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NEW CLASSIFICATION OF THE GENUS *CORDAITES* FROM THE CARBONIFEROUS AND PERMIAN OF THE BOHEMIAN MASSIF, BASED ON CUTICLE MICROMORPHOLOGY

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Abstract. A new classification of Bohemian cordaitalean leaves is based on the cuticular analysis of 83 specimens from Westphalian, Stephanian and Autunian strata. Five principal cuticular groups are distinguished mainly by characteristics of the abaxial cuticle. These five morphotypes are as follows:

Group A: species with stomata dispersed relatively regularly or sparsely in poorly defined, or irregular and rare stomatal rows. This group consists of the following new species: *Cordaites karvinensis, C. silesiacus, C. sustae, C. tuchlovicensis, C. lubnensis, C. ledecensis, C. rudnicensis, C. sudeticus* and *C. strazkovicensis.*

Group B: species with stomata arranged in well defined single or double stomatal rows. *Cordaites schatzlarensis* Šimůnek et Libertín is assigned to this group, which also includes the following new species: *Cordaites idae, C. rerichensis, C. blazkovicensis, C. pilsensis, C. krasovicensis, C. radvanicensis* and *C. risutensis.*

Group C: species with stomata arranged in double or multiple stomatal rows that form stomatiferous bands separated by non-stomatiferous bands. This group includes *Cordaites borassifolius* (Sternberg) Unger. New species assigned to this group are *Cordaites raconicensis, C. malesicensis, C. melnicensis, C. svatonovicensis, C. odolovensis, C. wilkischensis* and *C. touskovensis.*

Group D: species whose cuticles are characterised by stomatiferous and non-stomatiferous bands. The cells of both bands differ, and stomata are irregularly dispersed within the stomatiferous bands. This group contains *Cordaites kladnoensis* and *C. latus.*

Group E: species with cuticles similar to group D, though the cells in the stomatiferous and non-stomatiferous bands have the same shape. The stomata are arranged in several ill-defined rows within a stomatiferous band. Only two new species show these characteristics: *Cordaites wartmannii* and *C. polynervus.*

■ palaeobotany, Cordaites, cuticular analysis, Bohemian Massif

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Introduction

The genus *Cordaites* Unger 1850, as we understand it today (e.g. Arnold 1967), includes the sterile foliage of broad-leaved Palaeozoic coniferophytes. Current studies of cordaitalean leaves, stems, roots, pollen and reproductive structures have resulted in reconstructions of entire cordaitalen plants (Trivett and Rothwell 1991, Trivett 1991). These plants are usually reconstructed as large gymnosperm trees, 20–40 m tall, with long, ribbon-shaped, linear, or lanceolate leaves up to 80 cm long and to 15 cm wide (Crookall, 1970), growing in seasonally dry, well-drained alluvial plains (Falcon-Lang 2003), and/or in peat-swamp environments (Rothwell and Warner 1984). Their associated fructifications are reconstructed as spikes or cones that are actually compound fructifications consisting of a primary axis that bears secondary shoots in the axils of the bracts. These fructifications are generated in the axils of leaves (Stewart and Rothwell 1989). During the Pennsylvanian, cordaitalean plants adapted to life in peat-forming swamps, as well as in relatively arid upland areas. A bush form is known as *Cordaixylon dumusum* Rothwell et Warner, 1984 from the Stephanian of Ohio (U.S.A.). Cridland (1964) described another representative of cordaitaleans as a mangrove form. This group is distinguished from other coniferophyte plant groups in having characteristic large microphyllous leaves. They are commonly characterised by having elongate, ribbon-shaped, lanceolate to spatulate leaves, and parallel venation with alternating thick "true" veins and thin veins above the sclerenchymatous bands; this venation pattern is often used for classifying fossilised leaf fragments. However, venation is a highly variable characteristic in impression/compression specimens. According to Jongmans and Dijkstra (1968) and Josten (1991), only three cordaitalean species based on venation pattern are widespread in the Euramerican realm: *Cordaites borassifolius* (Sternberg) Unger, *C. palmaeformis* (Goepp.) and *C. principalis* (Germar) Geinitz.

About 50 cordaitalean species based on leaf morphology are known from Europe (Jongmans and Dijkstra 1968.). About a half of them have been sufficiently described and figured (Šimůnek 2001), whereas the other species are poorly documented, making further comparison difficult. Most of the species occur in the basins of the Massif Central in France, and in the Saar and Wettin Basins of Germany.

Meyen (1963) described the genus *Rufloria* Meyen, and later studied cordaitalean leaves from the Angara region (Meyen 1966). However, none of the European representatives of the genus *Cordaites* have so far been revised. Ignatiev and Meyen (1989) proposed a system of Euramerican cordaitalean fertile organs, but they did not classify cordaitalean leaves.

Table 1. Morphological characterisation of the selected cordaitalean species according to different authors

Species	Author	Leaf length [cm]	Leaf width [cm]	Number of thick veins on 1 cm	Number of thin veins between 2 thick veins
Cordaites angulosistriatus	Crookall 1970	35-80	4-12	15-30	2-5
	Rabitz 1966		1-2,7	30-40	1-5
	Ledran 1966	20-80	4-12	20-30	2-5
	Doubinger et al. 1995	20-30	4-12		2-5
Mean size		**20-80**	**1-12**	**15-40**	**1-5**
Cordaites borassifolius	Crookall 1970	25-60	3-12	20-30	1
	Rabitz 1966		0,8-3	20-54	1
	Ledran 1966	10-60	3,5-8	18-20	2-3
	Doubinger et al. 1995	10-60	3,5-8	18-20	2
	Josten 1991	20-50	to 5	20-30	1
Mean size		**10-60**	**0.8-12**	**18-54**	**1-(3)**
Cordaites lingulatus	Zeiller 1906		1,5-6	20-35	
	Seward 1963	to 35	4-11		1-3 in the basal part
	Ledran 1966	10-50	2-15	20-25	1-3 in the basal part
	Doubinger et al. 1995	10-50	to 15		1-3 in the basal part
Mean size		**10-50**	**1.5-15**	**20-35**	**(0) 1-3**
Poacordaites microstachys	Crookall 1970	3-30	0,4-0,8	30-40	1-2
	Ledran 1966	to 20	0,4-1	60-70	2-3
Mean size		**3-30**	**0.4-1**	**30-70**	**1-3**
Cordaites palmaeformis	Crookall 1970	to 80	to (10)	35-50	0
	Rabitz 1966		0,8-2,5	52-140	0
	Ledran 1966	30-60	1,5-5	30	0
	Doubinger et al. 1995	30-60	1,5-5		
Mean size		**30-80**	**0.8-5(10)**	**30-140**	**0**
Cordaites principalis	Crookall 1970	20-50	3-6	16-32	1-6
	Rabitz 1966	33,3	5,1	14-38	1-7
	Ledran 1966	50-60	4-15	30-36	2-5
	Doubinger et al. 1995	50-60	4-15		2-5
	Josten 1991	20-50	about 5		2-7
	Remy-Remy 1977	30-90	to 5	18-22	2-5
Mean size		**20-90**	**3-15**	**14-38**	**1-7**

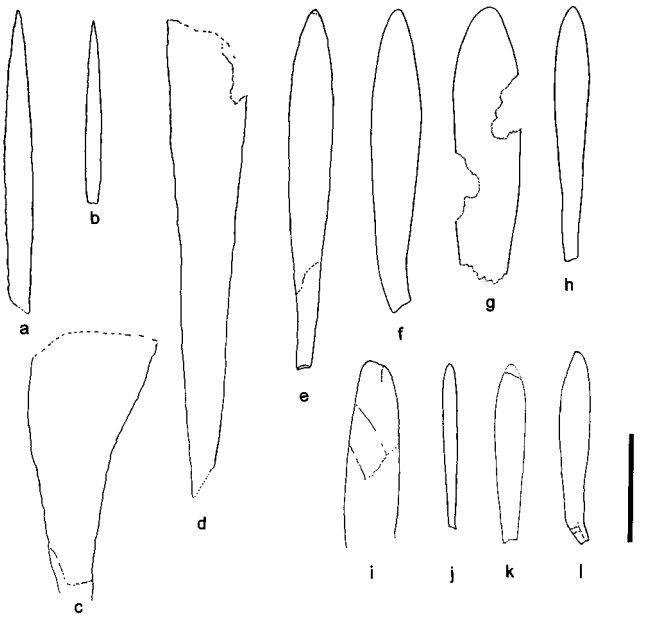
The Angaran cordaitalean leaves are usually small, less than 10 cm long. The general morphology, venation, and cuticles can generally be studied on such complete leaves. On the contrary, the most common species in the Euramerican region have long lanceolate leaves, 30–80 cm long and 4–15 cm wide. Such leaves are usually found in fragmentary conditions, often precluding the study of their overall morphology. The classification of leaves using only venation is very problematic, as venation is biased by preservation, can vary in different parts of the same side of a leaf,

and on the adaxial and abaxial sides of a single leaf. As will be shown in the following text, the method of cuticular analysis can further elucidate cordaitalean classification and stratigraphy.

Problems with the classification of cordaitalean leaves

Leaf shape and venation characteristics are often the only two features used for classifying cordaitalean leaves. The most important characteristics are leaf outline and the shape of the apex. Unfortunately, very few cordaitalean leaves are preserved complete, most specimens being preserved only as fragments that lack the base and apex. Furthermore, venation is not a reliable characteristic for classifying cordaitalean leaves, as it is biased by the mode of preservation. Cordaitalean leaves usually contain thick veins above vascular bundles, and thin veins above sclerenchymatous strips. Small transverse wrinkles can occur in the leaf blade. Most cordaitalean species have both the thick and thin veins. However, vein thickness varies from the base to the leaf apex. Thin and thick veins can be easily distinguished in the basal and middle parts of the same leaf, whereas it is difficult to distinguish them in the apical part of the same leaf (Text-fig. 5). If one were to find fossils of such leaf parts separately, one could easily consider them to belong to different species. The adaxial and abaxial sides of the same leaf can also show different venation patterns. In poorly preserved specimens the thin veins are usually not preserved at all, and such samples are thus nearly impossible to classify by venation. Apart from these problems, the cordaitalean leaves have a relatively wide range of venation characteristics variations. The venation is simple and parallel; however the vein density and number of alternating thin and thick veins can vary considerably in different specimens. The venation variability within one species is often large, venation characteristics of several species overlap, and it frequently occurs that cordaitalean leaves showing the same venation have different cuticle patterns (Šimůnek, 2000).

The most complete cordaitalean leaves from the Bohemian Massif are illustrated in Text-fig. 1. These leaves have different shapes: they are wide or narrow, and with rounded to sharp apices. Most of them have venation consistent with the "species" *Cordaites* "*principalis*".



Text-fig. 1. The most complete cordaitalean leaves from the Bohemian Permo-Carboniferous. × 0,14, Scale = 10 cm.
a – *Cordaites schatzlarensis* Šimůnek et Libertín., Žacléř, Šverma Mine (formerly Marie Julie), Duckmantian, Intrasudetic Basin.
b – *Cordaites* sp., Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Duckmantian, Intrasudetic Basin.
c – *Cordaites latus* sp. nov., Tuchlovice, Nosek Mine, Bolsovian, Kladno-Rakovník Basin.
d – *Cordaites dobranensis* sp. nov., Heřmanova Huť – Vlkýš, Asturian (Westphalian D), Plzeň Basin.
e – *Cordaites dobranensis* sp. nov., Heřmanova Huť – Vlkýš, Asturian (Westphalian D), Plzeň Basin.
f – *Cordaites rudnicensis* sp. nov., Vrchlabí, Rudník Horizon, Autunian, Krkonoše Piedmont Basin.
g – *Cordaites rudnicensis* sp. nov., Vrchlabí, Rudník Horizon, Autunian, Krkonoše Piedmont Basin.
h – *Cordaites rudnicensis* sp. nov., Vrchlabí, Rudník Horizon, Autunian, Krkonoše Piedmont Basin.
i – *Cordaites sudeticus* sp. nov. Vrchlabí, Rudník Horizon, Autunian, Krkonoše Piedmont Basin.
j – *Cordaites rudnicensis* sp. nov., Vrchlabí, Rudník Horizon, Autunian, Krkonoše Piedmont Basin.
k – *Cordaites* cf. *"principalis"*, Háje nad Jizerou, Háje Horizon, Autunian, Krkonoše Piedmont Basin.
l – *Cordaites* cf. *"principalis"*, Horní Kalná, Kalná Horizon, Autunian, Krkonoše Piedmont Basin.

Venation

Because complete cordaitalean leaves are very rare, palaeobotanists often use the venation pattern for classification. Crookall (1970) criticised this practice and mentioned the following obstacles that restrict the use of venation as a diagnostic character: "(a) The number and proximity of both the true veins and the sclerenchymatous strands may vary in the leaves of a plant according to such factors as age and position on a branch; (b) as has already been seen, the number and development of the sclerenchymatous strands on the two sides of one and the same leaf may differ; (c) the 'venation' towards the base of a leaf often differs from that higher up. In addition to the natural factors enumerated above, there are others, which are due to preservation and their effect can rarely be assessed. The leaves have often undergone some degree of maceration before fossilisation and the process may have affected the strength of the 'true' and 'false' veins."

Josten (1991) used venation for determining of the species of the genus *Cordaites* from the Westphalian of northeast Germany. According to that author, one thick vein alternating with 2–5 thin veins indicates the species *Cordaites principalis*, one thick vein alternating with one thin vein is diagnostic of *Cordaites borassifolius*, while the species *Cordaites palmaeformis* has all veins of a uniform thickness.

However, this criterion is artificial and does not allow the determination of other species of the genus *Cordaites*. Furthermore, a comparison of the venation pattern of the abaxial and adaxial leaf sides of the species *Cordaites principalis* (according to Harms and Leisman, 1961), based on samples from coal balls, demonstrates that the adaxial side looks like *Cordaites principalis*, while abaxial side corresponds to *Cordaites borassifolius*. Similarly, the abaxial side of *Cordaites crassus* resembles *Cordaites palmaeformis*. Many other species have venation patterns formed by alternating thick and thin veins (see Table 1), so that their venation resembles that of the species *Cordaites principalis*. Josten and Amerom (1999) stated that venation is not so significant for the determination of cordaitalean species, and they therefore classify the Stephanian and Permian cordaitalean species of Germany as *Cordaites* sp. The stratigraphical range of the species *Cordaites principalis* is very wide, being mentioned from the Lower Namurian to the Autunian. A single species cannot have such a wide stratigraphical range.

Barthel (1976) expressed scepticism about the possibility of distinguishing the three most common European cordaitalean species (*Cordaites principalis, C. palmaeformis* and *C. borassifolius*). He concluded that a series of transitions exists among these three basic types of venation, and that it is therefore impossible to safely classify fragments of cordaitalean leaves. The study of cordaitalean cuticles did not resolve this problem, as some specimens of *Cordaites principalis* yielded several different cuticular *Cordaites* morphotypes. Barthel (1976) proposed the unification of the wide-leaved cordaitalean species into one species type: *Cordaites principalis-borassifolius-palmaeformis*. The purposes for this proposal are, according Barthel (1976), again that fragmentary cordaitalean specimens cannot be macroscopically distinguished.

The study of venation is plagued by the difficulties mentioned above. Compression/impression material only enables the study of veins as they appear on the leaf surface. However, the veins usually reflect the inner structure of a leaf. Thicker veins are often developed above vascular bundles, while thinner veins occur above bands of sclerenchymatic tissue. This pattern was described by Harms and Leisman (1961) for the species *Cordaites principalis* and *Cordaites crassus* from American coal balls (see Text-fig. 2). Harms and Leisman (1961) showed that cordaitalean leaves were usually up to 3 mm thick at their base, 300–500 µm thick in the centre, and only 100 µm thick at their terminus. Canadian compression/impression specimens (Zodrow at al. 2000) are only 40–70 µm thick.

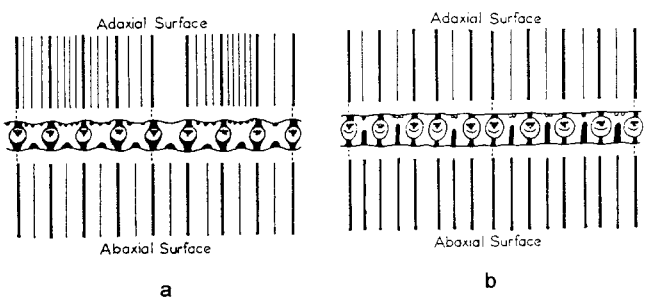
Parenchyma tissue is easily compacted, while vascular bundles and sclerenchymatous bands are more resistant and can therefore be preserved as prominent ribs on a fossil imprint. Cordaitalean vascular bundles differ from those of other plants by the presence of a special sheath. Furthermore, they are parallel along the entire blade of the leaf. According to Harms and Leisman (1961), they are 200–300 µm wide. Sclerenchymtous bands of various widths are developed above and below the vascular bundles, and connect them with the epidermal cells (see Text-fig. 3).

Well preserved Bohemian cordaitalean specimens usually have prominent relief. The widest and most prominent veins were probably present on the lower side of the leaf, while the upper side has narrower, less prominent veins. Some specimens even show negative relief on the rock imprint.

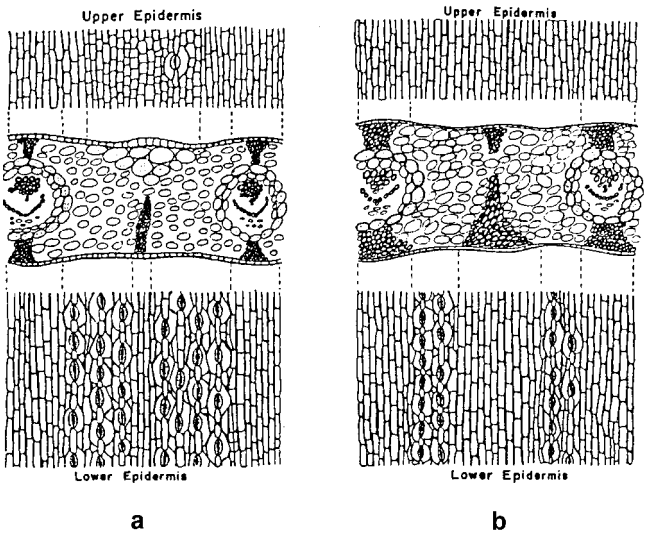
Sklerenchymatous bands are usually very narrow. The number of them that occur between two thick veins can also vary on the adaxial and abaxial sides of a single leaf (e.g. *Cordaites borassifolius* (Sternberg) Unger). Individual sclerenchymatous strands usually show positive relief, and are usually several cm to dm long. They are usually non-continuous in the leaf blade.

Venation is parallel, and the number of veins usually increases towards the leaf apex. However, vein forking is not observable, though the veins probably fork discreetly, so as to fill the space within the widening leaf.

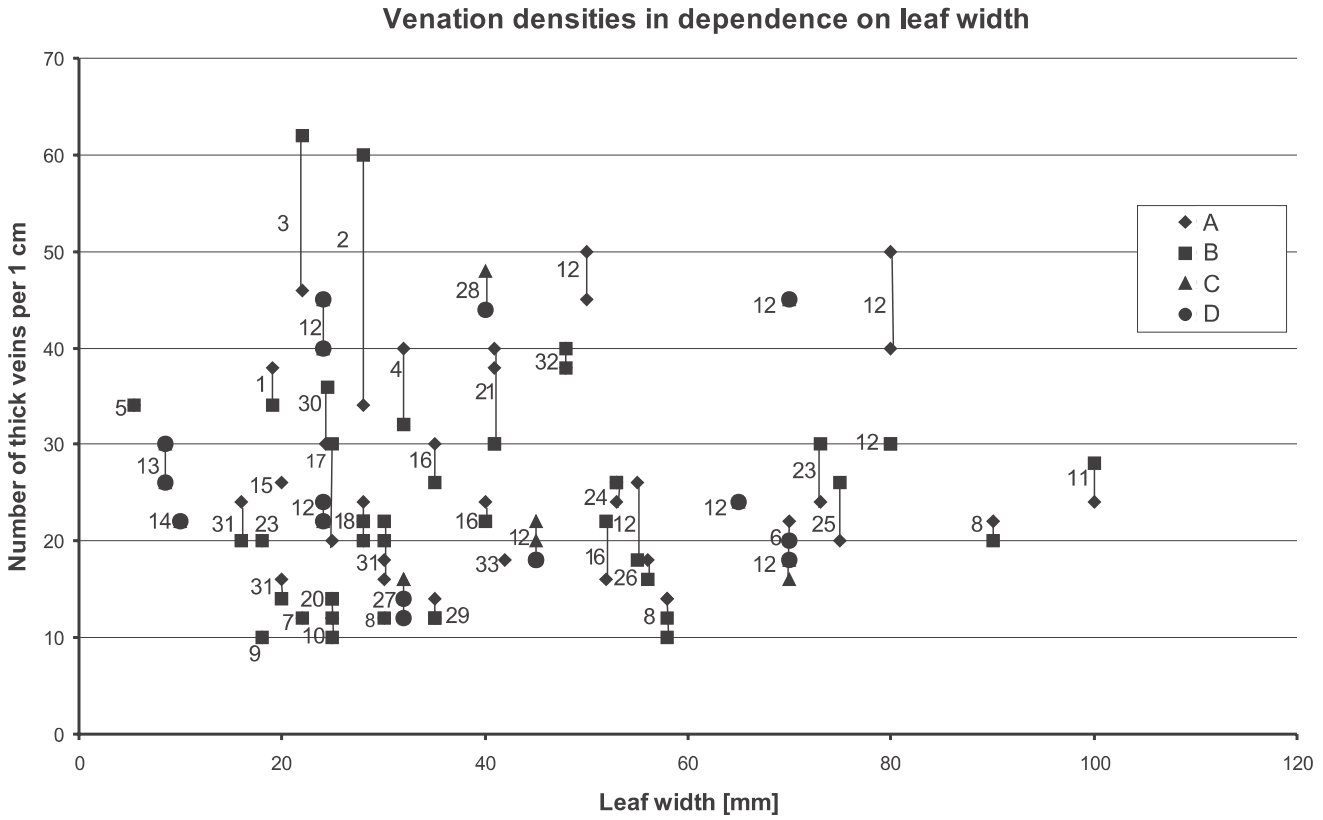
For the present study, 83 specimens have been measured and subjected to cuticular analysis. The leaf fragments are



Text-fig. 2. Correlation of adaxial and abaxial ribbing patterns with internal sclerotic tissues. a) *Cordaites "principalis"* (Germar) Geinitz, b) *C. crassus* Renault. Note differences of adaxial and abaxial surfaces (According to Harms and Leisman 1961).



Text-fig. 3. Correlation of epidermal patterns with internal anatomy for *Cordaites crassus*. a) distal region, b) proximal region, Kansas, USA, Bolsovian – Westphalian D. (According to Harms and Leisman 1961).



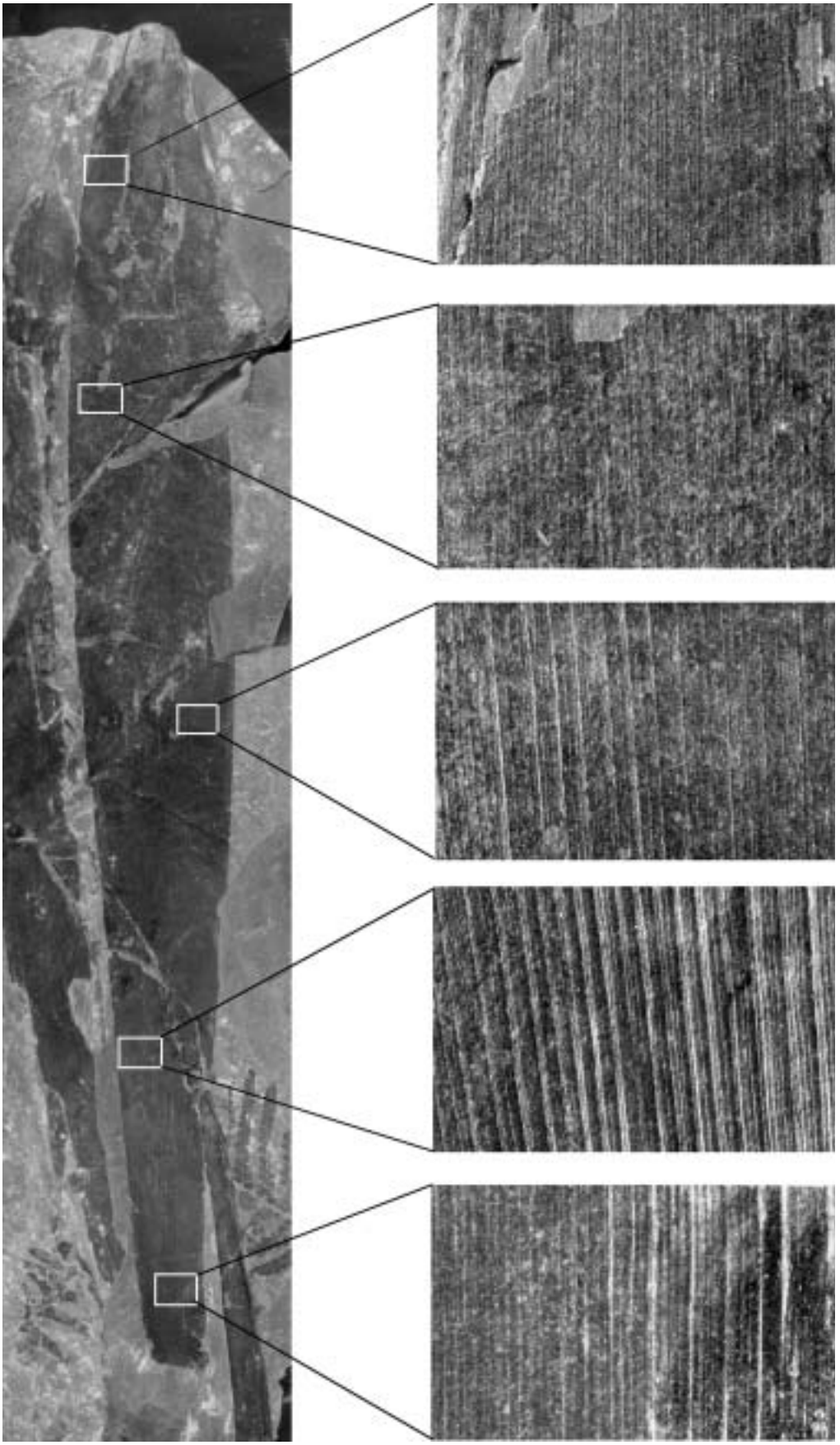
Text-fig. 4. Correlation of venation density and leaf width of studied cordaitalean species: 1 – *C. karvinensis*, 2 – *C. sustae*, 3 – *C. silesiacus*, 4 and 5 – *C. idae*, 6 – *C. schatzlarensis*, 7 – *C. tuchlovicensis*, 8 – *C. kladnoensis*, 9 – *C. wartmannii*, 10 – *C. polynervus*, 11 – *C. latus*, 12 – *C. borassifolius*, 13 – *C. lubnensis*, 14, *C. raconicensis*, 15 – *C. rerichensis*, 16, 17, 18, 23 – *C. dobranensis*, 19, 20, 27 – *C. blazkovicensis*, 21 – *C. ledecensis*, 22 – *C. pilsensis*, 24, 25 – *C. wilkischensis*, 26 – *C. krasovicensis*, 28 – *C. malesicensis*, 29 – *C. melnicensis*, 30 - *C. radvanicensis*, 31 - *C. rudnicensis*, 32 - *C. sudeticus*, 33 - *C. svatonovicensis*. A – Number of thick veins (near the middle of leaf) per 1 cm; B – Number of thick veins (near the margin) per 1 cm; C – Number of thick veins (near the middle of leaf) per 1 cm (leaf width incomplete); D – Number of thick veins (near the margin) per 1 cm (leaf width incomplete).

up to 235 (440) mm long and between 5.5 and 100 mm wide. Vein density varies within the interval of 10 to 62 veins per cm (see Text-fig. 4). Thus the veins (their canters) are 161 – 1000 μm apart. It was found that 0–7 thin veins occur between two thick veins. These characteristics are valid for 30 cordaitalean cuticular morphotypes known from the Langsettian (Westphalian A) to the Permian.

A 335 mm long cordaitalean leaf (*Cordaites dobranensis* sp. nov.) from the Asturian of the Plzeň Basin (Heřmanova Huť locality) was thoroughly studied (Text-fig. 5). The width of the leaf and its venation density were measured in 5 cm increments from the base of the leaf, through the middle, and to the leaf margin. In this case, the venation density is relatively constant at 14 to 18 veins per cm. The "thick" veins are generally thinner at the leaf terminus, where it is difficult to distinguish them from the "thin" veins. Vein density is higher in the middle of the leaf, at 24 veins per cm. The veins are most prominent in the basal part and near the leaf centre. The veins are indistinct at the very base of the leaf, probably from being hidden within the greater leaf thickness of this part. However, "thick" veins are prominent from 2 cm to 13 – 14 cm from the base and 21 – 22 cm near the leaf border (see Text-fig. 5). The veins become thinner near the apex, where it becomes difficult to distinguish them from the "thin" veins of the sclerenchymatous strands.

Vein density is relatively constant, whereas all other characteristics, such as leaf width and the number of thin veins between two thick veins, are variable. A combination of venation density, and the number and thickness of the "thick" and "thin" veins can help in determining some cordaitalean cuticular morphotypes.

Remarks on Terminology: Cordaitalean leaves possess two types of veins, "thick" and "thin". The thick veins usually display vascular bundles on the leaf surface, and Crookall (1970) therefore described them as thick or "true" veins. Variable numbers of thin veins occur between two thick veins in the leaf. The thin veins reflect sclerenchymatous tissue on the surface of the leaf. This tissue usually forms bands that can be continuous or discontinuous. Crookall (1970) referred to them as thin or "false" veins. These thin veins have been variously described by palaeobotanists as sclerenchymatous strands, bands, or strips. Pant and Verma (1964) described them as fibrous strands. However, as we have already mentioned, it is not always possible to distinguish vascular bundles and sclerenchymatous bands on compression/impression specimens, as both can have the same



Text-fig. 5. ***Cordaites dobranensis*** **sp. nov., Heřmanova Huť, × 0.65 showing details of venation in various parts of the leaf, ×6.5. Note that venation differs from base to the top. Near the base, the thick and thin veins are easily discernible, whereas near the top, all veins are approximately of the same thickness.**

thickness in a leaf (see Text-fig. 2b – Abaxial surface). The present author therefore uses the terminology of Crookall (1970) in distinguishing the veins as thick or thin, even if it is not anatomically or morphologically correct. It is true that approximately 90 % of the thick reins really represent vascular bundles, and that nearly 100 % of the thin veins represent sclerenchymatous bands, even though thick veins can also represent sclerenchymatous strands. In such cases, it is difficult or impossible to distinguish vascular bundles and sclerenchymatous strands in compression/impression material.

Cuticles

Cuticles are an important diagnostic character of cordaitalean plants. The relation of cuticles to the inner structure of leaves has been described by Harms and Leisman (1961) (Text-fig. 3). Stomatal complexes do not occur where vascular bands and sclerenchymatous strands are located. Instead, they occur in the stomatiferous bands between vascular bands and sclerenchymatous strands on the abaxial epidermis, and are usually only sparsely present in the adaxial cuticle. The stomatal complexes are of a uniform type within an entire, single leaf, while cell dimension and the number of stomatal rows per stomatiferous band are variable characteristics. *Cordaites* plants were a diverse and differentiated group. The present study describes 30 cordaitalean cuticular morphotypes from the Bohemian Permo-Carboniferous deposits, whereas only 3 or 4 species were previously defined based on venation. The evolutionary development of cuticles probably accelerated more quickly than that of the morphological structures of leaves, and thus the leaves do not show such a range of variability.

Material

The fossilised remains of cordaitalean plants studied here come from nearly all units of the Upper Carboniferous and Lower Permian of the Bohemian Massif. The localities at which the samples were obtained are shown in Text-fig. 6.

The oldest cordaitalean plants from the Bohemian Massif are known from the Middle Namurian to Langsettian of the Upper Silesian Basin (Karviná Formation). Three samples from the Šusta collection (Ostrava Museum, in Ostrava) have been used for cuticular analysis. They come from the Suchá Member of the Karviná Formation, and are therefore of Langsettian age.

Cordaitalean plants are very common in the Intrtasudetic Basin. The most frequent finds come from the Žacléř locality at the Jan Šverma (formerly Marie Julie) Mine, and from the Rtyně v Podkrkonoší locality at the Zd. Nejedlý (formerly Ida Gallery) Mine. Both localities belong to the Žacléř Formation of Duckmantian age. The Žacléř locality belongs to the Lampertice Member, whereas the Rtyně v Podkrkonoší locality belongs to the Prkenný Důl-Žďárky Member. The Central and Western Bohemian Upper Palaeozoic Region is another large area with rich findings of cordaitalean leaves. The Radnice Member of the Kladno Formation, of Bolsovian age, is known to contain most cordaitalean cuticular morphotypes. The cuticles of samples from Ovčín near Radnice locality (Whetstone Horizon), belonging to *Cordaites borassifolius* (Sternberg) Unger, and housed at the National Museum in Prague, have also been studied. Slightly younger samples come from the tuffaceous interbeds of the Upper Radnice Coal Seam of the Kladno-Rakovník Basin, mostly from the Tuchlovice locality at the Nosek Mine, and from Libušín near the Kladno locality at the Schoeller Mine. Further findings come from boreholes. The youngest stratigraphical unit of the Radnice Member is the Lubná Group of Coals. The studied cordaitalean plants come from laminated tuffites above the Z-tuff Horizon at the Filip II quarry in Lubná near Rakovník.

Most of the cordaitalean samples come from the Nýřany Member of Asturian age; however, they represent fewer morphotypes than Radnice Member. Cuticles of cordaitalean plants have been studied from the Touškov, Nýřany, and Chotíkov Group of Coals. Most of them come from the Dobřany locality of the Dobré štěstí Mine, and from the Heřmanova Huť road cut locality in the Plzeň Basin. Further samples come from boreholes of the Plzeň and Kladno-Rakovník Basin.

Cordaitalean plants have rarely been studied in younger units. Cordaitalean leaves from the Slaný Formation (Stephanian B) of the Kladno-Rakovník and Mšeno Basins, from the Slaný Mine locality and from several boreholes (e.g. Sušno, Sš 1 locality), have been subjected to cuticular analysis. Unfortunately, the cuticles of cordaitalean plants of the same age from the Jívka Member of the Odolov Formation in the Intrasudetic Basin, and from the Kateřina Mine at the Radvanice locality of the Radvanice Group of Coals, are not well preserved.

The cordaitalean samples of Permian age that are the best preserved for cuticular analysis come from the Vrchlabí locality in the Krkonoše Piedmont Basin. Two cuticular types have been identified from the bituminous rocks of the Rudník Horizon of the Vrchlabí Formation in this basin.

The collection of cordaitalean leaves contains several hundred specimens, from which 83 have been selected for cuticular analysis and for preparing 246 cuticular slides (Table 2).

Methods

The well preserved, coalified cordaitalean leaf fragments were separated from the encompassing rock by needle or hydrofluoric acid (HF). Cuticles were prepared according to the method described by Kerp (1990). These fragments were bleached in Schulze reagent (conc. $HN0_3$ with crystals of $KClO_3$). The maceration time was 50 to 70 minutes. Other leaf fragments were macerated in 40 % HNO_3 with crystals of $KClO_3$ (according to Krings and Kerp, 1997; and Kerp and Krings, 1999). This procedure takes longer, but does less damage to the fine cuticular structures. The maceration time was usually 20 to 40 hours. After the treatment in Schulze reagent, the cuticles were washed in 10 % potassium hydroxide (KOH) and rinsed in distilled water. Some

Table 2. List of slides

Locality	Age	Slide numbers
Upper Silesian Basin		
Karviná, Hlubina Mine, 19 seam	Langsettian (Westphalian A)	**171/1-2, 299/1-2**
Karviná, Františka Mine, 22 seam	Langsettian (Westphalian A)	**301/1-6, 336/1-7**
Intrasudetic Basin		
Žacléř, Šverma Mine (Marie Julie)	Duckmantian (Westphalian B)	**312/1-2,** 317/1-2
Rtyně v Porkrkonoší, Nejedlý Mine (Ida Gallery)	Duckmantian (Westphalian B)	**154/1-4, 161/1-3, 186/1-2, 225/1-3, 228/1-3, 314/1, 315/1-3**, **316/1-2,** 319/1, **320/1-3, 321/1-5, 322/1,** 323/1
Rtyně v Porkrkonoší, Nejedlý Mine (Ida Gallery)	Cantabrian	*167/1*
Radvanice, Kateřina Mine	Stephanian B	**318/1-2**
Rybníček	Stephanian B	342/1-4
Plzeň Basin		
Dobřany, Dobré štěstí Mine	Asturian (Westphalian D)	**163/1-4, 164/1-4, 241/1-5, 242/1-3, 243/1-4, 283/1-4, 284/1, 296/1-2**
Heřmanova Huť - Vlkýš	Asturian (Westphalian D)	**324/1-3, 326/1-5, 327/1-5, 328/1-4, 329/1-3, 330/1-5, 331/1-3**
Krašovice, vrt Kš 1	Asturian (Westphalian D)	**259/1-3, 260/1-3**
Nýřany - Tesla, vrt HJ 3/4	Asturian (Westphalian D)	**166/1-2**
Radnice Basin		
Ovčín-Přívětice, Pokrok Mine	Bolsovian (Westphalian C)	**108/1-6, 120/1-3, 352/1-5, 353/1-2, 354/1-5, 355/1-5, 356/1-6, 357/1-3, 358/1-5**
Svinná near Radnice	Bolsovian (Westphalian C)	**347/1-2**
Carboniferous relics		
Stradonice	Bolsovian (Westphalian C)	*168/1-2*
Kladno-Rakovník Basin		
Blažkovice, RPZ 30 borehole	Asturian (Westphalian D)	**188/1-3, 189/1-2**
Libušín, Schoeller Mine	Bolsovian (Westphalian C)	**113/1-2**
Lubná u Rakovníka, Filip II quarry	Bolsovian (Westphalian C)	**289/1-2,** *293/1-3,* **294/1-2,** 340/1
Řeřichy, Ře 3 borehole	Bolsovian (Westphalian C)	**246/1-2**
Tuchlovice, Nosek Mine (Tuchlovice)	Bolsovian (Westphalian C)	**182/1-3, 183/1-3, 184/1-2, 185/1-4, 285/1-4, 295/1-3**
Ledce, Le 8 borehole	Asturian (Westphalian D)	**171/1-2**
Řisuty, Ři 24 borehole	Stephanian B	**346/1-7**
Slaný, Slaný Mine construction	Stephanian B	**165/1-3**
Mšeno-Roudnice Basin		
Sušno, Sš 1 borehole	Stephanian B	**M9/1-2**

Locality	Age	Slide numbers
Mnichovo Hradiště Basin		
Pustá Proseč, well construction	Autunian	*325/1*
Krkonoše Piedmont Basin		
Fořt, F 2 borehole	Autunian	*169/1*
Roprachtice, Hradecký Creek	Autunian	332/1-2
Vrchlabí, road cut, layer no. 1	Autunian	*168/1,* **209/1-4, , M11/1-4,** *220/1*
Vrchlabí, road cut, layer no. 7	Autunian	**204/1-2, 205/1-2,** *206/1, 221/1,* **M10/1-5, M12/1-4**
Vrchlabí, road cut, layer no. 8	Autunian	*207/1-2*

Explanation: **209/1-4** cuticles depicted in this work
332/1-2 cuticles well preserved, not depicted
221/1 cuticles poorly preserved, corroded, fine structures indistinct

cuticles were stained with safranin for several hours to accentuate the anticlinal walls and stomata. The cuticles were dehydrated in pure glycerine before being embedding in glycerine gelatine slides. The remaining cuticular fragments were affixed to film for observation under a CamScan CS 3200 scanning electron microscope. The glycerine gelatine slides were observed under an Olympus 50 light microscope. Use of Nomarski Interference Contrast resulted in optimum conditions for observing the slides. The stomatal density and stomatal index were evaluated according to the following formula: SI = 100 x S/(B + S), where SI is stomatal index, B are cells, and S are stomata (Kerp, 1990).

Text-fig. 6. Location of fossil sites mentioned in this paper. Explanation: 1 – Permo-Carboniferous (Westphalian, Stephanian and Permian) covered by younger sediments (mostly Cretaceous), 2 – Stephanian and Permian (mostly Autunian), 3 – Westphalian, 4 – Namurian to Langsettian (mostly covered by Tertiary and Carpatian sediments), 5-10 – localities of investigated cordaitalean plants: 5 – Langsettian, 6 – Duckmantian, 7 – Bolsovian, 8 – Asturian (Westphalian D), 9 – Stephanian, 10 – Autunian.

The Study of Cuticles under Scanning Electron Microscope

The surface of the cuticle can be studied by scanning electron microscope. Cuticle is a protective layer of the epidermis, consisting of periclinal and anticlinal walls. Periclinal walls occur on the outer side of the epidermal cells, while anticlinal walls are situated where epidermal cells connect. The scanning electron microscope enables the study of the cuticle from two views:

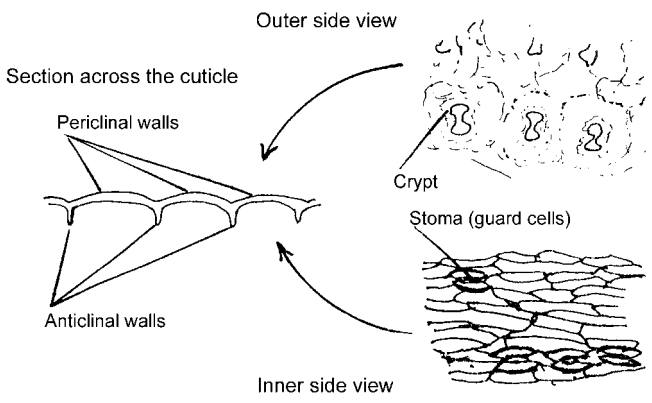
1) From the outside: The cell outlines are seldom discernible due to corrosion of the plant's fine structure. However, when the cuticle is well preserved, the ornamentation on the periclinal walls is visible. Anticlinal walls are usually less visible, or not observable at all. Guard cells are likewise unobservable, as they are sunken below the epidermis level in many Carboniferous plants. If the crypt is developed, it is visible only from the outer side.

2) From the inside: The guard cells and anticlinal walls are the most visible from this side. (See Text-fig. 7).

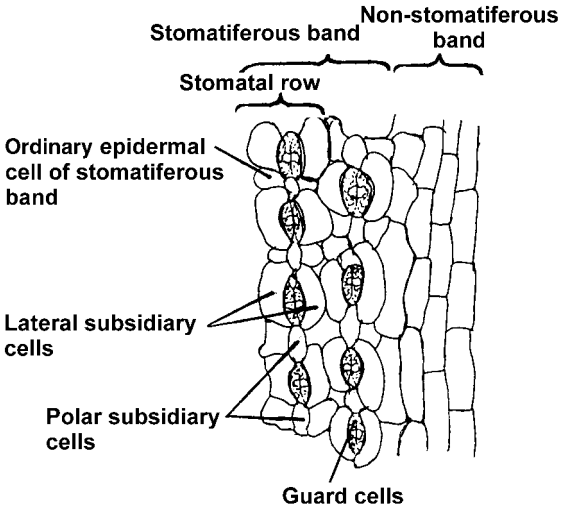
Descriptions of cuticles

Cuticles of the genus *Cordaites* Unger share many common characteristics. The cells are mostly longitudinal, and oriented parallel to veins. In some cases, the belts of oriented cells alternate with those of randomly oriented, ordinary epidermal cells, though the stomata that occur among them are oriented parallel to veins.

The stomata of the genus *Cordaites* are haplocheilic, similar to those of most gymnospermous plants. The stoma originates from one mother cell that divides directly into two guard cells, which are very often sunken below the epidermis level. They are surrounded by 4–7 subsidiary cells that are differentiated from ordinary epidermal cells, and that form a stomatal complex with the guard cells. The stomatal complex is usually composed of two guard cells, two lateral subsidiary cells, and two polar subsidiary cells. Such a stomatal complex is typical of the genus *Cordaites*. The stomatal complexes form stomatal rows and stomatal bands (Text-fig. 8). Several species have subsidiary cells of stomatal complexes of the same shape as ordinary epidermal cells. In this case,



Text-fig. 7. Important cuticular characters in SEM.



Text-fig. 8. Morphology of cordaitalean cuticular structures, example of typical abaxial cuticle.

the subsidiary cells vary in number from 4–7 cells per stoma. Most types of stomata have sunken guard cells covered by the outer stomatal cavity, or crypt, of elongate shape. It is usually a ring or elongated hollow, oriented transversely to the longitudial axis of the stoma. Stomata are often covered by various strongly cutinised projections of subsidiary cells, forming a narrow hole above the guard cells. The ordinary cells of some cuticles bear small flat papillae.

Leaves of the genus *Cordaites* are both hypostomatic, having stomata only on the abaxial side, and amphistomatic, having stomata on both sides of the leaves.

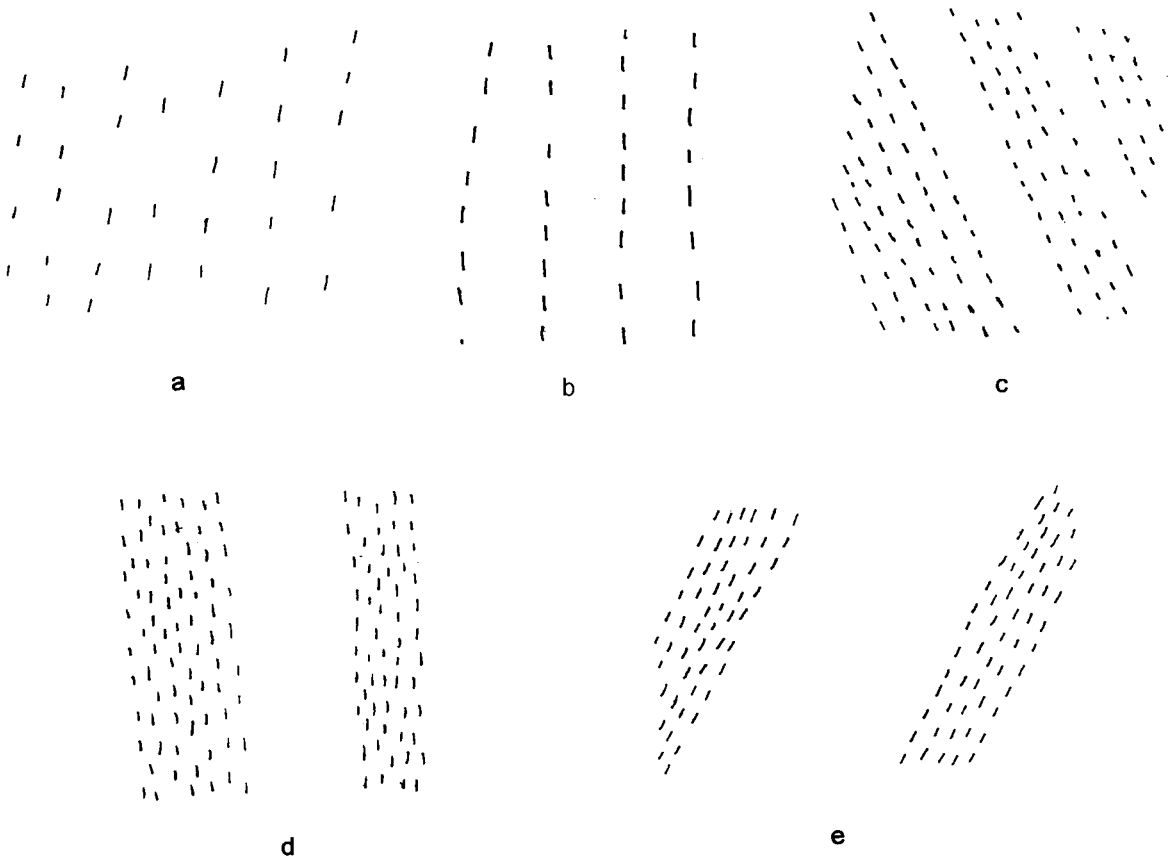
The abaxial cuticle contains more diagnostic characteristics than the adaxial cuticle, and was therefore chosen as the basis of the classification of 30 *Cordaites* species from the Bohemian Massif (see Text-fig. 9). Cleal and Shute (1995) similarly used the characteristics of the abaxial cuticle for the classification of Carboniferous pteridosperms.

Adaxial cuticles of the genus *Cordaites* usually show a simpler arrangement of stomata than do the abaxial cuticles. Some adaxial cuticles are witout stomata, while the other cuticles have only irregularly dispersed stomata. Stomatal complexes arranged into stomatal rows occur in very few species. Stomatiferous bands on adaxial cuticles have not been reported. Adaxial cuticles generally have lower stomatal density, which reflects the need to protect the higher transpiration of the side exposed to the sun. Abaxial cuticles often show higher stomatal densities.

Groups of Abaxial Cuticular Types

A) Stomata arranged in rare, poorly defined stomatal rows.

Stomata are dispersed relatively regularly but sparsely on the epidermal surface. Individual stomata are isolated and are separated by ordinary epidermal cells. There is no difference between stomatiferous and non-stomatiferous bands. The



Text-fig. 9. Distribution of stomata on abaxial cuticle for 5 cordaitalean cuticular groups.
a – Stomata regularly (irregularly) dispersed, or in rare ill defined stomatal rows. *Cordaites sudeticus*, slide No. 209/4, Vrchlabí, Autunian
b – Stomta in well defined, simple stomtal rows. *Cordaites rerichensis*, slide. No. 246/1, Řeřichy, borehole Ře 3, Bolsovian.
c – Stomata in well defined multiple stomatal rows that are connected into stomatiferous bands. *Cordaites dobranensis*, slide No. 163/4, Dobré štěstí Mine near Dobřany, Asturian (Westphalian D).
d, e – Stomata in stomatiferous bands with ill defined stomatal rows. d – Cells of stomatiferous bands are different from cells of non-stomatiferous bands. *Cordaites kladnoensis*, slide No. 183/2, Tuclovice, Nosek Mine, Bolsovian, e – Cells of stomatiferous bands are of the same shape as cells of non-stomatiferous bands. *Cordaites wartmannii*, slide No. 113/2, Libušín, Schoeller Mine, Bolsovian. All ×94.

guard cells are surrounded by subsidiary cells that can have the same or different shape than the ordinary epidermal cells.

B) Stomata arranged in well defined, simple or double rows.

The stomatal complex consists of a pair of guard cells, and two lateral and two polar subsidiary cells. The lateral cells of the stomata are in contact within one stomatal row. One polar cell is often common for two stomata. The stomatal row either contains only stomatal complexes, or these complexes can be separated by small ordinary epidermal cells that differ from those of non-stomatiferous bands.

C) Stomata in well defined, double or multiple rows that are connected into stomatiferous bands.

Up to seven stomatal rows can be joined together into a stomatiferous band that reflects the intercostal field. Either all cells belong to the stomatal complexes, or some small epidermal cells may occur among them that differ from the long cells of the non-stomatiferous bands.

D) Cells of stomatiferous band differ from those of the non-stomatiferous band; the stomata within stomatiferous bands are irregularly dispersed.

All cells (except guard cells) of the stomatiferous (intercostal) band are of the same shape and are nearly isodiametric. The ledges of the guard cells are sunken and very poorly preserved externally. In contrast to the cells of the stomatiferous band, the cells of non-stomatiferous band are distinctly elongated and oriented parallel to the veins.

E) Stomata arranged into stomatiferous bands separated by non-stomatiferous bands. The subsidiary and ordinary cells of stomatiferous and non-stomatiferous bands are of the same shape.

Systematics

This systematic classification is adapted according to Cleal and Thomas (1995).

Division Gymnospermophyta ('seed plants')
Class Pinopsida (Coniferopsida)
Order Cordaitanthales ('cordaites')
Family Cordaitanthaceae

Cordaites Unger 1850

Syn.
Flabellaria Sternberg 1821 *pro parte*
Neozamia Pomel 1846
Pychnophyllum Brongniart 1849
Pycnophyllum Tuzson 1911 (non Rémy 1846)

Type: *Cordaites borassifolius* (Sternberg) Unger 1850, p. 277.

Diagnosis: Leaves elongated, simple, strap-, sword-, or ribbon-shaped, entire margined, parallel veined, sessile. Leaves hypostomatic or amphistomatic with isolated haplocheilic stomata running parallel to the margin, in stomatal rows or stomatiferous bands.

Remarks: This morphogenus is reserved for both compressed/impressed and permineralised leaves. For description and emendation of the type species, see page. 130.

Discussion: The genus *Cordaites* was designated by Unger (1850), who distinguished it from palms of the genus *Flabellaria* Sternberg 1821. His decision was probably influenced by the opinion of Corda (1845), who doubted that *Flabellaria borassifolia* is a monocot. Unger's definition of *Cordaites* was based on the form and anatomy of the stem, and on the character of the leaves. Before Unger published the name Cordites, the name *Pychnophyllum* Brongniart (1849) was proposed for plants that could no longer be regarded as monocotyledons, though the orthographic variant of this name *Pycnophyllum* Tuzson 1911 had already been applied to a group of recent plants by Rémy (1846). Brongniart (1849) classified *Pychnophyllum* as Noeggerathiae, and placed it between cycads and conifers also related to Sigillariae. Goeppert (1852) admitted the Noeggerathiae as Monocotyledons, but agreed with the opinion of Goldenberg (1848) that they should be placed between the Cycadeae and the conifers based on their fructifications. Schimper (1869–1874) placed genus *Cordaites* (*Pycnophyllum*) in the Cycadeae. Weiss (1869) wrote that the fructifications of cordaitalean plants relate them to Cydadeae and the conifers. Heer (1876) admitted them into the conifers, while Lesquereux (1880) classified cordaitaleans as "Dicotyledonous Gymnosperms" between Cycadeae and conifers.

The first revision of *Cordaites* was undertaken by Grand'Eury (1877), who divided the genus *Cordaites* into three sub-genera: *Eucordaites, Dorycordaites* and *Poacordaites*. He also closely described its fructifications. The fructifications had already been described by Festmantel (1876) under the name *Cordaitanthus*. Sevard (1917) described *Cordaites* as trees whose habit resembled the recent conifer *Agathis*. Cordaitalean fructifications were studied by Schoute (1925) and later by Florin (1951). Florin (1931) studied the epidermal features of conifers and cordaitaleans, and demonstrated their close relationship based on cuticles. Beck (1960) proved that the Devonian stems *Callixylon* Zaleskij, which had been compared with cordaitalean and conifer stems *Dadoxylon* Endlicher, belong to *Archaeopteris* Dawson fronds. This enabled the establishment of Progymnospermophyta as a new group. Cordaitalean plants probably evolved from representatives of progymnosperms from the propinquity of *Archaeopteris*, though the evidence from the Lower Mississipian is rather poor.

A systematic revision of this group has not been attempted for many years. Crookal (1970) published a revision of the cordaitaleans of Great Britain, Ledran (1966) described French cordaitaleans with cuticles, while the thesis of Costanza (1984) is probably the last paper to have dealt generally with cordaitalean plants. Aside from these contributions, only small articles concerning one or several species of the cordaitalean plants have been published recently.

Remarks on nomenclature: *Cordaites* Unger, 1850 is retained instead of *Neozamia* Pomel, 1846 (Greuter et al. 2000). The situation with *Pychnophyllum* Brongniart, 1849 is more complicated. This name has an orthographic variant, *Pycnophyllum* Tuszon 1911, which is homonymous with *Pycnophyllum* Rémy, 1846. The latter is reserved for extant plants from the family Caryophyllaceae. If we admit that *Pycnophyllum* Tuszon 1911 is an orographic variant of *Pychnophyllum* Brongniart, 1849, then the name *Pycnophyllum* Tuszon (resp. *Pychnophyllum* Brongniart) is homonymous to *Pycnophyllum* Remy and should be rejected. However, if we consider the names *Pychnophyllum* Brongniart, 1849 and *Pycnophyllum* Rémy, 1846 as different names, the name *Pychnophyllum* Brongniart, 1849 would have priority over *Cordaites* Unger. Seward (1917) noted this problem and wrote: "It has recently been proposed to revive the forgotten designation *Pychnophyllum*, but the reasons given are hardly likely to induce botanists to discard the familiar generic name which perpetuates the memory of Corda". Although the present author strongly recommend using the name *Cordaites*, a definite solution should be reached by preserving the name *Cordaites* Unger, further discussion of which lies outside the scope of the present study.

Groups of abaxial cuticular types
Group A
(stomata arranged in rare, poorly defined stomatal rows)

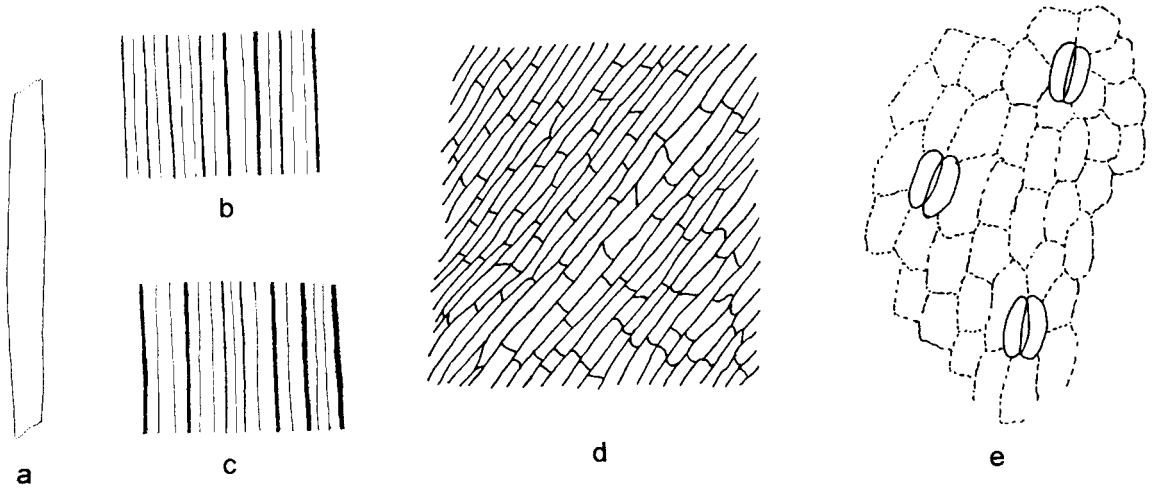
Cordaites karvinensis sp. nov.

Text-figs 10a-e, Pl. 2, fig. 1, Pl. 4, figs 1–4

2000 *Cordaites* sp. Šimůnek, p. 27, figs 2: 1.
2001 *Cordaites "principalis"* (Gemar) Geinitz (morphotype 1 sensu Šimůnek 2000) Šimůnek, p. 32–34, figs 15a–e, pl. 2, fig. 1, pl. 4, figs 1–4.

Holotype: Designated here, Ostrava Museum, Ostrava, inv. No. A 5999, coll. V. Šusta.

Derivation of name: From the type locality in the town of Karviná.



Text-fig. 10. ***Cordaites karvinensis*** **sp. nov., Karviná, Hlubina Mine, Upper Suchá Member, Langsettian, slide No. 173/2. a – leaf, ×0.25, b, c – leaf venation, ×20, d – adaxial cuticle, ×100, e – abaxial cuticle with stomata, ×250.**

T y p e l o c a l i t y : Karviná, Hlubina Mine, Upper Silesian Basin.

T y p e h o r i z o n : Karviná Formation, Upper Suchá Member, Coal seam No. 19, Langsettian (Westphalian A).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Haplocheilic, relatively narrow, lanceolte leaves with medium-dense parallel venation, 1 or 2 thin veins alternate with each thick vein. Adaxial cuticle with oblong to trapezoidal cells. Cells of abaxial cuticle are oblong, rectangular, stomata dispersed in poorly defined, rare stomatal rows.

D e s c r i p t i o n : The fragment of the leaf representing the holotype is 205 mm long and 20 mm wide in the middle. The venation is parallel. There are 34 veins per cm at the leaf margin, and 38 veins per cm in the midle of the leaf. One thin vein alternates with each thick vein near the leaf margin. One to two thin veins alternate with each thick vein in the middle of the leaf. The leaves are hypostomatic.

Adaxial cuticle (Text-fig. 10d, Pl. 4, fig. 1): The adaxial cuticle is weakly cutinised. The cells are not differentiated into costal and intercostal areas. They are markedly elongated, usually of oblong or trapezoidal shape. The cells are 40–80 μm long and 15–25 μm wide. The anticlinal walls are stright. The cells are oriented parallel to the veins.

Abaxial cuticle (Text-fig. 10 e, Pl. 4, fig. 2–4): The abaxial cuticle is weakly cutinised. The cells are not differentiated into costal and intercostal fields. They are usually of oblong or trapezoidal shape, rarely elongated pentagonal, 25–40 μm long and 20–30 μm wide. The anticlinal walls are nearly stright or slightly bent. The cells and stomatal complexes are oriented parallel to veins. Stomatal complexes are arranged in poorly defined rare stomatal rows. Stomata are of elliptical shape and are formed by pairs of guard cells, which are 27–30 μm long and 15–18 μm wide. The guard cells are usually surrounded by six subsidiary cells, of which 2–3 are polar and 2–4 lateral. They are of the same shape as ordinary epidermal cells. The stomatal density is 170 to 190 stomata per mm^2. The stomatal index was not determined.

