SONNERATIOXYLON FROM THE TERTIARY BEDS OF MOHGAONKALAN, M.P., INDIA

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ABSTRACT

A piece of fossil wood measuring 5 × 3·5 cm from the Deccan Intertrappean Series was collected by one of us (T.S.M.) at Mohgaonkalan, Dist. Chhindwara, M.P., India. Anatomy of it showed strong resemblance with the anatomy of stem in the genus *Sonneratia* L. (family-Sonneratiaceae), to which it in all probability belongs and, therefore, has been named as *Sonneratioxylon intertrappeum* sp. nov. A fossil fungus was obtained from this wood and it has been described separately elsewhere (Biradar & Mahabalé, 1972).

INTRODUCTION

A NUMBER of dicotyledonous woods from the Deccan Intertrappeans have been described by Rode(1936), Shukla (1941), Verma (1950), Prakash (1956, 1957, 1958 and 1962), Shallom (1960, 1963), Lakhanpal and Dayal (1962), Dayal (1964) and others from Mohgaonkalan (22° 1′N; 70° 11′E) in Dist. Chhindwara which is a well known fossiliferous locality of the Deccan Intertrappean Series in Madhya Pradesh, India. The specimen is a round piece of wood, measuring 5 cm in length and 3·5 cm in diameter. It consists of both secondary xylem and pith, but there is no cortex. Pith is not uniformly preserved, and hence it could not be studied entirely. The wood is very well preserved and appears to be an apical part of a stem or a young vegetative branch of medium-sized plant. The histological features of this fossil wood, as well as those of the twig in living *Sonneratia griffithii* agree. They were studied in different planes, viz., T.S., R.L.S. & T.L.S. and are described below.

