

ON TWO FOSSIL DICOTYLEDONOUS WOODS FROM SOUTH REWA, CENTRAL INDIA

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ABSTRACT

Two specimens of silicified fossil woods, one from Ghiar and the other from Kathotia in the South Rewa Gondwana basin, Central India, are described. The two woods resemble each other considerably. These are compared to several families of the present times to which they make nearest approach, but when coming to details, it is difficult to assign them to any definite genus of any family with which they are compared. But they are comparable to the nearest degree to Celastraceae and so they have been kept provisionally under this family in a newly created genus *Gondwanoxylon*, with two separate species *G. ghiarii* gen. et sp. nov. and *G. kathotiai* gen. et sp. nov. These woods come from an area which is generally referred to Upper Cretaceous age. The structure of these woods shows that the climatic conditions in those times were fairly uniform.

INTRODUCTION

PIECES of silicified wood were collected by the author from two localities, Ghiar (23°50' 81-19) and Kathotia (23°14' 81-20) in South Rewa, Central India (now in Madhya Pradesh), in March 1936. Near village Ghiar, on the right bank of Son river a huge log of fossil wood is partially exposed. From this log two small pieces were collected. The wood is well preserved. At Kathotia a single piece of very well-preserved silicified wood with a narrow and hollow pith was found lying loose on the ground.

The microphotographs of the sections of these fossil wood pieces were sent in 1946 for identification to Dr. K. A. Chowdhury. In 1950 the author went to Forest Research Institute Dehra Dun, but no final decision on the identification of these woods could be taken. But the author was advised by Dr. K. A. Chowdhury and Dr. S. S. Ghosh to take more sections and also attempt maceration of small pieces of wood in hydrofluoric acid. The maceration of wood from Ghiar has not yielded any appreciable result, as the material was completely silicified and all of it dissolved in the acid. The maceration of wood from Kathotia has yielded a few vessels.

The author is highly indebted to late Prof. Birbal Sahni for his able guidance and advice. He is thankful to Dr. K. A. Chowdhury, Wood Technologist and Dr. S. S. Ghosh of the Forest Research Institute, Dehra Dun, for taking keen interest in his work and for giving valuable directions during the course of this work. The facilities provided by Birbal Sahni Institute of Palaeobotany in taking sections of the wood pieces, and the services of late Shanker, who prepared these sections, are being acknowledged with thanks.

DESCRIPTION

1. *Gondwanoxylon ghiarii* gen. et sp. nov.

The type specimen described here is completely silicified and the preservation is fairly good. Only the wood portion of the stem is preserved.

The wood, cut transversely and polished, shows the arrangement of the vessels very clearly with the help of an ordinary hand lens or even with the naked eye. The vessels are mostly solitary and are arranged in a radial manner in between the medullary rays which are fairly uniform (PL. 1, FIGS. 1, 2). Some vessels seem to have wing-like expansions on their radial sides and give an idea of aliform parenchyma, but when the sections are seen under the microscope it becomes quite clear that the wing-like expansions around the vessels are simply either due to colouration or cracks in the wood. The wood is diffuse porous and the vessels are evenly distributed. In transverse section the vessels look round or slightly oval (PL. 1, FIG. 3). They are mostly of medium size, the average diameter ranging from 176 to 208 μ and the wall is approximately 3-6 μ thick.

Vessels are almost all isolated, the proportion of single vessels to those in groups being 96 to 4. Some vessels are in radial multiples of 2 to 3. Most of the vessels are

found in contact with the medullary rays either on one of their radial sides or on both. The remaining portion of the vessels is surrounded by septate fibres. The wood is fairly compact. The number of vessels per square mm. is 4-6, and the mean member length is 0.3-0.4 mm. The vessels have oblique end walls with simple perforation plates (PL. 1, FIG. 6). Some vessels have simple oval pits arranged alternately on their walls (PL. 1, FIG. 5). The intervascular pitting and the pits between the vessels and the medullary rays are not found. Tyloses are found in large numbers (PL. 1, FIG. 5).

