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NEW FINDING OF PETRIFIED AXIS OF CARBONIFEROUS PTERIDOPHYTE *ANKYROPTERIS BERTRANDII* CORSIN IN THE UPPER SILESIAN COAL BASIN

Nowe znalezisko skamieniałego pędu paproci karbońskiej *Ankyropteris bertrandii* Corsin w Górnośląskim Zagłębiu Węglowym

ABSTRACT. The described specimen of rare pteridophyte *Ankyropteris bertrandii* Corsin (*Coenopteridales*) is a calcitized fragment of a frond (phyllophore) in which the anatomical structure is almost completely preserved. The fossil is derived from the coal mine "Anna" at Pszów, near Rybnik (the district of Katowice), from a marine horizon in the Namurian A (the Arnsbergian stage) deposits. *Ankyropteris bertrandii* has been known, till now, only from one site in the vicinity of Ostrava (the Czechoslovak part of the Upper Silesian Coal Basin), from deposits of the Namurian A (Arnsbergian). It was described by Corsin in 1952 basing on specimens found by Bertrand in 1907. The morphological features of the present fossil are well in accordance with those of the holotype.

INTRODUCTION

In the Carboniferous coal bearing deposits of Poland (Namurian — Westphalian) petrified plant fossils with well preserved anatomical structure are very rare. They are present almost exclusively in the deposits of the Paralic Series (Namurian A), or, more precisely, in marine horizons. To the dozen or so taxons of "anatomical" Carboniferous plants recorded from the Paralic Series of the Upper Silesia (Brzyski 1969) another species in now added. This is a very rare fossil *Ankyropteris bertrandii* Corsin found in the vicinity of Rybnik.

Ankyropteris bertrandii was described by Corsin in 1952 basing on specimens found by Bertrand at 1907, at Petřvald near Ostrava (in the Czechoslovak part of the Upper Silesian Basin), in the Namurian A deposits (Arnsbergian), in the marine horizon "Koks" (IV), the Poruba Beds.

The genus *Ankyropteris* and its species are taxons established on anatomical features of axes. In this genus, the frond axis (phyllophore) possesses a very characteristic stele which in transversal section is H-shaped or, rather, of the shape of a double anchor (anchor — in Greek ankyra). The species included in *Ankyropteris* are a rich and diversified group of primitive ferns of the group *Coenopteridales*, which lasted from the Late Devonian to Early Permian reaching their acme in the Early Carboniferous. They are considered to be one of the links between *Psilophytes* and true ferns. *Coenopteridales* are especially similar to *Marattiales* which were important during the Late Carboniferous and exist also in Recent time. The richest in taxons family of *Coenopteridales* is the family *Zygopteridaceae* (21 genera) including also *Ankyropteris* with nine species described till now: *A. bertrandii* Corsin, *A. bibractensis* Renault, *A. corrugata* Williamson, *A. brongniartii* Renault, *A. grayi* Williamson, *A. hendricksii* Read, *A. scandens* Stenzel, *A. westfaliensis* Bertrand, *A. williamsonii* Bertrand (Andrews — in Boureau 1970 — mentioned only five species, not including *A. glabra* Baxter which is now considered to be *Tedelea glabra* Eggert and Taylor).

The present specimen has been collected by Docent dr. K. Matl. It is housed in the Palaeobotanical Collection of the Institute of Geology and Mineral Resources, Academy of Mining and Metallurgy in Kraków, specimen III-C-14.

The author wants to thank Doc. dr. K. Matl for the specimen, Prof. dr. W. Heflik for determining the type of mineralization of the fossil as well as Doc. dr. L. Stuchlik and A. Pachoński for making the micrographs.

DESCRIPTION OF THE NEW DISCOVERY OF *ANKYROPTERIS BERTRANDII* CORSIN

Localization and stratigraphic position. The petrified fragment of a pteridophyte is derived from the coal mine "Anna" at Pszów near Rybnik (the district of Katowice), from the lowermost intercalation in the marine horizon "Lower Enna" (VIII). This position corresponds to the topmost part of the Namurian A (according to the former division), presently the Arnsbergian Stage. The fossil was embedded in dark gray claystone; the rock is fairly compact, containing single syderitic concretions, fine plant detritus and poorly preserved shells of marine molluscs.

