Descriptive

Genus - Araucarioxylon Kraus 1870

Araucarioxylon lepekhinae sp.nov.

The specimen is a piece of reddish-black silicified wood measuring 6.5 cms long and 1.5 cms broad. It was collected from Satnaori in Nagpur District of Maharashtra and shows excellent preservation. There is no pith and primary xylem in it. The specimen consists of secondary wood only.

T.S. : The growth rings are distinct and their number is 8 within a distance of 4.5 cms. The secondary xylem is distinguished in to autumn wood and spring wood. The height of spring wood is 67 cells. The tracheids are squarish in outline thick-walled and show broad lumen. They are radially arranged and measure 39 x 33 µm. The autumn wood is 3-4 cells wide. It's tracheids are horizontally stretched and show narrow lumen. They measure 18 x 25 µm. (Text Fig.1 Pl.Fig. 1).

T.L.S. : Xylem rays are uniseriate as well as biseriate. However, uniseriate condition is more common than the biseriate. Xylem parenchyma is present. It is marked by transverse septa. Pits on the tangential walls of the tracheids are present. They are uniseriate circular separate or biseriate circular and separate. They measure 4 x 5 µm. Biconcave resin plugs are seen at several places. The height of xylem rays varies from 1 to 25 cells. Average height found is 7 cells in 25 count. They measure 20 x 18 µm. (Text Fig.2, 3, 4; Pl.Fig. 2, 3, 4).

R.L.S. : Pits on the radial walls of the tracheids are :-

(a) Uniseriate pits are circulars, contiguous or separate. They measure 7 x 7 µm. (Text Fig. 5 Pl. Fig. 5).

(b) Biseriate pits are circular and alternate. They measure 7 x 7 µm. The pit pore is circular and 3 µm. (Text Fig. 6 Pl. Fig. 6).

(c) Multiseriate pits are circular and alternate. They measure 6 x 6 µm. (Text Fig. 7 Pl. Fig. 7).

(d) Multiseriate pits are hexagonal alternate and compact. They are upto 4-seriate and measure 7 x 6 µm. (Text Fig. 8 Pl.Fig. 8).

(e) Circular pits are found in groups of 3,5 or 6. However, they do not show stellate cluster like arrangement. (Text Fig. 9 Pl.Fig. 9).

(f) Bars of sanio are present between the succcessive pairs of biseriate circular pits. (Text Fig. 10 Pl. Fig. 10).

Cross-field pits : They are circular to oval and bordered. Their number varies from 1-8. The pits measure 6 x 4 um. (Text Fig. 11, 12 Pl. Fig. 11, 12).

Identification and Comparison

The present wood shows, multiseriate hexagonal pits, 1-3 seriate circular pits. Xylem rays 1-2 seriate and cross-field pits of bordered type. These characters show affinities of

Araucariaceae. Recently Lepekhina (1972) has given a scheme of identification of Palaeozoic coniferous woods. Accordingly araucariaan woods with secondary xylem only should be placed under Araucarioxylon Kraus and those with primary characters should be placed under Dadoxylon Endlicher. Hence the wood is identified generically with Araucarioxylon Kraus.

It is compared with Araucarioxylon eocenum (Chitaley) Lepekhina in having 1-3 seriate radial pits, both circular and hexagonal pits in groups, presence of tangential pitting. 1-2 seriate xylem rays. But present wood differs from A.eocenum in having xylem parenchyma, bars of sanio, resin plugs and 1-8 simple or bordered field pits. In A.eocenum number of field pits is 1-7 and it is devoid of xylem parenchyma and bars of sanio. Further A. eocenum belongs to Eocene horizon while present wood comes from Upper Permian age.

It is compared with A.amaraparense (Sah and Jain) Bose and Maheshwari 1974 in having 1-3 rows of alternate to opposite, circular to hexagonal pits and 4-8 field pits. but present wood differs from A.amaraparense in having tangential pitting 1-2 seriate xylem rays bars of sanio and resin plugs. In A.amaraparense these characters are absent. Further A.amaraparense comes from Jurassic horizon while present wood belongs to Upper Permian age.

It is comparable with A.pranhitensis Rajnikanth & Sukh Dev 1989 in having 1-3 seriate radial pits and 1-2 seriate xylem rays. But present wood differs from A.pranhitensis in having

tangential pitting, presence of xylem parenchyma bars of Sanio and 1-8 field pits. In A. pranhitensis number of field pits is 3-6 and it is devoid of tangential pitting, xylem parenchyma and bars of sanio. Further A.pranhitensis comes from Kota Stage (Upper Jurassic) while present wood belongs to Kamthi Stage (Upper Permian).

It is further compared with A. nandorii Vagyani & Raju 1981 in 1-3 seriate circular to hexagonal radial pits and 1-2 seriate xylem rays. But present specimen differs from A.nandorii in having tangential pitting, xylem parenchyma, bars of sanio, pits in groups and 1-8 field pits. In A.nandorii number of field pits is 2-6 and it is devoid of tangential pitting, bars of sanio, xylem parenchyma and pits in groups. However, both these woods come from Kamthi Stage (Upper Permian) of Maharashtra.

Therefore, on the basis of above comparison it appears that present wood differs from known species of Araucarioxylon in one or other anatomical characters. Hence it is described as a new species viz. Araucarioxylon lepekhinae sp.nov. The specific name is after Dr. Lepekhina a Russian palaeobotanist who has given a new scheme of classification of Palaeozoic coniferous woods.

Diagnosis :

Growth rings distinct, spring wood 67 cells high tracheids squarish 39 x 33 µm. Autumn wood 3-4 cells thick tracheids horizontally stretched 18 x 25 µm. Xylem rays uniseriate to biseriate

1 to 25 cells, average height 7 cells. Ray cells 20 x 18 µm. Xylem parenchyma present. Tangential pits 1-2 seriate circular. Radial pits, uniseriate circular 7 x 7 µm. Biseriate pits circular 7 x 7 µm. Hexagonal pits multiseriate alternate 7 x 6 µm. Bars of sanio present. Crossfield pits 1-8 circular to oval simple or bordered 6 x 4 µm.

Type : SATN / 11/92

Locality : Satnavri, District - Nagpur, Maharashtra

Horizon : Kamthi Stage (Upper Permian)

Explanation of Text Figures

Text I Fig. 1-12 Araucarioxylon

1. T.S. showing secondary xylem differentiated into spring wood sp and autumn wood au x 187.
2. T.L.S. showing uniseriate and biseriate xylem rays and xylem parenchyma x 187.
3. T.L.S. showing biconcave resin plug rp x 187.
4. T.L.S. showing uniseriate and biseriate tangential pits x 124.
5. R.L.S. showing uniseriate circular continuous or seperate pits x 595.
6. R.L.S. showing Biseriate circular alternate pits x 595.
7. R.L.S. showing multiseriate circular alternate pits x 595.
8. R.L.S. showing multiseriate hexagonal alternate pits x 595.
9. R.L.S. showing circular pits in groups x 595.
10. R.L.S. showing bars of sanio BS x 595
11. & 12. R.L.S. showing circular to oval field pits cfp x 595.

Explanation of Plate Figures

Plate 1, Figs. 1-12 *Araucarioxylon lepekhinae* sp.nov.

1. T.S. showing secondary xylem differentiated into spring wood sp and autumn wood au x 124.
2. T.L.S. showing uniseriate and biseriate xylem rays and xylem parenchyma x 186.
3. T.L.S. showing biconcave resin plug rp x 310.
4. T.L.S. showing uniseriate circular tangential pits tp x 124.
5. R.L.S. showing uniseriate circular separate pits x 310.
6. R.L.S. showing biseriate circular alternate pits x 186.
7. R.L.S. showing multiseriate circular alternate pits x 186.
8. R.L.S. showing multiseriate hexagonal alternate pits x 248.
9. R.L.S. showing circular pits in groups x 248.
10. R.L.S. showing bars of sanio BS x 124.

11 & 12. R.L.S. showing circular to oval field pits cfp x 186.