Parenchyma is absent or sometimes a few cells are found either near a vessel on its radial side or scattered between the fibres (PL. 1, FIG. 5), but this is very rare.

Medullary rays are 2-3 cells thick and vary very widely in their height, ranging from 6 or 7 cells to more than 104 cells. They are simple and homogeneous or slightly heterogeneous (PL. 1, FIGS. 4, 6). The greater part of the wood is composed of multiseriate thick-walled septate fibres (PL. 1, FIG. 7).

Diagnosis — Wood diffuse porous, vessels almost all isolated radially arranged, medium size (176-208 μ), having oblique end walls with simple perforation plates, pits on the walls alternate, number of vessel 4-6 per square mm., mean member length 0.3-0.4 mm. Parenchyma absent or sparse and diffuse. Rays 2-3 seriate, 6-104 cells high, homogeneous or slightly heterogeneous, fibres abundant, thick-walled, septate, multiseriate.

Locality — Son river west of village Ghiar (23.50: 81.19), South Rewa, M.P.

Horizon — The locality is surrounded by flat-topped hills of the Deccan traps and intertrapean beds generally considered of Upper Cretaceous age. It is west of Tari-pather-Tiki area.

2. *Gondwanoxylon kathotiai* gen. et sp. nov.

The piece of wood described here was found lying loose in the forest near village Kathotia in the South Rewa division of Madhya Pradesh. The preservation of this piece is very good. The wood is silicified. Maceration of small bits of wood in hydro-fluoric acid has yielded good result. It was possible to detach some of the vessels completely. The piece of wood is almost half the segment of a cylindrical stem from

the pith to the cortex, though the latter is not preserved. The pith is hollow and measures approximately 1.3 cm. in diameter. It shows remains of discoid transverse septa.

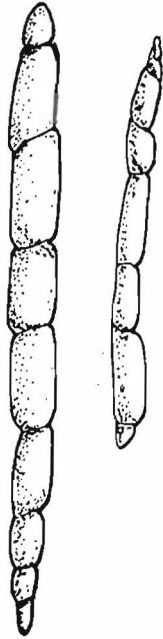
The radial arrangement of vessels in between the medullary rays is visible even with the naked eye. The wood is diffuse porous, there being no annual growth rings, and the vessels are evenly distributed. Vessels are mostly isolated, the proportion of single vessels with those in groups being 85 to 15. Vessels in groups are found mostly in radial multiples of two or rarely of three (PL. 1, FIG. 8). Large number of vessels are found in contact with the medullary rays along one of their radial sides, and in the remaining portion they are surrounded by short, thick-walled, septate fibres (PL. 1, FIG. 11).

In transverse section vessels look more or less round or slightly oval (PL. 1, FIGS. 8, 9). They are mostly of medium size, ranging from 104 to 198 μ and the wall is approximately 4-6 μ thick. The number of vessels per square mm. is 4-6, and the mean member length is 0.2-0.3 mm. The vessels have oblique end walls (PL. 1, FIG. 10) with simple perforation plates (PL. 1, FIG. 11). The pits on the walls are oval and are arranged either alternately or in rows (PL. 1, FIG. 12). Intervascular pitting, or pits common to vessels and fibres, or common to vessels and medullary rays have not been clearly seen.

The two vessels separated during maceration (TEXT-FIG. 1) show the size and nature of vessel members, and the oblique end walls very clearly. They measure 2880 and 1764 μ respectively, and are 198 and 108 μ at the widest portion.

Parenchyma is absent. Not a single parenchyma cell has been found. Medullary rays are mostly 2-3 cells thick and 6-20 cells high, but rays of 4 cells in width and up to 35 cells high are also frequently found. In tangential section they look more or less spindle-shaped. They are homogeneous or slightly heterogeneous.