External features of the specimen. The fossil presents a fragment of petrified axis 60 mm long and 10 mm wide; it is enveloped in a very thin, compact coal layer of fairly smooth, slightly shining surface with weakly marked irregularities. No traces of side branches are visible.

Character of mineralization. Two forms of calcitization occur within the petrified phyllophore within the stele as well as the primary cortex. The calcite filling the lumina of the cells is coarse crystalline; the size of the crystals is, as a rule, directly proportional to the cell size. The calcite occurring in cavities and crevices resulting from splitting of the tissues or separating of different tissues is very coarse and seems to be the younger generation of mine-

ralization than that occurring inside the cells. It seems that the chemical composition of the crystals of the two generations is slightly different. The crystals of the first generation contain an admixture of iron and magnezium while apparently pure calcite occurs in cavities outside the cells. Within the cortical phyllophore part, the size of the crystals diminishes concurrently with that of the cell lumina. At the extreme phyllophore part the crystals are so small that they appear as an isotropic mass; there the cellular structure is not distinguishable. The very thin coal layer enclosing the phyllophore is not petrified. The walls of the xylem cells of the stele are also partly impregnated by calcium; stronger mineralization occurs within cell corners. The walls of the cortical cells are only very weakly mineralized. Also pyrite occurs within the phyllophore tissues; it is present in small quantity and is distributed haphazardly. Its presence is almost completely restricted to the stele. Small single clusters of this mineral are most commonly grouped within the zone of destroyed phloem, especially in places where the phloem cells have vanished completely. Dispersed pyrite may also occur within the filaments, less often in places of protoxylem concentrations, exceptionally, between the tracheids of the proper metaxylem of the stele lateral arms and lamina. Pyrite occurs also irregularly at the contact of the coaly envelope and the enclosing rock. The latter is claystone of aleuritic structure and haphazard texture, consisting mostly of clay minerals developed as fine flakes displaying the optical features of illite. Moreover, there occurs detritic quartz, muskovite flakes and single, fine concentrations of coal matter. The approximate proportions are as follows: clay minerals (illite) 80%, quartz 15%, aggregations of coal and others 5%.

Description of anatomical structure. The structure of the frond axis (phyllophore) is well preserved except for the phloem and the peripheral parts of the cortex. The arrangement of some tissues of the axis suggests some deformation of the fossil but this does not influence essentially the character of the cellular structure (Pl. I, fig. 1). As *Ankyropteris bertrandii* was described in detail by Corsin (1952), in the present description, some details of the tissue structures are ommited. The axis is 9–10 mm wide; its central part is occupied by a relatively large, 5 mm wide stele. In spite of its complicated outline the stele represents a most primitive type, i.e. the protostele (lacking the central parenchymous medulla). The xylem of the stele is differentiated into metaxylem and protoxylem. Its central part, i.e. the medial lamina, is orientated tangentially in relation to the axis from which the frond departed. The lamina is narrow (0·3–0·4 mm), fairly long (4 mm) and straight. The deflection of the lamina observed in thin section is due to breaking during the fossilization process. The tracheids of the lamina xylem are polygonal, with rounded apices; some cells, especially the large ones, are semicircular or oval. The smallest tracheids are, as a rule, situated at the lamina extremities. Three to four, and most commonly three cells make the width of the lamina (Pl. III, fig. 1). In longitudinal crossection perpendicular to the length of the lamina the tracheids are densely scalariform (Pl. II, fig. 4). In places, the bands fork or bend loosing

