratracheal, vasicentric-aliform usually forming short irregular, undulating bands 5-8 cells wide, crystalliferous strands present. *Xylem rays* 1-3 (mostly 2 seriate), ray tissue heterogeneous. *Fibres* thick walled, septate. In all the above features the fossil shows resemblance with the extant woods of genus *Aglaia* Lour. of the Family Meliaceae (Ghosh *et al.*, 1963).

*Aglaia* Lour. a large genus of more than 105 spp. (Mabberley, 1997) consisting of small to moderate-sized trees distributed in tropical and subtropical forest of the Indo-Malayan region, southern China and north Australia. About 20 spp. are reported to occur in India and Burma (Ghosh *et al.*, 1963). About 10 spp. of *Aglaia* have been reported from the main land and 6 spp. of *Aglaia* occur in Andaman and Nicobar Islands. Amongst these *A. odoratissima* Bl. is the most widely distributed species in India.

The fossil wood was compared with the available wood slides and it was found that the wood shows nearest resemblance with *A. sapindina* Harms & *A. eusideroxylon* Koord. & Valeton. The authors are aware of only two fossil woods of *Aglaia*, viz. *Aglaioxylon mandlaense* Trivedi & Srivastava, 1982 from the Deccan Intertrappean sediments of Parapani, Mandla District, Madhya Pradesh and *Aglaia nahanensis* (Prakash) Yadav 1989 from the Lower Siwalik (Middle Miocene) of Nalagarh, Solan District of Himachal Pradesh. However, the present fossil differs from both of them. Both the fossil woods lack the anatomical structures of genus *Aglaia*. The former possess homocellular rays and diffuse and aggregate parenchyma, while in the later rays are broader mostly 3 seriate and crystalliferous strands absent. Consequently both the woods do not represent the fossil wood of *Aglaia* and hence they also differ from the present fossil. Thus the present fossil forms the first authentic record of genus *Aglaia* Lour. The genus ranges in distribution from evergreen to deciduous forests of India.

### SPECIFIC DIAGNOSIS

*Aglaia vastanensis* sp. nov.

*Wood* diffuse-porous. *Growth rings* not seen. *Vessels* small to medium, solitary and in radial multiple of 2-5, 6-8 vessels per sq. mm, t.d. 81-139  $\mu\text{m}$ , r.d. 121-222  $\mu\text{m}$ , plugged with gummy material, vessel members 315-401  $\mu\text{m}$  long with truncate ends, perforations simple, intervessel pits minute. *Parenchyma* paratracheal, vasicentric to aliform

