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Fossil wood of *Gmelina* Linn. (Verbenaceae) from the Deccan Intertrappean beds of Nawargaon with comments on the nomenclature of Tertiary woods

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A fossil dicotyledonous wood collected from the Deccan Intertrapean beds of Nawargaon, District Wardha, Maharashtra has been described. It has been assigned to the extant genus *Gmelina* Linn. of Verbenaceae and has been described as a new species *Gmelina tertiara*. This is the first authentic record of the family Verbenaceae from the Deccan Intertrappean beds, which extends the antiquity of this family to the Palaeogene in the Indian Subcontinent. The problem of the nomenclature of Tertiary fossil woods has also been discussed.

Key-words—Xylotomy, *Gmelina*, Verbenaceae, Deccan Intertrappean beds, Palaeogene (India).

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सारॉंश

तृतीयक युगीन काष्ठाश्मों की नामपद्धति पर टिप्पणियों सहित नवरगाँव के दक्खिन अन्तर्ट्रेपी संस्तरों से जिमॅलाइना लिन्नेयस (वर्बीनेसी) की काष्ठाश्म

मोहन बलवंत बाँडे

महाराष्ट्र के वर्धा जनपद में नवरगाँव के दक्खिन अन्तर्ट्रेपी संस्तरों से एकत्रित एक द्विबीजपत्री काष्ठाश्म को वर्बीनेसी कुल की वर्तमान प्रजाति जिमॅलाइना लिन्नेयस से नामाँकित किया गया है तथा जिमॅलाइना टर्शियॅरा नव जाति के नाम से इसका वर्णन किया गया है। दक्खिन अन्तर्ट्रेपी संस्तरों से वर्बीनेसी कुल का यह प्रमाणसिद्ध अभिलेख है जिससे भारतीय उपमहाद्वीप में पूर्व-तृतीयक युग में इस कुल की उपस्थिति इंगित होती है। इसके अतिरिक्त इस शोध-पत्र में तृतीयक युगीन काष्ठाश्मों की नामपद्धति की समस्या भी विवेचित की गई है।

ALTHOUGH the occurrence of fossil plants in the Deccan Intertrappean beds around Nawargaon (Wardha District, Maharashtra) was reported as early as 1916 by Haines (Shukla, 1946, p. 106), till about a decade ago only a few of them were described in detail. Shukla (1941) first recorded a fossil palm, *Palmoxylon nawargaoensis* from near Nawargaon and later on described one more species of *Palmoxylon, P. sclerodermum* Sahni from these beds (Shukla, 1946). Sahni (1964) also described a species of *Palmoxylon, P. intertrappeum* from the same area. The interest in the study of fossil plants of this region was revived after a gap of many years with the finding of a fossil wood comparable with the modern wood of *Aristolochia* by Kulkarni and Patil (1977b). Prakash and Ambwani (1980) and Ambwani (1981) described two more species of *Palmoxylon* from these beds of which one has been said to possess affinities with the modern genus *Livistona*. Similarly, Kulkarni and Patil (1977a) and Shete and Kulkarni (1980) have also described two palm peduncles *Palmocaulon costapalmatum* and *P. hyphaeneoides* from these beds of which affinities of the second species have been traced to the coastal branched palm *Hyphaene*. It is interesting to note that a fossil fruit showing a close similarity with the fruits of this genus has also been described from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh by Bande, Prakash and Ambwani (1982). Besides *Aristolochioxylon prakashii*, described by Kulkarni and Patil (1977b), the dicotyledonous plants so far described from these beds consist of fossil woods comparable to the modern genera *Evodia, Amoora, Aeschynomene, Sonneratia, Ardisia, Heterophragma* and *Phyllanthus* of the families Rutaceae, Meliaceae, Leguminosae, Sonneratiaceae, Myrsinaceae, Bignoniaceae and Euphorbiaceae respectively (Shete & Kulkarni, 1982; Bande & Prakash, 1984; Prakash, Bande & Lalitha, 1986). All the plant fossils so far described from this area have been listed in Table 1 and to this list one more fossil wood is being added through this paper. It has been assigned to the modern genus *Gmelina* of Verbenaceae. The occurrence of such a variety of forms from these beds indicates that further work on the fossil flora of this area would be of great help in dealing with the problems of palaeovegetation, palaeoclimate, palaeogeography, etc.

in central India during the Deccan Intertrappean period.