D i s c u s s i o n : *Cordaites karvinensis* has a very simple abaxial cuticle with more or less regularly dispersed stomata. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites sustae sp. nov.

Text-figs 11a–g, Pl. 2., fig. 2, Pl. 4, figs 5–9, Pl. 5, figs 1–3

2000 *Cordaites* sp. Šimůnek, p. 27, figs 2: 2.
2001 *Cordaites "principalis"* (Gemar) Geinitz (morphotype 2 sensu Šimůnek 2000) Šimůnek, p. 34–36, figs 16a–g, pl. 2. fig. 2, pl. 4, figs 5–9, pl. 5, figs 1–3.

H o l o t y p e : Designated here, Ostrava Museum, Ostrava, inv. No. A 6581, coll. V. Šusta.

D e r i v a t i o n o f n a m e : From Václav Šusta, a Czech palaeobotanist.

T y p e l o c a l i t y : Karviná, Hlubina Mine, Upper Silesian Basin.

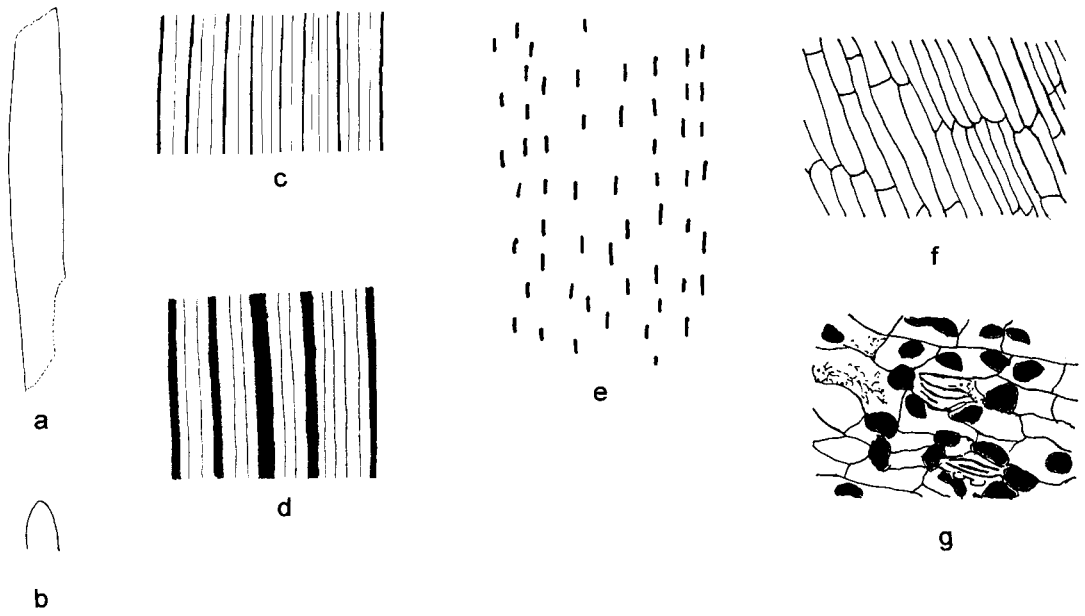
T y p e h o r i z o n : Karviná Formation; Upper Suchá Member, roof of the 19th coal seam, VI. floor west. Langsettian (Westphalian A).

M a t e r i a l : Only one specimen – the holotype

Diagnosis: Narrow lanceolate hypostomatic leaves with rounded apex. The venation is dense, parallel, 1–2 thin veins alternate with each thick vein. Adaxial cuticle with oblong cells, abaxial cuticle papillary with longitudinally tetragonal cells, stomata dispersed in rare, poorly defined stomatal rows.

D e s c r i p t i o n : A fragment of the leaf representing the holotype is over 180 mm long and 28 mm wide. The leaf apex (preserved on the opposite site of the slab) is rounded. The venation is parallel. The vein density is 34 per cm near the leaf border, and up to 60 relatively narrower veins per cm in the middle of the leaf. One to two thin veins are discernible between each 2 veins near the pinnule border. These veins are not discernible in the middle of the leaf. The leaf is hypostomatic.

Adaxial cuticle (Text-fig. 11 f, Pl.. 4, fig. 5–6): The cells are not discernible in the costal and intercostal areas. The



Text-fig. 11. ***Cordaites sustae*** **sp. nov., Hlubina Mine, Upper Suchá Member, Langsettian, slide No. 299/1-2. a – leaf, × 0.25, b – leaf apex from the opposite side of the sample, ×1/4. c – venation probably from the abaxial side of the leaf, 10, d – venation probably from the adaxial side of the leaf, ×20, e – distribution of stomata on the abaxial cuticle, ×50, f – abaxial cuticle, ×125, g – abaxial cuticle with stomata, ×250.**

cells are usually oblong, and the anticlinal walls are staight. The cells are conspicuously elongated, 50–100 µm long and 15–25 µm wide, and are oriented parallel to the veins.

Abaxial cuticle (Text-fig. 11g, Pl. 4, figs 7–9, Pl. 5, figs 1–3): These cells are likewise not discernible into costal and intercostal areas. They are elongated tetragonal (oblong), and strongly papilous. Papillae grow on nearly all of the epidermal cells. The cells are 35–60 µm long and 15–20 µm wide. Anticlinal walls are straight or bent. The cell orientation is parallel to the veins, similar to the orientation of the stomata. Very narrow unicellular rows of elongated oblong cells are visable on the cuticle. These rows are too narrow for the costal field. The cells are 100–200 µm long and only up to 10 µm wide. Stomatal complexes are dispersed in poorly defined stomatal rows. The subsidiary cells are identical to the ordinary epidermal cells. The pairs of guard cells are eliptical, 35–55 µm long and 15–25 µm wide. The stomata are partly overlain by the proximal papillae of the subsidiary cells. These papillae have not been observed in any other *Cordaites* specimen from the Bohemian Massif. The stomatal complex usually consists of 2–3 polar cells and 2–4 lateral cells. The stomatal density is 96–112 per mm^2. The stomatal index is 10.

D i s c u s s i o n : The abaxial cuticle of *Cordaites sustae* also has a very simple structure. It differs from *Cordaites karvinensis* by its papillary cells. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites silesiacus sp. nov.

Text-figs 12a–e, Pl. 2, figs 3, 4, Pl. 5, figs 5, 6, Pl. 6

2000 *Cordaites* sp. Šimůnek, p. 27, figs 2: 3.

2001 *Cordaites* sp. (morphotype 3 sensu Šimůnek 2000), Šimůnek, p. 36–38, figs 17a–e, pl. 2, figs 3, 4, pl. 5, figs 5, 6, pl. 6.

H o l o t y p e : Designated here, Ostrava Museum, Ostrava, inv. No. A 5989, coll. V. Šusta.

D e r i v a t i o n o f n a m e : From the region of Silesia in which the type specimen was discovered.

T y p e l o c a l i t y : Karviná, Františka Mine, Upper Silesian Basin.

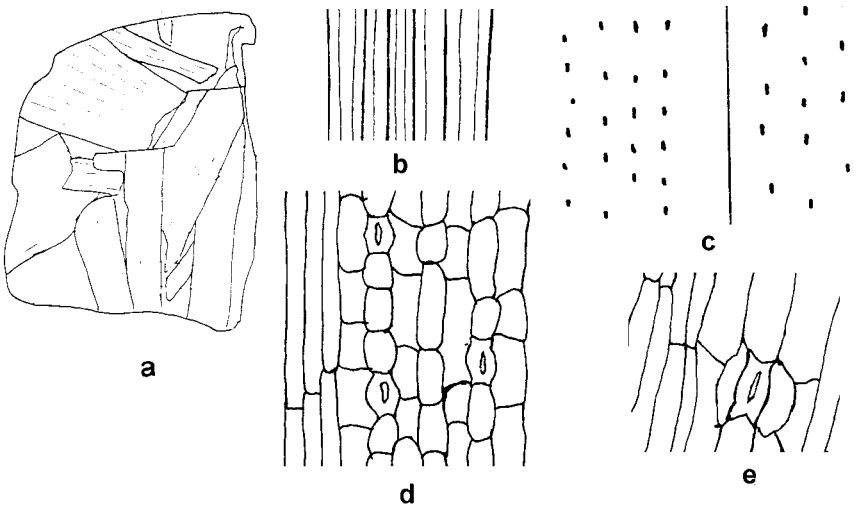
T y p e h o r i z o n : Karviná Formation, Upper Suchá Member, roof of 22nd coal seam, VIth floor west, Langsettian (Westphalian A).

M a t e r i a l : Several leaf fragments on one slab from Karviná. Cuticles prepared from 3 leaf fragments.

D i a g n o s i s : Amphistomatic, medium broad, lanceolate leaves with dense parallel venation, 1 – 2 thin veins alternate with each thick vein. Cells of both adaxial and abaxial cuticles mostly oblong, stomata of both sides dispersed in rare stomatal rows, polar ends of guard cells of "swallow-tail" shape.

D e s c r i p t i o n : A fragment of the leaf representing the holotype is over 60 mm long and 22 mm wide (the widths of other leaves in the same slab vary from 10 to 35 mm – see Text-fig. 12a). The venation is parallel. The density of veins near the leaf margin is 62 per cm, and 46 per cm in the middle of the leaf. Usually 1–2 thin veins alternate with each thick vein. The thin veins are not entirely discernible. The leaf is amphistomatic.

Adaxial cuticle (Text-fig. 12d, Pl. 5, fig. 5 Pl. 6 figs 1, 5, 7): The adaxial cuticle resembles the abaxial cuticle. The cells in the simple, rare, poorly-defined stomatal rows differ



Text-fig. 12 ***Cordaites silesiacus*** **sp. nov., Karviná, Františka Mine, Upper Suchá Member, Langsettian, Slide No. 301/1-7. a – sample with leafy fragments for cuticular slides, ×0.25, b – leaf venation, ×20, c – distribution of stomata on abaxial surface (left) and on adaxial surface (right), ×50, d – adaxial cuticle with stomata, ×200, e – abaxial cuticle with stoma, ×250.**

from those in non-stomatiferous bands. The shape of intercostal cells (stomatal rows) is oblong, 35–80 μm long and 15–20 μm wide. Anticlinal walls are straight. The cells are oriented parallel to the veins. The costal veins (in the non-stomatiferous band) are elongated, oblong, 60–150 μm long and 10–15 μm wide. The stomatal complexes are elliptical; each are formed by a pair of guard cells 20–25 μm long and 10–12 μm wide. Their polar ends have the swallow-tail shape. The guard cells are surrounded by subsidiary cells that are very similar to the ordinary epidermal cells. Each stomatal complex contains a pair of polar subsidiary cells, which are elongated, oblong, 35–80 μm long and 15–20 μm wide. Lateral subsidiary cells are also paired, elongated, oblong, 60–150 μm long and 10–15μm wide. The stomatal density is 60 per mm^2. The stomatal index is 6.

Abaxial cuticle (Text-fig. 12e, Pl. 5, fig. 6, Pl. 6, figs 1–4, 6): The abaxial cuticle is more weakly cutinised than the adaxial one, and has higher stomata density. The cells in simple rare stomatal rows do not differ from those in the non-stomatiferous (costal) bands. The cells in the stomatiferous (intercostal) bands are tetragonal, mostly oblong, 25–60 μm long and 14–20 μm wide. Anticlinal walls are straight or bent, and the orientation of the intercostal cells is parallel to veins. The costal cells are elongated, oblong, and form belts of 5–7 rows of cells. The cells are 80–170 μm long and 10–15 μm wide. The stomatal complexes are dispersed in irregular stomatal rows. The pairs of gurd cells are elliptical, 22–30 μm long and 15–20 μm wide. Their polar ends are swallow-tail shaped. They are surrounded by two, or rarely by three, polar subsidiary cells, and by two to four lateral subsidiary cells that are of the same shape as ordinary epidermal cells of the intercostal field. The stomatal density is 102 per mm^2. The stomatal index varies between 7 and 9.

D i s c u s s i o n : The specimen, described here as the holotype, was classified by V. Šusta as *Cordaites borassifolius* (Sternberg) Unger. This determination is incorrect, as its cuticles differ from those prepared from the holotype of *Cordaites borassifolius*. *Cordaites silesiacus* is amphistomatic, having stomata on both surfaces. This feature distinguishes it from *Cordaites karvinensis* and *C. sustae*. The swallow-tail ends of guard cells of the species *Cordaites silesiacus* are also remarkable. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

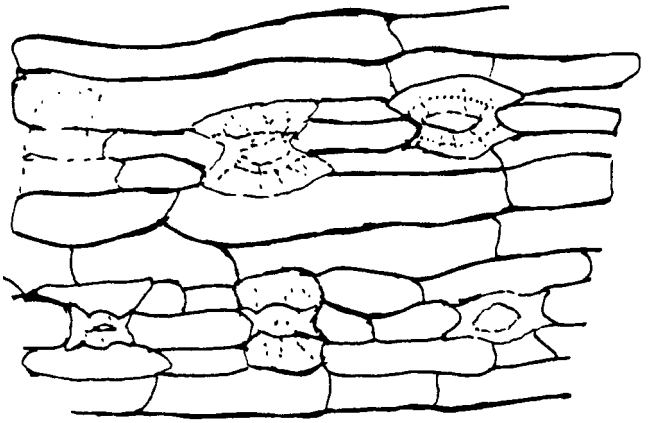
Cordaites strazkovicensis sp. nov.

Text-fig. 13, Pl. 7, figs 1–3

2001 *Cordaites* sp. (morphotype 34 – new morphotype), Šimůnek, p. 38, fig. 18, pl. 7, fig. 1–3)

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 203, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the type horizon of the Strážkovice Coals.



Text-fig. 13. ***Cordaites strazkovicensis*** **sp. nov., Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Žacléř Formation, Prkenný Důl-Žďárky Member, Duckmantian, slide No. 228/1-3. Adaxial cuticle with stomata, ×320.**

Type locality: Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin.

Type horizon: Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals. Duckmantian (Westphalian B).

Material: Only one specimen – the holotype.

Diagnosis: Narrow lanceolate leaves, cells of adaxial cuticle longitudinally oblong, swallow-tail shaped polar ends of guard cells.

Description: The holotype is a 100 mm long and 25 mm wide fragment of the apical part of a leaf. The apex is sharp. The leaf is probably amphistomatic. Abaxial cuticle is very poorly preserved.

Adaxial cuticule (Text-fig. 13, Pl. 7, figs 1–2): There is very little difference between the ordinary epidermal cells of intercostal field with stomata and those of the costal field. The cells are elongated, oblong, 40–100 μm long and 15–20 μm wide. Their anticlinal walls are straight or slightly bent. The cells are oriented parallel to the veins. The stomatal complexes are arranged in rare, poorly defined stomatal rows. Each is formed by a pair of elliptical sunken guard cells, 25–35 μm long and 18–22 μm wide. The polar ends of guard cells have the swallow tail shape. The guard cells are surrouded by subsidiary cells that do not markedly differ from ordinary epidermal cells. Each stomatal complex has two polar subsidiary cells, which are elongated, oblong, 35–60 μm long and 15–20 μm wide. Two or more lateral subsidiary cells are typical of each stomatal complex. They are elongated, oblong, and of similar dimensions as the ordinary epidermal cells. The stomatal density is 45 per mm^2 of leaf blade. The stomatal index varies between 10 and 12.

Abaxial cuticle (Pl. 7, fig. 3): The abaxial cuticle is very weakly cutinised and poorly preserved. Only oriented oblong cells are noticeble. The structure of the stomata is not observable.

Discussion: The adaxial cuticle of *Cordaites strazkovicensis* resembles that of *Cordaites sustae* of Langsettian age from Karviná by having swallow-tail shaped polar ends of guard cells. The studied specimen of *Cordaites strazkovicensis* is much younger, coming from the Duckmantian. An examination of the abaxial cuticle would be necessary for better comparison. There are slight differences in cell shapes and dimensisons, though the possibility of a close relation cannot be excluded.

For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites tuchlovicensis sp. nov.

Text-figs 14a–c, Pl. 2, fig. 5, Pl. 7, figs 4–6

2000 *Cordaites* sp. Šimůnek, p. 29, figs 2: 7.
2001 *Cordaites* sp. (morphotype 7 sensu Šimůnek 2000), Šimůnek, p. 40–41, fig. 19a–c, pl. 2, fig. 5, pl. 7, fig. 4–6.

Holotype: Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 204, coll. Z. Šimůnek.

Derivation of name: From the type locality at Tuchlovice.

Type locality: Tuchlovice, Nosek Mine, Kladno-Rakovník Basin.

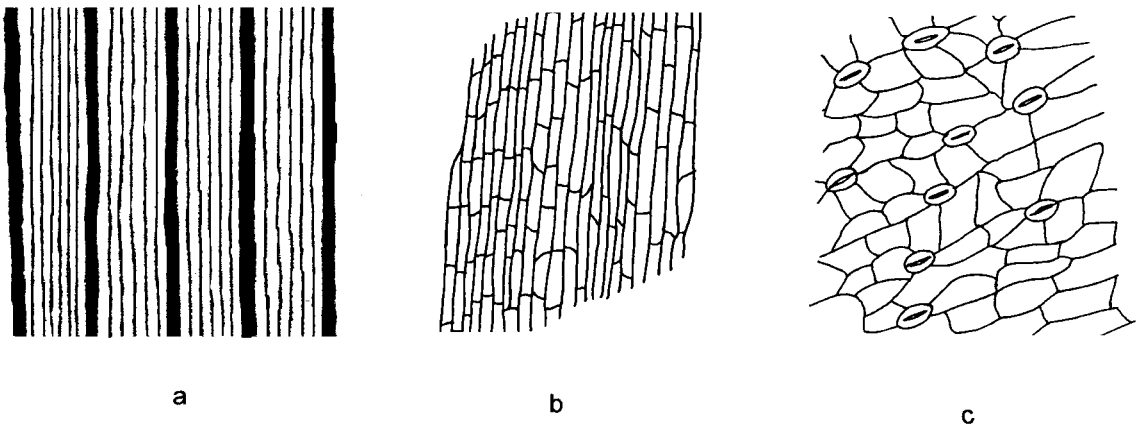
Type horizon: Kladno Formation, Radnice Member, Radnice Coals, intercalation of the Main Kladno coal seam. Bolsovian (Westphalian C).

Material: Only one specimen – the holotype.

Diagnosis: Hypostomatic, narrow lanceolate leaves, with infrequent parallel venation, 2–6 thin veins alternate with each thick veins. Adaxial cuticle with oblong cells, abaxial cuticle with tetra- to pentagonal cells, stomata dispersed in poorly defined stomatal rows.

Description: The holotype is a leaf fragment 86 mm long and 22 mm wide at its broader end. The actual leaf must have been broader, because it is enrolled. The venation is parallel and not very dense. About 12 thick veins occur per cm of leaf. The number of thin veins alternating with one thick vein vary from 2–3 near the margin up to 4–6 (7) in the center of the leaf. Delicate transverse striation is notable between thick veins. The leaf is hypostomatic, the cuticle was torn into strips during the maceration.

Adaxial cuticle (Text-fig. 14b, Pl. 7, figs 4, 5): The adaxial cuticle is slightly more strongly cutinised than the abaxial. The cells do not differ in the costal and intercostal fields. Their shape is oblong or trapezoidal. The cells are



Text-fig. 14. ***Cordaites tuchlovicensis*** **sp. nov., Tuchlovice, Nosek Mine, Kladno Formation, Radnice Member, Bolsovian, slide No. 184/1, a – leaf venation, ×20, b – adaxial cuticle, ×100, c – abaxial cuticle with stomata, ×250.**

60–160 μm long and 12–25 μm wide. The anticlinal walls are straight or only slightly bent. The cells are oriented parallel to the veins.

Abaxial cuticle (Text-fig. 14c, Pl. 7, fig. 6): The abaxial cuticle is weakly cutinised. The cells are distingushable into costal and intercostal (stomatal band) areas. The shape of the intercostal cells is tetra- to pentagonal. They are 25–50 μm long and 10–25 μm wide. The anticlinal walls are straight or slightly bent. The intercostal cells are mostly randomly oriented, whereas the stomatal complexes are oriented parallel to veins. The costal cells are oriented parallel to the veins; they are elongated tetragonal, arranged into bands composed of 3–6 cell rows. The costal cells are 40–100 μm long and 10–20 μm wide. The stomata in the intercostal field occur in poorly defined stomatal rows. The pairs of guard cells are elliptical, sunken, 18–24 μm long and 10–14 μm wide. The 4–7 subsidiary cells surrounding the stoma are of the same shape as ordinary epidermal cells. We can distinguish 2–3 polar cells and 2–4 lateral cells. The stomatal density in the intercostal band is 350–400 per mm^2 of leaf blade. The stomatal index in the intercostal band ranges from 12–15.

D i s c u s s i o n : *Cordaites tuchlovicensis* is assigned to Cuticular Group A due to the distribution of stomatal complexes on its abxial cuticle. However, only small fragments of the abaxial cuticle have been preserved, and it is not excluded that this cuticular morphotype could belong to Group E. *Cordaites tuchlovicensis* differs from all species of Group A by having tetra- to pentagonal, ordinary and subsidiary cells on the abaxial cuticle. This feature distinguishes it from all other species of this group. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites lubnensis sp. nov.

Text-figs 15a–e, Pl. 8, fig. 1–6

2000 *Cordaites* sp. Šimůnek, p. 29, figs 3: 13.
2001 *Cordaites* sp. (morphotype 13 sensu Šimůnek 2000), Šimůnek, p. 42–43, figs 20a–e, pl. 2, fig. 1, pl. 4, figs 1–4.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 205, coll. Z Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality in Lubná village.

T y p e l o c a l i t y : Lubná near Rakovník, quarry Filip II, loc. No. 32, Kladno-Rakovník Basin.

T y p e h o r i z o n : Kladno Formation, Radnice Member, Lubná Coals. Bolsovian (Westphalian C).

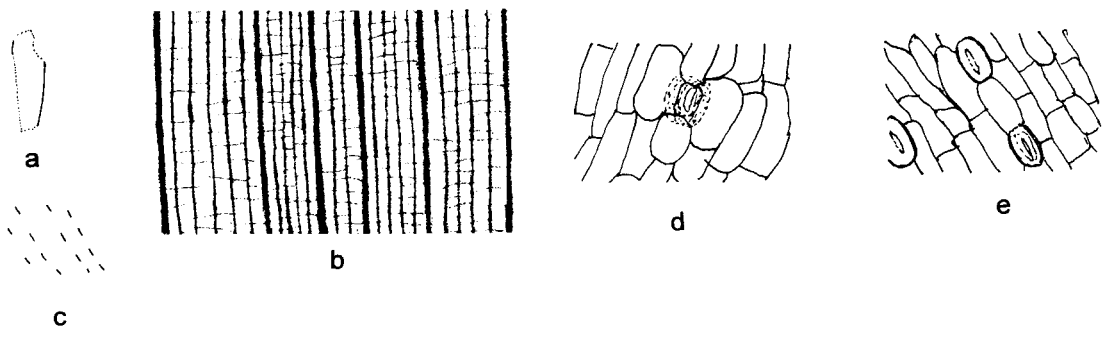
M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Small narrow, amphistomatic leaves with medium-dense parallel venation, 4–6 thin veins alternate each thick vein. Cells of adaxial cuticle are tetragonal, oblong, stomata irregularly dispersed. Cells of abaxial cuticle oblong, stomata in poorly defined, rare stomatal rows.

D e s c r i p t i o n : The holotype is a very small fragment of a leaf, 25 mm long and 8.5 mm wide. The venation is parallel. There are 26–30 veins per cm of leaf. There are 4–6 thin veins between each 2 thick veins that are prominent on the imprint without coal matter. Only fine transverse striation is visible between the thick veins on the opposite side of the leaf. The leaf is amphistomatic.

Adaxial cuticle (Text-fig. 15d, Pl. 8, figs 1–2): There is almost no difference between the cells of costal and intercostal areas. The cells are oblong, 40–100 μm long, 10–30 μm wide, and oriented parallel to the veins. The anticlinal walls are mostly straight or only slightly bent. The stomatal complexes are very rare and irregularly dispersed, and are oriented parallel to the veins. The pairs of guard cells are elliptical, sunken, about 20 μm long and 12 μm wide. They are usually surrounded by two lateral subsidiary cells and two polar subsidiary cells. The stomatal complexes (including subsidiary cells) are usually about 80 μm long and 70 μm wide. Polar subsidiary cells are oval, 25–40 μm long and 20–25 μm wide. Lateral subsidiary cells are also oval, larger than the polar cells, and are 50–80 μm long and 20–25 μm wide. The strong cutinisation of the proximal walls of the subsidiary cells towards the stoma is prominent. The stomatal density is about 4 per mm^2. The stomatal index is 0.5 – 0.6.

Abaxial cuticle (Text-fig. 15e, Pl. 8, figs 3–6): The abaxial cuticle is preserved in narrow strips that probably represent stomatiferous bands. The cells are oblong, 30–80 μm long and 10–20 μm wide. The anticlinal walls are straight or slightly bent. The cells are oriented parallel to the veins. The stomatal complexes occur in infrequent, poorly defined



Text-fig. 15. ***Cordaites lubnensis*** **sp. nov., Lubná near Rakovník, Filip II Quarry, Kladno Formation, Radnice Member, Lubná Group of coals, Upper Bolsovian, slide No. 294/1-2. a – leaf outline, ×0.5, b – leaf venation, ×20, c – distribution of stomata on abaxial cuticle, ×50, d – adaxial cuticle with stoma, ×200, e – abaxial cuticle with stomata, ×200.**

stomatal rows. The pairs of guard cells are sunken, elliptical, and oriented parallel to the veins. They are 20–30 μm long and 12–18 μm wide. The subsidiary cells are of the same shape as ordinary epidermal cells, and differ only in having higher cutinisation of the proximal walls towards the stoma, making the stomata very prominent on the cuticle. There are usually two, or rarely three, polar and lateral subsidiary cells per stoma. The stomatal density is about 280 per mm^2. The stomatal index is 15.

D i s c u s s i o n : *Cordaites lubnensis* is amphistomatic; however, it has a very low stomatal density on the adaxial cuticle. There is no difference between the ordinary and subsidiary cells on the abaxial cuticle. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites ledecensis sp. nov.

Text-figs 16a–g, Pl. 2, fig. 6, Pl. 8, fig. 7, Pl. 9

2000 *Cordaites* sp. Šimůnek, p. 32, figs 3: 21.
2001 *Cordaites* sp. (morphotype 21 sensu Šimůnek 2000), Šimůnek:, p. 43–46, figs 21a–e, pl. 2, fig. 1, pl. 4, figs 1–4.

H o l o t y p e : Designated here Czech Geological Survey, Prague, inv. No. ZŠ 206, coll. Z Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality at Ledce village.

T y p e l o c a l i t y : Ledce, borehole Le-8, depth 632,45 m, Kladno-Rakovník Basin.

T y p e h o r i z o n : Kladno Formation, Nýřany Member. Asturian (Westphalian D).

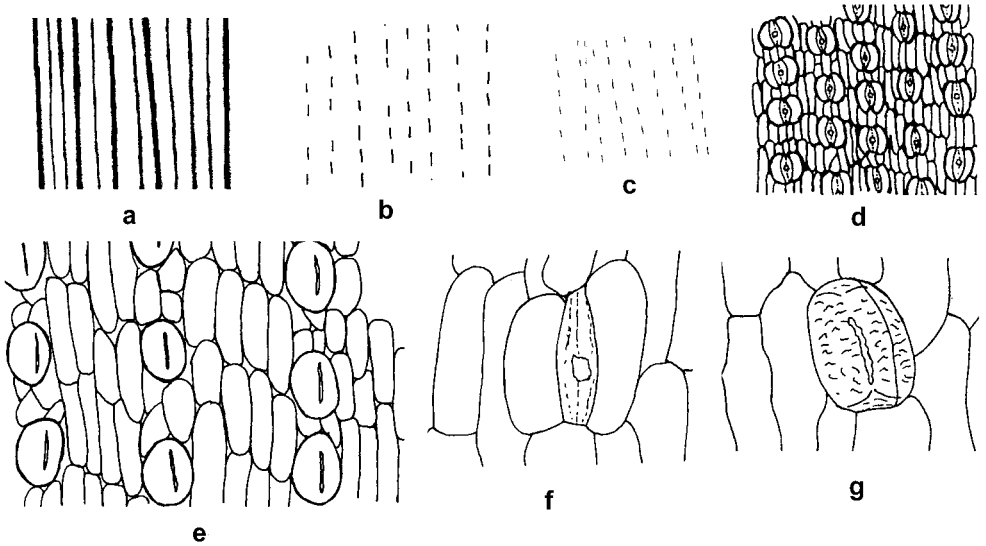
M a t e r i a l : Only one specimen – the holotype (part and counterpart).

D i a g n o s i s : Medium wide, amphistomatic leaves with dense parallel venation, 1–2 thin veins alternate with each thick vein. Adaxial cuticle with oval, oblong cells, stomata in infrequent rows, abaxial cuticle with oval, oblong cells, stomata separated in infrequent rows, prominent lateral subsidiary cells.

D e s c r i p t i o n : The holotype is a leaf fragment 50 mm long and 39 mm wide at its widest end. There are 38–40 thick veins per cm in the central part of the leaf, and about 30 thick veins per cm near the margin. One, or rarely 2, thin veins occur between 2 thick veins, which are more visible on the imprint without coal matter. The difference between thin and thick veins is less prominent near the leaf margin. The thin veins are indiscernible on the coalified leaf. The leaves are amphistomatic.

This morphotype has both cuticles approximately of the same cutinisation and with similar stomatal density, so it is difficult to determine which cuticle is adaxial and which is abaxial.

Cuticle 1 (Text-figs 16e,g, Pl. 8, fig. 7, Pl. 9, figs 1–3): The intercostal cells are irregular, oval to square, with broadly bent anticlinal walls rounded at the corners, 20–40 μm long and 12–22 μm wide. The costal cells are elongated, tetragonal, oblong to oval, rounded at the corners, orientated parallel to veins, 45–70 μm long and 14–22 μm wide. The stomatal complexes are dispersed, forming infrequent stomatal rows. The pairs of guard cells are sunken, of elliptical shape, 35–40 μm long and 15–20 μm wide. They are surrounded by subsidiary cells that are similar to the ordinary costal cells. The polar subsidiary cells are short and are of irregular oval, rhomboidal, or quadrangular shapes. They are 20–35 μm long and about 20–25 μm wide, and there occur 2–4 of them per stoma. The lateral subsidiary cells are of the same shape as ordinary epidermal cells (Text-fig. 16e). The guard cells are usually surrounded by 2 to 3 oblong lateral subsidiary cells 45–55 μm long and 12–20 μm wide. The stomatal complex is prominent in having distinct cutinisa-



Text-fig. 16 *Cordaites ledecensis* sp. nov., Ledce, borehole Le 8, depth 632.45 m, Kladno Formation, Nýřany Member, Asturian (Westphalian D), slide No. 171/1, a – leaf venation, ×16, b – Distribution of stomata on cuticle of the 2nd type (? abaxial), ×41, c – Distribution of stomata on cuticle of the 1st type (? abaxial), ×41, d – The cuticle of the 2nd type (?abaxial) with stomata, ×82, e – The cuticle of the 1st type (?adaxial) with stomata, ×205. f – Detail of a stoma on the cuticle of the 2nd type (?abaxial), ×410, g – Detail of a stoma on the cuticle of the 1st type (?adaxial) ×410.

tion of the proximal walls of the subsidiary cells. The stomatal density is about 104 per mm². The stomatal index is about 11.

Cuticle 2 (Text-figs 16d, f, Pl. 21, figs 4–7): The costal and itercostal bands are not differentiated. The cells separating the polar ends of the stomatal complexes are oval, oblong to square, 20–40 µm long and 12–22 µm wide; whereas those separating the lateral parts are elongated, tetragonal, 45–70 µm long and 14–22 µm wide. Their anticlinal walls are slightly bent, the cells are rounded at the corners. They are oriented parallel to the veins. Stomatal complexes are isolated, and form separated stomatal rows (Text-fig. 16d) The pairs of guard cells are sunken, elliptical, 35–45µm long and 25–30 µm wide. The stomatal complexes (including lateral subsidiary cells) are 52–70 µm wide and 40–50 µm long. Two to four polar subsidiary cells separate the stomata within a row, and they have the same shape as the ordinary intercostal cells. Lateral subsidiary cells are usually narrow and kidney-shaped (40–50 × 12–18 µm). There is usually one on each side of a stoma. The prominent cutinisation of the proximal walls of the lateral cells is pronounced. The stomatal density is 186 per mm². The stomatal index varies around 19.

D i s c u s s i o n : Both cuticles of *Cordaites ledecensis* have similar stomata density. The species *Cordaites silesiacus*, *C. rudnicensis* and *C. sudeticus* also show similar stomata density on their adaxial and abaxial cuticles. All species have differently shaped subsidiary cells. Moreover, *Cordaites silesiacus* has swallow-tail shaped polar ends. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites rudnicensis sp. nov.

Text-figs 1f–h, j, 17a–f, Pl. 2 fig. 7, 8, Pl. 10

1990 *Cordaites principalis* (Germar) Geinitz, Šimůnek, Drábková and Zajíc, p. 41, figs 1a–d, pl. 37, pl. 38, figs 1–2.
2000 *Cordaites* sp. Šimůnek, p. 32, figs 4: 31.
2001 *Cordaites* cf. "principalis" (Germar) Geinitz (morphotype 31 sensu Šimůnek 2000), Šimůnek, p. 46–48, figs 3f–h, i, 22a–f, pl. 2 figs 7, 8, pl. 10).

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 207 (Text-fig. 22a), coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Rudník Horizon, which is the type horizon of this species.

T y p e l o c a l i t y : Vrchlabí, road cut west from the town, Krkonoše Piedmont Basin.

T y p e h o r i z o n : Vrchlabí Formation, Rudník Horizon, layers 1, 7 and 9 (sensu Šimůnek, Drábková and Zajíc 1990). Permian, Lower Autunian.

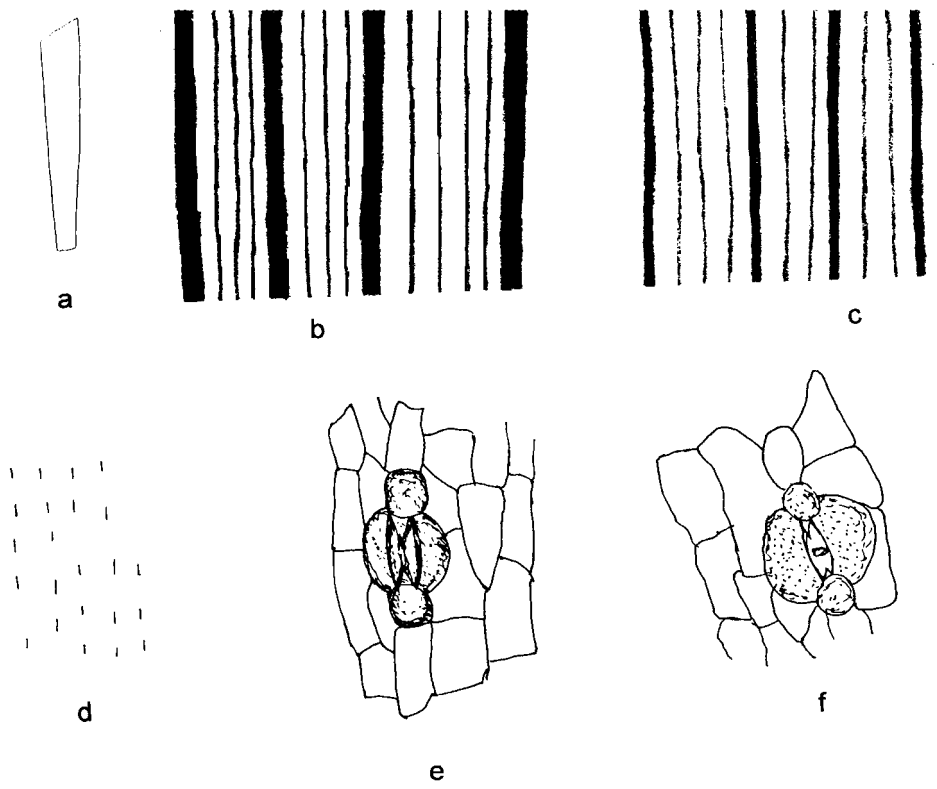
M a t e r i a l : 2 complete leaves and 6 fragments from Vrchlabí, Nos: ZŠ 207 – ZŠ 214.

D i a g n o s i s : Medium-large, lanceolate, amphistomatic leaves with rounded to blunt apices and infrequent parallel venation. Three to five thin veins alternate with each thick vein. Adaxial cuticle with oblong, square and trapezoidal cells, stomata dispersed in infrequent, poorly defined rows. Abaxial cuticle with oblong, pentagonal cells, stomata dispersed in infrequent ill-defined rows. There are 2 small rounded polar subsidiary cells, and 2 semicirculate lateral subsidiary cells.

D e s c r i p t i o n : The holotype is a leaf fragment 120 mm long that tapers from 20 to 10 mm in width towards the base. The thick veins are prominent. There are 14 – 16 veins per cm, and 3 – 5 very thin veins alternate with each thick vein. Only 2 – 3 veins are visible between each 2 thick veins towards the base. The small complete leaves are 15 and 27 cm long, though the adult leaves reach 50 cm in length. Their widths are within the interval from 9 to 43 mm. The leaves are narrow lanceolate, with the maximum width at their upper third. The apex is rounded to blunt. Each thick vein alternates with 2–5, or rarely even 6, thin veins (above the strips of sclerenchymatic tissue). Between 14 to 24 relatively thick veins, and 48 – 60 thin veins, occur per cm of leaf width. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 17e, Pl. 10, figs 1–3, 5, 6): The adaxial and abaxial cuticles are very similar. The more cutinised one is considered the adaxial. The stomata are oriented parallel to the veins and are isolated from each other by ordinary cells. They are dispersed more or less regularly and form infrequent stomatal "rows". In fact, there is no difference between the cells of the stomatal row and the non-stomatiferous band. The cells are oriented parallel to the veins. Their shapes are oblong, square, or trapezoidal, 20–65 µm long and 12–22 µm wide. The anticlinal walls are straight to slightly bent. The stomatal complexes are formed by pairs of sunken guard cells surrounded by two small polar subsidiary cells and two oblong to kidney-shaped lateral subsidiary cells. The subsidiary cells are remarkably strongly cutinised. The pairs of guard cells are elliptical, pointed on their ends, 30–38 µm long and 12–22 µm wide. The length of the stomatal complex (including the subsidiary cells) is 60–75 µm and its width is 40–55 µm. Polar subsidiary cells are usually 8–12 µm in the diameter. The lateral subsidiary cells are 50–60 µm long and 12–22 µm wide. The outer stomatal cavity has an irregular shape due to the stronger cutinisation of the subsidiary cells. The stomatal density is 120–130 per mm² of leaf balade. The stomatal index is 8.

Abaxial cuticle (Text-fig. 17f, Pl. 10, figs 4, 7–9): The narrow strips of cells without stomata (costal) separate poorly defined stomatal rows of isolated stomata. The ordinary epidermal cells of the stomatal "rows" and costal bands differ only very little. The cells are of oblong shape (intercostal cells also pentagonal), 22–75 µm long and 12–20 µm wide. The anticlinal walls are straight to slightly bent. The cell orientation is parallel to the veins. The stomatal complexes within one "row" are usually 100–150 µm apart. They are formed by a pair of sunken elliptical guard cells surrounded by two polar and two lateral subsidiary cells. The ends of each guard cell are pointed, and these acute ends are somewhat divergent within a pair of guard cells. The pairs of guard cells are 30–38 µm long and 14–20 µm wide. Each stomatal complex (including subsidiary cells) is thus 50–70 µm



Text-fig. 17. ***Cordaites rudnicensis*** **sp. nov., Vrchlabí – road cut, Vrchlabí Formation, Rudník Horizon, Autunian, slide No. M10/1-5, 205/1-2. a – leaf outline to the sample No. M10, ×0.25, b – leaf venation of the sample ZŠ 207, ×20, c – leaf venation of the sample 205, ×20, d – distribution of stomata on the adaxial cuticle, ×50, e – adaxial cuticle with a stoma (slide M12). ×200, f – abaxial cuticle with a stoma (slide M12). ×200.**

long and 55–65 μm wide. The polar subsidiary cells are rounded and have diameters between 10–18 μm. The lateral subsidiary cells are semicircular in shape, 55–65 μm long and 20–26 μm wide. The outer stomatal cavity has an irregular shape. The stronger cutinisation of the subsidiary cells is more prominent. The stomatal density is about 130 per mm^2 of leaf blade. The stomatal index is about 10.

D i s c u s s i o n : Similar to *Cordaites ledecensis*, *Cordaites rudnicensis* also has approximately the same stomatal density on its adaxial and abaxial cuticles. *Cordaites rudnicensis* has rounded polar ends and semicircular lateral subsidiary cells. Its guard cells are elliptical with acute polar ends. For a detailed comparison, see the discussion of the entire group beginning on page 117, and Table 3.

Cordaites sudeticus sp. nov.

Text-figs 1i, 18a–d, Pl. 2, fig. 9, Pl. 11

1990 *Cordaites palmaeformis* (Goeppert) Weiss, Šimůnek, Drábková and Zajíc, p. 41–42, pls 35–36.
2000 *Cordaites* sp. Šimůnek, p. 27, figs 4: 32.
2001 *Cordaites* cf. "palmaeformis" (Goeppert) Weiss (morphotype 32 sensu Šimůnek 2000), Šimůnek, p. 49–51 figs 1ch, 23a–d, pl. 2, fig. 9, pl. 11.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 215, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Sudetic region, the type region.

T y p e l o c a l i t y : Vrchlabí, road cut w. from town, Krkonoše Piedmont Basin.

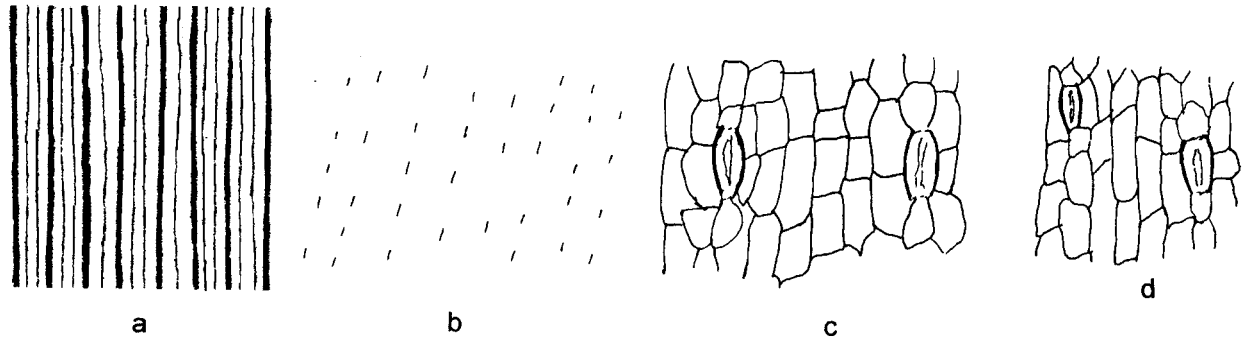
T y p e h o r i z o n : Vrchlabí Formation, Rudník Horizon, layers 1 and 8 (sensu Šimůnek, Drábková and Zajíc 1990). Permian, Lower Autunian.

M a t e r i a l : 4 leaf fragments from Vrchlabí, Nos ZŠ 215 – ZŠ 218.

D i a g n o s i s : Large, amphistomatic, lanceolate leaves with blunt apices. Venation is dense, 1–2 indistinct veins alternate with each thick vein. Adaxial and abaxial cuticles, oblong cells and stomata isolated from each other, separated in infrequent poorly defined stomatal rows.

D e s c r i p t i o n : The holotype represents the terminal part of a large leaf. The specimen is 110 mm long and 48 mm wide. The apex is rounded. The venation is dense, with 38–40 veins per cm. One to two very indistinct veins alternate with each thick vein. The leaf fragments are up to 110 mm long and 39–62 mm wide. They gradually taper to a blunt apex. The veins are fine and dense. There are 38–60 thick veins per cm of leaf. One or two very thin veins, only visible under a binocular microscope, occur between each two "thick" veins. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 18c, Pl. 11, figs 1–4, 7–10): The adaxial and abaxial cuticles are very similar in the sha-



Text-fig. 18. ***Cordaites sudeticus*** **sp. nov., Vrchlabí – road cut, Vrchlabí Formation, Rudník Horizon, Autunian, slide No. M11/1-4, a – leaf venation to the sample ZŠ 215, ×20, b – Distribution of stomata on adaxial cuticle, ×50, c – adaxial cuticle with stomata, ×200. d – abaxial cuticle with stomata, ×200.**

pes of their cells and stomata. The abaxial side is less cutinised than the adaxial one. In fact, there is no difference between the cells of the stomatal (intercostal) rows and non-stomatiferous bands. The shape of the cells is oblong, with lengths between 22–80 μm and widths between 15–28 μm. They are oriented parallel to the veins. The anticlinal walls are straight to slightly bent. The stomatal complexes are formed by pairs of guard cells and by subsidiary cells (2 polar and 2–3 lateral) that do not differ markedly from the ordinary epidermal cells. Stomata within one "row" are usually 80–100 mm apart. The pairs of guard cells are sunken, elliptical, and oriented parallel to the veins. The stomata are relatively large, 40–45 μm long and 20–25 μm wide. Polar subsidiary cells are square to trapezoidal, 20–30 μm long and 15–24 μm wide. Lateral subsidiary cells are oblong to trapezoidal, 35–60 μm long (exceptionally 80 μm long) and 12–28 μm wide (but rarely occur in widths as small as 8 μm). The stomatal density is about 50 per mm^2. The stomatal index is about 4.

Abaxial cuticle (Text-fig. 18d, Pl. 11, figs 5, 6): The abaxial cuticle is very slightly cutinised. There are only slight differences between the cells of the stomatal (intercostal) "rows" and the non-stomatiferous (costal) bands. The intercostal cells are oriented parallel to the veins; they are oblong or rhomboidal, 25–70 μm long and 15–20 μm wide. Their anticlinal walls are straight to slightly bent. The shape of the costal cells is oblong; their length is 25–70 μm and width 15–20 μm. The stomatal complexes occur isolated in rare stomatal "rows". They are formed by a pair of guard cells and by subsidiary cells that are very similar to ordinary epidermal cells. The pairs of guard cells are sunken, elliptical, 35–42 μm long and 18–24 μm wide. Two to three polar subsidiary cells are trapezoidal to rounded, 15–20 μm long and 10–15 μm wide. Lateral subsidiary cells occur in groups of 2–3 per stoma; they are usually oblong, 30–60 μm long and 15–20 μm wide. The stomatal density is 80–90 per mm^2 leaf blade. The stomatal index is 5.

D i s c u s s i o n : *Cordaites silesiacus* differs from all the species of this cuticular group by having trapezoidal or rounded polar and oblong to reniform lateral subsidiary cells. For a detailed comparison, see this page, and Table 3.

Discussion of Group A

The diagnostic characteristics of these species mainly involve the cuticles. Cuticular Group A is comprised of nine species: *Cordaites karvinensis*, *C. sustae*, *C. silesiacus*, *C. tuchlovicensis*, *C. lubnensis*, *C. ledecensis*, *C. rudnicensis*, *C. sudeticus* and *C. strazkovicensis*. This group is defined on the basis of the abaxial cuticle. Their stomata are either quite regularly dispersed, or they occur in infrequent, poorly defined stomatal rows.

The species *Cordaites karvinensis*, *C. sustae* and *C. tuchlovicensis* are hypostomatic. Their adaxial cuticle is formed by oblong cells, and these species are therefore unable to be distinguished only by the adaxial cuticle. However, their abaxial cuticles vary considerably. The guard cells of *C. karvinensis* are elliptical and prominent, while their subsidiary cells are oblong, similar to the ordinary cells. The anticlinal walls of the ordinary cells are indistinct. The guard cells of *C. sustae* are larger than those of *C. karvinensis.* The ordinary cells of the former are oblong, oval, or irregular in shape, and are distinct due to the presence of prominent papillae. The abaxial cuticle of *C. tuchlovicensis* resembles that of *C. karvinensis*, though the guard cells of the former are much smaller than those of the later. The ordinary cells of these two species also differ. The ordinary cells of *C. tuchlovicensis* are nearly isodiametric, and tetra- to pentagonal in shape. The abaxial cuticle of this species is preserved only in small pieces, and it is therefore possible that this species might belong to Group E.

The other 6 species are amphistomatic. The species *C. lubnensis* has very low stomatal density in adaxial cuticle (4 stomata per mm^2), and differs in this character from all other species of Group A. The ordinary cells of this species are oblong.

Only the adaxial cuticle is known from *C. strazkovicensis*. This species has stomata dispersed in poorly defined stomatal rows. The ordinary cells are usually oblong, while the polar ends of the guard cells have a swallow-tail shape. This characteristic also occurs in the species *C. karvinensis*, though the two can be distinguished by small differences in the shapes and dimensions of their cells. *C. strazkovicensis* has a much lower stomatal density than *C. silesiacus*. None-

Table 3. Important diagnostic features of the species from *Cordaites* cuticular group A.

Species				*Cordaites karvinensis*	*Cordaites sustae*	*Cordaites silesiacus*	*Cordaites strazkovicensis*	*Cordaites tuchlovicensis*	*Cordaites lubnensis*	*Cordaites ledecensis*	*Cordaites rudnicensis*	*Cordaites sudeticus*
Leaves				Hypostomatic	Hypostomatic	Amphistomatic	Amphistomatic	Hypostomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic
Adaxial cuticle	Difference between stomatiferous and non–stomatiferous bands			–	–	–	–	–	–	–	–	–
	Cell shape of stomatiferous bands			–	–	Oblong	Longitudinally oblong	–	Oblong	Oval, square, irregular	Oblong, square, trapezoidal	Oblong
	Size of stomatiferous cells (µm)			–	–	(35–80) x (15–20)	(40–100) x (15–20)	–	(40–100) x (10–30)	(20–40) x (12–22)	(20–45) x (12–22)	(22–70) x (15–24)
	Cell shape of non–stomatiferous bands			Oblong	Oblong	Oblong elongated	Longitudinally oblong	Oblong	Tetragonal – oblong	Oblong, elongated	Oblong	Oblong
	Size of non–stomatiferous cells (µm)			(40–80) x (15–25)	(50–100) x (15–25)	(60–150) x (10–15)	(40–100) x (15–20)	(60–160) x (12–25)	(40–100) x (10–30)	(45–70) x (14–22)	(22–65) x (12–22)	(30–80) x (16–28)
	Stomata	Distribution		–	–	Rare, ill–defined rows	Ill–defined, stomatal rows	–	Irregular	Simple, ± well–defined rows	Rare, ill–defined rows	Rare, ill–defined rows
		Density per 1 mm^2		–	–	60	45	–	cca 4	104	123	50
		Stomatal index		–	–	6–10	10–12	–	0,5 – 0,6	11	8	4
		length and width of guard cells (µm)		–	–	(20–25) x (10–12)	(25–35) x (18–22)	–	(20) x (12)	(35–40) x (15–20)	(30–38) x (12–22)	(40–45) x (20–25)
	Subsidiary cells	Polar	Number and shape	–	–	2; longitudinally oblong	2; longitudinally oblong	–	2; oval	2–4; irregular – oval, rhomboidal, square	2; oval	2; square, trapezoidal
			Size (µm)	–	–	(35–80) x (15–20)	(35–60) x (15–20)	–	(25–40) x (20–25)	(20–35 x (20–25)	8 – 12 in diameter	(20–30) x (15–24)
		Lateral	Number and shape	–	–	2; longitudinally oblong	2; longitudinally oblong	–	2; oval	0	2; oblong to kidney–shaped	0
			Size (µm)	–	–	(60–150) x (10–15)	(35–60) x (15–20)	–	(50–80) x (20–25)		(50–60) x (12–22)	
			Shape of crypt	–	–	–		–	Strong cutinisation of distal cell walls	Prominent, irregular	Strong cutinisation of distal cell walls	–
Abaxial cuticle	Difference between stomatiferous and non–stomatiferous bands			–	–	–	?	–	–	–	–	–
	Cell shape of stomatiferous bands			Oblong	Oblong, longitudinally tetragonal, Oblong, papillary	Oblong, tetragonal	?	Tetra– to pentagonal	Oblong	Oval to square, irregular	Oblong, pentagonal	Oblong
	Size of stomatiferous cells (µm)			(25–40) x (20–30)	(35–60) x (15–20)	(25–60) x (14–20)	?	(25–50) x (10–25)	(30–80) x (10–20)	(20–40) x (12–22)	(22–45) x (12–20)	(25–70) x (15–20)
	Cell shape of non–stomatiferous bands			± Rectangular	Oblong, longitudinal	Oblong, longitudinal	?	Longitudinally tetragonal	Oblong	Longitudinally tetragonal	Oblong	Oblong
	Size of non–stomatiferous cells (µm)			(25–40) x (20–30)	(100–200) x (up to 10)	(80–170) x (10–15)	?	?(40–100) x (10–20)	(30–80) x (10–20)	(45–70) x (14–22)	(25–75) x (12–20)	(25–70) x (15–20)
	Stomata	Distribution		Ill–defined, rare stomatal rows	Ill–defined, rare stomatal rows	Rare stomatal rows	?	Ill–defined, stomatal rows	Ill–defined, stomatal rows	Ill–defined, stomatal rows	Ill–defined, rare stomatal rows	Ill–defined, rare stomatal rows
		Density per 1 mm^2		170 – 190	96 – 112	102	?	?350–400 (stoma. band)	280	186	130	80 – 90
		Stomatal index		?	10	7 – 9	?	12 – 15 (stomat. band)	15	19	10	5
		Shape of guard cells		Elliptical	Elliptical	Elliptical, swallow–tail shaped polar ends	?	Elliptical	Elliptical	Elliptical	Elliptical, with acute polar ends	Elliptical
		Length and width of guard cells (µm)		(27–30) x (15 – 18)	(?35 – 55) x (?15 – 25)	(22–30) x (15–20)	?	(18–24) x (10–14)	(20–30) x (12–18)	(35–45) x (25–30)	(30_38) x (14–20)	(35–42) x (18–24)
	Subsidiary cells	Polar	Number and shape	0	0	0	?	0	0	2–4; irregular, oval, rhomboidal, square	2; rounded	2; trapezoidal to rounded
			Size (µm)				?	–	–	(22–35) x (12–18)	10 – 18 (in diameter)	(15–20) x (10–15)
		Lateral	Number and shape	0	0	2 – 4; ±reniform	?	0	0	2(3); oblong, partly reniform	2; semicirculate	2; oblong to reniform
			Size (µm)			(25–40) x (14–20)	?	–	–	(40–50) x (12–18)	(55–65) x (20–26)	(30–60) x (15–20)
			Shape of crypt	–	–	–	?	–		?	Strong cutinisation of distal cell walls	–

Remark: When subidiary cells are not distinguished from ordinary epidermal cell – their number = 0

theless, it is a problem that the cuticle of *C. strazkovicensis* is not very well preserved. It is therefore necessary to find further material toward deciding whether or not *C. strazkovicensis* and *C. silesiacus* are conspecific. *C. silesiacus* has an abaxial cuticle whose polar ends of the guard cells have a swallow-tail form, thus distinguishing it from all other species of Group A.

Another three species, *C. ledecensis*, *C. rudnicensis* and *C. sudeticus*, have adaxial cuticles with stomatal densities that are a little lower than those of the abaxial sides. The greatest difference is in the shape of the stomatal complexes, including the subsidiary cells. *C. ledecensis* differs from the other two species by having stomata in quite well defined stomatal rows. The ordinary cells of the adaxial cuticle of *C. ledecensis* are elongated, oval or oblong, while its guard cells are broad and elliptical, and its subsidiary cells are not differentiated.

The species *C. rudnicensis* and *C. sudeticus* have stomata dispersed in poorly defined stomatal rows. Stomata of *C. rudnicensis* have prominent oval or rounded polar subsidiary cells and narrow lateral subsidiary cells. The guard cells of *C. sudeticus* are elliptical and narrow. Its subsidiary cells do not differ from its ordinary epidermal cells.

The abaxial cuticles of these three species also differ. The stomatal complexes of these species occur in poorly defined stomatal rows. *C. ledecensis* has prominent reniform lateral subsidiary cells. The subsidiary cells of *C. sudeticus* are of the same shape as its ordinary epidermal cells.

Group B
(stomata in well defined, single or double stomatal rows)

Cordaites schatzlarensis Šimůnek et Libertín

Text-figs 19a–c, Pl. 2, fig. 10, Pl. 12, Pl. 13, fig. 1

2000 *Cordaites* sp. Šimůnek:, p. 29, figs. 2: 6.
2001 *Cordaites* sp. (morphotype 6 sensu Šimůnek 2000), Šimůnek, p. 51–53, figs 24a–c, pl. 2, fig. 10, pl. 12, pl. 13, fig. 1.
2006 *Cordaites schatzlarensis* Šimůnek et Libertín, p. 47–55, fig.4, pls 1–3, pl. 4, figs 1–2.

H o l o t y p e : Šimůnek and Libertín (2006): pl. 1, fig. 11, Coll. Czech Geological Survey, Prague, No. ZŠ 102.

T y p e l o c a l i t y : Žacléř, Šverma Mine (formerly Marie Julie), Intrasudetic Basin.

T y p e h o r i z o n : Žacléř Formation; Lampertice Member, Šverma Mine group of coals, Duckmantian (Westphalian B).

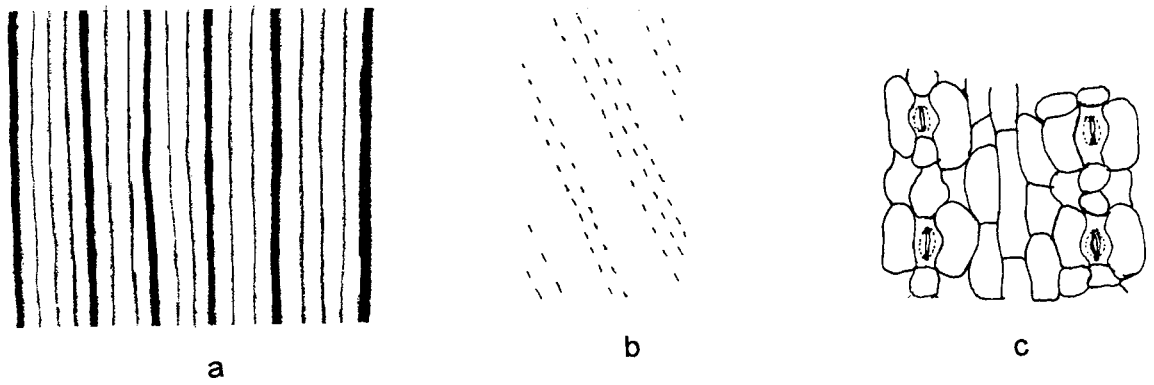
M a t e r i a l : About 40 specimens from Žacléř, Nos ZŠ 96–103; ZŠ113–143.

D e s c r i p t i o n : Narrow large leaves of lanceolate shape, with acute or bluntly pointed apex, 15 – 70 mm wide and 250 – 600 mm long. The leaf itself is relatively thin and therefore the venation is not prominent. Venation is parallel; vein density varies from 18 to 36 per cm. One to three, or exceptionally four, thin veins occur between each two thick veins. The thick veins are not very prominent, and the thin veins are often discontinuous. The leaves are amphistomatic.

Adaxial cuticle (Pl. 12, figs 1, 6, Pl. 13, fig. 1): The cells are not distinguishable into costal and intercostals areas. They are oblong, 35–100 μm long and 10–20 μm wide. Their anticlinal walls are straight. The cells are oriented parallel to the veins. The stomata are very rare on the adaxial cuticle, usually isolated, occasionally occurring in short rows of two to five stomata. They are usually separated by distances between 0.4 to 1.1 mm. The "rows" are 0.4 – 0.7 mm apart. Some parts of the cuticle are stomata free. The stomatal complexes are usually formed by two guard, two polar, and two lateral subsidiary cells. The pairs of guard cells are slightly sunken, elliptical, with their polar ends extending into a swallow-tail projection. The guard cells are 20 – 28 μm long (with projections up to 35 μm), and 10 – 17 μm wide. The swallow-tail projections and the parts of the periclinal walls towards the guard cells are strongly cutinised, forming an irregular crypt above the stoma. The lateral subsidiary cells are usually oblong, 35 – 55 μm long and 18 – 30 μm wide, with rounded corners. The polar subsidiary cells are either small, rounded, 15 – 20 μm in diameter, or relatively large, oval, up to 35 μm long and 17 – 20 μm wide. The large polar and lateral subsidiary cells are comparable to ordinary epidermal cells. The stomatal density varies from 0 to 40 per mm^2, but is usually between 2 and 5 per mm^2. The stomatal index also varies considerably from 0 to a usual value of 0.3, but goes as high as 3.