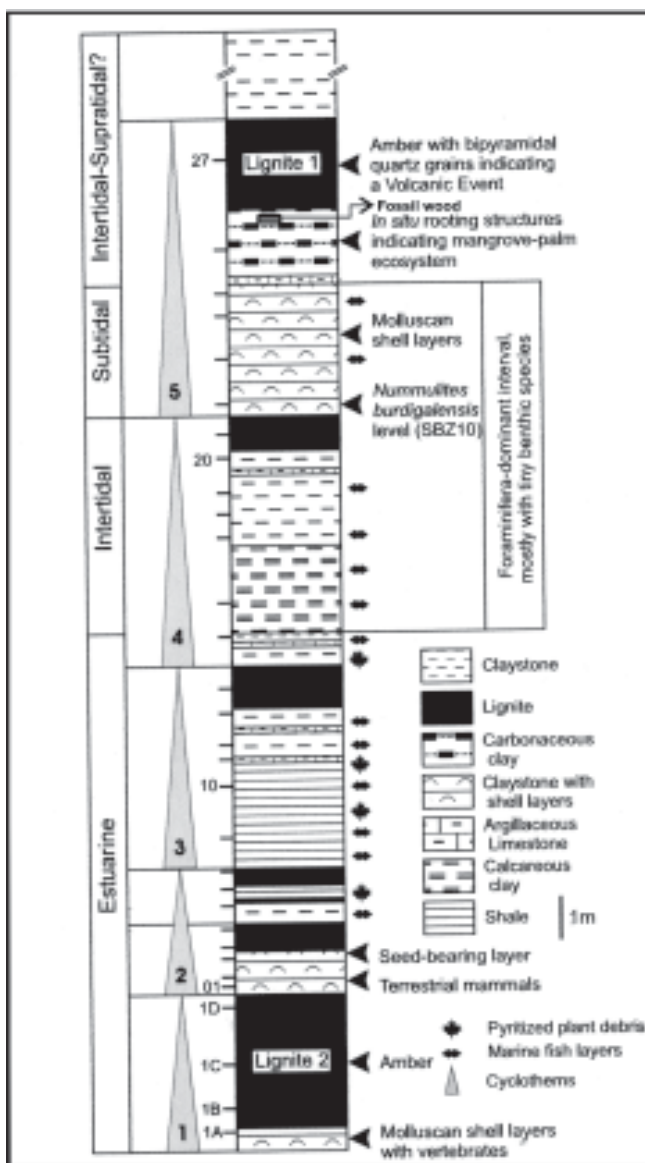


Fig. 2—Litholog of Vastan Lignite Mine (Sahni *et al.*, 2006) showing occurrence of the fossil wood.

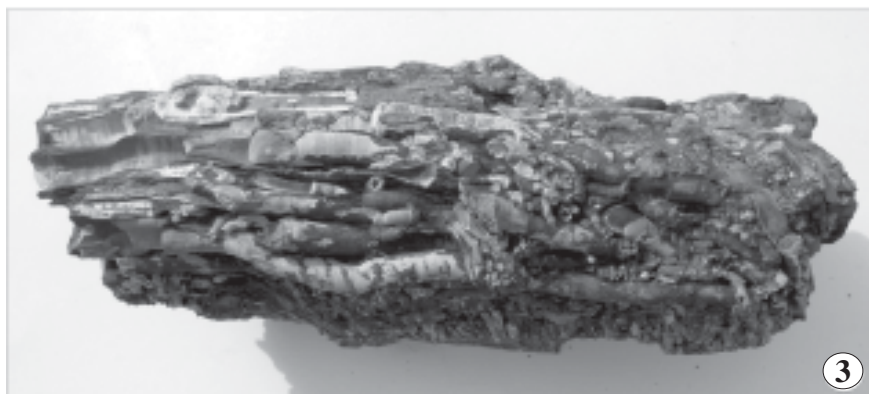


Fig. 3—Carbonised wood heavily infested by *Teredolites* (x 1/2 of the specimen size).

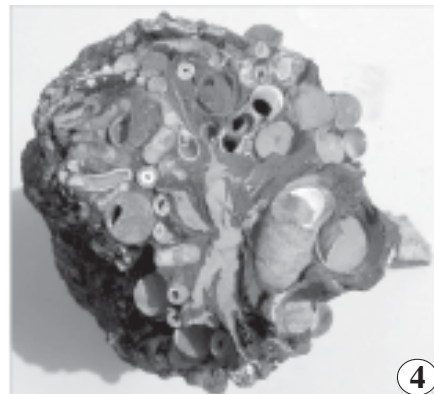


Fig. 4—A part of the infested carbonised wood in cross section.

forming short, irregular, undulating bands 5-8 cells wide, cells thin walled, t.d. 12-21  $\mu\text{m}$ , 38  $\mu\text{m}$  in length, crystalliferous strands present. *Xylem rays* 1-3 (mostly 2 seriate), 10-44  $\mu\text{m}$  wide 3-22 cells or 52-349  $\mu\text{m}$  high, 7-15 per sq. mm, rays tissue heterogeneous. *Fibres* thick walled, polygonal in cross section, 7-18  $\mu\text{m}$  in diameter, septate.

*Repository*—Museum, Birbal Sahni Institute of Palaeobotany, Lucknow.

*Holotype*—BSIP Museum No. 39793.

*Locality*—Vastan Lignite Mine, Gujarat.

*Horizon*—Vastan Lignite.

*Age*—Early Eocene.

