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# A PETRIFIED CARBONIFEROUS LEPIDODENDRID — *LEPIDOPHLOIOS FULIGINOSUS* WILLIAMSON — FROM THE VICINITY OF RYBNIK (UPPER SILESIAN COAL BASIN)

Skamieniały widłak karboński *Lepidophloios fuliginosus* Williamson z okolic Rybnika (Górnośląskie Zagłębie Węglowe)

## INTRODUCTION

Among the various fossils representing the Carboniferous *Lepidophyta*, the most frequently encountered are casts and compressions of the bark of stems with characteristic persistent leaf-bases and leaf-scars. Quite frequent are similarly preserved underground parts of the *Lepidophyta* and also leaves. Comparatively seldom do there occur in the sediments the strobili which occasionally contain spores. In a few cases petrified *Lepidophyta* fragments are found which make possible the investigation of their structure. Such well preserved structures are very valuable material for studies. Petrifactions of this type were produced in special conditions and their occurrence is limited to certain Carboniferous sediments, especially to paralic basins. Descriptions of petrified *Lepidophyta* (besides other plant groups) of this period mainly concern the material preserved in the form of the so called coal balls, found in the Carboniferous rocks of Great Britain, Germany, Russia, and some other European countries and also in North America and Asia. In Poland no true coal balls with petrified plant fragments have been found hitherto.

The first group of the structure showing plant remains of the younger Palaeophyticum of Poland are silicified woods. Here belong the so called Permocarboniferous (according to Raciborski) but according to Siedlecki Stephanian stems of *Dadoxylon* (*Araucarites*) from the vicinity of Chrzanów (Raciborski 1889, Reymanówna 1962) and the woods of Westphalian age from the Infrasudetic Basin (Dziedzic 1958, Turnau-Morawska 1959, Kwiecińska, Heflik 1963).

To the second group belong the extremely rare plant fragments of Westphalian age from the vicinity of Jaworzno. They are preserved in clay nodules ("Tonsteine") and show plant structure. Here belongs the Sphenophyllean strobilus *Bowmanites Roemeri* described by Solms-Laubach (1895) and fragments of various plants figured by Bocheński and Bolewski (1959).

Apart from this petrified *Pteridophyta* remains from the Lower Carboniferous of Lower Silesia were described (Goeppert 1859, Feistmantel 1873, Gothan 1932, 1937).

From the region of Ostrawa-Karwina in Czechoslovakia, which is the extension of the Cracow-Silesian Basin, Kubart (1914) described petrified fragments of Pteridosperms belonging to *Heterangium* and *Lyginodendron* which were found in the paralic sediments of the Upper Namurian A.

In 1962 K. Matl, of the Chair of Coal Deposits, Academy of Mining and Metallurgy in Cracow, found in the Poruba beds of the pit "Jankowice" in Boguszowice near Rybnik a petrified fragment of a Carboniferous Lepidodendrid with very well preserved structure. He very kindly gave the author this specimen for investigation. It was determined as *Lepidophloios fuliginosus* Williamson and is the first Lepidodendrid fragment with preserved structure described from the Namurian of Poland [1].

The structure of Lepidodendrid stems is comparatively well known. However in most specimens there is an empty space between the primary cylinder and the outer cortex, so that any stem with this area preserved is of interest. Unfortunately, the author had at his disposal only three thin sections as the rest of the specimen was lost. As a result, he was able only to touch on the interesting question of the "anomalous" secondary growth in Lepidodendrids which has recently been discussed by Arnold (1960), Eggert (1961) and others.

## STRATIGRAPHY AND LITHOLOGY OF THE LOCALITY AND KIND OF PRESERVATION OF THE SPECIMEN

The investigated specimen was found in a horizon with marine fauna, named by Matl (1964) the "Upper Jankowice seam" ("Jankowicki górny"), at the stratigraphic distance 7·3 m. from its top surface and 30·1 m. above the floor surface of the coal seam 0·64 m. thick, called in the Jan-

[1] The author has at his disposal further petrified plant fragments from the Upper Silesian Coal Basin and he intends to continue the investigations.

kowice colliery "seam O". This marine horizon (lb) formed by a rock layer 11·3 m. thick, belongs to the uppermost section of the Poruba beds (warstwy porębskie), uppermost Namurian A, which close from above the paralic series of the productive Carboniferous.

The specimen, though containing calcium carbonate, was found in a solid, strongly diagenetic mudstone (clay slate) which does not react with hydrochloric acid. This mudstone is dark grey (streak test light), has a conchoidal fracture, and contains numerous spherosiderites. On certain bedding planes occur thin (a few mm. thick) layers of calcite. This shale contains a marine macrofauna and also single plant compressions. They are accompanied occasionally by pyrite scales. All the plant remains are deposited in accordance with the stratification of the rock.

According to N. M. Strachov (Bocheński, Bolewski, Michałek 1955) the presence of many spherosiderites indicates also sedimentation in a shelf zone. Preserved plant tissues indicate transport from a not distant land.

The petrifaction of the Lepidodendrid stem was effected by impregnation of its tissues by calcium carbonate in marine surroundings. In thin sections the calcium carbonate is seen under the microscope in the form of numerous calcite crystals of the characteristic rhombohedral shape. Calcite also forms veins through the plant tissues and the carbonaceous layer on the surface of the specimen.

## *Lepidophloios fuliginosus* Williamson

(Pl. I—V)

1903. *Lepidophloios fuliginosus* Williamson, Weiss (in Hirmer 1927, P. 243—248, Figs. 275—283).
1910. *Lepidodendron fuliginosum* Williamson, Seward, P. 141, Figs. 162—171.
1920. *Lepidophloios fuliginosus* Williamson, Scott, P. 118—155, Fig. 72.
1934. *Lepidodendron fuliginosum* Williamson, Calder, P. 114, Pl. I, Figs. 1—4, 9.
1964. *Lepidophloios fuliginosus* Williamson, Gothan-Weyland, P. 127.

### Description

The specimen was a calcified fragment of a stem 3 cm. long and 2 cm. in diameter, covered by a thin and brittle layer of vitrite coal. The three thin sections (transverse, radial and tangential) show very well preserved structure in the entire petrified part of the fossil.