their regular scalariform pattern. The remaining part of the xylem forms two pairs of lateral arms of the stele: the abaxial arms are shorter than the adaxial ones. The arms of both pairs are gently curved towards each other forming an imperfect circle. They are slightly narrower than the central lamina except for the thickened baculiform tips (Pl. I, fig. 1). According to Corsin (1952), in *Ankyropteris bertrandii*, the lateral arms may display a tendency towards a characteristic curvature towards the center. The xylem of the arms consists of tracheids of variable size; those close to the center represent, similar as those of the lamina, the metaxylem tracheids of wide lumen. These are slightly larger than the tracheids of the lamina and are more often obovally elongated perpendicular to the arms. The arm width corresponds to one or two cells at the base to three or four cells at arm termination. At the outer margin of the arms and in the region of their terminations there occur 1 mm wide bands of tissue consisting of metaxylem tracheids of small lumen. These are the so called filaments (Pl. II. figs. 1-b — 5-c). They consist of two to five layers (most often three layers) and are slightly wider at the terminal part of the arms, where they thicken and pile ambracing the tips of the proper metaxylem (Pl. II, fig. 2-b). At the tips of the adaxial (longer) arms the terminal piles of the filament tracheids are slightly less well developed. In longitudinal section, the tracheids of the proper metaxylem and the filaments display, similarly as those of the lamina, dense scalariform bands (Pl. II, fig. 6-a, -b). Within the lateral arms, between the proper metaxylem and the filaments, there occur poorly discernible, fine and irregularly distributed aggregations of tracheids of small lumen belonging to protoxylem (Pl. III, fig. 2-c) and associated deformed parenchymous cells. The tracheids of the protoxylem are irregularly polygonal. At the margin of the xylem there occurs phloem with hardly discernible cells; these are preserved only as poor remnants at the terminal part of the lateral arms (Pl. II, fig. 2-c). At the poles of the stele, this is at the outside of bases of the lateral arms, there are weakly marked, gentle concavities of the margin. Thick layer of parenchyma forming the primary cortex encircles the stele. The part of this tissue between the lateral arms and the lamina is the inner cortex consisting of thin-walled cells the outline of which is circular or polygonal, with rounded apices. The cells adjoining the central lamina, and, to a lesser degree, those close to lateral arms, are distinctly larger, of more circular outline and have thicker walls. At the corners between the central lamina and the bases of lateral arms, there occur probably parts of endodermis (Pl. III, fig. 1-c): the parenchymous layer adjoining the inner cortex between the lateral arms and surrounding these represents the outer cortex. Its inner part hardly differs from the inner cortex. The outer part, that to the outside from one half of the outer cortex width, consists of histologically more differentiated cells. Their lumen becomes gradually narrower and their outline more circular. Within the outermost zone the cells are thickened and closely packed, forming the hypodermic layer acting as mechanical tissue (Pl. III, figs. 5, 7-b). Within

some parts of the phyllophore margin the hypodermic zone has been peeled off. In longitudinal section, the cells of the primary cortex are axially elongated presenting a typically prosenchymatous tissue. Within the inner cortex the cells are 3 to 8 times longer than wide and are of irregular width (the shape is more or less elongated-trapeziform). The peripheral cells of the outer cortex, and especially those of the hypodermis, are, as a rule, parallel-sided (Pl. III, fig. 7-a). The coaly layer at the petrified phyllophore surface originated probably from the hipodermic tissue and from the epidermis. The fairly large cavities filled with calcite, visible in thin sections (Pl. I, fig. 1; Pl. II, figs. 1, 4), resulted not from destruction of the tissues during the fossilization but from shrinking of the primary cortex and from detachment of its inner part from the stele. It may be added in supplement to the above description that in phyllophore sections no vascular strands extending through the primary cortex to the branches of higher order have been observed. The explanation is, that the described specimen represents a part of an axis from between two successive levels of vascular strand development.

Base for systematic determination of the specimen. In the family *Zygopteridaceae* the genus *Ankyropteris* is characterized by some features differing it from other genera of which some may have a similarly organized stele. An H-shaped stele occurs in a few species of *Zygopteris*, *Etapteris*, *Tedelea*. The taxonomically important features of *Ankyropteris* concern the anatomy of the stem, phyllophore and branches of higher order. The described specimen has been included in *Ankyropteris* basing on following features of the phyllophore: in transverse section, the stele is similar to a double anchor; the main elements of the dissected stele are relatively narrow; the lateral arms are more or less arcuate; the adaxial arms are longer than the abaxial ones; there are filaments at the tips of the arms; the marginal line of the stele does not display distinct concavities at the poles, outside of the arm bases.