Nawargaon (20°1′ and 78°35′ E) is a small forest village approachable from Wardha via Paunar, Sailu and Bordam. The Deccan Intertrappean beds are exposed on both the sides of the forest road which joins the villages Nawargaon and Sindhi Vihira. The fossil woods occur as stray pieces in the fields all along this road and also on slopes of the hills near the villages Nawargaon and Maragsur (Bande & Prakash, 1984, Maps 1, 2). The wood which is described here was collected from the base of one such hillock. However, before it is described in detail, the problem of the nomenclature of Tertiary fossil woods is discussed in detail.

Nomenclature—The nomenclature of fossil woods, especially Tertiary onwards, has always remained a matter of personal choice and also controversy Although different authors have used different names for describing them, the most common practice (followed by the present author also till recently) is to describe them under a new generic name coined by adding the ending *oxylon* or *inium* to the name of the nearest modern genus or the family. Sometimes they are also named after their rock formation or age. However, in the past few years the use of modern generic names without the ending *-oxylon* has become quite common when the generic affinities of the fossil wood are considered certain. This practice has been opposed by many workers and some of them have even gone to the extent of systematically adding the ending—*oxylon* to the names of those fossil woods described under modern generic names. This problem has been dealt with in great detail by Lakhanpal and Prakash (1980) and the salient points of their discussion as well as conclusions are summarised here for ready reference and also to explain the present author's shift from describing a fossil wood under a generic name ending with—*oxylon* to describing it under modern genus.

The main argument raised against describing a fossil wood as a species of a modern genus is that it is not possible to designate a fossil wood as a new species of an extant genus because the types of extant genera are entire plants; in the generic diagnosis (of the extant genera) no data about the wood structure are to be found. Therefore, one cannot place any species whose holotype is a wood in an extant genus. Whenever no connection with other organs can be demonstrated, a detached organ of a fossil plant can only be placed as a species of an organ genus, which frequently will have the characters of a form genus (Lakhanpal & Prakash, 1980, p. 201).

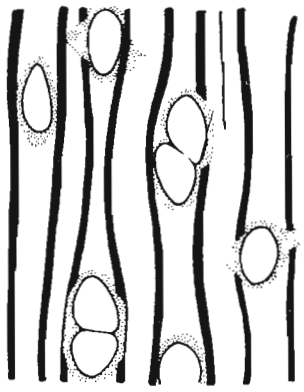
Lakhanpal and Prakash (1980, p. 202) have replied to these objections by quoting the observations made by Matten *et al.* (1977, p. 207) that....

"There does not appear to be anything in the 1972 International Code of Botanical Nomenclature which justifies such an approach to assigning names. According to the Article 9, the type of a species or a taxon below the rank of species is a single specimen or other element. If it is possible to have as the type of an extant species only part of an entire plant, as indicated by the word element, then why fossil (almost invariably detached organs) cannot be assigned to modern genera is unclear."*

Lakhanpal and Prakash (1980, p. 202) have further mentioned that there is a general aversion, especially on

Table 1—Fossil plants so far described from the Deccan Intertrappean beds of Nawargaon and nearby area

Fossil Species	*Comparable living Taxa*	*Reference*
PALMAE		
Palmoxylon nawargaoensis	Palmae	Shukla, 1941
P. sclerodermium	Palmae	Shukla, 1946
P. intertrappeum	Palmae	Sahni, 1964
P. livistonoides	*Livistona*	Prakash & Ambwani, 1980
P. arviensis	Palmae	Ambwani, 1981
Palmocaulon costapalmatum	Palmae	Kulkarni & Patil, 1977a
P. hyphaeneoides	*Hyphaene*	Shete & Kulkarni, 1980
RUTACEAE		
Evodinium indicum	*Evodia roxburghiana*	Bande & Prakash, 1984
E. intertrappeum	,,	Shete & Kulkarni, 1982
MELIACEAE		
Amooroxylon deccanensis	*Amoora rohituka* & *A. wallichii*	Bande & Prakash, 1984
LEGUMINOSAE		
Aeschynomenoxylon nawargaoensis	*Aeschynomene indica*	Shete & Kulkarni, 1982
SONNERATIACEAE		
Sonneratioxylon nawargaoensis	*Sonneratia* sp.	Bande & Prakash, 1984
S. caeseolarioides	*Sonneratia caeseolaria*	Shete & Kulkarni, 1982
MYRSINACEAE		
Ardisioxylon indicum	*Ardisia involucrata* & *A. paniculata*	Shete & Kulkarni, 1982
BIGNONIACEAE		
Heterophragmoxylon indicum	*Heterophragma adenophyllum*	Shete & Kulkarni, 1982
VERBENACEAE		
Gmelina tertiara sp. nov.	*Gmelina arborea*	
ARISTOLOCHIACEAE		
Aristolochioxylon prakashii	*Aristolochia* sp.	Kulkarni & Patil, 1977b
EUPHORBIACEAE		
Paraphyllanthoxylon palaeoemblica	*Phyllanthus emblica*	Prakash, Bande & Lalitha, 1986



