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Two new species of *Lagerstroemioxylon* (family: *Lythraceae*) from the Eocene sediments of Bikaner, Rajasthan, India

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ABSTRACT

Harsh R. & Shekhawat S. 2022. Two new species of *Lagerstroemioxylon* (family: *Lythraceae*) from the Eocene sediments of Bikaner, Rajasthan, India. Geophytology 52(1&2): 47–56.

The present paper deals with the fossil woods of family *Lythraceae*. Anatomy of petrified woods of family *Lythraceae* collected from the Tertiary rocks of Bikaner, Rajasthan is discussed in detail. Two new species of the genus *Lagerstroemioxylon* are described. These woods show variation in distribution and size of vessels, the position of apotracheal and paratracheal parenchyma and the nature of wood rays including fibers. Comparison is made with the allied extant as well as extinct taxa of angiosperms. Palaeoecological conditions of this area during Eocene are also described.

Keywords: Angiospermous woods, *Lythraceae*, *Lagerstroemioxylon*, Neogene, Western Rajasthan, India.

INTRODUCTION

Das Gupta (1973, 1977) and Bhatia (1977) divided the West Rajasthan shelf into four main basins, viz. Bikaner-Nagaur basin, Jaisalmer basin, Barmer basin and Sanchore basin. The Tertiary rocks of Bikaner are divided into the Jogira Formation, Palana Formation and Kolayat Formation (Shrivastava 1971, Das Gupta 1977). On the basis of palaeontological study, Bhatia (1977) divided Tertiary sediments of Rajasthan as Lower Tertiary sediments occurring in Bikaner and Jaisalmer districts and Upper Tertiary sediments occurring in the Barmer district. Lower Tertiary sediments are further divided into three formations, viz. Palana lignite Formation, Khuiala (Lakhi) Formation and Bundah Formation. Guleria (1990) considered Bikaner rocks as Mar Formation and assigned Post Eocene to Late Pleistocene age.

A number of papers on fossil records (Rao & Misra 1949, Rao & Vimal 1950, 1952, Sah & Kar 1974, Harsh & Sharma 1992, Ambwani & Singh 1996, Tripathi et al. 1998, Harsh & Shekhawat 2018, 2020) from Bikaner lignite have been published. Findings are based on extinct angiospermous leaves and fruits recovered from the Tertiary sediments of Rajasthan are carried out by many workers (LaTouche 1902, Bose 1949, 1950, 1952, Lakhanpal & Bose 1951, Lakhanpal 1964, Deshmukh & Sharma 1978). However, the records of petrified fossil woods are few. Guleria (1984, 1990) published the description of four genera of woods from Jaisalmer and Bikaner. Harsh

and Sharma (1990) discovered Tertiary exposures and collected a large number of woods belonging to families *Lythraceae*, *Lecythidaceae*, *Combretaceae*, *Sonneratiaceae*, *Meliaceae* (Harsh & Sharma 1990, 1992, 1995, Harsh et al. 1992, Sharma & Harsh 1996, 1997, Harsh & Shekhawat 2014). Many of the fossil woods are new and reported for the first time from Tertiary sediments of Rajasthan. A coniferous wood, *Araucarioxylon bikaneriense*, was also described from the locality by Harsh and Sharma (1988). In the present paper, petrified woods have been collected from Bikaner area (Figure 1) and described as new species of the genus *Lagerstroemioxylon*.

MATERIAL AND METHODS

The material (fossil woods) has been collected from places known as Harsolav, Sansolav, and Karmisar, very close (2–3 km) to the city of Bikaner (Lat. 27.5229°N, Long. 72.52269°E) (Figure 1). The woods were found embedded 1–2 meters deep below the surface in distinct strata in horizontal orientation or scattered on the surface in gravel mines (Figure 2). The woods range from a few centimeters to 4 meters or more in length and 2–25 cm in diameter. These are hard silicified and whitish-grey or reddish-brown in colour.

Wood sections were prepared by the standard method of cutting, grinding, and polishing techniques. For anatomical purposes, sections have been prepared in three different planes i.e. T.S., T.L.S, and R.L.S. either with the help of a diamond edge wheel or small chips were taken out by a light hammer and a chisel. Grinding was done on the motor-driven grinding lap using different grades of carborundum powder. Hot Canada balsam was used to adhere the fossil chip to a glass slide. Mounting was also attempted but could not get satisfactory results probably due to the oversilicification of woods.

Slides were examined in transmitted light with low and high-power objectives of the microscope. For photographs of microscopic structures and their measurement software named 'Capture Pro', was used.