TEXT 1

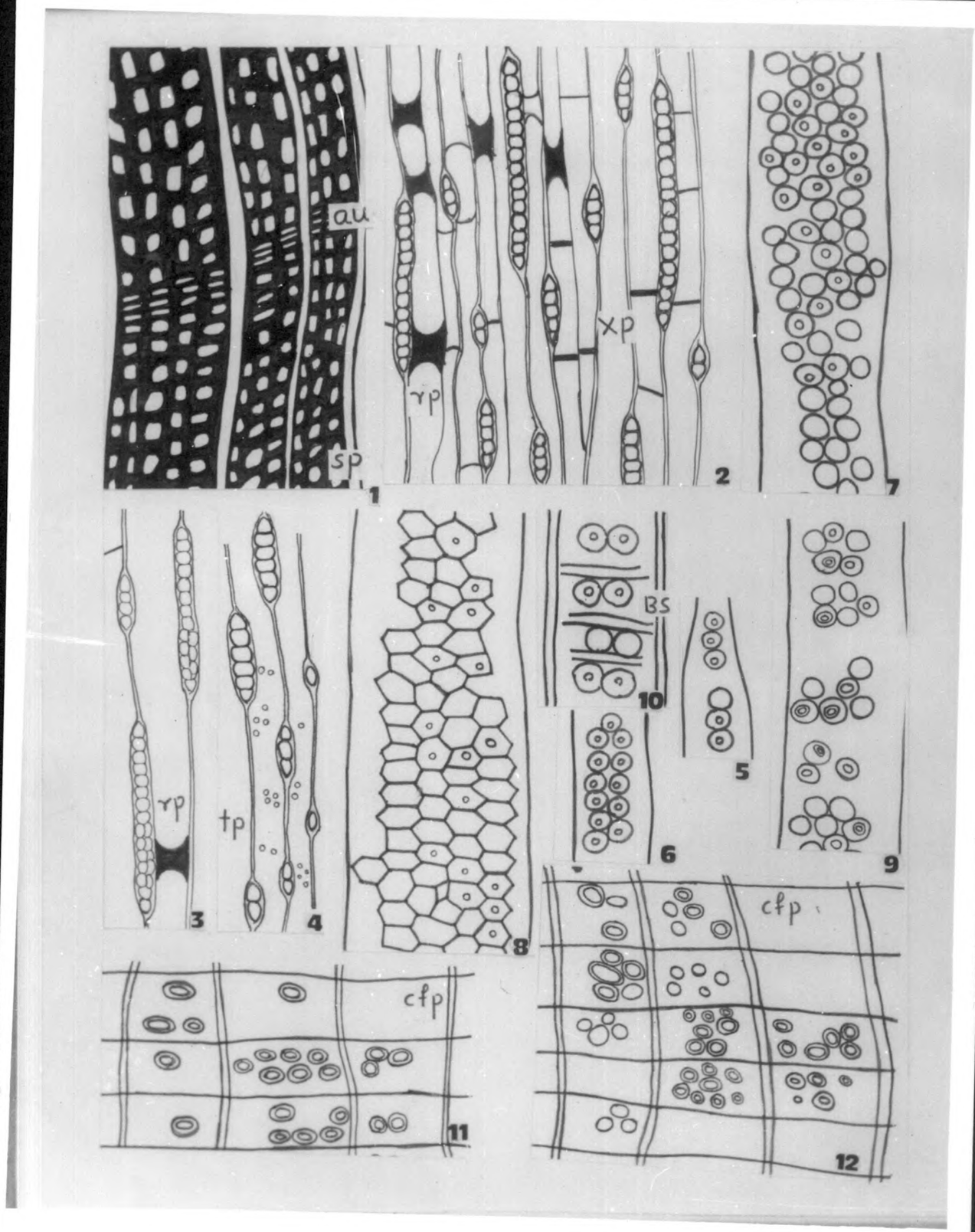
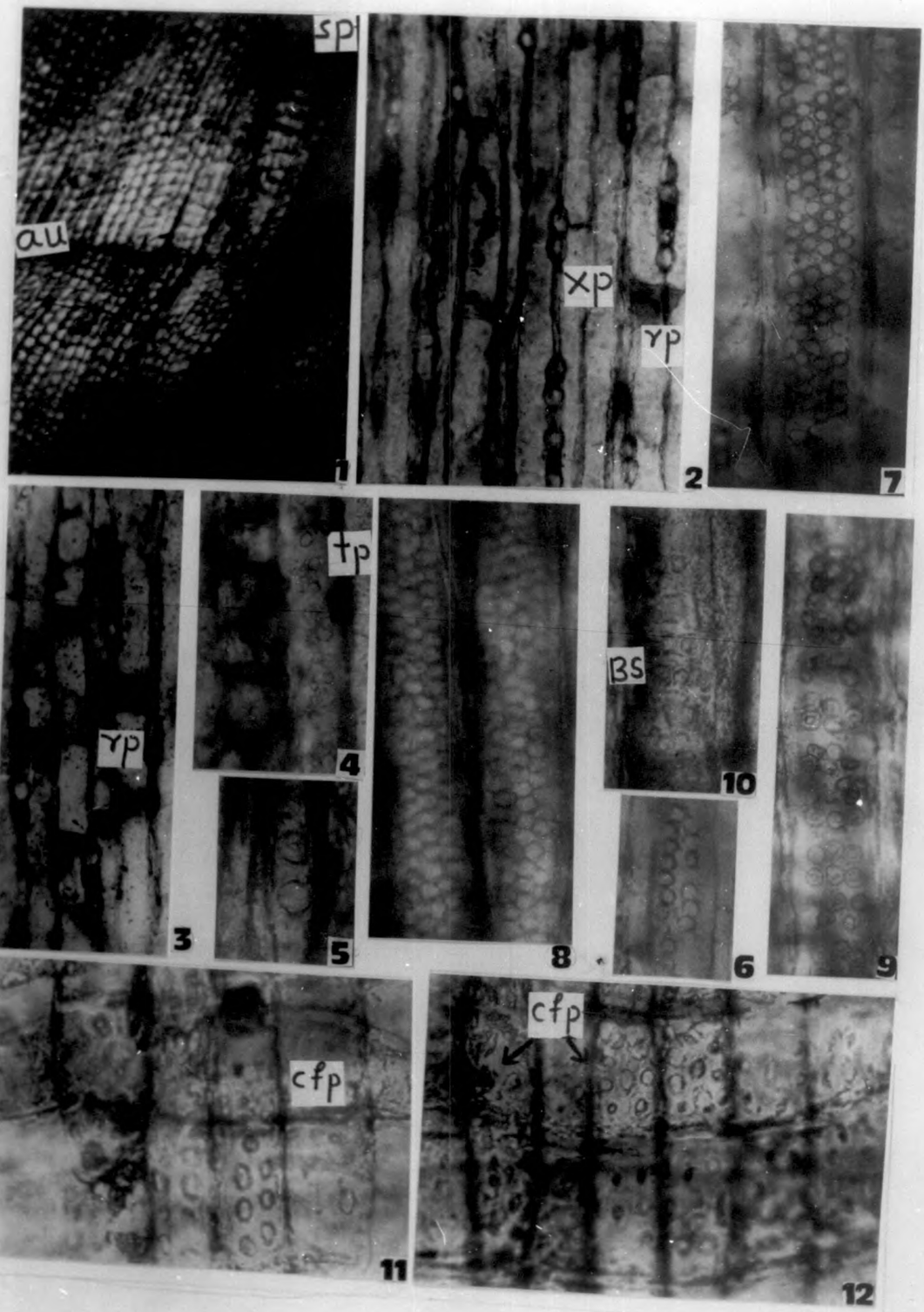


PLATE I



Genus - Kamthioxylon Mahabale and Vagyani 1980

Kamthioxylon satnavariense sp.nov.

Several petrified woods were collected from Satnaori in the Nagpur district of Maharashtra. On examination they turned out as coniferous woods. One of the specimen showing promising characters is selected for the present investigation.

The specimen is brownish-red in colour and measures 6 cms long and 7.5 cm broad. It is a piece of secondary wood without primary characters like primary xylem and pith. The wood was cut into different planes like T.S., T.L.S. and R.L.S. Followed anatomical characters are noticed in it.

T.S. : Twenty five growth rings are found within a distance of 7.5 cm. The secondary xylem is distinguished into spring wood and autumn wood. The spring wood consists of rectangular tracheids with broad lumen. They measure 28 x 34 µm. The autumn wood is 1 to 2 cells in thickness. Its tracheids are thick walled horizontally stretched and show narrow lumen. They measure 49 x 16 µm. Some of the tracheids are filled with resinous contents. (Text Fig. 13, Pl. Fig. 13).

T.L.S. : Xylem rays observed here are uniseriate and biseriate. Uniseriate condition is more dominant, than the biseriate. The height of rays varies from 6 to 41 cells. The average height is 19 cells in 25 counts. The ray-cells are barrel-shaped, measuring 21 x 27 µm. A distinct feature observed

here is presence of pits on the tangential walls of the tracheids. They are uniseriate circular and separate. The pits measure 6 x 5 µm. Another distinct feature observed is presence of xylem parenchyma. It is represented by horizontal septa. Resin plugs are seen at few places. They are dark structures with biconcave shape (Text Fig. 14, 15 Pl.Fig. 14).

R.L.S. : Radial pits on the tracheid walls shows following patterns.

1. Uniseriate pits are circular and contiguous or separate. They measure 7 x 7 µm (Text Fig. 16, 16A, Pl.Fig.15).
2. Biseriate pits are circular separate and alternate. They measure 7 x 7 µm. (Text Fig. 17, Pl.Fig. 16).
3. Hexagonal pits are compact and alternate. They show both biseriate and multiseriate type. They measure 7 x 6 µm (Text Fig. 18, 18A Pl.Fig. 17, 17A).
4. Vestured pits are seen at places. They are circular, uniseriate or biseriate type. Their pit-pore is circular. (Text Fig. 19, 20, Pl.Fig. 18, 19).
5. Bars of sanio are observed. They are present between the successive pairs of circular pits (Text Fig.21, Pl. Fig. 20).

Cross-field pits : They are circular to ellpitcal in shape and simple or bordered. Their number varies from 1 to 7. They measure 7 x 5 µm. (Text Fig. 22, Pl.Fig. 21, 22).

Identification and comparison :

The characters observed here show a wide range of characters not found in any living family of conifers. Hence it is easily not agreeing with many fossil coniferous genera described earlier. The multiseriate hexagonal radial pits indicate affinities of Araucariaceae. But vestured pits, presence of xylem parenchyma are not characteristic of the Araucariaceae. Therefore, the wood under investigation belongs to a group called as transitional conifers. Several genera are instituted to accomodate such fossil confiers by Seward (1919), Stopes (1914) and others. Most of them come from countries other than India. Recently, Mahabale and Vagyani (1980) have instituted the genus Kamthioxylon showing characters of Araucariaceae and Cupressaceae. They have pointed out that vestured pits are not common among the living conifers. They are seen in some genera of Araucariaceae, Pinaceae and Cupressaceae. The pits found here closely agree with those in the genus Libocedrus a member of Cupressaceae. Hence Kamthioxylon is a characteristic genus found in the Kamthi rocks of India showing combination of characters found in two families. The present wood closely agrees with the generic characters of Kamthioxylon, therefore, it is identified with.

So far only one species of Kamthioxylon has been described viz. K. adhariense by Mahabale and Vagyani in 1980. Present wood agrees with it in having uniseriate to biseriate

xylem rays, tangential pits showing uniseriate circular separate condition. Presence of xylem parenchyma and biconcave resin plugs bars of sanio and vestured pits.

But it differs from K. adhariense in having multiseriate hexagonal pitting. 1-2 seriate circular pitting and 1-7 crossfield pit.

In K. adhariense 1-2 seriate circular pits and multiseriate hexagonal pits are absent. It shows only multiseriate circular pits. The number of field pits in K.adhariense is 3-9 which are of cupressoid type. Further presence of hexagonal pitting in our wood shows strong evidence of Araucarian affinities which are wanting in K.adhariense. This may be due to little work on this new genus. Hence it is quite clear that present wood differs from K.adhariense in some characters while agree with others. Therefore it is described as a new species viz. K.satnavriense sp.nov. The specific name is given after the locality Satnaori in Nagpur distirct of Maharashtra. It belongs to Kamthi Stage. This suggests wider distribution of the genus found in two different districts. Regarding the plant fossils described from Satnaori not much work has been carried out except Agashe et al. (1971), Varadpande (1977) and Chitnis and Vagyani (1979). The plant fossils are mostly impressions preserved in typical Kamthi sandstones. Varadpande (1977) first noted the occurance of fossil gymnospermous woods from it. The present work is further addition to this little known fossil flora of Satnavri.

Diagnosis :

A piece of secondary wood 6 x 7.5 cm spring wood 84 to 64 cells in height having rectangular tracheids. Autumn wood 1 to 2 cells thick having horizontally stretched tracheids. Xylem rays uniseriate and biseriate, 6 to 41 cells high, showing barrel-shaped cells. Tangential pits uniseriate circular and separate. Biconcave resin plugs present. Radial pits 1-3 seriate. Uniseriate pits circular separate or contiguous. Biseriate pits are circular and alternate. Hexagonal pits are multiseriate and alternate. Vestured pits are circular 1-2 seriate. Bars of sanio present, field pits 1-7. Simple or bordered circular to elliptical.

Type : SATN / 19/92

Locality : Satnavri, Dist : Nagpur, Maharashtra

Horizon : Kamthi Stage (Upper Permian).

Explanation of Text Figures

Text - II Fig. 13-22 *Kamthioxylon satanavarense* sp.nov.

13. T.S. showing secondary xylem differentiated into spring wood *sp* and autumn wood *au* x 187.

14. T.L.S. showing uniseriate and biseriate xylem rays xylem parenchyma - *xp* and resin plugs *rp* x 187.

15. T.L.S. showing uniseriate xylem ray and tangential pits *tp* x 595.

16. & 16A. R.L.S. showing uniseriate circular pits x 595.

17. R.L.S. showing biseriate circular pits x 595.

18. & 18A R.L.S. showing biseriate and multiseriate hexagonal pits x 595.

