

# A fossil wood of *Gynocardia* from the Valia Lignite Mine, Bharuch District, Gujarat

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## ABSTRACT

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The Valia Lignite Mine situated near Bharuch (Gujarat) is poorly explored as far as the animal and plant remains are concerned. In order to explore the mine for building the palaeofloristics and reconstruction of the palaeoenvironment, a few wood pieces were collected from there. Subsurface beds of the early Eocene (Cambay Shale Formation) age are exposed in this open cast mine. A new fossil wood, *Gynocardia eocenica* sp. nov., of the Achariaceae is described for the first time from there. *Gynocardia* is monotypic and found in evergreen rain forests of northeast India, Bangladesh and Myanmar. The occurrence of present fossil indicates that the genus was originated in India during the early Eocene when the climatic conditions were warm and humid. Later on, it became extinct from western India due to the presence of arid to semiarid conditions and confined to northeast India having the equable climate.

**Key-words**—Fossil wood, *Gynocardia*, Achariaceae, Early Eocene, Cambay Shale, Gujarat.

वालिया भूराकोयला, जिला भरुच, गुजरात से प्राप्त गायनोकार्डिया जीवाश्म काष्ठ

अनुमेहा शुक्ला, हुकम सिंह एवं आर. सी. मेहरोत्रा

## सारांश

भरुच (गुजरात) के पास स्थित वालिया भूरा कोयला खान, जहाँ तक पशु एवं पादप अवशेष संबंधित हैं, कम (शायद) ही अन्वेषित की है। पुरापादपअध्ययन रचित करने और पुरापर्यावरण की पुनर्संरचना हेतु खान को अन्वेषित करने को वहाँ से कुछ काष्ठ अंश संगृहीत किए गए थे। इस विवृत खान में प्रारंभिक आदिनूतन (कैंबे शेल शैलसमूह) कालीन की उपपृष्ठीय संस्तरें अनावरित हुई हैं। वहाँ से पहली बार एकैरिएसी की एक अभिनव (नूतन) काष्ठ, गायनोकार्डिया इओसेनिया, जाति नवम वर्णित की गई है। गायनोकार्डिया एकलप्ररूपी है तथा उत्तरपूर्व भारत, बांग्लादेश एवं म्यांमार के सदाहरित वर्षा वनों में मिलती है। मौजूदा जीवाश्म की प्राप्ति द्योतित करती है कि प्रारंभिक आदिनूतन के दौरान जब जलवायवी स्थितियाँ कोष्ण एवं आर्द्र थीं इस वंश की भारत में उत्पत्ति हुई थी। तत्पश्चात, शुष्क से अर्धशुष्क स्थितियों की विद्यमानता की वजह से पश्चिमी भारत से यह विलुप्त हो गई तथा स्थिर जलवायु पाने से (रहने से) उत्तरपूर्व भारत तक सीमित रह गई।

**सूचक शब्द**—जीवाश्म काष्ठ, गायनोकार्डिया, एकैरिएसी, प्रारंभिक आदिनूतन, कैंबे शेल, गुजरात।

## INTRODUCTION

THE subsurface beds of Cambay Shale Formation (early Eocene) are exposed in an open cast lignite mine at Valia, situated near Surat in Gujarat (Fig. 1). This mine is considered as an extension of the Vastan Lignite Mine because shale–lignite sequence of both the mines lies directly over the Deccan Trap (Punekar & Saraswati, 2010) in southern

Cambay Basin. The Valia Lignite Mine is poorly explored as far as the animal and plant remains are concerned (Samanta *et al.*, 2013). Therefore, a field trip was made to collect fossils and one of us (HS) collected a few wood pieces from there. However, a number of plant and animal remains were described from the nearby Vastan Lignite Mine by various workers (Samant & Tapaswi, 2000, 2001; Samant & Bajpai, 2001; Rana *et al.*, 2004, 2005, 2008; Bhandari *et al.*, 2005;

Mandal & Guleria, 2006; Nolf *et al.*, 2006; Garg *et al.*, 2008; Punekar & Saraswati, 2010; Rao *et al.*, 2013).