For the identification and comparison of the sections with those of the extant and extinct plants, different institutions and universities were visited, e.g. Botany Department, Burdwan University, Burdwan, Birbal Sahni Institute of Palaeosciences, Lucknow and

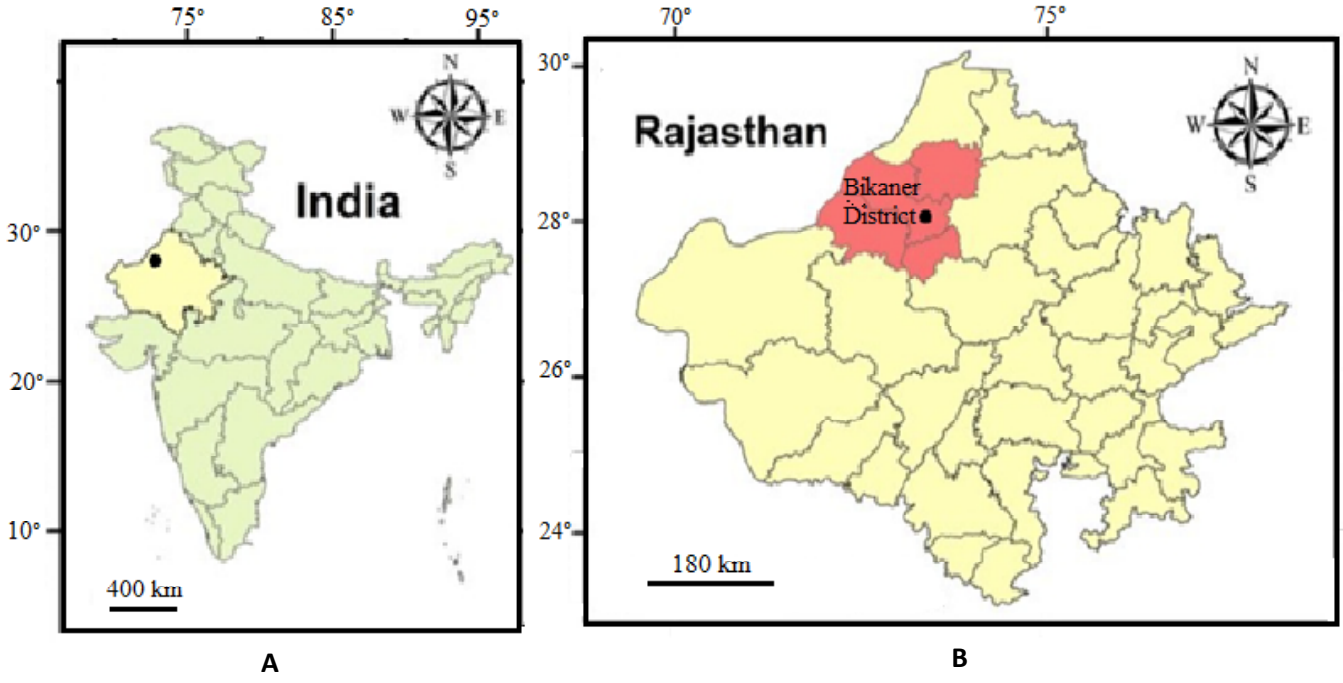

Figure 1. A. Map of India showing location of Rajasthan. **B.** Map of Rajasthan showing location of Bikaner District.