Abaxial cuticle: (Text-fig. 19a, Pl. 12, figs 2–5): The cells in the stomatiferous bands consisting of one to two (exceptionally three) stomatal rows differ from those in the non-stomatiferous bands. The stomatiferous bands are formed only by stomatal complexes. The non-stomatiferous (costal) bands consist of 3–6 rows of elongated tetragonal cells. These cells are 30–100 μm long and 10–22 μm wide, with rounded corners, and straight or slightly bent anticlinal walls. The cell orientation is parallel to the veins. The stomatal complexes are formed by a pair of elliptical guard cells, two polar subsidiary cells, and two lateral subsidiary cells. The pairs of guard cells have their polar ends formed into a swallow-tail shape (Pl. 12, figs 3, 4, 5,). They are 18 – 25 μm long and 12 – 15 μm wide. The stomatal complexes (including the subsidiary cells) are 60 – 75 μm long and 55 – 65 μm wide. Polar subsidiary cells are rounded to oval in shape, and oriented transversely to the guard cells (leaf length). One polar cell is often shared by two neighbouring stomata. The polar cells are 18 – 25 μm long and 16 – 22 μm wide, or rounded and 10 – 15 μm in diameter. Lateral subsidiary cells are tetragonal, trapezoidal, to slightly kidney-shaped. The anticlinal walls are bent; the cells are rounded at the corners. Lateral cells are 35 – 48 μm long and 15 – 25 μm wide. The stomatal density varies between 270 – 320 per mm^2 of leaf area. The stomatal index varies between 11 and 15 (including non-stomatiferous bands).

D i s c u s s i o n : *Cordaites schatzlarensis* Šimůnek et Libertín has amphistomatic leaves. However, the adaxial cuticle has a different stomatal density, as stomata are absent in some parts. The abaxial cuticle has stomata arranged in



Text-fig. 19. ***Cordaites schatzlarensis*** **Šimůnek et Libertín, Žacléř, Jan Šverma Mine (formerly Marie Julie), Žacléř Formation, Lampertice Member, Duckmantian, slide No. 312/1-2, a – leaf venation, ×22, b – distribution of stomata on adaxial cuticle, ×56, c –abaxial cuticle with stomata, ×224.**

single or double stomatal rows. Prominent tetragonal, or slightly reniform lateral subsidiary cells, and swallow-tail shaped polar ends of guard cells, are typical of *Cordaites schatzlarensis*. This feature occurs in the Permian species *Cordaites baodeensis* Sun et Ge in China. Its adaxial cuticle differs slightly. These species may be closely related. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites idae sp. nov.

Text-figs 20a–h, Pl. 12, fig. 11–14, Pl. 13, fig. 2–11, Pl. 14, Pl. 15, figs 1, 2

2000 *Cordaites* sp. Šimůnek, p. 27, figs. 2: 4, 2: 5.
2001 *Cordaites* sp. (morphotype 4 sensu Šimůnek 2000), Šimůnek, p.53–55, fig. 25a–i, pl. 12, figs 11–14, pl. 13, figs 2–11, pl. 14.
2001 *Poacordaites* cf. *"microstachys"* (Goldenberg) Zeiller (morphotype 5 sensu Šimůnek 2000), Šimůnek, p. 55–57, figs 26a–c. pl. 15, figs 1, 2.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 219 (Text-fig. 20a), coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From Ida Gallery, the former name of the type locality.

T y p e l o c a l i t y : Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin.

T y p e h o r i z o n : Žacléř Formation; Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).

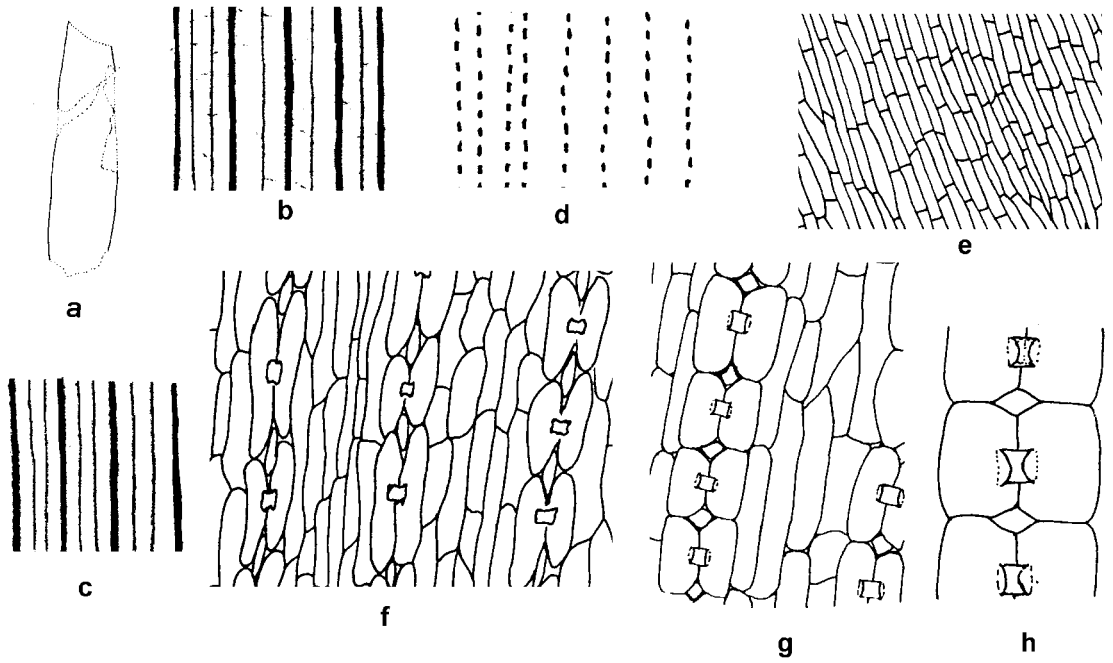
M a t e r i a l : 8 incomplete specimens from Rtyně, Nos: ZŠ 219 – ZŠ 227.

D i a g n o s i s : Narrow, hypostomatic, lanceolate leaves, dense venation, 1–2 thin veins alternate with each thick vein. Adaxial cuticles with oblong cells, abaxial cuticle with longitudinally oblong cells, stomata composed of 2 rhomboidal or oval polar, and 2 oblong lateral subsidiary cells, forming single or double stomatal rows.

D e s c r i p t i o n : The holotype represents a leaf fragment 95 mm long and 32 mm wide with nearly parallel margins. The venation is prominent and of medium density – 32–40 thick veins per mm. Usually one to two thin veins alternate with each thick vein. The course of thin veins is not always distinct, and sometimes nearly disappears. The leaf fragments are up to 135 mm long and 24 to 36 mm wide. Their margins are nearly parallel. The vein density varies from 30 to 40 thick veins per cm of leaf. The thin and thick veins are difficult to discern near the leaf border, but one to two (and sometimes three) thin veins occur between each two thick veins further into the middle of the leaf. Longitudinal cell orientation and rare fine tranverse wrinkles or striae are observable. The course of the thin veins is discontinuous in places, or nearly disappears. The leaves are hypostomatic.

Adaxial cuticle (Text-fig. 20e, Pl. 13, figs 2–7, 9–11 Pl. 14, figs 1, 2, 5, 6): The adaxial cuticle is weakly cutinised. The differentiation of cells into costal and intercostal areas is not prominent. The shape of the cells is oblong, with lengths varying between 50–160 μm, and widths between 15–25 μm. The anticlinal walls are straight, or only slightly bent. Narrow strips of stronger cutinised cells are more prominent and are formed by two to three cell rows. These cells are only up to 10 μm wide. They might represent the costal field. The cells are oriented parallel to veins.

Abaxial cuticle (Text-figs 20f–h, Pl. 13, fig. 8, Pl. 14, figs 3, 4, Pl. 15, figs 1, 2): The abaxial cuticle is weakly cutinised, only the prominent stomatal rows are more cutinised. The cells are differentiated into simple or double stomatal (intercostal) rows and non-stomatiferous (costal) bands. All cells of the stomatal rows belong to stomatal complexes. The non-stomatiferous bands are formed by 3–4 rows of costal cells that are elongated, oblong to trapezoidal, 40–100 μm long and 10–20 μm wide. The cells of one fragment are only 5–15 μm wide (Pl.15, figs 1,2). The anticlinal walls are straight, or slightly bent. The cells are rounded at the corners. The cells and stomata are oriented parallel to the veins. All cells of stomatal rows form stomatal complexes that are formed by two guard, two polar, and two lateral subsidiary cells. The pairs of guard cells are elliptical, sunken beneath the epidermal level, 12–14 μm long and 6–8 μm wide. The stomatal complexes (including subsidiary cells)



Text-fig. 20. ***Cordaites idae*** **sp. nov., Rtyně v Podkrkonoší, Žacléř Formation, Prkenný Důl-Žďárky Member, Duckmantian, slide Nos: 154/1-4, 161/1-3, 314/1, 320/1-3, 321/1-5, a – leaf outline to the sample No. 161/1-3, ×0.25, b – leaf venation to the sample No. 161/1-3, ×20, c – leaf venation to the sample 186/1, ×20, d – distribution of stomata on the abaxial cuticle, slide No. 161/1-3, ×50, e – adaxial cuticle (slide No. 154/3), ×100. f – abaxial cuticle with stomatal rows, slide No. 186/1 ×250., g – abaxial cuticle with stomatal rows (slide No. 154/3). ×250. h – detail of a stomatal row with stomata (slide No. 154/3). ×500.**

are 40–50 μm long and 40–45 μm wide. The stomatal complexes depicted in Text-fig. 20f, Pl. 15, figs. 1, and 2 are more elongated at 65–100 μm long and 24–32 μm wide, and the polar subsidiary cells are also more elongated, of oval shape, 20–25 μm long and 4–6 μm wide, whereas the polar subsidiary cells of most samples are small, nearly isodiametric, rhomboidal, oval to rounded. They measure 8–12 μm in diameter. The lateral subsidiary cells are more or less oblong with rounded corners, 40–50 μm (or perhaps as large as 50–80 μm (Text-fig. 20f)) long and 18–22 μm (or as small as 12–16 μm) wide. Polar subsidiary cells are common to two neighbouring stomata in a row, and their lateral subsidiary cells are in contact. Outer stomatal cavities or crypts have more or less square shapes and constrict the space above the guard cells by arching the walls of the lateral subsidiary cells towards the stomatal aperture. The stomatal density is 200–250 per mm^2 of leaf blade. The stomatal index varies between 12–15 (including the non-stomatiferous bands).

D i s c u s s i o n : *Cordaites idae* leaves are hypostomatic. The abaxial cuticle has stomata arranged into stomatal rows. Large oblong subsidiary cells and small pores between them covered by a small square crypt are typical of this species. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites rerichensis sp. nov.

Text-figs 21a–e, Pl. 15, figs 4, 5, Pl. 16

2000 *Cordaites* sp. Šimůnek, p. 29, figs 3: 15.
2001 *Cordaites* sp. (morphotype 15 sensu Šimůnek 2000), Šimůnek, p. 57–59, figs 27a–e, pl. 15, figs 4, 5, pl. 16.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 67, coll. J. Šetlík.

D e r i v a t i o n o f n a m e : From the type locality at Řeřichy village.

T y p e l o c a l i t y : Řeřichy, borehole Ře 3, depth 293,2 – 293,5 m, Kladno-Rakovník Basin.

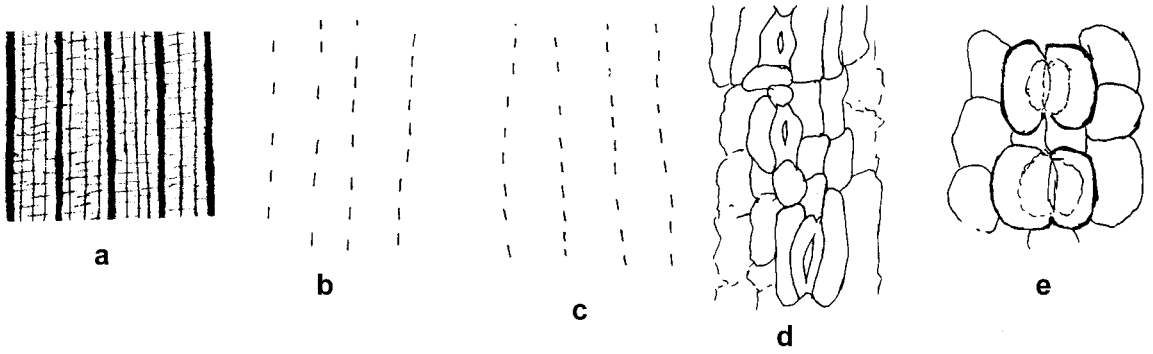
T y p e h o r i z o n : Kladno Formation; Radnice Member, Lubná Group of coals, Bolsovian (Westphalian C).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Amphistomatic leaves, medium-dense venation, 2–3 thin veins alternate with each thick vein. Adaxial cuticle with oblong cells and stomata arranged in single stomatal rows, abaxial cuticle with oblong cells and stomata having 2 kidney-shaped lateral subsidiary cells in single or double stomatal rows.

D e s c r i p t i o n : The incomplete leaf fragment represents the holotype 60 mm long and 20 mm wide. Its leaf shape is unknown. There are 26 veins per cm. Two to three thin veins that are barely visible alternate with each thick vein. The fine transverse striation is prominent. Adaxial and abaxial cuticles are very similar. These cuticles have been isolated along with cuticles of Lesleya sp. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 21e, Pl. 15, figs 4, 5, Pl. 16, figs 3, 5): Cells of adaxial cuticle are differentiated into simple stomatal rows and non-stomatiferous (costal) bands. Stomatal complexes within the stomatal rows are separated by similar cells as in the non-stomatiferous bands. These cells are 20–40 μm long and 20–30 μm wide. Their anticlinal walls are straight. The costal cells are oriented parallel to veins; they are oblong, 35–100 μm long and 25–35 μm wide.



Text-fig. 21. ***Cordaites rerichensis*** **sp. nov., Řeřichy, borehole Ře 3, depth 293.2 – 293.5 m. Kladno Formation, Radnice Member, Lubná Group of coals, Bolsovian, slide No. 246/1. a – leaf venation, ×20, b – distribution of stomata on adaxial cuticle, ×50, c – distribution of stomata on abaxial cuticle, ×50, d – abaxial cuticle with stomata, ×250, e – adaxial cuticle with stomata, ×250.**

The stomatal complexes are formed by a pair of elliptical guard cells with polar ends extended into a swallow-tail shape, with two lateral subsidiary kidney-shaped cells. The polar subsidiary cells are of the same shape as ordinary epidermal cells. The pairs of subsidiary cells are sunken, oriented parallel to the veins, 35–40 μm long and 20–30 μm wide. The stomatal complex (including the subsidiary cells) is 60–80 μm long and 50–70 μm wide. The polar subsidiary cells occur in groups of 2–4. The lateral subsidiary cells are 45–70 μm long and 15–30 μm wide; they are strongly cutinised and very prominent in the cuticle. The stomatal density is about 90 per mm^2. The stomatal index varies between 11 and 13.

Abaxial cuticle (Text-fig. 21d, Pl. 16, figs 1, 2, 4, 6–8): The abaxial cuticle is more weakly cutinised than the adaxial cuticle. The cells are differentiated into simple stomatal rows and non-stomatiferous (costal) bands. Individual stomatal complexes within the stomatal rows are separated by cells that are very similar to those of the costal area. They are 30–60 μm long and 20–30 μm wide. The anticlinal walls are straight or slightly bent. The costal cells are oblong, 40–50 μm long and 25–40 μm wide. Their orientation is parallel to the veins. The stomatal complexes consist of two elliptical guard cells and two lateral subsidiary cells of kidney shape. The polar subsidiary cells are of the same shape as the ordinary epidermal cells. It is possible to distinguish 2–4 polar subsidiary cells by each stoma. The pairs of guard cells are sunken, and oriented parallel to veins. They are 35–45 μm long and 18–25 μm wide. The stomatal complexes (including the subsidiary cells) are 55–80 μm long and 45–55 μm wide. The lateral subsidiary cells are 45–75 μm long and 12–20 μm wide; they are strongly cutinised and very prominent on the cuticle. The stomatal density is 70 per mm^2. The stomatal index is about 10.

D i s c u s s i o n : *Cordaites rerichensis* is another example of a species with the same stomatal density on both cuticles. Both cuticles have stomata arranged in stomatal rows. The lateral subsidiary cells are of reniform shape. Only *Cordaites krasovicensis* from this cuticular group has cuticles that are similar to those of *Cordaites rerichensis*. Both cuticles of *Cordaites krasovicensis* have single or double stomatal rows, though the adaxial lateral subsidiary cells are usually oblong to oval, while those of the abaxial cuticle are trapezoidal to reniform. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites pilsensis sp. nov.

Text-figs 22a–d, Pl. 2, fig. 15, Pl. 17, figs 1–4

2000 *Cordaites* sp. Šimůnek, p. 32, fig 3: 22.
2001 *Cordaites* sp. (morphotype 22 sensu Šimůnek 2000), Šimůnek, p. 59–61, figs 28a–d, pl. 2, fig. 15, pl. 17, figs 1–4.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 228, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the German name of the town Plzeň (Pilsen), in the basin where remains of *Cordaites pilsensis* have been found.

T y p e l o c a l i t y : Heřmanova Huť - Vlkýš, Plzeň Basin.

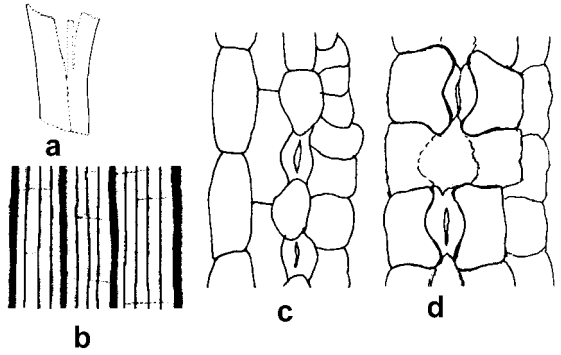
T y p e h o r i z o n : Kladno Formation; Nýřany Member. Asturian (Westphalian D).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Relatively narrow, amphistomatic leaves with infrequent venation, 3 thin veins alternate with each thick vein. Adaxial and abaxial cells mostly oblong shape, swallow-tail shapes of polar ends of guard cells.

D e s c r i p t i o n : The holotype is a leaf fragment 65 mm long and up to 28 mm wide. The leaf margins are nearly parallel. The leaf is jagged on one end. The venation is parallel and relatively sparse – about 20 veins per cm in the middle, and 22 veins per cm near the leaf margin. One thick vein alternates with about three thin veins that are hardly discernible in some places. Numerous transverse wrinkles occur between the thick veins.

Adaxial cuticle (Text-fig. 22c, Pl. 17, figs 2–4): This cuticle is differentiated into non-stomatiferous (costal) bands and dark (intercostal) bands, the stomata occurring in the latter. The shape of the intercostal cells is oblong to irregularly hexagonal. Their lengths are 30–72 μm and



Text-fig. 22. ***Cordaites pilsensis*** **sp. nov., Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D), slide No. 331/1-3. a – a leaf fragment, ×0.25, b – leaf venation, ×20, c – adaxial cuticle with stomata, ×250, d – abaxial cuticle with stomata, ×250.**

widths 15–25 μm. The anticlinal walls are usually straight. The orientation of the intercostal cells is parallel to veins. The costal cells are usually oblong, 24–60 μm long and 15–32 μm wide. The stomatal complexes are irregularly dispersed in the dark bands. They consist of a pair of sunken, elliptical guard cells, two polygonal to oval (hexagonal) polar subsidiary cells, and 2–3 oblong lateral cells that are nearly of the same shape as the ordinary epidermal cells of the intercostal band. The stomata are oriented parallel to the veins. The pairs of guard cells are 28–30 μm long and 16–20 μm wide, and their polar ends form a swallow-tail shape. The polar subsidiary cells are 25–35 μm long and 20–25 μm wide. The lateral subsidiary cells are 40–60 μm long and 20–25 μm wide. The stomatal density is 35 per mm^2 leaf surface. The stomatal index is 3.5.

Abaxial cuticle (Text-fig. 22d, Pl. 17, fig. 1): The cells of the abaxial cuticle are differentiated into non-stomatiferous (costal) bands and stomatal (intercostal) rows. Intercostal cells are oblong to square, rarely pentagonal, 15–25 μm in diameter. The anticlinal walls are usually bent. The intercostal cells are oriented parallel to the veins. The shape of the costal cells is longitudinally quadrangular, with lengths between 40–90 μm and widths of 15–20 μm. The stomatal complexes form stomatal rows. The pairs of sunken, elliptical guard cells are surrounded by two polar subsidiary cells and two lateral subsidiary cells. A typical characteristic of the guard cells are their swallow-tail projections at their polar ends. The pairs of guard cells are 30–35 μm long and 18–24 μm wide. The stomatal complexes (including the subsidiary cells) are 80–90 μm long and 70–80 μm wide. The polar subsidiary cells are rhomboidal to oval, 28–35 μm long and 15–25 μm wide. The lateral subsidiary cells are broadly rectangular, or forming broad regular trapezoids with rounded corners. The lateral subsidiary cells are 45–55 μm long and 25–30 μm wide. The stomatal density is about 80 per mm^2. The stomatal index is 7.

D i s c u s s i o n : *Cordaites pilsensis* has the stomata of its adaxial cuticle arranged in dark rows. Stomata occur infrequently among ordinary cells. The stomata of the abaxial cuticle are arranged into single stomatal rows. The swallow-tail shaped polar ends of the guard cells are typical of this species, similar to *Cordaites schatzlarensis*. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites krasovicensis sp. nov.

Text-figs 23a–e, Pl. 3, fig. 1, Pl. 18

2000 *Cordaites* sp. Šimůnek, p. 32, figs 3: 26.
2001 *Cordaites* cf. *"principalis"* (Germar) Geinitz (morphotype 26 sensu Šimůnek 2000), Šimůnek, p. 62–64, figs 29a–e, pl. 3, fig. 1, pl. 18.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 229, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality at Krašovice village.

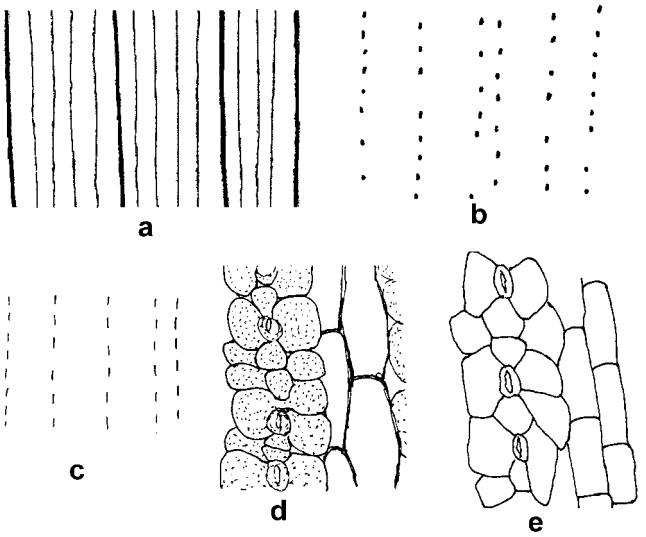
T y p e l o c a l i t y : Krašovice, borehole Kš 1, depth 368.6 m, Plzeň Basin.

T y p e h o r i z o n : Kladno Formation; Nýřany Member, Touškov Coals. Asturian (Westphalian D).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Relatively wide, amphistomatic leaves with infrequent venation, 4–6 thin veins alternate with each thick vein. Stomata of adaxial and abaxial cuticles are arranged into single or double stomatal rows with prominent oval to reniform lateral and rounded to oval polar subsidiary cells.

D e s c r i p t i o n : The holotype represents of the terminal part of a leaf. The fragment is 88 mm long and 56 mm wide (in the widest part). There are 18 thick veins per cm of leaf in the central part, and about 16 veins per cm at the margin. There are 4–6 thin veins between each two thick veins. The veins are the most discernible in the leaf impressions. The leaf is amphistomatic.



Text-fig. 23. ***Cordaites krasovicensis*** **sp. nov., Krašovice, borehole Kš 1, depth 368.6 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Group of coals, Asturian (Westphalian D), Slide No. 259/1-3. a – leaf venation, ×20, b – distribution of stomata on adaxial cuticle, ×50, c – distribution of stomata on abaxial cuticle, ×50, d – adaxial cuticle with stomata, ×200, e – abaxial cuticle with stomata, ×200.**

Adaxial cuticle (Text-fig. 23d, Pl. 18, figs 1–3): The cells are differentiated into single or double stomatal rows (intercostal fields) and non-stomatiferous (costal) bands. The cells of the intercostal bands generally belong to stomatal complexes. The shape of the costal cells is mostly oblong with strongly rounded corners, and the anticlinal walls are straight or bent. The cells are oriented parallel to the veins. The costal cells are 40–160 μm long and 10–30 μm wide. The stomatal complexes are composed of a pair of sunken elliptical guard cells, 2 polygonal (pentagonal) to oval polar subsidiary cells, and 2–4 oblong to kidney-shaped lateral subsidiary cells. The subsidiary cells are strongly cutinised, and the stomata are therefore very prominent in the cuticle. The pairs of guard cells are 18–25 μm long and 15–22 μm wide. The stomatal complex (including subsidiary cells) is 55–65 μm long and 60–70 μm wide. The polar subsidiary cells are 15–20 μm long and 12–20 μm wide. The lateral subsidiary cells are 38–52 μm long and 15–24 μm wide. The stomatal density is 140 stomata per mm^2 of leaf surface. The stomatal index varies around 13.

Abaxial cuticle (Text-fig. 23e, Pl. 18, figs 4–6): The abaxial cuticle is slightly cutinised. The cells are different in stomatal (intercostal) rows and in non-stomatiferous (costal) bands. Those of the stomatal row belong mostly to the stomatal complexes, which are separated only by small trapezoidal or rectangular cells 25–40 μm long and 15–20 μm wide. The anticlinal walls of these cells are bent along the stomatal complexes. The costal cells are usually elongated, oblong or trapezoidal, 35–130 μm long and 15–20 μm wide. The stomatal complexes are usually arranged in single, or rarely double, well defined stomatal rows. They consist of a pair sunken, elliptical guard cells, 2 polar subsidiary cells of different, usually isodiametric in shape (pentagonal, hexagonal, oval, rhomboidal, or trapezoidal), and 2 lateral subsidiary cells that are usually of an approximately trapezoidal or reniform shape. They are oriented parallel to the veins. The pairs of guard cells are 18–25 μm long and 12–16 μm wide. The stomatal complexes (including the subsidiary cells) are 60–70 μm long and 70–90 μm wide. The polar subsidiary cells are 20–30 μm in diameter. The lateral subsidiary cells are usually 50–60 μm long (though some are only 30 μm) and 20–28 μm wide. The stomatal density is 140–150 per mm^2 of leaf surface. The stomatal index is about 12.

D i s c u s s i o n : *Cordaites krasovicensis* has approximately the same stomatal density in both adaxial and abaxial cuticles, similar to *Cordaites rerichensis*. The stomata of both cuticles are arranged into stomatal rows. The polar cells are pentagonal, hexagonal, oval or trapezoidal, whereas the lateral cells are trapezoidal or reniform. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites blazkovicensis sp. nov.

Text-figs 24a–f, Pl. 3, fig. 2, Pl. 19

2000 *Cordaites* sp. Šimůnek, p. 32, figs 3: 27, 4: 19 and 4: 20.
2001 *Cordaites* sp. (morphotypes 27, 19 and probably 20 sensu Šimůnek 2000), Šimůnek, p. 64–66, figs 30a–f, pl. 3, fig. 2, pl. 19.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 230, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality at Blažkovice village.

T y p e l o c a l i t y : Blažkovice, borehole RPZ 30, depth 338 m, Kladno-Rakovník Basin.

T y p e h o r i z o n : Kladno Formation; Nýřany Member. Mirošov Horizon, Lover Asturian (Westphalian D).

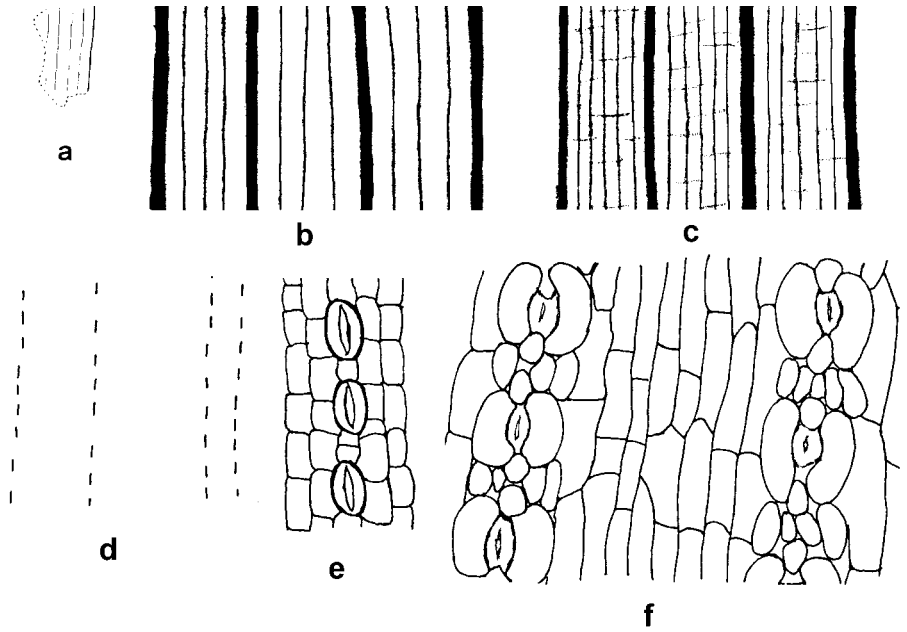
M a t e r i a l : 4 specimens from Blažkovice and Heřmanova Huť - Vlkýš, Nos. ZŠ 230 – ZŠ 233.

D i a g n o s i s : Wide, amphistomatic leaves with infrequent venation, 2–7 very delicate thin veins alternating with each thick vein. Adaxial cuticle with oblong cells, stomata in rows, abaxial cuticle with oblong cells, stomata in rows, prominent reniform lateral subsidiary cells.

D e s c r i p t i o n : The holotype is a wide leaf fragment with parallel margins. It is 95 mm long and 83 mm wide. The venation is infrequent, with a density of about 14 per cm. The thin veins are indistinct, but usually 3 thin veins alternate with each thick vein when visible. The leaf fragments are 60–95 mm long and 32–83 mm wide. Leaf margins are usually non-parallel. The venation density slightly differs from the margin to the center within the same leaf, varying from 12 to 22 veins per cm of leaf. There are 2–7 very thin veins alternating with each thick vein. The transverse ridges and wrinkles are very prominent. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 24e, Pl. 19, figs 1–5): The cells are differentiated into stomatal (intercostal) rows and non-stomatiferous (costal) bands 70–300 μm wide. The shape of the intercostal cells is usually oblong, as in the costal area. The cells of the intercostal band are usually shorter: 30–40 μm long and 15–20 μm wide. Their anticlinal walls are staight or slightly bent. Their orientation is parallel to the veins. The costal cells are usually oblong, 30–110 μm long and 15–30 μm wide. The stomatal complexes are arranged in single, or rarely double, well defined stomatal rows. They are foremed by a pair of sunken, elliptical guard cells, 32–45 μm long and 22–35 μm wide, oriented parallel to the veins. The polar and lateral subsidiary cells do not differ in appearence from the ordinary epidermal cells of the costal area. Usually two polar and two to four lateral subsidiary cells border each guard cell. The stomatal density is about 40 per mm^2 of leaf blade. The stomatal index varies around 3.

Abaxial cuticle (Text-fig. 24f, Pl. 19, fig. 6): The abaxial cuticle is very delicately cutinised. The cells are differentiated into stomatal rows with stomatal complexes, and into non-stomatiferous (costal) bands with rows of ordinary epidermal cells. The cells of the costal bands are oriented parallel to the veins. They are usually oblong or of trapezoidal shape, with straight to slightly bent anticlinal walls. The cells are 35–80 μm long and 10–20 μm wide. The stomatal complexes are arranged into stomatal rows at various distances from each other. The non-stomatiferous bands are 30–100 μm broad. The pairs of sunken, elliptical guard cells are surrounded by two large, lateral, bean-shaped subsidiary cells, and two small polar cells of oval to rounded shape. The pairs of guard cells are around 20 μm long and 15 μm wide,



Text-fig. 24. ***Cordaites blazkovicensis*** **sp. nov., a,c,d,e – Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, slide No. 328/1-2; b,f – Blažkovice, borehole RPZ-30, depth 338 m, Kladno-Rakovník Basin, slide No. 188/1-3, Nýřany Member, Asturian (Westphalian D). a – leaf fragment with marked course of veins, material to slides No. 328/1-2, ×0.25, b – leaf venation from which slides No. 188/1-2 have been prepared, ×20, c – venation of the specimen from which cuticular slides No. 328/1-3 are derived, ×20, d – distribution of stomata of adaxial cuticle from specimen on fig. a, ×50. e – adaxial cuticle with stomatal row from specimen on fig. a, ×125. f – abaxial cuticle with stomatal rows, slide No. 188/2, ×250.**

and have a small incision on their wide polar ends. The lateral subsidiary cells are 42–50 µm long and 15–20 µm wide. The polar subsidiary cells are 15–20 µm long and 12–16 µm wide. The lateral cells in rows are separated by small cells that are similar in shape to the polar cells. Some of them are of a triangular or trapezoidal shape. The subsidiary cells of the stomata are more strongly cutinised and more prominent than the normal epidermal cells. Stomata are variably covered by the strongly cutinised proximal walls of the lateral subsidiary cells. The stomatal density is about 185 per mm^2. The stomatal index is approximately 7.

D i s c u s s i o n : *Cordaites blazkovicensis* has the stomata of its adaxial cuticle arranged in infrequent stomatal rows. The lateral subsidiary cells are of the same shape as the ordinary cells. The abaxial cuticle of this species has its stomata aranged in stomatal rows. The polar cells are small, oval or rounded, while the lateral cells are large and bean-shaped. For a detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites radvanicensis sp. nov.

Text-figs 25a–e, Pl. 3, fig. 3, Pl. 20

2000 *Cordaites* sp. Šimůnek, p. 32, figs 4:30.
2001 *Cordaites* sp. (morphotype 30 sensu Šimůnek 2000), Šimůnek, p. 67–69, figs 31a–e, pl. 3, fig. 3, pl. 20.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 234, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality at Radvanice village.

T y p e l o c a l i t y : Radvanice, Kateřina Mine, Intrasudetic Basin.

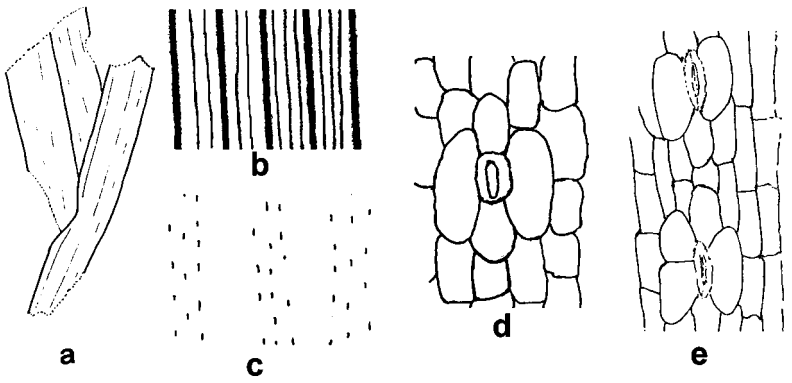
T y p e h o r i z o n : Odolov Formation; Jívka Member, Radvanice Coals. Stephanian B.

M a t e r i a l : 3 leaf fragments preserved in one slab from Radvanice.

D i a g n o s i s : Narrow, amphistomatic leaves, with medium-dense venation. Two to three thin veins alternate with each thick vein. Adaxial cuticle with oval, rounded, toroidally oblong cells. Stomata dispersed in dark bands. Abaxial cuticle with oblong, oval to trapezoidal cells, stomata in rows, lateral subsidiary cells elongated, oval to reniform.

D e s c r i p t i o n : The holotype is a leaf fragment 90 mm long and 24.5 mm wide. The leaf margins are parallel. The venation is relatively dense: 30 thick veins per cm in the central part of the leaf, and about 36 veins per cm near the leaf margin. Both the thick and thin veins are prominent. There are 2–3 thin veins usually alternating with each thick vein. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 25d, Pl. 20, figs 1–3): The cells are differentiated into dark bands with stomata (intercostal) and non-stomatiferous (costal) bands. The intercostal cells are oval, rounded, or roundish-oblong. Their lengths range between 25–80 µm and their widths from 15–30 µm. Their anticlinal walls are usually bent. The cells are oriented parallel to the veins. The costal cells are oblong, 30–90 µm long and 18–30 µm wide. The stomatal complexes occur in irregular rows within the stomatiferous bands. The pairs of guard cells are elliptical, sunken, and oriented parallel to veins. They are 22–28 µm long and 8–14 µm wide. The guard cells



Text-fig. 25. ***Cordaites radvanicensis*** **sp. nov., Radvanice, Kateřina Mine, Intrasudetic Basin, Odolov Formation, Jívka Member, Radvanice Group of coals, Stephanian B, slide No. 318/1-2. a – outline of three leaves, ×0.25, b – leaf venation, ×20, c – distribution of stomata in dark bands on adaxial cuticle, ×50, d – adaxial cuticle with stoma, ×250, e – abaxial cuticle with stomata in stomatal row, ×200.**

are surrounded by 2–3 rounded polar subsidiary cells that reach 22–30 μm in diameter, and 2–3 oval to kidney-shaped subsidiary cells, 40–60 μm long and 20–30 μm wide. The lengths of the stomatal complexes (including the subsidiary cells) are 75–95 μm, and their widths are 55–70 μm. Due to the condition of the cuticle, it is not possible to estimate the stomatal density or stomatal index.

Abaxial cuticle (Text-fig. 25e, Pl. 20, figs 4–6): The cells of this cuticle are differentiated into stomatal rows (intercostal) and into non-stomatiferous (costal) bands. The intercostal cells are oblong, oval or trapezoidal, and strongly rounded at the corners. They are 20–45 μm long and 12–20 μm wide. Their orientation is parallel to the veins. The anticlinal walls are bent. The costal cells are oblong, 40–100 μm long and 12–20 μm wide. The stomata form stomatal rows. Pairs of guard cells are sunken, elliptical, and oriented parallel to the veins. They are usually surrounded by 2 (or exceptionally 3) polar subsidiary cells of rounded shape, and commonly with 2 (or rarely 4) lateral subsidiary cells of oval to kidney-shaped form. The pairs of guard cells are 25–38 μm long and 12–20 μm wide. The stomatal complexes (including the subsidiary cells) are 50–60 μm long and 80–110 μm wide. The polar subsidiary cells are about 22–30 μm in diameter, while the lateral subsidiary cells are 20–60 μm long and 14–25 μm wide. The preservation of the cuticle is poor, and it is therefore impossible to estimate the stomatal density and index.

Discussion: *Cordaites radvanicensis* has the stomata of its adaxial cuticle arranged in irregular rows within stomatiferous bands. The polar cells of the adaxial cuticle are rounded, and the lateral subsidiary cells are oval to reniform. The stomatal complexes of the abaxial cuticle are very similar, though they are arranged in single stomatal rows. The cuticle is not well preserved enough to enable a thorough evaluation. Nevertheless, for a more detailed comparison, see the discussion of the entire group beginning on page 127, and Table 4.

Cordaites risutensis sp. nov.

Text-figs 26a–e, Pl. 21

2001 *Cordaites* sp. (morphotype 35 – new morphotype), Šimůnek, p. 69–71, figs 32a–e, pl. 21.

Holotype: Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 235, coll. Z. Šimůnek.

Derivation of name: From the type locality at Řisuty village.

Type locality: Řisuty, borehole Ři 24, depth 74.45 m, Kladno-Rakovník Basin.

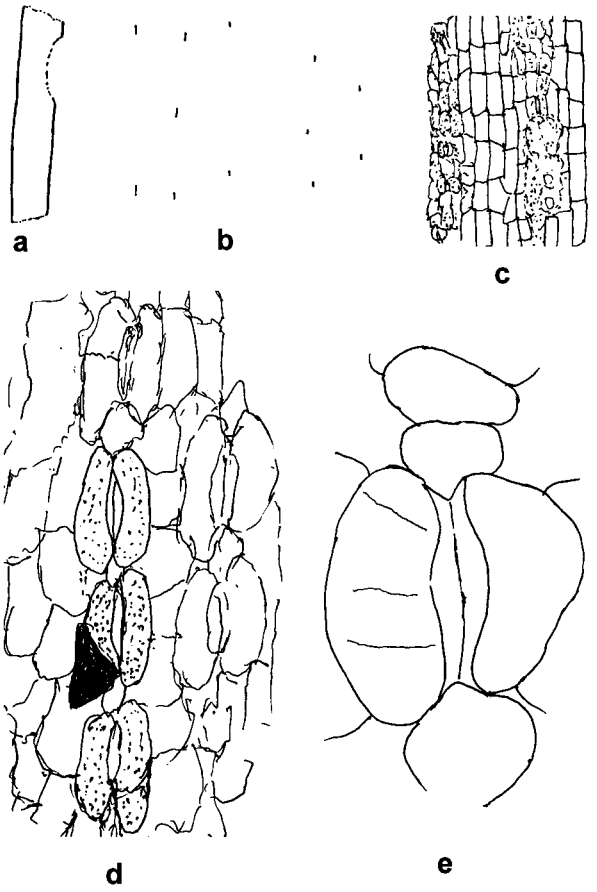
Type horizon: Slaný Formation; Malesice (Hředle) Member. Stephanian B.

Material: Only one specimen – the holotype.

Diagnosis: Narrow, amphistomatic leaves with dense indistinct venation, and indefinite number of thin veins. Cells of adaxial cuticle tetragonal, stomata in dark bands, cells of abaxial cuticle oblong, stomata in single stomatal rows, polar ends of guard cells swallow tail-shaped, lateral subsidiary cells oval to reniform.

Description: The holotype is a very narrow leaf fragment only 10 mm wide and 60 mm long. Its margins are nearly parallel. The leaf surface is strongly corroded, and the venation is indistinct but very dense. There are 50–60 veins per cm. The thin veins are poorly distinguishable and discontinuous. The leaves are amphistomatic.

Adaxial cuticle (Text-figs 26c,e, Pl. 21, figs 1–7): The cells are differentiated into dark stomatiferous (intercostal) bands and non-stomatiferous bands (costal). The relatively narrow stomatiferous bands are separated by non-stomatiferous bands consisting of 4–13 ordinary costal cells. The width of non-stomatiferous bands is 60–230 μm. The ordinary cells of the stomatiferous band are small, dark, of nearly square or oblong shape, 30–75 μm long and 15–30 μm wide. Their anticlinal walls are usually straight. The cells of the non-stomatiferous bands are narrow and distinctly elon-



Text-fig. 26. ***Cordaites risutensis*** **sp. nov., Řisuty, borehole Ři 24, depth 74.45 m, Kladno-Rakovník Basin. Slaný Formation, Malesice (Hředle) Member, Stephanian B, slide No. 346/1-6. a – leaf outline, ×0.5, b – distribution of stomata on adaxial cuticle, ×50, c – adaxial cuticle, stomata occur in dark bands, ×100, d – abaxial cuticle with stomata, ×250, e – adaxial cuticle, detail of stoma, ×500.**

gated. They are of tetragonal shape (oblong, trapezoidal, or rhomboidal), 35–100 μm long and 15–25 μm wide. The stomatal complexes occur rarely and irregularly in narrow, dark stomatiferous bands (rows) that are 50 to 100 μm wide. The stomatal complexes are formed by pairs of guard cells that are usually surrounded by two small oblong polar subsidiary cells and two large oval, oblong, or narrow kidney-shaped lateral subsidiary cells. The pairs of guard cells are sunken and elliptical, with polar ends forming the swallow-tail pattern. They are 50–60 μm long and 18–22 μm wide. The polar subsidiary cells are about 25–30 μm in diameter. The lateral subsidiary cells are 65–82 μm long and 25–30 μm wide. Strongly cutinised proximal walls of the subsidiary cells partly cover the guard cells. The stomatal density is variable, but usually within the range of 25 to 30 stomata per mm^2. The stomatal index varies between 3 and 3.3.

Abaxial cuticle (Text-fig. 26d, Pl. 21, fig. 8): The abaxial cuticle is very poorly preserved. Only fragments with single stomatal rows and costal cells between them are preserved. The lateral subsidiary cells appear more prominently after being stained with safranin. The cells of the stomatal rows belong generally to the stomatal complexes, while the other cells are of the same shape as the costal cells. The cells are square or oblong, 30–60 μm long and about 15–25 μm wide. Each stomatal complex consists of a pair guard cells, two polar subsidiary cells, and two lateral subsidiary cells. The guard cell pairs are strongly sunken, elliptical, and relatively long: they measure about 40–45 μm in length, and their visible parts are only 6–10 μm wide. They are covered by the strongly cutinised proximal walls of the lateral subsidiary cells, which are prominent, very prolongated, and oval to nearly kidney-shaped. They are about 60–70 μm long and 15–20 μm wide. The polar cells are usually very small, rounded to oval in shape, and generally 20–30 mm long and 10–20 μm wide. The small cuticular fragments of this specimen do not allow the stomatal density or index to be estimated.

Discussion: *Cordaites risutensis* has the stomata of its adaxial cuticle dispersed in dark bands, similar to *Cordaites pilsensis*. The abaxial cuticle of *Cordaites risutensis* has stomata arranged in single stomatal rows. Lateral subsidiary cells are oval to reniform, while the polar ends of the guard cells form a swallow-tail shape. For a detailed comparison, see the following discussion of the entire group, and Table 4.

Discussion of Group B

Cuticular Group B contains one hypostomatic species, *Cordaites idae*, while the other species are amphistomatic: *C. schatzlarensis, C. rerichensis, C. pilsensis, C. krasovicensis, C. blazkovicensis, C. radvanicensis* and *C. risutensis*. The common characteristics of this group are well-defined single or double stomatal rows in the abaxial cuticle. The subsidiary cells usually differ from the ordinary cells and are differentiated into two polar and two lateral subsidiary cells.

The adaxial cuticle of *C. idae* is formed of oblong cells. The cuticles of *C. schatzlarensis* are very similar in having oblong cells on the adaxial cuticle. The stomata are irregularly dispersed on the adaxial cuticle, so that parts of it are stomata free, while the stomata are either isolated or form incomplete rows of 2–5 stomatal complexes in other parts. The stomatal density varies from 0 to 40 per mm^2. The abaxial cuticles of these two species differ principally in the shape of the subsidiary cells. The stomatal complexes of *C. idae* are more prominent, their polar subsidiary cells are small and rhomboidal, and their lateral subsidiary cells are mostly oblong, whereas the polar subsidiary cells of *C. schatzlarensis* are rounded to oval, and their lateral subsidiary cells are mostly reniform in shape. Moreover, the guard cells of *C. schatzlarensis* have swallow-tail shaped polar ends.

Other *Cordaites* species of this group have a relatively constant stomatal density. Two species have stomata dispersed in dark stomatal rows of low stomatal density (*C. risutensis* and *C. pilsensis*). *C. pilsensis* has guard cells whose polar ends are swallow-tail shaped, polar subsidiary cells that are polygonal to oval, and lateral subsidiary cells that are mostly oblong, whereas the polar cells of *C. risutensis* are small and oblong, and its subsidiary cells are oval,

Table 4. Important diagnostic features of the species from *Cordaites* cuticular group B.

Species				*Cordaites schatzlarensis*	*Cordaites idae*	*Cordaites rerichensis*	*Cordaites pilsensis*	*Cordaites krasovicensis*	*Cordaites blazkovicensis*	*Cordaites radvanicensis*	*Cordaites risutensis*
Leaves				Amphistomatic	Hypostomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic
Adaxial cuticle	Difference between stomatiferous and non–stomatiferous bands			–	–	+	+	+	+	+	+
	Cell shape of stomatiferous bands			Oblong	–	Oblong	Oblong to irregularly hexagonal	All belong to stomatal complexes	Mostly oblong	Oval, rounded, toroidally oblong	Small, dark, square to oblong
	Size of stomatiferous cells (µm)			(35–100) x (10–20)	–	(20–40) x (20–30)	(30–72) x (15–25)	?	(30–40) x (15–20)	(25–80) x (15–30)	(30–75)x(15–30)
	Cell shape of non–stomatiferous bands			Oblong	Oblong	Oblong	Mostly oblong	Oblong	Mostly oblong	Oblong	Longitudinally tetragonal
	Size of non–stomatiferous cells (µm)			(35–100) x (10–20)	(50–160) x (15–25)	(35–100) x (25–35)	(24–60) x (15–32)	(40–160) x (10–30)	(30–110) x (15–30)	(30–90) x (18–30)	(30–100) x (12–25)
	Stomata	Distribution		Isolated or incomplete rows	–	Single stomatal rows	Dark rare stomatal rows	Single or double well–defined stomatal rows	Well–defined single to double stomatal rows	Irregular rows within a stomatiferous band	Dispersed in dark bands
		Density per 1 mm^2		0 – 40	–	90	35	140	40	?	20–30
		Stomatal index		0 – 3	–	11 – 13	3,5	13	3	?	3–3.3
		Length and width of guard cells (µm)		(20–28) x (10–17)	–	(35–40) x (20–30)	(28–30) x (16–20)	(18–25) x (15–22)	(32–45) x (22–35)	(22–28) x (8–14)	(50–60) x (18–22)
	Subsidiary cells	Polar	Number and shape	2; small, rounded to oval	–	2; oval	2; polygonal to oval (hexagonal)	2; polygonal, (pentagonal to oval	2; oblong, square	2–3; rounded	2; small, oblong
			Size (µm)	(15–20(35)) x (17–20)	–	–	(25–35) x (20–25)	(15–20) x (12–20)	(15–20) x (10–20)	22 – 30 (in diameter)	25–30 (in diameter)
		Lateral	Number and shape	2; oblong	–	2; reniform	2(3); oblong	2–4; oblong to reniform	2; longitudinally tetragonal	2(3); oval to reniform	2; oval, oblon or narrov reniform
			Size (µm)	(35–55) x (18–30)	–	(45–70) x (15–30)	(40–60) x (20–25)	(38–52) x (15–24)	(30–110) x (15–30)	(40–60) x (20–30)	(62–82) x (25–30)
			Shape of crypt	–	–	Strong cutinisation of subsidiary cells	–	Rounded, strong cutinised	–		Strong cutinisation of distal cell walls
Abaxial cuticle	Difference between stomatal rows and non–stomatiferous bands			+	+	+	+	+	+	+	+
	Cell shape of stomatal rows			Only stomatal complexes	Only stomatal complexes	Oblong	Oblong to square	Small trapezoidal to triangular	Small, rounded to oblong	Oblong – oval (trapezoidal)	All stomatal camplexes
	Size of stomatiferous cells (µm)			–	–	(30–60) x (20–30)	(15–25) x (15–25)	(25–40) x (15–20)	(8–16) x (5–8)	(20–45) x (12–20)	
	Cell shape of non–stomatiferous bands			Longitudinally tetragonal	Longitudinally oblong	Oblong	Longitudinally tetragonal	Mostly oblong	Oblong or trapezoidal	Oblong	Mostly oblong
	Size of non–stomatiferous cells (µm)			(30–100) x (10–22)	(40–100) x (5–20)	(40–50) x (25–40)	(40–90) x (15–20)	(35–130) x (15–20)	(35–80) x (10–20)	(40–100) x (12–20)	(40–60) x (15–25)
	Stomata	Distribution		Well–defined single to double stomatal rows	Well–defined single to double stomatal rows	Well–defined single to double stomatal rows	Mostly well–defined single stomatal rows	Well–defined single to double stomatal rows	Well–defined single stomatal rows	Single stomatal rows	Single stomatal rows
		Density per 1 mm^2		180 – 220	200 – 250	70	? 80	143	185	?	?
		Stomatal index		11–15 (incl. non–st. bands)	11 – 15 (incl. non–st. bands)	10	7	12	7	?	?
		Shape of guard cells		Elliptical, polar ends in swallow–tail shape	Elliptical	Elliptical	Elliptical, polar ends in swallow–tail shape	Elliptical	Elliptical	Elliptical	Elliptical with swallow–tile shaped polar ends
		Length and width of guard cells (µm)		(18–25) x (12–15)	(12–14) x (6–8)	(35–45) x (18–25)	(30–35) x (18–24)	(18–25) x (12–16)	20 x 15		(20–30) x (10–20)
	Subsidiary cells	Polar	Number and shape	2; rounded to oval	2; rhomboidal, oval	0	2; rhomboidal to oval	2; pentagonal, hexagonal, oval, rhomboidal, trapezoidal	2; oval to rounded	2–3; rounded	2; small, rounded to oval
			Size (µm)	(18–25) x (16–22)	(8–25) x (4–12)	–	(28–35) x (15–25)		(15–20) x (12–16)	22 – 30 (in diameter)	(60–70) x (15–20)
		Lateral	Number and shape	2; tetragonal, slightly kidney–shaped	2; ± oblong; longitudinally oval	2; wide, renoform	2; wide oblong or regular trapezoid	2(3); ±trapezoidal, reniform	2; bean–shaped	2–4; oval to reniform	2; elongated, oval to renoform
			Size (µm)	(35–48) x (15–25)	(40–75) x (10–22)	(45–75) x (12–20)	(45–55) x (25–30)	((30) 50–60) x (20–28)	(42–50) x (15–20)	(20–60) x (14–25)	(60–70) x (15–20)
			Shape of crypt	–	± Square	Indistinct	–	–	Strongly cutinised distal walls of lateral cells.	–	Strongly cutinised distal walls of lateral cells.

Remark: When subidiary cells are not distinguished from ordinary epidermal cell – their number = 0

oblong, or reniform. The abaxial cuticles of these two species differ in cell shape. Both species have guard cells whose polar ends are swallow-tail shaped, although this characteristic is not as prominent as in *C. risutensis*. *C. pilsensis* has rhomboidal to oval polar cells and wide oblong or trapezoidal lateral cells, whereas *C. risutensis* has small, rounded to oval polar cells and elongated oval to reniform lateral cells.

The stomata of the adaxial cuticle of *C. radvanicensis* occur in irregular rows within the stomatiferous band. Similar stomatiferous bands do not occur in any other species of this group.

Three other species have the stomata of their adaxial cuticle arranged in single or double stomatal rows. These are *C. rerichensis*, *C. krasovicensis* and *C. blazkovicensis*. The stomatal rows of *C. blazkovicensis* are separated from each other, resulting in a very low stomatal density of 40 per mm^2. The subsidiary cells of this species resemble the ordinary epidermal cells. The stomatal rows of *C. rerichensis* and *C. krasovicensis* are more densely arranged. The lateral cells of *C. krasovicensis* are wide and oblong to oval, whereas those of *C. rerichensis* are narrow and reniform. Moreover, the polar ends of the guard cells of *C. rerichensis* are swallow-tail shaped.

The abaxial cuticles of these species differ mainly in the shapes of the subsidiary cells. The lateral cells of *C. rerichensis* are wide and reniform, while those of *C. krasovicensis* are trapezoidal or reniform, those of *C. blazkovicensis* are reniform, and those of *C. radvanicensis* are oblong to reniform. The polar cells of *C. rerichensis* are of the same shape as its ordinary epidermal cells, whereas those of *C. krasovicensis* are pentagonal, hexagonal, rhomboidal or trapezoidal, those of *C. blazkovicensis* are small, rounded or oval, and those of *C. radvanicensis* are large and mostly rounded. Additional differences concern the dimensions and densities of the stomatal complexes, and differences in the shapes of the ordinary epidermal cells.

Group C

(stomata in well defined double or multiple stomatal rows joined into stomatiferous bands)

Cordaites svatonovicensis sp. nov.

Text-figs 27a–e, Pl. 3, fig. 4, Pl. 22, Pl. 23, fig. 1.

2001 *Cordaites* sp. (morphotype 33 – new cuticular morphotype), Šimůnek, p. 72–74, figs 33a–e, pl. 3, fig. 4, pl. 22, pl. 23, fig. 1

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 236, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the type locality at Malé Svatoňovice, next to Rtyně v Podkrkonoší.

T y p e l o c a l i t y : Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin.

T y p e h o r i z o n : Žacléř Formation; Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).

M a t e r i a l : Only one specimen – the holotype.

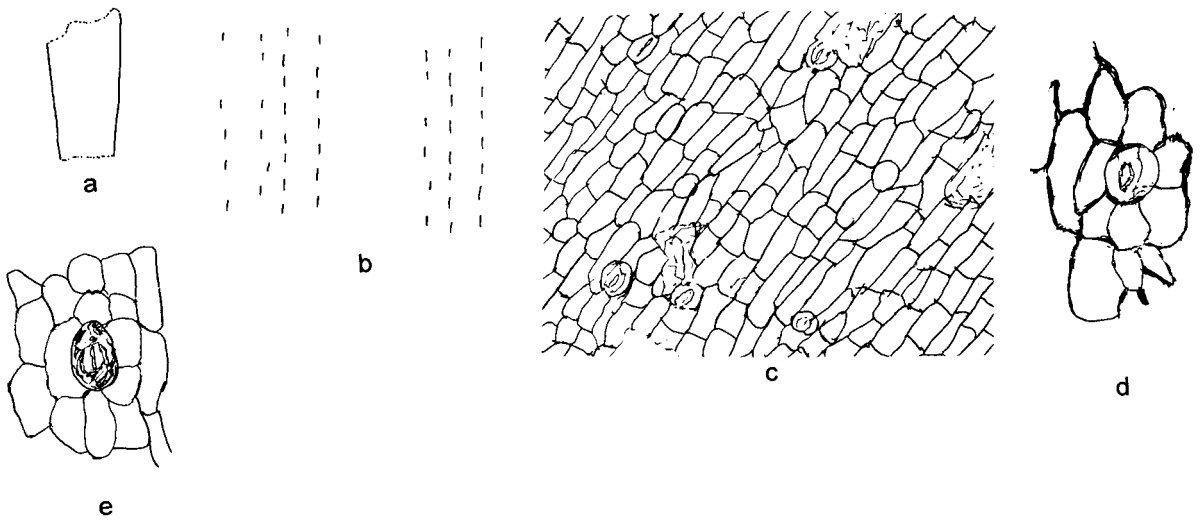
D i a g n o s i s : Medium-sized, amphistomatic leaves with infrequent venation, 2–3 thin veins alternating with each thick vein. Cells of adaxial cuticle oblong, stomata irregularly dispersed. Cells of abaxial cuticle oblong, pentagonal to hexagonal, stomata in stomatal rows forming stomatiferous bands, prominent oval crypt.

D e s c r i p t i o n : The holotype is a leaf fragment 85 mm long with non-parallel margins, 30 mm wide in the narrowest part and 42 mm in the widest part. The venation is indistinct and infrequent, there being 18 thick veins per cm of leaf with 2–3 very indistict, discontinuous thin veins occurring between each 2 thick veins. The leaves are amphistomatic.

Adaxial cuticle (Text-figs 27c,d, Pl. 22, figs 1–3): The cells of the costal and intercostal fields differ very slightly. The cells are elongated and oblong, 35–110 μm long and 15–30 μm broad. They are oriented parallel to the veins, and their anticlinal walls are straight or slightly bent. The stomatal complexes occur in irregular rows dispersed within the intercostal field, and they are oriented parallel to the veins. The stomatal complexes are formed by a pair of sunken elliptical guard cells, and by subsidiary cells that are similar to the ordinary epidermal cells. The pairs of guard cells are 30–40 μm long and 25–35 μm wide. Usually two to three polar subsidiary cells and two or three lateral subsidiary cells are present. The stomatal density is about 25 per mm^2. The stomatal index varies between 4 and 5.

Abaxial cuticle (Text-fig. 27e, Pl. 22, figs 4–6, Pl. 23, fig. 1): The cells are differentiated into stomatiferous (intercostal) bands and non-stomatiferous bands (costal).The intercostal cells are oriented parallel to the veins; they are oblong, pentagonal to hexagonal, 25–60 μm long and 12–24 μm wide. Their anticlinal walls are staight or only slightly bent. The costal cells are elongated, oblong, 40–85 μm long and 15–30 μm wide. The stomatal complexes occur in single to triple stomatal rows, and are oriented parallel to the veins. They are formed by a pair of sunken, elliptical guard cells, two to three square, oblong, oval to rhomboidal polar subsidiary cells, and two to three elongated, oblong, lateral subsidiary cells. The pairs of guard cells are 26–32 μm long and 18–24 μm wide. The stomatal complexes (including the subsidiary cells) are 60–80 μm long and 35–50 μm wide. The polar subsidiary cells are 15–25 μm long and 10–15 μm wide. The lateral subsidiary cells are 40–50 μm long and 10–15 μm wide. The outer stomatal cavity (crypt) is strongly cutinised, of oval shape, and oriened transversely to the gurd cells. The stomatal densisty is 130–160 per mm^2 of leaf surface. The stomatal index is about 12.

D i s c u s s i o n : *Cordaites svatonovicensis* differs from all other species of this cuticular group by the stomata on its adaxial cuticle having subsidiary cells of the same shape as ordinary epidermal cells. This may also be the case with *Cordaites touskovensis*, though this is uncertain because the cuticle of the later is poorly preserved and its stomata are



Text-fig. 27. ***Cordaites svatonovicensis*** **sp. nov., Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Group of coals, Duckmantian, slide No. 315/1-3. a – leaf outline, ×0.25, b – distribution of stomata on abaxial cuticle, ×20, c – adaxial cuticle with stomata, ×125, d – adaxial cuticle, stoma, ×250, e – abaxial cuticle, detail of stoma, ×250.**

present only as dark spots. All other species of this group have distinct subsidiary cells on the adaxial cuticle. The stomata on the abaxial cuticle form stomatal rows and stomatiferous bands consisting of 1–3 stomatal rows. This species would appear to be intermediate between Groups B and C. The stomata of the abaxial cuticle are prominent because of the strongly cutinised oval crypt. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites odolovensis sp. nov.