Pith. In the centre of the stem is situated the oval pith, its longer and shorter diameters being 2·6 and 1·7 mm. respectively. It is solid apart from one or two cracks. At one side it consists of thin-walled, isodiametric cells about 80 μ in diameter but the other side is collapsed tissue. The longitudinal section shows that the pith consists of square or triangular cells which are arranged in longitudinal files, as if they were formed by subdivision of elongated cells with tapering ends. No tracheids were observed in the pith.

Primary xylem. The pith is surrounded by a ring of primary xylem: It consists of a metaxylem zone 5—7 tracheids (0·6 mm.) wide with exarch protoxylem groups on the outside.

The metaxylem tracheids are polygonal or oval in transverse section, they are often arranged radially and with their longer axis radially orientated; their diameters are about 200 and 100 μ respectively. The smallest tracheids occur in the peripheral part of the ring and their width increases gradually towards the pith. The tracheids are 1·5—3·5 mm. long, and somewhat shorter nearer the pith. The longitudinal walls of the tracheids show parallel scalariform bars which are about 2 μ wide and 8 μ apart. The bars are connected by a system of fibrils which anastomose once or twice.

The outer margin of the metaxylem is more or less crenulate and shows protruding groups of small (about 33 μ in diameter) protoxylem elements occurring at fairly regular intervals.

Next to the primary xylem lies a zone of parenchyma 4—6 cells wide. The cells are isodiametric both in transverse and longitudinal section, up to 30 μ in diameter, and tend to be arranged in longitudinal files. They have light brown contents.

Secondary parenchyma and xylem. Next lies a ring of secondary tissues. First comes a zone of secondary parenchyma of varying thickness which reaches in places 0·6 mm. It consists of radially arranged cells which are elongated in the radial direction (up to 3 times their width). These cells have dark contents. They do not show any thickenings on their walls and hence are of a truly parenchymatous character. Among them are interspersed groups of isodiametric tracheids showing transverse bars.

In one half of the stem this parenchyma extends till the secretory zone but in the other half it is succeeded by a crescent of secondary xylem. This xylem consists of square tracheids arranged in radially seriated rows, up to 12 tracheids in a row. The xylem is interrupted by leaf-traces and medullary rays.

The tracheids are much smaller than in the metaxylem, only 40 μ in diameter, and 300—600 μ long. They have a distinctly undulating course and they show scalariform bars and anastomosing fibrils similar to those found in the metaxylem. The medullary rays appear in tangential section as groups of small parenchyma cells.

After the secondary xylem follows a zone consisting of about 5 layers of small isodiametric parenchyma cells. It differs from the adjacent zones in the smaller size of the cells, their dark contents, and the presence in most of them of a small brown body which resembles a cell nucleus.

These cells are arranged into more or less distinct radial files which, however, are not continuous with the files of tracheids, as up to 3 parenchyma cells abut on one tracheid.

As seen in longitudinal section, these parenchyma cells are square, brick-like, and occur in horizontal rows. Occasionally they are narrow and elongated in the vertical direction. These parenchyma cells either abut on mature secondary tracheids or there is in between a layer of elongated thin-walled cells with tapering ends. These elongated cells are largest near the tracheids and become shorter and narrower towards the parenchyma. Their walls are smooth, only occasionally showing faintly marked thickenings. They are evidently initial stages of tracheids. It is not possible to make out with certainty whether these initial tracheids intergraded into the parenchyma layer; there is a place in the longitudinal section which might suggest this (Pl. III, fig. 9).

Beyond the crescent of the secondary xylem this parenchyma layer disappears gradually. Where present it forms radially alligned rows which are continuous with the above described seriated parenchyma (Pl. IV fig. 12).

S e c r e t o r y   t i s s u e. Next follows the zone of the so called secretory tissue which consists of about 7 layers of cells with a diameter varying from 17 to 48 μ. The cells are isodiametric or irregular in transverse section and often form groups of circular outline. The cells often have dark contents. These cells are more uniform and smaller in diameter on the side of the stem where the secondary xylem is lacking. As seen in longitudinal section, this zone consists of parenchyma cells, isodiametric or vertically elongated, and of vertical canals. The canals are up to 700 μ long, irregular in outline, and they occasionally divide into two. They correspond with the widest cells seen in transverse section. They appear to originate from parenchyma cells in which the walls facing the interior of the canal break down. Inside one of the large canals there are seen smaller cells with their walls breaking down. There occur also intermediate stages, such as vertical files of cells with most of the transverse walls disintegrated, but a few still present.

P r i m a r y   c o r t e x. The primary cortex consists of three well differentiated zones: the inner, middle and outer cortex. The inner cortex is 0·3 mm. wide and consists of about 20 layers of compactly arranged cells. The cells are about 48 μ long and about 30 μ wide, the cell walls being 3 μ thick. As seen in transverse section, the cells are polygonal, elongated, in tangential direction, occasionally arranged in concentric rows. The cell walls and occasionally the cell contents are dark brown. In longitudinal section the cells are square and form vertical files.

The middle cortex is 1·7—2·6 mm. thick and is built of thin walled parenchyma. This is seen to consist both in transverse and longitudinal section of isodiametric cells among which occur undulating septate filaments. There occur areas where the cells are collapsed and small lacunae are seen in the tissue. The boundary with the outer cortex is marked by a few layers of smaller, flattened cells.

The outer primary cortex is 4—5·8 mm. thick and is composed of a compact layer of thick-walled cells. The cells are isodiametric or slightly elongated in transverse section and about twice as long as wide in longitudinal section. The peripheral part of the outer cortex is followed by a dark layer of vitrite coal and there the structure cannot be seen. Two wedges of the same substance are seen in the outer cortex on opposite sides.

Leaf traces. The leaf-traces begin in the protoxylem but the exact relation of these two tissues was not established. At the beginning and in the secondary parenchyma the course of the leaf-traces is very steep, as they are cut transversely by the transverse section of the stem. In the secondary xylem their course seems to be more horizontal but it is again very steep in the secretory zone and in the primary cortex. Only in the peripheral part of the cortex is their course less steep and they are cut obliquely.