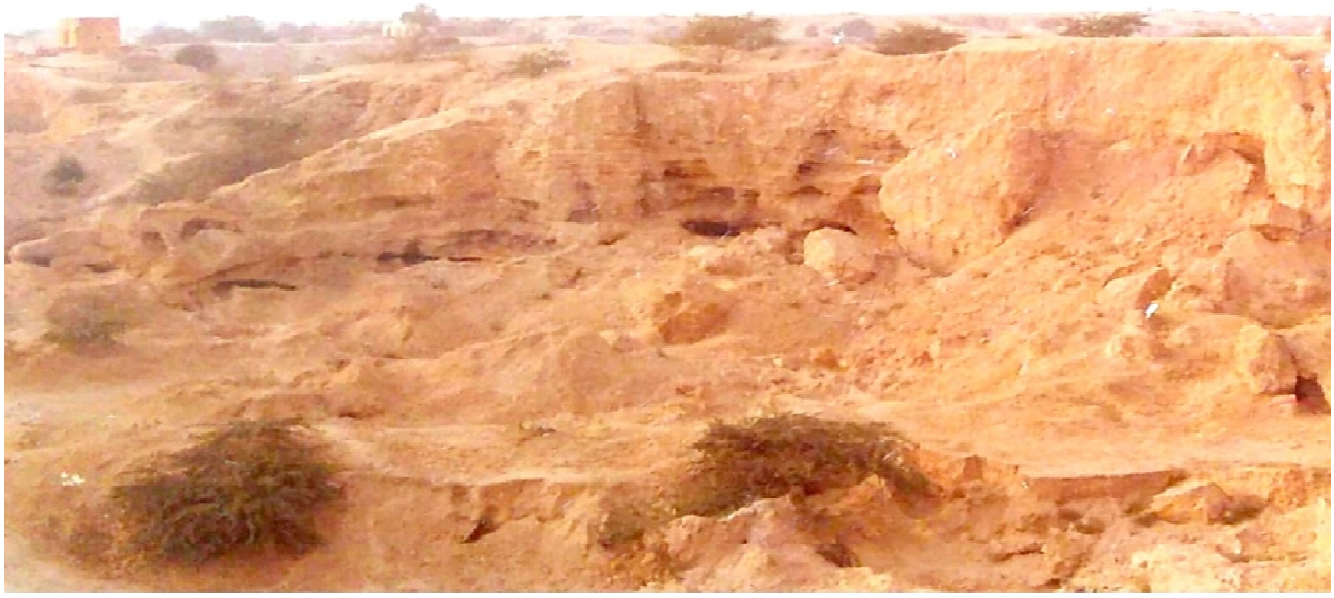

Figure 2. Showing locality of plant fossil collection (gravel mine) in Bikaner, Bikaner District, Rajasthan.

Forest Research Institute, Dehradun. All woods belong to dicot possessing vessel elements in the secondary xylem. The woods have been identified on the basis of parameters of literature by Metcalfe & Chalk (1950) and Purkayastha (1982).

SYSTEMATIC DESCRIPTION

Phylum: *Tracheophyta* Kenrick & Crane

Class: *Magnoliopsida* Cronquist et al.

Order: *Myrtales* Juss. ex Bercht. & Presl

Family: *Lythraceae* J. St.-Hil.

Genus: *Lagerstroemioxylon* Mädler 1939

Lagerstroemioxylon compactum Harsh & Shekhawat **sp. nov.**

Figure 3

Morphology

A well-preserved petrified piece of wood measuring 10 × 4 × 3 cm with clear differentiation of growth rings. The outer portion is grey in colour.

Anatomy

(1) Gross structures: Wood: Semi-ring porous. **Growth rings:** Distinct to the naked eye, delimited by larger vessels, more and compactly arranged early wood pores which grade gradually into smaller pores and are sparsely arranged in the outer portion of growth rings. **Pores:** Earlywood pores are larger, more in number and compactly arranged, clearly visible to the eye, latewood pores are small to very small, less in number, unevenly distributed and sparsely placed, exclusively solitary, elliptical-shaped, filled with crystals, tyloses rarely present in larger vessels, particularly at growth ring. **Soft tissue:** Only paratracheal vasicentric parenchyma is present. **Rays:** Fine, not visible to the naked eye, distinct under hand lens appearing as compactly placed and uniformly distributed lines in cross-section.

(2) Microscopic structure: Wood: Semi-ring-porous having larger and gradually smaller pores, larger pores, more in number and compactly arranged, clearly visible to the eye, smaller pores small to very small, less in numbers, unevenly distributed and sparsely placed, exclusively solitary, elliptical-shaped, filled with crystals, tyloses rarely present in larger vessels particularly at growth ring. **Growth rings:** Present, delimited by larger vessels, and thin layer of 2–3 cell thick-walled fibers (Figure 3.1) Pores are arranged radially. **Vessels:** Larger to gradually smaller in size. Larger vessels are 40 to 150 µm in tangential diameter and radially 100 to 250 µm, while smaller vessels vary from 30 to 170 µm tangentially and 110 to 200 µm in