DESCRIPTION

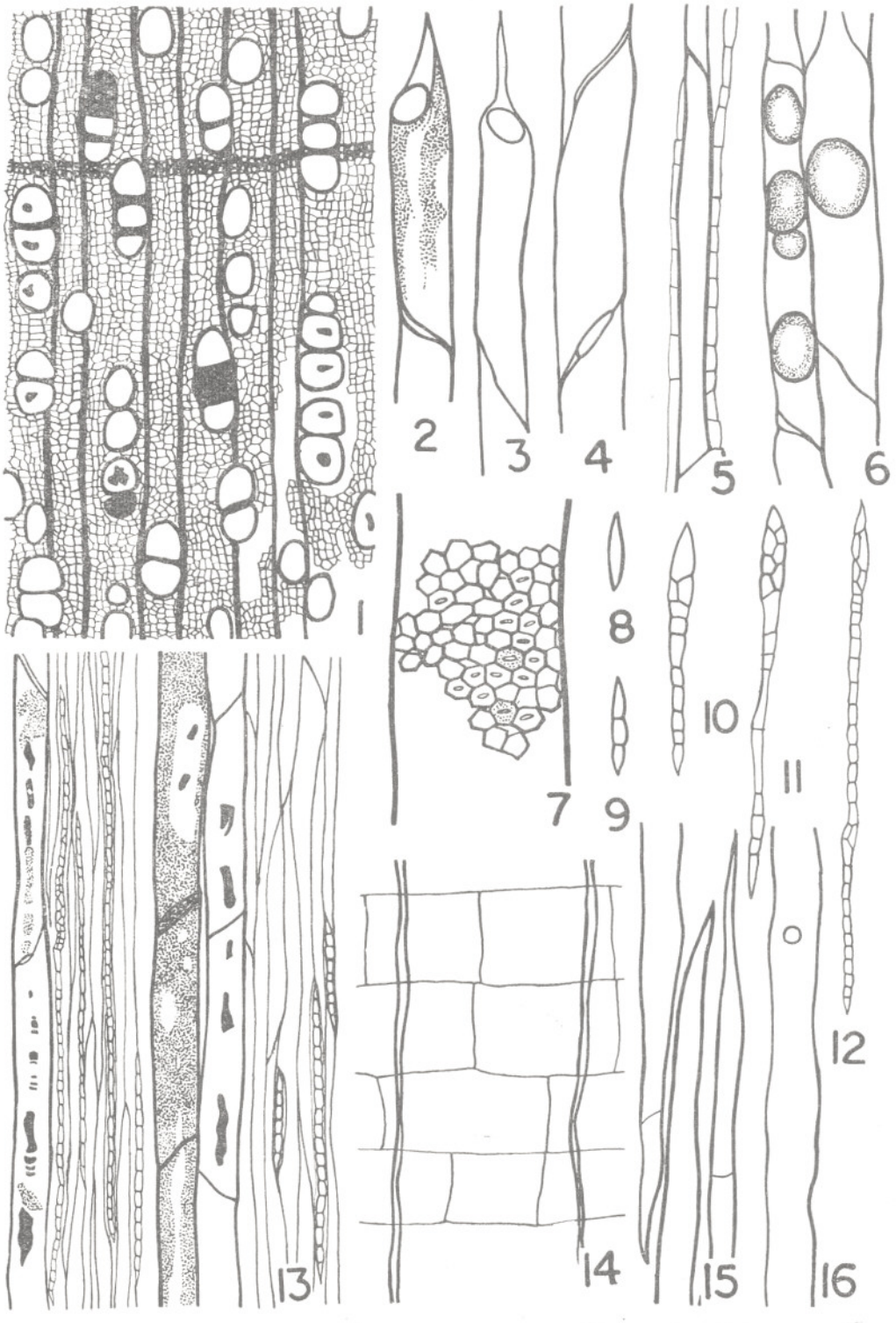
Family — SONNERATIACEAE

Genus — *Sonneratioxylon* Hofmann, 1952

Sonneratioxylon intertrappeum sp. nov.

Pl. 1, figs. 1-15; Text-figs. 1-16

The *wood* is diffuse porous (Pl. 1, figs. 1-3; Text-fig. 1), having distinct *growth rings* (Text-fig. 1). *Vessels* are visible as minute dots even to the naked eye against the ground mass. They are small to medium sized, solitary, and in radial multiples of 2-5, but mostly 2-3-celled. Occasionally they occur in irregular clusters, usually 28-30 per sq mm (Pl. 1, figs. 1-2; Text-fig. 1). Vessels are numerous, crowded, 45 per sq mm towards the pith region. The solitary vessels 84×64 μ are round to oval in T.S., those in radial multiples are round or square and tangentially flattened due to mutual pressure (Pl. 1, fig. 1; Text-fig. 1). Each vessel in the radial multiple group measures 75 ×75 μ. Small to medium-sized vessel elements measure 187×75 μ in L.S., the larger ones measure 546×76 μ. The vessel elements get attenuated at one or both the ends; or they may be obliquely inclined or truncate. Vessel perforation is simple (Pl. 1, fig. 6; Text-figs. 2-4). Intervessel pits small, 6-7 μ in diameter, circular, hexagonal, vestured with linear-lenticular, horizontal apertures (Pl. 1, figs. 8-9; Text-fig. 7). Tyloses are numerous, thin, brownish to pinkish in colour. They occur in great



TEXT-FIGS. 1-16

profusion (Pl. 1, fig. 7; Text-fig. 6). In a number of places, the vessels in T.S. and L.S. are filled with brown to dark brown contents appearing as secretary canals (Pl. 1, fig. 14; Text-fig. 13). Vessel-ray pits not seen (Pl. 1, figs. 4 & 5).

Xylem parenchyma is totally absent.

Xylem rays indistinct to the naked eye, but visible under a microscope, closely, spaced as radiating lines on the transverse surface of the wood. Each ray is separated by 1-3 tangential rows of fibres. They are fine, uniseriate to biseriate, but mostly uniseriate (Pl. 1, figs. 10, 12, 13; Text-figs. 8-13). Ray tissue thin-walled, heterogeneous, 1-80 cells high, made up of upright and square cells (Pl. 1, figs. 10, 12, 13; Text-figs. 11-13). The upright cells measure 54×15 μ, and the square cells 21×21 μ. A number of leaf traces (knots) are clearly seen in T.L.S. in their developmental stages (Pl. 1, figs. 11, 12). In L.S. the rays touch vessel walls (Text-fig. 5). The uniseriate rays become biseriate at places (Pl. 1, figs. 10, 13; Text-fig. 12). They show considerable variation in their height. A few are one-celled, others 3-4 celled, still others 7-30 celled, while still others are as high as 80 cells.