## GEOLOGICAL SETTING

Deposition of shales in this mine is variable in thickness. There are two main lignite seams separated by grey shales and carbonaceous shales (Fig. 2) belonging to the Cambay Shale Formation which overlies the Palaeocene–early Eocene Vagadkhol Formation and underlies the late Eocene Numulitic limestone and marl of the Amravati Formation (Sudhakar & Basu, 1973). On the basis of dinoflagellate cysts from the Vastan Lignite Mine, Garg *et al.* (2008) assigned Ypresian (early Eocene) age to the Cambay Shale Formation. The basal lignite seam was 2.8 m thick and the fossil wood pieces were collected from the upper layer (at 2.6 m) of this seam (Fig. 2).

## MATERIAL AND METHODS

The carbonized wood for the present study was collected from the subsurface of the Valia Open Cast Lignite Mine (21°34'25" N; 73°10'7" E), located about 30 km SE of Bharuch in Gujarat (Fig. 1). The site can be approached from the National Highway (NH–8) connecting Kim Four Road Junction. The fossil wood pieces were found embedded in the upper layer of the basal lignite seam (Fig. 2).

The cross (CS), tangential longitudinal (TLS) and radial longitudinal (RLS) sections of the fossil were prepared by the standard method of grinding, polishing and mounting in canada balsam (Lacey, 1963). The type slides are deposited in the Museum of the Birbal Sahni Institute of Palaeobotany, Lucknow (BSIP). The thin sections were examined under the high power light microscope and the anatomical terms used

in describing it are those adopted by Wheeler *et al.* (1986) and International Association of Wood Anatomists (1989).

## SYSTEMATICS

Family—ACHARIACEAE

Genus—GYNOCARDIA R.Br.

*Gynocardia eocenica* Shukla *et al.*, sp. nov.

(Pl. 1.1–7)

*Description*—Wood diffuse porous (Pl. 1.1). Growth rings absent. Vessels poorly preserved but distinct at places, round to oval, small to medium, tangential diameter 60–160  $\mu\text{m}$ , evenly distributed, open (Pl. 1.1); perforations simple; intervessel pits bordered, alternate, minute. Axial parenchyma absent or very rare (Pl. 1.4). Rays closely spaced, 25–35 per mm, 1–3 (rarely 4 celled) seriate, uniseriate rays made up of procumbent cells, 14–18  $\mu\text{m}$  in width and 8–15 cells or 15–515  $\mu\text{m}$  in height; multiseriate rays made up of both procumbent and upright or square cells with 1 to 4 rows of upright/square cells at one or both the ends, 30–60  $\mu\text{m}$  in width and 14–40 cells or 249–600  $\mu\text{m}$  in height (Pl. 1.2, 3); ray to ray fusion present; ray tissue heterogeneous (Pl. 1.5); procumbent cells about 30  $\mu\text{m}$  in radial length and 13–23  $\mu\text{m}$  in tangential height; upright/square cells 33–37  $\mu\text{m}$  in tangential height and about 30  $\mu\text{m}$  in radial length; prismatic crystals present (Pl. 1.5); perforated ray cells observed with scalariform thickening (Pl. 1.6). Fibres aligned in radial rows, thick walled, polygonal in cross section, septa present but poorly preserved (Pl. 1.7).

*Holotype*—Specimen No. BSIP 40817.