radial diameter. Vessel wall thickness is approximately 7 to 10 µm. The frequency of vessels is lesser than the other taxa described in the present paper. In earlywood, the frequency is 5–7/mm^2 while 4–5/mm^2 in the latewood portion. Vessels are unevenly distributed in early as well as latewood portions (Figure 3.1–3). Vessel elements are small (Figure 3.5, 7), length as measured in the longitudinal section range from 81.2 to 396.6 µm with an average length of 81.66 µm. Perforation plate multiple, two to three pores are visible and end wall mostly transverse, rarely oblique. Inter vascular pitting is not so distinct. **Parenchyma:** Only paratracheal, 2–3 cell thick vasicentric parenchyma is present. **Fibers:** Aligned in radial rows (2–3) in between two consecutive rays (Figure 3.4), circular to angular in cross-section, approximately 18–20 µm in diameter with wall thickness from 3.9 to 4.2 µm as measured in T.L.S. commonly septate, subdivided into crystalliferous locules having crystal. **Xylem rays:** Exclusively uniseriate (Figure 3.4, 6), uniformly and compactly placed, separated by 2–3 rarely 4 fibers, frequency is 72–80/mm^2 highly dense (tangential section), 3 to 32 cells high, measuring 96.2 to 532 µm in length. Almost homogeneous consisting of procumbent cells. The procumbent cells range from 8.3 to 20.2 µm × 10.4 to 20.9 µm in size, almost circular in shape.

Diagnosis: Wood: Ring porous. **Growth rings:** Distinct to the naked eye, delimited by larger vessels, more and compactly arranged early wood pores which grade gradually into smaller pores and are sparsely arranged in the outer portion of growth rings. **Vessels:** Larger to gradually smaller in size. Larger vessels are 40 to 150 µm in tangential diameter and radially 100 to 250 µm, while smaller vessels vary from 30 to 170 µm tangentially and 110 to 200 µm in radial diameter. Vessel wall thickness is 7 to 10 µm. Vessel's frequency is comparatively lesser. In earlywood, it is 5–7/mm^2 while 4–5/mm^2 in the latewood portion. Vessels are unevenly distributed in early as well as latewood portions. Vessel element average length 81.66 µm. Perforation plate multiple, two to three pores are visible and end wall mostly transverse, rarely oblique. **Parenchyma:** Only paratracheal vasicentric parenchyma. **Fibers:** circular to angular, 18–20 µm in diameter with wall thickness from 3.9 to 4.2 µm, septate having crystals. **Xylem rays:** Exclusively uniseriate, uniformly and compactly placed, frequency is 72–80/mm^2 highly dense, 3 to 32 cells high, measuring 96.2 to 532 µm in length, homogeneous, procumbent cells range from 8.3 to 20.2 µm × 10.4 to 20.9 µm in size, almost circular.

Holotype: Specimen no. BKN–W–44; Slide no.: W–44/1–6.

Repository: Palaeobotany Laboratory, Department of Botany, M.S. Government Girls College, Bikaner, India.

Locality and Age: Harsolav; Eocene.

Etymology: The specific name has been given to its specific characters, i.e. compact arrangement of rays. The diagnosis is given below.

Comparison: Presence of the ring to semi-ring porosity in the present wood is of great diagnostic value. There are about 105 families among the dicotyledonous plants in which the wood ring to semi-ring porous characters are observed. There are a number of families in which the wood possesses paratracheal parenchyma and uniseriate rays with a tendency towards semi-ring porosity like *Apocynaceae*, *Asclepiadaceae*, *Dipterocarpaceae*, *Euphorbiaceae*, *Leguminosae*,

→

Figure 3. ***Lagerstroemioxylon compactum*** Harsh & Shekhawat **sp. nov. 1.** T.S. wood, semi ring-porous, elliptical-shaped (due to pressure); exclusively solitary vessels filled with crystals, rays are very compact, broad and distinct, growth ring distinct due to tangential line of large vessels. ×30. **2.** Same, T.S. wood, showing sparsely distributed vessels with typical vasicentric parenchyma. ×25. **3.** Same (enlarged), T.S. wood, showing only paratracheal vasicentric (2–3 layers) parenchyma, and compactly arranged broad rays. ×45. **4.** T.L.S. wood, showing distinct compactly arranged uniseriate rays, 3–32 cells high. ×40. **5.** R.L.S. wood, showing a single vessel having a transverse perforation plate (arrow), filled with crystals. ×20. **6.** T.L.S. wood, showing exclusively uniseriate closely placed rays. ×25. **7.** R.L.S. wood, showing vessels and rays. ×20.