The specific determination of the fossil is based upon the well preserved anatomical features which are in agreement with those of the holotype. Generally, selected, taxonomically important features of *Ankyropteris bertrandii* Corsin are as follows: the stele is very large in comparison with the phyllophore width; the central lamina is elongated, narrow and straight; the lateral arms are regularly arcuate (in some specimens of the type material these display a tendency towards curvature of the arms towards the center); the elements of protoxylem are irregularly distributed within the lateral arms at the border between the filaments and the proper metaxylem; the phloem occurs as a zone encircling completely the stele. The organization of vascular strands extending to the side branches of higher order is also taxonomically important but these have not been observed in the short fragment of axis concerned here.

The shape of the stele in *Ankyropteris bertrandii* Corsin is similar to that in *A. westfaliensis* Bertrand, but in the latter species the central lamina is of a characteristic arcuate shape.

COMPLEMENTARY REMARKS

Ankyropteris bertrandii Corsin has been recorded, till now, only from one site, Petžvald near Ostrava, from deposits of the Poruba Beds. The present discovery of this species, from Pszów near Rybnik, concerns much older strata (the Hrušov Beds). The two stratigraphic levels are separated by the Jaklovice Beds which are devoid of typical marine horizons. Geographically, the localities concerned here are 20 km apart. It is worth noting that there is a third, probable site with *Ankyropteris bertrandii*, also in the Upper Silesia. Among some petrifactions described by Brzyski (1969) one specimen was determined as *Ankyropteris grayi* Williamson. Due to poor state of preservation the determination was considered somewhat doubtful as the specimen possessed some features of *Ankyropteris bertrandii*. The poorly preserved stele of the phyllophore fragment has a general shape characteristic of *A. bertrandii* but the stele diameter is to small in relation with that of the phyllophore. Moreover, the basic elements of the stele, and especially of the central lamina, are relatively shorter and apparently wider in comparison with the dimensions of the stele of the Pszów specimen. This doubtful specimen was derived from the mine Knurów at Knurów near Gliwice, from the marine horizon Henryk (III), from the Upper Poruba Beds (uppermost Namurian A), therefore from a stratigraphic level slightly higher than that of the site near Ostrava. The species *Ankyropteris grayi*, on the other hand, is known from younger strata, from the lower Westphalian.

The majority of species belonging to *Ankyropteris*, recorded from different regions of the World (England, France, Germany, the United States), occur in strata younger than those where *A. bertrandii* was found, i.e. in the Westphalian and Lower Permian. The described specimen of *A. bertrandii* from the mine "Anna" at Pszów is the oldest petrifaction with well preserved anatomy known from the Upper Carboniferous deposits of the Upper Silesian Basin. It is possible that *Ankyropteris bertrandii* from the Upper Silesia represents an endemic species.

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STRESZCZENIE

NOWE ZNALEZISKO SKAMIENIAŁEGO PĘDU PAPROCI KARBOŃSKIEJ *ANKYROPTERIS BERTRANDII* CORSIN W GÓRNOŚLĄSKIM ZAGŁĘBIU WĘGLOWYM

Skamieniałość roślinną, znalezioną w 1965 r. przez doc. dr inż. K. Matla, oznaczono jako bardzo rzadki gatunek prymitywnej paproci karbońskiej *Ankyropteris bertrandii* Cors. (rodzina *Zygopteridaceae*, rząd *Coenopteridales*). Okaz o wymiarach 60 mm długości i 9–10 mm średnicy przedstawia zmineralizowany kalcytem fragment fylloforu (osi liścia) z bardzo dobrze zachowaną budową anatomiczną. Szczątek pochodzi z kopalni „Anna" w Pszowie koło Rybnika, z osadów poziomu morskiego „Anna Górna" (VII), z najwyższego odcinka warstw gruszowskich (środkowa część piętra arnsberg — dawniej wierzchołkowa partia dolnego namuru A). *Ankyropteris bertrandii* jest gatunkiem znanym dotychczas tylko z jednego stanowiska w Pietwałdzie koło Ostrawy, z poziomu morskiego „Koks", z warstw porębskich (piętro arnsberg — dawniej górny namur A), skąd na podstawie okazów znalezionych przez Bertranda w 1907 r. został opisany przez Corsina w 1952 r. Obydwa stanowiska usytuowane w paralicznej serii dolnego namuru, stratygraficznie oddzielone są brakicznymi osadami warstw jaklowieckich.