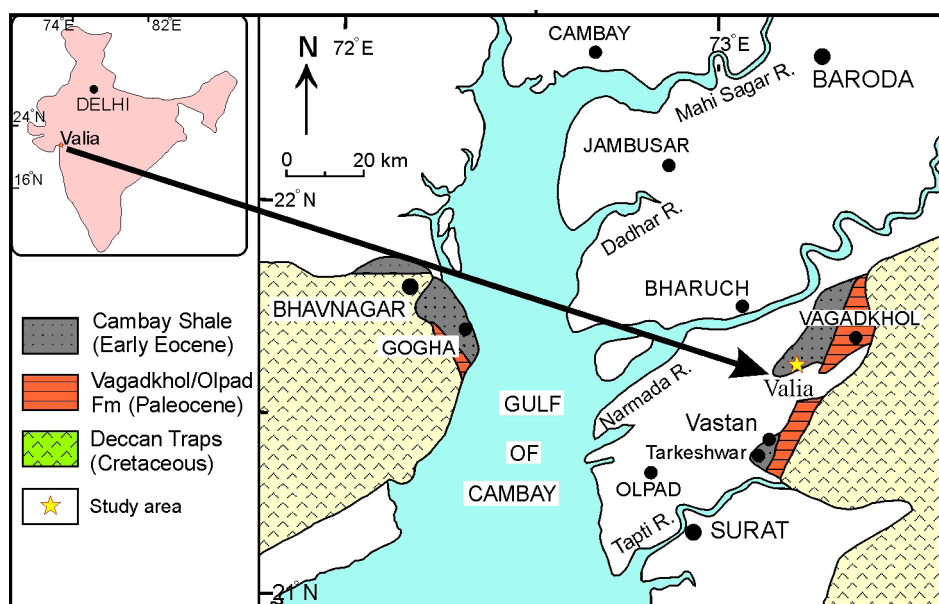


Fig. 1—Geological map showing the Valia Lignite Mine (after Sahni *et al.*, 2006).

*Horizon*—Cambay Shale Formation.

*Locality*—Valia Lignite Mine, Bharuch District, Gujarat.

*Age*—Early Eocene.

*Affinities*—The important anatomical features of the fossil such as absence of parenchyma, simple perforations, narrow and closely spaced rays with marginal extensions, heterogeneous ray tissue and septate fibres, etc. indicate its affinities with Flacourtiaceae (Pearson & Brown, 1932; Metcalfe & Chalk, 1950; Kribs, 1959; Ilic, 1991). In India, the family is represented by nine genera, namely *Casearia* Jacq., *Flacourtia* Comm.ex L'Hér., *Gynocardia* R.Br., *Hydnocarpus* Gaertner, *Homalium* Jacq., *Ryparosa* Bl., *Scolopia* Schreb., *Taraktogenos* Hassk. and *Xylosma* G.Forst. (Purkayastha, 1958). A perusal of the insidewood database (<http://insidewood.lib.ncsu.edu>) indicates that the present fossil shows nearest affinities with *Gynocardia odorata* R.Br., especially in having small to medium vessels, absence of parenchyma, closely spaced 1–3 seriate homo to heterocellular rays, septate fibres and perforated and/or crystalliferous ray cells. The other genera can be differentiated either in having broader rays (4–10 seriate) or scalariform perforations.

## DISCUSSION

Taxonomists have dumped the family Flacourtiaceae and its genera have been placed to various families, namely Achariaceae, Salicaceae and Samydeaceae (APG III, 2009). The genus *Gynocardia* is now placed under Achariaceae. It is monotypic and found in evergreen rain forests of India, Bangladesh and Myanmar (Fig. 3). In India, it occurs in Sikkim and northeast India (Hooker, 1872; Mabberly, 1997).

As far as our knowledge is concerned, no fossil wood of *Gynocardia* has yet been described from any part of the world. As it is being reported for the first time, it is described as *Gynocardia eocenica*, Shukla *et al.*, sp. nov., the specific name indicating its age. Only a few leaves and a seed of *Gynocardia* are known (Fig. 3) to date from the Siwalik sediments (Neogene) of India and Nepal (Konomatsu & Awasthi, 1999; Prasad *et al.*, 1999; Khan *et al.*, 2014). Thus, the present fossil becomes the oldest record of the genus. Its presence indicates that the genus was originated in India during the early Eocene when the climatic conditions were warm and humid. Later on, it became extinct from western India due to the shift in monsoon pattern (Shukla *et al.*, 2013, 2014) resulting in arid to semiarid climate (Merh, 1995). The genus, at present, is confined to northeast India having the equable climate.