Text-fig. 1 — *Gmelina tertiara*: Cross section showing vessels in radial pairs, paratracheal vasicentric to aliform parenchyma and xylem rays. × 85; Slide no. B.S.I.P. 35770/1.

the part of taxonomists dealing with living plants to accept species based on fossil material as belonging to extant genera. At the same time it is common knowledge that almost all plants of the Quaternary and most species of the Late Tertiary are structurally identical with extant plants even while only their dispersed organs are compared. Why they should not be included in the same genera, when the basis of identification is primarily morphological comparison? If fossil plants are deliberately kept apart from the living, it would be impossible to trace the appearance, distribution and evolution of modern taxa in the geological time, thus defeating the main objects of the study of fossil plants. They have, therefore, advocated that whenever there is a close similarity between the structure of a fossil (dicot woods included) with that of a modern genus, it should be assigned to the later.**

Before the present author was fully convinced about the above suggestion an argument which still remained unexplained was that before describing a fossil wood as a new species of a modern genus one must be sure that it differs from all the known species of the genus in its wood anatomy. However, it is usually a rare chance that all the modern species of a genus are available for comparison with the fossil. Further, these species may not be separable from each other on the basis of wood anatomy alone. How far, then, will it be justified to describe a fossil as a new species of a modern genus? By putting it under a different genus, i.e. by adding—*oxylon* we can avoid this mistake. The point was raised by the present author in a personal discussion with Dr Lakhanpal to which his reply was "by trying to avoid the mistake of creating a wrong species you are committing a bigger mistake of describing your fossil under a new genus!"

Another discrepancy pointed out by Lakhanpal and Prakash (1980, p. 203) is that though some advocates of compulsory organ genera say that they add *oxylon* to the name of the modern genus because they are sceptical about the generic identity of the fossil wood found detached from its parent plant, yet when they make palaeoecological deductions from these taxa, they tend to regard them in terms of their comparable modern genera. This sounds rather paradoxical. They make new organ genera by adding *oxylon* to the comparable extant genera and they derive ecological inferences on the basis of these extant genera, thus all the time admitting the affinity of the fossil with them. Why not describe these fossils as species of such extant genera where the structural similarity is definite? Why be afraid of a possible mistake in identification? A great advantage of the above proposal is that if such reference of a fossil wood to a modern genus is subsequently found to be erroneous, it can easily be transferred to another more appropriate modern genus, for which the International Code provides suitable rules. On the other hand, a fossil dicot wood referred to a new organ genus cannot be transferred to another organ genus even if its affinities are changed, warranting a change in the name, because Article 62 of the International Code of Botanical Nomenclature prohibits such a change. It says: "A legitimate name or epithet must not be rejected merely because it is inappropriate or disagreeable, or because another is preferable or better known, or because it has lost its original meaning". For example, the fossil wood of *Hopeoxylon indicum* Navale (1963), originally thought to be a wood of *Hopea* of the family Dipterocarpaceae, has now been found to belong to the genus *Sindora* of Leguminosae (Awasthi, 1977). As we are not allowed to change the name of the genotype even if its affinities are changed, we would always be using the name *Hopeoxylon* for the fossil wood of *Sindora* thus creating a lot of confusion. In the preamble of the International Code of Botanical Nomenclature it is said that "This code aims at the provision of a stable method of naming taxonomic groups, avoiding and rejecting the use of names which may cause error or ambiguity or throw science into confusion". Seeing the above example, the use of modern generic name in this case would definitely have avoided the confusion created by the forced organ genera.