The leaf-traces begin as strands of small tracheids. During their course through the secondary parenchyma and the secondary xylem they are surrounded by a sheath of parenchyma which is present round the leaf-trace through its further course. Outside the secondary xylem the trace includes larger tracheids and is extended in a tangential direction. The tracheids show scalariform bars which often anastomose and are connected by anastomosing fibrils similar to those of the metaxylem and secondary xylem. Beyond the zone of secretory tissue the xylem is accompanied on its abaxial side by a strand of secretory tissue, consisting of larger elongated elements and of small, usually dark cells. The xylem is separated from the secretory tissue by a few layers of small parenchyma cells. In longitudinal section this parenchyma is seen to consist of narrow elongated cells, their length exceeding several times their width.

Beyond the middle cortex the leaf-traces are accompanied on their abaxial side by a strand of tissue corresponding in structure with the tissue of the middle cortex. This strand is kidney-shaped in transverse section.

## Discussion and comparison

The generic determination as *Lepidophloios* is only tentative. The specimen has no leaf-cushions preserved and the *fuliginosus* type of structure may be found both well in *Lepidodendron*, and in *Lepidophloios*.

The structure of our specimen agrees closely with that of *Lepidodendron fuliginosum* as described by Williamson (1887, 1895), Seward

(1910) and Calder (1934). It agrees also with the two slides of *Lepidodendron fuliginosum* from the English coal-balls which are to be found in the collections of the Botanical Institute in Cracow. But the structure of our specimen also agrees closely with *Lepidophloios fuliginosus* described by Weiss (1903) and Scott (1920). According to Gothan and Weyland (1964) the name *Lepidophloios fuliginosus* is now generally used for this type of structure. Therefore the specimen from Rybnik is determined as *Lepidophloios fuliginosus* Williamson.

In the first place, the specimen from Rybnik agrees with *Lepidophloios fuliginosus* in showing the complete sequence of tissues up to the outer cortex. Next, the specimen agrees with *Lepidophloios fuliginosus* in the structure of the pith, in the presence of the "anomalous" secondary zone, in the undulating course of the secondary tracheids and also in the structure of the three zones of the primary cortex.

*Lepidophloios fuliginosus* is distinguished from the most species by the presence of the "anomalous" secondary zone which in different specimens may consist either of parenchyma alone or also of a smaller or larger amount of xylem. A zone of "anomalous" secondary xylem consisting of undulating tracheids may occur also in *Lepidophloios pachydermatikos,* described by Andrews and Murdy (1958). This species, however, does not show radially elongated secondary parenchyma.

In fact, the species *Lepidophloios fuliginosus* probably represents a stage of growth of the stem, such as the beginning of the formation of the secondary xylem, or else a pathological condition.

The most interesting feature of the stem from Rybnik are the secondary tissues. Especially interesting is the zone of isodiametric parenchyma cells outside the secondary xylem. Some authors, such as Weiss (cit. Hirmer 1927) described this parenchyma as cambium but Seward (1910) regarded it as a meristem producing only xylem. Recently Arnold (1960) described a similar layer in *Lepidodendron schizostelicum* as a periderm-like layer.

Now the longitudinal section through the sector with secondary xylem in the specimen from Rybnik shows that this parenchyma is not cambium. Its cells are almost isodiametric instead of being strongly elongated like true cambium cells. But they are either a meristem, or else parenchyma which occupies the place of a meristem because in one or two places the cells are somewhat elongated and there occur intermediate stages between them and the tracheids (Pl. III, fig. 9).

In transverse section the parenchyma cells are smaller than the secondary tracheids and hence do not form continuous files with them. The transverse section of the secondary tissues where no xylem is present shows a fragment where flattened parenchyma cells are of the same size as the radially elongated parenchyma cells and form with them continuous files. What is more, these files appear to comprise at least the first cells of the secretory tissue (Pl. IV, fig. 12). This fragment shows apparently an earlier stage of development when the meristem was active and produced secondary parenchyma.

There is also an indication that it might have produced the secretory tissue. But the longitudinal section of such a stage is not known and the evidence is not sufficient to draw any conclusions as to the origin of the secretory tissue which was thought by Seward (1910) and Arnold (1960) to be a primary tissue.

The longitudinal sections of the leaf-traces show narrow and very much elongated parenchyma cells between the xylem and secondary tissue, which resemble true cambium. But again, there is not enough evidence particularly as similar elongated cells occur in the parenchyma sheath of the leaf-trace. Only new material can help to solve these questions.

Another interesting feature of the specimen from Rybnik are the anastomosing fibrils between the scalariform tracheids. Walton and Pant (1961) found that most Lepidodendrids possess simple, only occasionally anastomosing fibrils such as those of *Lepidodendron kilpatrickensis* figured by Smith (1962). One of the exceptions is *Levicaulis arranensis* (Beck 1958) where the fibrils form a dense network. In our specimen the network is less complicated as the fibrils anastomose only once or twice.


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## STRESZCZENIE

### SKAMIENIAŁY WIDŁAK KARBOŃSKI *LEPIDOPHLOIOS FULIGINOSUS* WILLIAMSON Z OKOLIC RYBNIKA (GÓRNOŚLĄSKIE ZAGŁĘBIE WĘGLOWE)

W kopalni węgla kamiennego „Jankowice" koło Rybnika (Górnośląskie Zagłębie Węglowe) znaleziony został w 1962 roku przez mgra inż. K. M a t l a fragment spetryfikowanego pędu widłaka karbońskiego z doskonale zachowaną budową anatomiczną. Jest to pierwsze o takim charakterze fosylizacji znalezisko paprotnika, pochodzące z dolnej części karbonu produktywnego (piętro namurskie) w Polsce. Okaz wydobyty został z łupku ilastego, zawierającego makrofaunę morską, liczne konkrecje syderytowe oraz cienkie i z rzadka rozmieszczone przewarstwienia kalcytu. Wspomniany łupek tworzy jeden z najwyższych poziomów morskich (poziom 1 b) w szczytowym odcinku warstw porębskich (najwyższy namur A), zamykających od góry serię osadów o charakterze paralicznym w Górnośląskim Zagłębiu Węglowym.