The plant megafossils from the nearby Vastan Lignite Mine belong to *Melanorrhoea* Wall. and *Swintonia* Griff. of the Anacardiaceae (Singh *et al.*, 2015), *Annona* Linn. of

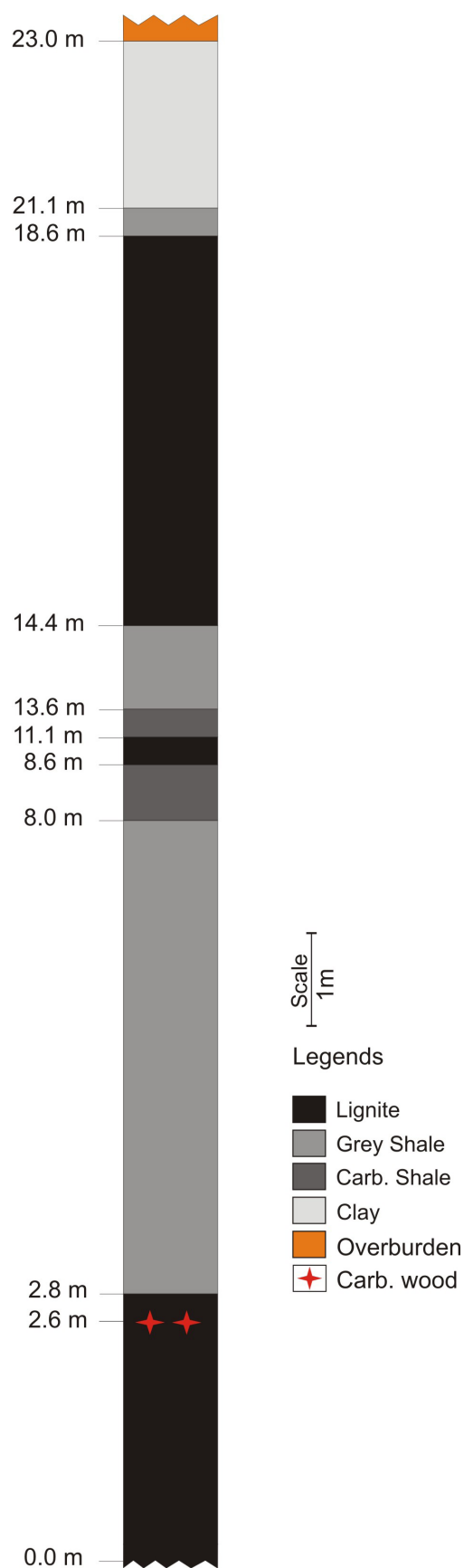


Fig. 2—Litholog of the Valia Lignite Mine showing the location of carbonized wood (marked by stars).