19. R.L.S. showing circular uniseriate vestured pits *vp* x 595.

20. R.L.S. showing circular biseriate vestured pits *vp* x 595.

21. R.L.S. showing bars of sanio *BS* x 595

22. R.L.S. showing circular to elliptical field pits *cfp* x 595.

Explanation of Plate Figures

Plate II, Fig. 13-22 *Kamthioxylon satanavariense* sp.nov.

13. T.S. showing secondary xylem differentiated into spring wood sp x autumn wood au x 124.

14. T.L.S. showing uniseriate and biseriate xylem rays, tangential pits tp xylem parenchyma xp and resin plugs rp x 248.

15. R.L.S. showing uniseriate circular pits x 186.

16. R.L.S. showing biseriate circular pits x 186.

17 & 17A R.L.S. showing biseriate and multiseriate hexagonal pits x 310.

18 & 19 R.L.S. showing circular uniseriate and biseriate vestured pits vp x 434.

20. R.L.S. showing bars of sanio BS x 62.

21. & 22. R.L.S. showing circular to elliptical field pits cfp x 124.Rs

Genus - Dadoxylon Endlicher

Dadoxylon maheshwarii sp.nov.

The specimen is a decorticated piece of silicified wood showing Pith, Primary xylem and Secondary xylem. It is reddish brown in colour and measures 5.5 cm long and 8 cm broad.

T.S. : It shows distinct growth rings within a width of 8 cm. The secondary xylem is differentiated into spring wood and autumn wood. The spring wood is fairly thick and 125 cells high. Its tracheids are thick-walled rectangular in shape with broad lumen and arranged radially. They measure 24 x 32 µm. The autumn wood is narrower and consists of 1-2 cells. The tracheids are transversely elongated with narrow lumen. They measure 24 x 13 µm. (Text Fig. 23, Pl.Fig. 23).

Pith : It is oval in shape and measures 1.8 cm long and 0.4 cm broad. The pith is homogenous in nature and made up of large oval parenchymatous cells. Secretary cells or canal like structures are absent. The pith-cells measure 6.3 x 8 µm. (Text Fig. 24, Pl.Fig. 24).

Primary Xylem : It is present outside the pith and about 9 cells thick. The zone of primary xylem appears as blunt wedge shaped structure. Primary xylem is endarch in nature. In the R.L.S. the tracheids of primary xylem show scalariform thicknings. (Text Fig. 25, Pl.Fig. 25).

T.L.S. : The Xylem rays observed are of uniseriate type only. Their height varries from 2-16 cells. Average height found is 7 cells in 25 counts. The ray-cells are higher than the broad, and measure 18 x 22 um. Biconcave shaped resin plugs are present. The pits on the tangential walls of the tracheids are circular, biseriate and alternate. They measure 6 x 7 µm. (Text Fig. 26, 27, Pl.Fig. 26, 27).

R.L.S. : Pits on the radial walls of the tracheids are

a) Uniseriate pits are circular and contiguous measuring 7 x 7 µm. (Text Fig. 28, Pl.Fig. 28).

b) Biseriate pits are circular and alternate measuring 7 x 6.41 µm. (Text Fig. 29, Pl.Fig. 29).

c) Multiseriate pits are circular and alternate. They measure 7 x 7 µm. (Text Fig. 30, Pl.Fig. 30).

d) Multiseriate pits are hexagonal and alternate. They measuring 9 x 7 µm. (Text Fig. 31, 31A, Pl.Fig. 31, 31A).

e) Bars of sanio are present between successive pairs of circular pits. Some times they are seen associated with uniseriate circular pits. (Text Fig.32, Pl.Fig.32).

Cross-field pits :

In the cross-field area 1-5 circular bordered pits are present. They measure 6.6 x 5 µm. (Text Fig.33, Pl.Fig. 33).

Identification and comparison :

On account of following characters like, homogenous pith endarch, primary xylem and secondary xylem the specimen agrees with the generic characters of Dadoxylon Endlicher (Lepekhina's Scheme of 1972). Hence it is generically identified with it.

It is compared with Dadoxylon jamuriense Maheshwari 1965. In having homogenous pith, endarch primary xylem with scalariform thickening, 1-3 seriate, radial pits and number of field pits 1-3 (rarely 5). But it differs from D. jamuriense in having uniseriate xylem rays, tangential pitting, presence of bars of sanio and resin plugs.

It is also compared with D.adhariense Prasad 1986 in having endarch primary xylem, presence of tangential pitting, 1-3 seriate radial pitting and 1-5 bordered field pits. But it differs from D.adhariense in having homogenous pith, bars of sanio, uniseriate xylem rays and presence of resin plugs.

In D.adhariense pith is heterogenous, bars of sanio are absent and xylem rays are 1-2 seriate and resin plugs are absent.

It is comparable with D.parenchymosum Surange and Maithy 1962 in having homogenous pith, endarch primary Xylem, presence of tangential pitting and 1-4 seriate radial pitting.

But it differs from D.parenchymosum in having bars of Sanio, presence of xylem parenchyma and 2-5 field pits. In D.parenchymosum Xylem parenchyma and bars of sanio are absent. The number of field pits is 2-8.

From the above comparison it appears that the present wood differs from known species of Dadoxylon in one or other characters. Hence it is described as a new species namely Dadoxylon maheshwarii sp.nov. The specific name is after the eminent Palaeobotanist Dr. H.K. Maheshwari of Birbal Sahni Institute of Palaeobotany, Lucknow who made large contributions to the Palaeozoic flora.

Dignosis :

Oval homogenous pith, primary Xylem endarch, consisting scalariform elements, secondary Xylem with spring wood and autumn wood. Spring wood is 125 cells high. Tracheids rectangular 24 x 32 µm. Autumn wood is narrow 1-2 cells thick. Tracheids transversely elongated 24 x 13 µm. Xylem rays uniseriate 2-16 cells high. Ray cells barrel-shaped 18 x 22 um. tangential pitting present. Radial pits 1-3 seriate, uniseriate pits circular contiguous 7 x 7 um. Biseriate pits circular contiguous 7 x 6.4 um. Multiseriate pits circular alternate 7 x7 um. Hexagonal pits are multiseriate, alternate 9 x 7 um. Bars of sanio present. Cross-field pits 1-5 circular and bordered 6 x6.5 um.

Type : SATN 7/93

Locality : Satnavri, District-Nagpur, Maharashtra

Horizon : Kamthi Formation (Upper Permian).

Explanation of Text Figures

Text - III Fig. 23-33 Dadoxylon maheshwarii sp.nov.

23. T.S. showing secondary xylem distinguished into spring wood sp & autumn wood au x 187.

24. T.S. showing pith region having large parenchyma cells pc x 595.

25. R.L.S. showing tracheids of primary xylem with scalariform thicknings sct x 595.

26. T.L.S. showing uniseriate xylem rays, xylem parenchyma xp x 187.

27. T.L.S. showing uniseriate and biseriate tangential pits tp x 595.

28. R.L.S. showing uniseriate circular pits x 595.

29. R.L.S. showing biseriate circular alternate pits x 595.

30. R.L.S. showing multiseriate circular alternate pits x 595.

31.& 31A R.L.S. showing multiseriate hexagonal alternate pits x 595.

32. R.L.S. showing bars of sanio BS x 595.

33. R.L.S. showing 1-5 circular bordered pits cfp x 595.

Explanation of Plate Figures

Plate III, Figs. 23-33 Dadoxylon maheshwarii sp.nov.

23. T.S. showing secondary xylem distinguished into spring wood sp and autumn wood au x 310.

24. T.S. showing pith region having large oval parenchyma cells x 248.

25. R.L.S. showing tracheids of primary xylem with scalariform thicknings - sct x 62.

26. T.L.S. showing uniseriate xylem rays and xylem parenchyma xp x 248.

27. T.L.S. showing biseriate circular alternate tangential pits tp x 310.

28. R.L.S. showing uniseriate circular pits x 372.

29. R.L.S. showing biseriate circular alternate pits x 248.

30. R.L.S. showing multiseriate circular alternate pits x 248.

31 & 31A R.L.S. showing multiseriate hexagonal alternate pits x 186.

32. R.L.S. showing bars of sanio BS x 124

33. R.L.S. showing 1-5 circular bordered pits cfp x 186.

Genus - Prototaxoxylon Krausel & Dolianti 1958

Prototaxoxylon satnavarii sp.nov.

Several petrified woods were collected from Satnavri in Nagpur district of Maharashtra belonging to Kamthi formation. A piece numbered SATN-11/94 was selected for present work on account of its better preservation.

It is a piece of secondary wood without pith and primary xylem. It is reddish brown in colour and measure 5 cm long and 9 cm broad. Its sections showing T.S., T.L.S. and R.L.S. were prepared and following characters were observed in it.

T.S. : It shows 8 growth rings within a width of 9 cm. Secondary xylem consist of spring wood and autumn wood. Height of spring wood is 93 cells. Its tracheids are squarish in shape, thick-walled and show broad lumen. They measure 33 x 35 um. The autumn wood is 2-3 cells in thickness and consists of horizontally stretched tracheids. They measure 18 x 12 um. (Text Fig. 34, Pl.Fig. 34).

T.L.S. : Xylem rays observed here are uniseriate and biseriate, uniseriate condition is more common than the biseriate. The height of rays varies from 1-24 cells. Average height being 8 cells in 25 counts. The tangential walls of the tracheids are smooth. Xylem parenchyma is absent. The ray cells are barrel-shaped measuring 19 x 17 um. (Text Fig.35, Pl. Fig. 35).

R.L.S. : Radial walls of the tracheids show following types of pitting.

a) Uniseriate pits are circular, contiguous or seperate. The pits measure 6 x 6 um. (Text Fig.36,36A, Pl.Fig.39).

b) Multiseriate pits are circular and alternate measuring 6 x 6 um. (Text Fig. 37, Pl.Fig. 36).

c) Circular pits are in groups of 3 & 4 measuring 7 x 6.6 um. (Text Fig. 38, Pl.Fig. 41).

d) Multiseriate pits are hexagonal, alternate and compact. Measuring 7 x 7 um. (Text Fig. 39, Pl. Fig. 40).

e) Spirals are associated with biseriate circular pits. Pits measure 5 x 55 um. and spiral is 5 u thick. (Text Fig. 40, 40A, Pl.Fig. 37, 38).

Cross-field pits :

The pits in the field area are circular and bordered. Their number varies from 1-8. They measure 5 x 4 um. (Text Fig. 41, Pl. Fig. 42).

Identification :

The present wood represents secondary wood only and shows multiseriate hexagonal pits having Araucarian affinities. It also shows presence of spirals which show Taxinean affinities. These characters agree with the generic characters of Prototaxoxylon Krausel and Dolianti (1958) and hence it is identified with it.

It is compared with Prototaxoxylon africanum (Walton)

Krausel & Dolianti (1958) in having uniseriate circular pits, and hexagonal pits and 2-8 field pits. But it differ from P.africanum in having 1-2 seriate Xylem rays, circular pits in groups of 3 & 4 and multiseriate circular pits. In P.africanum xylem rays are only uniseriate type and circular pits in groups are absent in it. Further P.africanum belongs to Mesozoic horizon while present wood comes from Upper permian of India.