Fibres are thin-walled to slightly thick-walled, aligned in radial rows, short and tapering at both ends (Pl. 1, fig. 13; Text-fig. 15). They are sometimes singly septate, but mostly non-septate, rectangular to square in T.S. (Pl. 1, figs. 2-3; Text-figs. 1 & 15). The smaller cells measure 18×20 μ, and the larger ones 19×27 μ. The tapering fibres measure 592×23 μ in L. S. Inter-fibre pits are sometimes present, but unpitted fibres are more common.

DISCUSSION

Comparison of the Present Wood with that of Living Species of Sonneratia — The important characters of the genus *Sonneratia* are: vessels numerous but uniformly distributed, solitary or in multiples of 2-4, mostly 2-3, open or occluded with tyloses. Vessel segments attenuate, tailed or truncate with simple perforations, growth rings inconspicuous but distinct; vestured pits present; parenchyma absent; fibres sometimes septate; fine xylem rays uniseriate to biseriate, heterogeneous, a few to many cells in height. The characters of the present fossil wood show the closest resemblance with the wood of the living genus *Sonneratia* Linn. belonging to the family Sonneratiaceae (*vide* Metcalfe & Chalk, 1950; pp. 660-664; Pearson & Brown, 1932, pp. 600-605).

For ascertaining further identity of the fossil, it was compared with the sections of young and old stem of the living species of *Sonneratia*, *S. apetala* Ham., *S. acida* Benth., *S. alba* Griff. and *S. griffithii* Kurz. A careful examination of the anatomy of stem in these species showed that the present fossil does have a very close resemblance with the medium-sized young stem of *S. griffithii* Kurz, of all the living species, in the major characters. This species does not occur in Deccan today but is common in the Sunderbans near Calcutta and Malay Islands.

Comparison with Fossil Species of Sonneratia — Fossil woods resembling *Sonneratia* have been named as *Sonneratioxylon* by Hofmann (1952) and were described by various authors as cited below.

Four species of *Sonneratioxylon*, three Indian and one Austrian, are known so far. Awasthi (1968) has described *S. preapetala* from the Middle Tertiary of South India. Krishna Rao and Ramanujam (1966) have described *S. dudukurense* from the Deccan Intertrappean Series at Dudukur, Rajahmundry, Andhra Pradesh. Ramanujam (1957) has also described *S. dakshinense*

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TEXT-FIGS. 1-16 — *Sonneratioxylon intertrappeum* sp. nov. Fig. 1. T.S. of secondary wood showing arrangement of vessels in multiple groups of 2 & 3: Note that some of the vessels are filled with a brownish substances at places × 95. Figs. 2-4. L.S. of vessel showing the tapering end and oblique perforation in Fig. 3 × 145. Fig. 5. T.L.S. of a vessel showing adpressed nature of xylem rays on both sides × 145. Fig. 6. L.S. of vessel showing numerous tyloses × 145. Fig. 7. L.S. of vessel magnified to show the nature of pitting: Note that some of the pits are vestured × 645. Figs. 8-12. Uniseriate and biseriate xylem rays, Figs. 8-11 × 145 and Fig. 12 × 95. Fig. 13. T.L.S. showing xylem rays, fibres and vessels: Vessels at some places are filled with brown contents × 95. Fig. 14. R.L.S. showing absence of vessel ray pits × 85. Fig. 15. L.S. of fibres showing transverse septa × 495. Fig. 16. L.S. of a fibre showing a simple pit × 495.

from the Tertiary of South Arcot District, Tamil Nadu. All these woods come from the Tertiary beds of Southern India. *Sonneratioxylon prambachense* described by Hofmann (1952) is also a Tertiary species belonging to the Oligocene of Austria. In addition to these, Verma (1950) and Shallom (1963) have compared some fossil woods with the living *Sonneratia*, but without fixing their generic or specific rank. They only stated that their wood resembles with the wood of the living *Sonneratia* (see Table 1).

Characters of the present fossil wood resembles somewhat with those of *S. preapetala* of Awasthi (1968), but it differs from that wood in having distinct growth rings, xylem rays nearly uni-biseriate, 1-80 cells in height. In Awasthi's wood growth rings are absent and xylem rays 3-20 cells high, mostly uniseriate.