Diagnosis — Wood diffuse porous, vessels mostly isolated, radially arranged, medium size (104-198 μ), having oblique end walls with simple perforation plates, pits on the walls either alternate or in rows; number of vessels 4-6 per square mm., mean member length 0.2-0.3 mm. Parenchyma absent. Rays 2-4 seriate and 6-35 cells high,



TEXT-FIG. 1 — Vessels obtained from the maceration of bits of wood from Kathotia locality 17/1. $\times 32$.

homogeneous or slightly heterogeneous. Fibres abundant, short, thick-walled septate and multiseriate.

Locality — Near Kathotia village (23:14: 81:20) in the South Rewa division, Madhya Pradesh (India).

Horizon — Upper Cretaceous.

DISCUSSION

The fossil woods from Ghiar and Kathotia resemble each other almost completely in broad features. Characters common to both are — diffuse porous wood, vessels mostly solitary, distribution of vessels 4-6 per square mm., absence of parenchyma, rays 2-3 cells wide, homogeneous or slightly heterogeneous, mean member length of vessels near about 0.3 mm. and multiseriate septate fibres. However, they differ in certain features and anatomical details. The wood from Ghiar has larger vessel diameter in transverse section than the wood from Kathotia. But one cannot depend on this character alone because the size of the vessels varies in different portions of the stem (SEBASTINE, 1958). How-

ever, there are other characters which are more reliable. The rays in Ghiar wood are long, up to 104 or even more cells high and uniformly 2-3 cells wide, while in Kathotia wood the rays are short, rarely more than 35 cells high and up to 4 cells wide. In wood from Ghiar a few parenchyma cells are sometimes found either associated with the vessels or diffused in between the septate fibres, but in Kathotia wood the parenchyma is totally absent.

From the nature of secondary wood and vessels it is quite evident that these fossil woods are of dicotyledonous plants. In an attempt to assign them to a particular family one has to compare their characters to those of the woods of the modern families. In such a comparison one has to depend on most conservative characters. Even then such a comparison may at times be quite misleading if in a family to which the fossil woods belong some of the characters change during the course of evolution. Therefore such assignments are necessarily provisional.

In the case of fossil woods one has a very limited number of dependable characters on which he has to base the comparison. Sebastian (1958) has shown that mean number of vessels per unit area varies at different levels and in various portions of the same level. The mean radial diameter of the vessels also varies in different portions of the same level in the secondary wood. Similarly, vessel member length varies considerably in various parts of the same level and in different levels of the tree trunks. So one cannot rely much on these characters of the vessels only. In this case multiseriate septate fibres, width and nature of rays and absence of parenchyma have been given first importance and vessel characters second importance during the course of comparison with the present-day families.

These fossil woods have multiseriate septate fibres, and as it has been pointed out by Spackmann & Swamy (1949) that where septate fibres are abundant parenchyma is small in amount, the parenchyma in these woods is either absent or very sparse. The size of the pieces of these fossil woods clearly shows that the plants to which these belong were tall woody trees.

Septate fibres are found in 89 families of the present-day dicotyledonous plants. Out of these families 58 have either small vessels or are composed of herbaceous plants.

From the remaining 31 families, fifteen families have either very broad rays, abundant parenchyma or mean member length of the vessels more than one mm. The remaining sixteen families have several characters common to these fossil woods and therefore are discussed here in details. The important characters are shown in Table 1.

From Table 1 it is quite clear that the fossil woods from Ghiar and Kathotia do not compare in all respects with any one of the above sixteen families. Broadly speaking families Juglandaceae and Simarubaceae make nearest approach. If in family Simarubaceae some genus be having solitary vessels, or in family Juglandaceae some genus has no parenchyma then such genera would compare in all respects with these fossil woods.

In Meliaceae, Rutaceae, Sapindaceae (except *Blighia* and *Cubilia*) and Simarubaceae vessels are in multiples of two, three or more; besides this in the first three of these families parenchyma is generally present in abundance. In Juglandaceae, Lecythidaceae, Melastomaceae, Rosaceae and Sapotaceae parenchyma is always present either in paratracheal or apotracheal form. In Euphorbiaceae-Phyllanthoideae (both *Aporosa* and *Glochidion* types) the rays are 4-17 or 4-11 cells wide, and are heterogeneous; while in Crotonoideae there is abundance of parenchyma and the rays are heterogeneous.