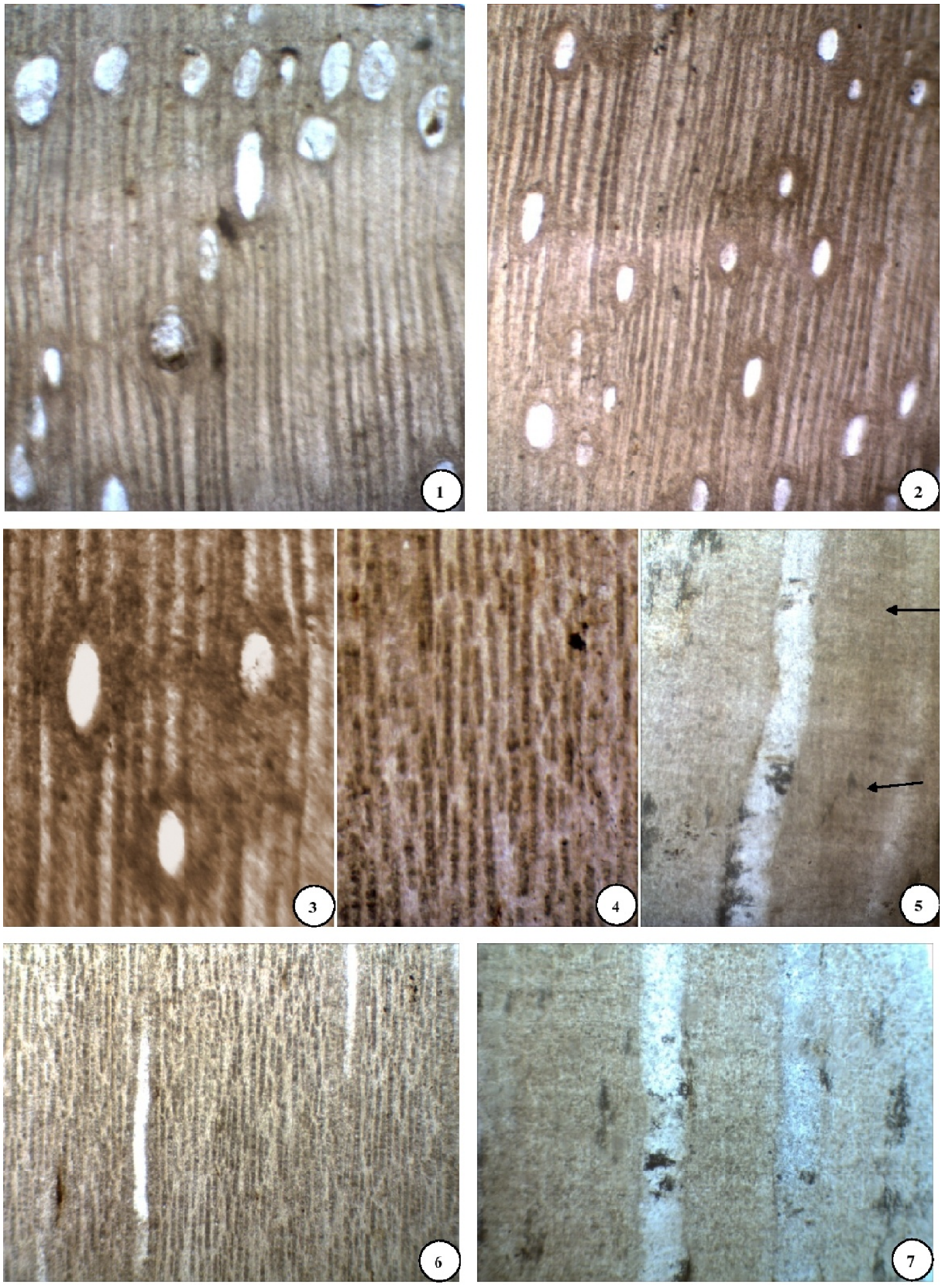

Figure 3

Loganiaceae, *Combretaceae*, *Lythraceae*, *Oleaceae* and *Sonneratiaceae*. However, after the critical examination of the present fossil, most of the above-mentioned families need no comparison. The genera with which the present fossil resembles are *Terminalia* (*Combretaceae*), *Duabanga* (*Sonneratiaceae*), and *Lagerstroemia* (*Lythraceae*). In *Combretaceae*, the genus *Terminalia* has predominantly paratracheal parenchyma, uniseriate rays with moderately large vessels having vestured pits and often showing semi-ring porosity. Similarly, in *Lythraceae*, several species of the genus *Lagerstroemia* are predominantly semi-ring porous showing parenchyma and rays are very similar to *Terminalia* of *Combretaceae*. However, the most diagnostic feature of the fossil wood under investigation is chambered crystals in the fibers, a feature rarely found in dicotyledonous woods. In *Duabanga* of *Sonneratiaceae* crystals have peculiar shapes different from that of the present fossil. The present fossil wood shows anatomical details quite similar to that of the genus *Lagerstroemia* Linn. and thus, it has been described under the genus *Lagerstroemioxylon* (Mädler 1939). At present, there are about 50 species of trees and shrubs of the genus *Lagerstroemia*, chiefly distributed from South East Asia to Australia. The present fossil wood has been compared with the slides of Indian and foreign species of *Lagerstroemia* available at the "Wood Anatomy Section" of the Forest Research Institute, Dehradun, and also with published literature like Lecomte (1926), Pearson and Brown (1932), Metcalfe and Chalk (1950), Desch (1957), Kribs (1959), Normand (1960), etc. None of the species was found identical to the present fossil. A comparison was also made with the slides of different species of *Lagerstroemioxylon* available at the Birbal Sahni Institute of palaeobotany, Lucknow, e.g. *L. durum* Mädler 1939, *L. eoflosreginum* Prakash & Tripathi 1970, *L. parenchymatosum* Prakash 1965, *L. irrawaddiensis* Prakash & Bande 1980, *L. arcotense* Awasthi 1981, and *L. deomaliense* Lakhanpal et. al. 1981. On the basis of the comparison given above, the present fossil wood is described as a new species, i.e. *Laerstroemioxylon compactum.*