It also resembles in some characters with *S. dudukurense* of Krishna Rao and Ramanujam (1966) obtained at Dudukur near Rajahamundary (A.P.). But it differs from their wood in having distinct growth rings, vessels numerous, solitary or mostly in radial groups of 2-3, xylem rays heterogeneous, 1-80 cells in height. Fibres are sometimes singly septate and pitted. In *S. dudukurense* growth rings are absent, vessels are solitary, but sometimes 2-3-celled in radial groups; xylem rays homogeneous, 2-15 cells in height and fibres profusely pitted and usually with one or two septa.

The present fossil wood also differs from *S. dakshinense* described by Ramanujam (1957) from Mortandra, a well known Tertiary locality near Pondicherry (South India), in having distinct growth rings, absence of vessel-ray pits, heterogeneous ray cell and 1-80 cells, high xylem rays as against the absence of growth rings, presence of vessel ray pittings, homogeneous xylem rays 3-12 cells high in that species, viz., *S. dakshinense*.

The fossil wood *S. prambachense* of Hofmann (1952) from the Oligocene of Austria also shows some resemblance with our wood. But that wood differs from the present material, mainly in having paratracheal parenchyma which is absent in our specimen.

In 1963, Shallom described a fossil wood from Paladon, Dist. Chhindwara and placed it under the family Sonneratiaceae. She compared this wood with the wood of two living genera of this family, viz., *Sonneratia* and *Duabanga*, particularly with *Sonneratia*. But she has not indicated that it belongs to one or the other genus; nor does she name it as *Sonneratioxylon*. She has only vaguely suggested that her specimen belongs to the Sonneratiaceae.

The present specimen differs from her wood in having distinct growth rings and xylem rays with square and upright 1-80 cells high, vessel ray pits being absent. In her wood the growth rings are said to be absent and xylem rays homogeneous, its cells being upright, 4-31 in height. Vessel ray pits in her wood are present.

Verma (1950) has described a fossil wood resembling *Sonneratia* from Mohgaonkalan in the Deccan Intertrappean Series. However, in our wood, growth rings are distinct, xylem rays heterogeneous, uni-biseriate, 1-80 cells high, as against the absence of growth rings in Verma's wood, having homogeneous to aggregate heterogeneous xylem rays and gum canals. He further states that xylem rays are homogeneous in his wood but they appear to be heterogeneous near a knot with leaf traces, as in our specimen. Verma (1950) however, thought that these may be the gum canals.

Our wood also resembles in some characters with *Dryoxylon mohgaoense* of Rode (1936) obtained from Mohgaonkalan. But the present wood differs in having xylem rays 1-80 cells high, nonpitted and without any contents. Xylem parenchyma is also absent here. In *D. mohgaoense* xylem rays are 6-20 cells high, pitted, and have gum-like contents. Xylem parenchyma is present.

In the Tangential sections of the stem and branches of living species of *Sonneratia*, numerous knots are seen, just as in the present fossil. They have not been reported in any of the previously described species of *Sonneratioxylon*. Previous, workers on *Sonneratioxylon* have attached much importance to the presence of septa on the fibres in the wood. In the living wood septa in fibres represent primary wall, which may be badly preserved or not at all. In a few woods they may be partly preserved or may be totally absent, in living as well as in fossil.

The same holds good for the pits on fibres. An evolved fibre may not show clear pitting on it, as its lumen gets much reduced, there by allowing a very small space for pits. Moreover, the pits are seen on radial walls

TABLE 1 — GIVING COMPARISON OF THE STRUCTURAL CHARACTERS OF FOSSIL INDIAN SPECIES OF *SONNERATIOXYLON* HOFMANN WITH THEIR AGE AND LOCALITY