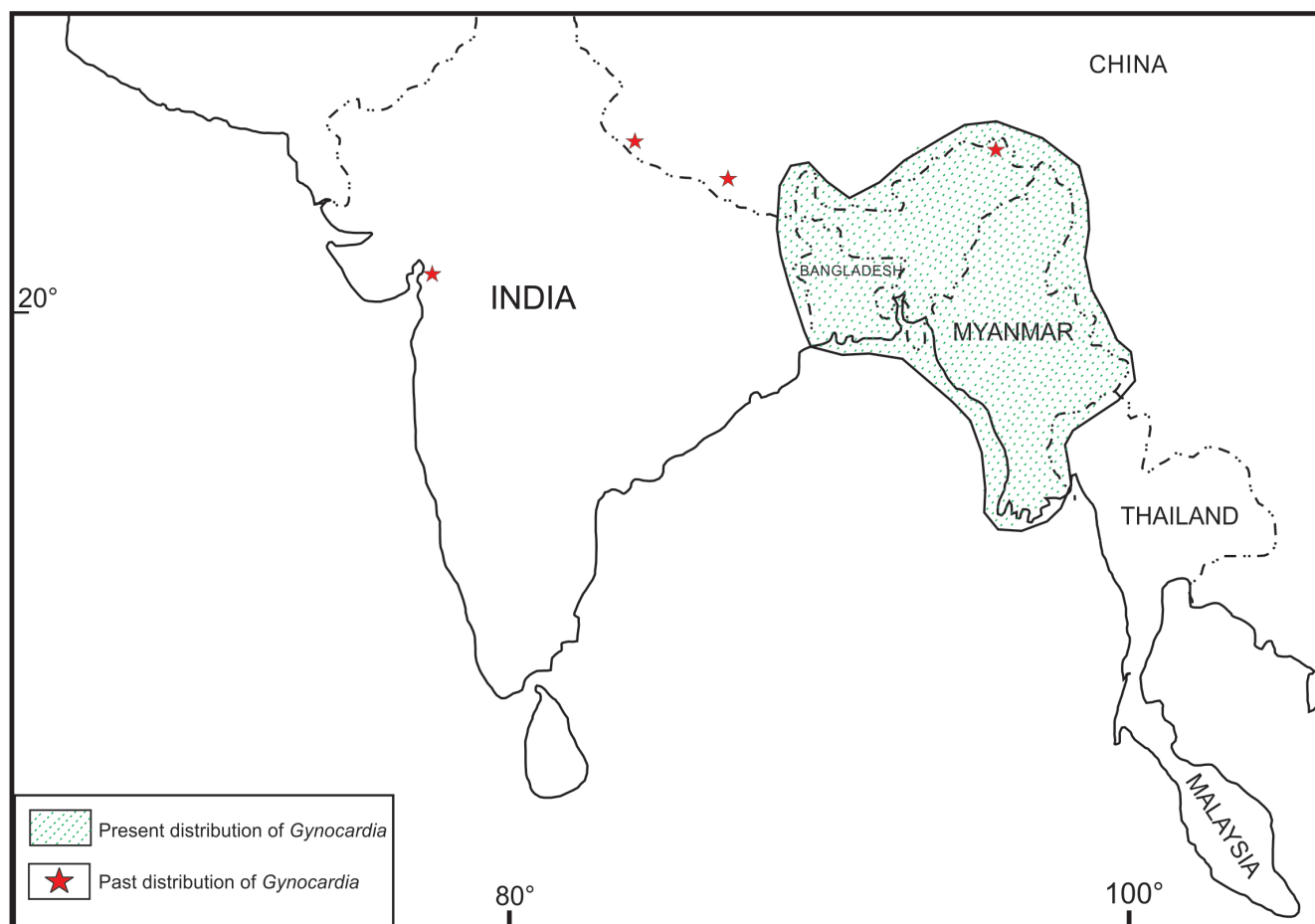


Fig. 3—Distribution of *Gynocardia* in time and space.

the Annonaceae (Prasad *et al.*, 2014), *Calophyllum* Linn. of the Calophyllaceae, *Combretum* Loefl. and *Terminalia* Linn. (Singh *et al.*, 2010, 2015) of the Combretaceae, *Diospyros* Linn. of the Ebenaceae (Singh *et al.*, 2015), *Lagerstroemia* Linn. of the Lythraceae (Singh *et al.*, 2010, 2015), *Pterospermum* Schreb. of the Malvaceae (Singh *et al.*, 2015), *Aglaia* Lour. of the Meliaceae (Guleria *et al.*, 2009), *Ziziphus* Mill. of the Rhamnaceae (Singh *et al.*, 2010), *Gardenia* J. Ellis and *Anthocephalus* A. Rich. of the Rubiaceae, *Sarcomelicope* Engler of the Rutaceae, *Schleichera* Lour. of the Sapindaceae (Singh *et al.*, 2015), besides a palm (Prasad

*et al.*, 2013). All these evidences indicate tropical warm and humid climate favouring luxurious growth of rain forest in the region during the period of deposition. The present finding from the Valia Lignite Mine supports this view.

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## PLATE 1

*Gynocardia eocenica* Shukla, Singh & Mehrotra, sp. nov. ➔

1. Cross section of the fossil wood in low power showing shape, size and distribution of vessels (marked by arrows) (Scale = 500  $\mu$ m).
2. Tangential longitudinal section of the fossil in low power showing closely spaced rays (MSR = multiseriate ray; USR = uniseriate ray) (Scale = 200  $\mu$ m).
3. Tangential longitudinal section of the fossil in high power showing structure of rays (Scale = 100  $\mu$ m).
4. Cross section of the fossil wood in high power showing absence of parenchyma (Scale = 100  $\mu$ m).
5. Radial longitudinal section of the fossil showing heterogeneous ray tissue and prismatic crystals (PC) (Scale = 200  $\mu$ m).
6. An enlarged multiseriate ray showing perforated ray cell (PRC) with scalariform thickening (Scale = 50  $\mu$ m).
7. Tangential longitudinal section of the fossil showing septate fibres (SF) (Scale = 50  $\mu$ m).