In Elaeocarpaceae the medium sized vessels are found in some species of *Elaeocarpus* only, but in them the vessels are in radial multiples of 4 or more and the rays are 4-10 cells wide. Parenchyma is absent in *Aristotelia* but in it the vessels are small and are arranged in radial multiples. *Dicraspedia* has solitary vessels but it has uniseriate rays.

Genera *Rhodosphaera* and *Loxopterigium* of family Anacardiaceae resemble these woods in many characters, but *Rhodosphaera* has markedly heterogeneous rays and *Loxopterigium* has abundant parenchyma. Some genera of Burseraceae have medium sized vessels which are mostly solitary with a few multiples of 2-3, but in them the parenchyma is present and the rays are heterogeneous. Similarly family Combretaceae differs only in the presence of abundant parenchyma. Family Rubiaceae affords a very close comparison in most of the charac-

ters except that in Rubiaceae the rays are heterogeneous.

Celastraceae is the only family left which resembles in maximum number of characters with these fossil woods. This family has moderately small vessels (100-200 μ), exclusively solitary or nearly so, 5 or less per square mm. in *Perrottetia* (perforation plates with simple perforation are found in a single species of *Perrottetia*). Parenchyma absent, sparse or diffuse. Rays 2-8 homogeneous. Multiseriate bands of septate fibres are present. Due to close comparison both the fossil woods are provisionally assigned to family Celastraceae. Both the fossil woods resemble each other to such an extent that they can safely be put under a single genus. In view of close resemblance with *Perrottetia* these woods could have been named "*Perrottetioxylon*", but as they show very close resemblance with families Simarubaceae, Juglandaceae and Rubiaceae too, and the assignment to family Celastraceae is only provisional, therefore, they have been kept in a newly created genus *Gondwanoxylon*. The woods differ from each other in minor details already mentioned hence they are kept as two separate species — *Gondwanoxylon ghiarii* and *Gondwanoxylon kathotiai*. These woods have close affinity with Rubiaceae, Combretaceae, Juglandaceae, Burseraceae, Anacardiaceae and Simarubaceae and hence they are compared to the fossil woods of the above families described from other Indian localities.

No fossil wood from South Rewa has been described so far, and within the knowledge of the author fossil wood belonging to family Celastraceae has been described only from Tertiary of South Arcot district, Madras (RAMANUJAM, 1954a).

Dipterocarpoxylo which was described from Burma by Holden (1916) was renamed *Irrawadioxylo* by Gupta (1935), who showed that the wood could not be placed in family Dipterocarpaceae, and had affinities with Ebenaceae and Anacardiaceae. It differs from *Gondwanoxylon* in having heterogeneous rays, presence of parenchyma and resin canals.

There arises no question of comparing *Gondwanoxylon* with *Homoxylon rajmahalense* (SAHNI, 1932) as the latter was devoid of vessels.

Glutoxylo assamicum (CHOWDHURY, 1934, 1936, 1942) from Assam, *Glutoxylo burmense* from South East Asia (CHOWDHURY, 1952), *Glutoxylo* from West Bengal (CHOWDHURY