Lagerstoemioxylon delicatum Harsh & Shekhawat **sp. nov.**

Figure 4

Morphology

A well-preserved blackish piece of petrified wood measuring 22 × 6 × 4 cm with clear differentiation of growth rings. The outer portion is somewhat brownish in colour.

Anatomy

(1) Gross structures: Wood: Semi-ring porous. **Growth rings:** Distinct to the naked eye, delimited by larger early wood pores which grade gradually into smaller pores in the outer portion of growth rings. **Pores:** Earlywood pores are larger, clearly visible to the eye, latewood pores are small to very small, unevenly distributed and sparsely placed, exclusively solitary, circular to oval in outline, open or filled with blackish content. **Soft tissue:** Visible to the eye, distinct under a hand lens, mostly forming 3–5 cells thick circular ring surrounding each pore. **Rays:** Fine, not visible to the naked eye, distinct under hand lens appearing as closely placed and uniformly distributed lines in cross-section.

(2) Microscopic structure: Wood: Semi-ring-porous having a broad ring in which pores in the outer portion (Figure 3.1) small and larger ones in the inner portion, change in vessel size at the growth ring is not so conspicuous to observe by the naked eye. **Growth rings:** Present, delimited by larger vessels and a thin layer of 2–3 cells of darker fibers (Figure 4.1) Earlywood pores are arranged tangentially. **Vessels:** Mostly oval in shape but some circular-shaped vessels are also present. Exclusively solitary, exceptional tangential multiple of 4 vessels (Figure 4.5) is also present, at growth ring vessels are very close to each other, giving the appearance of tangential multiple and vary small to large in size, apart from growth ring vessels are sparsely present (frequency is very low) (Figure 4.2). In early wood the vessels are 125 to 210 μm in tangential diameter and radially 125 to 330 μm, while in the latewood vessels vary from 32 to 58 μm tangentially and 52 to 75 μm in radial diameter. Vessel wall thickness