It is also compared with Prototaxoxylon mahabalei Biradar and Bonde (1978) in having 1-2 seriate circular pits and hexagonal alternate pits, 1-2 seriate xylem rays. But it differs from P.mahabalei in having circular pits in groups and 1-8 field pits. In P.mahabalei number of field pits in 1-7 and circular pits in groups are absent in it. Another interesting fact is both these woods come from Upper Permian of Maharashtra suggesting a common horizon i.e. Kamthi formation.

It is comparable with Prototaxoxylon indicum (Mehta) Prakash and Srivastava (1961) in having 1-2 seriate circular pits. But it differs from P.indicum in having circular pits in groups of 3-4, multiseriate hexagonal pits and 1-8 field pits.

In P.indicum number of field pits is 6-7 and it lacks circular pits in groups. Further P.indicum comes from Lower Permian while present wood belongs to Upper Permian.

From the above comparison it is found hat present wood is distinct from known species of Prototaxoxylon in one or other

characters. Hence it is described as a new species viz. Prototaxoxylon satnavarii sp.nov. The specific name is after the locality Satnavari from which it was collected.

Diagnosis :

Growth rings distinct and 8 in number. Spring wood 93 cells thick, tracheids squarish 33 x 35 um. Autumn wood 2 celled, tracheids horizontally stretched 18 x 12 um. Xylem rays 1-2 seriate height varies from 1 to 24 cells, average height 8 cells. Xylem parenchyma and tangential pitting absent. Uniseriate pits are circular 6 x 6 um. Multiseriate circular pits 6 x 6 um. Circular pits in groups of 3 and 4. Hexagonal pits multiseriate 7 x 7 um. Spirals are associated with biseriate pits.

Cross field pits circular, bordered 1-8 and measure 5 x 4 um.

Type	:	SATN-11/94.
Locality	:	Satnavari, District Nagpur, Maharashtra.
Horizon	:	Upper Permian (Kamthi Stage).

Explanation of Text Figures

Text - IV Fig. 34 - 41 *Prototaxoxylon satnavarii* sp.nov.

34. T.S. showing secondary xylem differentiated into spring wood *sp* and autumn wood *au* x 187.

35. T.L.S. showing uniseriate and biseriate xylem rays x 187.

36. & 36A R.L.S. showing uniseriate circular contiguous or separate pits x 595.

37. R.L.S. showing multiseriate circular pits x 595.

38. R.L.S. showing circular pits in groups of 3 & 4 pits x 595.

39. R.L.S. showing multiseriate hexagonal alternate and compact pits x 595.

40 & 40A R.L.S. showing biseriate circular pits with spiral thickning *spt* x 595.

41. R.L.S. showing circular and bordered filed pits *cfp* x 595.

Explanation of Plate Figures

Plate _ IV Fig.34 - 42 *Prototaxoxylon satnavarii* sp.nov.

34. T.S. showing secondary xylem differentiated into spring wood *sp* & autumn wood *au* x 124.

35. T.L.S. showing uniseriate xylem rays x 248.

36. R.L.S. showing multiseriate circular pits x 248.

37.& 38. R.L.S. showing biseriate circular pits with spiral thickening *spt* x 186.

39. R.L.S. showing uniseriate circular, contiguous or seperate pits x 372.

40. R.L.S. showing multiseriate hexagonal, alternate and compact pits x 248.

41. R.L.S. showing circular pits in groups of 3 & 4 pits x 186.

42. R.L.S. showing circular and bordered field pits *cfp* x 124.

TEXT II

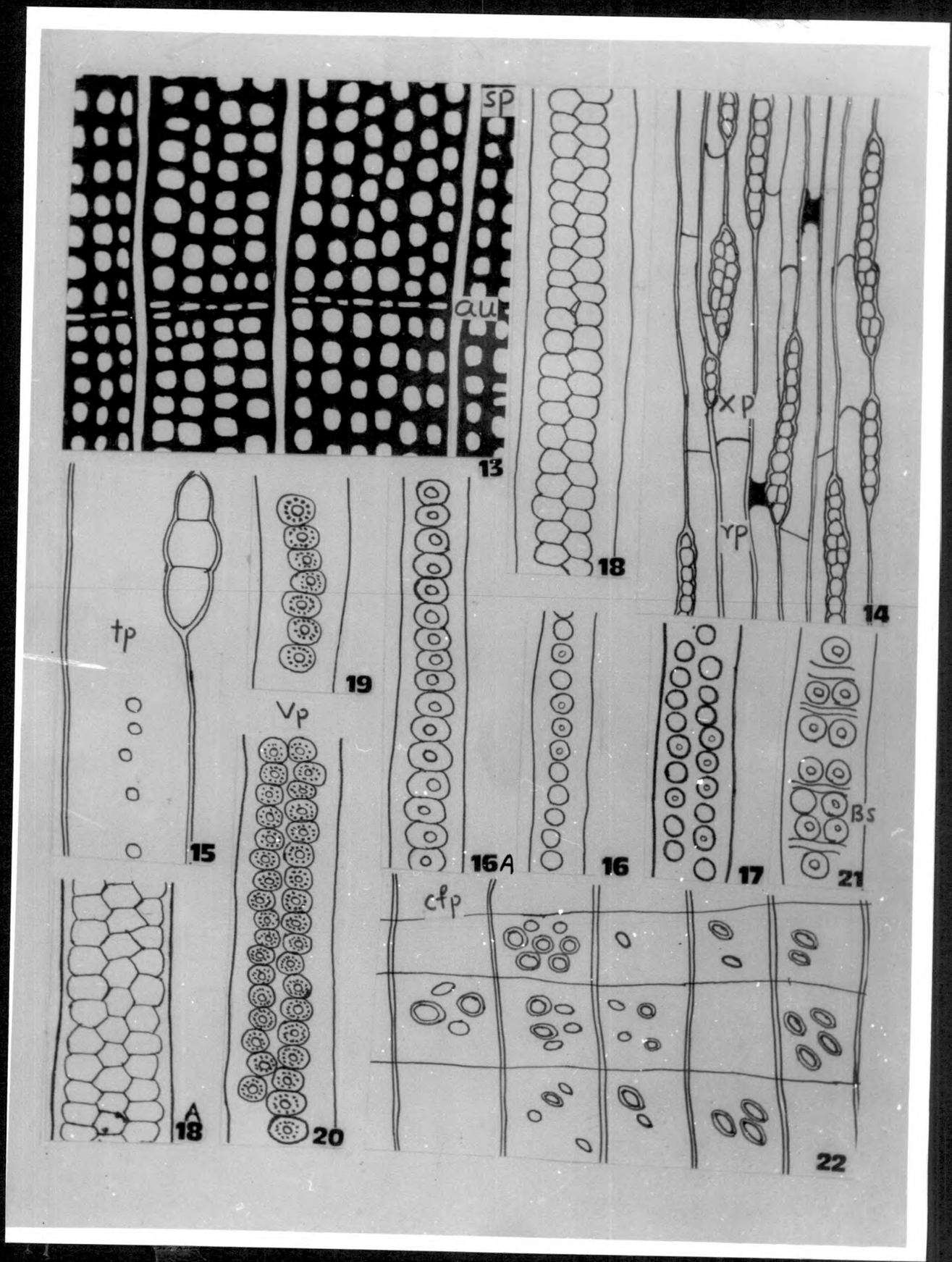
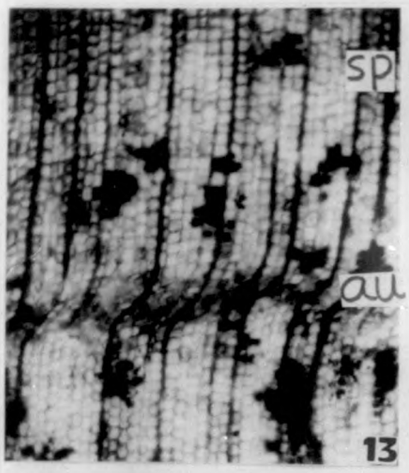


PLATE II



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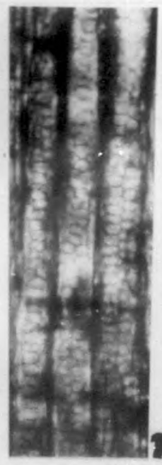
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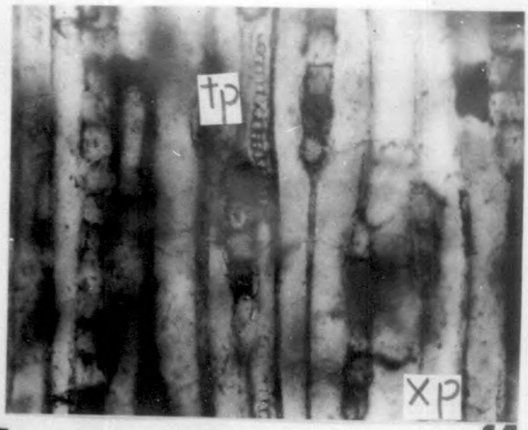

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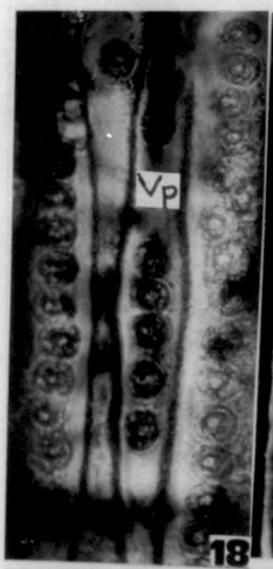

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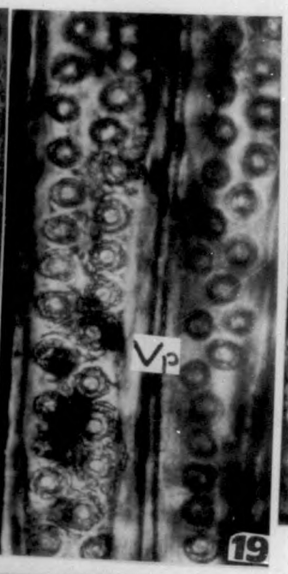

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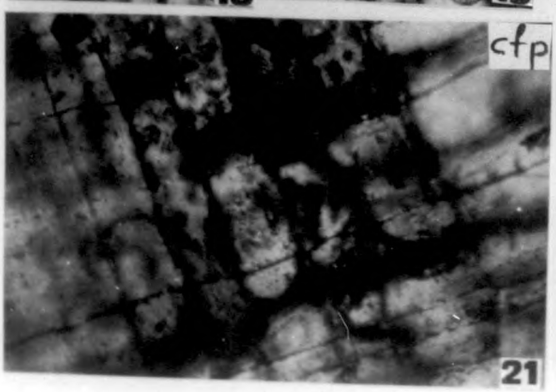