## ICHNOFOSSIL

## SYSTEMATICS

### Family—TEREDINIDAE

### Genus—TEREDOLITES LEYMERIE, 1842

*Teredolites longissimus* Kelly & Bromley, 1984

(Figs 3, 4; Pl. 1.1)

*Material*—The material consists of a piece of carbonised wood 25 cm long and 7 cm wide bearing a large number of wood borings.

*Description*—The long worm-like subparallel bore tubes/ tunnels/ channels range from 0.2 cm to 1.2 cm in diameter and as long as the available wood specimen, i.e., 25 cm and even longer. The tubes are straight or wavy and unbranched, running parallel to wood grain, concameration or interior rings seen in the tunnels (Figs 3, 4). They are open or filled by detrital sediments and are covered by smooth calcareous lining (Figs 3, 4), (Pl. 1.1), sometimes broken fragments of

## PLATE 1

(Bar indicating the magnification of each figure)



*Aglaia vastanensis* sp. nov.

- 1-3. Cross sections of fossil eaten by wood borers and showing nature and distribution of vessels, parenchyma, xylem rays and fibres. BSIP Museum Slide No. 39793-1, 2.
4. Cross section of *Aglaia eusideroxylon* showing similar distribution of vessels, parenchyma, xylem rays and fibres. BSIPw Slide No. 1215.
- 5, 7. Tangential longitudinal section of fossil showing narrow rays, crystalliferous strands and septate fibres.

BSIP Museum Slide No. 39793-3.

6. Tangential longitudinal section of *Aglaia eusideroxylon* showing similar narrow rays, crystalliferous strands and septate fibres. BSIPw Slide No. 1215.
8. Radial longitudinal section of the fossil showing heterocellular rays. BSIP Museum Slide No. 39793-4.
9. Tangential Longitudinal Section of the fossil showing intervessel pits. BSIP Museum Slide No. 39793-3.