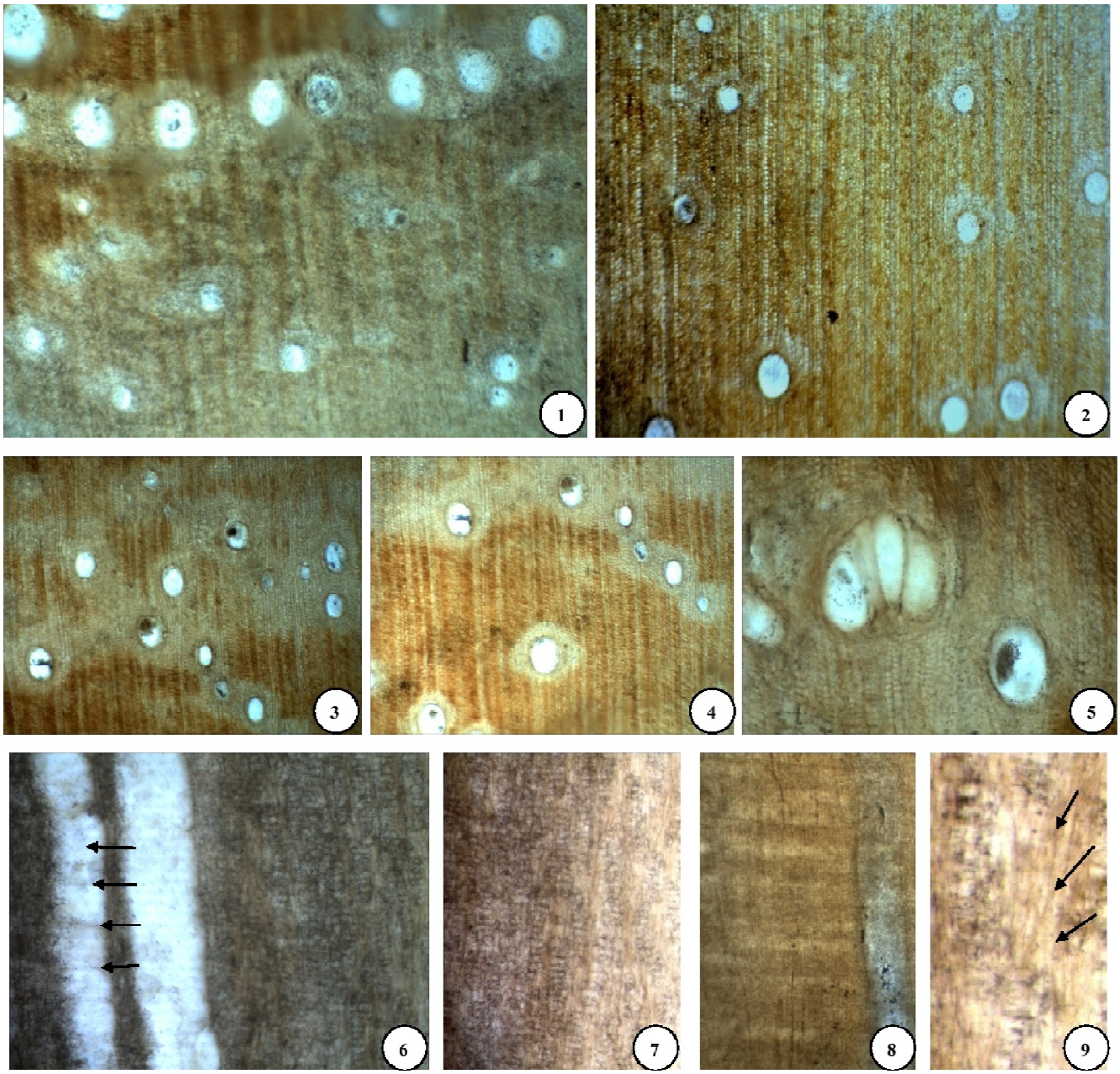

Figure 4. ***Lagerstoemioxylon delicatum*** Harsh & Shekhawat **sp. nov. 1.** T.S. wood, semi-ring-porous, circular to oval, exclusively solitary vessels, at growth ring frequency of vessels is normal. ×25. **2.** T.S. wood, apart from growth ring vessels sparsely present (frequency is very low) rays are straight. ×25. **3–4**. Same T.S. wood, showing paratracheal parenchyma vasicentric (4–6 layers) and aliform to aliform -confluent in oblique bands, abundant apotracheal diffuse parenchyma. ×15. **5**. T.S. wood, exceptional tangential multiple of 4 vessels. ×20. **6**. T.L.S. vessels elements very short (arrow) to large, showing transverse and slightly oblique perforation plate and thick-walled fibers. ×40. **7.** T.L.S. wood rays uni to biseriate, closely placed, separated by 3–5 layers of fiber. ×40. **8**. R.L.S. wood, showing vessels with transverse wall and procumbent cells of ray. ×40. **9**. T.L.S. wood, showing rays separated by septate fibers (arrow). ×100.

is approximately 3 to 4 µm. Vessel's frequency is comparatively lesser than the other taxa. In early wood, the frequency is 5.4 /mm^2, and in latewood, the frequency is 4/mm^2. Vessels are unevenly distributed in early as well as latewood portions. Vessel elements (Figure 4.6) are very short to large, length as measured in a longi-section range from 50 to 130 µm with an average length of 85.7 µm. Perforation plate simple,