Rodzaj *Ankyropteris* i jego gatunki są taksonami wyróżnialnymi w oparciu o cechy budowy anatomicznej łodyg, fylloforów i odgałęzień dalszego rzędu. Fyllofor u tych form odznacza się charakterystycznie zbudowaną stelą, przypominającą na przekroju poprzecznym literę H lub podwójną kotwicę. Nowo znaleziony szczątek wykazuje daleko idącą zgodność cech anatomicznych z cechami formy holotypowej z okolicy Ostrawy. Budowa anatomiczna okazu z kopalni „Anna" w dużym uproszczeniu przedstawia się następująco. Środek fylloforu zajmuje stosunkowo duża stela o średnicy 5 mm. Ksylem steli składa się z cienkiej (0,3–0,4 mm), prostej i dość długiej (4,0 mm) płytki środkowej oraz dwu par łukowato wygiętych ramion bocznych, z których doosiowe są nieco dłuższe od odosiowych. Charakterystyczną cechą opisywanego taksonu jest występowanie tzw. filamentów, czyli pasm drobnych tracheid stanowiących zewnętrzne obrzeżenia ksylemu ramion bocznych. W ksylemie steli gros masy przypada na metaksylem (płytka środkowa i ramiona boczne łącznie z filamentami), podczas gdy protoksylem ograniczony jest do drobnych i słabo wyróżnialnych skupień tracheid, rozlokowanych między filamentami a zasadniczym metaksylemem ramion bocznych. Floem, zachowany tylko w postaci nikłych resztek ze zdeformowanymi komórkami, dostrzec można głównie w otoczeniu zakończeń ramion bocznych. Wokół steli rozciąga się gruba warstwa kory pierwotnej, zróżnicowana na część wewnętrzną, zbudowaną z cienkościennych komórek parenchymatycznych, zawartą pomiędzy płytką środkową a ramionami bocznymi steli oraz część zewnętrzną, obwodową, złożoną z komórek najpierw delikatnych, a dalej ku obrzeżom fylloforu coraz bardziej

zgrubiałych, zwężających się i zwartych, przechodzących przy obwodzie fyllo-foru w postać hypodermy. Na przekroju podłużnym komórki kory pierwotnej są wyraźnie osiowo wydłużone, przedstawiając tkankę typu prozenchymatycznego. Skamieniały okaz od zewnątrz otoczony jest cieniutką warstewką materii węglowej, powstałej prawdopodobnie z epidermy i peryferycznych partii kory. Szczegóły struktur tkankowych skamieliny zilustrowano na tablicach I–III.

Nowo znaleziony szczątek *Ankyropteris bertrandii* Cors. z kopalni „Anna" w Pszowie koło Rybnika przedstawia kolejną nową formę dla kopalnej flory Polski. Należy on też do najstarszych znalezisk spetryfikowanych szczątków roślin górnokarbońskich o dobrze zachowanej budowie anatomicznej z obszaru Górnośląskiego Zagłębia Węglowego. Nie jest wykluczone, że gatunek *Ankyropteris bertrandii*, znany wyłącznie z granic karbonu górnośląskiego, jest formą endemiczną.

Opisany okaz paproci znajduje sie w zbiorach paleobotanicznych Zakładu Złóż Węgla Kamiennego AGH w Krakowie (Nr okazu: III-C-14).