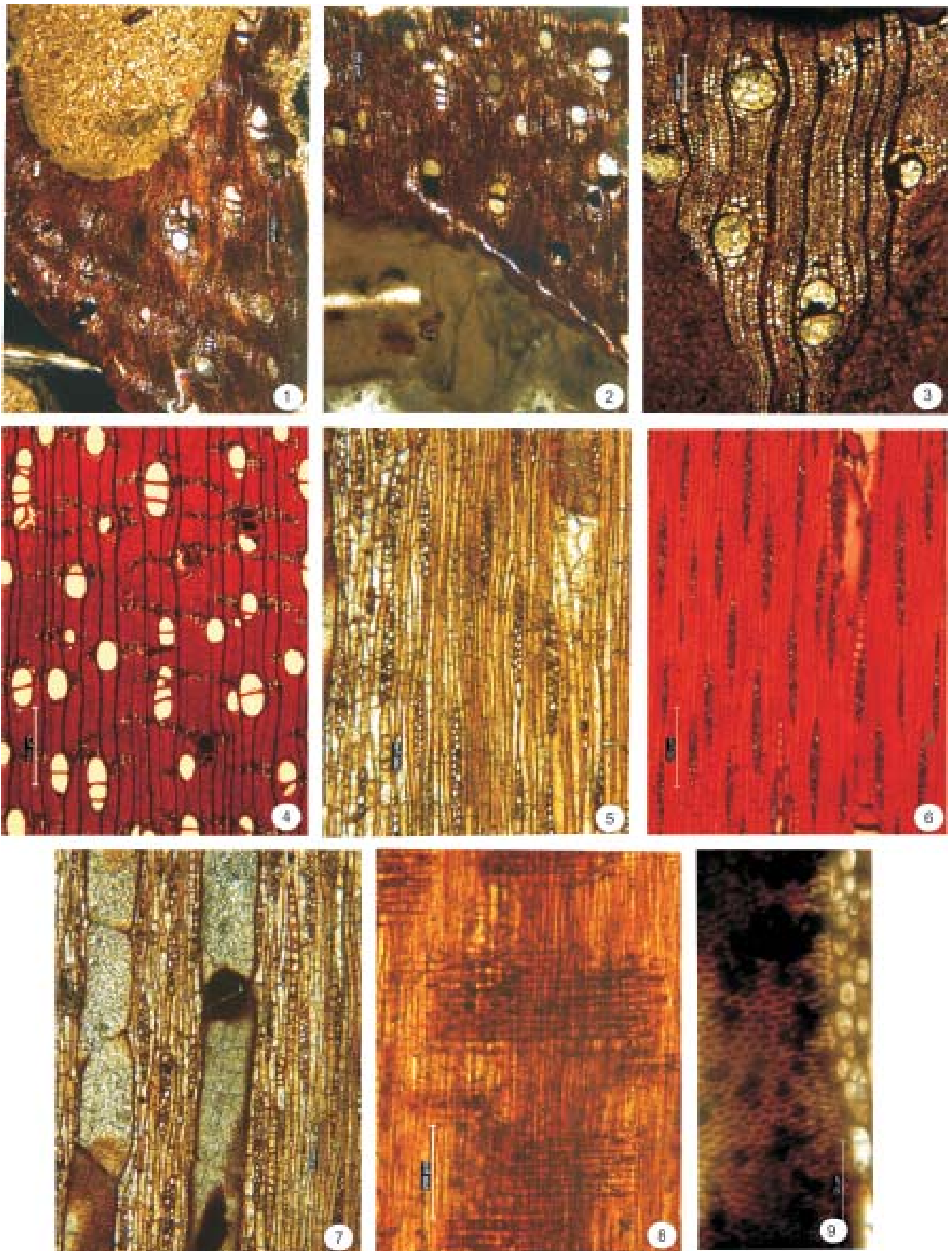


PLATE 1

calcite lining are seen in sections. Length-width ratio of the tunnels is  $>5$ . The borings are circular in cross-section with smooth walls (Fig. 4). They are closely spaced and occupy more than 70% of the wood sample.

The above kind of morphological structures reported from xylic substrate have been assigned to ichnogenus *Teredolites* Leymerie, 1842. Obviously the present specimen belongs to the genus *Teredolites* Leymerie. Further on the basis of length-width ratio which is more than five in the present specimen so it has been assigned to *Teredolites longissimus* sp. Kelly and Bromley, 1984 (see also Kriz & Mikulas, 2006) a well known and wide spread species. Calcite tubes (teredolithus), secreted by teredinid bivalves all along or part of their borings are usually associated with *T. longissimus* (Savrda & Smith, 1996).

## DISCUSSION

The family Meliaceae includes about 50 genera and is primarily pantropical in distribution with two genera *Toona* and *Melia* extending into temperate north. The family is well represented by its fossil remains in India. Woods and leaves of the following genera have been reported: *Aglaiia*, *Amoora*, *Aphanamixis*, *Beddomia*, *Chisocheton*, *Chukrasia*, *Chloroxylum*, *Dysoxylum*, *Heynea*, *Melia*, *Toona*, *Trichilia*, *Turraeanthus* and *Walsura* (see Lakhanpal *et al.*, 1976; Srivastava, 1991; Srivastava & Guleria, 2006; Prasad 2008). It is evident from the fossil records that antiquity of the family Meliaceae in India goes back to Late Maastrichtian and it has continued to exist in India till today. The oldest record of the family in the form of fruit and seed is known from Campanian-Maastrichtian boundary of Senegal in Africa (Monteillet & Lappartient, 1981).

The presence of the wood suggests a fluvial transport from its natural habitat of an inland moist tropical forest to a nearby coastal region or marginal marine area. The lignite strata, containing twigs, woods, fruits, seeds, etc. are deposits of extensive low lying fluvial deltaic system which prograded into shallow sea under humid tropical climate. The elongate and subparallel excavations predominate in marine or marginal marine settings (Miller, 2008).

The occurrence of *Teredolites* represents slow deposition in marshy or swampy areas of peat accumulation most common in estuarine, deltaic or brackish water environments. The profuse infestation of the wood by teredos (*Teredolites longissimus* Kelly & Bromley, 1984) indicates considerable exposure before burial probably in a near shore lagoon or tidal flat area. Teredo affected petrified woods have earlier been reported from the late Tertiary sediments of Piram Island off the coast of Bhavnagar in Gujarat (Guleria & Awasthi, 1997, p. 248, fig. 1b).

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