end walls mostly transverse and slightly oblique, thick-walled fibers. Inter vascular pitting is not so distinct. **Parenchyma:** Parenchyma is distinct, paratracheal, vasicentric (4–6 layers) (Figure 4.2), sometime aliform to aliform-confluent involving 2–3 vessels in oblique bands (Figure 4.3–4), at growth ring continuous tangential parenchymatous bands are present. Abundant apotracheal diffuse parenchyma is also present. Parenchymatous cells are circular to angular in cross-sections ranging from 10 to 25 μm in diameter. **Fibers:** Aligned in radial rows of 3–5 in between two consecutive rays (Figure 4.9), circular to angular in cross-section, approximately 16.8 μm in diameter with wall thickness from 3.9 to 4.2 μm as measured in T.L.S. Inter fiber pits are not seen on radial walls due to poor preservation, the lumen in fiber near the end of a growth ring is absent. **Xylem rays:** Mostly uniseriate, exceptionally biseriate, in part may be triseriate in the middle portion (Figure 4.7) closely placed separated by 3–5 fibers, and 16–19/mm^2 (Tangential section), 8 to 37 cells high, measuring 87.2 to 676 μm in length. Almost homogeneous consisting of procumbent cells (Figure 4.8). The procumbent cells range from 24.3 to 25.2 μm × 21.4 to 23.9 μm in size.

Diagnosis: Wood: Semi-ring-porous. **Growth rings:** Distinct delimited by larger early wood pores which grade gradually into smaller pores. **Vessels:** Mostly oval, exclusively solitary, very small to large, early wood vessels diameter is 125 to 210 μm tangentially and 125 to 330 μm radially, in the latewood vessels 32 to 58 μm tangentially and 52 to 75 μm in radial diameter, wall thickness is 3 to 4 μm, in early wood frequency is 5.4 /mm^2, and in latewood, frequency is 4/mm^2. Vessels are unevenly distributed. Vessel elements average in length, 85.7 μm. **Parenchyma:** paratracheal, vasicentric (4–6 layers), sometime aliform to aliform-confluent covering 2–3 vessels, but oblique in bands, at growth ring continuous tangential parenchyma band are present. Abundant apotracheal diffuse parenchyma is also present. **Fibers:** Aligned in radial rows (3–5) in between two consecutive rays, circular to angular in cross-section, approximately 16.8 u in diameter with wall thickness from 3.9 to 4.2 μm. **Xylem rays:** Mostly Uniseriate exceptionally biseriate, frequency is 16–19/mm^2, 8 to 37 cells high, measuring 87.2 to 676 μm in length, homogeneous, procumbent cells range from 24.3 to 25.2 μm × 21.4 to 23.9 μm in size.

Holotype: Specimen no. BKN–W–25; Slide no.: W–25/1–5.

Repository: Palaeobotany Laboratory, Department of Botany, M.S. Government Girls College, Bikaner, India.

Locality and Age: Harsolav; Eocene.

Etymology: The specific name has been given due to the presence of an extraordinary amount of parenchyma (soft tissue).

Comparison: The present fossil wood has been compared to earlier wood no. 44. Anatomical details are quite similar to that of the genus *Lagerstroemia.* Wood was compared with the known living (*Lagerstroemia*) and fossil (*Lagerstroemioxylon*) species available at Forest Research Institute, Dehradun and Birbal Sahni Institute of Palaeosciences. Lucknow respectively and found it different. On the basis of comparison and characters of the wood, it has been identified as a new species, i.e. *Lagerstoemioxylon delicatum.*

PALAEOECOLOGY

It is obvious from the plant fossil data gathered from the Tertiary sediments of Rajasthan that the plants exhibit significant habitat variety. Extinct remains of *Cocos*, *Mesua* and *Garcinia* at Kapurdi, as well as pollen grains of palm, *Barringtonia*, *Rhizophora* and other plants, show that sea conditions existed in this area. The discovery of fossils of marine fishes, echinoderm, and other organisms supports this notion. However, megafossils, discovered from the west shelf of Rajasthan, such as broad and large-sized dicot plant leaves from Barmer, *Mangiferoxylon* and *Glutoxylon* from Jaisalmer, and the current collection of dicot woods described in this paper, support the presence of a warm and humid climate, but not necessarily of marine conditions.

On presence of two ecologically different types of fossil leaves from Rajasthan, lowland and highland habitats are thought to have existed throughout the Tertiary period. The sea intruded fairly deeply into the land in the former, creating a gulf-like formation. Plants such as *Cocos*, *Mesua*, *Garcinia*, *Rhizophora*, and others grew abundantly in the lowlands. While the climatic conditions were humid and warm in the 'upland' places, they were not affected by the 'sea gulf,' which is why broad and large-sized leaves are found in several Eocene localities on Rajasthan's West coast. Although, more database is required to further strengthen the above idea.

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