S. No.	Fossil species	Growth rings	Vessels				Paren-chyma	Xylem rays	Fibres	Locality	Horizon and age	Remarks
			Shape, size and distribution of vessels	Perforation	Pitting	Tyloses						
1.	*Sonneratioxylon intertrappeum* sp. nov.	Present	Round to oval when solitary, square and flattened in radial multiples of 2-3; vessels numerous; small to medium-sized, 28-30 per sq mm. Solitary vessel in T.S. measure 84 × 64 μ	Simple, end plate attenuated	Intervessel pit pairs bordered, 6-7 μ, alternate, hexagonal with lenticular, horizontal orifices, Vessel ray pits not seen	Present	Absent	Uni-biseriate, mostly uniseriate, heterogeneous; made up of upright and square cells; upright cells 54 × 15 μ, square cells 21 × 21; height 1-80 cells	Angular, small to medium sized, tapering at both ends; small cells 18 × 20 *u*, large-19 × 27 μ in L.S. 592 × 23 μ. Pits and septa sometimes present	Mohagaonkalan, Dt. Chhindwara, M.P.	Deccan Int. Ser. Early-Eocene	Resembles with the modern Twig wood of *Sonneratia griffithii* Kurz
2.	*S. preapetala* Awasthi (1968)	Not seen	Solitary vessels circular to oval, those in radial multiples of 2-4 cells, flattened, mostly medium sized, 28-50 per sq mm measuring t.d. 45-150 μ, r.d. 45-165 μ	Simple, end plate truncated or slightly tapered	Intervessel pits medium to large, 6-8 μ, circular or oval, vestured; lenticular aperture, vessel ray pits not seen	Present	Absent	Uniseriate, rarely biseriate, heterogeneous; procumbent cells 14-20 μ, square cells 32-48 μ; ray cells-containing solitary crystals; rays 3-20 cells in height	Oval to angular, septate; pits not seen	Chinnakottaikuppam, Pondicherry, South India	Cuddalore Sseries Middle Tertiary	Resembles *Sonneratia apetala*-Ham.
3.	*S. dudukurense* Krishna Rao and Ramanujam (1966)	—	Vessels mostly solitary sometimes in radial multiples of 2-3. Tangential diameter of vessels mostly 70-95 μ, 15-20 per sq mm	Simple, oblique	Intervessel pits vestured alternate or angular	Present	Absent	Uni-biseriate, mostly uniseriate, 2-15 cells high	Angular 18-25 μ in diam. 750-950 μ in length; septate; pits on the fibres in 1 or 2 rows	Dudukur, Rajahamundry	Intertrappean Series Eocene	Compared with *Sonneratia* rather than with *Duabanga* by Ramanujam (1966)
4.	*S. dakshinense* Ramanujam (1956)	Absent	Orbicular to oval or flattened, mostly small sometimes of medium size, solitary to radial multiples of 2-3	Simple, mostly oblique, attenuated	Intervessel pitting, vestured, alternate, hexagonal; vessel ray pits minute and many	Absent	Absent	Mostly uniseriate, rarely biseriate, homogeneous 3-12 cells high	Polygonal, short, distinctly septate; pits few, minute, simple	Mortandra, Pondicherry, South India	Cuddalore Series, Middle Tertiary	*Sonneratia apetala and S. acida*
5.	Fossil wood of *Sonneratia* by Shallom (1963)	Absent	Vessels solitary or in multiples of 2-3	Simple, plate oblique to horizontal	Intervessel pitting bordered, alternate, vestured, round sometimes hexagonal; vessel ray pits smaller	Sometimes seen	Absent	Uniseriate, sometimes biseriate, homogeneous very slightly heterogeneous, rays 4-31 cells high	Angular, of same size and shape; non-septate and non-pitted; 600-1000 μ in length and 17-22 μ in diameter	Paladon, Dt. Chhindwara, M.P.	Deccan Intertrappean Series, Eocene	Compared with *Sonneratia and Duabanga* by Shallom (1963)
6.	Fossil wood of *Sonneratia* by Verma (1950)	Absent	Vessels numerous, small, in radial multiples and clusters	Simple, plate nearly horizontal to oblique	Intervessel pits pairs bordered, circular or oval	Sparse	Absent	Two types (1) Uniseriate-homogeneous; (2) Aggregate-heterogeneous with 1-3 resin canals in the body of the ray	Angular	Mohgaonkalan, Dist. Chhindwara, M.P.	Deccan Intertrappean Series, Eocene	Compared with *Sonneratia* by Verma (1950)

rather than on tangential walls. It should be remembered, therefore, that these two characters are rather flexible and should be taken into account along with other characters of the plant, rather than singly or each exclusively.

The present wood thus shows a very close resemblance with that in the genus *Sonneratia* (family-Sonneratiaceae) and has been placed under the form genus, *Sonneratioxylon*, of Hofmann. It has been named *Sonneratioxylon intertrappeum* sp. nov., the specific name indicating the Intertrappean Series from which it came. Further it shows the closest resemblance with the wood of a living species, *Sonneratia griffithii* Kurz.