Petryfikacja („kamienienie") znalezionego szczątka widłaka nastąpiła w wyniku przepojenia jego tkanek przez węglan wapnia, przekrystalizowany w formę kalcytu. Minerał ten wypełnia światła komórek oraz impregnuje ciemniej zabarwione ściany komórkowe.

Nadzwyczaj dobre zachowanie struktur tkankowych opracowanej formy roślinnej pozwoliło na zaliczenie jej do znanego już od dawna z innych krajów (zwłaszcza z Anglii) gatunku *Lepidophloios fuliginosus* Williamson.

Skamieniałość o wymiarach około 3 cm długości i 2 cm średnicy przedstawia fragment młodej gałęzi lepidofita, otoczony od zewnątrz warstewką węgla (witrynu), powstałego prawdopodobnie z powierzchniowych tkanek korowych.

Środek pędu zajmuje pojedyncza stela z centralnie umieszczonym, jednorodnym (bez elementów ksylemowych) rdzeniem parenchymatycznym (fig. 1, 2, 3). Wokół niego rozwinięty jest cylinder metaksylemowy o drabinkowato zgrubiałych tracheidach, otoczony drobnymi i nieregularnie rozmieszczonymi grupkami komórek protoksylemowych (fig. 1, 2, 4, 6, 7). Na zewnątrz ksylemu występuje cienka warstewka drobnych komórek parenchymatycznych a nad nią wtórna tkanka parenchymatyczna o komórkach wydłużonych w kierunku promienistym (fig. 1, 2, 6, 7, 11). Po jednej stronie steli wykształcone jest nieregularnie (półksiężycowato) drewno wtórne (fig. 1, 8, 9, 10). Tracheidy tego drewna na przekroju podłużnym (fig. 8, 9) są podobnie jak w ksylemie drabinkowato zgrubiałe, lecz w odróżnieniu od tamtego falisto powyginane. Pomiędzy zgrubieniami tracheid zarówno w ksylemie, jak i w drewnie wtórnym, dostrzegalne są poprzecznie przebiegające włókienka, tzw. fibryle (fig. 5). Po zewnętrznej stronie drewna wtórnego, a także na jego bocznym przedłużeniu, wśród wyżej wspomnianej wtórnej tkanki parenchymatycznej, widoczne są pasemka komórek przypominające merystem (fig. 12). Wtórna parenchyma i wtórne drewno z domniemaną strefą merystematyczną lub drobnokomórkową, ciemno zabarwioną parenchymą, otoczone są tzw. tkanką wydzielniczą (fig. 1, 6, 8, 9, 11, 12).

Kora pierwotna składa się z trzech zróżnicowanych części — wewnętrznej, środkowej i zewnętrznej (fig. 1). Wewnętrzna część kory złożona jest z około 20 warstw zwartych, tangencjalnie poszerzonych komórek o lekko zgrubiałych ścianach (fig. 6, 11, 13). Środkowa część kory pierwotnej posiada charakter delikatnej tkanki aerenchymatycznej. Charakterystyczne jest występowanie w niej kilkukomórkowych elementów o nieregularnym, falistym przebiegu (fig. 14, 15). Tkanka ta, często ulegająca zupełnemu zniszczeniu w procesie fosylizacji, jest w naszym okazie doskonale zachowana (fig. 1, 13, 14, 15, 16, 17). Zewnętrzna część kory pierwotnej, w odróżnieniu od części środkowej, zbudowana jest ze zwartych komórek, których ściany w miarę zbliżania się ku zewnętrznym partiom pędu stopniowo grubieją i przyjmują postać właściwą dla komórek tkanki wzmacniającej (fig. 16, 17, 18, 19, 20, 21).

Poczynając od grup komórek protoksylemu, aż do otoczki węglowej na powierzchni okazu, widoczne są szlaki liściowe, które w miarę wznoszenia się ku górze i odchylania ku obwodowi łodygi przedstawiają coraz bardziej złożoną, lecz wyrazistą i dobrze zachowaną budowę (fig. 1, 6, 22, 23, 24).

*Zakład Paleobotaniki i Petrografii Węgli*
*przy Katedrze Złóż Węgli AGH w Krakowie*