Text-figs 28a–d, Pl. 23, figs 2–5

2001 *Cordaites* sp. (morphotype 36 – new morphotype), Šimůnek, p. 74–76, fig. 34a–d, pl. 23, fig. 2–5.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 237, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From Odolov, village of the Nejedlý Mine area.

T y p e l o c a l i t y : Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), stope 507, Intrasudetic Basin.

T y p e h o r i z o n : Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, 1st tuffitic interbed above the base of the 3rd Žďárky coal seam. Duckmantian (Westphalian B).

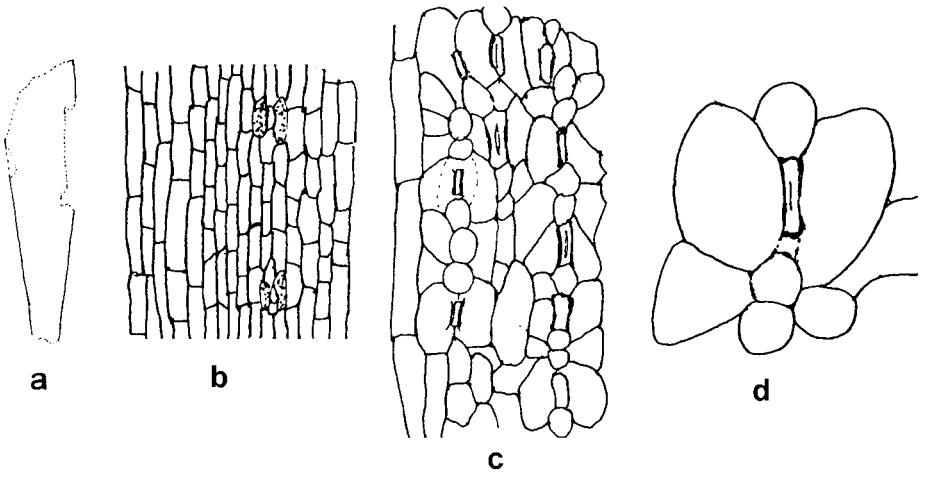
M a t e r i a l : Only one specimen – the holotype.

Diagnosis: Narrow, lanceolate, amphistomatic leaves with infrequent venation, 4–5 very thin veins alternate with each thick vein. Cells of adaxial cuticle are oblong with dispersed stomata, abaxial cuticle with rounded and oblong cells, stomata arranged in stomatal rows joined into stomatiferous bands. Crypt distinct, oval.

D e s c r i p t i o n : The holotype is a leaf fragment 135 mm long. Its margins diverge from the 13 mm wide basal part, up to a maximum width of 27 mm. Its actual width and length must have been much greater. The venetion slightly differs on both sides of the leaf, being more prominent on one side (probably abaxial) than the other. The thick veins are prominent. There are 4–5 very thin but pronounced veins occuring between each two thick veins. Occasionally, a broader vein half the thickness of the thick veins occurs among the thin veins on the opposite side of the leaf. The thick veins are indistinct and flat, and the thin veins are visible as narrow furrows. Vein density is low: 8 to 10 thick veins per cm.

Adaxial cuticle (Text-fig. 28b, pl. 23, figs 2–3): There are only slight differences between the cells of the costal and intercostal bands. The cells of the intercostal band are slightly shorter than those of the costal band. The cells are oblong, 40–95 μm long and 15–28 μm wide. They are oriented parallel to the veins, and their anticlinal walls are straight or only slightly bent. The stomatal complexes are arranged irregularly within the intercostal band (Text-fig. 28b). They are formed by two elliptical, strongly sunken guard cells, two oval polar subsidiary cells, and two elongate oblong to oval lateral subsidiary cells. They cannot be measured due to their pronounced sunkeness and their being covered by subsidiary cells. The stomatal complexes (including the subsidiary cells) are about 90 μm long and 40 μm wide. The polar subsidiary cells are 25–35 μm long and 15–20 μm wide, and are of concordant shape with the ordinary epidermal cells. The lateral subsidiary cells are 45–55 μm long and about 15–18 μm wide. The lateral subsidiary cells are strongly cutinised. The stomatal density is about 14 per mm^2. The stomatal index varies between 1.8 and 2.2.

Abaxial cuticle (Text-figs 28c,d, Pl. 23, figs 4–5): The abaxial cuticle is slightly cutinised. The cells are differentiated into stomatiferous (intercostal) bands and non-stomatiferous (costal) bands. Most of the cells of the stomatiferous bands belong to the stomatal complexes, only the lateral sub-



Text-fig. 28. ***Cordaites odolovensis*** **sp. nov., Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Group of coals, first tuffaceous interbed in base of 3rd Žďárky coal seam, Duckmantian, slide No. 316/1, 2. a – leaf outline, ×0.28, b – adaxial cuticle with stomata, ×112, c – abaxial cuticle with stomata, ×224, d – abaxial cuticle, detail of stoma, ×560.**

sidiary cells in the stomatal row being separated by small rounded cells that resemble the polar subsidiary cells. The ordinary cells of the costal field are elongated, oblong, 40–85 µm long and about 12–18 µm wide. They are oriented parallel to the veins. The stomatal complexes are organised in well defined stomatal rows, 4–5 of which join to make a stomatiferous band about 180 µm wide. The stomata are formed by a pair of sunken, elliptical guard cells, two small rounded polar subsidiary cells, and two large oval or kidney-shaped lateral subsdiary cells. The pairs of subsidiary cells are 14–20 µm long and 10–15 µm wide. The stomata are partly covered by the strongly cutinised proximal walls of the lateral subsidiary cells, so that the pit above the guard cells is only 3–5 µm wide. The stomatal complexes (including the subsidiary cells) are 45–55 µm long and 42–50 µm wide. The polar subsidiary cells are 10–15 µm in diameter. Sometimes, one polar cell is shared by two neighbouring stomata. The lateral subsidiary cells are 32–42 µm long and 18–24 µm wide. The stomatal density is about 416 stomata (including costal band) per mm^2, though there are about 530 stomata per mm^2 in the stomatiferous band. The stomatal index is about 18–20.

D i s c u s s i o n : *Cordaites odolovensis* has dispersed stomata on its adaxial cuticle, forming infrequent irregular rows. This feature occurs in several species of this cuticular group, such as *Cordaites borassifolius*, *C. raconensis* and *C. melnicensis*. However, *C. odolovensis* differs in having strongly cutinised, oblong, lateral subsidiary cells. The abaxial cuticle of *Cordaites* odolovensis has very wide bean-shaped lateral, and small rounded polar subsidiary cells of the stomata. This feature distinguihes *Cordaites odolovensis* from all other species of this cuticular group. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites borassifolius (Sternberg) Unger

Text-figs 29a–j, Pl. 1, fig. 1, 2, Pl. 3, fig. 5, 6, Pl. 24–27, Pl. 28, fig. 1, 2

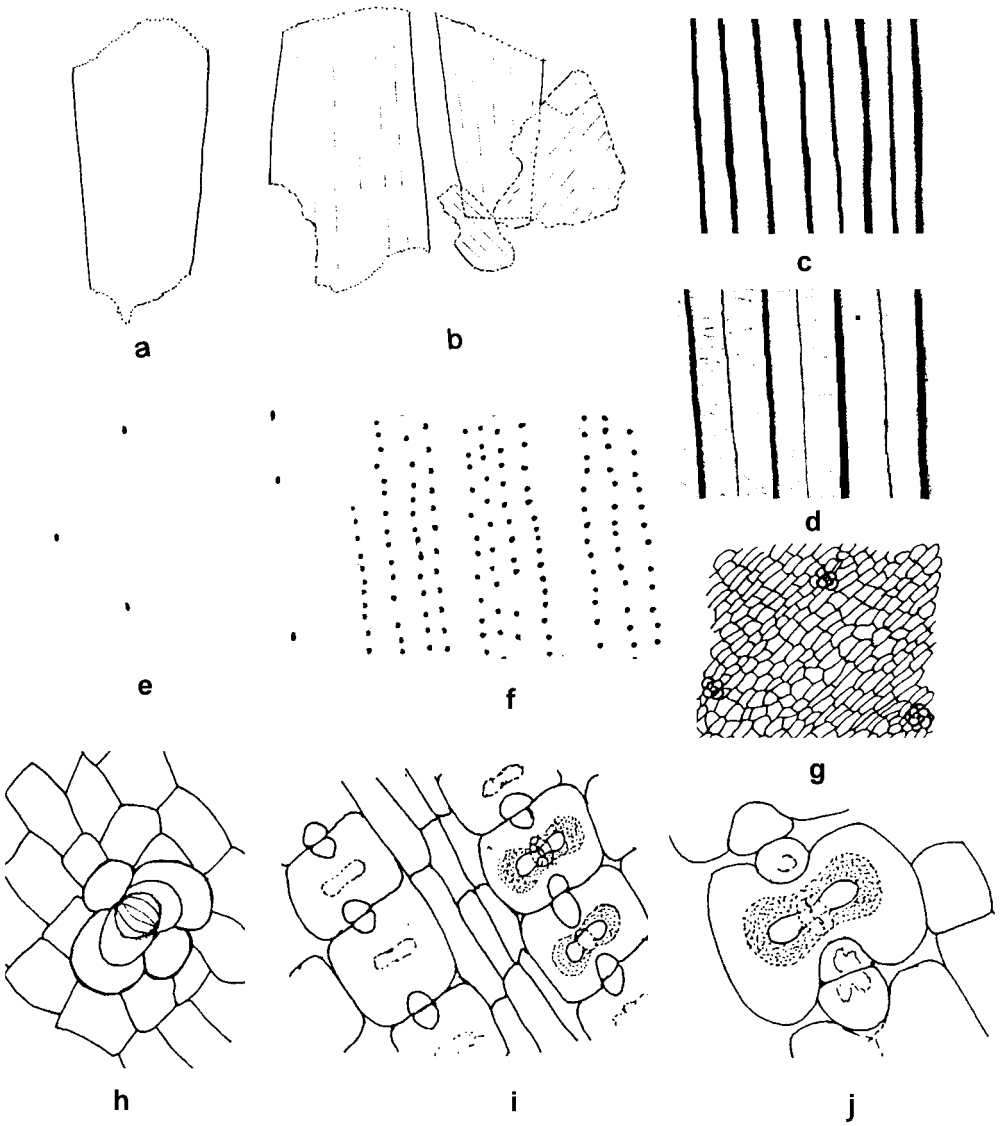
1821 *Flabellaria borassifolia* Sternberg, Sternberg, vol. I, 2: tent. 28, 32, pl. XVIII.
1825 *Flabellaria borassifolia* Sternberg, Sternberg, vol. I, 4: tent. 34, pl. XXXIV, fig. 1.
1825 *Cycadites palmatus* Sternberg, Sternberg, vol. I, 4, p. 39, tent. 33, pl. XXXX.
1845 *Flabellaria borassifolia* Sternberg, Corda, p. 44, pl. 24, figs 1–3, 8.
1850 *Cordaites borassifolius* (Sternberg) Unger, p. 227.
1852 *Cordaites borassifolius* (Sternberg) Unger; Ettingshausen, p. 16–17, pl. 5, fig. 5.
1968 *Cordaites borassifolius* (Sternberg) Unger; Němejc, p.219, pl. 26, fig. 1.
2000 *Cordaites borassifolius* (Sternberg) Unger; Šimůnek, p. 29, fig. 3: 12.
2001 *Cordaites borassifolius* (Sternberg) Unger (morphotype 12 sensu Šimůnek 2000); Šimůnek, p. 76–79, fig. 35a–l, (holotype, fig. 1d, pl. 1, fig. 1, 2,) pl. 3, fig. 5, 6, pl. 24–27, pl. 28, fig. 1, 2.
2003 *Cordaites borassifolius* (Sternberg) Unger; Zodrow, Mastalerz and Šimůnek, p. 97, Figs 1A,B,D and 2.

H o l o t y p e : E 5738, Sternberg 1821, pl. 18, (coll. National Museum, Prague).

T y p e l o c a l i t y : Svinná, near Radnice, Radnice Basin.

T y p e h o r i z o n : Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Carboniferous, Bolsovian.

M a t e r i a l : Svinná, Břasy, Ovčín near Radnice locality, Pokrok Mine, (Coll. National Museum, Prague, Nos. E 4749, E 4750, E 5738, E 5889 – E 5892; E 5895 – E 5898, E 6221 – E 6223, coll. Czech Geological Survey, Prague, No. ZŠ 301).



Text-fig. 29. ***Cordaites borassifolius*** **(Sternberg) Unger, Ovčín – Přívětice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Group of coals, Whetstone Horizon, Bolsovian, Slides No. 108/1-6, 120/1-3, 352/1-5, 353/1-2, 354/1-5, 355/1-5, 356/1-6, 357/1-3, 358/1-5. a, b – leaf outlines, ×0.25, a – sample No. E 5897, b – sample No. E 5898 – material to slides No. 354/1-5 (left), 353/1-2 (in the middle), 355/1-5 (below) and 352/1-5 (right), c-g – leaf venations ×20, c – leaf venation to slide No. 108/1-5 representing adaxial side, ×20, d – leaf venation to slides Nos. 355/1-5 representing abaxial side, e – distribution of stomata on adaxial cuticle, slide No. 108/5, ×50, f – distribution of stomata on abaxial cuticle, slide No. 108/5, ×50, g – adaxial cuticle with stomata, slide No. 108/5, ×50. h – adaxial cuticle, detail of stoma, slide No. 108/5, ×250, i – stomata on abaxial cuticle, slide No. 108/5, ×250, j – abaxial cuticle, detail of stoma with crypt, slide No. 108/5, ×500.**

E m e n d e d d i a g n o s i s : Amphistomatic leaves large, entire, thick, ovate-lanceolate, apex bluntly pointed, occasionally deeply lacerated, veins medium-dense to dense. On adaxial side all veins approximately of the same thickness, on abaxial side 1 or 2 thin veins alternate with each thick vein. Abaxial cuticle with tetragonal, oblong square cells and irregularly dispersed stomata, abaxial cuticle with oblong cells and stomata arranged into stomatal rows forming stomatiferous bands. Polar cells rounded, lateral cells oblong to reniform. Tranverse oval crypt constricted in the center.

D e s c r i p t i o n : The holotype is preserved as an imprint without coal matter on a 440 mm long and 350 mm wide (Pl. 1, fig. 1) slab which is also without coal matter. It consists of two large leaf fragments and several small fragments. The largest fragment is in the midle of the leaf rosette. It is 425 mm long and 50 mm wide at its widest part in the middle. Another leaf is preserved behind this first one, as can be seen in Sternberg's (1821) figure. The leaf on the right is 390 mm long and 68 mm wide in its middle part. The leaf margins taper towards the base and towards the apex, which is not preserved in this slab. Another three narrow leaf

fragments occur among the large, wide leaves. These smaller fragments were apparently enrolled before burial. There are another three smaller leaf fragments to the right from the middle of the large fragment, the largest of which is about 180 mm long and 40 mm wide. However, this cannot have been its true width, as its apex is not preserved and it tapers to the base. The base is also not preserved in these three leaves, and the smalest widths represented here are 18, 20 and 28 mm. Due to the coarse nature of the rock, the venation is preserved only in a few parts (Pl. 1, fig. 2). It is very dense and partly discontinuous. About 50 thick veins occur per cm of leaf.

The leaves are spirally arranged on twigs. They are large, entire-margined, thick, ovate-lanceolate, and rarely somewhat obovate. They range from 350 – 900 mm in length and 35 – 90 mm in width. Most of the specimens from the Ovčín locality are 450–550 mm long. The apex is bluntly pointed, but often apparently acute (because of revolute leaf margins). The leaves are amphistomatic and very seldom lacerated.

The veins run parallel to the margins. The venation pattern differs on the adaxial or abaxial sides, and was affected by the fossilisation process. It has been confirmed based on cuticular characters that one (or two) thin veins alternate with each thick (or "true") vein on the abaxial side (fig. 29d), and that veins of equal width occur on the adaxial side (Text-fig. 29c). The sclerenchymatous strands and vascular bands are apparently of the same thickness, and it is impossible to distinguish between them. The vein density varies considerably between 18 – 62 veins per cm. In most cases the vein densities fall into intervals between 24 to 26 veins per cm and 46 to 50 veins per cm. This means that the leaves have an average of 24 to 26 vascular bundles. The sclerenchymatous strands on the adaxial side have the same thickness as the vascular bundles.

Adaxial cuticle (Text-figs 29g,h, Pl. 24, figs 2–7, Pl. 25, figs 1–3, Pl. 28, figs 1, 2): The adaxial cuticle is weakly cutinised, but more prominently than the abaxial cuticle. Ordinary cells are the same in both the costal and intercostals areas, being tetragonal, mostly oblong, less square and more pentagonal to hexagonal. The cells are 30–75 μm long and 20–35 μm wide. The anticlinal walls are slightly to strongly bent. The cells are rounded at their corners, and are oriented parallel to the veins. Stomatal complexes occur rarely and are randomly dispersed among these cells at distances of approximately 400 μm. They are oriented parallel to the veins. Stomatal complexes are formed by a pair of sunken elliptical guard cells, two polar subsidiary cells, and two lateral subsidiary cells. Guard cell pairs are 22–26 μm long and 13–16 μm wide. The stomatal complexes (including the subsidiary cells) are 60–80 μm long and 60–70 μm wide. Polar lateral veins are prominent and oval shaped, with diameters from 20–30 μm. Lateral subsidiary cells are prominent oblong, and have bulging anticlinal walls. They are 34–50 μm long and 16–25 μm wide. An outer stomatal cavity is developed on the outer side of the stomatal complex. It is square to rounded in form. The stomatal density is very low at 6–9 per mm^2. The stomatal index varies from 0.7 to 0.9.

Abaxial cuticle (Text-figs 29i,j, Pl. 24, fig. 1, Pl. 25, figs 4–7, Pl. 26–27): The abaxial cuticle is weakly cutinised. The cells are differentiated into stomatiferous (intercostal) bands 200–300 μm wide, and non-stomatiferous (costal) bands 60 μm wide that are formed by three rows of cells. All cells of the intercostal field belong to the stomatal complexes. Those of the non-stomatiferous band are tetragonal, mostly elongated, oblong, 35–110 μm long and are 15–30 μm wide. Their anticlinal walls are straight or slightly bent. Cell orientation is parallel to the veins. The stomatal complexes are formed by pairs of sunken elliptical guard cells, two polar subsidiary cells, and two lateral subsidiary cells. The stomatal complexes are arranged into stomatal rows, three to six of which form a stomatiferous band. The stomata are oriented parallel to the veins. Pairs of guard cells are 22–26 μm long and 12–16 μm wide. The stomatal complexes (including subsidiary cells) are 40–60 μm long and 40–60 μm wide. The polar subsidiary cells are rounded, with diameters of 15–20 μm. The lateral subsidiary cells of two neighbouring stomata in a row are in contact. They are oblong to kidney-shaped in form, 40–50 μm long and 20–28 μm wide. The outer stomatal cavity is developed across the lateral subsidiary cells. It is elongated, and constricted in the central part. The stomatal density is 350–370 per mm^2. The stomatal index varies from 16 to 20.

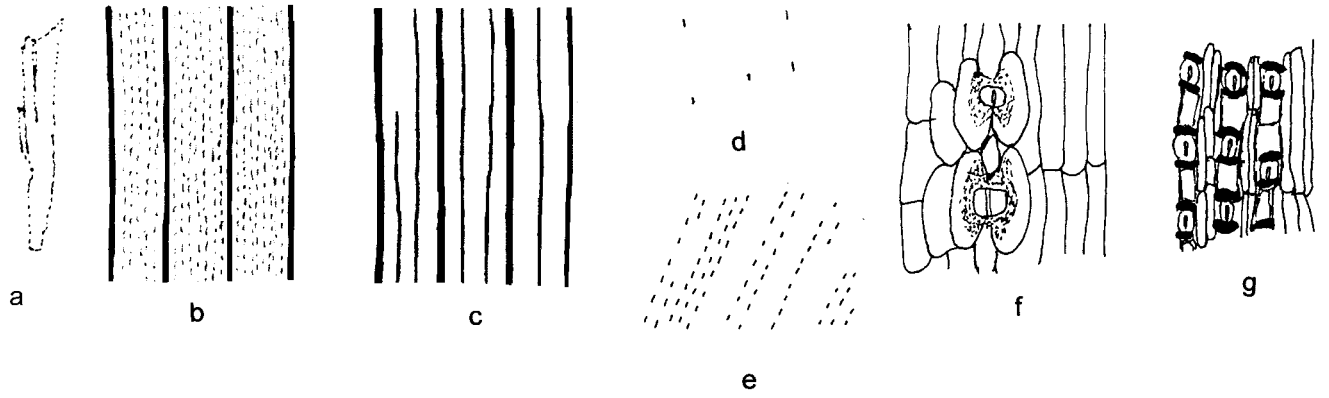
Discussion: *Cordaites borassifolius* has stomata irregularly dispersed on its adaxial cuticle. This feature occurs in some other species of this group, such as *Cordaites dobranensis, C. melnicensis* and *C. odolovensis*. The stomata of *Cordaites borassifolius* are very prominent, having two oval polar and two oblong lateral subsidiary cells, with the characteristic bulging of the anticlinal walls. This feature does not occur in the other above-mentioned species. The abaxial cuticle of *Cordaites borassifolius* has stomata arranged into stomatal rows and stomatiferous bands. The shape of the lateral subsidiary cells is mostly wide and oblong, while the polar subsidiary cells are very small and usually rounded. The transverse oval, strongly cutinised crypt, which is constricted in the centre, is a diagnostic feature of this species. A similar feature can be seen in *Cordaites dobranensis* (see Text.-figs 31 1, m). However, *Cordaites dobranensis* has reniform lateral subsidiary cells, and its polar subsidiary cells are much larger then those of *Cordaites borassifolius*. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites raconicensis sp. nov.

Text-figs 30a–g, Pl. 3, fig. 7, Pl. 28, fig. 3–10, Pl. 29, figs 1–2

2000 *Cordaites* sp. Šimůnek, p. 32, figs 4: 30.
2001 *Cordaites* sp. (morphotype 14 sensu Šimůnek 2000), Šimůnek, p. 80–81, figs 36a–g, pl. 3, fig. 7, pl. 28, figs 3–10, pl. 29, figs 1–2.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 238, coll. Z. Šimůnek.



Text-fig. 30. ***Cordaites raconicensis*** **sp. nov., Lubná near Rakovník, Filip II Quarry, locality No. 34, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Group of coals, Bolsovian, slide No. 289/1-2. a – leaf fragment, ×0.5, b, c – venations of different sides of the same leaf, ×20, d – distribution of stomata on adaxial cuticle, ×50, e – distribution of stomata on abaxial cuticle, ×50, f – adaxial cuticle with stomata, ×200, g – abaxial cuticle with stomata, ×200.**

Derivation of name: From the Latin name of the town of Rakovník, near the type locality.

Type locality: Lubná near Rakovník, Filip II quarry, Kladno-Rakovník Basin.

Type horizon: Kladno Formation; Radnice Member, Lubná Coals. Bolsovian (Westphalian C).

Material: Only one specimen – the holotype.

Diagnosis: Amphistomatic, small and narrow leaves, infrequent vein density, 2 thin veins alternate with each thick vein. Adaxial cuticle with longitudinally tetragonal cells, stomata in poorly defined stomatal rows, reniform lateral subsidiary cells, abaxial cuticle with oblong cells, stomata in well-defined stomatal rows forming stomatiferous bands. Crypt has "Florin ring" shape.

Description: The holotype is a leaf fragment 60 mm long and 11 mm wide. The venation is infrequent, there being 22 veins per cm. Two thin veins alternate with each thick vein in the impression without coal matter. The parallel orientaton of cells is visible on the coalified parts, and fine veins are not discernible. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 30f, Pl. 28, figs 3, 6–9): There are only slight differences between cells of the costal and intercostal bands. The cells are usually oriented parallel to the veins. They are elongated, tetragonal, mostly oblong, 50–125 μm long and 12–28 μm wide. The anticlinal walls are straight or slightly bent. The stomatal complexes occur in irregular, infrequent stomatal rows. Less commonly, two stomata share a polar cell. The pairs of guard cells are oriented parallel to the veins. They are sunken, elliptical, 25–35 μm long and 20–25 μm wide, surrounded by two polar subsidiary cells and two lateral subsidiary cells that differ from ordinary epidermal cells. The stomatal complexes (including subsidiary cells) are 75–95 μm long and 50–55 μm wide. The polar subidiary cells are rhomboidal, 15–25 μm long and 10–15 μm wide. Most of the lateral subsidiary cells are kidney-shaped; they are 60–70 μm long and 15–20 μm wide. The outer stomatal cavity (crypt) is strongly cutinised, rounded or slightly elongated, and oriented tranversely to the guard cells. The stomatal density is about 57 per mm^2. The stomatal index varies between 5–6.

Abaxial cuticle (Fig. 30g, Pl. 28, figs 4, 5 and 10, Pl. 29, figs 1–2): The abaxial cuticle is weakly cutinised. The cells are differentiated into stomatiferous (intercostal) and non-stomatiferous (costal) bands. All cells of the stomatiferous bands belong to the stomatal complexes. The cells are oriented parallel to the veins. The costal cells are oblong, 40–80 μm long and 10–18 μm wide. The stomatal complexes are organised in well defined stomatal rows, forming stomatiferous bands (up to six rows per band). The arrangement of the stomata is so tight that both polar and lateral cells are common to the neighbouring stomata. The pairs of sunken, elliptical stomata are 15–20 μm long and are 8–15 μm wide. The whole stomatal complex (including subsidiary cells) is 45–52 μm long and 28–30 μm wide. The polar subsidiary cells are square to oblong, 10–15 μm long and about 10 μm wide. The lateral subsidiary cells are also oblong, 40–60 μm long and 10–18 μm wide. Outer stomatal cavity (crypt) is strongly cutinised, of oval to rounded shape, and closely resembles the Florin ring morphology known from some conifers (e.g. Podocarpaceae, Stockey et al., 1992). The stomatal density is about 390 per mm^2. The stomatal index is about 17.

Discussion: *Cordaites raconicensis* has stomata occurring on the adaxial cuticle in poorly defined, discontinuous stomatal rows. The stomata are either isolated, or 2 or 3 stomata are in contact within a row (Text-fig. 30f). The polar cells are rhomboidal, while the lateral subsidiary cells are reniform. The adaxial cuticle of this species has the highest stomatal density of this cuticular group. The stomata of the abaxial cuticle are also arranged in stomatiferous bands, and differ from all other stomata of this cuticular group. Lateral subsidiary cells are very narrow, like the ordinary epidermal cells, but the polar cells are square. The most significant feature of the crypt is that it is strongly cutinised in its polar parts. It thus forms a Floring ring structure not observed in any other *Cordaites* species. For a detailed comparison with other species, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites dobranensis sp. nov.

Text-figs 1d,e, 31a–n, Pl. 2, figs 8, 9, Pl. 29, figs 3–6, Pls 30, 31, 32, figs 1–3

1994 *Cordaites* cf. *principalis* (Germar) Geinitz; Šimůnek, figs 2a,b, 3a,b,c, pl. 3, figs 6–8, pls. 4, 5, 6.

2000 *Cordaites* sp. Šimůnek, p. 29, 32, figs 4: 16, 4: 17, 4: 18 and 3: 23.

2001 *Cordaites* cf. *"principalis"* (Germar) Geinitz; (morphotypes 16, 17, 18 & 23 sensu Šimůnek 2000), Šimůnek p. 82–86, figs 37a–v, pl. 2, figs 8, 9, pl. 29, figs 3–6, pl. 30, 31, 32, figs 1–3.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 58, coll. Z. Šimůnek.

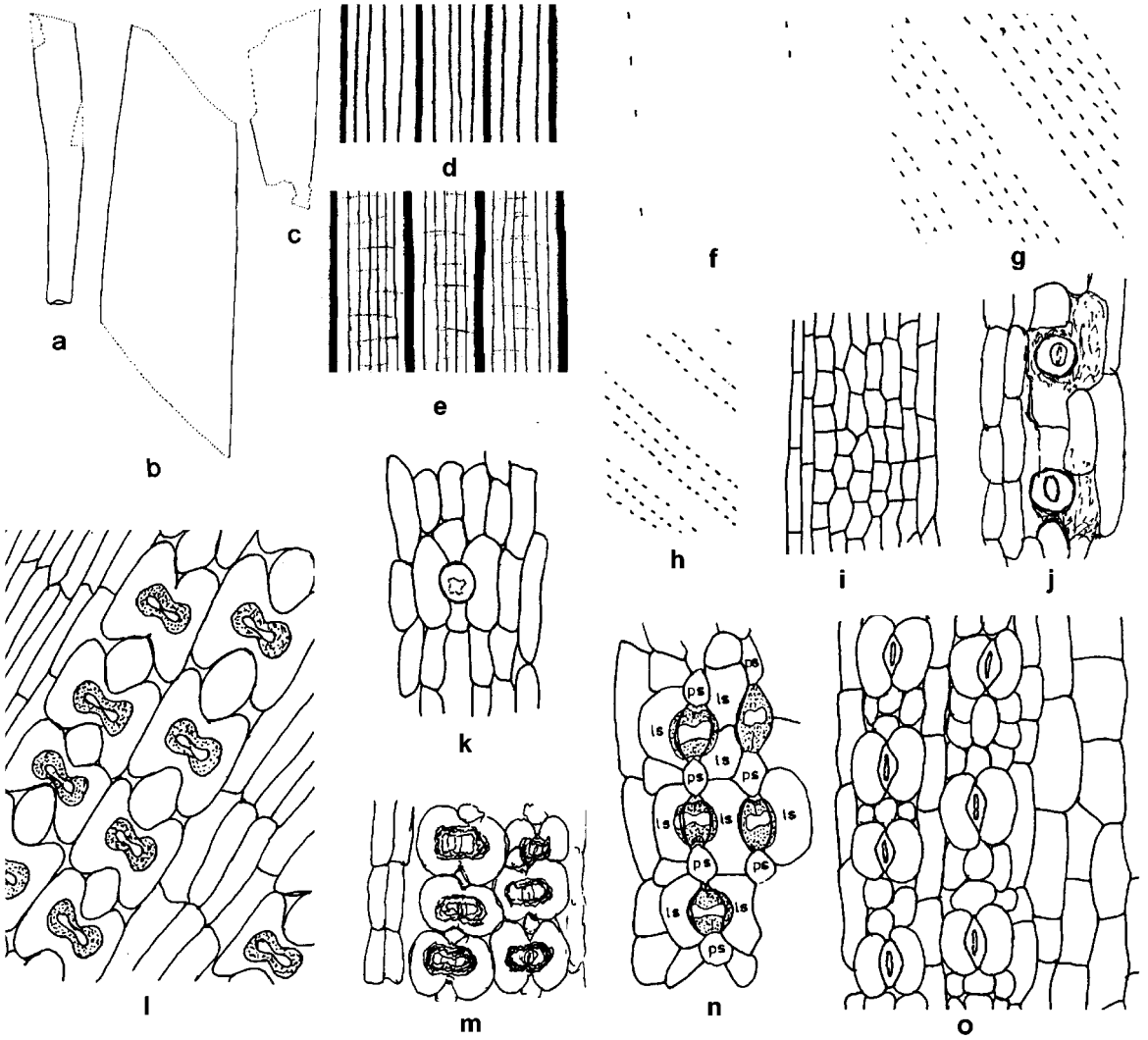
D e r i v a t i o n o f n a m e : According to the type locality Dobřany village.

T y p e l o c a l i t y : From Dobřany, the tip of the Dobré štěstí Mine in the Plzeň Basin.

T y p e h o r i z o n : Kladno Formation; Nýřany Member, Chotíkov Coals. Asturian (Westphalian D).

M a t e r i a l : Old Dobré štěstí Mine near Nová Ves and Dobré štěstí (Hugo) Mine near Dobřany, road cut near Heřmanova Huť, borehole HV 3/1 near Nýřany-Tesla, Nos. ZŠ 56 – ZŠ 59; ZŠ 249 – 299.

D i a g n o s i s : Amphistomatic, large, lanceolate leaves, with bluntly pointed apices, infrequent venation, with 3–7 thin veins alternating with each thick one. Adaxial cuti-



Text-fig. 31. ***Cordaites dobranensis*** **sp. nov., Nýřany Member, Plzeň Basin (Asturian, Westphalian D). a – material to slide No. 166/2, Nýřany – Tesla, borehole HV-3/1, 94 m, ×0.25, b – material to slide No. 283/1, 2, Dobřany, Dobré štěstí Mine, ×0.25, c – material to slide No. 242/1-3, Dobřany, Dobré štěstí Mine, ×0.25., d – leaf venation from fig. a, Nýřany – Tesla, borehole HV-3/1, 94 m, ×20, e – leaf venation to slides No. 164/1-4, Dobřany, Dobré štěstí Mine, ×20, f – distribution of stomata on adaxial cuticle slide No. 164/3, from the basal part of leaf, Dobřany, Dobré štěstí Mine, ×50, g – distribution of stomata on abaxial cuticle, slide No. 164/3, Dobřany, Dobré štěstí Mine, ×50, h – distribution of stomata on abaxial cuticle, slide No. 283/2, Dobřany, Dobré štěstí Mine, ×50. i – adaxial cuticle without stomata, slide No. 243/1, Dobřany, Dobré štěstí Mine, ×100, j – adaxial cuticle with stomata, Dobré štěstí Mine, slide No. 283/1, ×200, k – adaxial cuticle with stomata, Nýřany – Tesla, borehole HV 3/1, slide No. 166/2, ×250, l – abaxial cuticle with stomatal rows and bands, Dobré štěstí Mine, slide No. 164/3, ×200, m – abaxial cuticle with stomatal rows and bands, Dobré štěstí Mine, slide No. 283/1, ×200, n – abaxial cuticle with stomatal rows and bands, Dobré štěstí Mine, slide No. 242/3, ×250, o – abaxial cuticle with stomatal rows and bands, Nýřany – Tesla, borehole HV 3/1, slide No. 166/2, ×250.**

Table 5. Comparison of stomatal index and width of stomatal complexes of three samples of *Cordaites dobranensis* sp. nov. (According to Šimůnek, 1994).

Slide No.	243/1	242/2	241/2
Width of stomatal complex (mm)	38-44	43-55	48-64
Stomatal index in stomatiferous band	20-25	15-20	10-15

cle with oblong or longitudinally oblong cells, stomata present or absent. Abaxial cuticle with oblong or longitudinally oblong cells. Stomata in stomatal rows connected into stomatiferous bands. Two rhomboidal square to oblong polar and 2 oblong to reniform lateral subsidiary cells, crypt transverse oval, constricted in the center.

D e s c r i p t i o n : The holotype is a leaf fragment 100 mm long with an incomplete width of 40 mm. The venation is of medium density, having about 25 veins per mm. The venation is indistinct, with only 3–4 thin veins alternating with each thick one. Other leaf fragments are more than 250 mm long and 14–90 mm wide. Various numbers of thin veins (usually between 3 and 7) occur between each two thick veins. The thick veins are irregularly spaced from each other within a single leaf. There are only 12–30 thick veins per cm. Some very thin transverse wrinkles occur among the veins. The leaves are amphistomatic. The stomata on the adaxial cuticle occur only locally, so that stomata are not present on some of the cuticular fragments.

Adaxial cuticle (Text-figs 31i–k, Pl. 29, figs 3–6, Pl. 30, figs 1–5, Pl. 32, fig. 3): The cells of the adaxial cuticle are oriented parallel to the veins and are distinguishable as costal and intercostal bands, though this difference is not prominent in some cuticles. The costal bands are 70–90 µm wide and correspond to thick veins above the vascular bundles, while the intercostal bands are about 300 µm wide. The stomata are observed to be rare, such as in slides 163, 166 and 283 (Text-figs 31j,k). The cells of the costal field are elongated and oblong in shape, 35–150 µm long and 10–20 µm wide. Most of the cells in the intercostal band are elongated, oblong, pentagonal to hexagonal in shape, 20–80 mm long and 15–30 µm wide. The anticlinal walls are usually straight. The stomatal complexes are isolated, or occur in very rare stomatal rows 400–450 µm apart from each other, depending on position within the leaf blade. The stomata of a single stomatal row are 130–180 µm apart from each other. The stomatal complexes are formed by pairs of elliptical to oval guard cels, 2–4 oblong to oval lateral subsidiary cells, and two usually rounded to oval polar subsidiary cells. The pairs of guard cells are sunken, oriented parallel to veins, 25–30 µm long and 22–25 µm wide. The stomatal complexes (including the subsidiary cells) are therefore 80–100 µm long and 60–70 µm wide. The polar subsidiary cells are 20–40 µm long and 15–25 µm wide. The lateral subsidiary cells are 50–70 µm long and 15–25 µm wide. A strongly cutinised, rounded, outer stomatal cavity (crypt) is developed among the lateral subsidiary cells. The stomatal density varies depending on position within the leaf from 0 to 14 stomata per mm^2. The stomatal index varies from 0 to 1.

Abaxial cuticle (Text-figs 31l–o, Pl. 30, figs 6–7, Pl. 31, figs 1–7, Pl. 32, figs 1 and 2): The cells are differentiated into stomatiferous (intercostal) and non-stomatiferous (costal) bands. The non-stomatiferous bands are usually 70–90 µm wide. The width of the stomatiferous (intercostal) bands depends mainly on the degree of leaf development, and ranges between 120–350 µm. The costal cells are elongated, oblong, 35–120 µm long and 10–25 µm wide, and their anticlinal walls are usully staight. The stomatal complexes in the intercostal fields are arranged into 3 to 7 stomatal rows forming a stomatiferous band. The stomata of young or small leaves (Pl. 31, fig. 1) are arranged very densely. Polar cells are small and rhomboidal, each of which are common to two stomata. The lateral cells within the stomatal rows are in contact with those of the neighbouring stomatal rows. Some lateral cells are also common to two stomata. The lateral cells are oblong in the young leaves, becoming bean-shaped in adult leaves. Polar cells are also larger in adult leaves, and are usually of an oval shape (Text-fig. 31 l). The youngest leaves have not developed outer stomatal cavities (crypt). Only the strong cutinisation of the proximal walls of the lateral cells is visible. The wider and older leaves have larger and wider cells. The outer stomatal cavity is developed above the guard cells. It is of a rounded or transversely oval shape, with a narrow tranverse pit in the centre. The stomatiferous bands are formed almost exclusively by stomatal complexes, but these complexes are rarely separated by a row of elongated, oblong ordinary epidermal cells. The pairs of guard cells are elliptical, sunken, 20–25 µm long and 12–18 µm wide. The stomatal complexes have different dimensions depending on the degree to which the leaf was developed, ranging from 38–68 µm long and 40–70 µm wide. Polar subsidiary cells are 15–40 µm long and 12–20 µm wide. Each stomatal complex usually consists of 2–3 lateral subsidiary cells that are 40–60 µm long and 16–28 µm wide. The transverse outer stomatal cavity is strongly cutinised, 20–30 µm long and 20–35 µm wide. The stomatal density is approximately 270 per mm^2 in the stomatiferous bands and about 230 per mm^2 throughout the entire leaf area. The stomatal index in the stomatiferous bands varies from 10 to 25, depending on the degree of development of the leaves (see Table 5).

D i s c u s s i o n : Cuticles of *Cordaites dobranensis* are highly variable. The adaxial cuticle is without stomata, or with stomata dispersed in infrequent and poorly defined stomatal rorws, and the stomatal density is very low. A similar occurrence of stomata on the adaxial cuticle is known from *Cordaites schatzlarensis* from Cuticular Group B. The abaxial cuticle of *Cordaites dobranensis* resembles that of the species *Cordaites borassifolius*. However, *Cordaites dobranensis* has reniform lateral subsidiary cells, and its polar cells are much larger. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites wilkischensis sp. nov.

Text-figs 32 a–i, Pl. 3, fig. 10, Pl. 32, figs 4–7, Pls 33, 34, figs 1–5

2000 *Cordaites* sp. Šimůnek, p. 32, figs 3: 24, 3: 25.
2001 *Cordaites* sp. (morphotype 24 and 25 sensu Šimůnek 2000) Šimůnek, p. 86–88, figs 38 a–ch, pl. 3, fig. 10, pl. 32, fig. 4–7, pls 33, 34, figs 1–5.

H o l o t y p e : designated here, Czech Geological Survey, Prague, inv. No. ZŠ 239, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the German name of the type locality, Wilkischen (Vlkýš).

T y p e l o c a l i t y : Heřmanova Huť – Vlkýš, Plzeň Basin.

T y p e h o r i z o n : Kladno Formation; Nýřany Member, Asturian, Westphalian D.

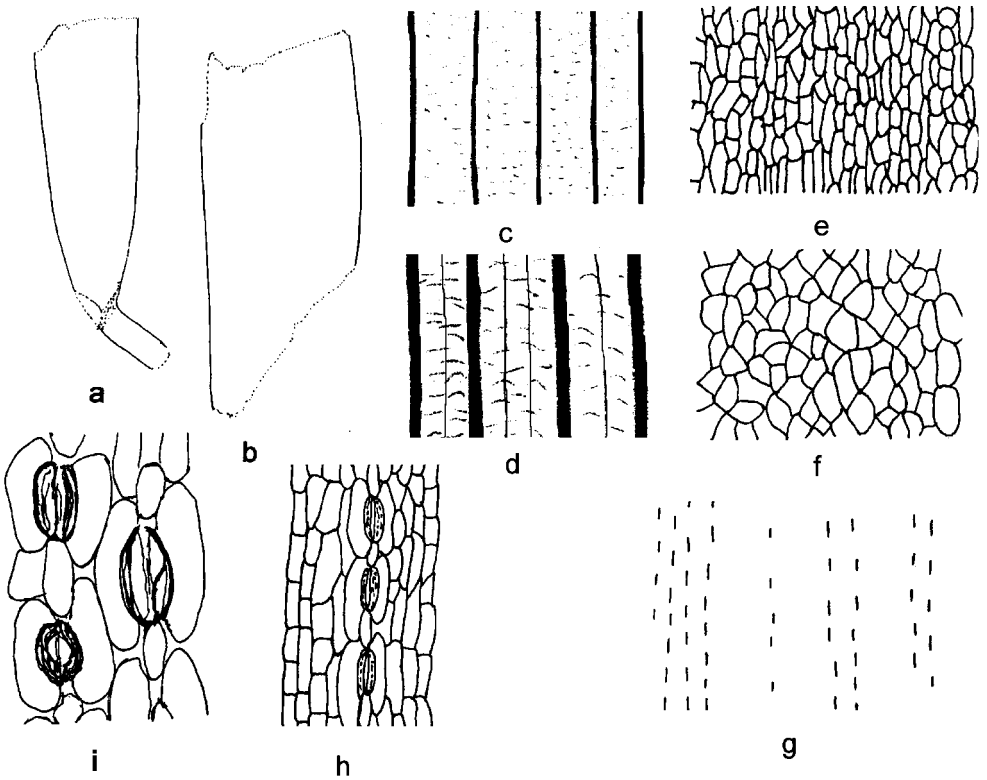
M a t e r i a l : 2 specimens from Heřmanova Huť, Nos: ZŠ 94 and ZŠ 239.

D i a g n o s i s : Relatively large, hypostomatic, lanceolate leaves with inferquent venation, 1–2 very indistinct thin veins per thick vein. Adaxial cuticle with isodiametric polygonal cells, abaxial cuticle with stomata arranged into well defined stomatal rows joined into stomatiferous bands. Lateral subsidiary cells are elongate, reniform.

D e s c r i p t i o n : The holotype is a leaf fragment more than 180 mm long and 53 mm wide, but only 15 mm wide near the base. The venation is relatively infrequent, at 24–26 veins per cm. The thin veins are indistinct. Only transverse wrinkles and ridges are visible. Other relatively large leaf fragments are more than 20 cm long and 50–75 mm wide. The venation is parallel and relatively rare, with 20–26 thick veins per cm in the middle of the leaf and about 26 thick veins per cm near the margin. The thin veins are discernible only in parts of the larger leaves where 2–3 of them occur between two thick veins. The leaf surface contains wrinkles. In the narrow leaves, the thin veins are not discernible towards the base, where only transverse wrinkles and ridges are visible. The leaves are hypostomatic.

Adaxial cuticle (Text-figs 32e–f, Pl. 32, figs 4–7, Pl. 34, fig. 5): The cells of the costal and intercostal fields are distinct. The intercostal cells are randomly oriented, isodiametric, polygonal, and measure 25–44 μm in diameter. The anticlinal walls are usually straight. The costal cells are oriented parallel to the veins; they are oblong, 25–60 μm long and 12–25 μm wide.

Abaxial cuticle (Text-figs 32h–i, Pl. 33, figs 1–7, Pl. 34, figs 1–4): The cells are differentiated into stomatiferous (intercostal) and non-stomatiferous (costal) bands. The stomatiferous bands contain only stomatal complexes and small, oblong, square or oval cells, 20–30 μm long and 15–20 μm wide. Their anticlinal walls are usualy strongly arched. The costal cells are elongated and of tetragoal shape. They are 25–90 μm long and 12–20 μm wide. The stomatal complexes in the stomatiferous (intercostal) bands are usually arranged in double to pentamerous well defined stomatal



Text-fig. 32. *Cordaites wilkischensis* sp. nov., Heřmanova Huť – Vlkýš, layer No. 12, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D), slide No. 327/1-5, 330/1-5, a – leaf outline, material to slides No. 327/1-5, ×0.25, b – leaf outline, material to slides No. 330/1-5, ×0.25, c – leaf venation, from fig. a, ×20, d - leaf venation, from fig. b, ×20, e – adaxial cuticle, slide No. 327/3, ×125, f – adaxial cuticle, slide No. 330/4, ×200, g – distribution of stomata on abaxial cuticle, slide No. 327/3, ×50, h – abaxial cuticle with stomatal rows, slide No. 327/3, ×125, i – abaxial cuticle with stomatal rows, slide No. 330/4, ×250.

rows, though they rarely occur also in single rows. They are oriented parallel to the veins. Neighbouring stomatal rows are usually somewhat shifted. The pairs of sunken, elliptical guard cells are surrounded by two oval or rhomboidal polar subsidiary cells and two elongate kidney-shaped lateral subsidiary cells. The polar cells are often common to two stomata, and the lateral subsidiary cells of the neighbouring rows are in contact. The guard cell pairs are 28–40 μm long and 18–22 μm wide. The stomatal complexes (including subsidiary cells) are 90–120 μm long and 50–60 μm wide. The polar subsidiary cells are 20–40 μm long and 13–18 μm wide. The lateral subsidiary cells are 52–80 μm long and 12–18 μm wide. The strongly cutinised proximal walls of the subsidiary cells are very distinct. The stomatal density is about 150 per mm^2 in the leaf blade, though the stomatal density in the stomatiferous bands is 300–350 per mm^2. The stomatal index in the leaf blade is about 10, while that of the stomatiferous bands about 20.

D i s c u s s i o n : *Cordaites wilkischensis* and *Cordaites malesicensis* are the only hypostomatic species known from this cuticular group. The adaxial cuticle of both species differs considerably. *Cordaites wilkischensis* has isodiametric polygonal cells, whereas *Cordaites malesicensis* has elongated, oblong cells. *Cordaites wilkischensis* differs from other species of this group by having very elongated, reniform lateral subsidiary cells of the guard cells. The proximal cell walls of the lateral subsidiary cells are strongly cutinised and form a sort of crypt that is also characteristic of this species. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites malesicensis sp. nov.

Text-figs 33a–e, Pl. 3, fig. 12, Pl. 34, figs 6–8, Pl. 35, figs 1–3

2000 *Cordaites* sp. Šimůnek, p. 32, figs 4: 28.
2001 *Cordaites* sp. (morphotype 28 sensu Šimůnek 2000), Šimůnek, p. 88–90, figs 39a–e, Pl. 3, fig. 12, Pl. 34, figs 6–8, Pl. 35, figs 1–3.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 240, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Malesice unit, which includes the Mšec Members.

T y p e l o c a l i t y : Slaný, Slaný Mine, Kladno-Rakovník Basin.

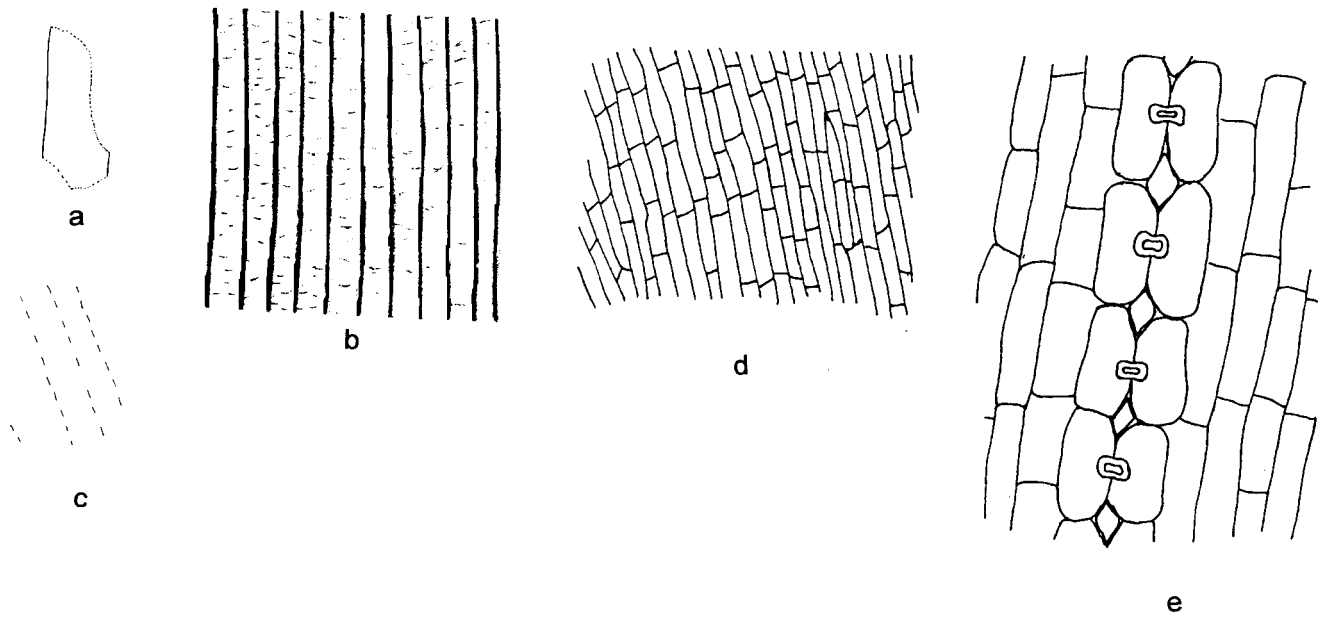
T y p e h o r i z o n : Slaný Formation; Mšec Member, Stephanian B.

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Hypostomatic leaves with relatively dense venation. Thin veins are indiscernible. Adaxial cuticle with oblong cells, abaxial cuticle with stomata arranged into well defined stomatal rows joined into stomatiferous bands. The lateral cells are oblong, the polar cells rhomboidal, characteristic transverse crypt.

D e s c r i p t i o n : The holotype is a leaf fragment 80 mm long and 40 mm wide. The venation is relatively dense, there being 48 thick veins per cm in the centre and 44 thick veins per cm near the leaf margin. No thin veins are visible. The leaf surface is finely wrinkled (perhaps due to corrosion). The leaf is hypostomatic.

Adaxial cuticle (Text-fig. 33d, Pl. 34, fig. 6): The adaxial cuticle is weakly cutinised. The cells slightly differ in the



Text-fig. 33. *Cordaites malesicensis* sp. nov. Slaný, Slaný Mine, Kladno-Rakovník Basin, Slaný Formation, Mšec Member, Stephanian B, Slide No. 165/1-3. a – leaf outline, ×0.25, b – leaf venation, ×20, c – distribution of stomata on abaxial cuticle, ×50. d – adaxial cuticle, ×100, e – abaxial cuticle with stomatal row, ×250.

costal and intercostal fields. The intercostal cells are oblong, 60–120 μm long and 16–25 μm wide. They are oriented parallel to the veins. The anticlinal walls are straight. The costal cells are oblong to trapezoidal, 60–160 μm long and 15–20 μm wide.

Abaxial cuticle (Text-fig. 33e, Pl. 34, figs 7 and 8, Pl. 35, figs 1–3): The cells are differentiated into non-stomatiferous (costal) bands and stomatal rows (intercostal) forming stomatiferous bands. Most of the cells in the stomatal rows (bands) belong to stomatal complexes. There are, however, some small oblong cells situated among the stomatal complexes. The anticlinal walls are staight. The costal cells are elongated and oblong, ranging from 40–100 μm long and 12–22 μm wide. The stomatal complexes are arranged in single to triple stomatal rows that form stomatiferous bands. The pairs of guard cells are oriented parallel to the veins; they are sunken, elliptical, surrounded by two polar subsidiary cells of rhomboidal, oval, or lenticular shape, and by two oblong lateral subsidiary cells that are 30–40 μm long and 14–20 μm wide. The pairs of guard cells are about 30 μm long and about 22 μm wide. The stomatal complexes (including the subsidiary cells) are 55–65 μm long and 45–55 μm wide. The polar subsidiary cells are 15–20 μm long, 8–10 μm wide, and are often common to two neighbouring stomata within a row. The outer stomatal cavity is small, oblong, and not prominent. The stomatal density is about 280–290 per mm^2 of leaf surface. The stomatal index is about 18.

D i s c u s s i o n : *Cordaites malesicensis* and *Cordaites wilkischensis* are the only known hypostomatic species of this cuticular group. *Cordaites malesicensis* has elongated, oblong cells, whereas *Cordaites wilkischensis* has isodiametric polygonal cells. The oblong shape of latreral subsidiary cells as in *Cordaites malesicensis* is uncommon in this cuticular group, occurring also only in *Cordaites borassifolius, C. melnicensis* and *C. touskovensis*. *Cordaites borassifolius* has much wider lateral subsidiary cells, while the other species of this cuticular group have other cell shapes. The transverse crypt is also typical of *Cordaites malesicensis*. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites melnicensis sp. nov.

Text-figs 34 a–f, Pl. 3, fig. 13, Pl. 35, figs 4–6, Pls 36, 37, figs 1–3

2000 *Cordaites* sp. Šimůnek, p. 32, figs 4: 29.
2001 *Cordaites* sp. (morphotype 29 sensu Šimůnek 2000), Šimůnek, p. 90–93, figs 40 a–f, Pl. 3, fig. 13, Pl. 35, figs 4–6, Pl. 36, 37, fig. 1–3.

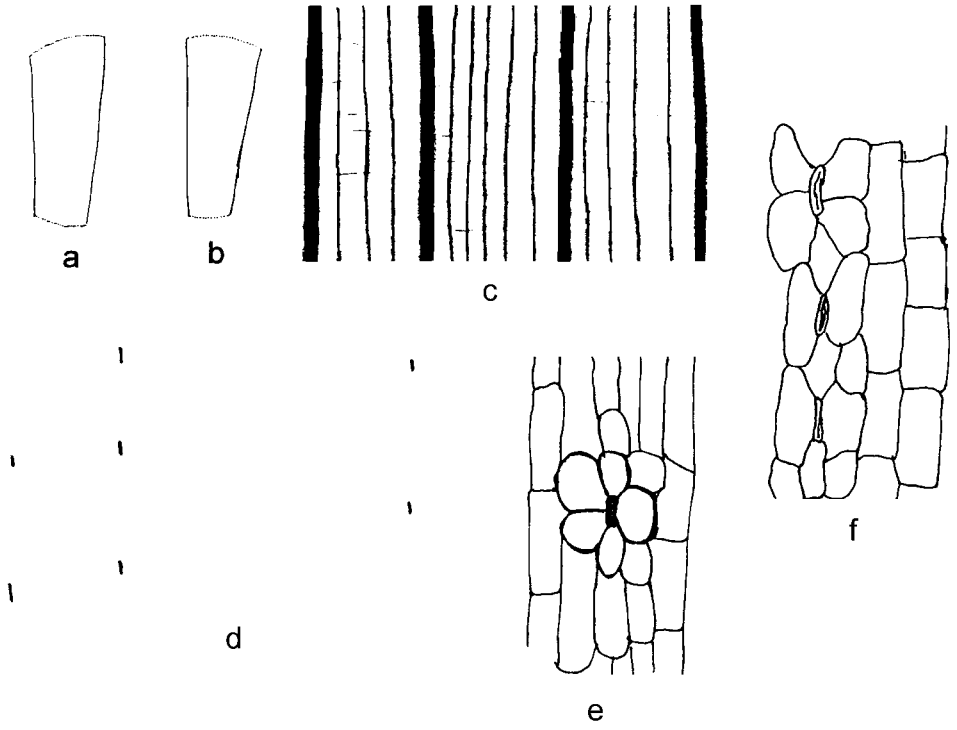
H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 241, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Mělník Coals, the stratigraphical type unit.

T y p e l o c a l i t y : Sušno, Sš 1 borehole, depth 724.9 m, Mšeno-Roudnice Basin.

T y p e h o r i z o n : Slaný Formation; Jelenice Member, Mělník Coals, Stephanian B.

M a t e r i a l : Only one specimen – the holotype (part and counterpart).



Text-fig. 34. ***Cordaites melnicensis*** **sp. nov., Sušno, borehole Sš 1, depth 724.9 m, Mšeno-Roudnice Basin, Slaný Formation, Jelenice Member, Mělník Group of coals, Stephanian B, slide No. M9/1-2. a, b – leaf outlines, ×0.25, c – leaf venations, ×20, d - distribution of stomata on adaxial cuticle, ×50, e - adaxial cuticle with stoma, ×200, f - abaxial cuticle with stomatal row, ×200.**

D i a g n o s i s : Amphistomatic leaves with infrequent venation, 3–5 thin veins alternate with each thick vein. Adaxial cuticle with oblong cells and stomata in very infrequent stomatal rows, abaxial cuticle with oblong, trapezoidal or polygonal cells, stomata in well defined stomatal rows forming a stomatiferous band. There are 2 oval, polygonal to lenticular polar and 2 oblong or trapezoidal lateral subsidiary cells.

D e s c r i p t i o n : The holotype is a leaf fragment 85 mm long and 35 mm wide. Its margins are non-parallel. Venation is relatively infrequent, there being 12–14 veins per cm in the center, and about 12 per cm near the leaf margin. One thick vein alternates with 3–5 thin veins. The thickness of the thick veins varies. The tranverse wrinkles are very prominent.

Adaxial cuticle (Text-fig. 34e, Pl. 35, figs 4–6, Pl. 36, figs 1–5, 8): The cells of this cuticle are differentiated into dark (intercostal) and non-stomatiferous (costal) bands. Their difference in shape is, however, slight. Intercostal cells are oblong, oriented parallel to the veins, 28–80 μm long and 8–15 μm wide. Their anticlinal walls are straight. The costal cells are elongated, oblong, 32–100 μm long and 10–20 μm wide. The stomatal complexes occur in very infrequent stomatal rows, which are either 200 or 600 μm apart. Each two rows are thus considerably separated. The stomatal complexes (see Pl. 35, figs 4, 5) within a single stomatal row are 100–250 μm apart. Stomata are oriented parallel to the veins, and they are formed by a pair of sunken, elliptical guard cells, two polar subsidiary cells of various shapes (rhomboidal, trapezoidal, oblong or oval), and two to three lateral subsidiary cells that are wide, oblong, pentagonal, or oval. They are strongly rounded at the corners, and very similar to the polar cells. The pairs of guard cells are 17–23 μm long and 10–15 μm wide. The stomatal complexes (including subsidiary cells) are 55–70 μm long and 40–55 μm wide. The polar subsidiary cells are 25–32 μm long and 12–16 μm wide. The lateral subsidiary cells are 25–30 μm long (though exceptionally up to 40 μm) and 18–28 μm wide. The outer stomatal cavity (crypt) has the shape of a narrow slit. It is formed by the strongly cutinised proximal walls of the lateral subsidiary cells. The stomatal density is only 8 to 9 per mm^2. The stomatal index varies from 1 to 1.4.

Abaxial cuticle (Text-fig. 34f, Pl. 36, figs 6 and 7, Pl. 37, figs 1–3): The cells are differentiated into stomatiferous (intercostal) and non-stomatferous (costal) bands. Most of the cells of the stomatiferous bands belong to the stomatal complexes. Those that do not are ordinary cells similar to costal cells, among which very short square to oval cells also occur. Intercostal cells are oriented parallel to the veins; they are oblong, trapezoidal or polygonal, 30–80 μm long and 18–28 μm wide. The anticlinal walls are usually bent. The costal cells are usually oblong, 35–65 μm long and 15–20 μm wide. The stomatal complexes are arranged in 3 to 5 indistinct stomatal rows, forming a band. Each stomatal complex is formed by a pair of sunken elliptical guard cells, two oval, elongated, polygonal, or lenticular polar subsidiary cells, and 2–3 tetragonal, (oblong, or trapezoidal) lateral subsidiary cells, similar to those of the costal band. The guard cell pairs are 25–32 μm long and 12–15 μm wide. The stomatal complexes (including subsidiary cells) are 42–50 μm wide and 80–95 μm long. The polar subsidiary cells are 25–40 μm long and 17–22 μm wide. The lateral subsidiary cells are 50–70 μm long and 17–22 μm wide. The proximal walls of the lateral subsidiary cells constrict the outer stomatal cavity above the guard cells, though their walls are slightly cutinised. The stomatal density is about 150 per mm^2 of leaf blade. The stomatal index varies from 10 to 12.