TABLE 1

FAMILIES	AVERAGE DIAMETER OF VESSELS AND ARRANGEMENT	MEAN MEMBER LENGTH IN MM.	VESSELS PER SQ. MM.	WIDTH AND NATURE OF RAYS	NATURE OF PARENCHYMA
(A) Fossil wood from Ghjar	176-208 μ , almost all isolated	0.3-0.4	4-6	2-3 cells, homogeneous	Absent or very sparse
(B) Fossil wood from Kathotia	104-198 μ , mostly solitary	0.2-0.3	4-6	2-3 cells, homogeneous	Absent
1. Celastraceae	50-100 or 100-200 μ , solitary	0.6-1.0	5-200	2-8 cells, homogeneous	Absent, sparse, diffuse
2. Rubiaceae	25-200 μ , solitary	0.5-1.3	5-20	2-3 cells, heterogeneous	Absent in those with septate fibres
3. Combrataceae	100-200 μ , solitary	0.3-0.5	5-20	1-5 cells, homogen. or heterogen.	Aliform
4. Juglandaceae	100-200 μ , mostly solitary	0.4-0.9	5	2-4 cells, homogeneous	Apotracheal
5. Burseraceae	50-100 or 100-200 μ , solitary	0.3-0.6	4-15	1-4 (2-3) cells, heterogeneous	Paratracheal, scanty
6. Anacardiaceae	50-200 μ or more, mostly solitary	0.2-0.8	2-25	2-3 cells, heterogeneous	Paratracheal, scanty
7. Simarubaceae	100-200 μ or more in multiples	0.3-0.7	1.5-20	2-4 cells, homogen. or heterogen.	Absent or very sparse
8. Elaeocarpaceae	100-200 μ , solitary or in multiples	0.3	5-20	2-3-10 cells, heterogeneous	Paratracheal
9. Meliaceae	50-200 μ , multiples of 2-3	0.3-0.7	5-20	2-3 cells, homogen. or heterogen.	Paratracheal, variable
10. Rutaceae	25-100-200 μ , never solitary	0.2-0.6	4-100	2-6 cells, homogen. or heterogen.	Terminal, paratracheal
11. Sapindaceae	50-200 μ , in numerous multiples of 2-3	0.2-0.7	2-50	2-3 cells, homogen. or heterogen.	Diffuse or in bands
12. Lecythidaceae	100-200 μ	0.4-0.6	1.5-5	2-3 cells, homogen. or heterogen.	Abundant
13. Melastomaceae	50-200 μ	0.3-0.8	4-80	2-5 cells, heterogeneous	Paratracheal
14. Rosaceae	25-300 μ	0.4-0.95	5-40	2-5 cells, homogen. or heterogen.	Apotracheal, diffuse
15. Sapotaceae	100-200 μ	0.3-1.6	5-20	2-3 cells	Apotracheal
16. Euphorbiaceae Phyllanthoideae	50-210 μ	0.9-1.6	10-20	4-17 cells, heterogeneous	Abundant
Aporosa type	25-200 μ	0.5-1.0	6-40	4-11 cells, heterogeneous	Absent or few
Glochidion type	50-200 μ	0.3-1.4	5-17	2-3 cells, heterogeneous	Abundant

& TANDON, 1952) have been assigned to family Anacardiaceae. *Dipterocarpoxyylon garoense* (CHOWDHURY, 1938) is the only fossil wood belonging to family Dipterocarpaceae found from Assam. *Cynometroxylon indicum* (CHOWDHURY & GHOSH, 1946) and *Kayeoxylon assamicum* (CHOWDHURY & TANDON, 1949) from Assam belong to families Leguminosae and Guttiferae respectively. *Dryoxylon mohgaense* (RODE, 1935) from Mohgaon kalan, Madhya Pradesh, shows affinity with Combretaceae. Several species of *Terminalioxylon* and other fossil woods belonging to families Guttiferae, Celastraceae, Leguminosae, Sonneratiaceae, Euphorbiaceae, Dipterocarpaceae, Anacardiaceae and Combretaceae have been described from South Arcot district, Madras (RAMANUJAM, 1954, 1954a, 1954b, 1955, 1956 and NAVALE, 1955). Some more fossil dicotyledonous woods from Intertrappean cherts of Mohgaon (VERMA, 1947-48, 1950) and from Deccan Intertrappean beds of Mahurzari (SHALLOM, 1958) have been compared with families Datisceae, Anacardiaceae and Burseraceae.