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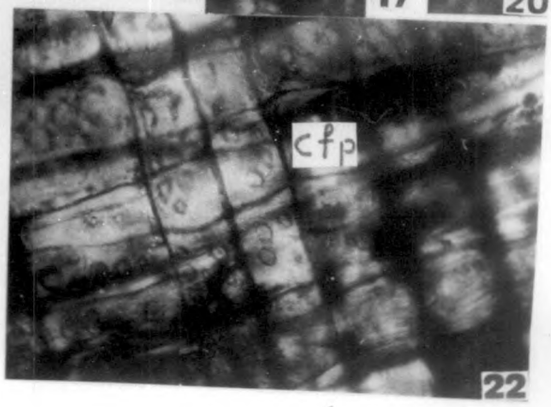

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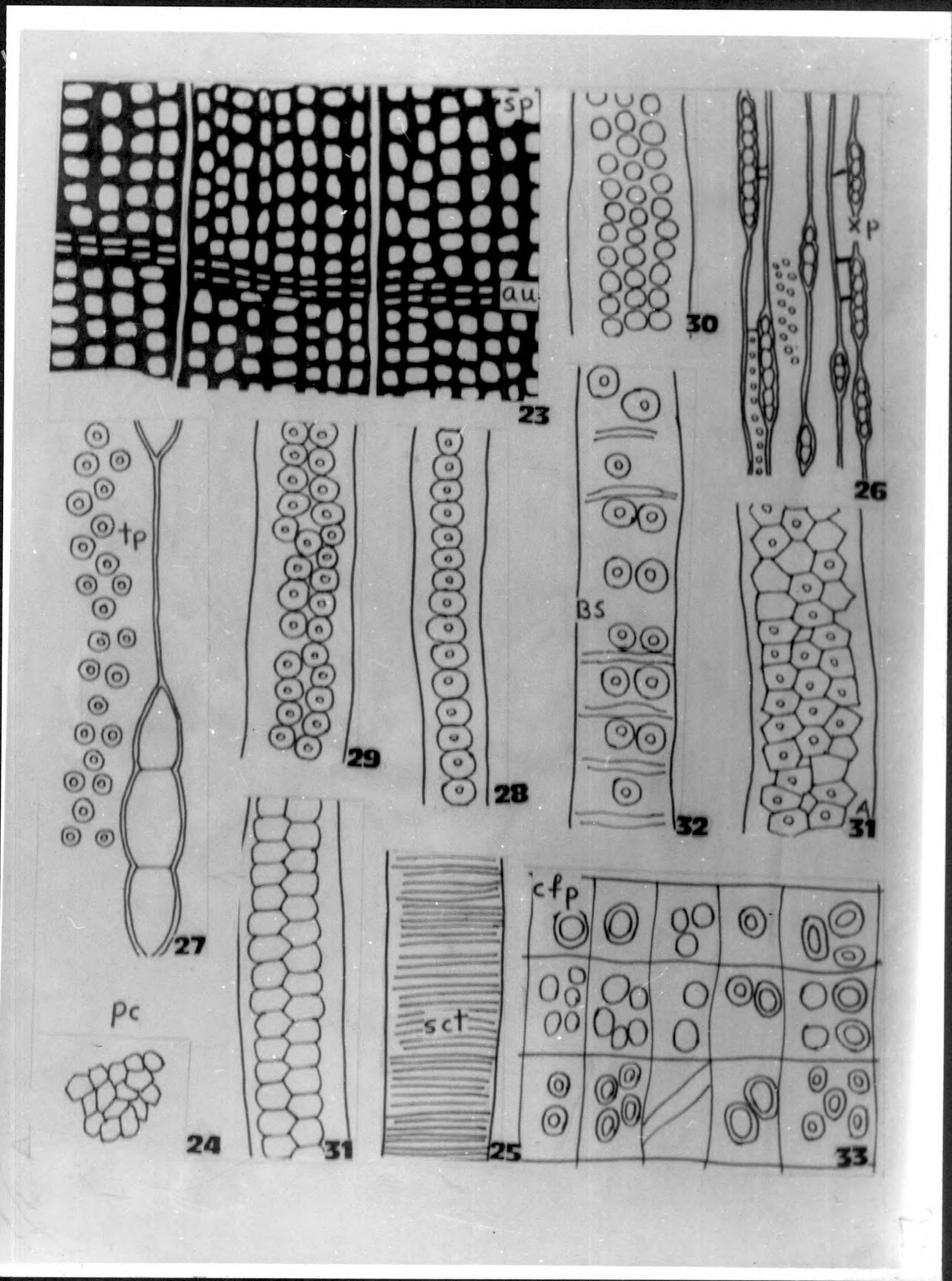

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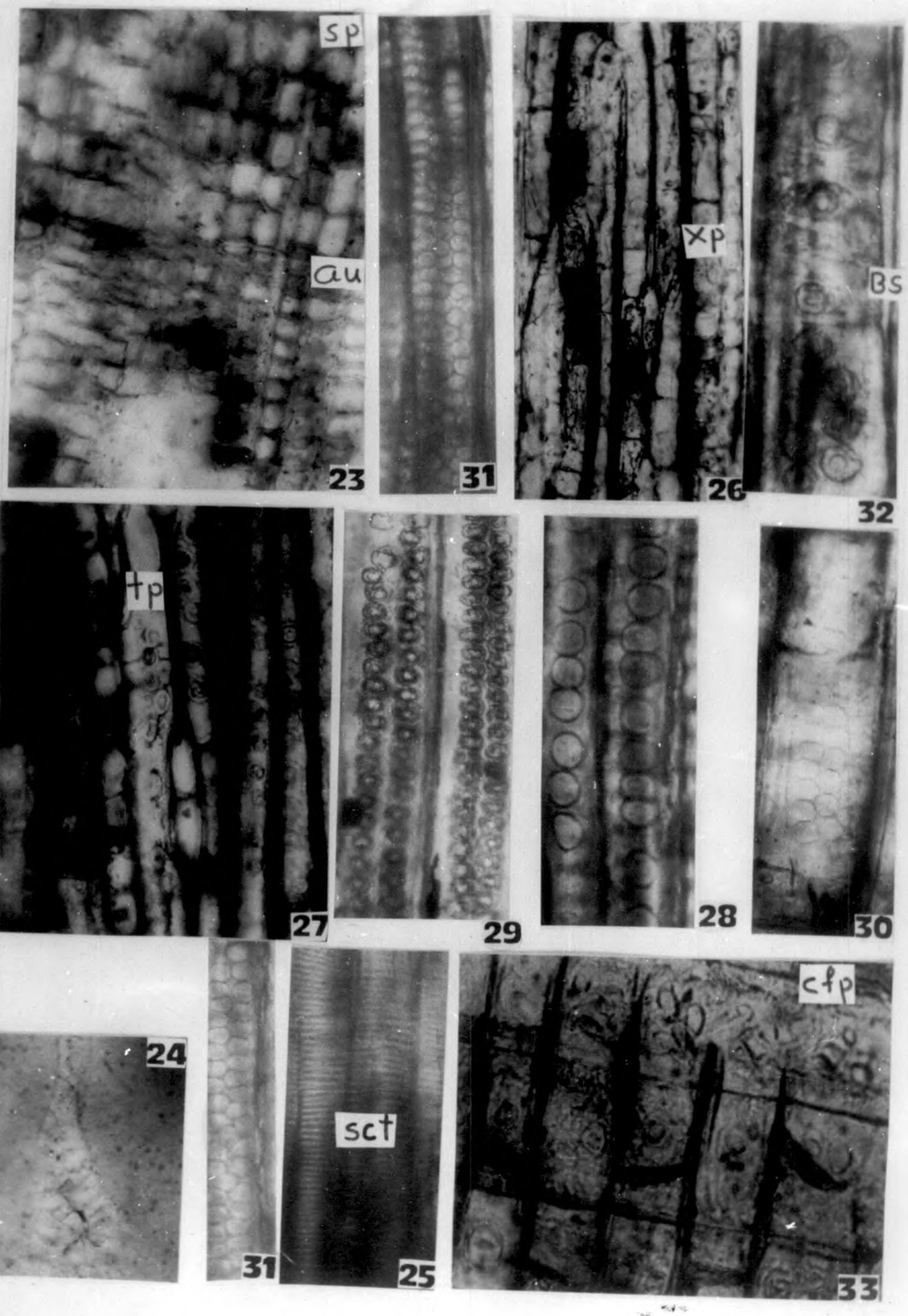

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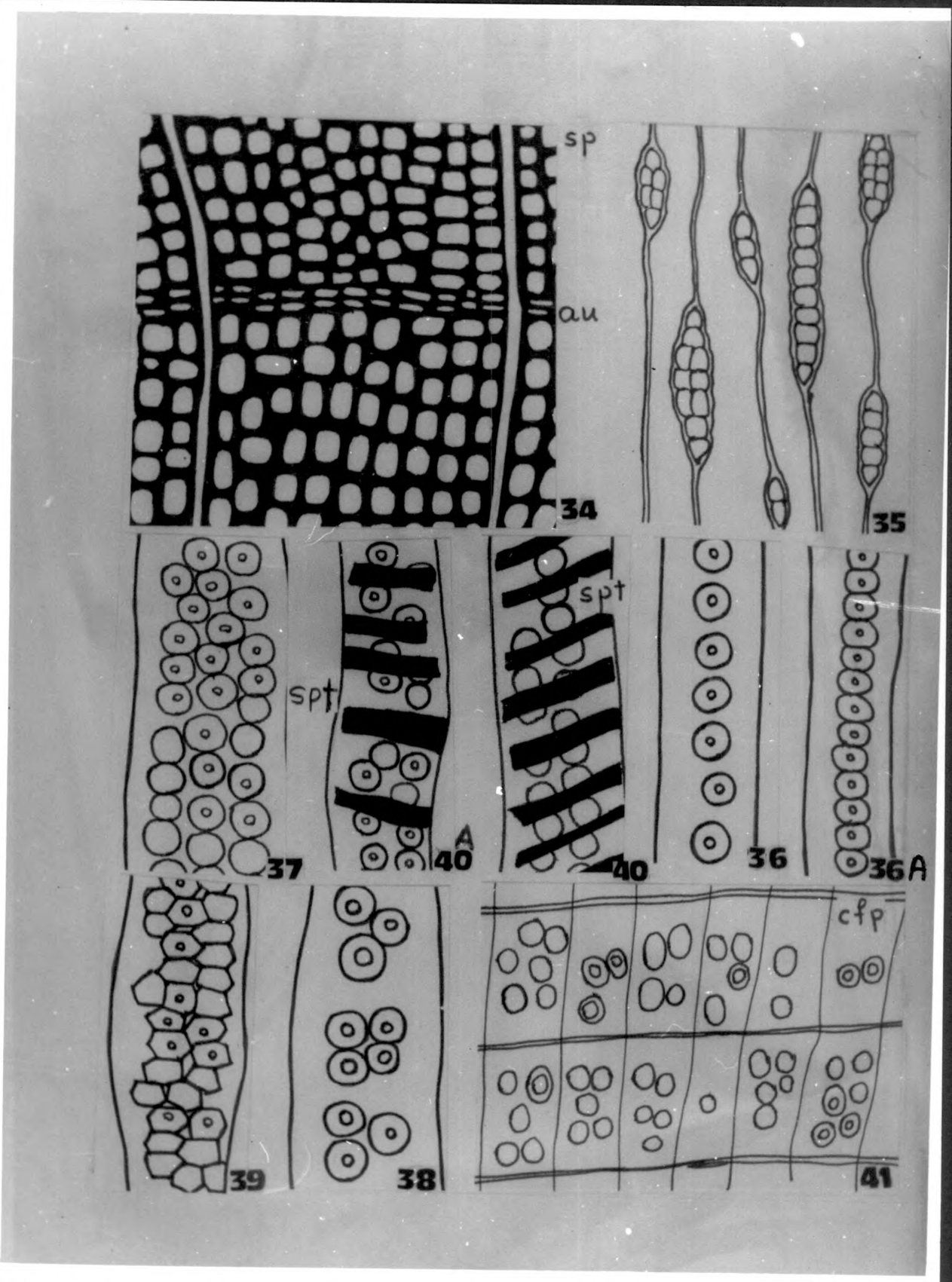