D i s c u s s i o n : The species *Cordaites melnicensis* differs from all others of this cuticular group by having stomata on the adaxial cuticle arranged in very infrequent, dark stomatal rows. The stomata are surrounded by 4–6 rounded to oval subsidiary cells, which are distinct from those of all other species of this cuticular group. The stomata of the abaxial cuticle are arranged relatively densely in stomatal rows joined into stomatiferous bands. The shapes of the lateral subsidiary cells of *Cordaites melnicensis* are mostly trapezoidal or oblong, and resemble the oblong or irregular cells of *Cordaites touskovensis*. However, the shapes of the latter are more irregular. It seems that the crypt is not developed in *Cordaites touskovensis*, just as with *Cordaites odolovensis* and maybe even *C. touskovensis*. For a detailed comparison, see the discussion of the entire group beginning on page 141, and Table 6.

Cordaites touskovensis sp. nov.

Text-figs 35a–d, Pl. 3, fig. 11,
Pl. 37. figs 4–6, Pl. 38, fig. 1

2001 *Cordaites* cf. *"principalis"* (Germar) Geinitz; (morphotype 37 – new morphotype) Šimůnek p. 93–95, figs 35a–d, pl. 3, fig. 11, pl. 37. figs 4–6, pl. 38, fig. 1.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 242, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Touškov Coals, the type stratigraphical unit.

T y p e l o c a l i t y : Krašovice, borehole Kš 1, depth 368.65 m, Plzeň Basin.

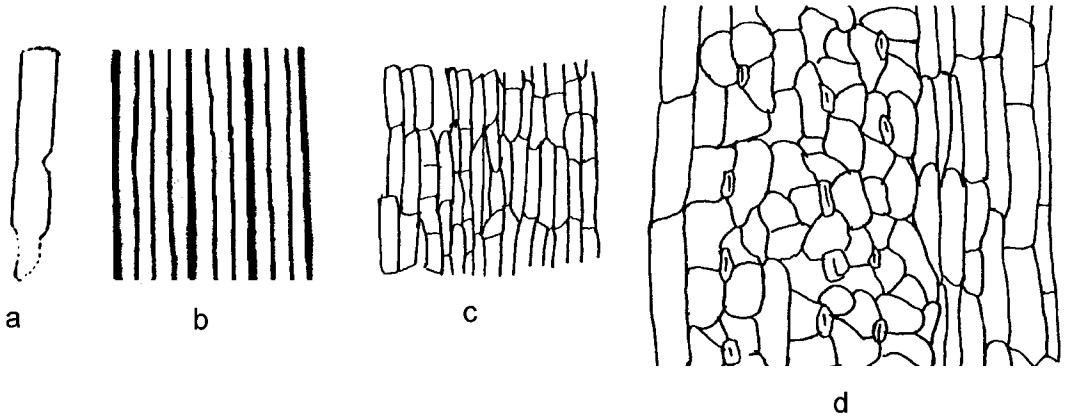
T y p e h o r i z o n : Kladno Formation; Nýřany Member, Touškov Coals, Asturian (Westphalian D).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Amphistomatic, small, narrow leaves with medium-dense venation, 2–3 indistinct thin veins alternating with each thick vein. Adaxial cuticle with tetragonal cells, stomata irregularly dispersed, abaxial cuticle with longitudinally oblong cells, stomata in stomatal rows forming stomatiferous bands.

D e s c r i p t i o n : The holotype is a leaf fragment about 6 cm long and 9 mm wide. Its margins are nearly parallel. The thick veins are prominent and numerous, there being 28–30 veins per cm. There are 2 to 3 indistinct thin veins between each two thick veins. A fine transverse striation in the areas among the thick veins is noticeable. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 35c, Pl. 37. figs 4–5): The cuticles are not very well preserved. The ordinary cells of the stomatiferous (intercostal) bands partly differ in their dimen-



Text-fig. 35. ***Cordaites touskovensis*** **sp. nov., Krašovice, borehole Kš 1, depth 368.65 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Group of coals. Asturian (Westphalian D), slide No. 260/1-3. a – leaf outline, ×0.54, b – leaf venation, ×22, c – adaxial cuticle, ×108, d – abaxial cuticle with stomata, ×216.**

sions from the cells of the non-stomatiferous (costal) bands. The cells are tetragonal and usually oblong, with straight or only slightly bent anticlinal walls, and their sizes range between 35–70 μm long and 12–18 μm wide. Their orientation is parallel to the veins. The dark spots in the cuticle probably represent the stomatal complexes (see Pl. 37, fig. 4). The guard cells are not discernible due to poor preservation, and the shape of the polar cells is likewise not observable. The stoma probably have two oval or oblong lateral subsidiary cells with rounded corners, 40–50 μm long and about 15 μm wide. The supposed stomatal density is about 15 per mm^2. The stomatal index would be about 1.8 to 2.

Abaxial cuticle (Text-fig. 41d, Pl. 37. fig. 6, Pl. 38, fig. 1): The abaxial cuticle is very weakly cutinised. The cells are differentiated into non-stomatiferous (costal) and stomatiferous (intercostal) bands. Both bands are very prominent, as they occur in different optical levels. The cells of the non-stomatiferous bands probably bulge outward while those of the stomatiferous bands are sunken. The costal bands are about 100 μm wide. The widths of the stomatal bands vary between 150 and 250 μm. The cells of the non-stomatiferous bands are longer than those of the stomatiferous bands. The cells are elongated, oblong in shape, 40–100 μm long and 10–18 μm wide. The anticlinal walls are usually straight. The cells are oriented parallel to the veins. The stomatal complexes are arranged into stomatal rows that are separated by ordinary epidermal cells within the stomatiferous bands. The pairs of guard cells are usually not observable; they are strongly sunken and surrounded by two oblong (sometimes also irregular) lateral subsidiary cells and two oblong polar cells that are oriented transversely to the guard cells (see Pl. 38, fig. 1). The lateral subsidiary cells are 35–40 μm long and 15–20 μm wide. The polar subsidiary cells are 25–35 μm long and around 15 μm wide. The narrow outer stomatal cavity (crypt) is developed above the guard cells, and represents the more cutinised proximal walls of the lateral subsidiary cells towards the center of stoma. The stomatal density within the stomatiferous bands is about 110 per mm^2. The stomatal index is not estimated due to the bad state of preservation.

Discussion: The adaxial cuticle of *Cordaites touskovensis* is poorly preserved. The stomata of the adaxial cuticle are seen only as dark spots, precluding any comparison with other adaxial cuticles. The abaxial cuticle of *Cordaites touskovensis* has lateral subsidiary cells that are oblong or irregular, thus distinguishing it from all other species of this cuticular group. For a detailed comparison, see the discussion of the entire group beginning on this page and Table 6.

Discussion of Group C

Cuticular Group C contains nine species. Most of them are amphitomatic, while only two are hypostomatic (*Cordaites wilkichensis* and *C. malesicensis*). The common characteristic of this group is the presence of stomatiferous bands composed of well defined stomatal rows on the abaxial cuticle. The structure of the stomatal complexes on the abaxial cuticle is the same as in Group B: two large lateral cells and two small polar cells.

An adaxial cuticle without stomata occurs in *C. wilkischensis*. The cells are isodiametric, polygonal, and randomly oriented. Similar cells do not occur in any other species of this group. *C. malesicensis* has oblong cells on its adaxial cuticle. The abaxial cuticle of *C. wilkischensis* has oval polar cells and narrow reniform lateral cells, while that of *C. malesicensis* has oblong lateral cells and rhomboidal polar cells.

The stomata of *C. borassifolius*, *C. odolovensis*, *C. touskovensis* and *C. svatonovicensis* are dispersed among the cells of the adaxial cuticle. These species have very low stomatal densities. The abaxial cuticles of these species differ mainly in the shapes of the subsidiary cells, and also in the presence and the shape of the outer stomatal cavity (crypt). *C. borassifolius* has very wide, oblong to reniform lateral subsidiary cells, and small rounded polar cells. *C. odolovensis* also has irregular, large, bean-shaped or nearly oblong lateral subsidiary cells, and two small rounded polar cells. *C. touskovensis* has subsidiary cells that are mostly irregular, sometimes oblong, and its polar and lateral cells are approximately of the same shape. The stomata of *C. svatonovicensis* have square, oblong, oval to rhomboidal polar, and elongated hexagonal to octagonal lateral sub-

Table 6. Important diagnostic features of the species from *Cordaites* cuticular group C.

Species	*Cordaites svatonovicensis*	*Cordaites odolovensis*	*Cordaites borassifolius*	*Cordaites raconicensis*	*Cordaites touskovensis*	*Cordaites dobranensis*	*Cordaites wilkischensis*	*Cordaites melnicensis*	*Cordaites malesicensis*
Leaves	? Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic	?Amphistomatic	Amphistomatic	Hypostomatic	Amphistomatic	Hypostomatic
Adaxial cuticle									
Difference between stomatiferous and non-stomatiferous bands	–	–	–	–	–	–	+	+	–
Cell shape of stomatiferous bands	Oblong	Oblong	Tetragonal - oblong, square	Longitudinally tetragonal, oblong	Tetragonal (oblong)	Oblong, penta- to hexagonal	Isodiamertic, polygonal	Oblong	
Size of stomatiferous cells (µm)	(35-100) x (15-25)	(45-95) x (15 - 28)	(30-75) x (20 - 35)	(50-125) x (12-28)	(35-70) x (12-18)	(20-80) x (15-30)	25 - 44 (in diameter)	(28-80) x (8-15)	
Cell shape of non-stomatiferous bands	Longitudinally oblong	Oblong	Tetragonal - oblong	Longitudinally tetragonal	Tetragonal (oblong)	Longitudinally oblong	Oblong	Oblong	Oblong
Size of non-stomatiferous cells (µm)	(40-110) x (15-30)	(45-95) x (15 - 28)	(30-75) x (20 - 35)	(50-125) x (12-28)	(35-70) x (12-18)	(35-150) x (10-20)	(25-60) x (12-25)	(32-100) x (10-20)	(60-120) x (16-25)
Stomata – Distribution	Irregularly in stomatiferous band	Dispersed	Irregularly dispersed	In ill-defined stomatal rows	Dispersed (dark spots)	Rare stomatal rows	–	In very rare stomatal rows	–
Stomata – Density per 1 mm^2	? cca 25	cca 14	6 - 9	57	15	0-14	–	8	–
Stomata – Stomatal index		1.8 - 2.2	0.7 - 0.9	5 - 6	1.8 - 2	0.75 - 1	–	1 - 1.4	–
Stomata – Length and width of guard cells (µm)	(30-40) x (25-35)	(22-26) x (13-16)	(22-26) x (13-16)	(25-35) x (20-25)	?	(22-25) x (25-30)	–	(17-23) x (10-15)	–
Subsidiary cells – Polar – Number and shape	2(3); longitudinally oblong	2; oblong	2; prominent, oval	2; rhomboidal	?	2; oblong, rhomboidal	–	2; rhomboidal, trapezoidal	–
Subsidiary cells – Polar – Size (µm)	(35-50) x (15-25)	(25-35) x (15-20)	20-30 (in diameter)	(15-25) x (10-15)	?	(20-40) x (15-25)	–	(25-32) x (12-16)	–
Subsidiary cells – Lateral – Number and shape	2 (3); longitudinally oblong	2; oblong, strongly cutinised	2; prominent, oblong	(?2-4); kidney-shaped	2; oblong or oval	2; oblong	–	2-3; wide oblong, pentagonal, rounded	–
Subsidiary cells – Lateral – Size (µm)	(35-100) x (15-25)	(45-55) x (15-18)	(34-50) x (16-25)	(60-70) x (15-20)	(40-50) x (15)	(50-70) x (15-25)	–	(25-30 (40)) x (18-28)	–
Subsidiary cells – Shape of crypt	–	–		Strongly cutinised, ?circular	–	Prominent, circular	–	Only narrow slit	–
Abaxial cuticle									
Difference between stomatiferous and non-stomatiferous bands	+	+	+	+	+	+	+	+	+
Cell shape of stomatiferous bands	Oblong, penta- to hexagonal	Small, rounded	Only stomatal complexes	Only stomatal complexes	Longitudinally oblong	Irregualar, tetra- to pentagonal, oblong, square	Small oblong, square to oval cells	Oblong, trapezoidal, polygonal	Only stomatal compllexes
Size of stomatiferous cells (µm)	(25-60) x (12-24)	12-18 in diameter	–	–	(40-80) x (10 - 18)	(20-40) x (10 - 15)	(20-30) x (15-20)	(35-80) x (18-28)	–
Cell shape of non-stomatiferous bands	Longitudinally oblong	Longitudinally oblong	Longitudinally oblong (tetragonal)	Oblong	Longitudinally oblong	Oblong	Longitudinally tetragonal (oblong)	Oblong	Longitudinally oblong
Size of non-stomatiferous cells (µm)	(40-85) x (15-30)	(40-85) x (12-18)	(35-110) x (15-30)	(40-80) x (10-18)	(40-100) x (10 - 18)	(35-120) x (10-25)	(25-90) x (12-20)	(35-40) x (15-20)	(40-100) x (12-22)
Stomata – Distribution	Stomatiferous bands - 1-3 stomatal rows	Stomatiferous bands with 4-5 stomatal rows	Stomatiferous bands	Stomatiferous bands	Stomatiferous bands with 3-5 stomatal rows	Stomatiferous bands - up to 5 stomatal rows	Stomatiferous bands - 2-5 stomatal rows	Stomatiferous bands - 3-5 stomatal rows	Stomatiferous bands - 1-3 stomatal rows
Stomata – Density per 1 mm^2	130-160	416 (530 in stomat. band)	350-370	390	110	230-270 (in stomat. bands)	–	150	280-290
Stomata – Stomatal index		18 – 20 (in stomat. band)	16-20	17	?	10-25 (in stom. bands)	–	10 - 12	18
Stomata – Shape of guard cells	Elliptical	Elliptical	Elliptical	Elliptical	?	Elliptical	–	Elliptical	Elliptical
Stomata – Length and width of guard cells (µm)	(26-32) x (18-24)	(14–20) x (10–15)	(22-26) x (12-16)	(15-20) x (8-15)	?	(20-25) x (12-18)	(28-40) x (18-22)	(25-32) x (12-15)	30 x 22)
Subsidiary cells – Polar – Number and shape	2(3); square, oblong, oval to rhomboidal	2; rounded	2; rounded	2; square	2 (3); oblong or irregular	2; rhomboidal, square to oval	2; oval (rhomboidal)	2; oval, polygonal, lenticular	2; rhomboidal
Subsidiary cells – Polar – Size (µm)	(15-25) x (10-15)	10 – 15 (in diameter)	15 – 20 (in diameter)	10 x 10	(25-35) x (15)	(15-40) x (12-20)	(20-40) x (13-18)	(25-40) x (17-22)	(15-20) x (8-10)
Subsidiary cells – Lateral – Number and shape	2(3); usually elongated, hexa- to octagonal	2; bean-shaped (oblong)	2; oblong to kidney-shaped	0	2 (3); oblong or irregular	2(3);oblong to reniform	2; reniform	2; tetragonal (oblong, trapezoidal)	2; oblong
Subsidiary cells – Lateral – Size (µm)	(40-50) x (10-15)	(32-42) x (18-24)	(40-50) x (20-28)	–	(35-40) x (15-20)	(36-60) x (12-28)	(52-80) x (12-18)	(50-70) x (17-22)	(30-40) x (14-20)
Subsidiary cells – Shape of crypt	Strongly cutinised, transverse oval	–	Transverse oval, constricted in the centre	Florin ring-shape	Narrow, elongated, proximal parts of lateral cells strongly cutinised	Transverse oval, constricted in the centre, strongly cutinised	Proximal cell walls strongly cutinised	–	Transverse oblong

Remark: When subidiary cells are not distinguished from ordinary epidermal cell – their number = 0

sidiary cells. This species has a prominent oval crypt. The crypt of *C. borassifolius* is also very prominent; it is of a transverse oval shape, and is constricted in the centre.

The species *C. dobranensis* seems to be intermediate between the species without stomata on their adaxial cuticle and those with stomata in incomplete, infrequent, poorly defined stomatal rows. This is similar to the case of *C. schatzlarensis* in Cuticular Group B. The abaxial cuticle of this species resembles that of *C. borassifolius. C. dobranensis* has square, oval or rhomboidal polar cells, and mostly reniform (or oblong) lateral subsidiary cells. The crypt is also often of a transverse oval shape, and constricted in the centre.

The species *C.malesicensis* and *C. raconicensis* have the stomata on their adaxial cuticle arranged into poorly defined, infrequent stomatal rows. The polar and lateral subsidiary cells of *C. melnicensis* are mostly rounded, while the polar cells of *C. raconicensis* are rhomboidal and its lateral cells are narrow and reniform. Their abaxial cuticles also differ. *C. melnicensis* has oval, polygonal lateral cells, whereas the cellular pattern of *C. raconicensis* features square polar cells, the lateral ones of which are of the same shape as ordinary cells, and a prominent, rounded crypt of Florin ring morphology.

Group D
(cells of stomatiferous bands differing from those of the non-stomatiferous bands, stomatal rows poorly defined)

Cordaites kladnoensis sp. nov.

Text-figs 36a–i, Pl. 3, fig. 14, Pl. 38, figs 2–6, Pls 39, 40, figs 1–3

2000 *Cordaites* sp. Šimůnek, p. 32, figs 2: 8.

2001 *Cordaites* sp. (morphotype 8 sensu Šimůnek 2000) Šimůnek, p. 95–98, figs 42a–k, pl. 3, fig. 14, pl. 38, fig, 2–6, pls 39, 40, figs 1–3.

Holotype: Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 204, coll. Z. Šimůnek.

Derivation of name: From the Kladno Formation, in which this species occurs.

Type locality: Tuchlovice, Nosek Mine, Kladno-Rakovník Basin.

Type horizon: Kladno Formation; Radnice Member, Radnice Coals, interbeds of the Main Kladno coal seam, Bolsovian (Westphalian C).

Material: 3 leaf fragments from Tuchlovice, Nos. ZŠ 204, ZŠ 243 and ZŠ 244.

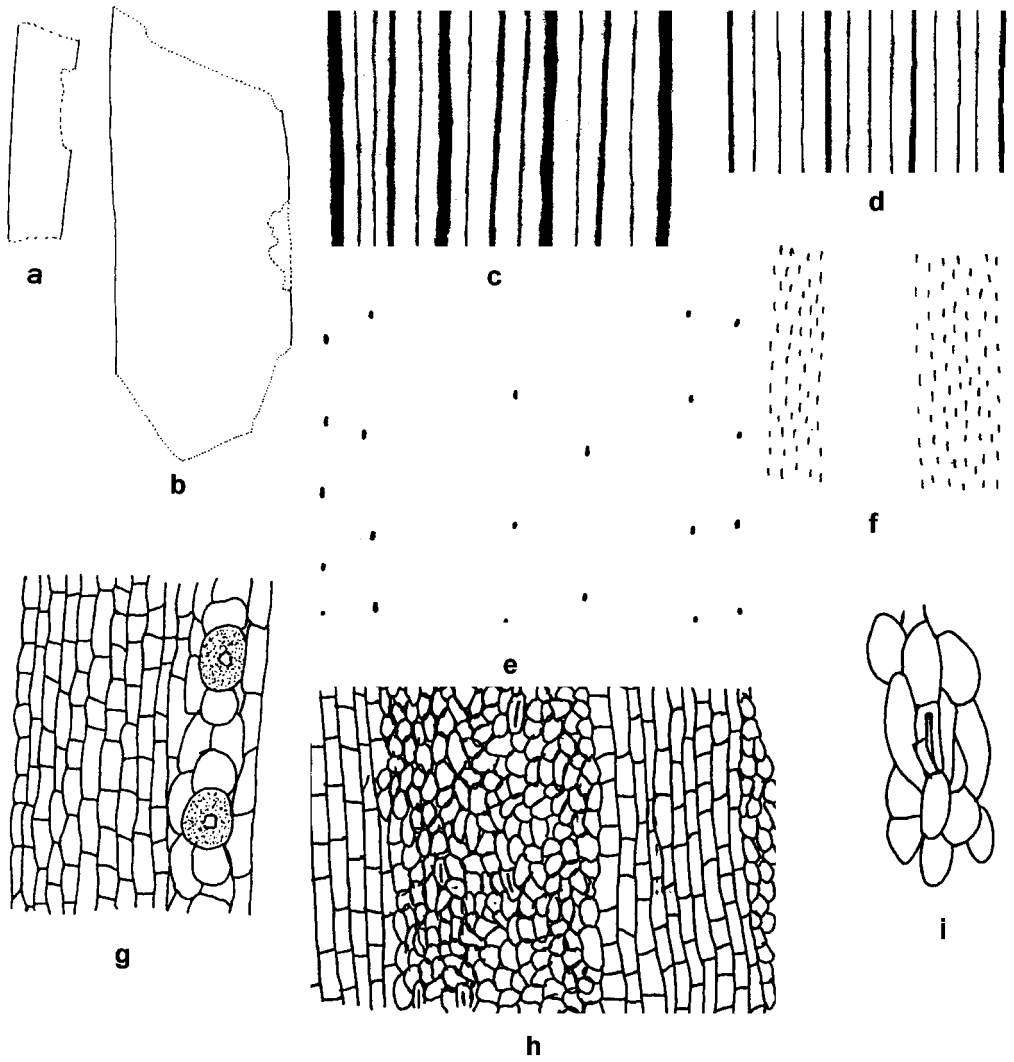
Diagnosis: Amphistomtic, large, lanceolate leaves with infrequent venation, 2–7 thin veins alternate with each thick vein. Cells of adaxial cuticle oblong, stomata in infrequent stomatal rows, crypt very prominent. Cells of abaxial cuticle oval to irregularly pentagonal, stomata in stomatiferous bands without discernable stomatal rows.

Description: The holotype is a leaf fragment 185 mm long and 30 mm wide, with nearly parallel margins. The venation is rare, being 12 thick veins per cm. The thin veins are indistinct.

The leaf fragments are up to 230 mm long, and have nearly parallel margins. The leaf width is 30–90 mm. The venation density varies from 10 to 22 thick veins per cm. The venation is denser in broader leaves and towards the center of a leaf, and its pattern is highly variable. On narrow leaves the thin veins are only slightly discernable. Three different vein thicknesses are occasionally observable. This might be explained by the superposition of two sides of a leaf. Such leaves can have 4–7 thinner veins between two thicker veins. The broadest leaves generally have thin veins and thicker veins that are yet relatively thin. Only 2–3 thin veins occur between each two thicker veins. The leaves are amphistomatic, and the cuticle tends to disolve into strips after maceration.

Adaxial cuticle (Text-figs 36g, Pl. 38, figs 2–6, Pl. 39, fig. 3, Pl. 40, figs 2–3): The adaxial cuticle is weakly cutinised. The cells of the costal and intercostal bands are distinct. Those of the intercostal area form dark, strongly cutinised strips. The intercostal cells are square to oblong, 30–60 μm long and 10–20 μm wide. The anticlinal walls are straight, but rounded at the corners. They are oriented parallel to the veins, just as the costal cells. The costal cells are oblong, 40–70 μm long and 10–25 μm wide. One or two poorly defined stomatal rows are developed in the stomatiferous (intercostal) band. Their orientation is parallel to the veins. The dimensions of guard cells are difficult to estimate, as they are sunken and overlapped. The stomatal complexes (two polar and two lateral cells) are 25–30 μm in diameter. The polar and lateral subsidiary cells are of the same shape, rounded, very darkly coloured, and 10–15 μm in the diameter. They are very compactly arranged, so that the anticlinal walls between them are only slightly discernible. Each stoma is surrounded by 4 to 5 of such cells. The outer stomatal cavity (crypt) is rounded and strongly cutinised. The stomatal density is about 30 per mm^2 of leaf surface, and the stomatal index varies from 3 to 3.5 (including costal region).

Abaxial cuticle (Text-figs 36h, i, Pl. 39, figs 1–6, Pl. 40, fig. 1): These cells are differentiated into stomatiferous (intercostal) and non-stomatiferous (costal) bands, both of which vary in width between 150–250 μm. The cells of the stomatiferous bands are oval to irregularly pentagonal, 25–50 μm long and 12–25 μm wide. The anticlinal walls are rounded. The intercostal cells are randomly oriented. The costal cells are elongated and tetragonal; they form bands containing 10–15 cell rows. The cells are 30–80 μm long and 10–25 μm wide. The stomata are not prominent; they occur in stomatiferous bands with poorly defined stomatal rows. The stomata are oriented parallel to the veins. The pairs of guard cells are sunken and elliptical, 20–30 μm long and 10–15 μm wide. Usually only the pits above the stomata, which are narrowed due to the gibbous and strongly cutinised proximal walls of the subsidiary cells, are observable. The stomatal complexes (including subsidiary cells) are 50–65 μm long and 40–50 μm wide. The subsidiary cells, number 4–5 per stoma, are of the same shape as the ordinary epidermal cells. The stomatal density in the stomatifetous band is 350–400 per mm^2. The stomatal index in the stomatiferous bands is 13–15.



Text-fig. 36. ***Cordaites kladnoensis*** **sp. nov., Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Group of coals, interbeds of Main Kladno Coal Seam, Bolsovian, slides No. 183/1-3, 285/1-4, 295/1-3. a – shape of leaf, material to slide No. 183/1-3, ×0.25, b – shape of leaf, material to slide No. 295/1-3, ×0.25, c – leaf venation, specimen to slides 285/1-4, ×20, d – venation of leaf, from fig. b, ×20, e – distribution of stomata on adaxial cuticle, slide No. 183/1, ×50, f – distribution of stomata on abaxial cuticle, from fig. a, slide No. 183/3, ×50, g – adaxial cuticle with stomatal row, neighbouring cells dotted, from fig. a, slide No. 183/3, ×100, h – abaxial cuticle with stomatiferous band, slide No. 183/3, ×100, i – abaxial cuticle, detail of stoma, slide No. 183/3, ×250.**

D i s c u s s i o n : The adaxial cuticle of *Cordaites kladnoensis* has stomata arranged in infrequent stomatal rows. The guard cells are covered by a circular crypt, which distinguishes this species from the others of the genus *Cordaites*. Its abaxial cuticle is a diagnostic feature of this species The stomatiferous bands are formed by circular, polygonal and oval cells with irregularly dispersed, inconspicuous stomata among them. The stomatiferous bands are separated by non-stomatiferous bands of oblong cells. This type of cuticular topography is not known in other *Cordaites* species. For a detailed comparison, see the discussion of the entire group beginning on page 147, and Table 7.

Cordaites latus sp. nov.

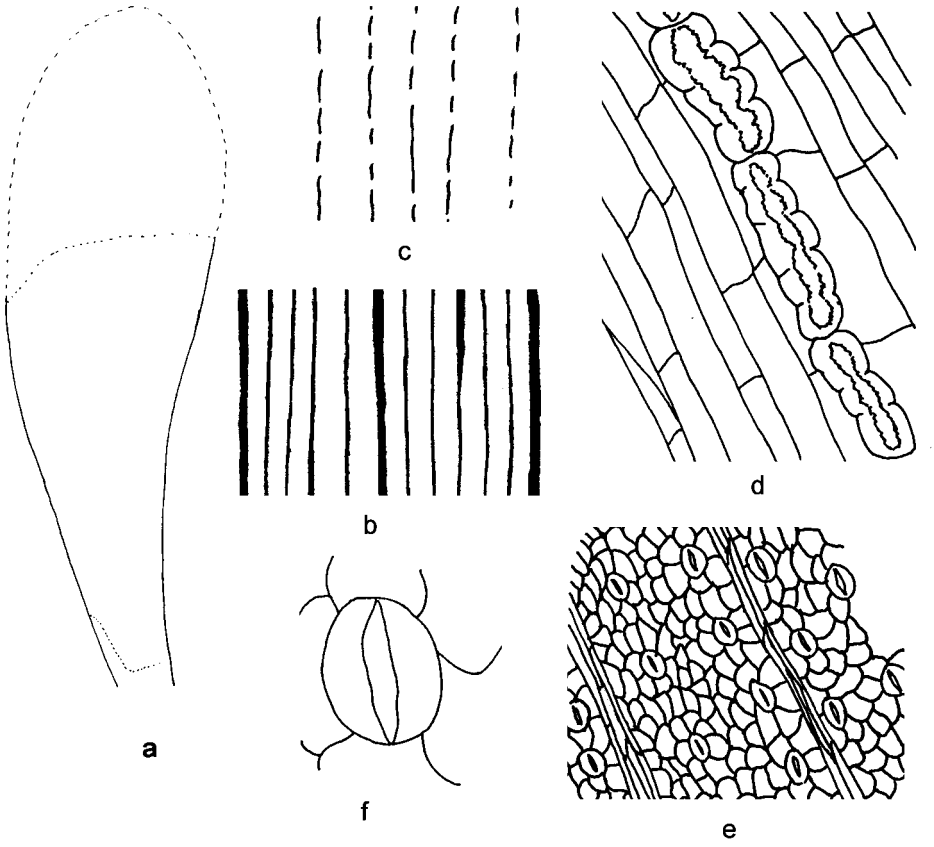
Text-figs 1c, 37a–f, Pl. 40, figs 4–7, Pl. 41, figs 1–4

2000 *Cordaites* sp. Šimůnek, p. 32, figs 2: 11.
2001 *Cordaites* sp. (morphotype 11 sensu Šimůnek 2000), Šimůnek, p. 98–100, figs 43a–f, pl. 40, figs 4–7, pl. 41, figs 1–4.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 245, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From the Latin word latus, meaning ‘wide’, as this species has wide leaves.

T y p e l o c a l i t y : Tuchlovice, Nosek Mine, Kladno-Rakovník Basin.



Text-fig. 37. ***Cordaites latus*** **sp. nov., Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Group of coals, interbeds of the Main Kladno Coal Seam, Bolsovian, slide No. 185/1. a – probable reconstruction of the leaf, ×0.25, b – leaf venation, ×20, c – distribution of stomata-like structures on adaxial cuticle, ×50. d – distribution of stomata-like structures on adaxial cuticle, ×250. e – abaxial cuticle with stomata, ×100, f – abaxial cuticle, detail of stoma, ×500.**

T y p e h o r i z o n : Kladno Formation, Radnice Member, Radnice Coals, interbeds of the main Kladno coal seam, Bolsovian (Westphalian C).

M a t e r i a l : Only one specimen – the holotype (part and counterpart).

D i a g n o s i s : Broad lanceolate leaves with dense venation, up to 3 thin veins alternating with each thick vein. Adaxial cuticle with mostly oblong cells, stomata in specialised stomatal rows, resembling the dorsal furrows of *Ruffloria.* Abaxial cuticle with oblong cells, stomata in bands.

D e s c r i p t i o n : The holotype is a leaf fragment 235 mm long. The leaf expands quickly from its 47 mm wide basal part to a maximum width of 97 mm. However, the complete leaf was much wider. There are 24 thick veins per cm in the center and 28 thick veins per cm near the leaf margin. Sixty thick veins per cm were counted in the widest part of the leaf, where they are all of the same thickness. In the other part of the leaf, 1–3 (or rarely 4) thin veins alternate with each thick vein. The thin veins are locally indiscernible, mainly in the distal part of the leaf. The leaves are amphistomatic.

Adaxial cuticle (Text-fig. 37d, Pl. 40, figs 4–7, Pl. 41, figs 1–2): The cells are of two types. In the first, the cells of what is probably a costal band are oriented, tetragonal, usually oblong, 60–120 μm long and 12–25 μm wide, and with straight anticlinal wall. Pairs of the second type of cells form narrow strips. They are strongly cutinised, 75–100 μm long and 15–25 μm wide. A fissure is visible between the pairs of these cells, the margins of which are strongly cutinised and lobate. The guard cells are not observable due to the bad state of preservation. It is not clear whether these cells belong to stomatal complexes or some other epidermal structure.

R e m a r k : These structures slightly resemble the dorsal furrows of the genus *Rufloria* Meyen. These furrows occur only on the abaxial cuticle, and the presence of stomata have been confirmed in the case of *Rufloria*.

Abaxial cuticle (Text-figs 37e–f, Pl. 41, figs 3–4): The cells are differentiated into 200–300 μm wide stomatiferous (intercostal) bands, and 25–30 μm wide non-stomatiferous (costal) bands formed by two to three rows of long cells. The intercostal cells are randomly oriented, nearly isodiametric, pentagonal, square, rhomboidal, or oblong in shape, 25–60 μm long and 18–35 μm wide. Their anticlinal walls are usually strongly bent. The costal cells are oriented parallel to the veins; they are elongate, oblong to trapezoidal, 100–160 μm long and 8–14 μm wide. Their anticlial walls are straight.

Table 7. Important diagnostic features of the species from *Cordaites* cuticular groups D and E.

				Cuticular group D		Cuticular group E	
Species				***Cordaites kladnoensis***	***Cordaites latus***	***Cordaites wartmannii***	***Cordaites polynervus***
Leaves				Amphistomatic	Amphistomatic	Amphistomatic	Amphistomatic
Adaxial cuticle	**Difference between stomatiferous and non–stomatiferous bands**			+	+	+	+
	Cell shape of stomatiferous bands			Oblong	Only stomatal complexes	Tetra– to pentagonal, nearly isodiametric	Tetragonal to oval
	Size of stomatiferous cells (µm)			(40–70) x (10–25)		(25–60) x (10–22)	(25–50) x (10–30)
	Cell shape of non–stomatiferous bands			Square to oblong	Tetragonal – oblong	Tetragonal – oblong	Rectangular – oblong
	Size of non–stomatiferous cells (µm)			(30–60) x (10–20)	(60–120) x (12 – 25)	(40–90) x (16–30)	(30–70) x (25 – 35)
	Stomata	**Distribution**		Rare stomatal rows		In dark bands	In stomatal rows
		Density per 1 mm^2		?30	70 – 80	54	40 – 45
		Stomatal index		3–3.5 (incl. non–st. band)	8 – 10	5 – 7	about 10 in dark bands
		Length and width of guard cells (µm)		Sunken and covered	?	(18–22) x (10–13)	(25–30) x (15–20)
	Subsidiary cells	Polar	**Number and shape**	2–3; rounded (dark)	–	2–3; trapezoidal to oval	2; oblong to oval
			Size (µm)	10 – 15 (in diameter)	–	20 – 32 (in diameter)	(35–52) x (25–30)
		Lateral	**Number and shape**	2–3; rounded (dark)	0	2–3; trapezoidal to oval	2–4; oblong to oval
			Size (µm)	11 – 15 (in diameter)	–	20 – 32 (in diameter)	(25–60) x (25–30)
			Shape of crypt	Rounded, strongly cutinised	Lobed, strongly cutinised	–	–
Abaxial cuticle	**Difference between stomatiferous and non–stomatiferous bands**			+	+	+	+
	Cell shape of stomatiferous bands			Oval to irregularly pentagonal	Pentagonal, oblong, isodiametric	Tetragonal, oblong to trapezoidal	?
	Size of stomatiferous cells (µm)			(25–50) x (12–25)	(25–60) x (18–35)	(30–60) x (8–18)	?
	Cell shape of non–stomatiferous bands			Longitudinally tetragonal	Longitudinally oblong to trapezoidal	Tetragonal, oblong to trapezoidal	Rectangular – oblong
	Size of non–stomatiferous cells (µm)			(30–80) x (10–25)	(100–160) x (8–14)	(30–60) x (8–18)	(30–75) x (20–30)
	Stomata	**Distribution**		In stomatiferous bands	In stomatiferous bands	In stomatiferous bands	?
		Density per 1 mm^2		350–400 (in stom. band)	?	400 (530 in stom. band)	?
		Stomatal index		13 – 15 (in stomat. band)	7	12 (15 in stomat. band))	?
		Shape of guard cells		Elliptical	Elliptical	Elliptical	?
		Length and width of guard cells (µm)		(20–30) x (10–15)	(30–40) x (20–25)	(25–30) x (8–14)	?
	Subsidiary cells	Polar	**Number and shape**	2; as ordinary cells	2–3; as ordinary cells	2; as ordinary cells	?
			Size (µm)	–	–	–	?
		Lateral	**Number and shape**	2–3; as ordinary cells	2–4; as ordinary cells	2–3; as ordinary cells	?
			Size (µm)	–	–	–	?
			Shape of crypt	–	–	Distal cell walls – stronger cutinisation	?

Remark: When subidiary cells are not distinguished from ordinary epidermal cell – their number = 0

The stomatal complexes in the stomatiferous (intercostal) band are oriented parallel to the veins and are irregularly dispersed in poorly defined stomatal rows. The guard cell pairs are elliptical, sunken, and surrounded by 5–6 subsidiary cells that are of the same shape as ordinary epidermal cells – and therefore stomata are not very distinct in the cuticle. The stoma are 30–40 µm long and 20–25 µm wide. There are 2–3 polar and 2–4 lateral cells per stoma. The stomatal density is difficult to estimate due to the poor state of preservation, though the stomatal index is about 7.

D i s c u s s i o n : The species *Cordaites latus* is typified by the unusual structure on its adaxial cuticle that resembles the dorsal furrow of *Rufloria*. However, evidence of its possession of stomata is still lacking, even though it is very probable. This feature does not occur in any other representative of the genus *Cordaites*. The abaxial cuticle of *Cordaites latus* is divided into stomatiferous and non-stomatiferous bands. In contrast to *Cordaites kladnoensis*, the ordinary cells of *Cordaites latus* are prominent and of polygonal shape, whereas they are usually of oval shape in *Cordaites kladnoensis*. For a detailed comparison, see the discussion of the entire group beginning on this page, and Table 7.

Discussion of Group D

Cuticular Group D contains only two species, both of which are amphistomatic. *C. kladnoensis* has the stomata on its adaxial cuticle arranged in infrequent stomatal rows. However, the common characteristics of this group are the stomatiferous bands containing stomata and cells that are distinct from the ordinary cells of the non-stomatiferous bands. The subsidiary cells are of the same shape as the ordinary cells of these bands. These cells are rounded and oval in *C. kladnoensis*, and mostly polygonal in *Cordaites latus*. The widths of the stomatiferous and non- stomatiferous bands differ considerably in these two species. *C. latus* has an unusual type of cell in rows on its adaxial cuticle, which resembles the dorsal furrows Ruffloria and probably protects the guard cells. These structures are not known in any other *Cordaites* species.

Group E
(cells of stomatiferous bands are of the same type as those of non-stomatiferous bands)

Cordaites wartmannii sp. nov.

Text-figs 38a–h, Pl. 3, fig. 15, Pl. 41, figs 5, 6, Pls 42, 43, figs 1–2

? 1969 *Cordaites* sp. Wartmann, p. 199, pl. 34, figs 1–6.
2000 *Cordaites* sp. Šimůnek, p. 32, figs 2: 9.
2001 *Cordaites* sp. (morphotype 9 sensu Šimůnek 2000) Šimůnek, p. 101–103, figs 44a–h, pl. 3, fig. 15, pl. 41, figs 5, 6, pls 42, 43, figs 1–2.

H o l o t y p e : Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 246, coll. Z. Šimůnek.

D e r i v a t i o n o f n a m e : From R. Wartmann, who first described similar cuticles.

T y p e l o c a l i t y : Libušín, Schoeller (Nejedlý) Mine, Kladno-Rakovník Basin.

T y p e h o r i z o n : Kladno Formation; Radnice Member, Radnice Coals, interbeds of the main Kladno coal seam, Bolsovian (Westphalian C).

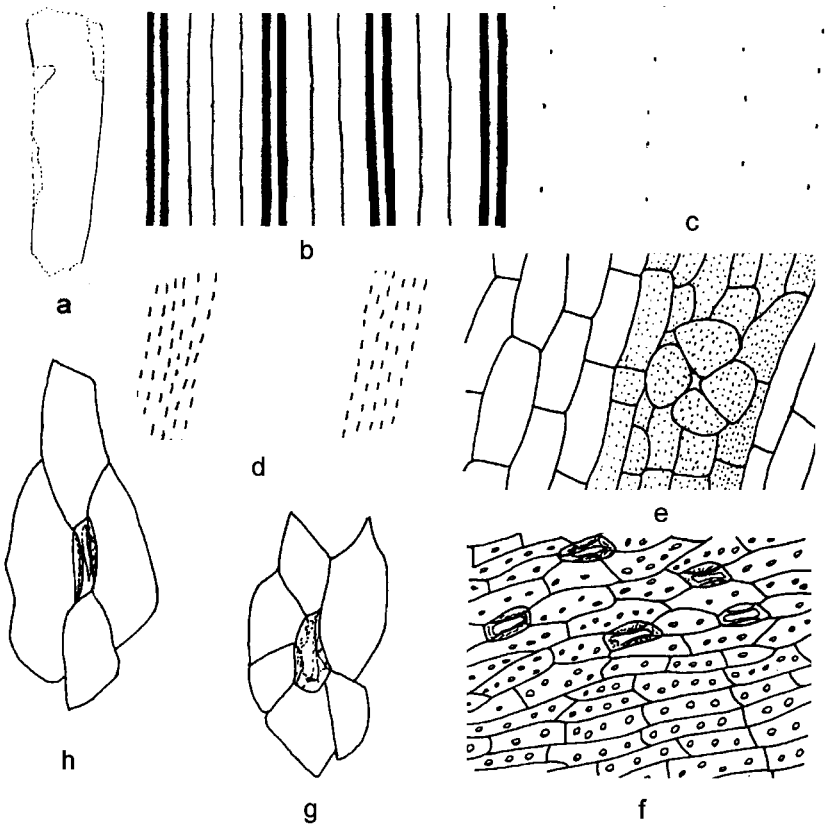
M a t e r i a l : 6 specimens from Libušín, Nos ZŠ 246, 302–306.

D i a g n o s i s : Amphistomatic, relatively narrow lanceolate leaves with infrequent venation, thick veins doubled, 2–3 thin veins alternating with each pair of thick veins. Adaxial cuticle with oblong cells, cells of dark stomatal band tetra- to pentagonal, isodiametric, abaxial cuticle with oblong to trapezoidal cells, stomata in stomatiferous bands without defined stomatal rows.

D e s c r i p t i o n : The holotype is a leaf fragment 75 mm long and 18 mm wide with revolute margins. There are 10 thick veins per cm, and each thick vein is composed of two parallel veins (Text-figs 38b). Two to three very thin veins occur between each two thick veins. The leaves are amphistomatic. The cuticles dissolve into strips after maceration. The leaf fragments are up to 150 mm long and 45 mm vide, their margins are nearly parallel or somewhat divergent, and the margins are revolute. There are 10 to 16 thick veins per cm, and 2–3 thin veins alternate with each thick vein.

Adaxial cuticle (Text-figs 39e, Pl. 41, figs 5, 6, Pl. 42, figs 6–7): The adaxial cuticle is weakly cutinised, and only cells in the dark stomatiferous (intercostal) bands are strongly cutinised. These bands are 60–120 µm wide, whereas the light non-stomatiferous (costal) bands between them are 100–200 µm wide. The cells of these bands difffer both in colour and shape. The ordinary intercostal cells are tetragonal to pentagonal, 25–60 µm long and 10–22 µm wide. Their anticlinal walls are straight or slightly bent. They are oriented parallel to the veins. The costal cells (in non-stomatiferous band) are tetragonal, mostly oblong, 40–90 µm long and 16–30 µm wide. The stomatal complexes occur in dark stomatiferous (intercostal) bands. They are formed by pairs of guard cells and usually 4 subsidiary cells of approximately equael shape, of which 2 cells are polar and 2 are lateral. The pairs of guard cells are deeply sunken, elliptical, and oriented parallel to the veins. They are 18–22 µm long and 10–13 µm wide. The stomata within a row are usually spaced 90–180 µm apart. Sometimes two stomatal rows are connected into one stomatiferous band. The stomatal complexes (including subsidiary cells) are 60–80 µm long and 45–55 µm wide. The subsidiary cells are trapezoidal to oval, 20–32 µm in diameter. The stomatal density is 54 per mm^2 of leaf surface. The stomatal index varies between 5 and 7.

Abaxial cuticle (Text-figs 39f–h, Pl. 42, figs 1–5, Pl. 43, figs 1–2): The abaxial cuticle is slightly cutinised. The cells of the 150–280 µm wide stomatiferous (intercostal) bands and the 100–350 µm wide non-stomatiferous (costal) bands are of the same shape. The stomatiferous and non-stomatiferous bands differ only by the presence of stomata. The ordinary cells are papillose, tetragonal, oblong to trapezoidal,



Text-fig. 38. ***Cordaites wartmannii*** **sp. nov., Libušín, Schoeller Mine (formerly Nejedlý), Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Group of coals, interbeds of the Main Kladno Coal seam, Bolsovian, slide No. 113/1-2. a – leaf outline, ×2, b – leaf venation, ×20, c – distribution of stomata on adaxial cuticle, ×50, d – distribution of stomata on abaxial cuticle, ×50, e – adaxial cuticle, darker strip with stoma, ×250, f – abaxial cuticle with stomata and numerous papillae, ×250, g, h – stomata on abaxial cuticle with neighbouring cells, ×500.**

30–60 μm long and 8–18 μm wide. The papillae are inconspicuous, rounded or irregular in shape, and 3–10 μm in diameter; there are up to 7 of them per cell. The anticlinal walls of these cells are straight or slightly bent. The cells are oriented parallel to the veins. Pairs of guard cells in the stomatiferous (intercostal) bands are sunken, elliptical, 25–30 μm long, 8–14 μm wide, and oriented parallel to the veins. The subsidiary cells are of the same shape as the ordinary epidermal cells. There are usually 4–6 subsidiary cells, of which 2–3 are polar and 2–3 are lateral. The cutinisation of the proximal walls of the subsidiary cells towards the stomatal slit is distinct, and gives the outline above the guard cells an oblong shape. The stomatal density is about 400 per mm^2 of leaf surface, though the stomatal density in the stomatiferous band is about 530 per mm^2. The stomatal index is 12, but 15 in the stomatiferous band.

Discussion: The specimen described by Wartmann (1969) from the Bolsovian of the Saar region (Germany) as *Cordaites* sp. has a similar cuticular structure as the above described species. In spite of this, the identity of both specimes cannot yet be confirmed, as Wartmann (1969) did not describe the adaxial cuticle. The abaxial cuticle of the German specimen bears many strongly cutinised papillae in contrast to the more weakly cutinised papillae of the Bohemian *Cordaites wartmannii*. This difference may be due to differing paleoecological conditions. The adaxial cuticle of *Cordaites wartmannii* differs from that of *Cordaites polynervus* by having its stomata of arranged in infrequent, dark stomatiferous bands, whereas those of *Cordaites polynervus* are very inconspicuous and arranged in infrequent stomatal rows. *Cordaites wartmannii* has a papillose abaxial cuticle with prominent stomata in stomatiferous bands. The abaxial cuticle of *Cordaites polynervus* is so poorly preserved that a detailed comparison is not possibe. For a more detailed evaluation, see the discussion of the entire group beginning on page 150, and Table 7.

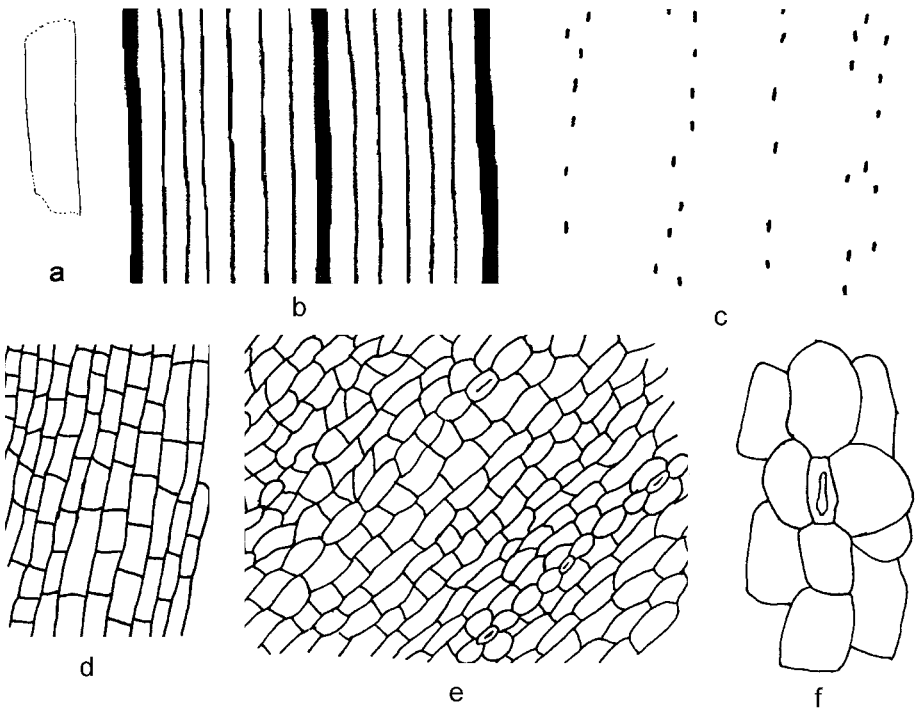
Cordaites polynervus sp. nov.

Text-figs 39a–f, Pl. 43, figs 3–7, Pl. 44, figs 1–3

2000 *Cordaites* sp. Šimůnek, p. 32, figs 2: 28.
2001 *Cordaites* sp. (morphotype 10 sensu Šimůnek 2000) Šimůnek, p. 103–105, figs 45a–f, pl. 43, figs 3–7, pl. 44, figs 1–3.

Holotype: Designated here, Czech Geological Survey, Prague, inv. No. ZŠ 247, coll. Z. Šimůnek.

Derivation of name: From the Latin word polynervus, meaning 'multiveined', as this species has numerous veins.



Text-fig. 39. ***Cordaites polynervus*** **sp. nov., Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Group of coals, interbeds of the Main Kladno Coal Seam, Bolsovian, slide No. 182/1-3. a – leaf outline, ×0.25, b – leaf venation, ×20, c – distribution of stomata on adaxial cuticle, ×50, d – abaxial cuticle, ×100, e – adaxial cuticle with stomata, ×100, f – adaxial cuticle, detail of stoma, ×250.**

T y p e l o c a l i t y : Tuchlovice, Nosek Mine, Kladno-Rakovník Basin.

T y p e h o r i z o n : Kladno Formation; Radnice Member, Radnice Coals, interbeds of the Main Kladno coal seam, Bolsovian (Westphalian C).

M a t e r i a l : Only one specimen – the holotype.

D i a g n o s i s : Relatively narrow, amphistomatic leaves with infrequent venation, 4–6 thin veins alternate with each thick vein. Stomata on adaxial cuticle are dispersed or occur in infrequent incomplete rows. Cells of abaxial cuticle are oblong.

D e s c r i p t i o n : The holotype is a leaf fragment 25 mm wide and about 130 mm long with nearly parallel margins. The venation is infrequent, with 10–12 thick veins per cm in both the center and the margins of the leaf. Four to six thin veins alternate with each thick vein. The thin veins are poorly discernible near the leaf margin, but become more prominent and less distinguishable from the thick veins towards the center of the leaf. The leaves are amphistomatic.

Adaxial cuticle (Text-figs 39e–f, Pl. 43, figs 3–6, Pl. 44, figs 1–2): The adaxial cuticle is somewhat more strongly cutinised than the abaxial one. The cells that occur in dark stomatiferous (intercostal) bands, 80–140 μm wide, differ from those of the 120–200 μm wide non-stomatiferous (costal) bands. The intercostal ordinary cells are tetragonal to oval, 25–50 μm long and 10–30 μm wide. The anticlinal walls are bent. These cells are oriented parallel to the veins. The costal cells are larger than the intercostal cells, are rectagular, usually oblong, 30–70 μm long and 25–35 μm wide. The stomatal complexes in the stomatiferous bands occur in rare, irregular single to double stomatal rows oriented parallel to the veins. Pairs of guard cells are sunken, elliptical, 25–30 μm long and 15–20 μm wide. They are surrounded by 4–5 subsidiary cells that are slightly different from the ordinary epidermal cells of the dark bands. The guard cells are partly covered by the proximal walls of the subsidiary cells. The stomatal complexes (including subsidiary cells) are 90–125 μm long and 60–75 μm wide. They usually contain 2 oblong to oval polar subsidiary cells, 35–52 μm long and 25–30 μm wide, and 2–4 oblong to oval lateral subsidiary cells, 25–60 μm long and 25–30 μm wide. The stomatal density is about 40–45 per mm^2 of leaf blade. The stomatal index in the dark bands is about 10.

Abaxial cuticle (Text-fig. 39d, Pl. 43, Text-fig. 7, Pl. 44, fig. 3): The abaxial cuticle is very slightly cutinised and poorly preserved. The cells in stomatiferous (intercostal) bands are distinct from those of the non-stomatiferous (costal) bands. The ordinary costal cells are oblong rectangular, 30–75 μm long and 20–30 μm wide. The anticlinal walls are straight. The cells of the stomatiferous (intercostal) bands are not observable.

D i s c u s s i o n : The species *Cordaites polynervus* has the stomata of its abaxial cuticle either dispersed or occurring in infrequent, incomplete stomatal rows. It is quite distinct from *Cordaites wartmannii*, though the abaxial cuticle of *Cordaites polynervus* is too poorly preserved to allow a detaied comparison. For detailed evaluation of this entire group, see the discussion beginning on the next page, and Table 7.

Discussion of Group E

Cuticular Group E contains the two species *C. wartmannii* and *C. polynervus*. Both are amphistomatic. This cuticular group resembles Group D, though the subsidiary cells of the stomata in the latter have the same shape as the ordinary cells of the non-stomatiferous band.

Stomata on the adaxial cuticle of *C. wartmannii* occur in dark bands, whereas those of *C. polynervus* are arranged in stomatal rows. They are surrounded by 2 oblong to oval polar and 2–4 oblong to oval lateral subsidiary cells. The abaxial cuticle of *C. wartmannii* is papillose. The abaxial cuticle of *C. polynervus* is non-papillose, although further details are not observable due to its poor preservation.

F) Morphotypes that are Difficult to Classify

Cordaites sp.

Pl. 44, figs 4 and 5

2001 *Cordaites* sp., Šimůnek, p. 106, fig. Pl. 44, figs 4 and 5.

L o c a l i t y : Heřmanova Huť – Vlkýš, Plzeň Basin.

H o r i z o n : Kladno Formation; Nýřany Member, Asturian (Westphalian D).

M a t e r i a l : Specimen No. ZŠ 248.

D e s c r i p t i o n : The basal part of leaf is 85 mm long and 27 mm wide. The cuticles were prepared from the very base of the leaf.

A d a x i a l c u t i c l e : The adaxial cuticle is well cutinised and completely lacks stomata (Pl. 44, figs 4, 5). The cells are oriented, of square or oblong shape, and have straight anticlinal walls.

A b a x i a l c u t i c l e : Most of the abaxial cuticle is weakly cutinised. The stomata are infrequent, relatively small and inconspicuous. The complete classification of these cuticles is not currently possible.

Evaluation of the *Cordaites* of the Bohemian Massif

In this study we have examined cordaitalean cuticles from strata within the Langsettian to Lower Autunian interval from three regions. The oldest species come from the Langsettian of the Upper Silesian Basin, and all belong to Cuticular Group A, meaning that the stomata of their abaxial cuticles are dispersed in poorly defined stomatal rows, or in irregular infrequent stomatal rows. Stomatiferous and non-stomatiferous bands are not distinguished. *Cordaites karvinensis* sp. nov., *C. silesiacus* sp. nov. and *C. sustae* sp. nov. have been found in the Langsettian of the Upper Silesian Basin (Table 8). The specimens of *Cordaites karvinensis* sp. nov. and *C. sustae* sp. nov. come from the Šusta's collection (Ostrava Museum, Ostrava), and were originally classified as *Cordaites principalis* (Germar) Geinitz. Both species are hypostomatic. They differ only in the presence of papillae on the abaxial cuticle of *Cordaites sustae*. *Cordaites silesiacus* is amphistomatic; it was classified by Šusta as *Cordaites borassifolius* (Sternberg) Unger. Its adaxial and abaxial cuticles are very similar, differing only in stomatal density. The stomata of this type differ from those of the above mentioned types, so that they can be distinguished even on the basis of small fragments.

Representatives of cordaitalean Cuticular Groups A, B and C have been found in the Duckmantian of the Intrasudetic Basin. The species *Cordaites strazkovicensis* sp. nov. is assigned to Cuticular Group A. The species *Cordaites idae* sp. nov. and *C. schatzlarensis* Šimůnek et Libertín belong to Cuticular Group B, which is distinguished by having stomata arranged in well defined single or double stomatal rows that are separated by non-stomatiferous bands. The species *Cordaites svatonovicensis* sp. nov. and *C. odolovensis* are placed into Cuticular Group C. This group has stomata arranged into well defined double or multiple stomatal rows, joined into stomatiferous bands that are separated by non-stomatiferous bands. The most common species, *Cordaites idae*, is hypostomatic, while the other species are amphistomatic. Two large lateral and two small polar subsidiary cells are typical of these species. The species *Cordaites strazkovicensis* sp. nov. is similar to the *Cordaites silesiacus* from the Langsettian of the Upper Silesian Basin because of its adaxial cuticle. *Cordaites svatonovicensis* differs from above mentioned species by its prominent crypt.

Most of the cordaitalean cuticular species and cuticular groups are known from the Bolsovian of the Central and Western Bohemian Upper Palaeozoic Basins. The species *Cordaites tuchlovicensis* sp. nov. and *C. lubnensis* sp. nov. belong to Cuticular Group A. The species *Cordaites rerichensis* sp. nov. is assigned to Group B, while the species *Cordaites borassifolius* (Sternberg) Unger and *C. raconicensis* sp. nov. are classified as Group C. *Cordaites kladnoensis* sp. nov. and *C. latus* sp. nov. are placed into Group D, which is defined by the cells of the stomatiferous band being different than those of the non-stomatiferous band. However, the stomatal rows of these two species are poorly defined within the scope of the stomatiferous band, and the polar and lateral subsidiary cells and ordinary epidermal cells are approximately of the same shape. The last two species, *Cordaites wartmannii* sp. nov. and *Cordaites polynervus* sp. nov., belong to Group E, which is characterised by the cells of the stomatiferous band having the same shape as those of the non-stomatiferous band. They differ only by the arrangement of their stomata, which are organised in poorly defined stomatal rows. Each stoma is surrounded by several subsidiary cells. Two species from the Radnice Member are hypostomatic, and seven species are amphistomatic. Their adaxial cuticles are characterised by low stomatal density, and only in one case is the stomatal density similar to that on the abaxial cuticle (*Cordaites rerichensis*). The guard cells of the abaxial cuticle are usually variously sunken below the epidermal level. Crypts on the abaxial cuticle are developed on the two species *Cordaites borassifolius* and *Cordaites raconicensis*. Crypts are more commonly developed

Table 8. Distribution of cordaitalean cuticular groups in the Westphalian, Stephanian and Autunian of the Bohemian Massif

Age	Cordaitalean cuticular group	Species
Langsettian	A	*C. karvinensis* , *C. silesiacus* , *C. sustae*
Duckmantian	A	*C. strazkovicensis* ,
	B	*C. idae* , *C. schatzlarensis*
	C	*C. svatonovicensis* , *C. odolovensis*
Bolsovian	A	*C. tuchlovicensis* , *C. lubnensis*
	B	*C. rerichensis*
	C	*C. borassifolius* , *C. raconicensis*
	D	*C. kladnoensis* , *C. latus*
	E	*C. wartmannii, C. polynervus*
Asturian	A	*C. ledecensis*
	B	*C. pilsensis* , *C. krasovicensis* , *C. blazkovicensis*
	C	*C. dobranensis* , *C. wilkischensis* , *C. touskovensis*
Stephanian B	B	*C. radvanicensis* , *C. risutensis*
	C	*C. malesicensis* , *C. melnicensis*
Autunian	A	*C. rudnicensis* , *C. sudeticus*

at the stomata of the adaxial cuticle. Most of the morphotypes described here are known only from single specimens.

Although the greatest number of samples come from the Asturian of the Central and Western Bohemian Upper Palaeozoic Basins, only seven species are identified here: *Cordaites ledecensis* sp. nov. from Cuticular Group A, *Cordaites pilsensis* sp. nov., *C. krasovicensis* sp. nov. and *C. blazkovicensis* sp. nov. from Cuticular Group B, and *Cordaites dobranensis* sp. nov., *C. wilkischensis* sp. nov. and *C. touskovensis* nov. sp from Cuticular Group C.

Hypostomatic leaves are rare among these species. Three cordaites cuticular morphotypes (*Cordaites ledecensis, C. pilsensis* and *C. krasovicensis*) have approximately the same stomatal density on both cuticles. The abaxial cuticle is usually weakly cutinised. Cordaitalean species of the Nýřany Member are highly variable.

Four species have been described from the Stephanian B deposits of the Intrasudetic Basin and the Kladno-Rakovník Basin. Two of these belong to cordaitalean Cuticular Group B: *Cordaites radvanicensis* sp. nov., and *C. risutensis* sp. nov. The other two species, *Cordaites malesicensis* sp. nov. and *C. melnicensis* sp. nov., are assigned to Group C. *Cordaites malesicesnis* is very similar to *Cordaites dobranensis* from the Asturian of the Dobré štěstí Mine, Dobřany locality, while *Cordaites melnicensis* (Sušno, borehole Sš 1) is very similar to *Cordaites wartmannii* from the Schoeller Mine, Libušín locality, from the Radnice Member (Bolsovian). A very similar morphotype was also found in the Westphalian D of Poland (in the Upper Sileian Basin; Florjan, 1997) and from the Zwickau – Lugau region in Germany (cuticles of samples obtained from the Museum für Naturkunde, Berlin). There are characteristic differences that enable these morphotypes to be distinguished. The two species *Cordaites radvanicensis* and *C. risutensis* are amphistomatic, and similar species have not been found in other stratigraphic levels of the Bohemian Massif.