The localities of Assam, Burma, South Arcot district, Madras, Mahurzari near Nagpur and Mohgaon Kalan in Madhya Pradesh have been referred to Tertiary period. Deccan Intertrappean beds at Mohgaon Kalan are considered of Upper Cretaceous or Eocene (RODE, 1935). The fossil wood of Celastraceae described from South Arcot district (RAMANUJAM, 1954a) is of Tertiary period.

These fossil woods (*Gondwanoxylon*) come from a fossiliferous area which is variously

assigned from Upper Triassic to Upper Cretaceous age. Son river west of village Ghiar has been described under Taripather-Tiki area. The Tiki beds near Beohari in South Rewa are referred to Upper Triassic age (KRISHNAN, 1956, p. 270). The area is surrounded by flat-topped hills of the Deccan Traps and Intertrappean beds which generally are considered of Upper Cretaceous. So these fossil woods may be of Upper Cretaceous but as Arnold says that Celastraceae has no pre-Tertiary records (GUNDERSEN, 1950, p. 5) these may be assigned to Eocene.

Angiosperms evolved somewhere in the Jurassic period, and if these woods are from Upper Cretaceous then they are pretty old, and it is quite natural that these plants may have undergone considerable changes in their wood structure, and this may be the reason why it is difficult to assign them to a particular genus of family Celastraceae.

Gondwanoxylon has a combination of primitive and advanced characters. The sloping end walls of vessels, diffuse porous wood, parenchyma absent or scanty and diffuse, non-stratified cells and fibre tracheids are primitive characters (TIPPE in GUNDERSEN, 1950); while short and circular vessels in transverse section, opposite or alternate pitting of vessels, homogeneous rays are advanced characters.

The diffuse porous wood itself shows that the climatic conditions in those times, specially at the locality where these plants were growing, were fairly uniform. The well-formed vessels are indicative of moderate climate.

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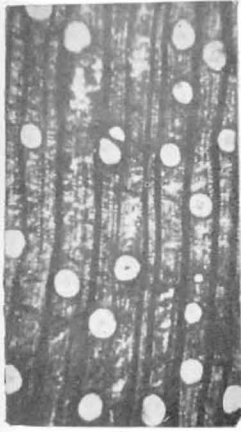
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EXPLANATION OF PLATE 1

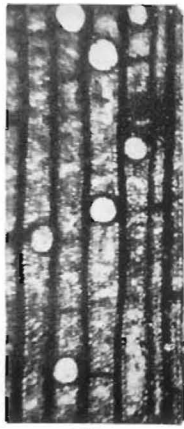
(All the photographs have been taken by the author from unretouched negatives)

1. Transverse section of fossil wood from Ghiar (Locality R.S. 9/13). Slide 488. × 22.

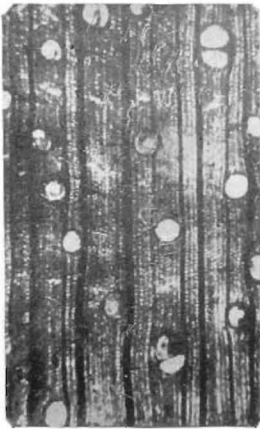
2. Transverse section of fossil wood from Ghiar. Slide 489. × 22.