PLATES

PLATE 1

1. Phyllophore (frond axis) of pteridophyte *Ankyropteris bertrandii* Corsin. Transverse section, × 12; a — central lamina of stele xylem; b — adaxial lateral arms of stele xylem; c — abaxial lateral arms; d — inner primary cortex; e — outer primary cortex; f — hypodermis; g — structureless (colinite) coal layer; h — cavities and crevices filled with calcite; i — clayey rock embedding petrifaction

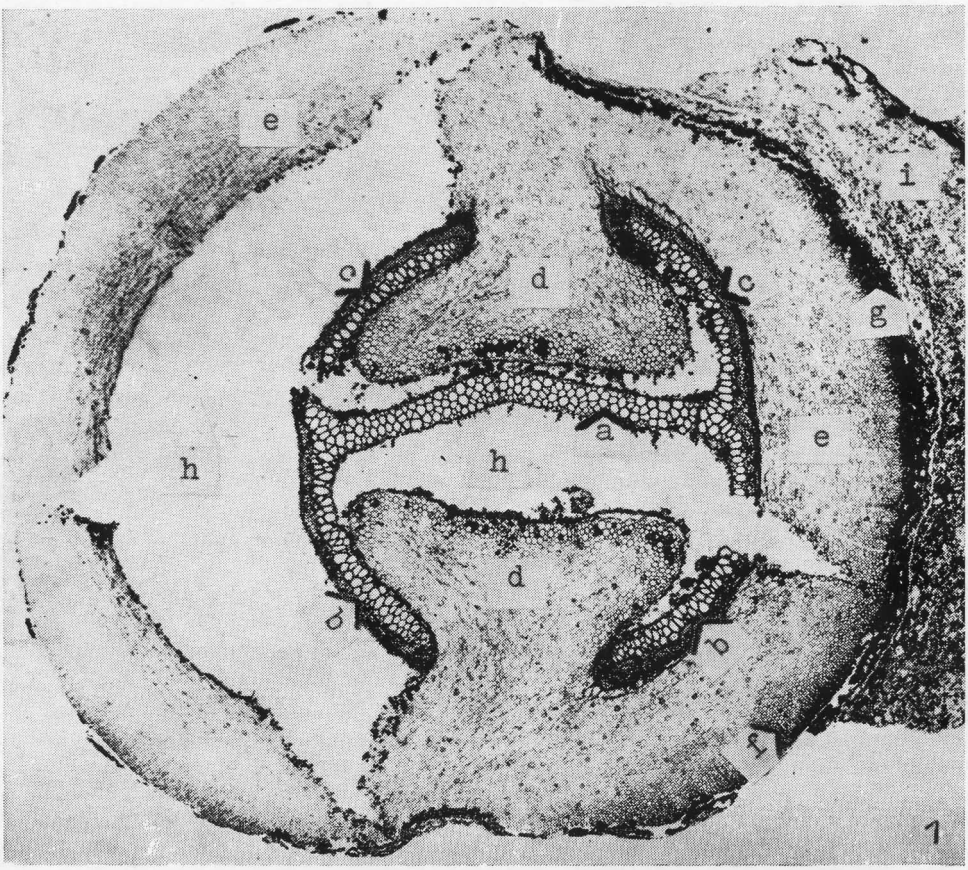

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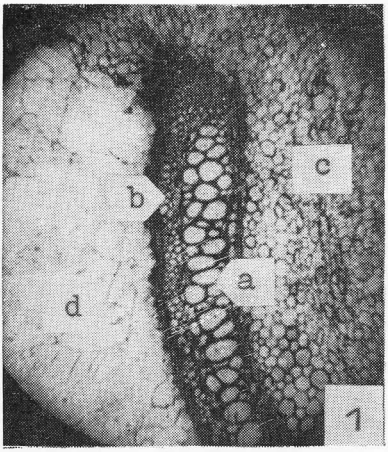
PLATE II