The yougest cuticles of the corditalean species described here are of *Cordaites rudnicensis* sp. nov. and *C. sudeticus* sp. nov. from the Lower Autunian of the Krkonoše Piedmont Basin (Šimůnek, Drábková and Zajíc, 1990). They both belong to Cuticular Group A (tab. 8), and are amphistomatic. Their stomata are arranged in infrequent, poorly defined rows that are roughly regular distances apart. The species *Cordaites rudnicensis* has two prominent, strongly cutinised, small, rounded polar subsidiary cells, and two large, strongly arched lateral cells, so that the stomatal com-

plex has a rounded shape. Its adaxial and abaxial cuticles are very similar, though the adaxial cuticle has a lower stomatal density than the abaxial one. The other of the two species, *Cordaites sudeticus*, differs from *Cordaites rudnicensis* in having relatively narrow guard cells as the most prominent characteristic of its stomata.

Comparison

The first *Cordaites* cuticles discovered in the Bohemian Massif were described by Florin (1931, p. 499, fig. 105a). He depicted abaxial cuticles from a specimen identified as *Cordaites* sp. 1 from the Radnice Member (Bolsovian) of the Rakovník locality, along with another specimen, *Cordaites* sp. 2, from New Brunswick (Westphalian D) in Canada. Both specimens have similarly structured stomatal complexes formed by two large lateral subsidiary cells and two small polar subsidiary cells. They differ only in the shape of these cells. *Cordaites* sp. 1 was described by Florin (1931) as having a developed a crypt. It does not seem to be identical to *Cordaites borassifolius* (Sternberg) Unger, as the two differ in the shape of their subsidiary cells and in the distribution of their stomata. The stomata of *Cordaites* sp. 1 Florin are arranged in simple stomatal rows, whereas those of *Cordaites borassifolius* are in multiple stomatal rows joined into stomatiferous bands. *Cordaites* sp. 1 Florin belongs to Cuticular Group B, while *Cordaites borassifolius* is assigned to Cuticular Group C.

Further work concerning cordaites cuticles was published in the 1960s (Barthel 1962a,b, 1964, Rabitz 1966, Ledran 1966 and Pant and Verma 1964). Barthel (1962a) described three cordaites cuticular morphotypes on the basis of dispersed cuticles from the Autunian of the Döhlen Basin. Many of the subsidiary cells of the stomatal complexes are papillate. None of those cordaites cuticular types have been identified in the Bohemian Massif. Barthel (1962b) described two further morphotypes, designated as 4 and 5. Morphotype 4 comes from the Westphalian D of the Zwickau Basin. It is very difficult to compare these cuticles with the Bohemian ones due to the bad state of preservation of the German specimens. Barthel's morphotype 5 comes from the Duckmantian of the Upper Silesian Basin (Poland). The stomatal complexes of its abaxial cuticle are very similar to those of *Cordaites wartmannii* from the Bolsovian (Radnice Member) of the Kladno-Rakovník Basin. The Polish specimen (*Cordaites* sp., morphotype 5 Barthel) has a low stomatal density and its cells are mostly trapezoidal in shape, and less commonly spindle-shaped. The Bohemian *Cordaites wartmannii* has oblong cells on its abaxial cuticle. The adaxial cuticle of *Cordaites* sp., morphotype 5 Barthel lacks stomata, whereas the Bohemian *Cordaites wartmannii* has guard cells surrounded by rounded subsidiary cells in dark bands that contain cells which are much shorter than the elongated oblong cells of the non-stomatiferous band. Barthel (1962b) classified morphotypes 3–5 as *Cordaites principalis*. The same author (Barthel, 1964) later described two further morphotypes (6 and 7) from the Autunian of the Döhlen Basin. His morphotype 6 has a transverse crypt across the guard cells, and is very similar to the Bohemian species *Cordaites borassifolius* (Sternberg) Unger from the Radnice Member. Barthel compared this species with Florin's (1931) *Cordaites* sp. 1 from the Bolsovian of Rakovník. The adaxial cuticle from the German morphotype 6 is not known. It is unclear whether the German specimen is a descendent of the Bohemian *Cordaites borassifolius*, or if it only represents a convergeance caused by identical ecological conditions. Barthel's morphotype 7 has papillae on the polar subsidiary cells of its stomata, which distinguish it from all of the Bohemian species. Barthel (1976) went on to describe cordaites cuticular morphotype 8 as being characterised by numerous papillae on its ordinary cells. This characteristic distinguishes it from all of the Bohemian species. Barthel (1962a,b, 1964, 1976) thus described 8 cordaites cuticular morphotypes, of which three were obtained from the "species" designated as *C. principalis*.

Pant and Verma (1964) prepared cuticles from five species: *Cordaites principalis* (Germar) Geinitz from the Stirling locality from the Langsettian of the Scottish Basins; *Cordaites angulosostriatus* Gr.'Eury and *Cordaites borassifolius* (Sternberg) Unger from Gloucester (Asturian), Sommerset-Gloucester Basin of Great Britain; and *Cordaites mansfeldii* Lesquereux and *Cordaites serpens* Lesquereux from the Cannelton locality (Asturian) in Pennsylvania in the U.S.A. Even though these authors gave the venation density and short descriptions of their specimens, they are difficult to classify, as their features fit into several species. The cuticle of the Scottish *Cordaites borassifolius* is quite different from that derived from the holotype *Cordaites borassifolius* described in this article. It is evident that the British specimen of *Cordaites borassifolius* belongs to another species. The cuticles of *Cordaites principalis* also differ from those described by Barthel, and must therefore also belong to a different species. Pant and Verma (1964) mentioned this possibility and admitted that these German and British specimens belong to different species that are very similar in the morphology of their leaves. The abaxial cuticle of *Cordaites angulosostriatus* was poorly preserved.

The abaxial cuticles of the American species *C. mansfeldii* Lesquereux and *C. serpens* Lesquereux have stomata arranged in stomatal rows. They differ from the known Bohemian taxa. It is not possible to compare them due to poor state of preservation.

A very important study concerning the systematics of cordaitalean plants was presented by Ledran (1966). This author described 22 species, mostly from French type localities. She also tried to study the cuticles, though unfortunately the abaxial cuticles are described only for 11 species, from which at most six cuticular morphotypes can be distinguished. The cuticles described by Ledran (1966), prepared from *Cordaites angulosostriatus* Grand'Eury, have stomata arranged into stomatal rows and differ from those of *Cordaites angulosostriatus* prepared by Pant and Verma (1964) and Rabitz (1966), who described cuticles with stomata arranged in stomatiferous bands from the Ruhr Basin in Germany. Ledran (1966) depicted the abaxial cuticles of the species *Cordaites tenuistriatus* Grand'Eury, *Cordaites foliolatus* Grand'Eury, *Cordaites borassifolius* (Sternberg) Unger, and

Cordaiets "Pachycordailes" lingulatus Grand 'Eury, that have stomata arranged in stomatal rows joined into stomatiferous bands. The cuticles of the species *Cordaites tenuistriatus* and *Cordaites borassifolius* belong to the same cordaites cuticular group (C), and are very similar to the Bohemian *Cordaites dobranensis* sp. nov. also in their adaxial cuticle. *Cordaites regularis* is so poorly preserved that it is difficult to say which morphotype its abaxial cuticle belongs to. The comparison of other cuticles is also difficult because Ledran (1966) used small magnification (×100 and ×250), and the cuticles were generally poorly preserved (strongly corroded). A similar situation exists with the cuticles depicted by Rabitz (1966) from the species *Cordaites angulosostriatus* and *Cordaites principalis* (germar) Geinitz.

The cuticles of European cordaitaleans from the Autunian Guadalcanal Basin in Spain have been described by Broutin (1986). He briefly described and depicted cuticles of the species *Cordaites laticrassinervis* Broutin and *Cordaites* cf. schenkii Halle. Unfortunately, the cuticles of both species were not well preserved.

New cordaites cuticular morphotypes of the artificial species "*Cordaites principalis*" s.l. from the Maritime Basin of Canada, have been described by Zodrow et al. (2000). The samples come from three sub-basins and belong to three stratigraphical units from Bolsovian to Cantabrian. Morphotype 1 has stomata arranged in stomatal rows joined into stomatiferous bands, and differs from all of the European cuticular morphotypes. Morphotype 2, with stomata in stomatal rows and guard cells whose polar ends have the swallow-tail shape, resembles the Bohemian *Cordaites rerichensis* sp. nov., though it differs in the shape of the lateral subsidiary cells of the stomata. Poorly preserved cuticles were assigned to morphotype 3 (Zodrow et al. 2000), making its comparison to any other cuticular species impossible. Morphotype 4 (Zodrow et al. 2000) has abaxial cuticles with stomata that are very similar to those of the Bohemian *Cordaites touskovensis* sp. nov. Morphotype 5 (Zodrow et al. 2000) was defined on the basis of one specimen, and differs from all European specimens by having bands of strongly cutinised cells.

The comparison of cordaitalean cuticular morphotypes from different regions is complicated because the range of variability of individual cordaitalean cuticular morphotypes is not known. Further obstacles arise from the different modes and variable quality of preservation.

Palaeoecology

Cuticular structure reveals the ecological demands of plants. Cordaitaleans usually have their stomata sunken below the epidermal level. Many species have developed crypts (outer stomatal cavities) to protect the guard cells and reduce transpiration. Some cuticles without crypts have the proximal walls of their subsidiary cells strongly cutinised and partly covering the guard cells, so as to serve the function of the crypt. There also exist types without stronger cutinisation. Papillae that usually serve the same function as a crypt have been found only in *Cordaites sustae* and *C. wartmannii*.

It is interesting that most of the cuticular morphotypes are amphistomatic. This means that stomata occur on both the adaxial and abaxial sides. The adaxial side typically has stronger cutinisation and less stomatal density, even though some species have approximately the same stomatal density on both cuticles (such as *Cordaites ledecensis* and *C. rerichensis*). In such cases, it is difficult to discern which cuticle is adaxial and which abaxial. These plants probably grew somewhere in the understory of a tropical forest with enough moisture and protection of the adaxial side against direct solar radiation.

Table 9. Changes of stomatal density on cordaitalean abaxial cuticle through the geological time.

Age	Number of stomata per 1 mm^2 of the abaxial cuticle
Langsettian	96 – 190
Duckmantian	118 – 250 (416)
Bolsovian	70 – 400
Asturian	40 – 270
Stephanian	150 – 286
Autunian	80 – 130

As previously mentioned, papillae were very rare in cordaitalean plants, and neither trichomes nor hydatodes have been found.

Most of the cordaitalean plants have very low stomatal densities on the adaxial cuticle (only several stomata per mm^2), whereas several hundered stomata per mm^2 can occur on the abaxial ones. Such leaves probably belonged to higher arborescent forms. Two species, *Cordaites schatzlarensis* Šimůnek et Libertín and *Cordaites dobranensis* sp. nov., have adaxial cuticles either without stomata, or with low stomatal densities (up to 40 per mm^2). This characteristic could help to reflect the sun and the shade the leaves of the same species.

It has been demonstrated (Woodward, 1987, Van der Burgh et al., 1993) that C3 plants respond developmentally to changing atmospheric CO_2 pressures. The C4 plants which first appeared in the mid-Teriary, and expanded thereafter (Cerling et al., 1993), have developed metabolic pathways to compensate for changing atmospheric CO_2. The stomatal resistance to CO_2 within the diffusion pathsway of C3 plant leaves is mainly determined by the frequency and size of the stomata. The atmospheric increase of pCO_2 over the past 200 years has resulted in the decrease of stomatal frequency on the leaves of certain woody angiosperms (Woodward, 1987).

No representative data set of the stomatal densities of cordaitatean plants from the Bohemian Massif yet exists. Only a few species and samples have been studied from the Langsettian, Stephanian, and Autunian strata. However, the extant information has been gathered in Table 9. This table is not definitive, as the discovery of new samples can enlarge the extent of stomatal densities in individual substages. However,

it is improbable that this would occur for specimens from the Duckmantian, Bolsovian, and Asturian strata, as the cordaitalean plants of these strata are relatively well known.

It is not possible to identify relative changes of atmospheric CO_2 during the Pennsylvanian based on Table 9, as not only the stomatal density, but also the dimensions of the guard cells and crypts would also need to be considered. Moreover, such a study should concern plants of the same species or evolutionary line, whereas the cordaitalean plants of the Bohemian Massif are diversified and belong to five cuticular groups (Table 10).

It is evident that the cordaitalean plants of the Bohemian Permo-Carboniferous basins lived in a variety of habitats. Most of the specimens considered for the present study were found in mudstones and tuffitic rocks, among assemblages of peat-forming plants.

The imprints of cordaitalean leaves preserved mainly in the red sediments of the Týnec and Líně formations, and which occur as part of a community including Walchian plants, are known mainly from the research of Šetlík (1970) and Šetlík and Rieger (1970). These assemblages are considered xerophilous and non-peatforming. The coal matter of the leaf is usualy not preserved, and the cuticles are not able to be studied. An exception is provided by the cordaitaleans from the Autunian of the Vrchlabí locality, which are preserved in bitumenous rocks. They show low stomatal density on their cuticles, and their leaves are amphistomatic, with stomata on both sides.

Conclusions

1. The cuticles show that cordaitaleans were a highly diversified group during the Pennsylvanian and Autunian.

2. The evolution of cuticular structures occurred more quickly than that of leaf morphology, resulting in a much wider range of changes concerning the cuticles.

3. Studies have shown that venation can be used only to a limited extent for determining cuticular structures. Vein widths and the number of thin veins above the sclerenchymatous bands vary from the base to the top within a single leaf. The veins are stronger (150–200 μm) in the basal part of the leaf, where a small number of sclerenchymatous bands occur, whereas the thick veins can be only 30–50 μm thick in the terminal parts of the leaf. The difference between the thick and thin veins is prominent only in the basal part of a leaf. It is common for the "thick" veins above the vascular bundles and the "thin" veins above the sclerenchymatous bands to reach the same thickness at the terminal parts of a leaf. The stomatal density usually increases slightly towards the top. These observations demonstrate that the venation of different parts of the same leaf could be erroneously classified as indicating different species. Conversely, it has been shown that similar venation patterns can belong to different species.

4. It is common for the species of the genus *Cordaites* Unger to have different venation patterns on the abaxial and adaxial sides of its leaves.

5. Thirty cordaitalean species from the Bohemian Massif have been classified into the following five cordaitalean cuticular groups, based on the distribution of stomatal complexes on the abaxial cuticle (Table 10):

A) Stomata dispersed in poorly defined or irregular and rare stomatal rows.

B) Stomata in well defined single or double stomatal rows.

C) Stomata in well defined double or multiple stomatal rows that are joined into stomatiferous bands.

D) Cells of the stomatiferous bands are different than those of the non-stomatiferous bands, and the stomatal rows are poorly defined within the stomatiferous bands.

E) Cells of the stomatiferous bands are of the same shape as those of the non-stomatiferous bands, but differ by the presence of stomata that are arranged in poorly defined stomatal rows.

6. The cordaites cuticular morphotypes described here come from six stratigraphical levels in seven Permo-Carboniferous basins. Each of these cordaites cuticular morphotypes represents a natural biological species.

7. New species described in this paper are based mainly on cuticular structures. New names have been given for most of the species, because the cuticles known from cordaitalean leaves around the world were prepared either from undetermined specimens, or they are too poorly preserved to allow any comparison with the Bohenian species. Cuticles of European cordaitalean holotypes are not very well known (*Cordaites borassifolius* (Sternberg) Unger). Most of the holotypes do not have any coaly matter suitable for cuticular anaylsis, or else their coalified leaves are too poorly preserved to make cuticular analysis possible. Another obstacle is that some museums ban the taking of samples for cuticular analysis from original specimens. However, determinations based on overall morphology and venation are very problematical, because specimens with similar venation can have quite different cuticles. The cuticular pattern is important for classifying cordaitalean plants.

8. This is only the beginning of a study. The *Cordaites* from the Stephanian and Autunian horizons of the Bohemian Massif are still poorly known. These strata, just as those of most European basins, represent sources for future research on cordaitalean plants.

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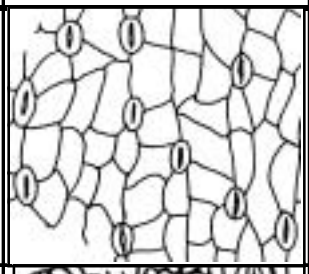
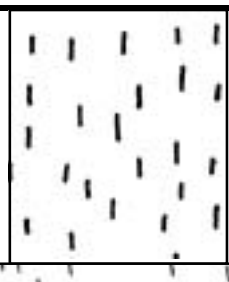
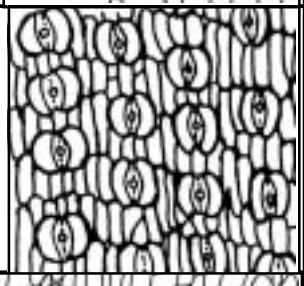
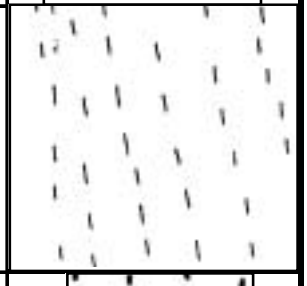
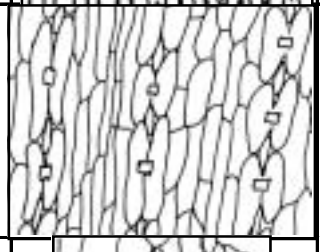
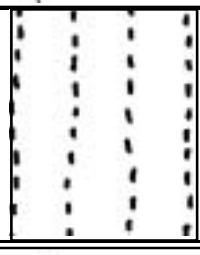
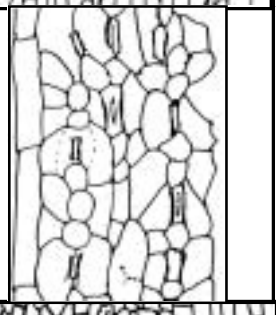
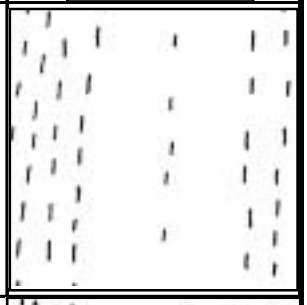
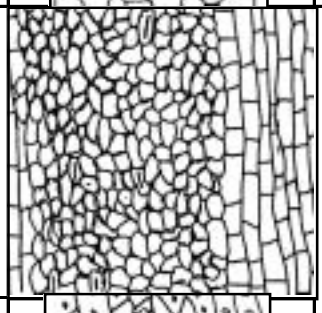
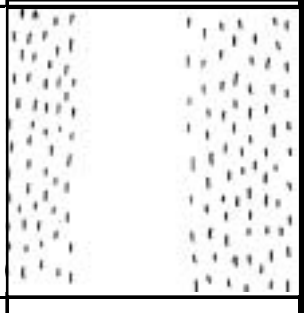
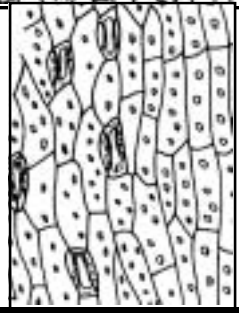
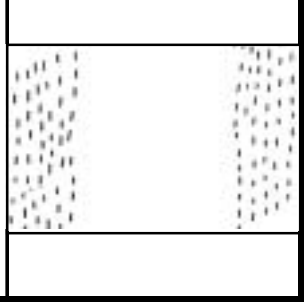
Table 10. Diagnostic features of *Cordaites* cuticular groups

Cordaites cuticular group	Subsidiary cells different from ordinary cells	Abaxial cuticle	Diagnostic features		Stomatal topography
A	–		Stomata dispersed		
	+		Stomata in ill-defined stomatal rows		
B	+		Stomata in well-defined stomatal rows		
C	+			forming stomatiferous bands	
D	–			Cells of stomatiferous band different from cells of non-stomatiferous band	
E	–		Stomata in ill-defined stomatal rows	Cells of stomatiferous band the same as cells of non-stomatiferous band	

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Explanation of plates

PLATE 1

***Cordaites borassifolius* (Sternberg) Unger**

1. Holotype, Svinná near Radnice, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C). Coll. National Museum, Prague, inv. No. E 5738, ×0.5, material to slides No. 347/1–2.
2. Venation detail of fig. 1, ×5.

***Cordaites dobranensis* sp. nov.**

3. Heřmanova Huť – Vlkýš, road cut, layer No. 12, Kladno Formation, Nýřany Member, Westphalian D. Coll. Czech Geological Survey, Prague, inv. No ZŠ 93, ×0.5.
4. Venation detail of fig. 3, ×10.

PLATE 2

Venation of the studied cordaitalean leaves

1. ***Cordaites karvinensis* sp. nov.**
   Karviná, Hlubina Mine, Upper Silesian Basin, Karviná Formation; Upper Suchá Member, 19th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta, Ostrava Museum, inv. No. A 5999, Specimen to slides No. 173/1–3, ×5.
2. ***Cordaites sustae* sp. nov.**
   Karviná, Hlubina Mine, Upper Silesian Basin, Karviná Formation; Upper Suchá Member, 19th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta, Ostrava Museum, inv. No. A 6581, Specimen to slides No. 299/1–2, ×5.

3, 4. ***Cordaites silesiacus* sp. nov.**
   Karviná, Františka Mine, Upper Silesian Basin, Karviná Formation, Upper Suchá Member, roof of the 22th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta (det. as *C. borassifolius* (Sternberg) Unger), Ostrava Museum, No. A 5989. Specimens to slides No. 301/1–6, 336/1–7, ×5.

5. ***Cordaites tuchlovicensis* sp. nov.**
   Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, intercalations of the Main Kladno Coal Seam, Bolsovian (Westphalian C). Coll. Czech Geological Survey, Prague, No. ZŠ 204. Specimen to slides No. 184/1–2, ×5.
6. ***Cordaites ledecensis* sp. nov.**
   Ledce, borehole Le 8, depth 632,45 m, Kladno-Rakovník Basin, Kladno Formation, Nýřany Member, Westphalian D. Coll. Czech Geological Survey, Prague, No. ZŠ 206. Specimen to slides No. 171/1–2, ×10.

7, 8. ***Cordaites rudnicensis* sp. nov.**
   Vrchlabí, road cut west of the town, Krkonoše Piedmont Basin, Vrchlabí Formation, Rudník Horizon – layer 7 – 425 m of the section, Permian, Lower Autunian. Coll. Czech Geological Survey, Prague, No. ZŠ 207 and ZŠ 210. Specimens to slides No. M10/1–5 and 204/1–2, ×10.

9. ***Cordaites sudeticus* sp. nov.**
   Vrchlabí, road cut west of the town, Krkonoše Piedmont Basin, Vrchlabí Formation, Rudník Horizon, layer 1 – 110 m of the section, Permian, Lower Autunian. Coll. Czech Geological Survey, Prague, No. ZŠ 215. Specimen to slides M11/1–4, ×10.
10. ***Cordaites schatzlarensis* Šimůnek et Libertín**
    Žacléř, Šverma Mine (formerly Marie Julie), Intrasudetic Basin, Žacléř Formation, Lampertice Member, Jan Šverma Coals, Langsettian – Duckmantian (Westphalian A – B). Coll. Czech Geological Survey, Prague, No. ZŠ 102. Specimen to slides No. 312/1–2, ×10.

11 – 13. ***Cordaites idae* sp. nov.**
    Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B). Coll. Czech Geological Survey, Prague, No. ZŠ 220, ZŠ 221. Specimens to slides No. 320/1–3, 314/1–2 and 321/1–5, ×10.

14. ***Cordaites idae* sp. nov.**
    Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B). Coll. Czech Geological Survey, Prague, No. ZŠ 227. Specimen to slides No. 186/1–2, ×10.
15. ***Cordaites pilsensis* sp. nov.**
    Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, Westphalian D, Kladno Formation, Nýřany Member. Coll. Czech Geological Survey, Prague, No. ZŠ 228. Specimen to slides No. 331/1–3, ×10.

PLATE 3

Venation of the studied cordaitalean leaves

1. ***Cordaites krasovicensis* sp. nov.**
   Krašovice, borehole Kš 1, depth 368,6 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Asturian (Westphalian D). Coll. Czech Geological Survey, Prague, No. ZŠ 229. Specimen to slides No. 259/1–3, ×10.
2. ***Cordaites blazkovicensis* sp. nov.**
   Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D). Coll. Czech Geological Survey, Prague, No. ZŠ 233. Specimen to slides No. 328/1–2, ×10.
3. ***Cordaites radvanicensis* sp. nov.**
   Radvanice, Kateřina Mine, Intrasudetic Basin, Odolov Formation, Jívka Member, Radvanice Coals, Stephanian B. Coll. Czech Geological Survey, Prague, No. ZŠ 234. Specimen to slides No. 318/1–2, ×10.
4. ***Cordaites svatonovicensis* sp. nov.**
   Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B). Coll. Czech Geological Survey, Prague, No. ZŠ 236. Specimen to slides No. 315/1–3, ×10.

5, 6. ***Cordaites borassifolius* (Sternberg) Unger**
   Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C), Natio-

nal Museum, Prague, No. E 5897 and E 5898. Specimens to slides No. 354/1–5 and 357/1–3, ×10.

7. ***Cordaites raconicensis* sp. nov.**
   Lubná near Rakovník, Filip II quarry, Loc. No. 34, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubá Coals, Bolsovian (Westphalian C). Coll. Czech Geological Survey, Prague, No. ZŠ 238. Specimen to slides No. 289/1–2, ×10.
8. ***Cordaites dobranensis* sp. nov.**
   Dobré štěstí Mine near Dobřany, tip, Kladno Formation, Nýřany Member, Chotíkov Coals, Westphalian D. Coll. Czech Geological Survey, Prague, No. ZŠ 282. Specimen to slides No. 164/1–4, ×10.
9. ***Cordaites dobranensis* sp. nov.**
   Dobré štěstí Mine near Dobřany, tip, Kladno Formation, Nýřany Member, Chotíkov Coals. Coll. Czech Geological Survey, Prague, No. ZŠ 251. Specimen to slides No. 296/1–2, ×10.
10. ***Cordaites wilkischensis* sp. nov.**
    Heřmanova Huť – Vlkýš, layer No. 12, Plzeň Basin, Westphalian D, Kladno Formation, Nýřany Member. Coll. Czech Geological Survey, Prague, No. ZŠ 94. Specimen to slides No. 330/1–5, ×10.
11. ***Cordaites touskovensis* sp. nov.**
    Krašovice, borehole Kš 1, depth 368.65 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Westphalian D. Coll. Czech Geological Survey, Prague, No. ZŠ 242. Specimen to slides No. 260/1–2, ×10.
12. ***Cordaites malesicensis* sp. nov.**
    Slaný Mine, Kladno-Rakovník Basin, Slaný Formation, Mšec Member, Stephanian B. Coll. Czech Geological Survey, Prague, No. ZŠ 240. Specimen to slides No. 165/1–3, ×10.
13. ***Cordaites melnicensis* sp. nov.**
    Sušno, borehole Sš 1, depth 724.9 m, Mšeno-Roudnice Basin, Slaný Formation, Jelenice Member, Mělník Coals, Stephanian B. Coll. Czech Geological Survey, Prague, No. ZŠ 241. Specimen to slides No. M9/1–2, ×10.
14. ***Cordaites kladnoensis* sp. nov.**
    Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno Coal Seam, Bolsovian (Westphalian C). Coll. Czech Geological Survey, Prague, No. ZŠ 243. Specimen to slides No. 285/1–4, ×10.
15. ***Cordaites wartmannii* sp. nov.**
    Libušín, Schoeller Mine (Nejedlý), Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno Coal Seam, Bolsovian (Westphalian C). Coll. Czech Geological Survey, Prague, No. ZŠ 246. Specimen to slides No. 113/1, 2, ×10.

PLATE 4

***Cordaites karvinensis* sp. nov.**

Karviná, Hlubina Mine, Upper Silesian Basin, Karviná Formation; Upper Suchá Member, 19th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta, Ostrava Museum, Ostrava, inv. No. A 5999.

1. Adaxial cuticle, slide No. 173/3, x 160.
2. Abaxial cuticle with stomata, slide No. 173/2, ×160.
3. Stoma on abaxial cuticle, slide No. 173/2, ×1000.
4. Stoma on abaxial cuticle, slide No. 173/3, ×1000.

***Cordaites sustae* sp. nov.**

Karviná, Hlubina Mine, Upper Silesian Basin, Karviná Formation, Upper Suchá Member, 19th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta, Ostrava Museum, Ostrava, inv. No. A 6581.

5. Adaxial cuticle, slide No. 299/1, ×250.
6. Adaxial cuticle, slide No. 299/1, ×50.
7. Abaxial cuticle with stomata, slide No. 299/1, ×250.
8. Abaxial cuticle with stomata, slide No. 299/1, ×50.
9. Stomata on abaxial cuticle, slide No. 299/1, ×500.

PLATE 5

***Cordaites sustae* sp. nov.**

Karviná, Hlubina Mine, Upper Silesian Basin, Karviná Formation, Upper Suchá Member, 19th Coal Seam, Langsettian (Westphalian A). Coll.: V. Šusta, Ostrava Museum, Ostrava, inv. No. A 6581.

1. Abaxial cuticle with stomata, slide No. 299/1, ×400.
2. A stoma on abaxial cuticle, slide No. 299/1, ×1000.
3. Stoma on abaxial cuticle, slide No. 299/1, ×1000.
4. Stoma on abaxial cuticle, slide No. 299/1, ×1000.

***Cordaites silesiacus* sp. nov.**

Karviná, Františka Mine, Upper Silesian Basin, Karviná Formation, Upper Suchá Member, roof of the 22th Coal Seam, VIth storey West, Langsettian (Westphalian A). Coll.: V. Šusta (det. Cordaites borassifolius (Sternberg) Unger), Ostrava Museum, Ostrava, inv. No. A 5989.

5. Stoma on abaxial cuticle, slide No. 301/6, ×1000.
6. Stoma on abaxial cuticle, slide No. 301/2, ×1000.

PLATE 6

***Cordaites silesiacus* sp. nov.**

Karviná, Mine Františka, Upper Silesian Basin, Karviná Formation, Upper Suchá Member, roof of the 22th Coal Seam, VIth storey West, Langsettian (Westphalian A). Coll.: V. Šusta (det. *Cordaites borassifolius* (Sternberg) Unger), Ostrava Museum, Ostrava, inv. No. A 5989.

1. Adaxial cuticle with stomata (right) and abaxial cuticle with stomata (left), slide No. 301/1, ×50.
2. Abaxial cuticle with stomata, slide No. 301/6, ×100.
3. Abaxial cuticle with stomata, slide No. 301/2, ×250.
4. Abaxial cuticle with stomata, slide No. 301/2, ×500.
5. Adaxial cuticle with stomata, slide No. 301/1, ×400.
6. Stoma on abaxial cuticle, slide No. 301/1, ×1000.
7. Adaxial cuticle with stomata, slide No. 301/1, ×400.

PLATE 7

***Cordaites strazkovicensis* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky

Member, Strážkovice Coals, Duckmantian (Westphalian B).
1. Adaxial cuticle with stomata, slide No. 228/1, ×400.
2. Adaxial cuticle with stomata, slide No. 228/1, ×400.
3. Abaxial cuticle poorly preserved, cell and stoma outlines are obscure due to corrosion, slide No. 228/1, ×400.

***Cordaites tuchlovicensis* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, intercalations of the Main Kladno Coal Seam, Bolsovian (Westphalian C).
4. Adaxial cuticle, slide No. 184/1, ×160.
5. Adaxial cuticle, slide No. 184/1, ×400.
6. Abaxial cuticle with stomata, slide No. 184/1, ×400.

PLATE 8

***Cordaites lubnensis* sp. nov.**

Lubná near Rakovník, Filip II quarry, Loc. No. 32, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Coal Seam, Bolsovian (Westphalian C).
1. Adaxial cuticle with stomata, slide No. 294/1, ×200.
2. Adaxial cuticle with stomata, slide No. 294/1, ×400.
3. Abaxial cuticle with stomata, slide No. 294/1, ×400.
4. Abaxial cuticle with stomata, slide No. 294/1, ×200.
5. Abaxial cuticle with stomata, slide No. 294/1, ×250.
6. Stomata on abaxial cuticle, slide No. 294/1, ×500.

***Cordaites ledecensis* sp. nov.**

Ledce, borehole Le 8, depth 632.45 m, Kladno-Rakovník Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D).
7. Cuticle of the 1st type (?adaxial) with stomata, slide No. 171/1, ×50.

PLATE 9

***Cordaites ledecensis* sp. nov.**

Ledce, borehole Le 8, depth 632.45 m, Kladno-Rakovník Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D).
1. Cuticle of the 1st type (?adaxial) with stomata, slide No. 171/1, ×100.
2. Cuticle of the 1st type (?adaxial) with stomata, slide No. 171/1, ×400.
3. A stoma on the cuticle of the 1st type (?adaxial), slide No. 171/1, ×1000.
4. Cuticle of the 2nd type (?adaxial) with stomata, slide No. 171/1, ×160.
5. Cuticle of the 2nd type (?adaxial) with stomata, slide No. 171/1, ×400.
6. A stoma on the cuticle of the 2nd type (?abaxial), slide No. 171/1, ×1000.
7. A stoma on the cuticle of the 2nd type (?abaxial), slide No. 171/1, ×1000.

PLATE 10

***Cordaites rudnicensis* sp. nov.**

Vrchlabí, road cut West from the town, Krkonoše Piedmont Basin, Vrchlabí Formation, Rudník Horizon – layer 7, Permian, Lower Autunian.
1. Stoma on adaxial cuticle, slide No. M10/3, ×500.
2. Adaxial cuticle with stomata, slide No. M12/2, ×400.
3. Stoma on adaxial cuticle, slide No. M12/2, ×1000.
4. Abaxial cuticle with stomata, slide No. M12/2, ×400.
5. Adaxial cuticle with stomata, slide No. 6b, ×133.
6. Stoma on adaxial cuticle, slide No. 6b, ×666.
7. Stoma on abaxial cuticle, slide No. 6b, ×666.
8. Abaxial cuticle with stomata, slide No. 6b, ×133.
9. Stoma on abaxial cuticle, slide No. 6b, ×666.

PLATE 11

***Cordaites sudeticus* sp. nov.**

Vrchlabí, road cut West from the town, Krkonoše Piedmont Basin, Vrchlabí Formation, Rudník Horizon, layer 1, Permian, Lower Autunian.
1. Adaxial cuticle with stomata, slide No. M11/2, ×100.
2. Adaxial cuticle with stomata, slide No. M11/2, ×250.
3. Stomata on adaxial cuticle, slide No. M11/2, ×400.
4. Stoma on adaxial cuticle, slide No. M11/2, ×1000.
5. Stomata on abaxial cuticle, slide No. M11/4, ×400.
6. Stoma on abaxial cuticle, slide No. M11/4, ×1000.
7. Inner view on adaxial cuticle with stomata in SEM, stub No. 6f, ×133.
8. Inner view on adaxial cuticle with stomata in SEM, stub No. 6f, ×133.
9. Inner view of stoma on adaxial cuticle in SEM, stub No. 6f, ×666.
10. Inner view of stoma on adaxial cuticle in SEM, stub No. 6f, ×666.

PLATE 12

***Cordaites schatzlarensis* Šimůnek et Libertín**

Žacléř, Šverma Mine (formerly Marie Julie), Intrasudetic Basin, Žacléř Formation, Lampertice Member, Jan Šverma Coals, Duckmantian (Westphalian B).
1. Adaxial cuticle with stomata, slide No. 312/1, ×200.
2. Abaxial cuticle with stomatal rows, slide No. 312/1, ×200.
3. Stomata on abaxial cuticle, slide No. 312/2, ×1000.
4. Stomatal rows on abaxial cuticle, slide No. 312/2, ×400.
5. Stomatal rows on abaxial cuticle, slide No. 312/1, ×400.
6. Stomata on adaxial cuticle, slide No. 312/1, ×400.

PLATE 13

***Cordaites schatzlarensis* Šimůnek et Libertín**

Žacléř, Šverma Mine (formerly Marie Julie), Intrasudetic Basin, Žacléř Formation, Lampertice Member, Jan Šverma Coals, Langsettian – Duckmantian (Westphalian A – B).
1. Adaxial cuticle with stoma, slide No. 312/2, ×400.

***Cordaites idae* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).
2. Abaxial cuticle, slide No. 154/3, ×200.
3. Abaxial cuticle showing stomatal row, slide No. 154/3, ×400.

4. Abaxial cuticle showing stomatal rows, slide No. 154/3, ×100.
5. Abaxial cuticle showing stomatal row, slide No. 321/4, ×400.
6. Stomatal rows on abaxial cuticle, slide No. 320/2, ×400.
7. Inner view of abaxial cuticle with stomata in SEM, stub No. 7j, ×333.
8. Adaxial cuticle in SEM, slide No. 7j, ×333.
9. Inner view on abaxial cuticle with stomata in SEM, stub No. 7j, ×666.
10. Outer view on abaxial cuticle with stomata in SEM, stub No. 7j, ×333.
11. Outer view on abaxial cuticle with stomata in SEM, stub No. 7j, ×666.

PLATE 14

***Cordaites idae* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).

1. Abaxial cuticle showing stomatal rows, slide No. 314/1, ×200.
2. Abaxial cuticle showing stomatal rows, slide No. 314/1, ×400.
3. Adaxial cuticle, slide No. 154/3, ×100.
4. Adaxial cuticle, slide No. 154/4, ×160.
5. Abaxial cuticle showing stomatal rows, slide No. 154/3, ×400.
6. Abaxial cuticle showing stomatal row, slide No. 154/3, ×1000.

PLATE 15

***Cordaites idae* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovické Coals, Duckmantian (Westphalian B).

1. Abaxial cuticle showing stomatal rows, slide No. 186/1, ×200.
2. Abaxial cuticle with stomatal rows, slide No. 186/1, ×400.

***Cordaites rerichensis* sp. nov.**

Řeřichy, boreholeŘe 3, depth 293.2–293.5 m. Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Coals, Bolsovian (Westphalian C).

3. Adaxial cuticle showing stomatal rows, slide No. 246/1, ×200.
4. Adaxial cuticle showing stomatal rows, slide No. 246/1, ×400.

PLATE 16

***Cordaites rerichensis* sp. nov.**

Řeřichy, boreholeŘe 3, depth 293.2–293.5 m. Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Coals, Bolsovian (Westphalian C).

1. Abaxial cuticle showing stomatal rows, slide No. 246/1, ×200.
2. Abaxial cuticle showing stomatal rows, slide No. 246/1, ×400.
3. Adaxial cuticle showing stomatal rows, slide No. 246/1, ×100.
4. Abaxial cuticle showing stomatal rows, slide No. 246/1, ×100.
5. Inner view on adaxial cuticle stomatal row, SEM, stub No. 2/1, ×400.
6. Inner view on abaxial cuticle showing stomatal rows, SEM, stub No. 2/1, ×400.
7. Inner view on abaxial cuticle showing stomatal row, SEM, slide No. 2/1, ×600.
8. Abaxial cuticle showing stomatal row, slide No. 246/1, ×400.

PLATE 17

***Cordaites pilsensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, Kladno Formation, Nýřany Member. Asturian (Westphalian D).

1. Abaxial cuticle showing stomatal row, slide No. 331/2, ×400.
2. Adaxial cuticle showing stomata, slide No. 331/2, ×250.
3. Stoma on adaxial cuticle, slide No. 331/2, ×500.
4. Stoma on adaxial cuticle, slide No. 331/2, ×500.

***Cordaites krasovicensis* sp. nov.**

Krašovice, borehole Kš 1, depth 368.6 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Asturian (Westphalian D.)

5. Abaxial cuticle showing stomatal rows, slide No. 259/1, ×100.
6. Adaxial cuticle showing stomatal rows, slide No. 259/3, ×50.
7. Adaxial cuticle showing stomatal rows, slide No. 259/1, ×100.
8. Adaxial cuticle showing stomatal rows, SEM, ×50.
9. Inner view on adaxial cuticle showing stomata in SEM, 750×.
10. Inner view on adaxial cuticle showing stomatal rows in SEM, ×250.

11 Inner view on adaxial cuticle showing stomatal row in SEM, ×450.

PLATE 18

***Cordaites krasovicensis* sp. nov.**

Krašovice, borehole Kš 1, depth 368.6 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Asturian (Westphalian D).

1. Adaxial cuticle showing stomatal rows, slide No. 259/1, ×400.
2. Stoma on adaxial cuticle, slide No. 259/3, ×1000.
3. Stoma on adaxial cuticle, slide No. 259/1, ×1000.
4. Abaxial cuticle showing stomatal rows, slide No. 259/1, ×400.
5. Stoma on abaxial cuticle, slide No. 259/1, ×1000.
6. Stoma on abaxial cuticle, slide No. 259/1, ×1000.

PLATE 19

***Cordaites blazkovicensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 5, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D).

1. Adaxial cuticle showing stomatal rows, slide No. 328/1, ×200.
2. Adaxial cuticle showing stomatal row, slide No. 328/1, ×400.
3. Detail of stoma on adaxial cuticle, slide No. 328/1, ×1000.
4. Adaxial cuticle showing stomata, slide No. 328/1, ×400.

***Cordaites blazkovicensis* sp. nov.**

Blažkovice, borehole RPZ 30, depth 338 m, Kladno-Rakovník Basin, Nýřany Member, Mirošov Horizon, Asturian (Westphalian D).

5. Adaxial cuticle showing stomatal row, slide No. 188/2, ×400.
6. Abaxial cuticle showing stomatal rows, slide No. 188/3, ×400.

PLATE 20

***Cordaites radvanicensis* sp. nov.**

Radvanice, Kateřina Mine, Intrasudetic Basin, Odolov Formation, Jívka Member, Radvanice Coals, Stephanian B.

1. Adaxial cuticle with stomatiferous bands, slide No. 318/1, ×200.
2. Detail of stomatiferous band on adaxial cuticle with stomata, slide No. 318/1, ×400.
3. Detail of stomatiferous band on adaxial cuticle with stomata, slide No. 318/1, ×400.
4. Abaxial cuticle showing stomatal rows, slide No. 318/1, ×200.
5. Abaxial cuticle showing stomatal row, slide No. 318/1, ×400.
6. Abaxial cuticle with stomata, slide No. 318/1, ×400.

PLATE 21

***Cordaites risutensis* sp. nov.**

Řisuty, borehole Ři 24, depth 74,45 m, Kladno-Rakovník Basin, Slaný Formation, Malesice (Hředle) Member, Stephanian B.

1. Adaxial cuticle with dark bands showing stomata, slide No. 346/2, ×50.
2. Adaxial cuticle showing dark bands, slide No. 346/2, ×200.
3. Detail of stomatiferous band on adaxial cuticle with stomata, slide No. 346/1, ×200.
4. Detail of stoma on adaxial cuticle, slide No. 346/1, ×400.
5. Detail of stoma on adaxial cuticle, slide No. 346/3, ×400.
6. Detail of stoma on adaxial cuticle, slide No. 346/2, ×400.
7. Adaxial cuticle, slide No. 346/3, ×200.
8. Detail of two stomata on abaxial cuticle, slide No. 346/1, ×500.

PLATE 22

***Cordaites svatonovicensis* nov. sp.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).

1. Adaxial cuticle, slide No. 315/1, ×200.
2. Adaxial cuticle showing stomata, slide No. 315/1, ×400.
3. Adaxial cuticle showing stomata, slide No. 315/1, ×400.
4. Abaxial cuticle showing stomatiferous bands, slide No. 315/2, ×200.
5. Detail of stomatiferous band on abaxial cuticle showing stomata, slide No. 315/1, ×400.
6. Detail of stoma on adaxial cuticle, slide No. 315/1, ×1000.

PLATE 23

***Cordaites svatonovicensis* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (Ida Gallery), Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, Duckmantian (Westphalian B).

1. Two stomata on abaxial cuticle, slide No. 315/1, ×1000.

***Cordaites odolovensis* sp. nov.**

Rtyně v Podkrkonoší, Nejedlý Mine (formerly Ida Gallery), stope 507, Intrasudetic Basin, Žacléř Formation, Prkenný Důl-Žďárky Member, Strážkovice Coals, 1st tuffaceous interbed above the footwall of the 3rd Žďárky Coal Seam. Duckmantian (Westphalian B).

2. Adaxial cuticle with stomata, slide No. 316/1, ×200.
3. Adaxial cuticle with stoma, slide No. 316/1, ×400.
4. Abaxial cuticle with stomatiferous band, slide No. 316/2, ×400.
5. Detail of stomatiferous band of the abaxial cuticle, slide No. 315/1, ×1000.

PLATE 24

***Cordaites borassifolius* (Sternberg) Unger**

Svinná near Radnice, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C).

1. Abaxial cuticle with stoma prepared from the holotype (E 5738, see pl. 1, fig. 1), slide No. 347/2, ×400.

***Cordaites borassifolius* (Sternberg) Unger**

Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C).

2–5. Adaxial cuticles with stomata, 2 – slide No. 108/5, 50x, 3 – slide No. 358/3, photo No. 145/32, (National Museum No. E 5896), 40x, 4 – slide No. 354/5, ×50, (National Museum No. E 5898), 5 slide No. 356/2, (National Museum No. E 5895), ×50.

6, 7. Adaxial cuticle with stomata, slide No. 353/2, (National Museum No. E 5898), ×200 and ×400.

8. Detail of stoma on adaxial cuticle, slide No. 357/2, (National Museum in Prague, No. E 5897), ×400.

PLATE 25

***Cordaites borassifolius* (Sternberg) Unger**

Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C). Cuticles prepared

from samples deposited in the National Museum in Prague.

1, 2. Adaxial cuticle with stoma and detail of the stoma prepared from a specimen No. E 5895, slide No.356/2, ×400 and ×1000.
3. Detail of stoma on abaxial cuticle, slide No. 108/5, (Coll. Czech Geological Survey), ×1000.
4. Abaxial cuticle with stomatiferous bands formed by joined stomatal rows, slide No. 356/1, (National Museum in Prague, No. E 5895), ×40.
5. Dtto, slide No. 108/5, (Czech Geological Survey), ×50.
6. Abaxial cuticle with stomatiferous bands formed by joined stomatal rows, slide No. 357/7, (National Museum in Prague No. E 5897), ×200.
7. Dtto, slide No. 356/1, (National Museum in Prague, No. E 5895), ×400.

PLATE 26

***Cordaites borassifolius* (Sternberg) Unger**

Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C). Cuticles prepared from specimens deposited in the National Museum in Prague.

1. Abaxial cuticle with stomatiferous bands formed by joined stomatal rows, slide No. 108/5, (Coll. Czech Geological Survey), ×400.
2. Detail of stoma from fig. 1, ×1000.
3. Details of three stomata of abaxial cuticle with pronounced crypt, slide No. 354/4, (National Museum, No. E 5898), ×1000.
4. Detail of stoma of abaxial cuticle with pronounced crypt, slide No. 358/5, (National Museum, No. E 5896), ×1000.
5. Outer view on adaxial cuticle with stomatal rows in SEM, stub No. 9f, (National Museum, No.E 5898), ×600.
6. Dtto, detail of crypt from fig. 5, slide No. 9f, ×3000.

PLATE 27

***Cordaites borassifolius* (Sternberg) Unger**

Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C). Abaxial cuticles in SEM prepared from specimens deposited in National Museum in Prague.

1, 2. Stomatiferous bands with stomata sunken in well pronounced crypt, outer view, stub No. 9ch, (National Museum in Prague, E 5896) ×500 and ×1600.
3, 4. Stomatiferous bands with stomata sunken in well pronounced crypt, outer view, stub No. 9h, (National Museum in Prague, E 5895) ×500 and ×1500.
5. Stomatiferous bands with stomata and guard cells, inner view, stub No. 9h, ×300.
6. Detail of stomata and guard cells in inner view, stub No. 9h, ×1500.

PLATE 28

***Cordaites borassifolius* (Sternberg) Unger**

Ovčín near Radnice, Pokrok Mine, Radnice Basin, Kladno Formation, Radnice Member, Radnice Coals, Whetstone Horizon, Bolsovian (Westphalian C). Cuticles in SEM in outer view, prepared from specimen No. E 5896 deposited in the National Museum in Prague.

1. Adaxial cuticle with stoma, stub No. 9ch, ×500.
2. Detail of stoma from fig. 1, ×3000.

***Cordaites raconicensis* sp. nov.**

Lubná near Rakovník, Filip II quarry, Loc. No. 34, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Coals, Bolsovian (Westphalian C).

3. Adaxial cuticle in outer view, SEM, stub No. 1A, ×333.
4, 5. Abaxial cuticle showing stomata with indication of Florin ring in outer view, SEM, stub No. 1A, ×333.
6. Detail of stoma on adaxial cuticle, slide No. 289/1, ×500.
7. Adaxial cuticle with stomata, slide No. 289/1, ×125.
8. Adaxial cuticle with stomata, slide No. 289/1, ×400.
9. Detail of stoma on adaxial cuticle, slide No. 289/1, ×1000.
10. Abaxial cuticle with stomatal rows joined into stomatiferous bands, slide No. 289/1, ×125.

PLATE 29

***Cordaites raconicensis* sp. nov.**

Lubná near Rakovník, Filip II quarry, Loc. No. 34, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Lubná Coals, Bolsovian (Westphalian C).

1, 2. Abaxial cuticle showing stomatiferous band with stomata having pronounced Florin ring, slide No. 289/2, ×400 and ×1000.

***Cordaites dobranensis* sp. nov.**

Dobřany, Dobré štěstí Mine, tip, Kladno Formation, Nýřany Member, Chotíkov Coals, Asturian (Westphalian D).

3. Adaxial cuticle showing stomata arranged in stomatal row, slide No. 164/3, ×100.
4. Adaxial cuticle showing stomata arranged in stomatal row, slide No. 164/3, ×200.
5. Detail of three stomata of adaxial cuticle, slide No. 164/3, ×400.
6. Adaxial cuticle without stomata (morphotype 16), slide No. 241/4, ×200.

PLATE 30

***Cordaites dobranensis* sp. nov.**

Dobřany, Dobré štěstí Mine, tip, Kladno Formation, Nýřany Member, Chotíkov Coals, Asturian (Westphalian D). (1, 2, 4–7)

1, 2. Detail of stomata of adaxial cuticle, slide No. 283/4, ×400 and ×1000.
3. Stoma on adaxial cuticle (morphotype 17 – Nýřany – Tesla locality, borehole HVJ 3/4, depth 94 m, Nýřany Member), slide No. 166/2, ×400.
4, 5. Adaxial cuticle from inner view, SEM, stub 2E, ×133 and ×666.
6, 7. Abaxial cuticle showing stomatal rows joined into stomatiferous bands, slide No. 164/3, ×100 and ×400.

PLATE 31

***Cordaites dobranensis* sp. nov.**

Dobřany, Dobré štěstí Mine, tip, Kladno Formation, Nýřany Member, Chotíkov Coals, Asturian, (Westphalian D).

1. Stomatiferous band of abaxial cuticles with stomatal complexes, slide No. 242/2, ×400.
2. Detail of stoma from fig. 1, ×1000.
3. Abaxial cuticle with transverse crypt above the guard cells, outer view, SEM, stub No. 3, ×300.
4. Abaxial cuticle with transverse crypt above the guard cells, outer view, SEM, stub No. 3, ×500.
5. Abaxial cuticle with transverse crypt above the guard cells, outer view, SEM, stub No. 3, ×900.

6, 7. Abaxial cuticle, with anticlinal walls and sunken guard cells, inner view, stub No. 2E, ×400.

PLATE 32

***Cordaites dobranensis* sp. nov.**

Dobřany, Dobré štěstí Mine, tip, Kladno Formation, Nýřany Member, Chotíkov Coals, Asturian (Westphalian D).

1. A stomatiferous band of abaxial cuticles with stomatal complexes, strong corrosion of periclinal walls, slide No. 283/4, ×400.
2. Abaxial cuticle, stomatiferous band with stomatal complexes some with transverse crypt, slide No. 241/4, ×400.

***Cordaites dobranensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 6, Nýřany Member, Asturian (Westphalian D).

3. Adaxial cuticle with two stomatal complexes, slide No. 329/3, ×400.

***Cordaites wilkischensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 12, Plzeň Basin, Westphalian D, Kladno Formation, Nýřany Member.

4. Adaxial cuticle, slide No. 330/5, ×200.
5. Adaxial cuticle, slide No. 327/1, ×400.

6, 7. Adaxial cuticle, inner view, SEM, stub 7a, ×200 and ×500.

PLATE 33

***Cordaites wilkischensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 12, Plzeň Basin, Westphalian D, Kladno Formation, Nýřany Member.

1. Abaxial cuticle with stomata in stomatiferous bands, slide No. 327/1, ×100.
2. Abaxial cuticle with stomata in stomatiferous bands, slide No. 330/5, ×200.
3. Detail of stomata of abaxial cuticle, slide No. 327/3, ×400.
4. Detail of stomata of abaxial cuticle, slide No. 330/5, ×400.

5–7. Abaxial cuticle with stomata, inner view, SEM, stub No. 7a, ×500, ×666 and ×333.

PLATE 34

***Cordaites wilkischensis* sp. nov.**

Heřmanova Huť – Vlkýš, layer No. 12, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D).

1. Abaxial cuticle, detail of stoma, slide No. 327/3, ×1000.

2, 3. Abaxial cuticle with stomata in stomatiferous bands, inner view, SEM, stub 7a, 7d–e, both ×133.

4. Abaxial cuticle, detail of stoma, inner view, SEM, stub No. 7d–e, ×666.
5. Adaxial cuticle, slide No. 327/3, ×200.

***Cordaites malesicensis* sp. nov.**

Slaný Mine, Kladno-Rakovník Basin, Slaný Formation, Mšec Member, Stephanian B.

6. Adaxial cuticle, slide No. 165/1, ×200.
7. Abaxial cuticle with stomata in stomatiferous bands, inner view, SEM, sample No. ZŠ 240, ×200.
8. Detail of three stomata of abaxial cuticle inner view, SEM, sample No. ZŠ 240, ×750.

PLATE 35

***Cordaites malesicensis* sp. nov.**

Slaný, Slaný Mine, Kladno-Rakovník Basin, Slaný Formation, Mšec Member, Stephanian B.

1. Abaxial cuticle with stomatal row, slide No. 165/1, ×200.
2. Abaxial cuticle, detail of stomata, cuticle is slightly overmacerated, slide No. 165/1, ×400.
3. Detail of stoma of abaxial cuticle, guard cells well pronounced, inner view, SEM, sample No. ZŠ 240, ×1500.

***Cordaites melnicensis* sp. nov.**

Sušno locality, borehole Sš 1, depth 724.9 m, Mšeno-Roudnice Basin, Slaný Formation, Jelenice Member, Mělník Coals, Stephanian B.

4, 5. Adaxial cuticle with dark bands containing stomata, slide No. M9/2 and M9/1, both ×40.
6. Detail of two bands of adaxial cuticle with stomata, slide No. M9/1, ×400.

PLATE 36

***Cordaites melnicensis* sp. nov.**

Sušno, borehole Sš 1, depth 724.9 m, Mšeno-Roudnice Basin, Slaný Formation, Jelenice Member, Mělník Coals, Stephanian B.

1. Adaxial cuticle with dark bands containing stomata, slide No. M9/1, ×200.
2. Detail of two stomata from dark stomatiferous band of adaxial cuticle, slide No. M9/1, ×400.
3. Adaxial cuticle with stomata photographed in ultraviolet fluorescence, No. ZŠ 241, 63×.
4. Adaxial cuticle with two stomata photographed in ultraviolet fluorescence, No. ZŠ 241, ×250.
5. Detail of stoma of adaxial cuticle photographed in ultraviolet fluorescence, No. ZŠ 241, ×400.
6. Abaxial cuticle with stomatiferous bands, slide No. M9/2, ×40.
7. Detail of stoma of abaxial cuticle, inner view, SEM, stub No. 7i, ×666.
8. Adaxial cuticle, inner view, SEM, stub No. 7i, ×133.

PLATE 37

***Cordaites melnicensis* sp. nov.**

Sušno, borehole Sš 1, depth 724.9 m, Mšeno-Roudnice Ba-

sin, Slaný Formation, Jelenice Member, Mělník Coals, Stephanian B.

1. Abaxial cuticle with stomata in stomatiferous bands, slide No. M9/1, ×400.
2. Abaxial cuticle with stomata in stomatiferous bands, slide No. M9/1, ×400.
3. Detail of two stomata of abaxial cuticle, slide No. M9/1, ×1000.

***Cordaites touskovensis* sp. nov.**

Krašovice, borehole Kš 1, depth 368.65 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Asturian (Westphalian D).

4. Adaxial cuticle with dark bands, slide No. 260/2, ×100.
5. Adaxial cuticle with stoma, slide No. 260/3, ×400.
6. Abaxial cuticle with stomatiferous bands, slide No. 260/2, ×100.

PLATE 38

***Cordaites touskovensis* sp. nov.**

Krašovice, borehole Kš 1, depth 368.65 m, Plzeň Basin, Kladno Formation, Nýřany Member, Touškov Coals, Asturian (Westphalian D).

1. Abaxial cuticle with stomata, slide No. 260/3, ×400.

***Cordaites kladnoensis* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of Main Kladno coal seam, Bolsovian (Westphalian C).

2. Adaxial cuticle with dark bands containing stomata, slide No.183/3, ×50.
3. Adaxial cuticle, slide No. 295/2, ×200.
4. Adaxial cuticle with stomata, slide No. 295/2, ×400.
5. Adaxial cuticle, inner view, SEM, stub No. 2C, ×200.
6. Dtto. stub No. 2C, ×500.

PLATE 39

***Cordaites kladnoensis* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

1. Abaxial cuticle showing stomatiferous band with dispersed stomata, slide No. 183/3, ×400.
2. Abaxial cuticle, detail of stoma from stomatiferous band, stub No.183/3, ×400.
3. Abaxial cuticle with stomatiferous band, inner view, SEM, stub No. 2C, ×200.
4. Abaxial cuticle, detail of stoma of stomatiferous band, inner view, SEM, stub No. 2C, ×500.
5. Abaxial cuticle showing stomatiferous bands with dispersed stomata, slide No. 285/1, ×200.
6. Abaxial cuticle showing stomatiferous bands with dispersed stomata, slide No. 183/3, ×200.

PLATE 40

***Cordaites kladnoensis* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

1. Abaxial cuticle showing stomatiferous band with dispersed stomata, slide No. 285/1, ×400.
2. Detail of stoma in dark band of adaxial cuticle, slide No. 285/2, ×400.
3. Adaxial cuticles with dark stomatiferous bands, slide No. 183/3, ×160.

***Cordaites latus* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

4. Adaxial cuticle with stomata-like furrow structures, slide No. 185/1, ×50.
5. Adaxial cuticle with stomata-like furrow structures, slide No. 185/1, ×100.
6. Adaxial cuticle with stomata-like furrow structures, slide No. 185/1, ×160.
7. Adaxial cuticle with stomata-like furrow structure, slide No. 185/1, ×400.

PLATE 41

***Cordaites latus* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

1. Detail of stomata-like furrow structure on adaxial cuticle, slide No. 185/1, ×1000.
2. Adaxial cuticle with stomata-like furrow structures, slide No. 185/2, ×400.
3. Abaxial cuticle, strongly corroded, stomata hardly visible, slide No. 185/1, ×160.
4. Abaxial cuticle with stomata in stomatiferous band, slide No. 185/2, ×400.

***Cordaites wartmannii* sp. nov.**

Libušín, Schoeller (Nejedlý) Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

5. Adaxial cuticle with dark bands showing stomata, slide No. 113/1, ×100.
6. Detail of a stoma from dark band of adaxial cuticle, slide No. 113/2, ×400.

PLATE 42

***Cordaites wartmannii* sp. nov.**

Libušín, Schoeller (Nejedlý) Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

1. Abaxial cuticle with stomatiferous bands showing stomata in ill defined stomatal rows, slide No. 113/2, ×100.
2. Abaxial cuticle with stomatiferous band showing stomata, slide No. 113/2, ×400.
3. Abaxial cuticle with stomatiferous band showing stomata, slide No. 113/2, ×400.
4. Details of three stomata of abaxial cuticle, slide No. 113/2, ×1000.

5. Details of three stomata of abaxial cuticle, slide No. 113/2, ×1000.
6. Adaxial cuticle with dark stomatifoerous band containing stomata, slide No. 113/2, ×400.
7. Detail of two stomata from dark band of adaxial cuticle, slide No. 113/2, ×1000.

PLATE 43

***Cordaites wartmannii* sp. nov.**

Libušín, Schoeller (Nejedlý) Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

1. Abaxial cuticle with stomatiferous bands showing stomata in ill defined stomatal rows, slide No. 113/2, ×160.
2. Adaxial cuticle, detail of stoma, slide No. 113/2, ×1000.

***Cordaites polynervus* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

3. Adaxial cuticle with darker bands showing stomata, slide No. 182/2, ×100.
4. Adaxial cuticle with darker bands showing stomata, slide No. 182/2, ×160.
5. Adaxial cuticle with light and dark bands showing stomata, slide No. 182/2, ×50.
6. Adaxial cuticle, detail of stoma, slide No. 182/2, ×400.
7. Strongly corroded abaxial cuticle, the stomata hardly discernible, slide No. 182/2, ×200.

PLATE 44

***Cordaites polynervus* sp. nov.**

Tuchlovice, Nosek Mine, Kladno-Rakovník Basin, Kladno Formation, Radnice Member, Radnice Coals, intercalations of the Main Kladno coal seam, Bolsovian (Westphalian C).