Lastly, quoting Lakhanpal and Prakash (1980, p. 203) again, : let us consider the proposition of Müller-Stoll & Mädel (1967) that a detached organ of a fossil plant can only be placed as a species of an organ genus because of the uncertainty of its representing one natural species or several. For this it must be admitted that the species of fossil woods or any other fossil organs referred to extant genera are species in a restricted sense, which may be termed as *organ species*. These organ species do not have the circumscription comparable with that of natural species. An organ species might very well include fossils

*This statement holds true also with the 1983 edition of the International Code of Botanical Nomenclature, Sydney.

**It is worth to quote here article 13.3 of the code (1983 edn.) which says that whether a name applies to a taxon of fossil plants or of recent plants is decided by reference to the specimen that serves directly or indirectly as its nomenclatural type.

representing several natural species if the whole plants were known or it may have been produced by one extinct species of the genus living in the geological past. This understanding and recognition of the fact that the fossil species of a modern genus are organ species provides a reasonable solution to this issue. Thus, in agreement with the suggestions made by Lakhanpal and Prakash (1980, p. 204), the present author is also of the view that:

1. In those cases where anatomical details of fossil dicot woods are well preserved and it is possible to assign them to modern genera based on comparative studies of authentic modern woods, the fossil woods should be given modern generic names without adding the suffix *oxylon*.

2. In such cases where two or more modern genera of a family are anatomically indistinguishable and it becomes impossible to assign a fossil wood to any one of them, an organ genus with the suffix *oxylon* is preferred. The ending *oxylon* should be added to any one of the modern genera, preferably following the alphabetical priority.

3. In cases where a fossil wood is anatomically very similar to the mature wood of a modern genus and other structurally similar representatives but not identical to any of them then an organ genus should be coined by adding the suffix *oxylon* and the prefix *para* to the name of the modern genus showing closest similarity to the fossil wood.

4. In instances when it is only possible to identify fossil woods to the family or some other suprageneric level, the addition of *oxylon* to the fiamily or other relevant name is preferable and should be done with the addition of *oxylon* to the ending -ceae, -eae, -oideae, -inae, etc. (e.g. *Betulaceoxylon, Combretaceoxylon*).

5. When the wood anatomy is not uniform in a particular family the designation of the fossil woods after the family names is incorrect; attempts should be made to identify the fossil wood to the level of the sub-family, tribe or sub-tribe, which may be anatomically homogeneous and the name should be coined only after such an appropriate group.

6. Attempts to create new genera of morphologically similar woods only on stratigraphical grounds should be avoided.

7. In cases where it is not possible to identify fossil woods even up to family level due to bad preservation or lack of sufficient information then instead of naming it after the names of palaeobotanists, fossil localities or rock formations, etc. it is advisable to put them under the non-committal form genus *Dryoxylon* Schleiden (in Schmid, 1853) till their better preserved specimens are found or more information is available to determine their genus or family.

Genus—*Gmelina* Linn.

Gmelina tertiara sp. nov.

Topography—Wood diffuse porous. *Growth rings* indistinct. *Vessels* small to large, solitary and in radial multiples of 2-3, small clusters and in short tangential rows (Pl. 1, figs 1, 2), somewhat unevenly distributed, 8-15 per sq mm; tyloses present. *Parenchyma* paratracheal forming 1-2 seriate sheath around the vessels which may extend laterally to form thin wings of aliform to aliform-confluent parenchyma (Pl. 1, figs 1, 2). *Xylem rays* fine to moderately broad, closely spaced, 10-13 per mm, weakly heterogeneous, made up of mostly procumbent cells with 1-2 upright cells at the ends or on the margins, 1-4 seriate (uniseriates rare) or 16-50 μm in width and 4-35 cells or 80-950 μm in height (Pl. 1, figs 3, 4). *Fibres* arranged in radial rows in between the rays (Pl. 1, fig. 2).