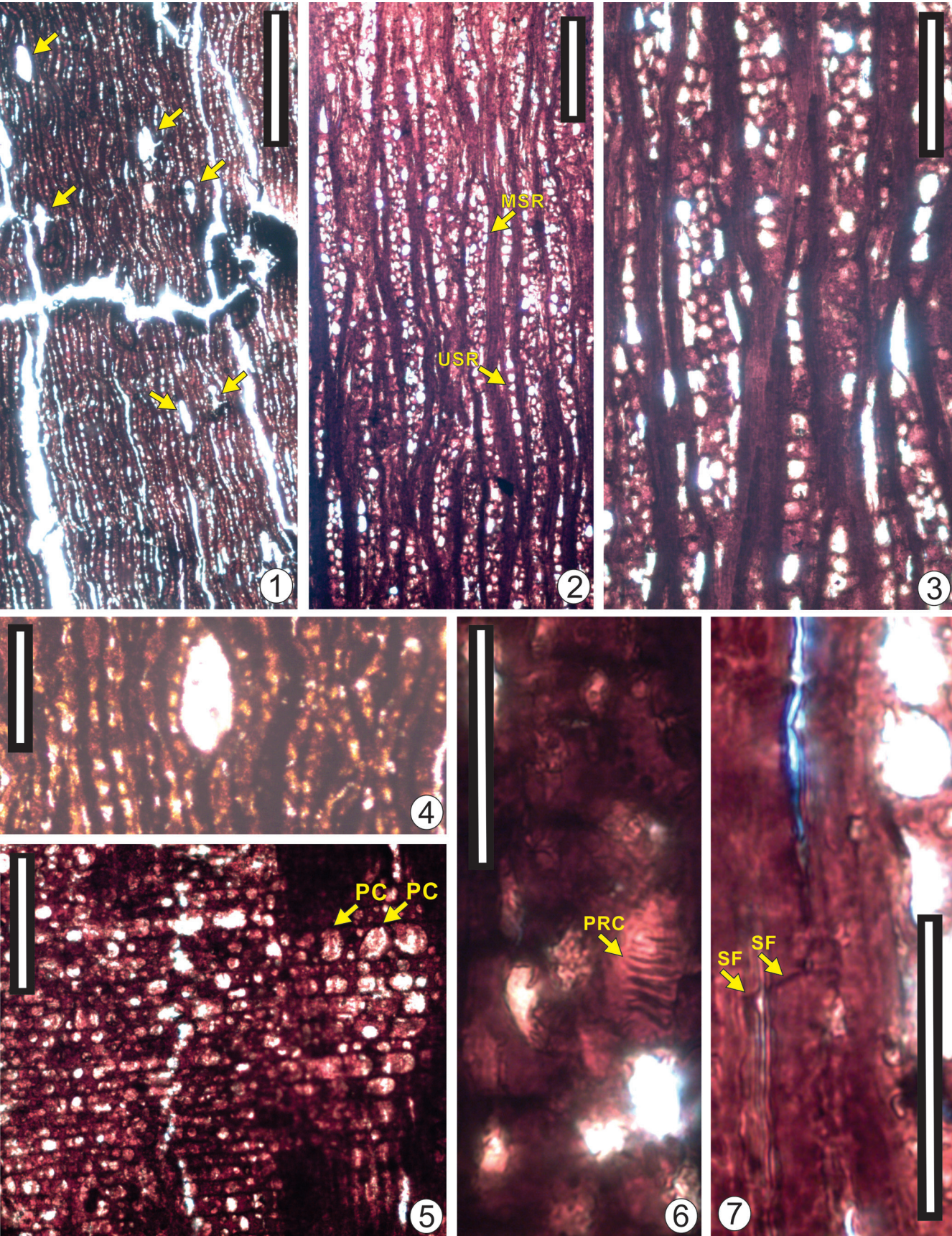


PLATE 1

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