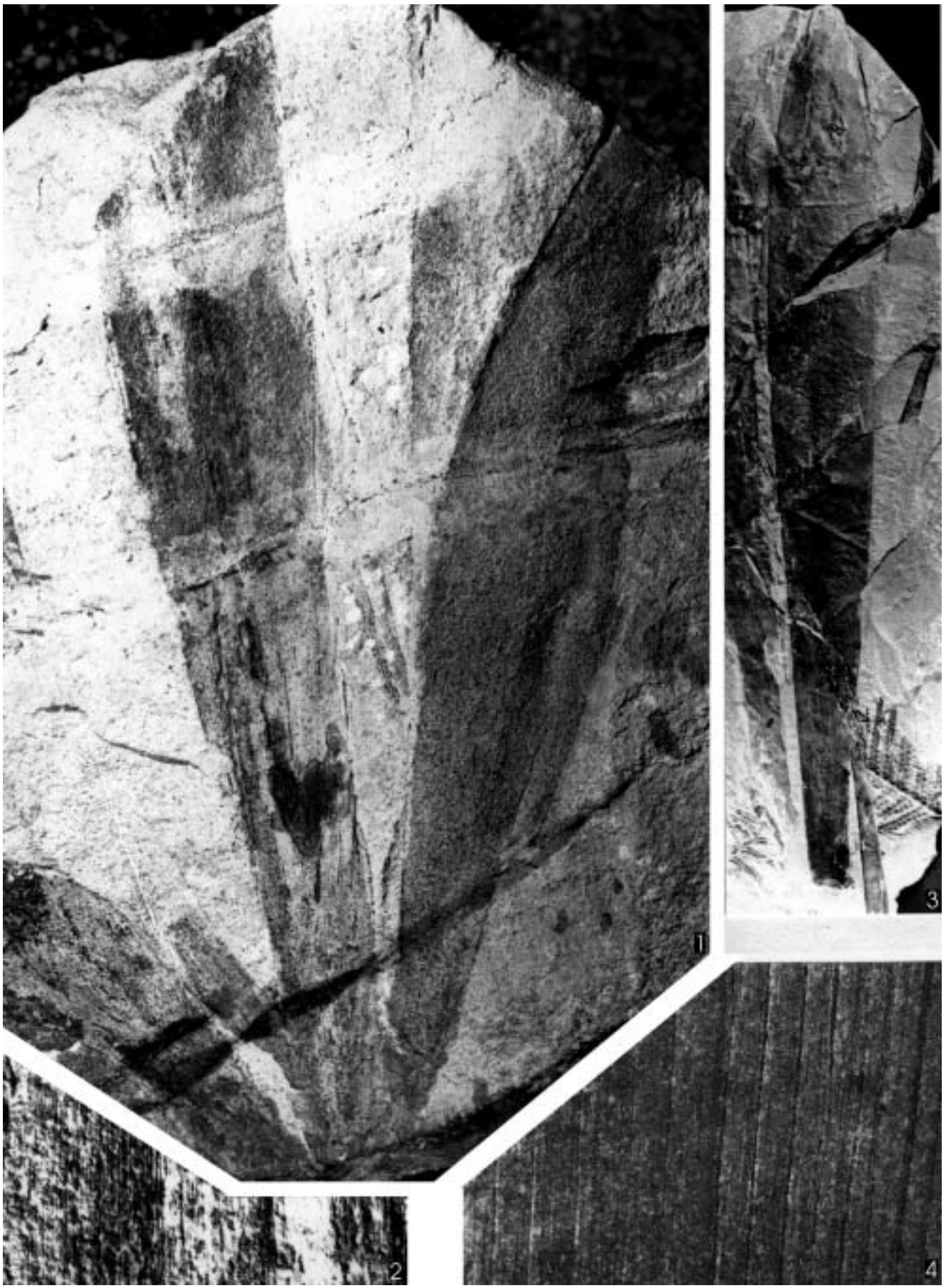
1. Adaxial cuticle, detail of stomata from darker band, slide No. 182/2, ×400.
2. Adaxial cuticle, detail of stoma from fig. 1, ×1000.
3. Strongly corroded abaxial cuticle showing strongly damaged stomata, slide No. 182/2, ×400.

***Cordaites* sp.**

Heřmanova Huť – Vlkýš locality, layer No. 5, Plzeň Basin, Kladno Formation, Nýřany Member, Asturian (Westphalian D).

4. Adaxial cuticle with square or oblong cells lacking of diagnostic features, slide No. 326/1, ×200.
5. Adaxial cuticle with square or oblong cells lacking of diagnostic features, slide No. 326/1, ×400.

PLATE 1



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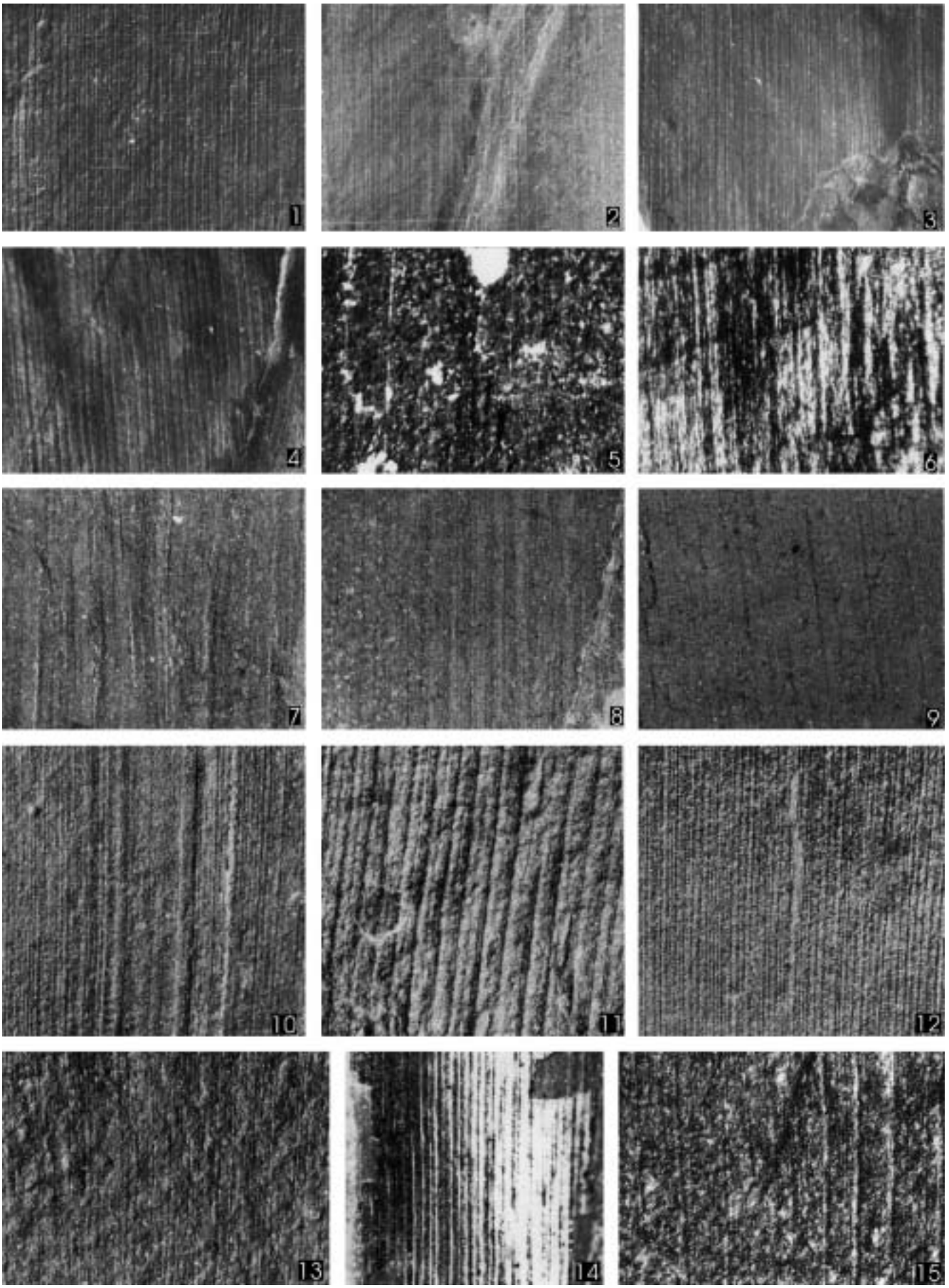

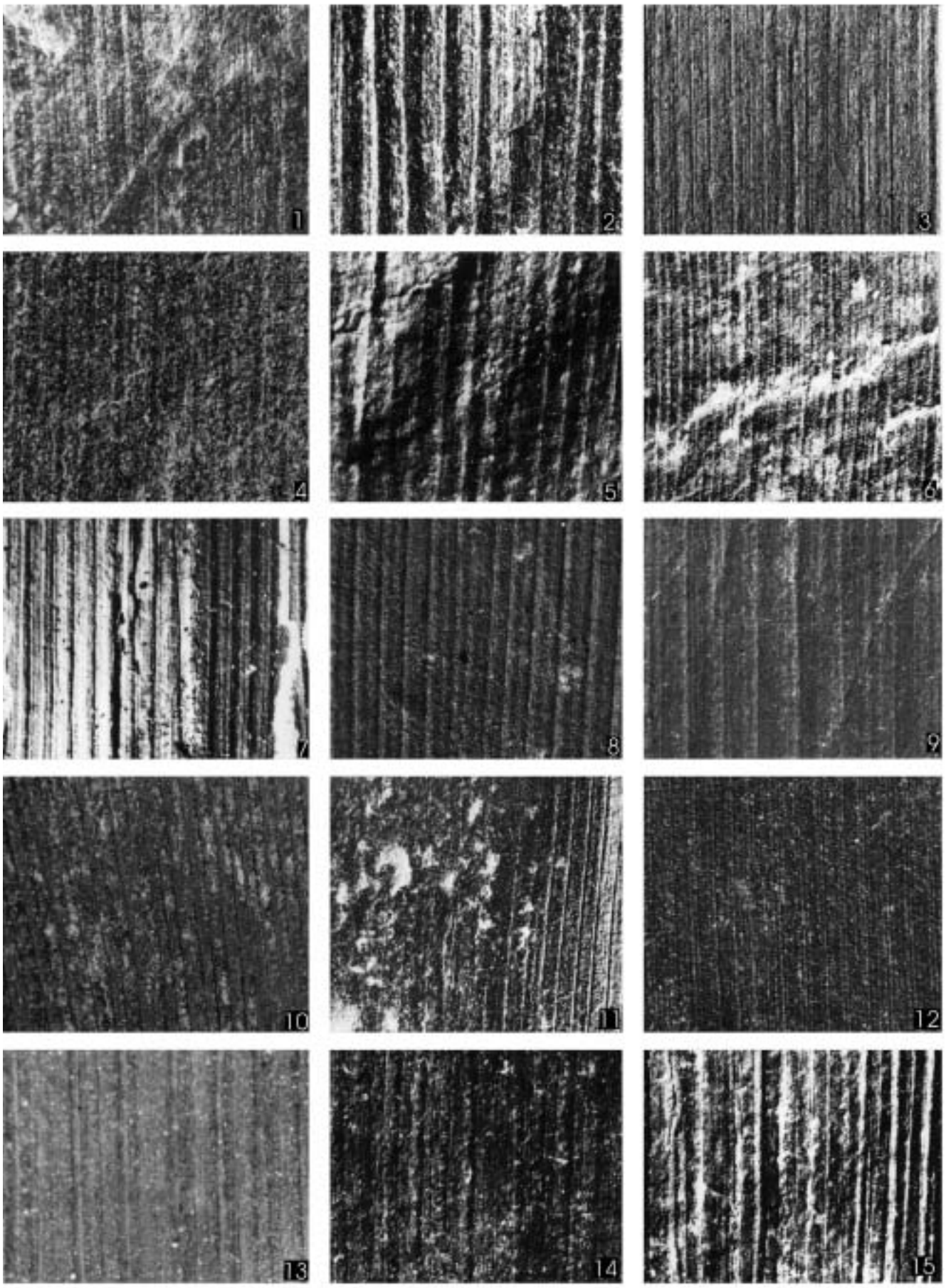
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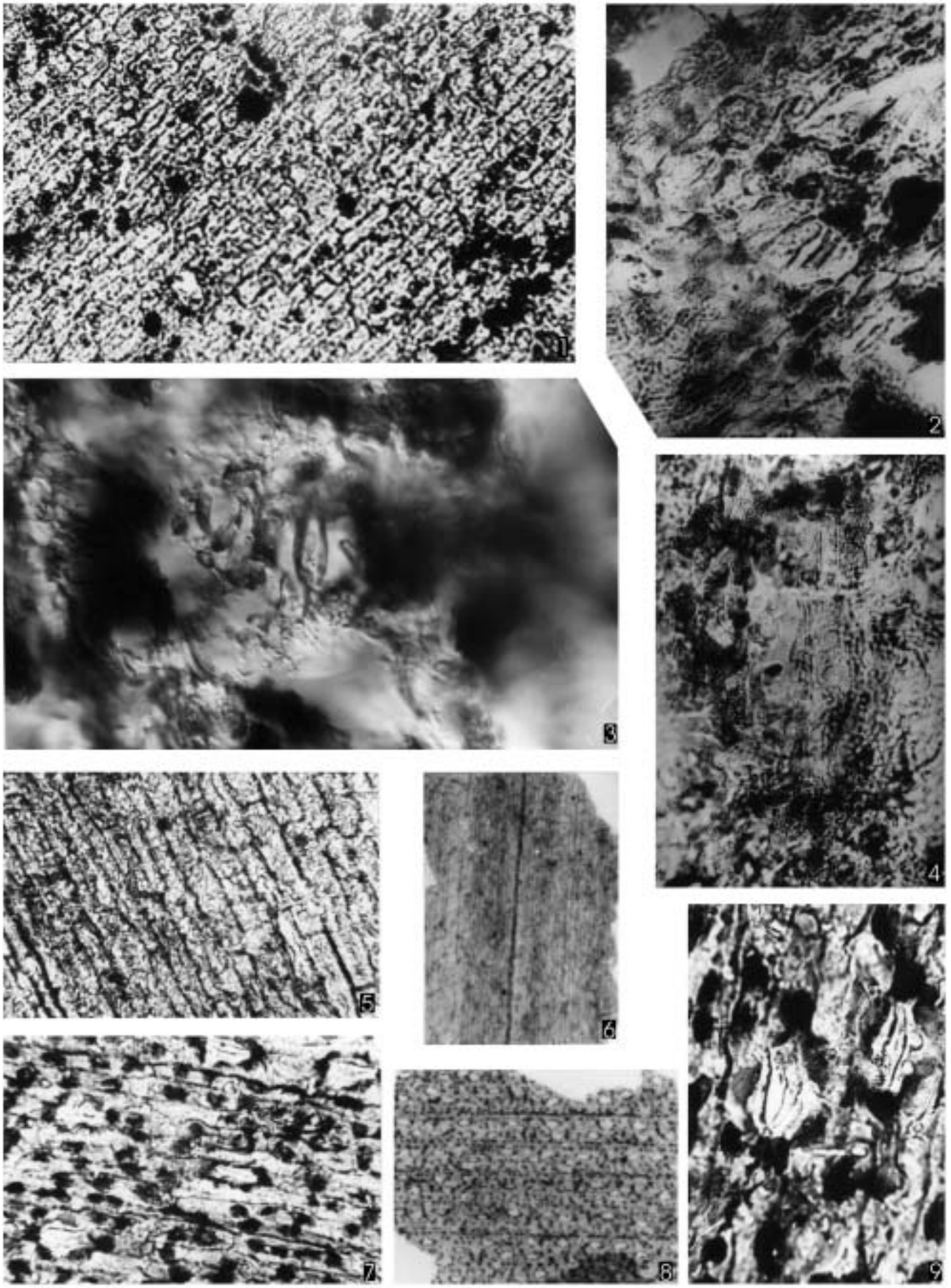
PLATE 4



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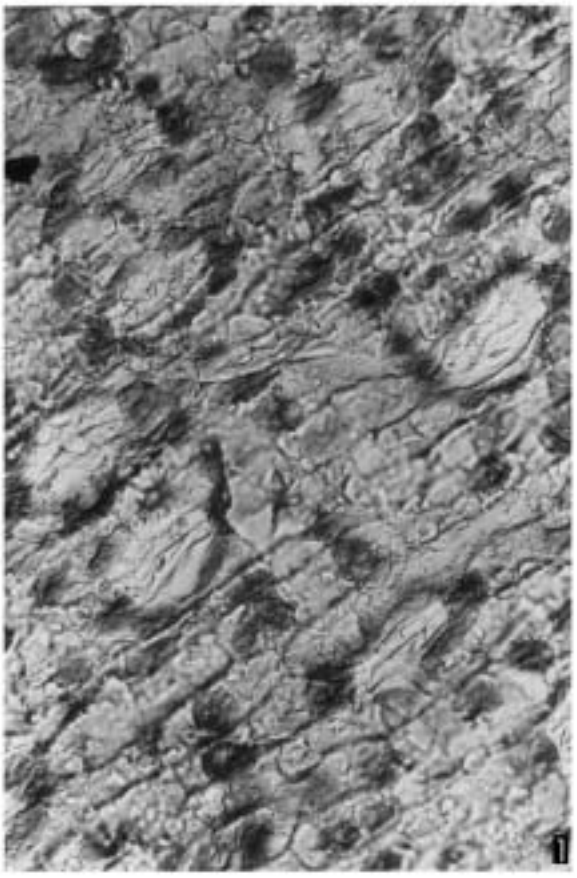

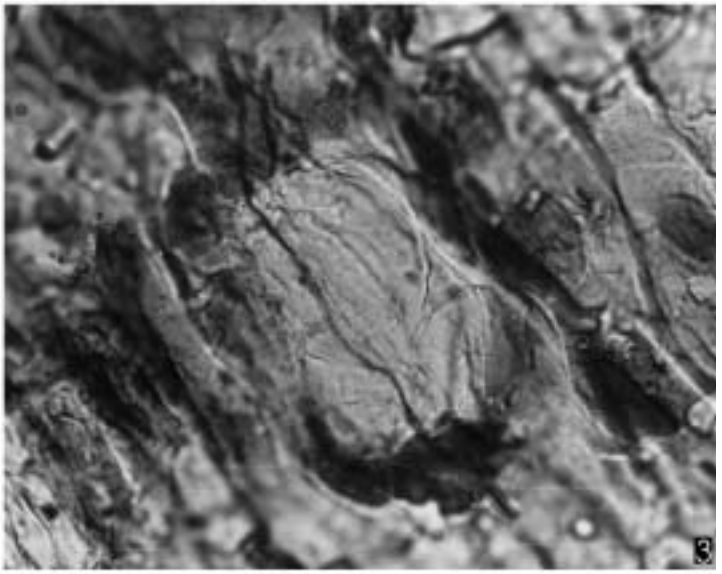

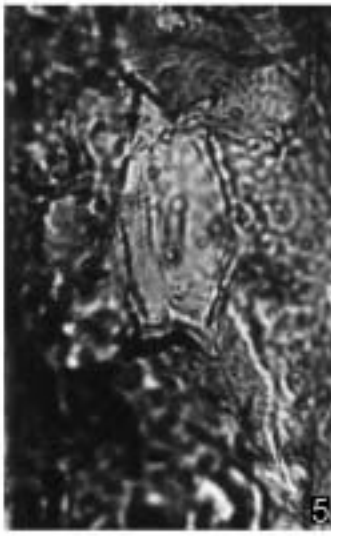

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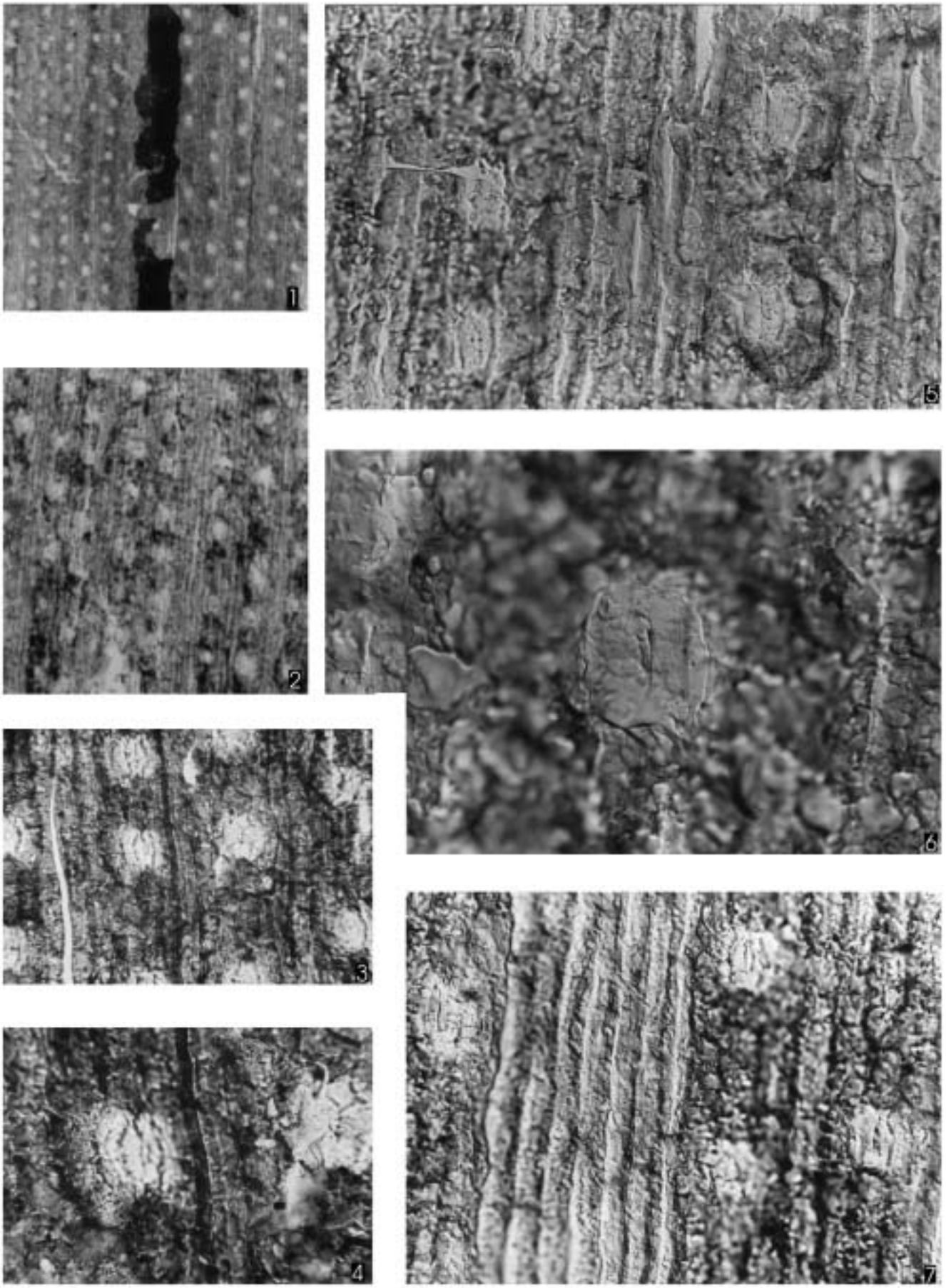

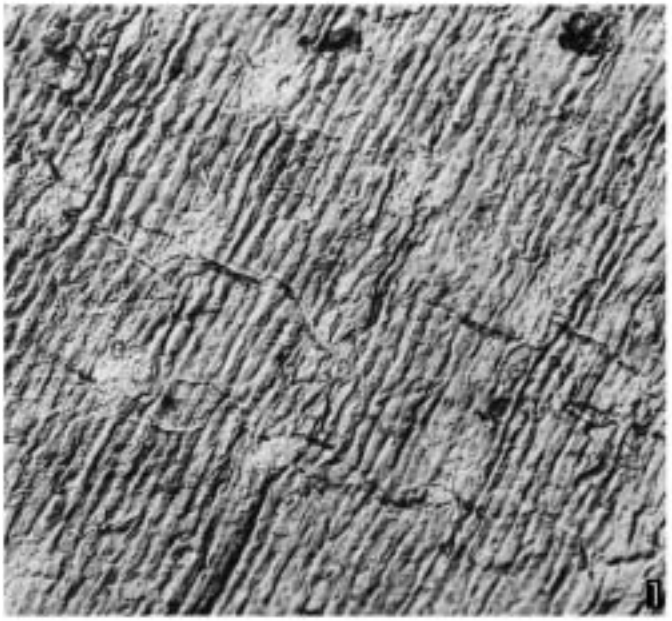
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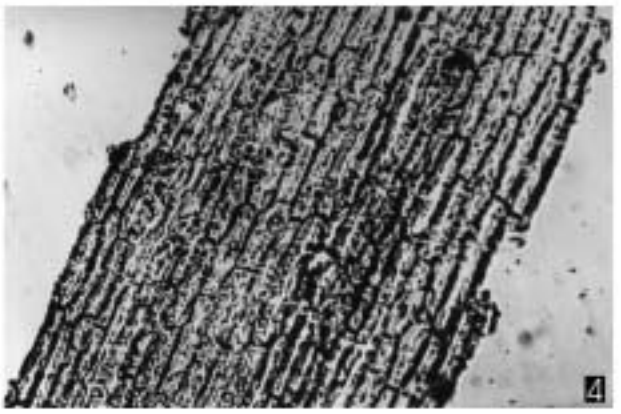
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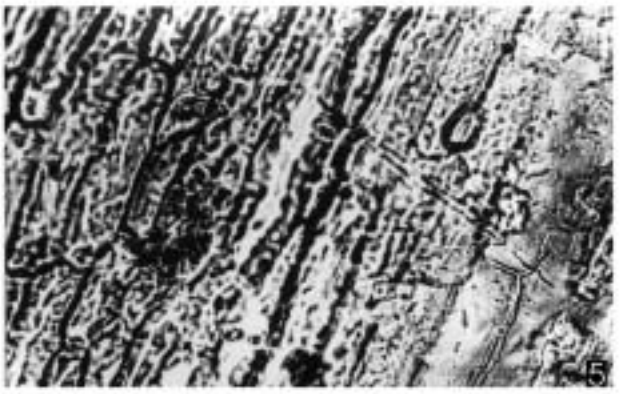
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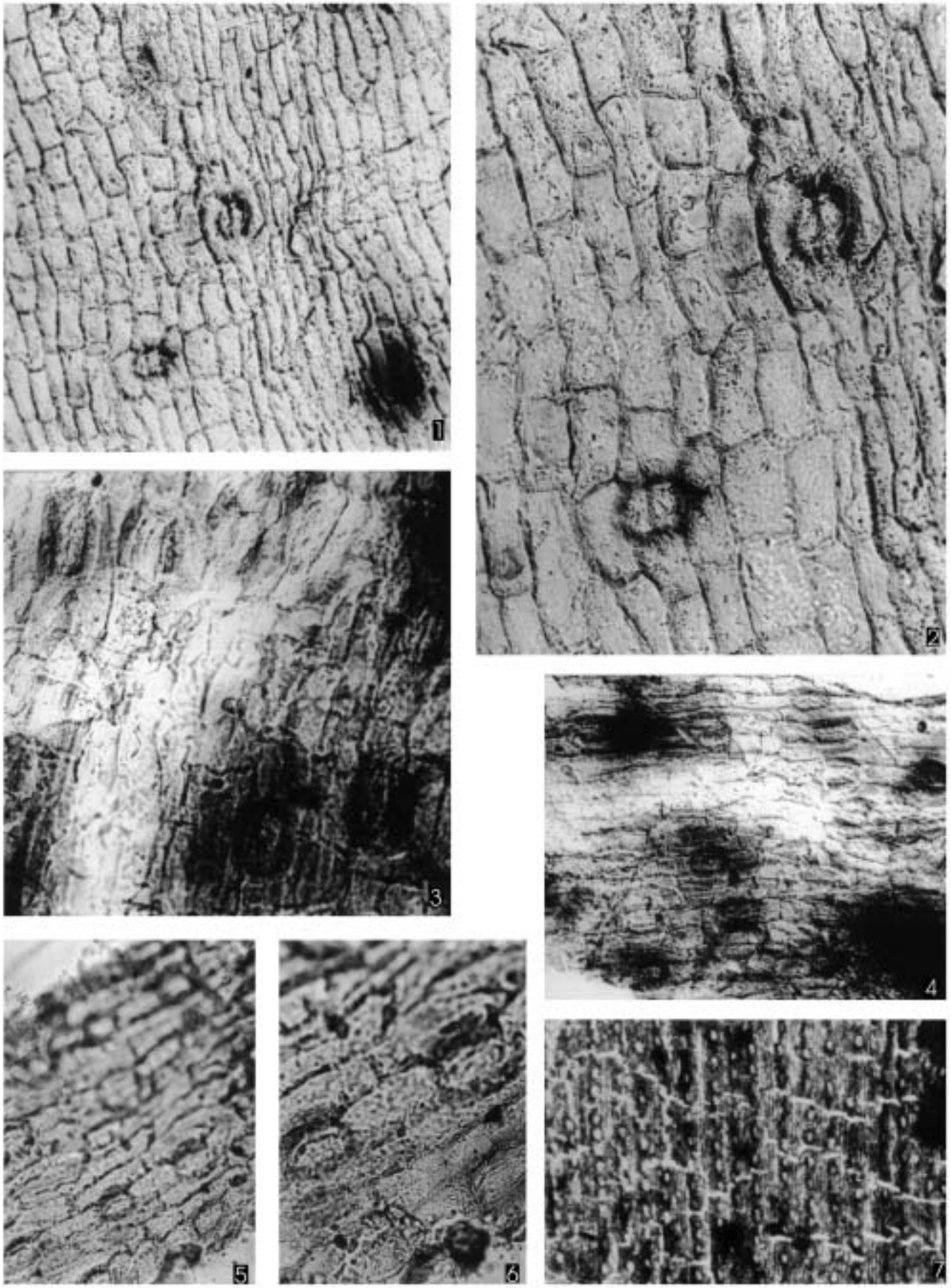

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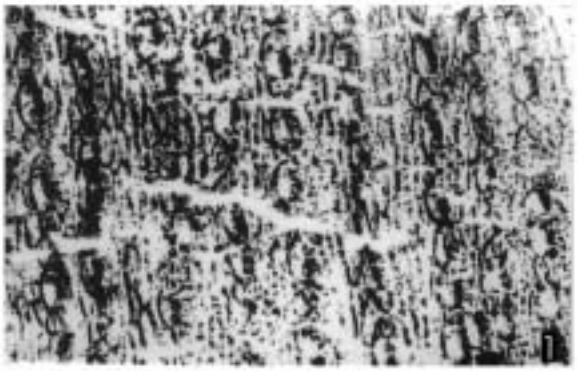

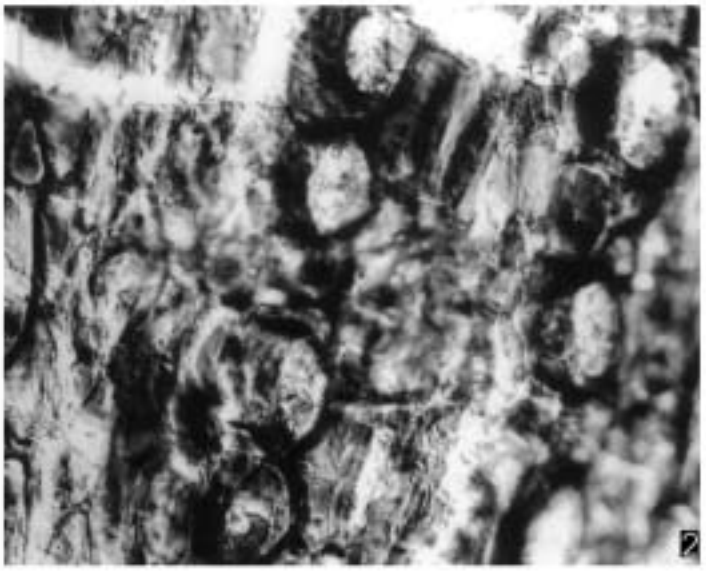

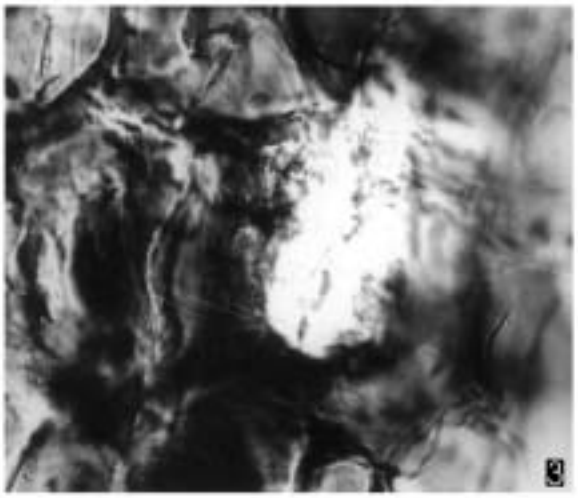

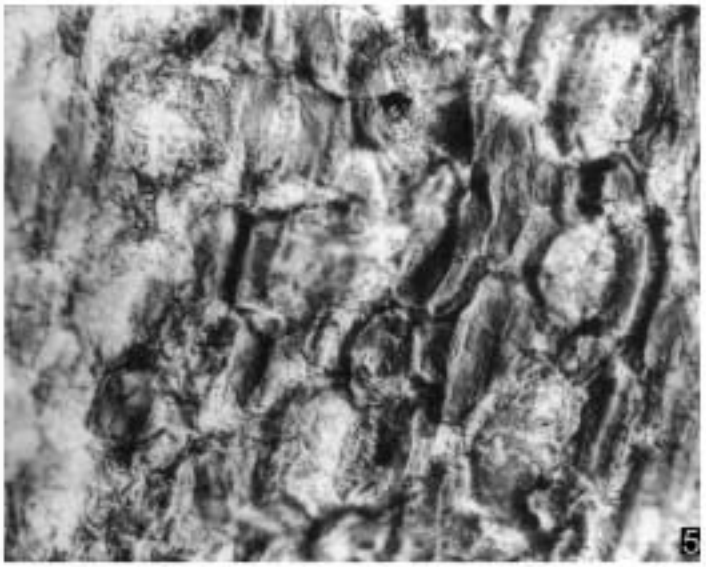

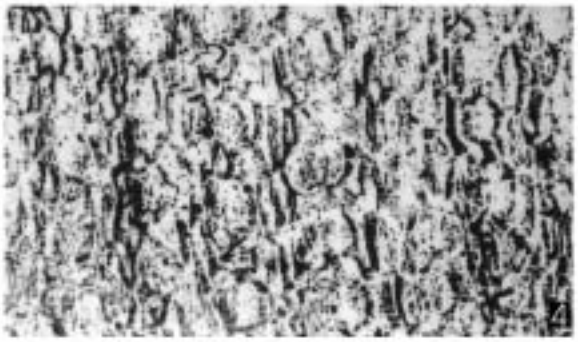

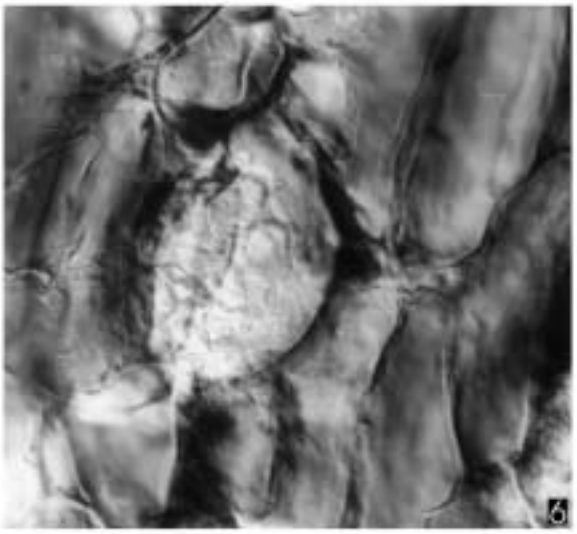

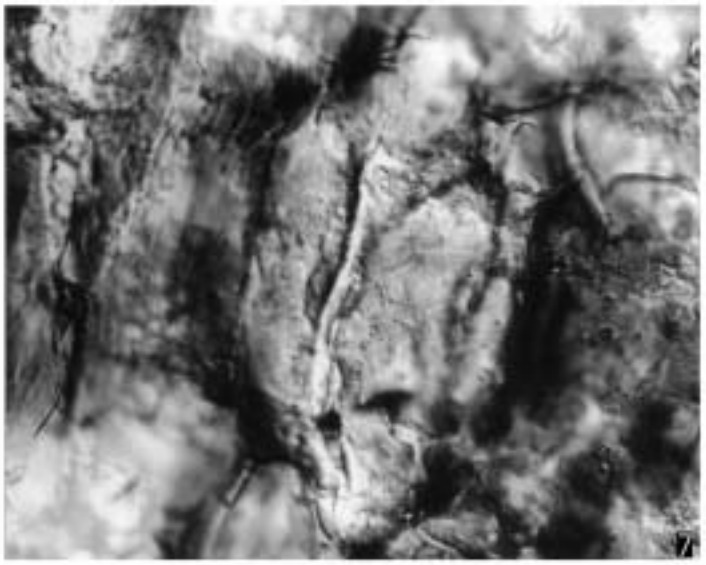

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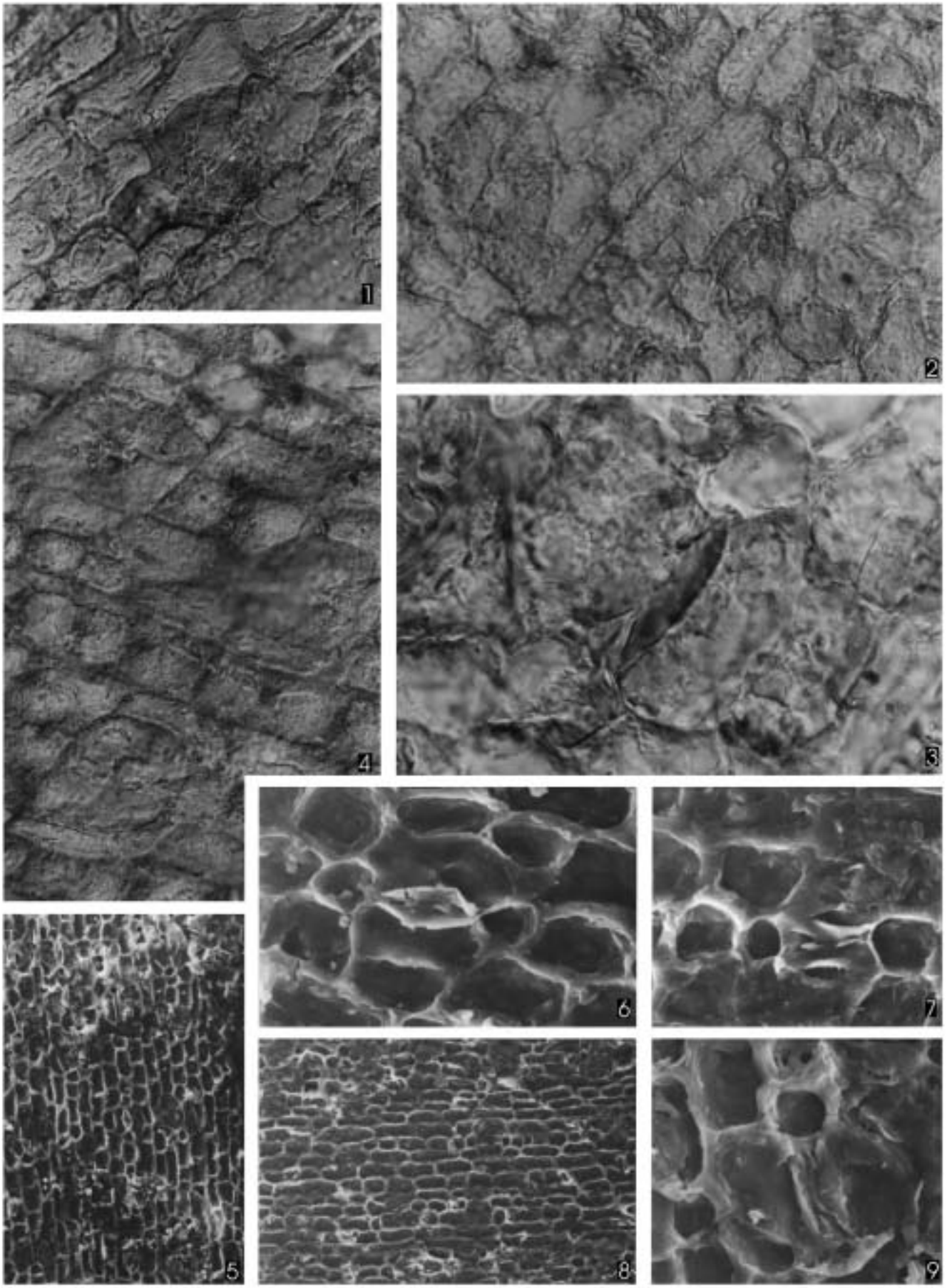

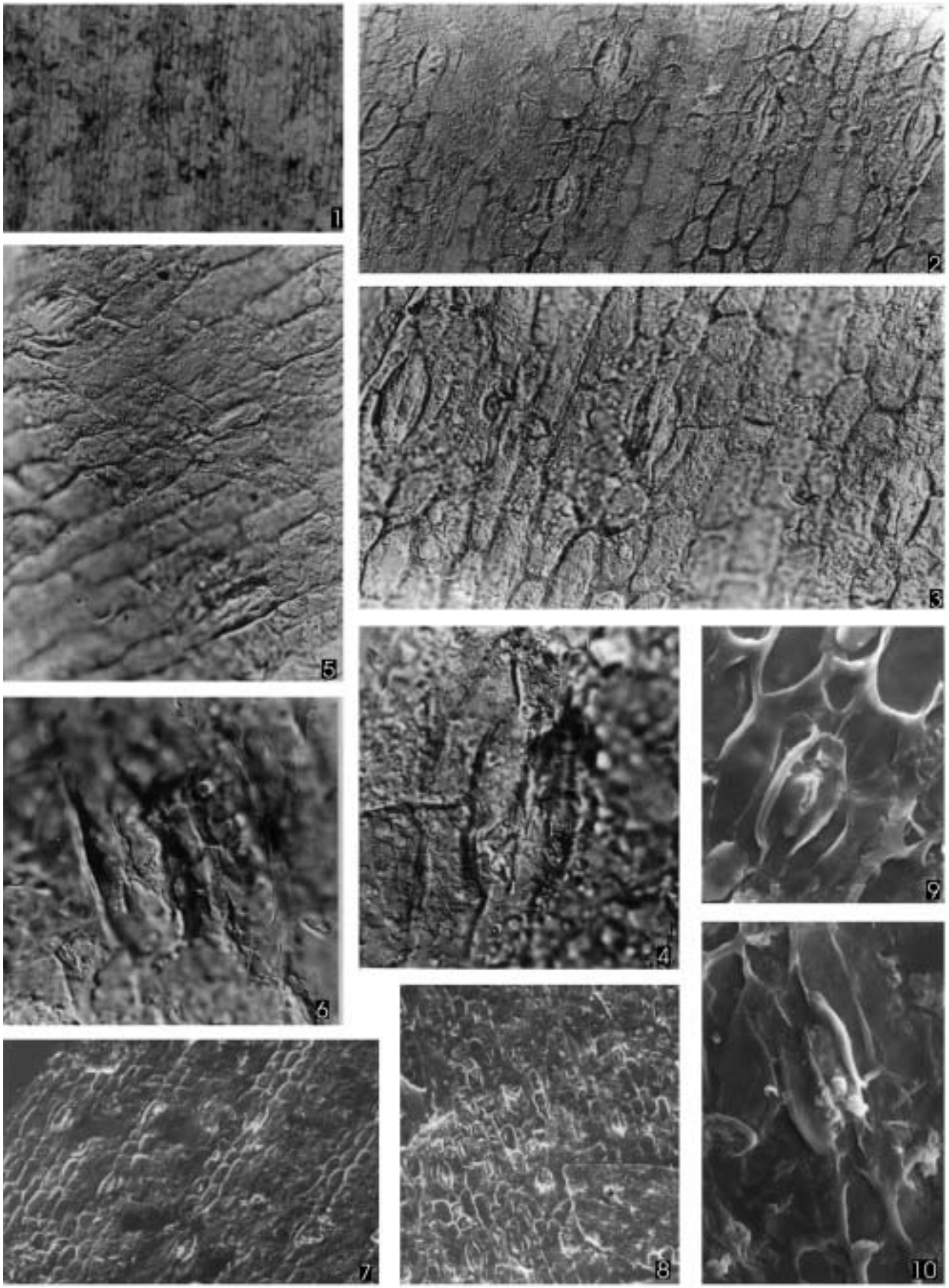
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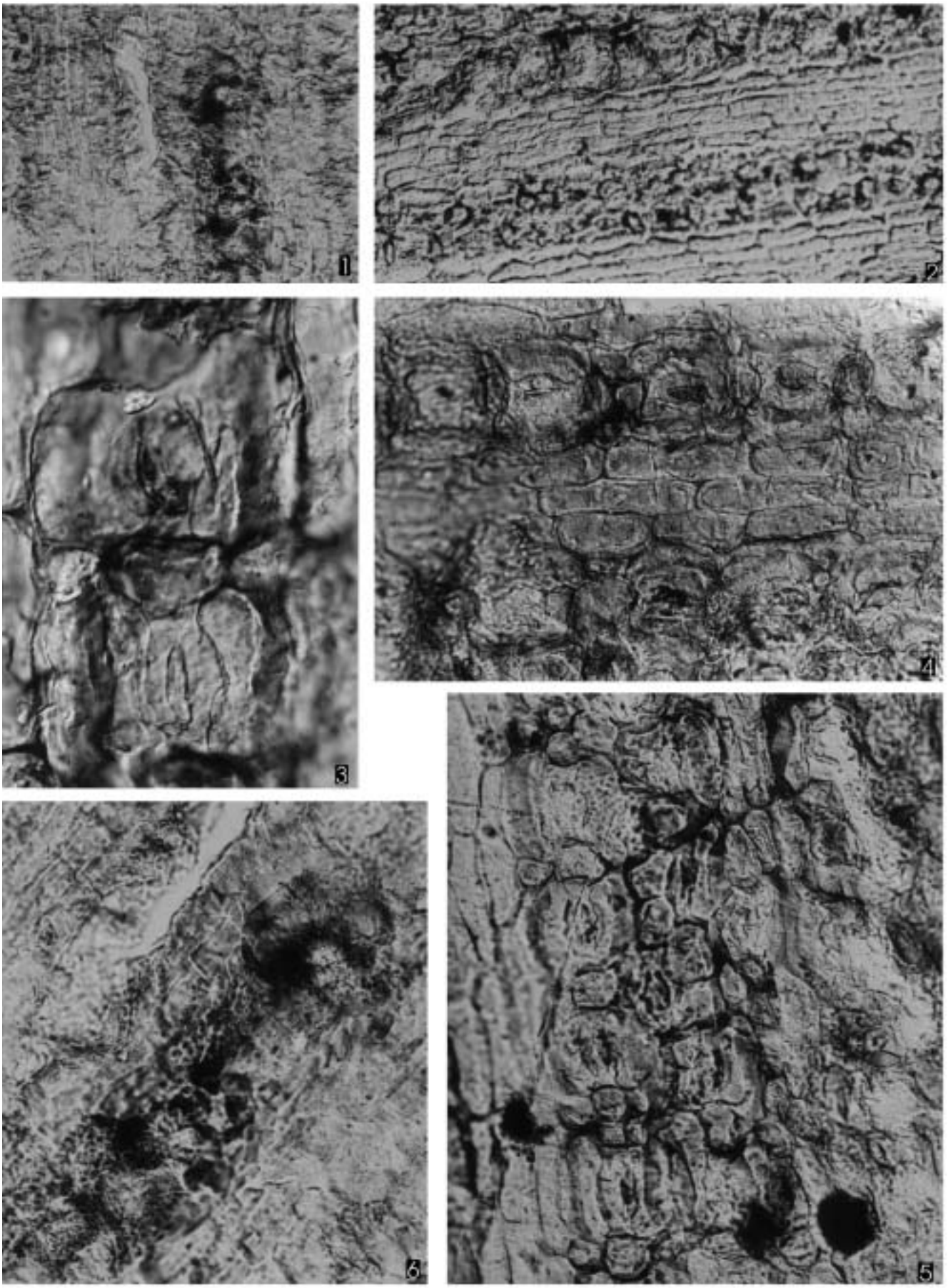
PLATE 12



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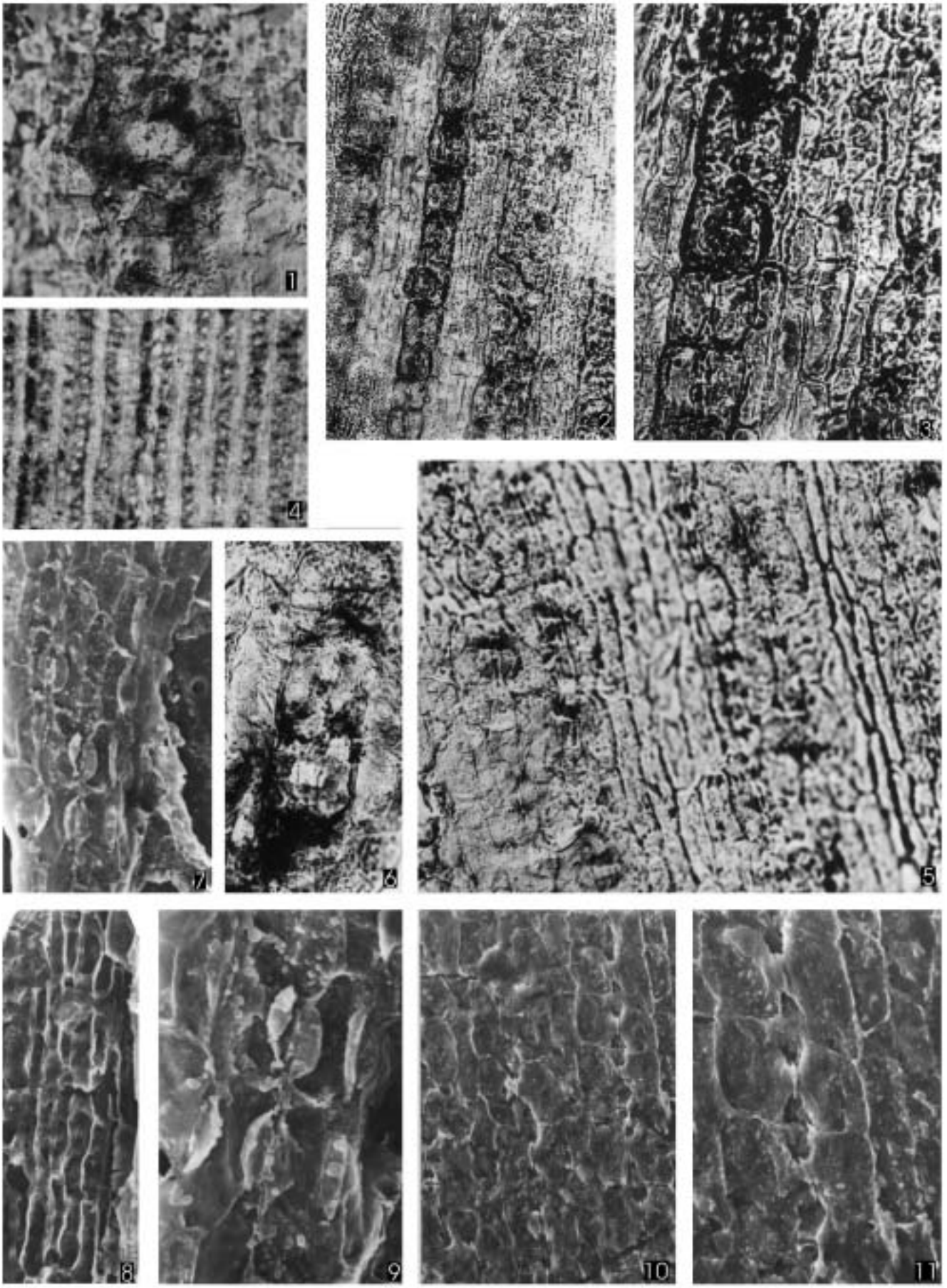

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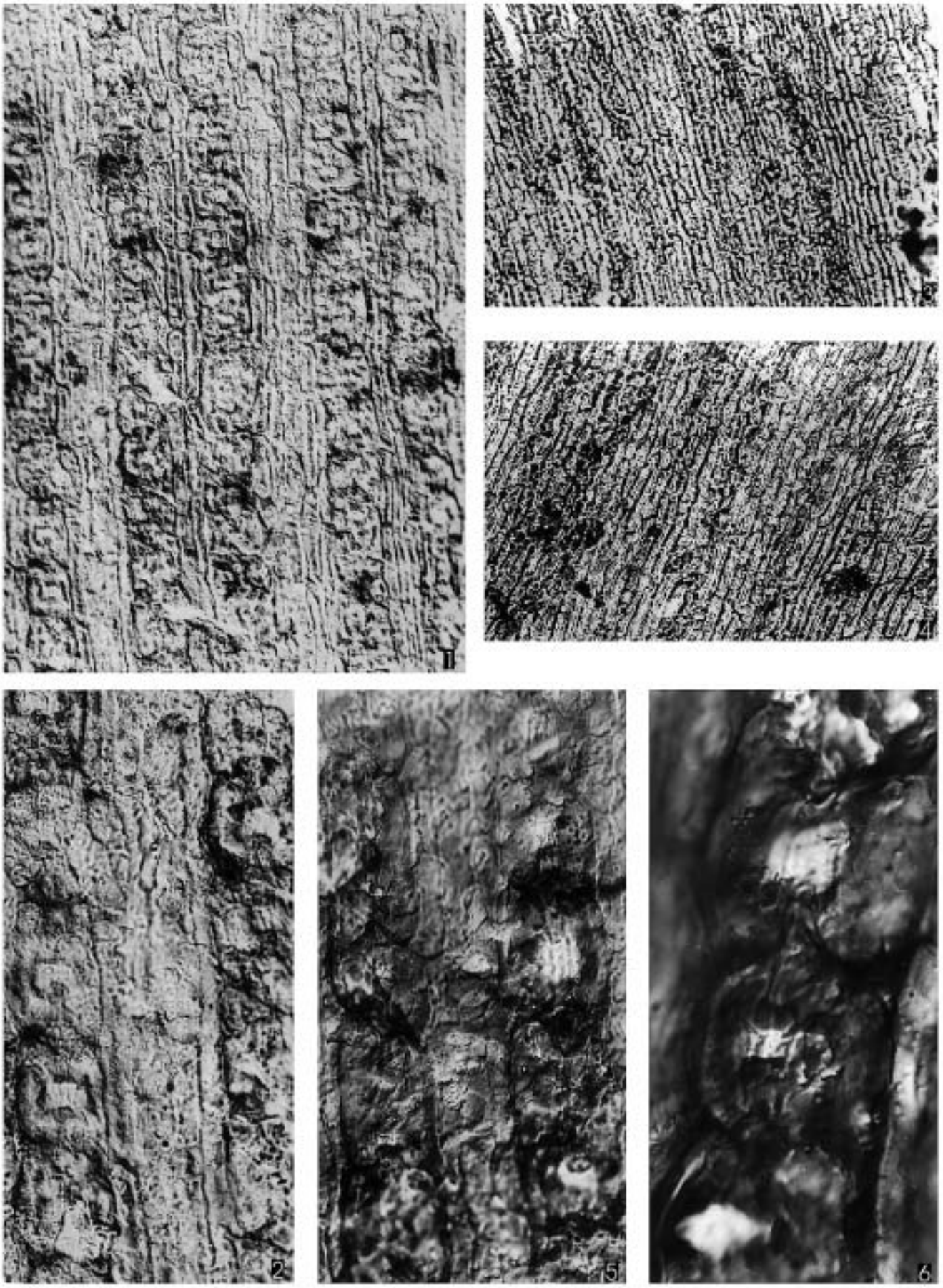

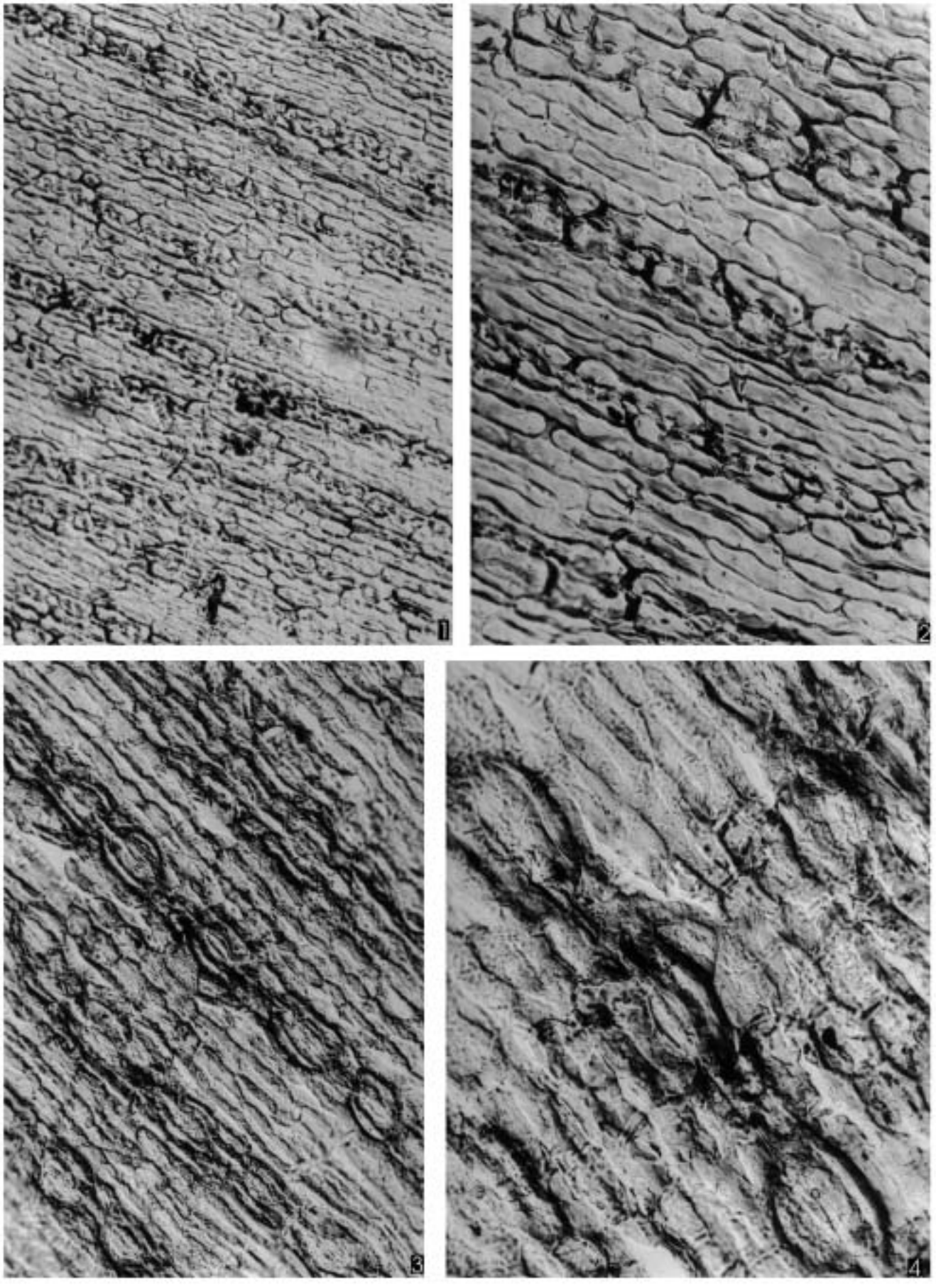
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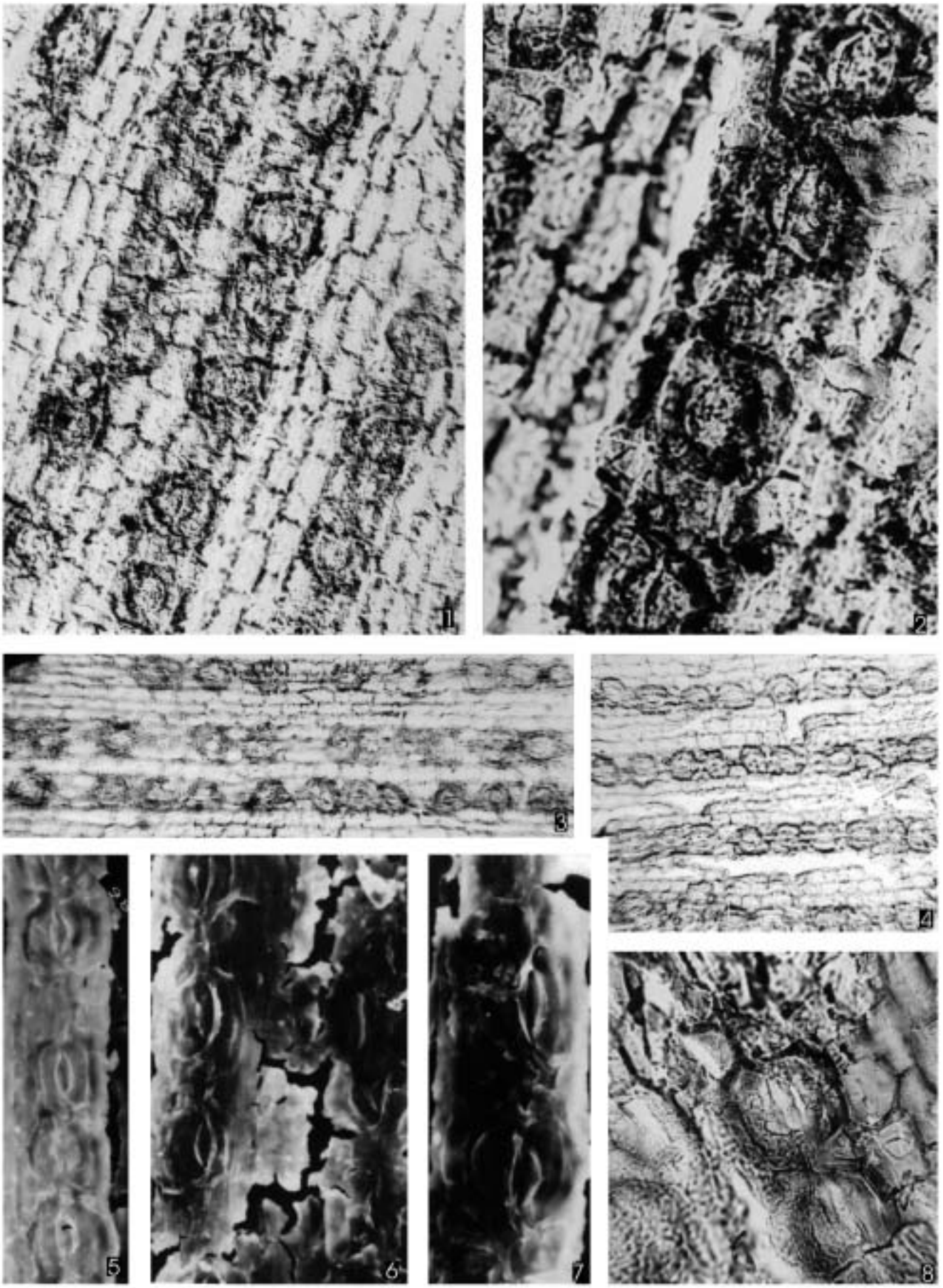
PLATE 16