PLATES

TABLICE

All the photographs are unretouched

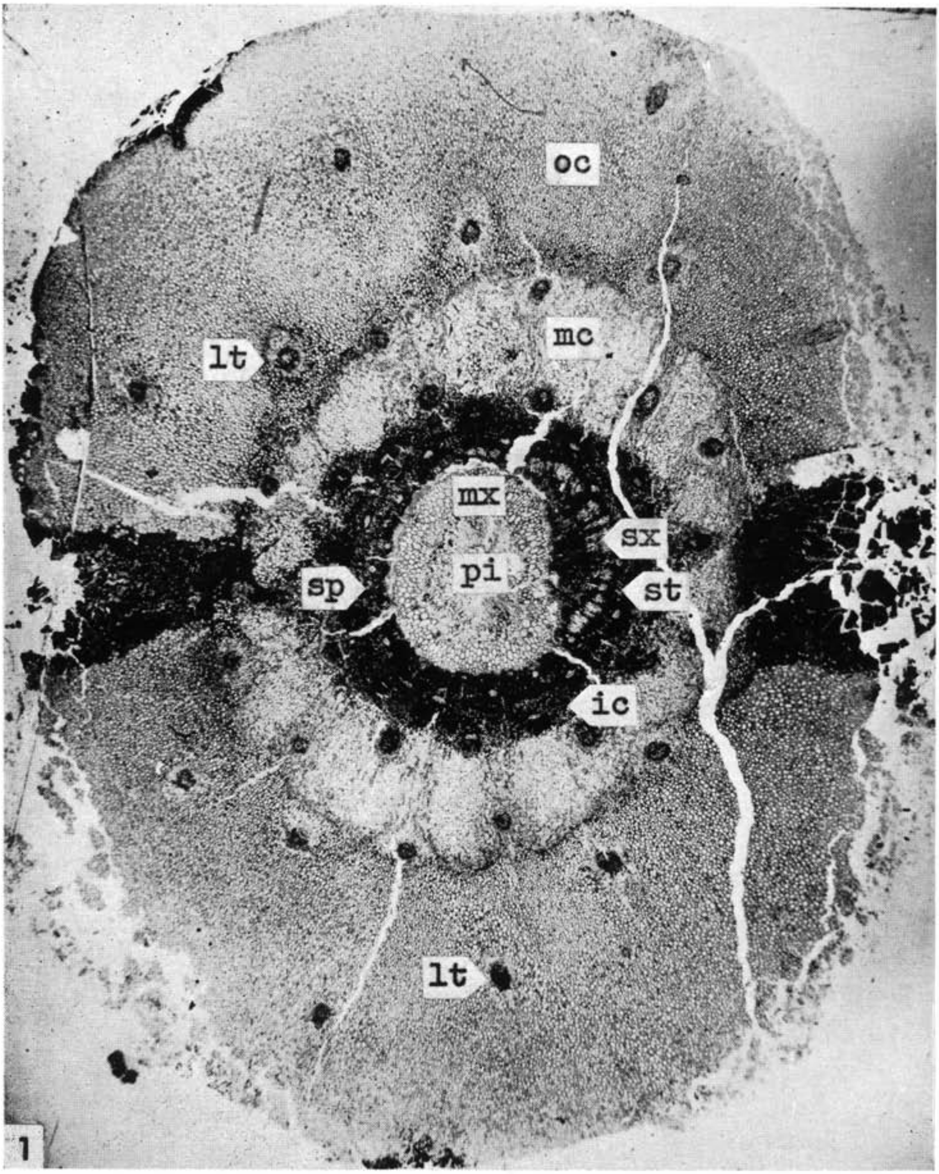
Wszystkie fotografie są nieretuszowane

Plate I

Fig. 1. *Lepidophloios fuliginosus,* transverse section of stem showing pith (pi), metaxylem (mx), protoxylem (px), secondary xylem (sx), secretory tissue (st), secondary parenchyma (sp), leaf-trace (lt), inner, middle and outer primary cortex (ic, mc, oc). Slide I a ×7.

Tablica I

Fig. 1. *Lepidophloios fuliginosus,* poprzeczny przekrój przez pęd, ukazujący rdzeń (pi), metaksylem (mx), protoksylem (px), drewno wtórne (sx), tkankę wydzielniczą (st), wtórną parenchymę (sp), szlak liściowy (lt), wewnętrzną, środkową i zewnętrzną korę pierwotną (ic, mc, oc). Preparat I a, ×7.


oc
mc
lt
mx
sx
pi
sp
st
ic
lt
1

## Plate II

Fig. 2. Transversely cut fragment of stele showing pith (pi), metaxylem (mx), protoxylem (px), secondary parenchyma (sp). Slide I a × ca. 70.

Fig. 3. Longitudinal section of pith. Slide I b × ca. 70.

Fig. 4. Longitudinal section of metaxylem tracheids showing scalariform bars (scb). Slide I b × ca. 70.

Fig. 5. Fragment of metaxylem tracheid showing scalariform bars (scb) and fibrils (f). Slide I b × ca. 1000.

Fig. 6. Fragment of transverse section of stem showing metaxylem (mx), protoxylem (px), secondary parenchyma (sp), secretory tissue (st), inner and middle primary cortex (ic, mc), leaf-trace (lt). Slide I a × ca. 45.

## Tablica II

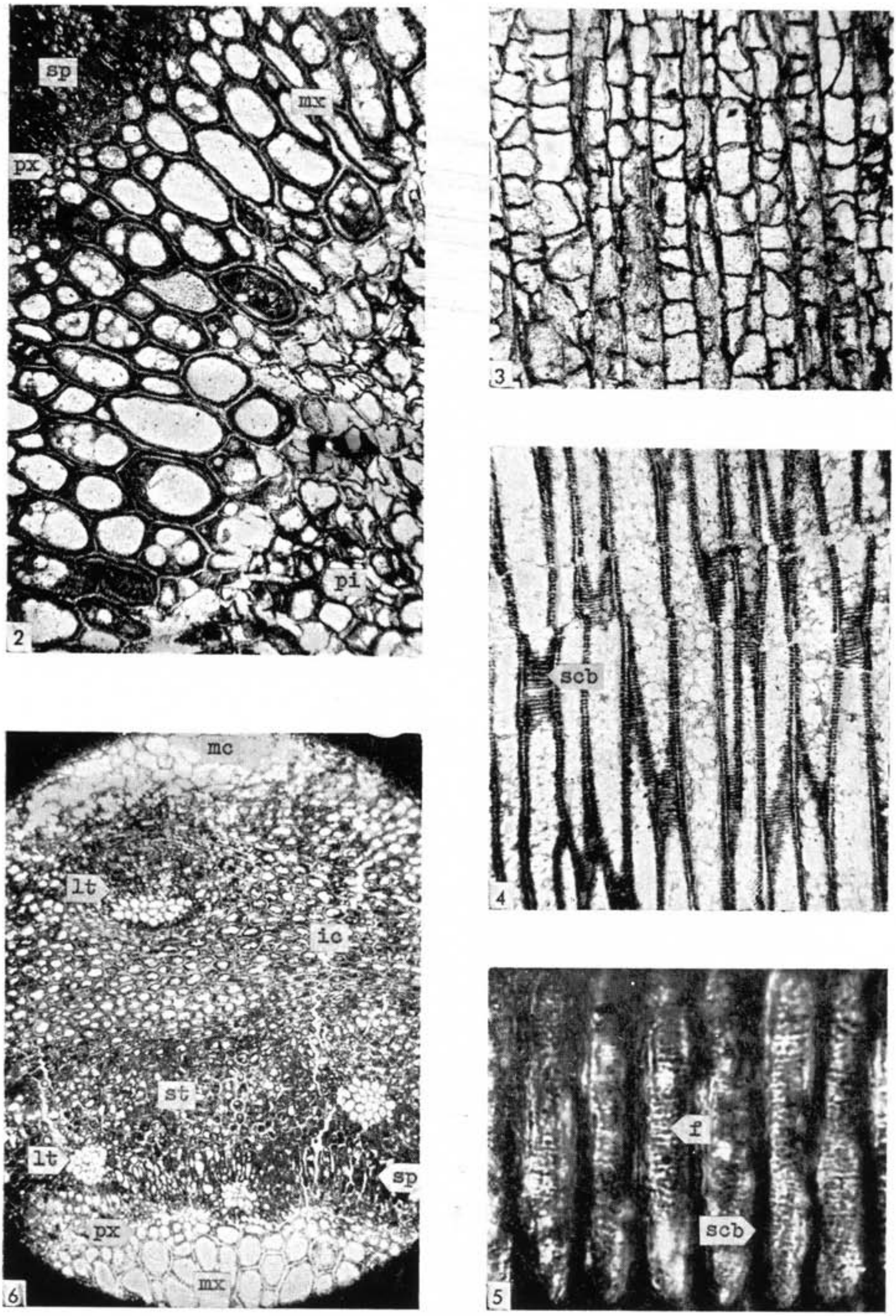
Fig. 2. Fragment poprzecznego przekroju steli z widocznym rdzeniem (pi), metaksylemem (mx), protoksylemem (px), i wtórną parenchymą (sp.). Preparat I a × ok. 70.