Elements—Vessels circular to elliptical when solitary, with flat contact walls when in groups; t.d. 50-180 μm, r.d. 80-250 μm; vessel members 200-350 μm in length with oblique ends; perforations simple; intervessel pit-pairs bordered, alternate, polygonal with lenticular apertures, 8-10 μm in diameter (Pl. 1, fig. 6). *Parenchyma cells* thin walled, 15-20 μm in width and 40-70 μm in length. *Ray cells* thin-walled, procumbent cells 15-20 μm in tangential height and 40-60 μm in radial length; upright cells 15-20 μm in radial length and 40-60 μm in tangential height. *Fibres* polygonal in cross-section, semi-libriform with big lumen, septate, 10-25 μm in diameter and 400-600 μm in length.

Affinities—Important structural features of the present fossil such as small to large vessels with simple perforations and alternate bordered pits, paratracheal vasicentric to aliform to aliform-confluent parenchyma, 1-4 seriate weakly heterogeneous xylem rays and septate fibres clearly indicate its affinities to the family Verbenaceae (Metcalfe & Chalk, 1950, pp. 1031-1041; Pearson & Brown, 1932, pp. 781-812; Kribs, 1959, pp. 160-162). Amongst the various genera of this family the fossil shows a close similarity to the woods of *Gmelina* Linn. Wood slides of four species of this genus, viz., *Gmelina elliptica, G. fasiciculiflora, G. hainensis*, and *G. arborea* were available for study besides the the published description and photographs of *Gmelina arborea* (Pearson & Brown, 1932, pp. 798-803; Kribs, 1959, p. 160; Normand, 1960). The study indicates that the fossil is nearest in its anatomical details to the extant species *G. arborea*. The similarities can be observed in the shape, size and distribution of vessels, perforation plates and intervessel pit-pairs, distribution of parenchyma, structure of the xylem rays and fibres. The study also indicated that there is some variation in anatomical details amongst different wood samples of the extant species, especially in the distribution of vessels. Thus while in some cases the wood is diffuse-porous, in some it is semi-ring-porous and in others it is even ring-porous. Similarly, in some cases the smaller vessels are arranged in the form of tangential rows at the beginning of the growth ring and aliform-confluent parenchyma of these vessels looks like terminal parenchyma. Under the circumstances the fossil has been assigned to the extant genus *Gmelina* Linn. and has been