1. Part of abaxial lateral arm of stele and part of primary cortex. Transverse section, × 30; a — tracheids of proper metaxylem of stele; b — fine tracheids of metaxylem of filaments; c — parenchyma of inner primary cortex; d — cavity between tissues filled with coarse calcite crystals
2. The same fragment as Fig. 1. Transverse section, × 60; a— proper metaxylem tracheids; b — metaxylem tracheids of filament, piled around tip of lateral arm; c — destroyed phloem cells; d — parenchyma of inner primary cortex
3. Part of adaxial lateral arm surrounded by primary cortex: a — inner cortex; b — outer cortex. Transverse section, × 30
4. Part of metaxylem central lamina of stele surrounded by very coarse calcite crystals. Longitudinal section, × 30
5. The same fragment as Fig. 1. Transverse section, × 100; a — tracheids of filament metaxylem; b — remnants of phloem
6. Fragment of abaxial lateral arm of stele (from zone in Fig. 5). Longitudinal section, × 100; a — tracheids of proper metaxylem with dense scalariform bands; b — tracheids of filament metaxylem with dense scalariform bands; c — possible remnants of protoxylem tracheids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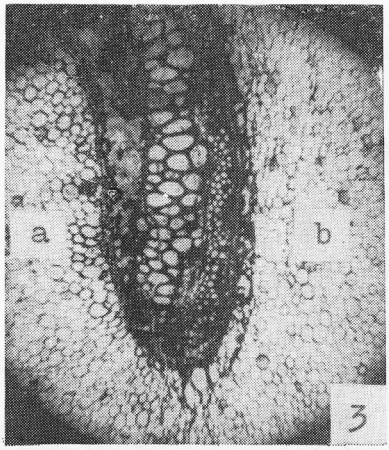
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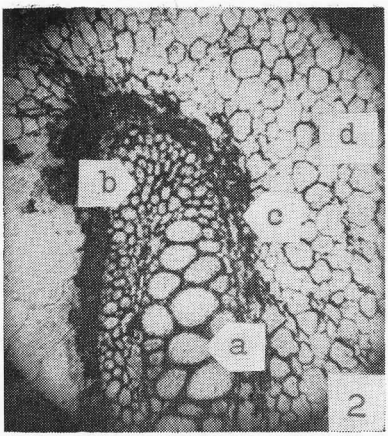
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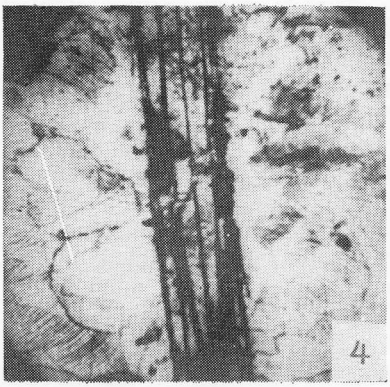
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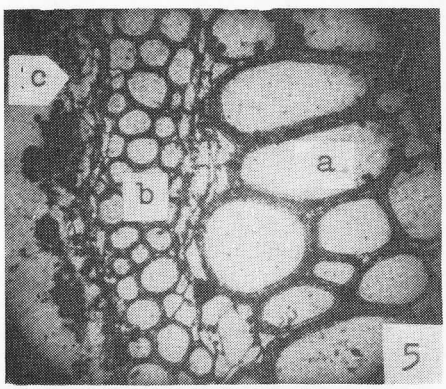
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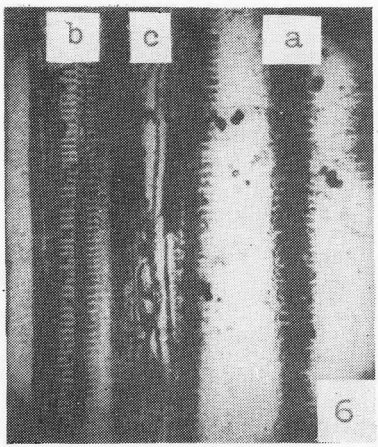
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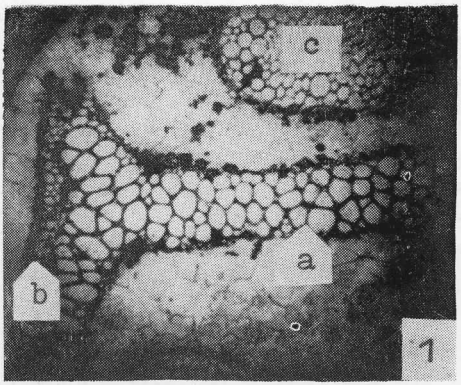
PLATE III