Fig. 3. Podłużny przekrój przez rdzeń. Preparat I b × ok. 70.

Fig. 4. Podłużny przekrój cewek metaksylemu z widocznymi drabinkowatymi zgrubieniami (scb). Preparat I b × ok. 70.

Fig. 5. Fragment cewki metaksylemu z widocznymi drabinkowatymi zgrubieniami (scb) i fibrylami (f). Preparat I b × ok. 1000.

Fig. 6. Fragment poprzecznego przekroju przez pęd, widoczny metaksylem (mx), protoksylem (px), wtórna parenchyma (sp), tkanka wydzielnicza (st), wewnętrzna i środkowa kora pierwotna (ic, mc) i szlak liściowy (lt). Preparat I a × ok. 45.


sp
mx
px
pi
2
3
scb
4
mc
lt
ic
st
lt
sp
px
mx
6
f
scb
5

## Plate III

Fig. 7. Longitudinally cut metaxylem (mx), protoxylem (px), secondary parenchyma (sp). Slide I b × ca. 70.

Fig. 8. Transverse section of secondary xylem (sx), parenchyma (p) and secretory tissue (st). Slide I a × ca. 70.

Fig. 9. Longitudinal section of undulating tracheids of secondary xylem (sx), initial stages of tracheids (it), parenchyma (p), and secretory tissue (st). Slide I b × ca. 70.

Fig. 10. Longitudinal section through the undulating tracheids (sx) of secondary tissues and initial stages of tracheids (it). Slide Ia × ca. 140.

Fig. 11. Transverse section of tissues consisting of secondary parenchyma (sp), secretory tissue (st), and inner primary cortex (ic). Slide I a × ca. 70.

## Tablica III

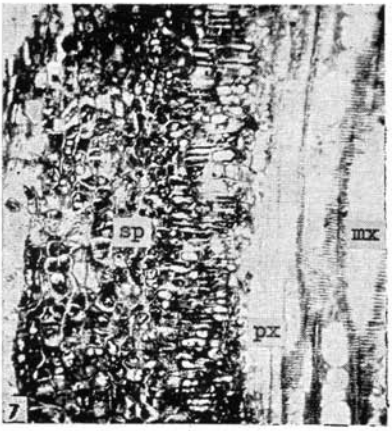
Fig. 7. Podłużny przekrój przez metaksylem (mx), protoksylem (px), i wtórną parenchymę (sp). Preparat I b × ok. 70.

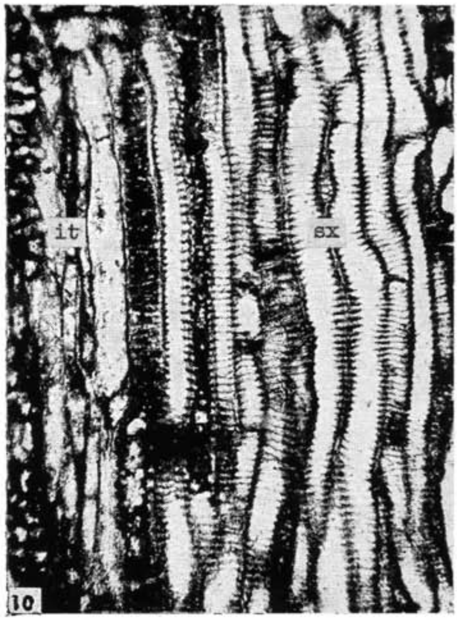
Fig. 8. Foprzeczny przekrój przez wtórne drewno (sx), parenchymę (p) i tkankę wydzielniczą (st). Preparat I a × ok. 70.

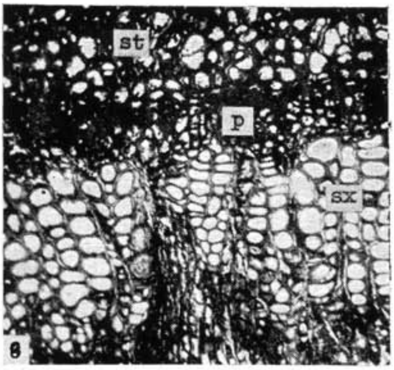
Fig. 9. Podłużny przekrój przez faliste cewki wtórnego drewna (sx), początkowe stadia rozwoju cewek (it), parenchymę (p) i tkankę wydzielniczą (st). Preparat I b × ok. 70.

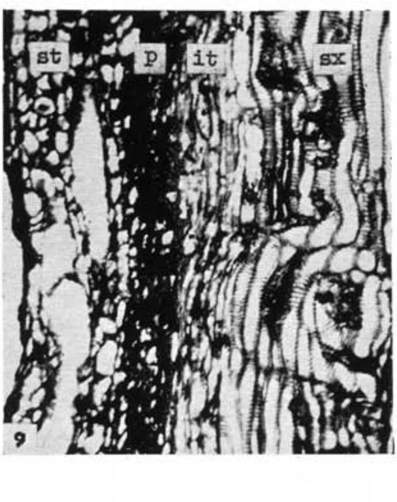
Fig. 10. Podłużny przekrój przez faliste cewki wtórnego drewna (sx) i początkowe stadia rozwoju cewek (it). Preparat I a × ok. 140.