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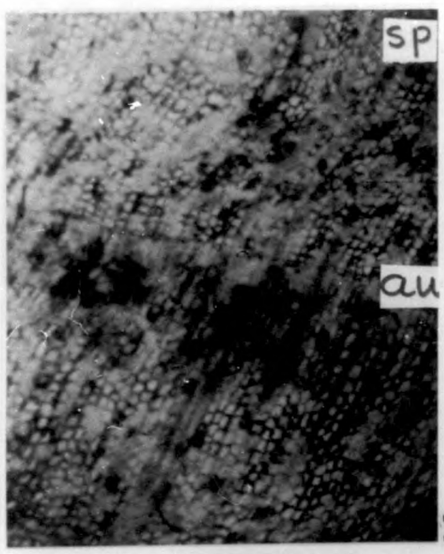

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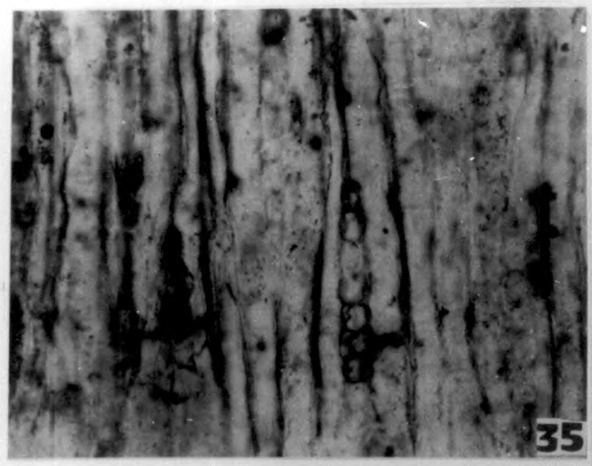
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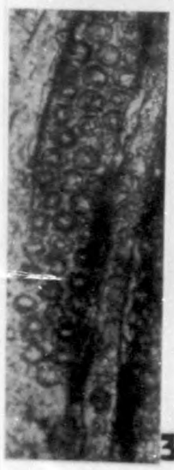
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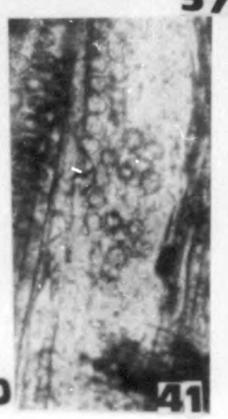
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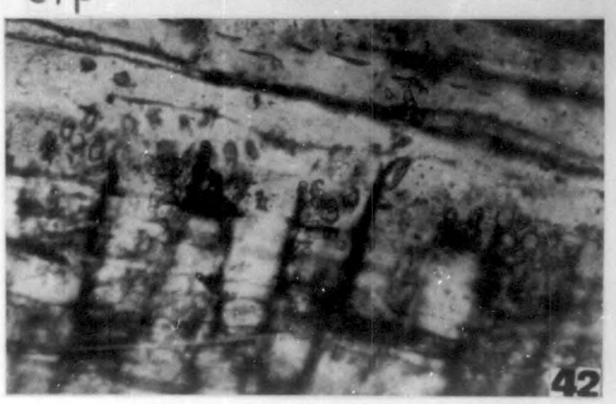
42

Glossopteris longicaulis Feistmantel 1880.

[Text Fig 1, Plate Fig 1]

The present specimen is a petiolate simple leaf measuring 17 cm long and 4.2 cm broad. The midrib is distinct and 3 mm thick in the basal region. It becomes narrower in the upper region. The apex is not preserved. The evanescent nature of the midrib is not clearly seen due to absence of apical region. But tendency of midrib getting narrower towards the upper region suggests the possiblility of becoming evanascent in this region. The secondary veins arise from the midrib at acute angles and dichotomises to form anastomosis resulting oblong polygonal meshes. The meshes near the margins are narrow elongate. The margins are entire. The petiole is partially preserved and 1.5 cm long.

Identification and Comparison :

The specimen closely resembles with the gross features of G.longicaulis Feistmantel in having oblong oval shape of the leaf presence of petiole and strong midrib. The evanescent nature of the midrib in the upper part is not confirmed when the original specimen of Feistmantel was examined by Maheshwari (1965). Hence it is evident that the species is based on long petiole and other features mentioned above. Hence it is identified and described as such. Srivastava (1957) described it from Raniganj Stage. Plumstead (1958 a) reported it from Transval in South Africa. Recently Bhattacharya (1963) described it from Panchet Stage of Bihar suggesting its

occurance in the Triassic. Present specimen comes from Bazargaon in Nagpur district of Maharashtra belonging to Kamthi Formation. This suggests wider distribution of the species in India.

Type	:	BAZ/2-90.
Locality	:	Bazargaon, Dist. Nagpur, Maharashtra State.
Horizon	:	Kamthi Formation.

Genus - Glossopteris Sternberg

Glossopteris emarginata Maheshwari & Prakash 1965.

[Text Fig 2, Pl Fig 2]

The specimen is a simple leaf measuring 5.2 cm in length and 1.7 cm in breadth. It is oblong in shape. The basal part is missing. The midrib is distinct, 1.5 mm thick and reaches upto the apex. The margins are entire and apex is emarginate. The secondary veins arise from the midrib at an angle of 50° and after curving reach the margins. The veins divide dichotomously and anastomose resulting the formation of elongated meshes. In the apical region the secondary veins show a tendancy of turning towards the midrib running nearly parallel and reach the margins. The number of veins found near the margins is 20 per cm.

Identification and comparison :

The present specimen closely agrees with the characters of G.emarginata, Maheshwari and Prakash in having

1. Oblong shape of the leaf.
2. Emarginate apex.
3. Strong midrib.
4. Characteristic venation forming elongated meshes.
5. Veins parallel in the apical part.

Therefore, it is identified and described as such, Maheshwari and Prakash (1965) instituted this species for the characters given above. The specimen described by authors comes from Barakar group (Damuda series) in Rajmahal hills,

Bihar. Later on Maheshwari (1965) described it from Raniganj stage of the Raniganj coalfield in Bengal. The present specimen comes from Satnavari in Nagpur district of Maharashtra belonging to Kamthi formation. Hence it appears that G.emarginata ranges from Barakar to Raniganj. The present report gives additional information about its occurance. It suggests wider distribution of G.emarginate in India.

Type	:	SATN - 3/94.
Locality	:	Satnavari, District - Nagpur (M.S.)
Horizon	:	Kamthi Formation.

Glossopteris sps.

[Text Fig 3, Pl. Fig 3]

The described specimen is a simple leaf measuring 3.8 cm long and 2.6 cm broad. It is obovate in shape becoming narrow towards the basal part. The apex is obtuse and shows a notch in the median region. The margins are entire but on one side it is notched. The midrib is indistinct and some what flat. Secondary veins arise from the midrib at an angle of 60° and after turning reaches the margins. They divide dichotomously and show anastomosis resulting narrow elongated meshes.

Identification and Comparison :

The specimen agrees with G.emarginata Maheshwari and Prakash (1965) in having emarginate apex and similar venation pattern in the apical part. But in G.emarginata the margins are entire. It is closely compared with G.retusa Maheshwari (1965) in having obovate shape notched apex and indistinct flat midrib. But present specimen shows a notched margin on one side only. It is not resembling with G.emarginata or G.retusa in all respects. Therefore, it is described as Glossopteris sps.

Type	:	SATN-21/93
Locality	:	Satnavari, dist. Nagpur, Maharashtra State.
Horizon	:	Kamthi formation.

Glossopteris retifera Feistmantel.

[Text Fig 4, Pl. Fig 4]

The described specimen is a simple leaf measuring 16cm long and 3.4 cm broad. It is linear to lanceolate in shape becoming narrow towards the basal part. Base is missing. Apex is obtuse. The margins are entire. The midrib is stout longitudinally striated about 3 mm broad near the basal part & 2 mm broad in the upper part. Secondary veins arise from the midrib at acute angles nearly and curve near the midrib producing broad polygonal meshes. The meshes are nearly of equal size in major part of the leaf.

Identification and Comparison :

The specimen closely agrees with the characters of Glossopteris retifera Feistmantel in having broad stout midrib, linear lanceolate shape of the leaf and venation showing broad prolygonal meshes of equal size. Hence it is described as such.

It also agrees with G.retifera described by Maheshwari and Prakash (1965) from Barakar Stage of Rajmahal hills in Bihar. But in that specimen apex is missing. According to Maheshwari and Prakash (1965) it is reported from Barakar Iron stone shale and Raniganj stages in India. Present specimen comes from satnavari in Nagpur district of Maharashtra belonging to Kamthi formation. It is first time reported from this place and suggests wider distribution of the species in India.

Type	:	SATN- 11/94.
Locality	:	Satnavari, Nagpur district (M.S.)
Horizon	:	Kamthi Stage.

Glossopteris surangei Chandra and Prasad 1981.

[Text Fig 5 Pl. Fig 5]

The specimen is a simple leaf measuring 9.8 cm long and 2.7 cm broad. It is elliptical in shape narrowing towards the base. The midrib is strong and 2 mm thick, and shows longitudinal striations. It becomes narrow in the upper region and shows evanascent nature. Secondary veins are numerous and arise from the midrib at an angle of 45°. They curve backwardly and form narrow elongated meshes. Margins are entire and apex is obtuse.

Identification and Comparison :

The specimen closely resembles with the description and figures of G.surangei Chandra and Prasad (1981) described from Kanhargaon in Chandrapur district of Maharashtra belonging to Kamthi formation. Therefore, it is described as such. The important features are -

1. Elliptical shape.
2. Obtuse base.
3. Evanascent nature of midrib in the apical part.
4. Venation showing narrow elongated meshes near margins.

It is compared with G.decipiens Feistmantel in having evanascent midrib in the upper part. But G.decipiens is lanceolate spathulate in shape and nature of the apex is not known. It is also compared with G.zeilleri Pant and Gupta (1968) in having evanascent midrib. But G.zeilleri is spathulate in shape. Hence it appears that G.surangei is a distinct species

having its own characteristic features. Present specimen is collected from Bazargaon in Nagpur district of maharashtra from which it is reported for the first time. Its occurance at kanhargaon and Bazargaon shows that it is some what restricted in the Maharashtra.