1



2



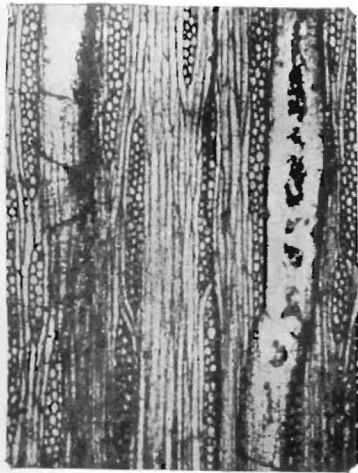
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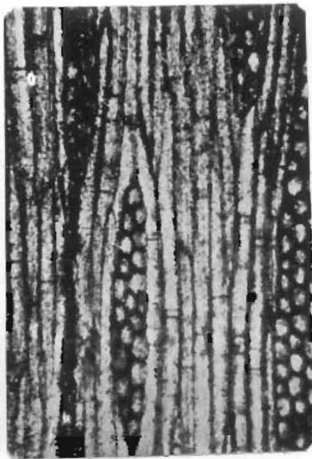
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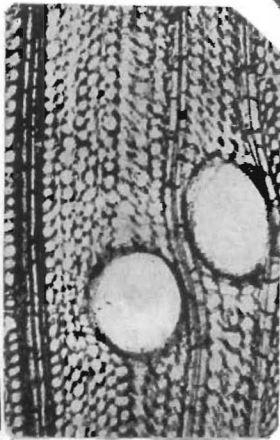
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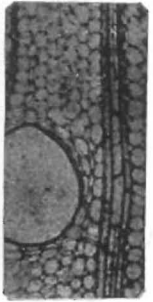
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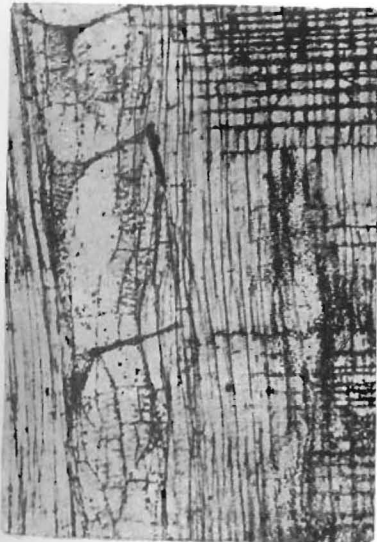
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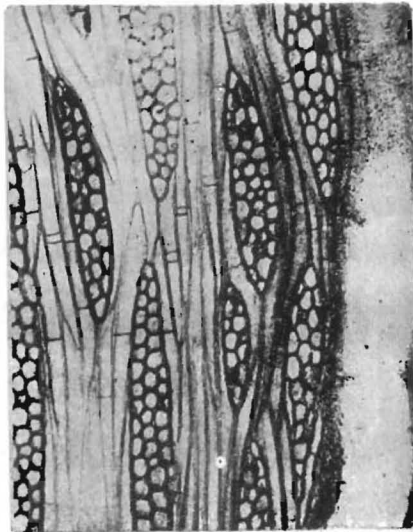
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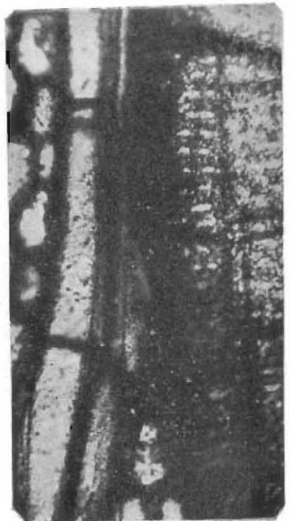
3



10



11



12

3. Transverse section of fossil wood from Ghiar. (Enlarged to show medullary rays clearly.) Slide 361. $\times 80$.
4. Radial longitudinal section of fossil wood from Ghiar. Slide 363 at A. $\times 83$.
5. Radial longitudinal section of fossil wood from Ghiar. Slide 363 at B. $\times 83$.
6. Tangential longitudinal section of fossil wood from Ghiar. Slide 490. $\times 45$.
7. Tangential longitudinal section of fossil wood from Ghiar. (Enlarged to show septate fibres clearly.) Slide 490. $\times 112$.
8. Transverse section of fossil wood from Kathotia. (Locality R.S. 17/1.) Slide. 497 $\times 22$.
9. Transverse section of fossil wood from Kathotia. (Enlarged to show medullary rays clearly.) Slide 357. $\times 80$.
10. Radial longitudinal section of fossil wood from Kathotia. Slide 249 at B. $\times 80$.
11. Tangential longitudinal section of fossil wood from Kathotia. Slide 248 at A. $\times 80$.
12. Tangential longitudinal section of fossil wood from Kathotia. (Enlarged to show pits on vessels clearly.) Slide 248 at B. $\times 300$.