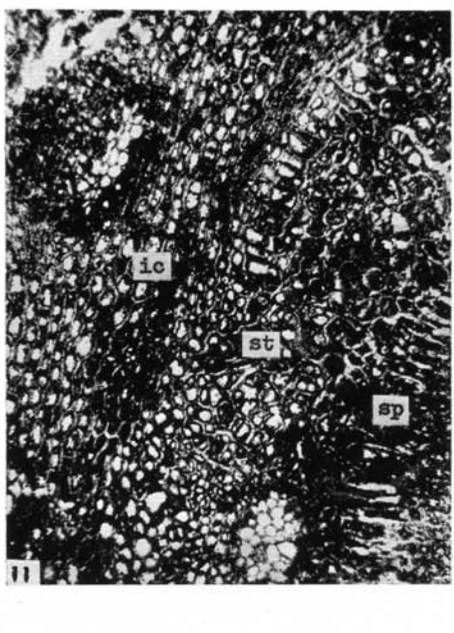
Fig. 11. Poprzeczny przekrój tkanek złożonych z wtórnej parenchymy (sp), tkanki wydzielniczej (st) i wewnętrznej kory pierwotnej (ic). Preparat I a × ok. 70.


sp
mx
px
7


it
sx
10


st
p
sx
8


st
p
it
sx
9

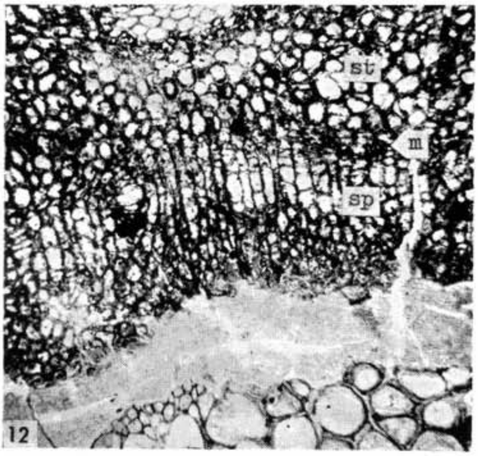

ic
st
sp
11

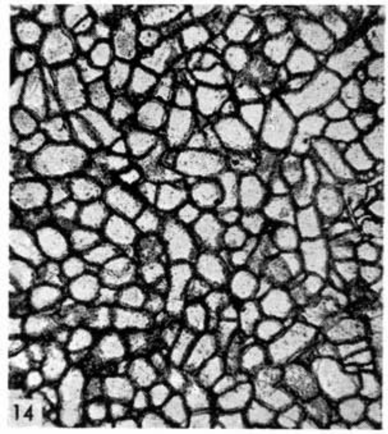
## Plate IV

Fig. 12. Transverse section of meristem (m) layer between secondary parenchyma (sp) and secretory tissue (st). Slide I a × ca. 70.
Fig. 13. Longitudinal section of inner and middle primary cortex (ic, mc). Slide I b × ca. 70.
Fig. 14. Transverse section of middle primary cortex. Slide I a × ca. 70.
Fig. 15. Longitudinal section of middle primary cortex. Slide I b × ca. 70.
Fig. 16. Transverse section of middle and outer primary cortex (mc, oc). Slide I a × ca. 70.
Fig. 17. Longitudinal section of middle and outer primary cortex (mc, oc). Slide I b × ca. 70.

## Tablica IV

Fig. 12. Poprzeczny przekrój przez merystem (m) pomiędzy wtórną parenchymą (sp) i tkanką wydzielniczą (st). Preparat I a × ok. 70.
Fig. 13. Podłużny przekrój przez wewnętrzną i środkową korę pierwotną (ic, mc). Preparat I b × ok. 70.
Fig. 14. Poprzeczny przekrój przez środkową korę pierwotną. Preparat I a × ok. 70.
Fig. 15. Podłużny przekrój przez środkową korę pierwotną. Preparat I b × ok. 70.
Fig. 16. Poprzeczny przekrój przez środkową i zewnętrzną korę pierwotną (mc, oc). Preparat I a × ok. 70.
Fig. 17. Podłużny przekrój przez środkową i zewnętrzną korę pierwotną (mc, oc). Preparat I b × ok. 70.


st
m
sp
12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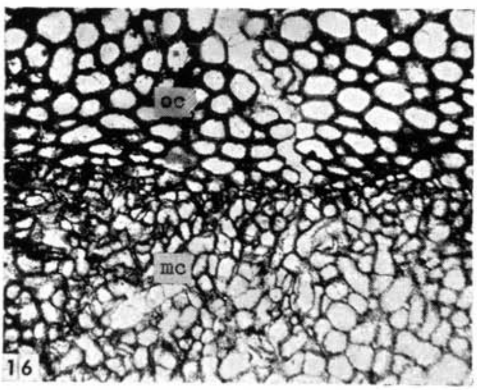
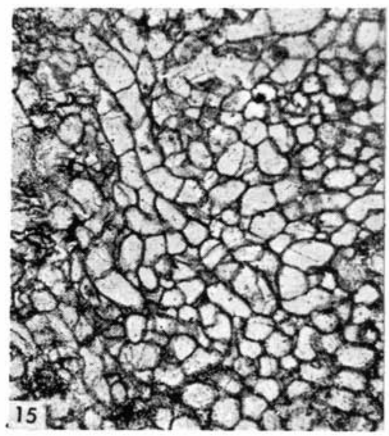
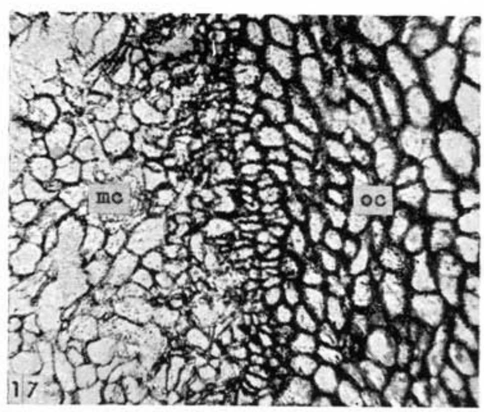

oc
mc
16


15


ic
mc
13


mc
oc
17

## Plate V

Fig. 18. Transverse section of the inner part of outer primary cortex. Slide I a × ca. 80.