The two form genera *Sahnianthus* and *Enigmocarpon* reported from the Deccan Intertrappean Series have been assigned to the family Sonneratiaceae rather than to Lytheraeae by Mahabale and Deshpande (1957). Chitaley (1968) has described its roots *Sonneratiorhizos*, showing similarities with the roots of *Sonneratia*. Thus on the basis of analogy of the fruit, root and stem, the occurrence of the genus *Sonneratia* in the Deccan Intertrappean Series looks a certainty. Chitaley (1968) while discussing the affinities of the dicot root, *Sonneratiorhizos raoi*, refers to a fossil dicot wood described by Shallom (1963) as *Sonneratioxylon duabangoides*. But Shallom (1963) in her own paper on "Fossil dicotyledonous wood from the Deccan Intertrappean beds of Chhindwara" has neither given the generic nor specific name to her wood nor has created the type for it. Shallom (1963) has not named her fossil wood as *S. duabangoides* as Chitaley (1968) states. This, therefore, is an example of *Nomina nudum*, and as such has to be rejected, not-withstanding the similarities pointed out by Shallom (1963). *Sonneratia* and *Duabanga* are two separate genera of the same family, but she has combined the names of two genera in one. One is made the generic name (*Sonneratioxylon*) and the other *Duabanga*, as specific name of the same wood, '*duabangoides*'. This is very confusing and has to be rejected as no holotype having that name has been prescribed by Shallom (1963).

Sonneratia is a small genus having 5-6 species spread in the Indo-Malayan region of which more than 4 species occur in India. It should not be surprising therefore, if we had more than one species of it in fossils in the Tertiary flora of India at different places.

The woods described by Rode (1936), Verma (1950) and Shallom (1963) apparently seem to be the same. These woods also, show resemblance with the present wood specially those described by Verma (1950) and Shallom (1963). As they have not attributed to their specimen any particular specific name, these woods are being merged with the present species, *S. intertrappeum* n. sp.

Diagnosis — *Wood* diffuse porous. *Vessels* numerous, 28-30 per sq mm, small solitary as well as in radial multiples of 2-5, mostly 2-3, solitary vessel round to oval, measuring 84×64 μ in T. S., short vessel elements measure 187×83 μ and long vessel elements 546×76 μ; vessels filled with brown to dark contents; end walls attenuated, tailed, thin-walled; perforation simple; tyloses present at places. Inter-vessel pits numerous, vestured, alternate, round to hexagonal, 6-7 μ, with linear-lenticular, horizontal orifices. *Parenchyma* absent, *xylem rays* fine, 1-80 cells in height, uniseriate, occasionally biseriate; ray tissue heterogeneous consisting both of upright and square cells measuring 54×15 μ and 21×21 μ respectively; leaf traces seen in different stages of development. *Fibres* angular, cells small and large, small cells measuring 18×20 μ and larger ones 19×27 μ, sometimes septate and pitted.

Locality — Mohgaonkalan, Dist. Chhindwara, M.P.

Horizon — Deccan Intertrappean Series, India.

Age — Tertiary (Eocene).

Type Specimen — 1/68, Botany Department, University of Poona, Poona-7.