Type	:	BAZ- 12/90
Locality	:	Bazargaon, Dist. Nagpur (Maharashtra State).
Horizon	:	Kamthi formation.

Genus - Gangmopteris Mc Coy

Gangmopteris major Feistmantel [Text Fig 6, Pl. Fig 6]

The specimen is a simple leaf measuring 4.5 cm long and 2.3 cm broad. It is rhomboidal in shape becoming narrower towards the base. The apex is missing. The median part of the leaf shows sub-parallel veins secondary veins arise from these median veins and form narrow elongated meshes near the margin and broader meshes near the median part of the leaf.

Identification and Comparison :

The specimen agrees with the morphological characters of Gangmopteris major Feistmantel, described by Maithy (1965) from Karharbari beds of Giridih Coal field. Hence it is described as such. Maithy (1965) also described another leaf as Gangmopteris major where apex is not preserved and leaf is spathulate in shape. Present specimen differs from it in having rhomboidal shape. It comes from Satnavari in Nagpur district of Maharashtra. This suggests wider occurance of G.major in India, and range covering Karharbari Stage to Kamthi formation.

Type	:	SATN - 18/93
Locality	:	Satnavari, Dist. Nagpur (Maharashtra State).
Horizon	:	Kamthi Formation.

Gangmopteris sp.

[Text Fig 7, Pl. Fig 7]

The specimen is a fragmentary simple leaf measuring 4 cm long and 3.2 cm broad. It is lanceolate in shape and becoming narrower towards the apex. The apex is bluntly pointed. The margins are entire. In the middle there are sub-parallel veins which are some what weaker in nature. From these median veins secondary veins arise at acute angle and after curving form narrow elongated meshes of equal size. The basal part is missing.

Identification :

It resembles with G.karharbarensis Maithy (1965) in having lanceolate shape and bluntly pointed apex. The cuticular feature of G.karharbariensis are known. While present specimen is devoid of cuticle. It is also compared with Cangomopteris obliqua McCoy in having broadly pointed apex and entire margin. But G.obliqua is spatulata in shape and shows broad polygonal meshes Present specimen differs from it is having narrow elongated meshes. Further shape of the leaf is not spathulate. Hence it is described as Gangmopteris sp.

Type : SATN- 15/93.

Locality : Satnavari, Dist-Nagpur, Maharashtra

Horizon : Kamthi Formation

Genus - Rubidgea Tate 1867

Rubidgea lanceolata Maithy 1965.

[Text-Fig 8, Pl. Fig 8]

The specimen is a oblanceolate leaf measuring 5 cm in length and 1.8 cm in breadth. The apex is acute. The leaf becomes narrower towards the base and shows entire margins. The midrib is absent. The venation shows a distinct pattern having few subparallel veins arising from the basal region and finally occupy the median part of the leaf. Secondary veins start from the median region run straight for some distance and then arch towards the margin. They divide dichotomously but do not form meshes.

Identification and Comparison :

The specimen closely agrees with the characters of R.lanceolata Maithy in having oblanceolate shape acute apex and venation pattern. Hence it is identified and described as such. Genus Rubidgea was instituted by Tate (1867) for leaves from Karoo beds of South Africa. Maithy (1965 a) emended the diiagnosis and described two species from Karharbari beds of Giridih Coal fields in Bihar. R.obovata is characterised by obovate shape while R.lanceolata shows oblanceolate shape Present leaf comes from Satnavari in Nagpur district of Maharashtra. It is recorded from this place for the first time. This suggests wider distribution of Rubidgea in India ranging from Bihar to Maharashtra.

Type : SATN - 25/94
Locality : Satnavari, Dist.Nagpur (Maharashtra State)
Horizon : Kamthi Formation.

Noeggerathiopsis hislopi (Bunb.) Feistmantel

[Text Fig 9 , Pl. Fig 9a]

The specimen is a simple leaf preserved on a reddish white sandstone. It measures 8 cm long and 1.8 cm broad. The leaf is linear to lanceolate in shape. It becomes narrower towards the basal region. The margins are entire and apex is obtusely rounded. Number of parallel veins arise from the basal region. They are almost errect and dichotomise in the upper part. The number of veins per centimeter is 14.

Identification and Comparison :

The specimen resembles with the morphological characters of N. hislopi in having linear to lanceolate shape, and obtuse apex and other details given by Maithy (1965 a). It is proposed that N. hislopi is restricted to the original description of Bunbury (1861) who first reported it from Bharatwada near Nagpur as Noggerathia ? (Cyclopteris) hislopi.

This suggestion by Maithy (1965 a) clears the confusion of mixing other species of the genus with N.hislopi. Our specimen agrees with these characters and they are described here as such. The specimen comes from Umred in Nagpur district and supports its earlier report in this region. It also suggests that N.hislopi is quite common in Nagpur district.

Type : $\frac{\text{UMR}}{5/93}$

Locality : Umred, Dist. Nagpur, Maharashtra State.

Horizon : Barakar Stage, Middle Permian.

Scale Leaf of Venustostrobus

[Text Fig 10, Pl. Fig 10]

The scale leaves of Glossopteris associated with reproductive organs are reported earlier by Feistmantel (1880-81, 1882) as Squamae. Recently Surange and Chandra (1973, 1974) have shown that different types of reproductive organs are associated with scale leaves. Detached scale leaves of male and female fructifications are described by Chandra and Surange (1976) and Surange and Chandra (1973, 1974).

Chandra & Surange (1977) have described fertile bracts and scales of Glossopteris fructifications from Lower Gondwana of India. These scales or fertile bracts show various types of shapes.

The specimen is a scale leaf of protective bract of female reproductive organ. It is assigned to the genus Venustostrobus Chandra and Surange (1977). The scale leaf is rhomoboidal in shape, tapering towards the upper region. It measures 6 cm long and 3.2 cm broad. The central part shows impressions of seeds. The scale leaf is thick and fleshy in nature, showing veins on the margins. They divide and form meshes. The margin is broad and 5 mm thick. The scale leaves of Venustostrobus are known from Hadappa in Denkenal district of Orissa. It belongs to Kamthi Stage. The present specimen comes from Sawanwari in Nagpur district of Maharashtra, belonging to Kamthi Stage. This suggest the wider distribution of Venustostrobus in India, ranging from Orissa to Maharashtra.

Genus - Noeggerathiopsis Feistmantel 1879

Noeggerathiopsis spatulata Dana

[Text Fig 11, Pl. Fig 11]

The specimen is a simple leaf measuring 12 cm in length and 3.5 cm in width. It is a symmetrical leaf having spatulate sheath. The leaf becomes gradually narrower towards the base. It is tapering towards the upper region and shows acute apex. The margins are entire. The veins arise from the basal part and becomes divergent in the upper region. They dichotomise repeatedly but anastomosing is not formed. Number of veins per centimeter is 16.

Identification and Comparison :

The leaf resembles with the morphological characters of N.spatulata Dana emended by Maithy (1965) and hence it is identified with it. The characteristic feature of this leaf is spatulate shape and acute apex and more divergent veins.

Maithy (1965) has given a comparative account of Noeggerathiopsis in India. It is observed that several authors have used the name N.hislopi for these leaves. It was further observed that different species are placed under one name. Hence morphologically as well as on the basic of cuticular studiess they were classified as distinct species. Hence N.spatulata Dana is based on morphological characters and differs from N.hislopi in having spatulae shape. Feistmantel (1879, 1882) described N.hislopi var. subrhomboides.

Now it is clearly defined species and described by

Maithy (1965 a) from Karharbari beds of Giridih coal fields in India. Present specimen comes from Umred in Nagpur district of Maharashtra belonging to Barakar stage.

Type	:	UMR - 17/93
Locality	:	Umred, Dist. Nagpur, Maharashtra State.
Horizon	:	Barakar Stage, Middle Permian.

Division - Sphenopsida

Order - Equisetales

Family - Equisetaceae

Genus - Neocalamites Halle

Neocalamites foxii Lele 1956

[Text Fig 12, Pl. Fig. 12]

The specimen represents a stem showing Equisetaceous affinities. It shows two distinct nodes and measures 9.2 cm long and 2 cm broad. The internodes show considerable length. A single internode is 6.8 cm long. It is distinctly marked by vertical parallel ridges and furrows. The number of ridges and furrows per cm is 12. They are continuous from one internode to another. The specimen resembles with Neocalamites foxii described by Lele from South Rewa Gondwana basin and hence described as such. Present specimen comes from Satnavri in Nagpur district of Maharashtra. This suggests the wider range of Neocalamites in India.

Type : SATN 16/92

Locality : Satnavari, Dist : Nagpur, Maharashtra State.

Horizon : Kamthi Formation (Upper Permian).

Text Figs. : 1-4 Plant Impressions from Nagpur District (M.S.)

1. Glossopteris longicaulis Feistmantel showing venation pattern and shape of the leaf x N.S.

2. Glossopteris emarginata Maheshwari & Prakash showing venation pattern and emarginate apex x N.S.

3. Glossopteris sp. showing venation pattern and shape of the leaf x 2.

4. Glossopteris retifera Feistmantel showing venation pattern and shape of the leaf x N.S.

Plate - I

Plate Fig. 1-4 Plant impressions from Nagpur district (M.S.)

1. Glossopteris longicaulis Feistmantel showing venation pattern & shape of the leaf x .75

2. Glossopteris emarginata Maheshwari & Prakash showing venation pattern & emarginate apex x 1.75

3. Glossopteris sp. showing venation pattern & shape of the leaf x 2

4. Glossopteris retifera showing venation pattern & shape of the leaf x .75

Text Figs. 5-10 Plant Impressions from Nagpur District (M.S.)

5. Glossopteris surangei Chandra & Prasad showing venation pattern and shape of the leaf x N.S.

6. Gangmopteris major Feistmantel showing venation pattern and shape of the leaf x 2.

7. Gangmopteris sp. showing venation pattern and shape of the leaf x 2.25

8. Rubidgea lanceolata Maithy showing venation pattern and shape of the leaf x 1.5

9. Noeggerathiopsis hislopi (Bunb.) Feistmantel showing venation pattern x 1.25

10. Scale leaf of Venustostrobus Chandra & Surange showing veins on the margins and seeds on the central region x 1.75

Plate - II

Plate Fig. 5-8 Plant Impressions from Nagpur District (M.S.)

5. Glossopteris surangei Chandra & Prasad showing venation pattern & shape of the leaf x 1.25

6. Gangmopteris major Feistmantel showing venation pattern & shape of the leaf x 2

7. Gangmopteris sp. showing venation pattern & shape of the leaf x 2

8. Rubidgea lanceolata Maithy showing venation pattern & shape of the leaf x 2.

Text Fig. 11-12 Plant impressions from Nagpur District (M.S.)

11. Noeggerathiopsis spathulata Dana showing shape of the leaf and parallel veins x 1.50

12. Neocalamites foxii Lele showing node, and parallel ridges and furrows x 1.5

Plate - III

Plate Fig. 9-12 Plant Impressions from Nagpur District (M.S.)