Fig. 19. Transverse section of outer part of outer primary cortex. Slide I a × ca. 80.

Fig. 20. Longitudinal section of inner part of outer cortex. Slide I b × ca. 80.

Fig. 21. Longitudinal section of outer part of outer primary cortex. Slide I b × ca. 80.

Fig. 22. Transverse section of leaf-trace in the middle primary cortex showing parenchyma sheath (ps), xylem (x), secretory tissue (st), dividing parenchyma (p). Slide I c × ca. 70.

Fig. 23. Transverse section of leaf-trace in outer primary cortex showing parichnos strand (par). Slide I c × ca. 80.

Fig. 24. Longitudinal section of leaf-trace showing middle cortex (mc), xylem of leaf-trace (x), secretory tissue of leaf-trace (st), parichnos (par), outer primary cortex (oc). Slide I b × ca. 70.

## Tablica V

Fig. 18. Poprzeczny przekrój przez wewnętrzną część zewnętrznej kory pierwotnej. Preparat I a × ok. 80.

Fig. 19. Poprzeczny przekrój przez zewnętrzną część zewnętrznej kory pierwotnej. Preparat I a × ok. 80.

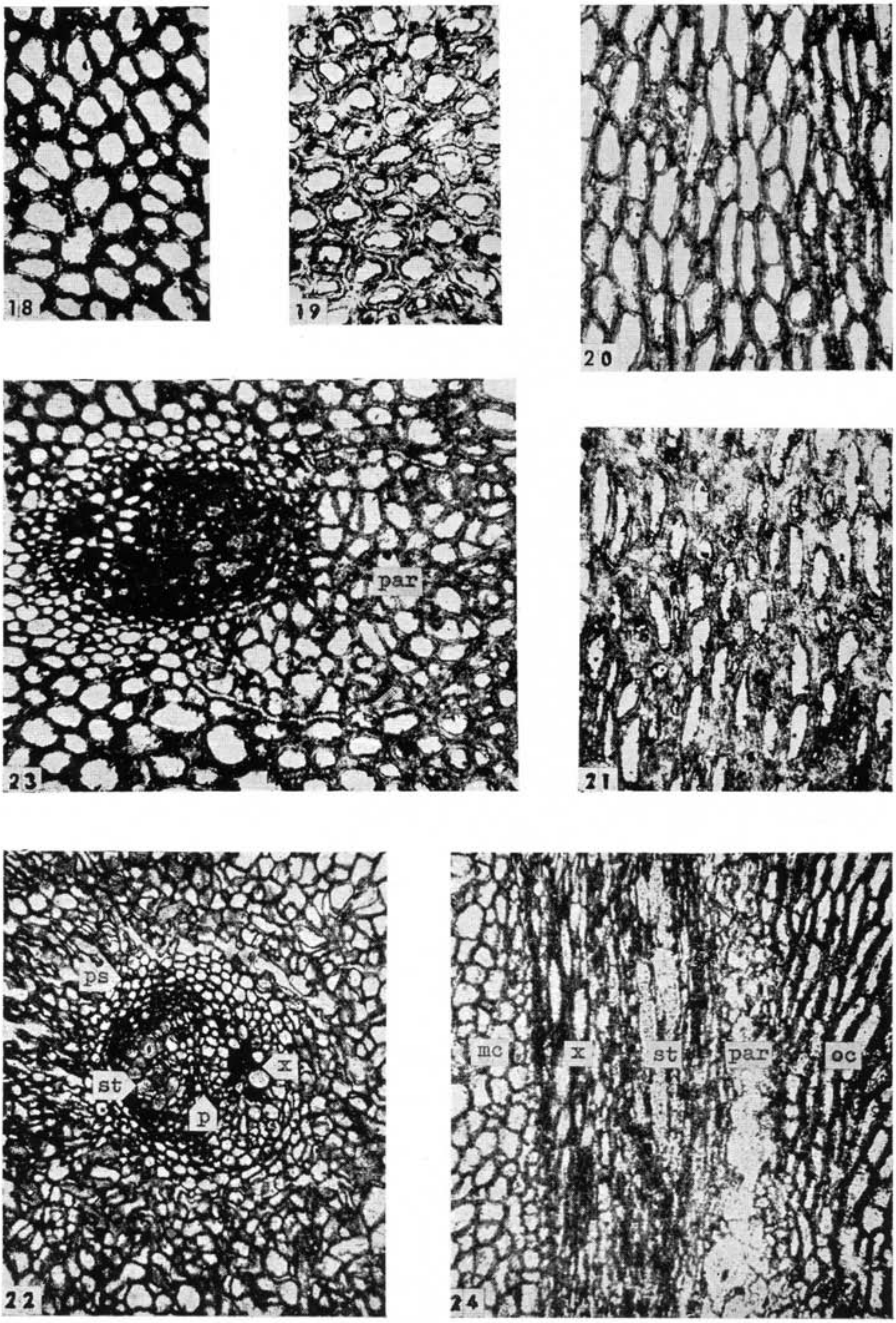
Fig. 20. Podłużny przekrój przez wewnętrzną część zewnętrznej kory pierwotnej. Preparat I b × ok. 80.

Fig. 21. Podłużny przekrój przez zewnętrzną część zewnętrznej kory pierwotnej. Preparat I b × ok. 80.

Fig. 22. Poprzeczny przekrój przez szlak liściowy w środkowej korze pierwotnej, widoczna pochwa parenchymatyczna (ps), drewno (x), tkanka wydzielnicza (st), oddzielająca je parenchyma (p). Preparat I c × ok. 70.

Fig. 23. Poprzeczny przekrój przez szlak liściowy w zewnętrznej korze pierwotnej, widoczne pasmo parichnos (par). Preparat I c × ok. 80.

Fig. 24. Podłużny przekrój przez szlak liściowy, widoczne: środkowa kora pierwotna (mc), drewno szlaku (x), tkanka wydzielnicza szlaku (st), parichnos (par), zewnętrzna kora pierwotna (oc). Preparat I b × ok. 70.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19
20
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23
21
ps
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p
22
mc
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24