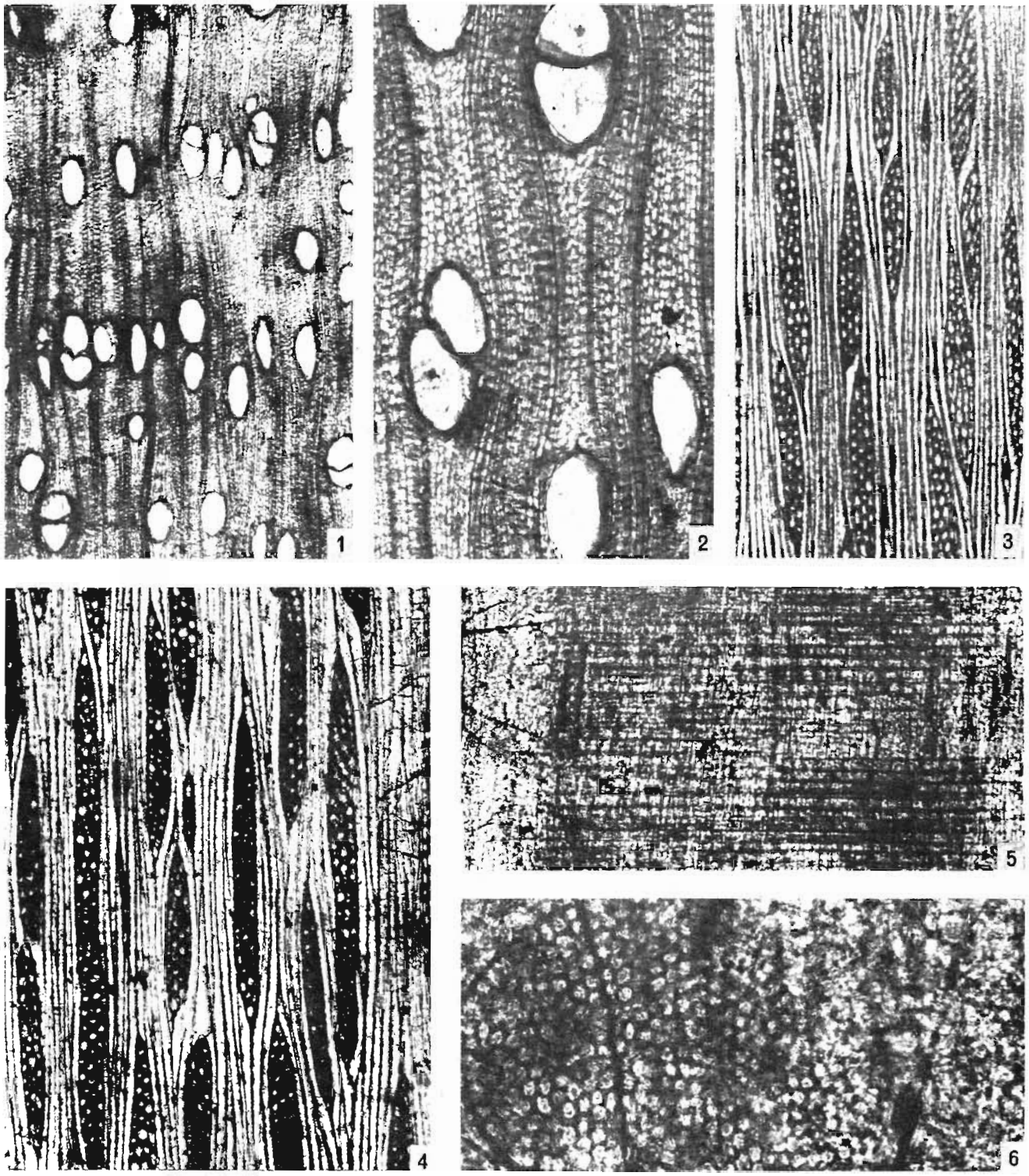


PLATE 1

Gmelina tertiara sp. nov.

1. Cross section showing shape, size and distribution of vessels, xylem rays and parenchyma. × 35; Slide no. B.S.I.P. 35770/1.
2. Cross section enlarged to show vessels in radial pairs, paratracheal parenchyma, xylem rays and semilibriform fibres. × 85; Slide no. B.S.I.P. 35770/1.
3, 4. Tangential longitudinal section showing 1-4 seriate, weakly heterogeneous xylem rays and septate fibres. × 85; Slide no. B.S.I.P. 35770/2.
5. Radial longitudinal section. × 85. Slide no. B.S.I.P. 35770/3.
6. Intervessel pit pairs. × 340. Slide no. B.S.I.P. 35770/2.

described as a new species *Gmelina tertiara* indicating its age.

Ingle (1972) had described a fossil wood said to possess affinities to the genus *Vitex* of Verbenaceae from the Deccan Intertrappean beds of Mandla District, Madhya Pradesh. However, the identification of this fossil has already been doubted by Prakash (1974) and thus, the present finding becomes the first authentic record of this family from the Deccan Intertrappean beds and extends its antiquity in India to the Palaeogene. The family Verbenaceae consists of about 75 genera almost all of which are tropical and subtropical in distribution. The genus *Gmelina* Linn. consists about 35 species, two of which occur in tropical Africa and the rest in East Asia, Indomalaya and Australia (Willis, 1973). In India the genus is represented by five species. *Gmelina arborea* to which the fossil bears nearest affinities is a moderate to large deciduous tree found throughout the deciduous and moist deciduous forests of India and Burma, in all Provinces, but nowhere common and very scarce in Uttar Pradesh and Punjab (Pearson & Brown, 1932, p. 799).

SPECIFIC DIAGNOSIS

Gmelina tertiara sp. nov.

Wood diffuse-porous. *Growth rings* indistinct. *Vessels* small to large, t.d. 50-180 μm, r.d. 80-250 μm, solitary and in radial multiples of 2-3, small clusters and in short tangential rows, 8-15 per sq mm; perforations simple; intervessel pit-pairs bordered, alternate, polygonal with lenticular apertures, 8-10 μm in diameter. *Parenchyma* paratracheal, 1-2 seriate, vasicentric to aliform to confluent. *Xylem* rays 1-4 seriate, weakly heterogeneous, up to 35 cells in height. *Fibres* semilibriform, septate.

Holotype—B.S.I.P. Museum no. 35770; Deccan Intertrappean beds; ?Palaeocene.

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