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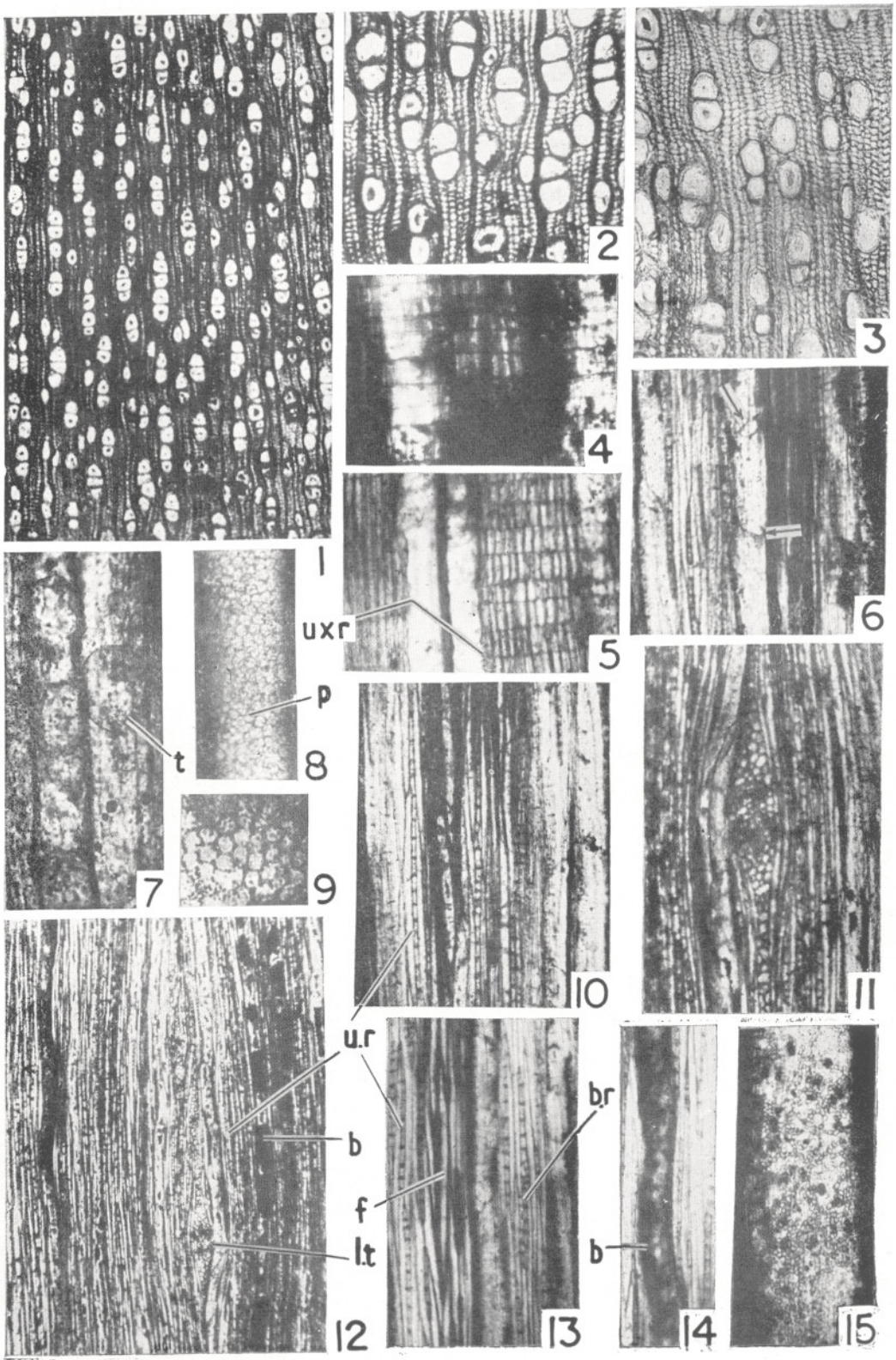
EXPLANATION OF PLATE

PL. 1, FIGS. 1-15 — *Sonneratioxylon intertrappeum* sp. nov.

FIG. 1 — T.S. of a secondary wood: Note vessels in multiple groups of 2 and 3 × 90. Fig. 2. The same showing a part of the central region of wood magnified × 150. Fig. 3. The same: A part from peripheral region of the wood magnified × 150. Fig. 4. R.L.S. showing absence of vessel ray pittings × 35. Fig. 5. The same: showing uniseriate xylem ray cells — *uxr* as if storied × 35. Fig. 6. T.L.S. showing uniseriate xylem rays and vessels with oblique perforations and tapering end plates × 35. Fig. 7. L.S. of vessel showing numerous tyloses — *t* × 60. Fig. 8. L.S. of vessel showing pittings — *p* × 90. Fig. 9. A portion of the same magnified to show the alternate arrangement of pits and some vestured pits × 170. Fig. 10. T.L.S. showing uniseriate — *ur* and partially biseriate xylem rays × 35. Fig. 11. Leaf trace (Knot) in T.L.S. × 30. Fig. 12. T.L.S. showing uniseriate xylem rays — *ur*, leaf traces — *lt* and vessels filled with a brown substance — *b* × 15. Fig. 13. T.L.S. showing short tapering fibres — *f*, uni-*ur* and biseriate — *br* xylem rays × 35. Fig. 14. L.S. showing vessels filled with a brown substance — *b* × 25. Fig. 15. L.S. of a vessel showing heavy infection caused by an Imperfect fossil fungus — *Tetracoccosporium eocenum* × 130.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