9. Noeggerathiopsis hislopi (Bumb.) Feistmantel showing venation pattern x 1.5

10. Scale leaf of venustostrobus Chandra & Surange showing veins on the margins & seeds on the central region x 2

11. Noeggerathiopsis spathulata Dana showing shape of the leaf & parallel veins x .75

12. Neocalamites foxii Lele showing node & parallel ridges & furrows x .75

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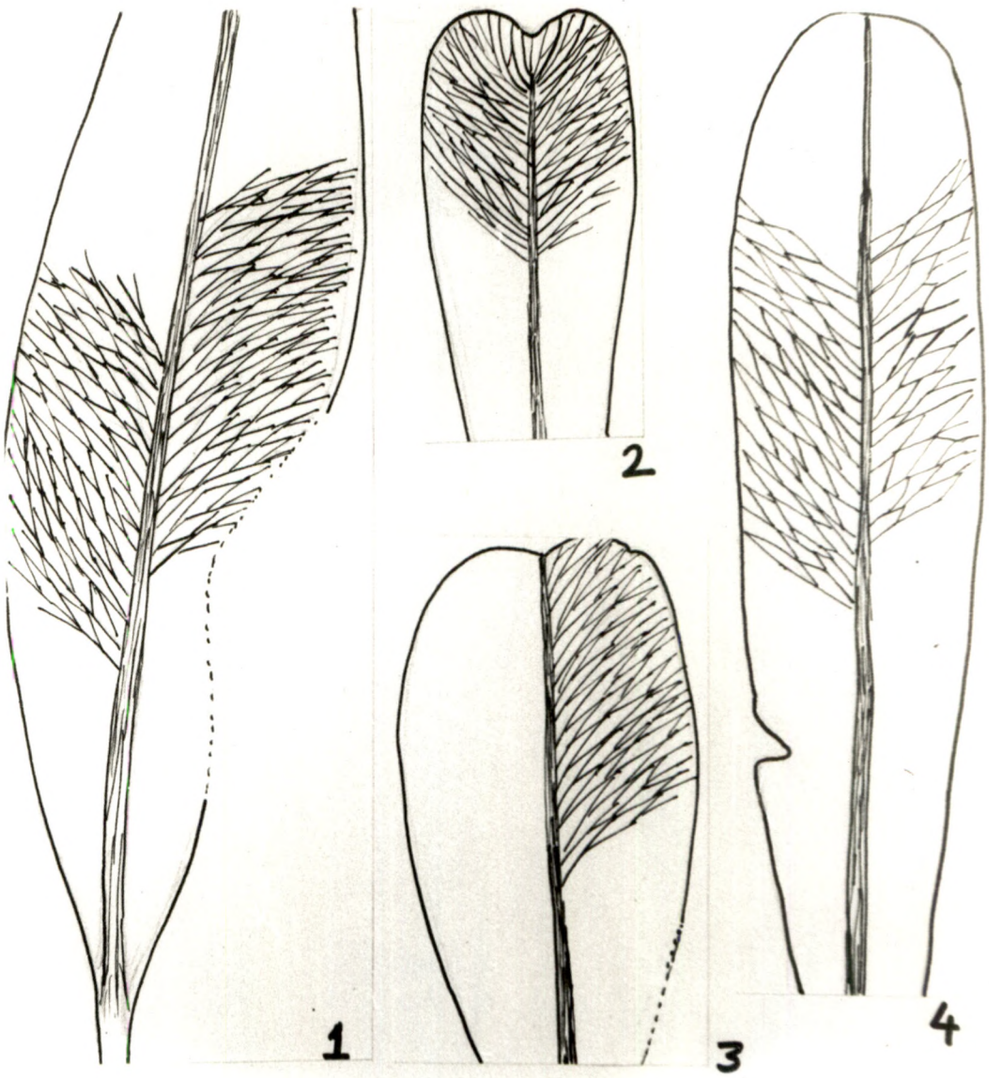

PLATE I

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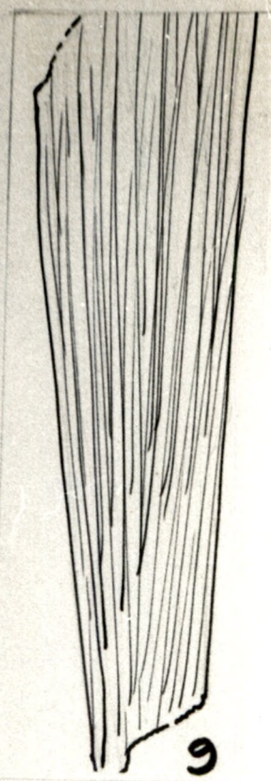

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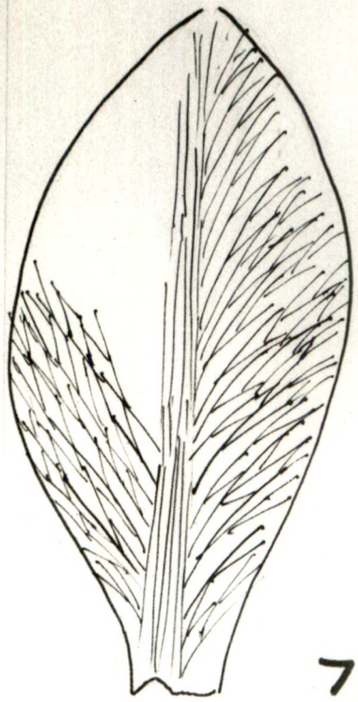

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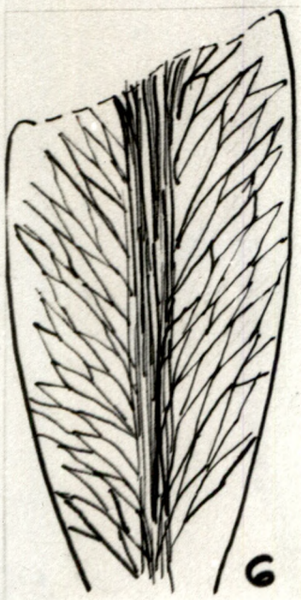

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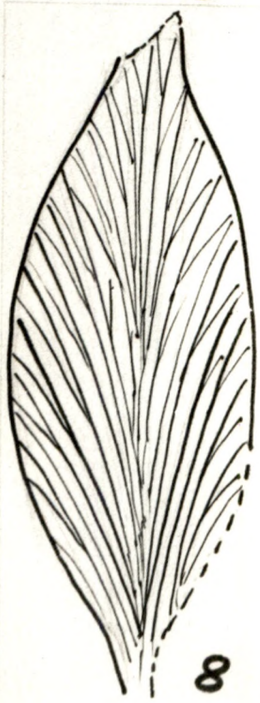

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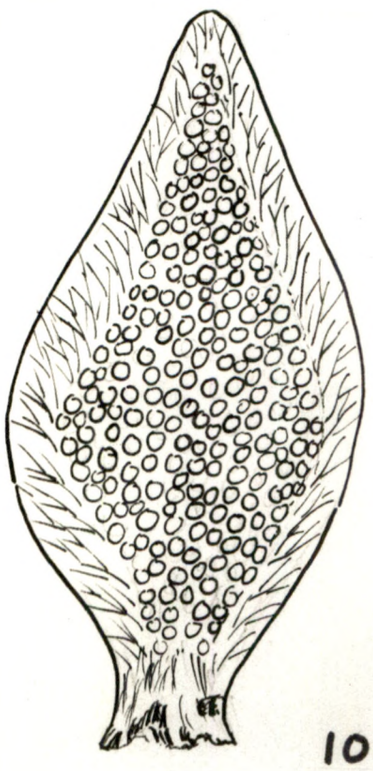

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PLATE II


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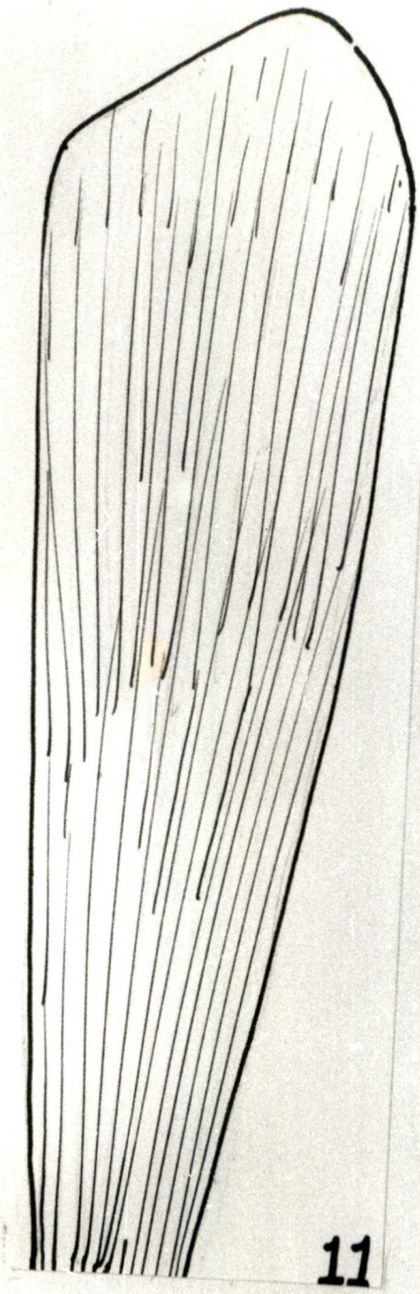
TEXT III



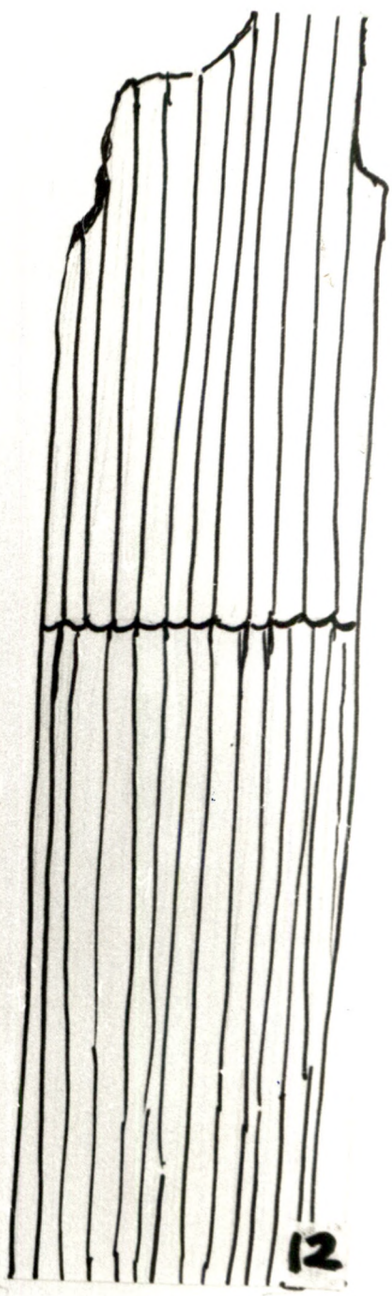


PLATE III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