1. Fragment of phyllophore central part. Longitudinal section, × 30; a — fragment of central lamina metaxylem; b — fragment of filament metaxylem; c — fragment of parenchyma of inner primary cortex surrounded by probable remnants of endodermis
2. Polar region of stele (at bases of lateral arms). Transverse section, × 50; a — tracheids of proper metaxylem; b — filament metaxylem tracheids with narrow lumen; c — fine concentrations of protoxylem tracheids; d — poorly preserved phloem cells
3. Parenchyma of inner primary cortex. Transverse section, × 50
4. Parenchyma of outer primary cortex. Transverse section, × 50
5. Peripheral part of primary cortex passing into hypodermis (at bottom), × 30
6. Fragment of stele and outer primary cortex. Longitudinal section, × 30; a — tracheids of proper metaxylem of lateral arm; b — tracheids of metaxylem of lateral arm filament; c — deeper part of parenchyma of outer primary cortex — cells axially elongated (typically prosenchymatous tissue)
7. Fragment of outer primary cortex. Longitudinal section, × 30; a — peripheral part of parenchyma of outer primary cortex — cells axially elongated (typical prosenchymatous tissue); b — zone of hypodermis with parallel-sided, axially elongated, densely packed cells; c — thin, structureless coal layer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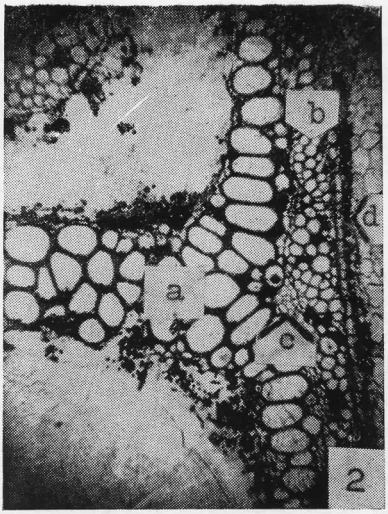
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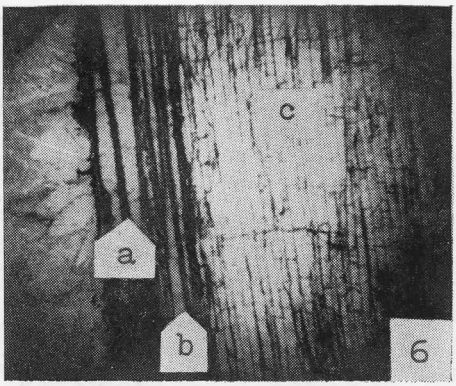
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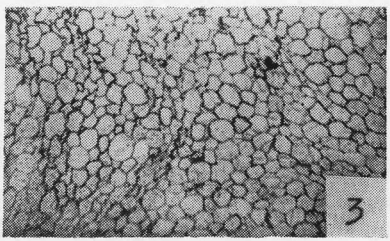
6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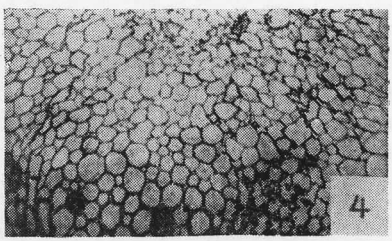
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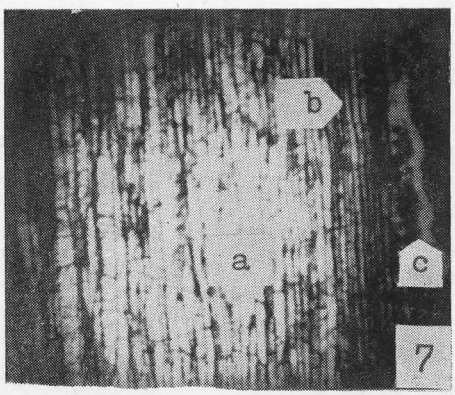
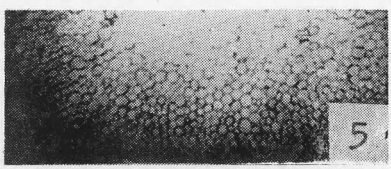

b
a
c
7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