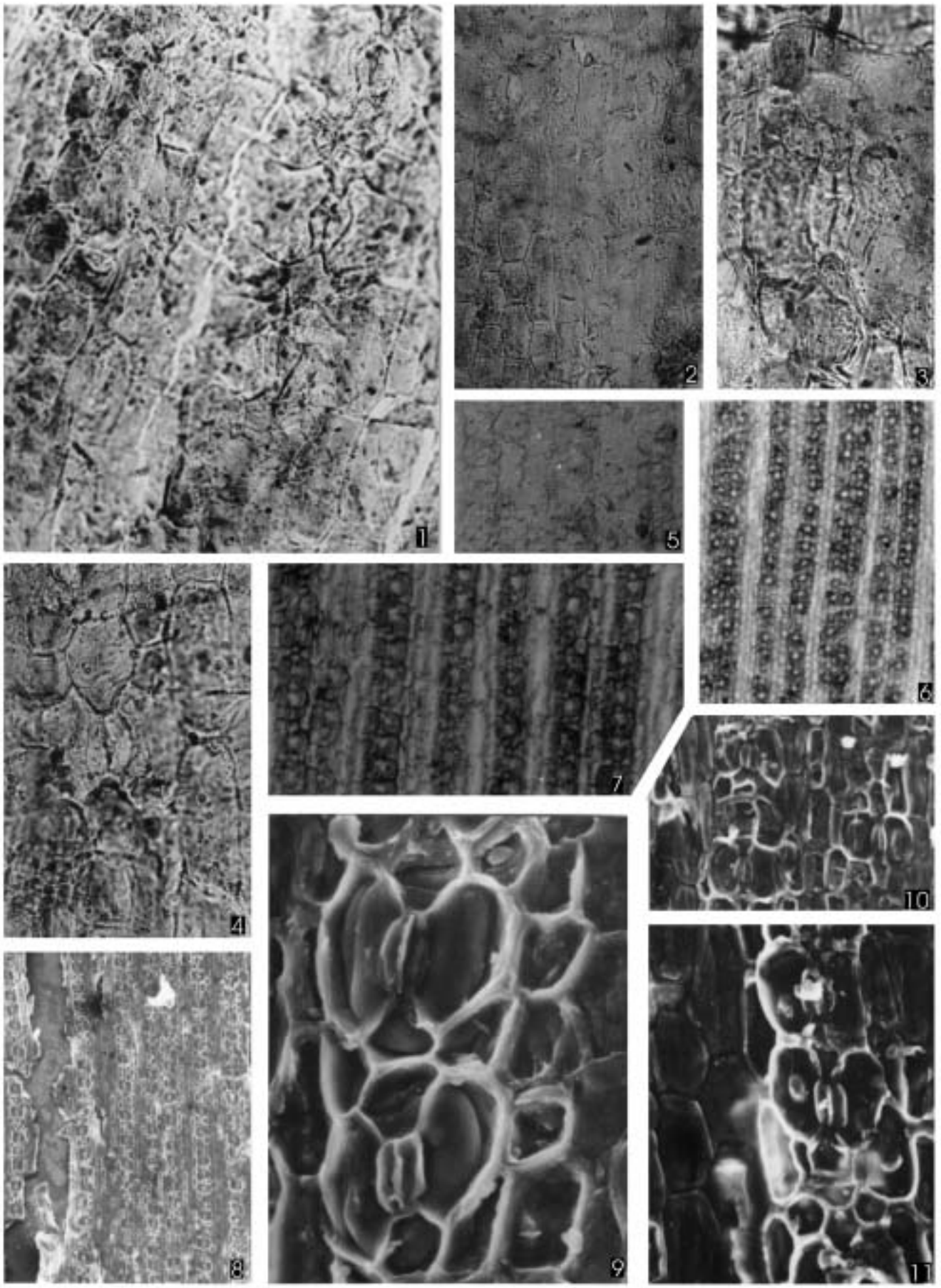

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PLATE 18

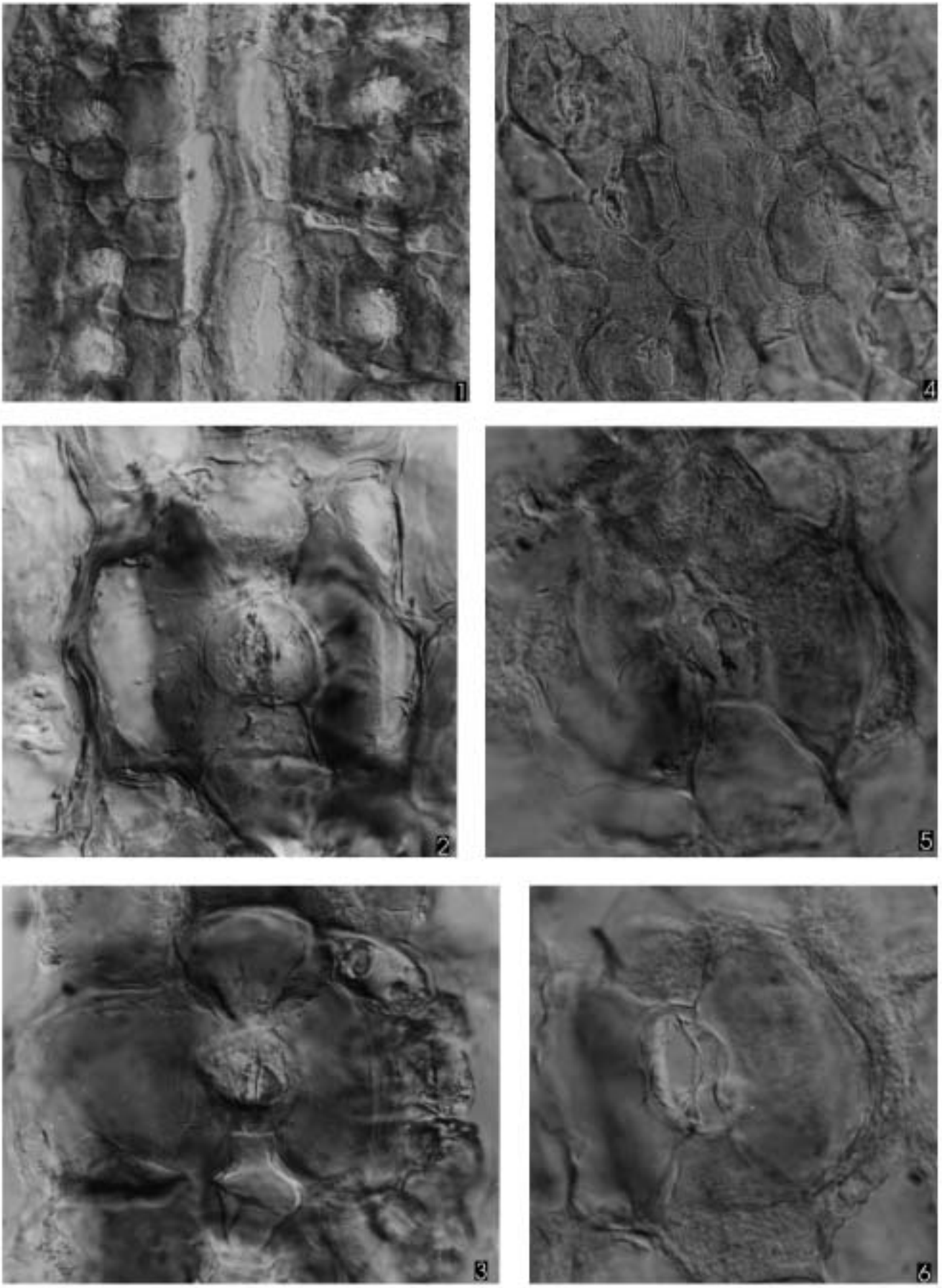
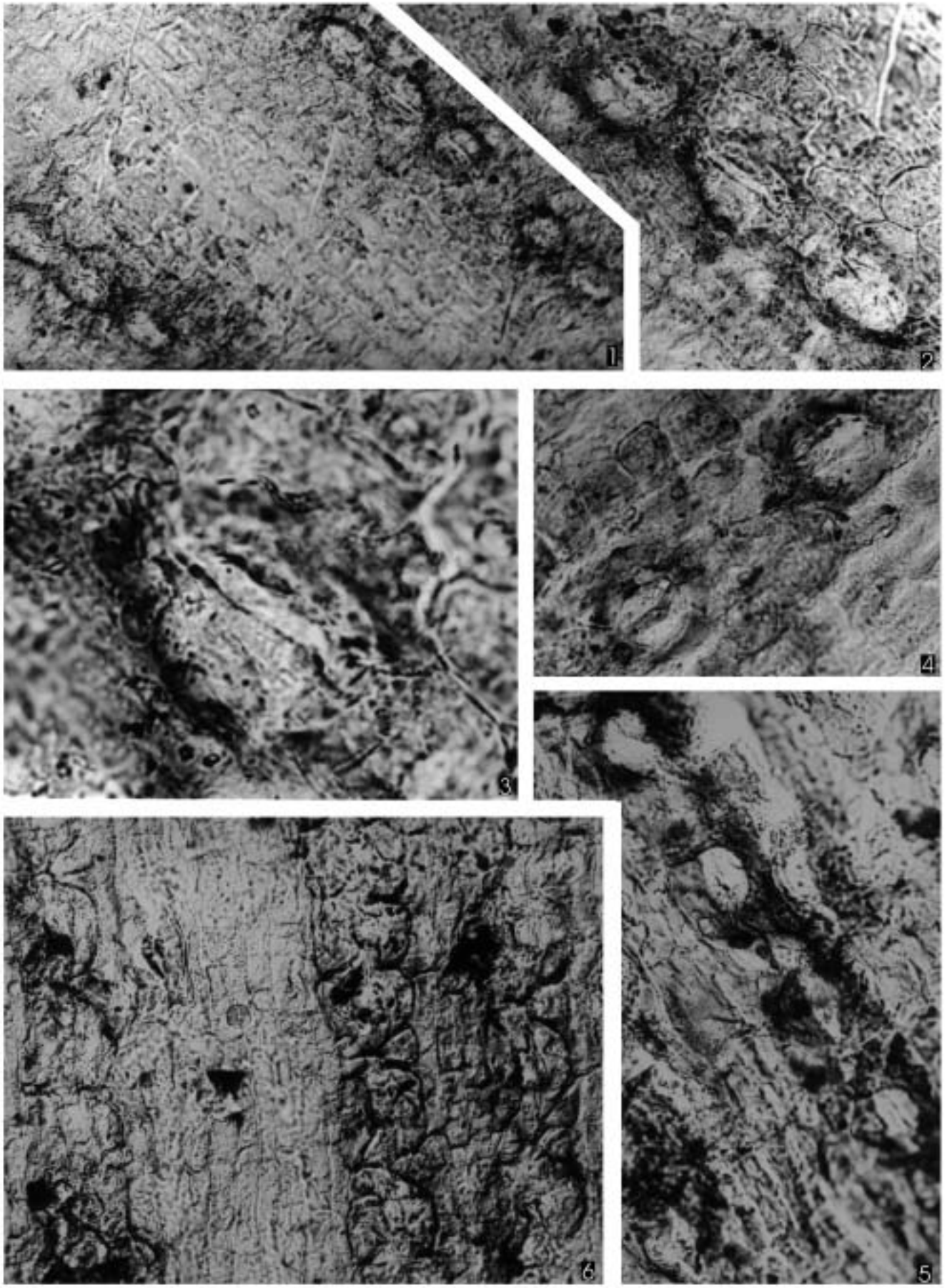


PLATE 19



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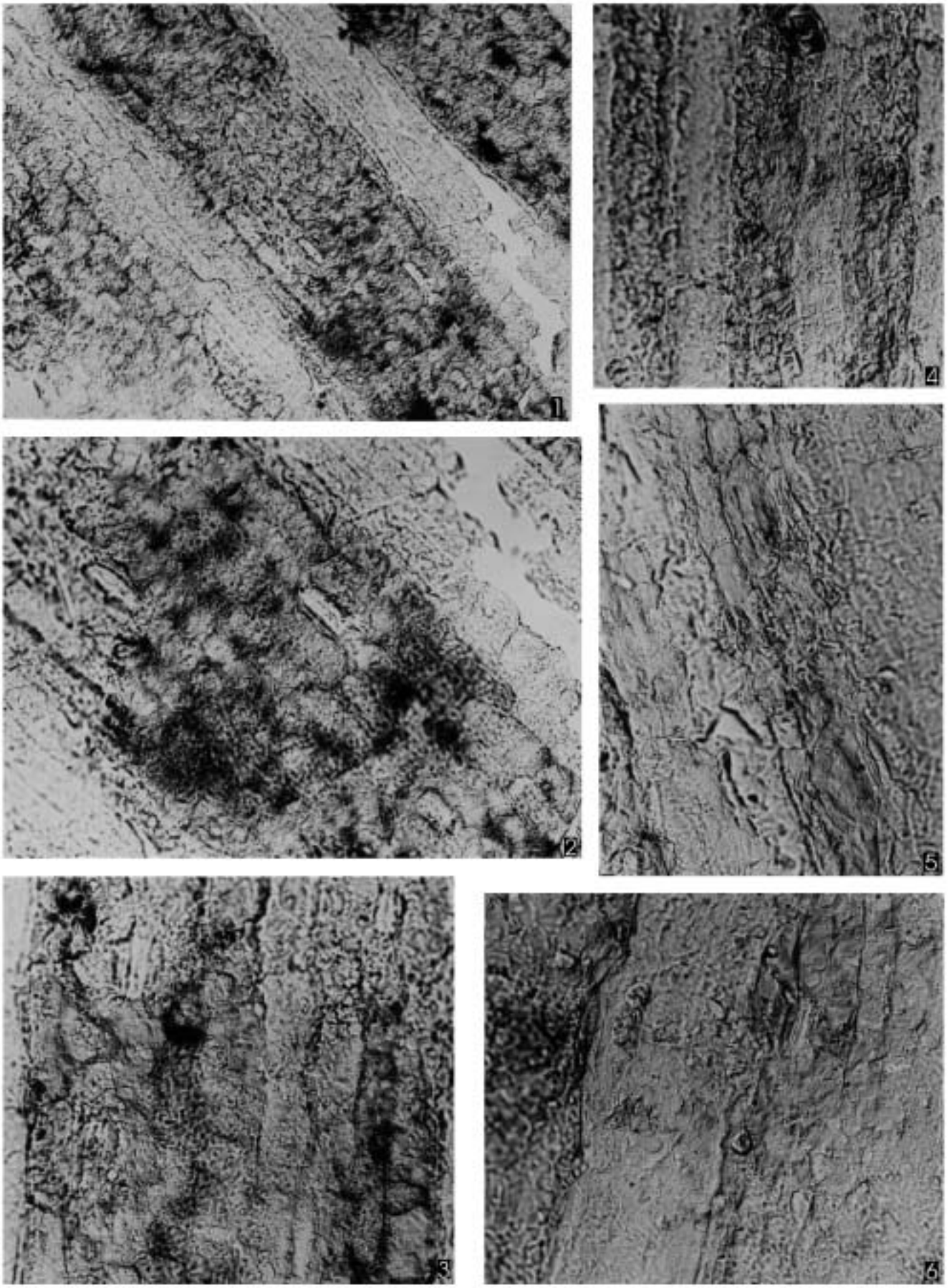

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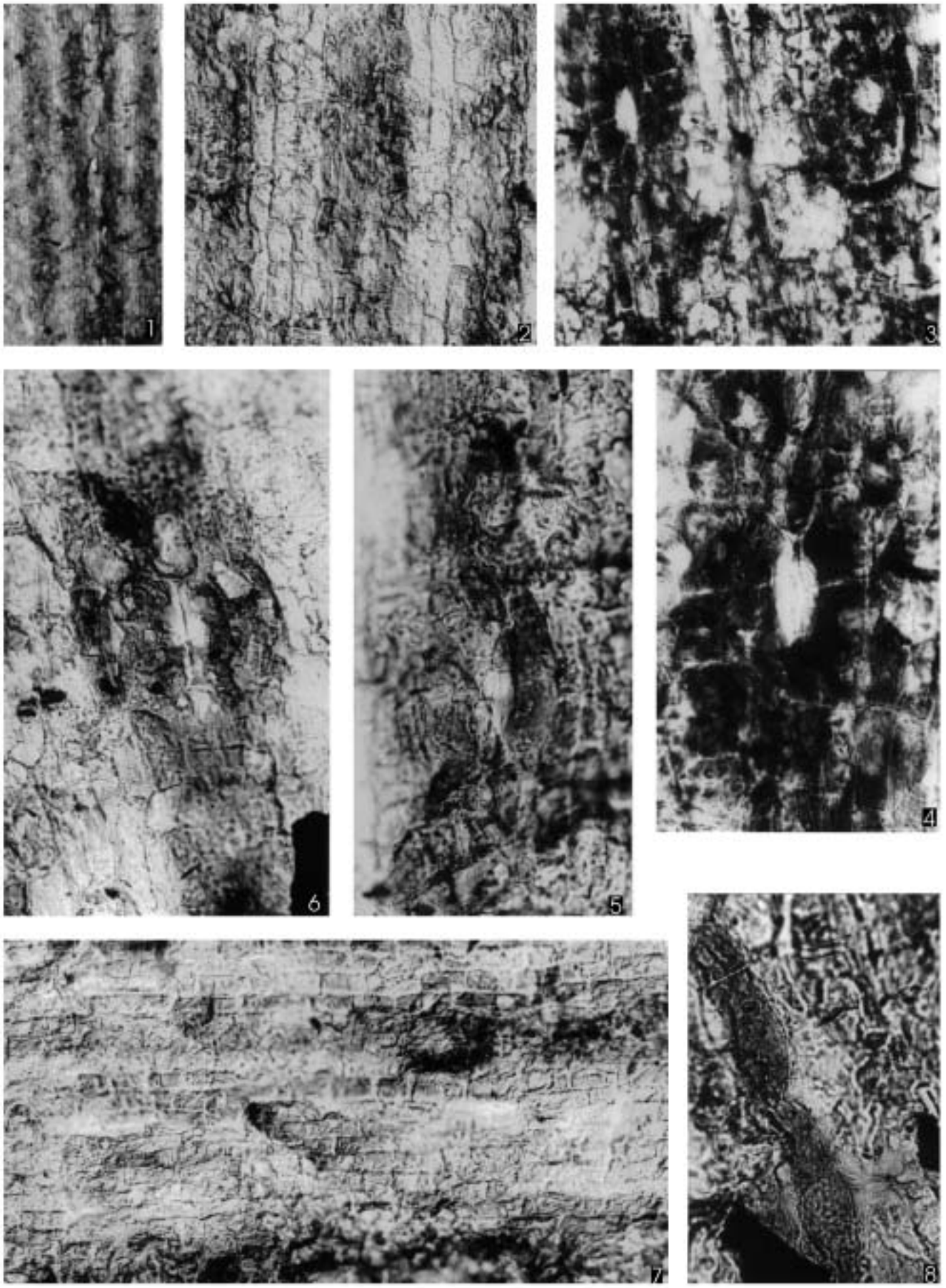
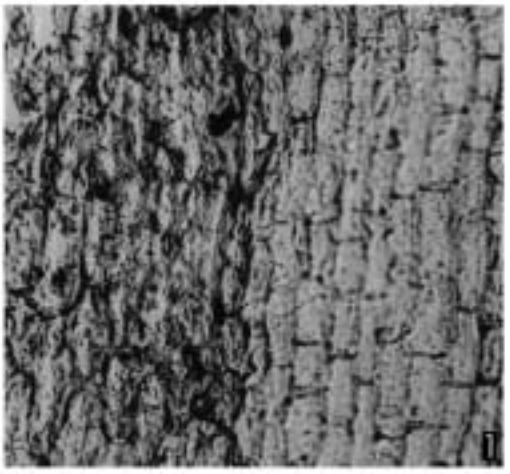
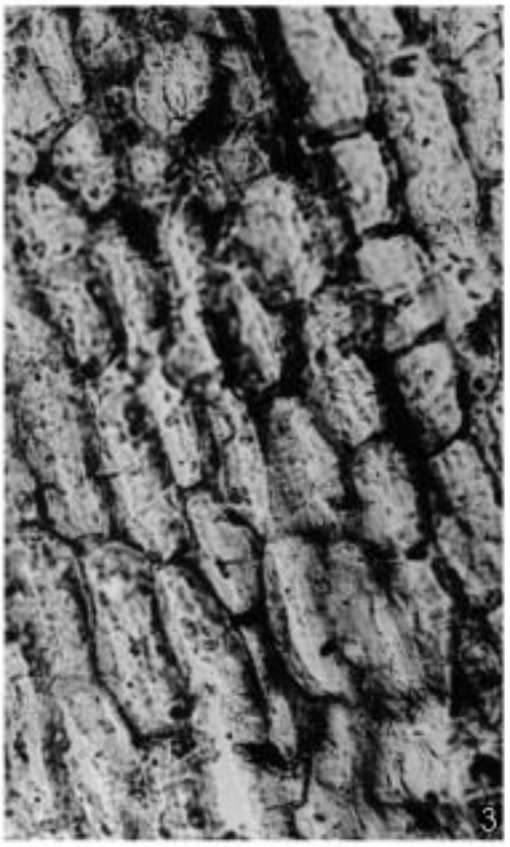
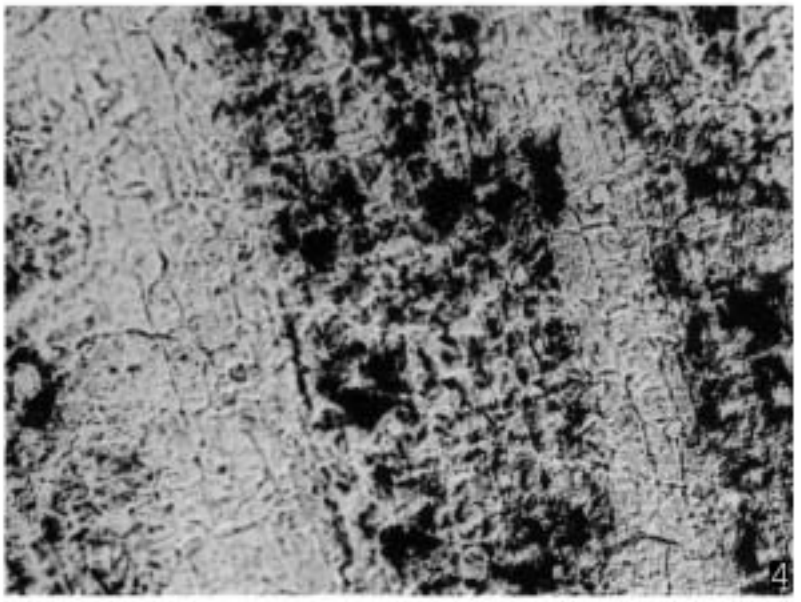
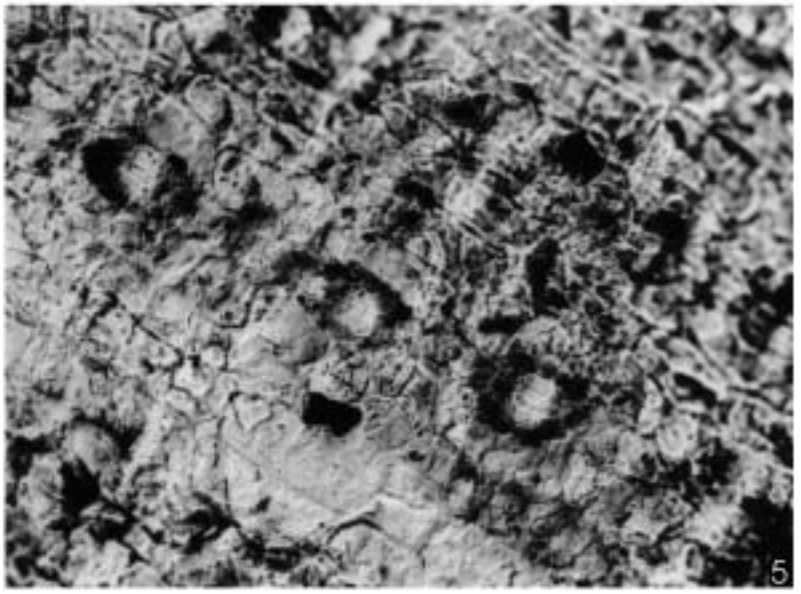


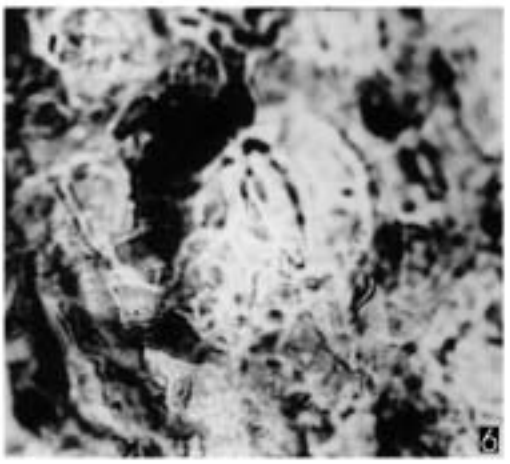
PLATE 22











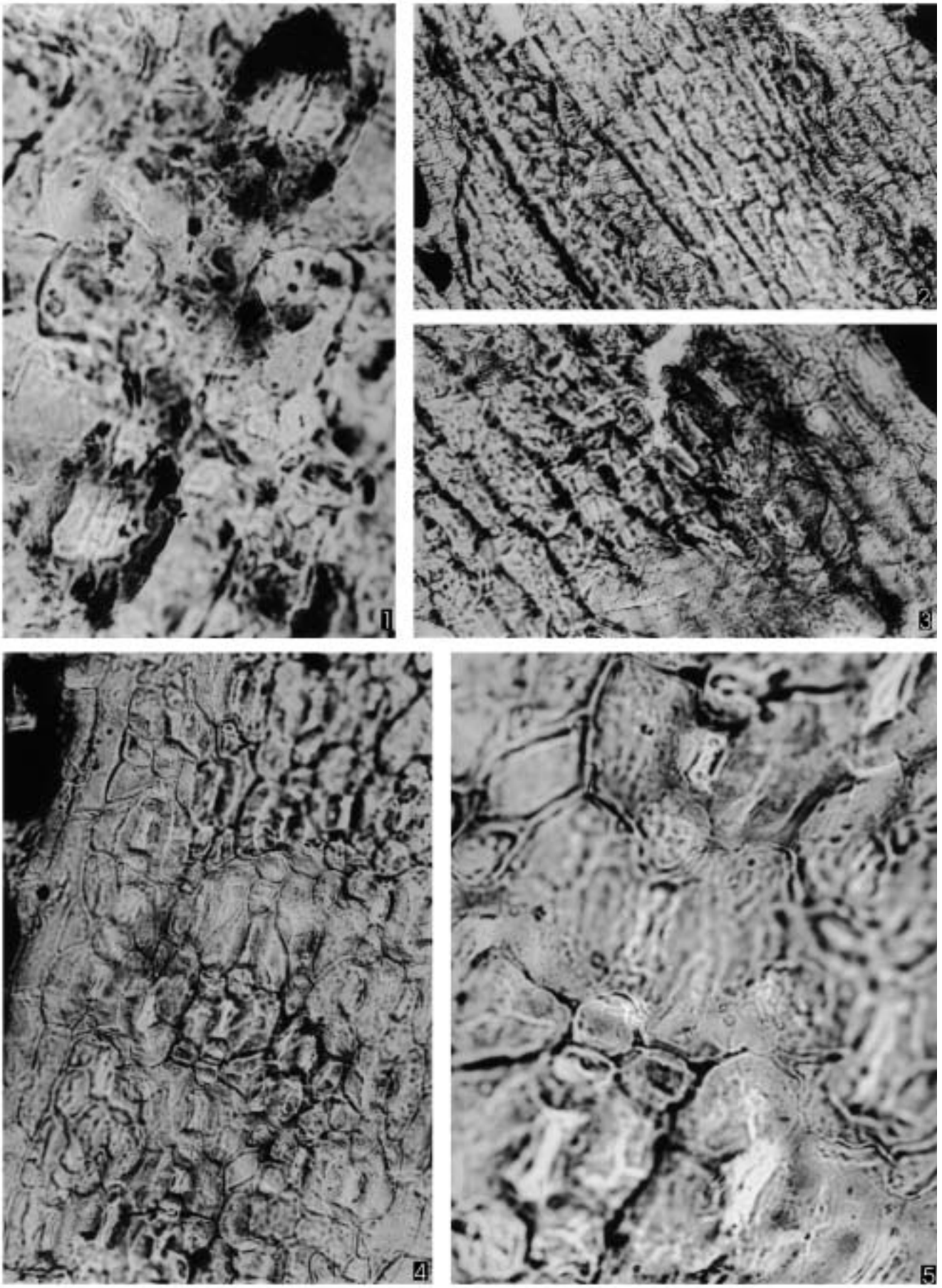

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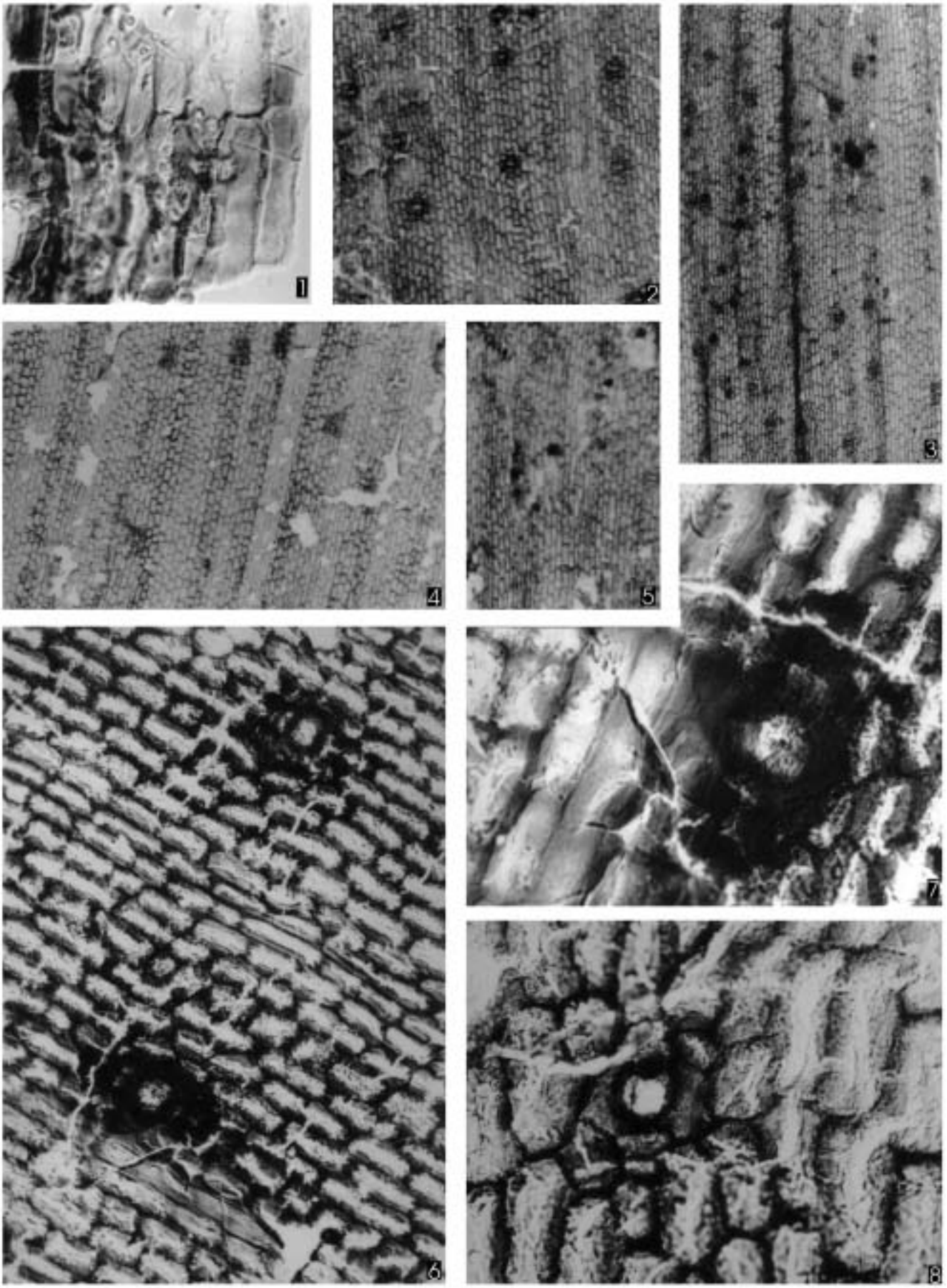
PLATE 24



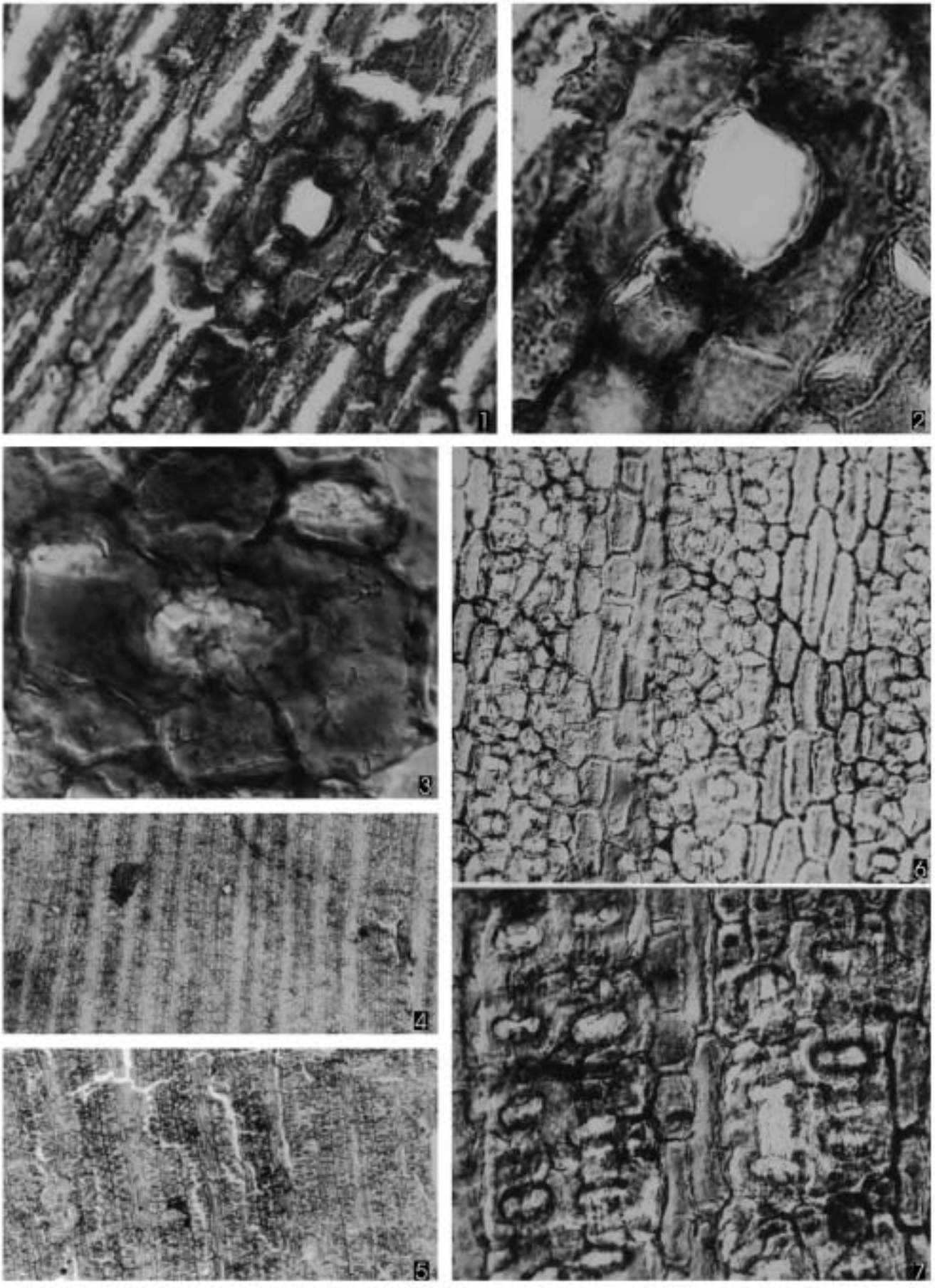

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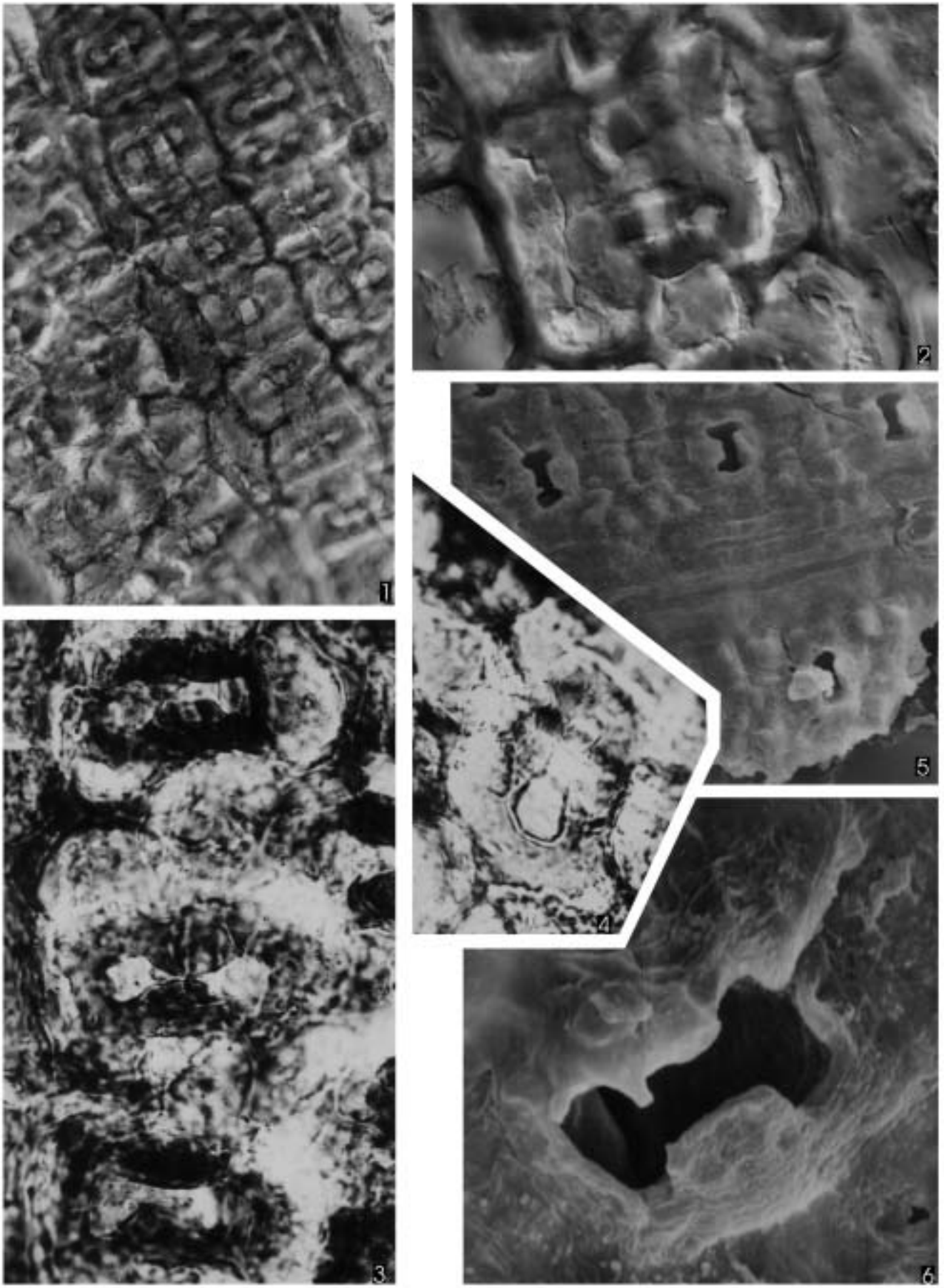
PLATE 26



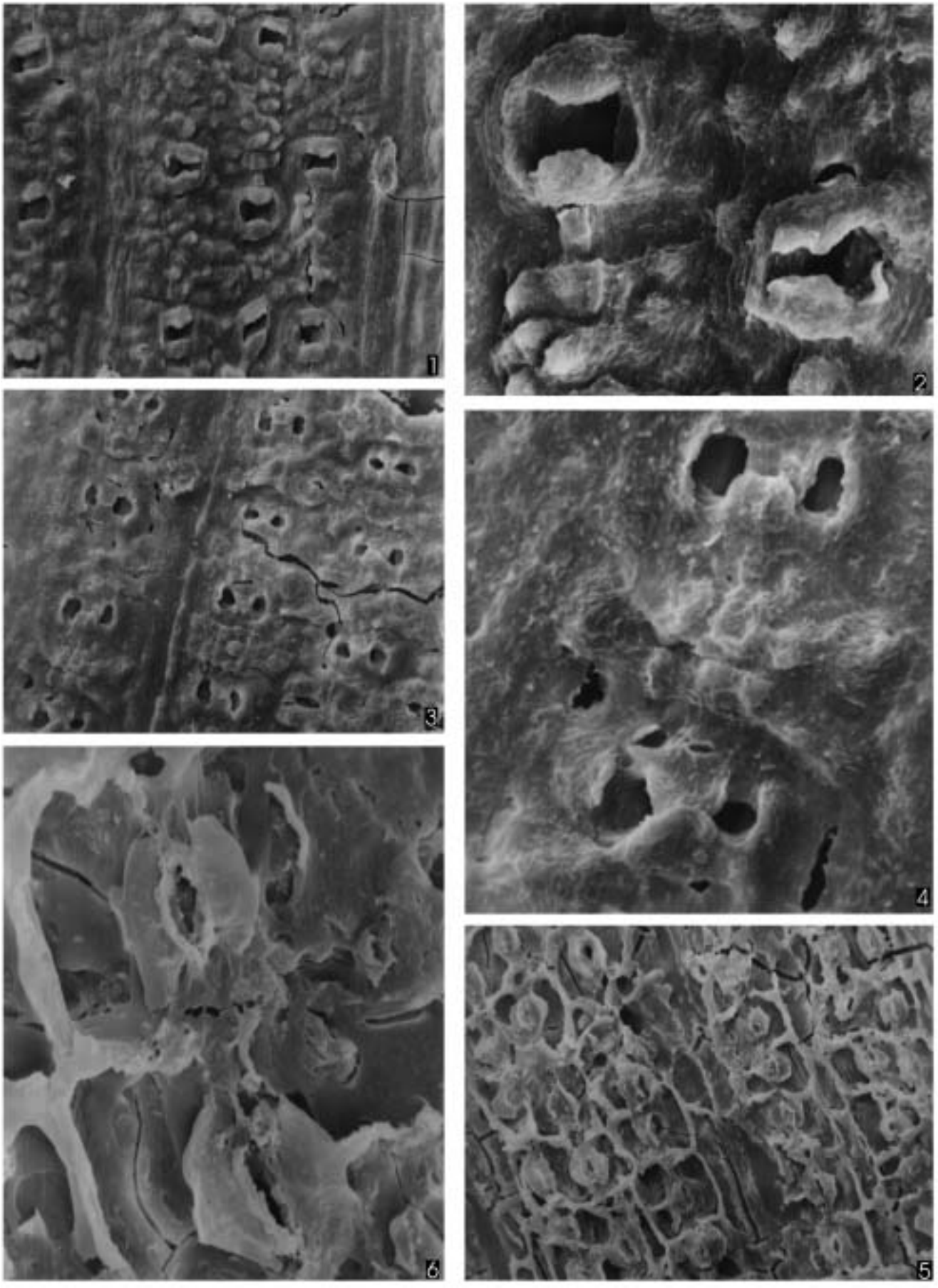

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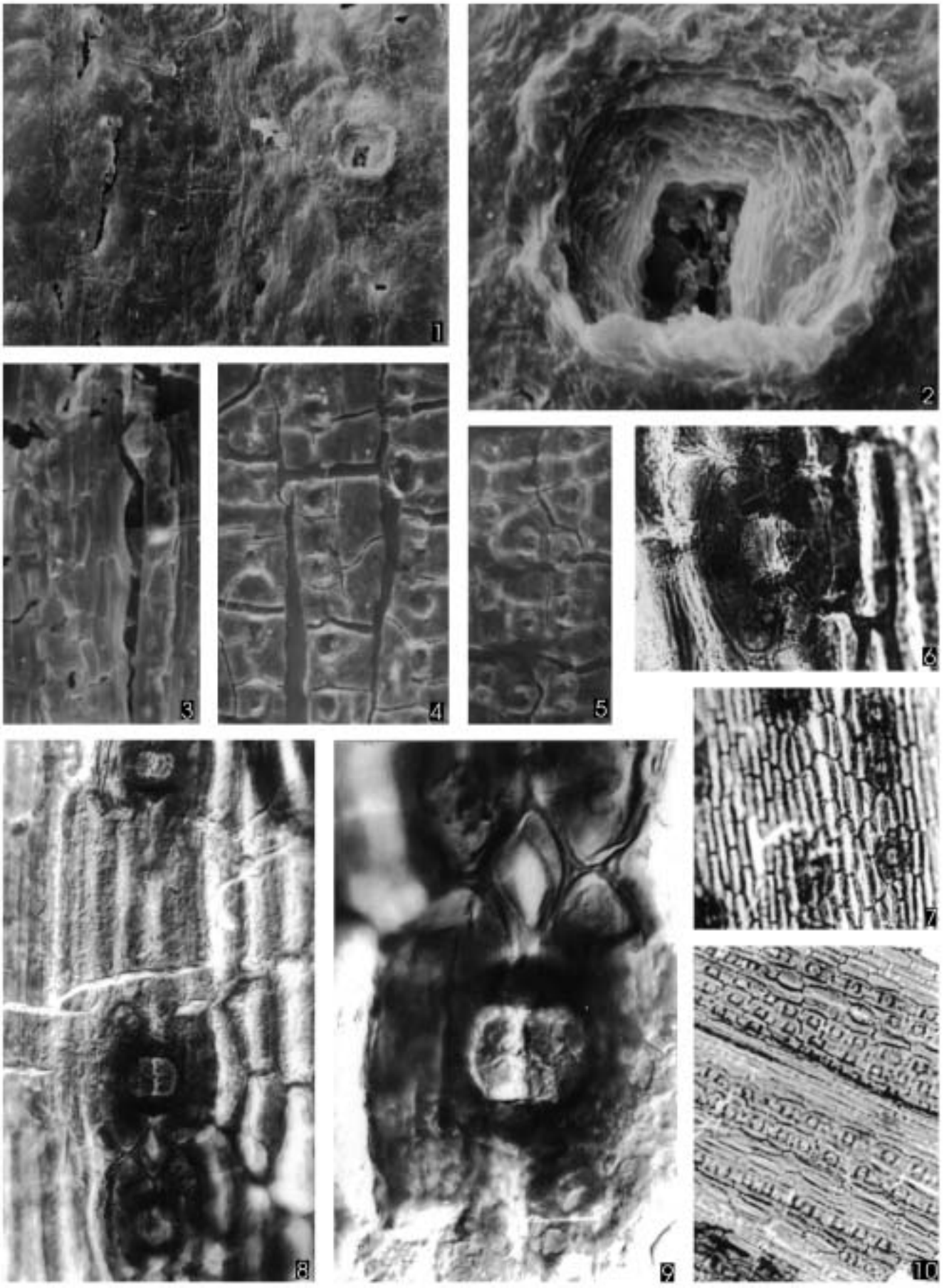
PLATE 28

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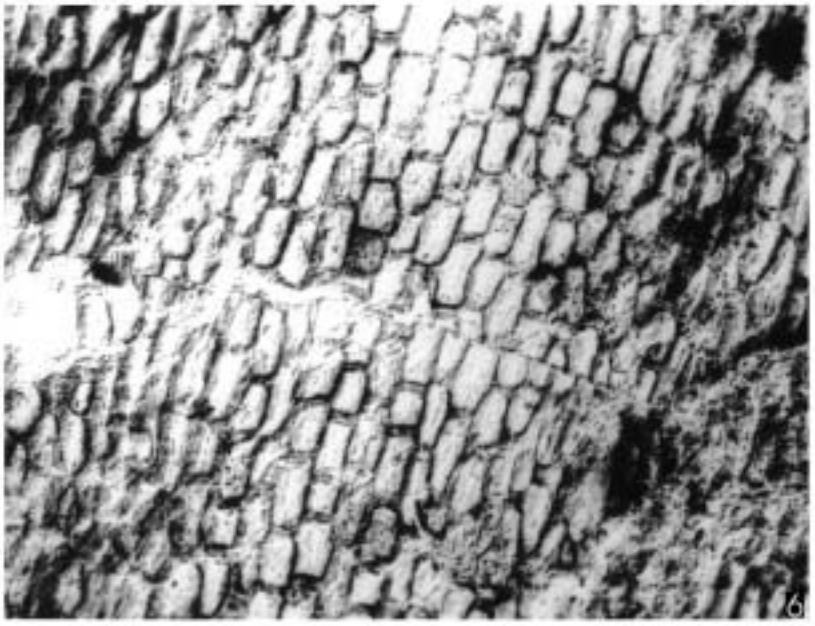
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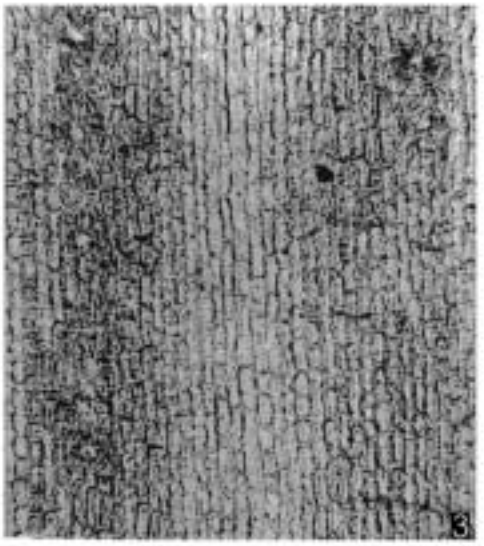
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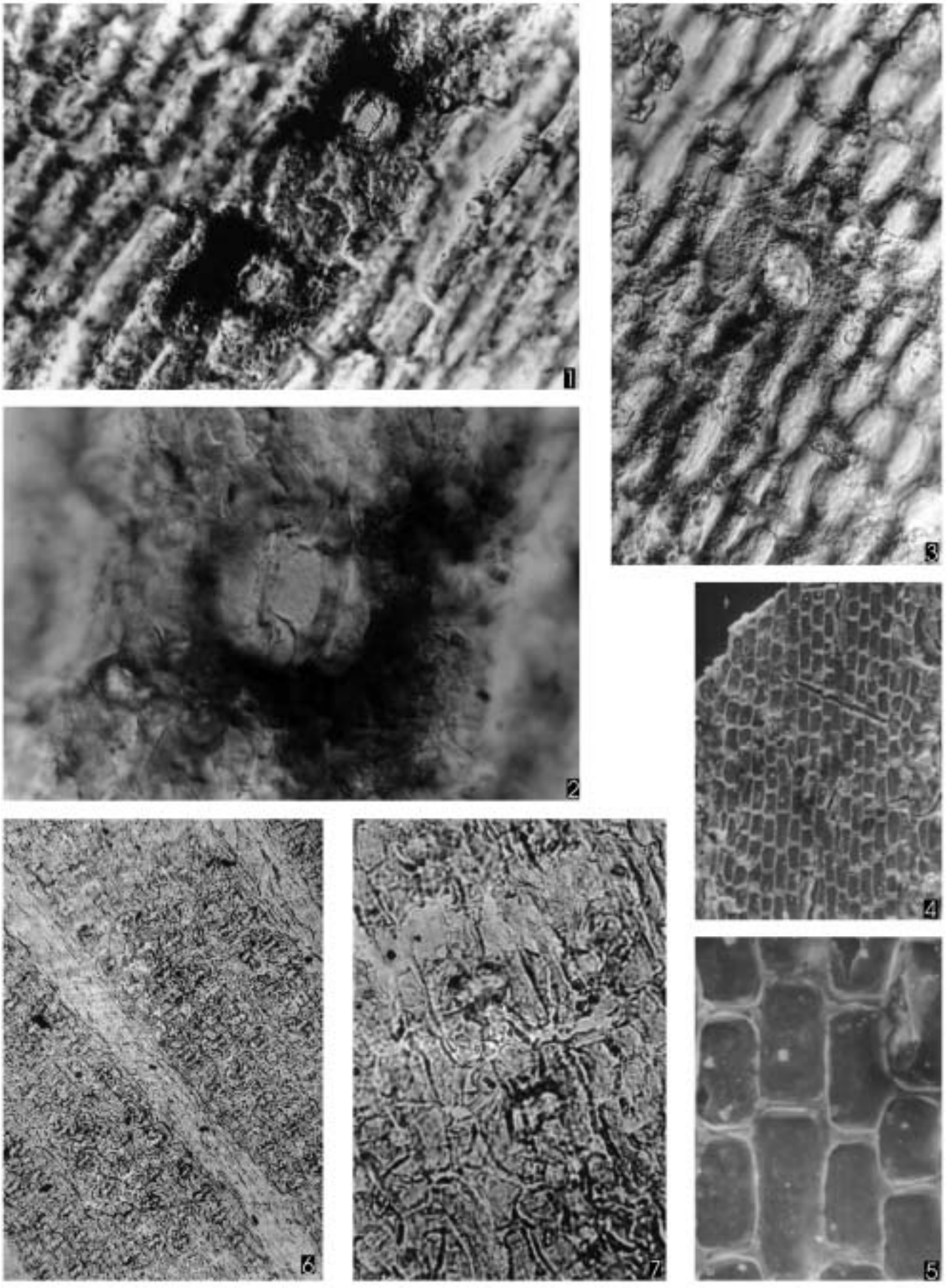
PLATE 30

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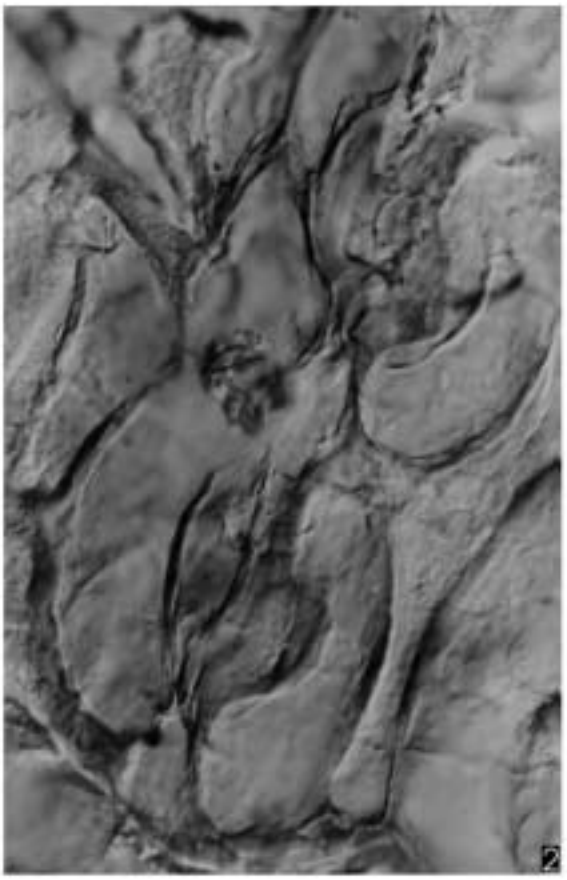
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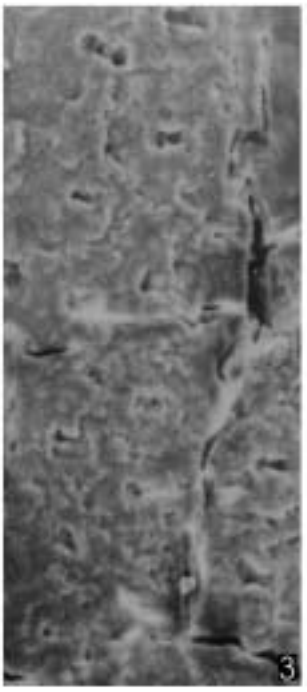
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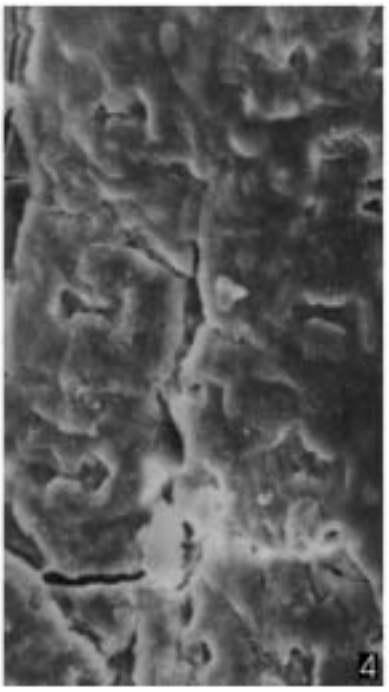
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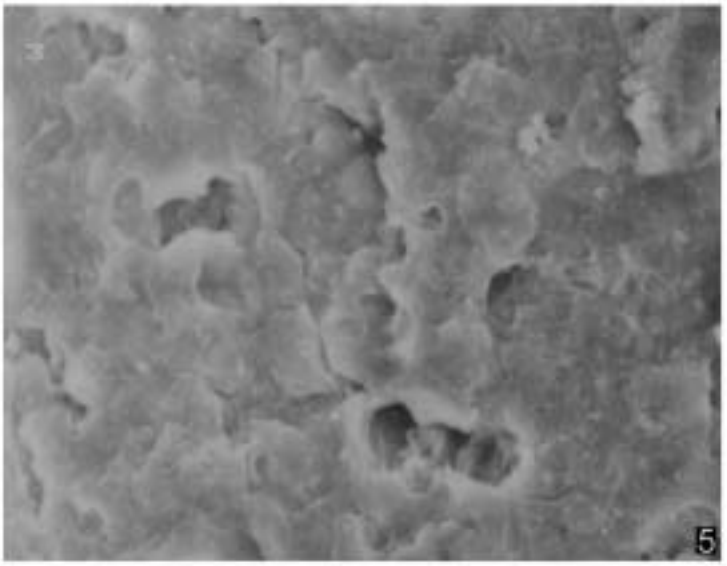
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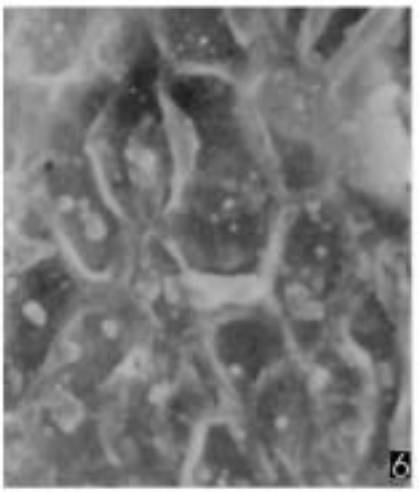
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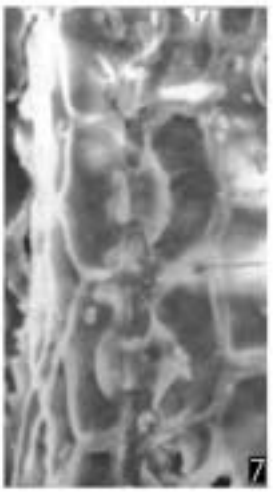
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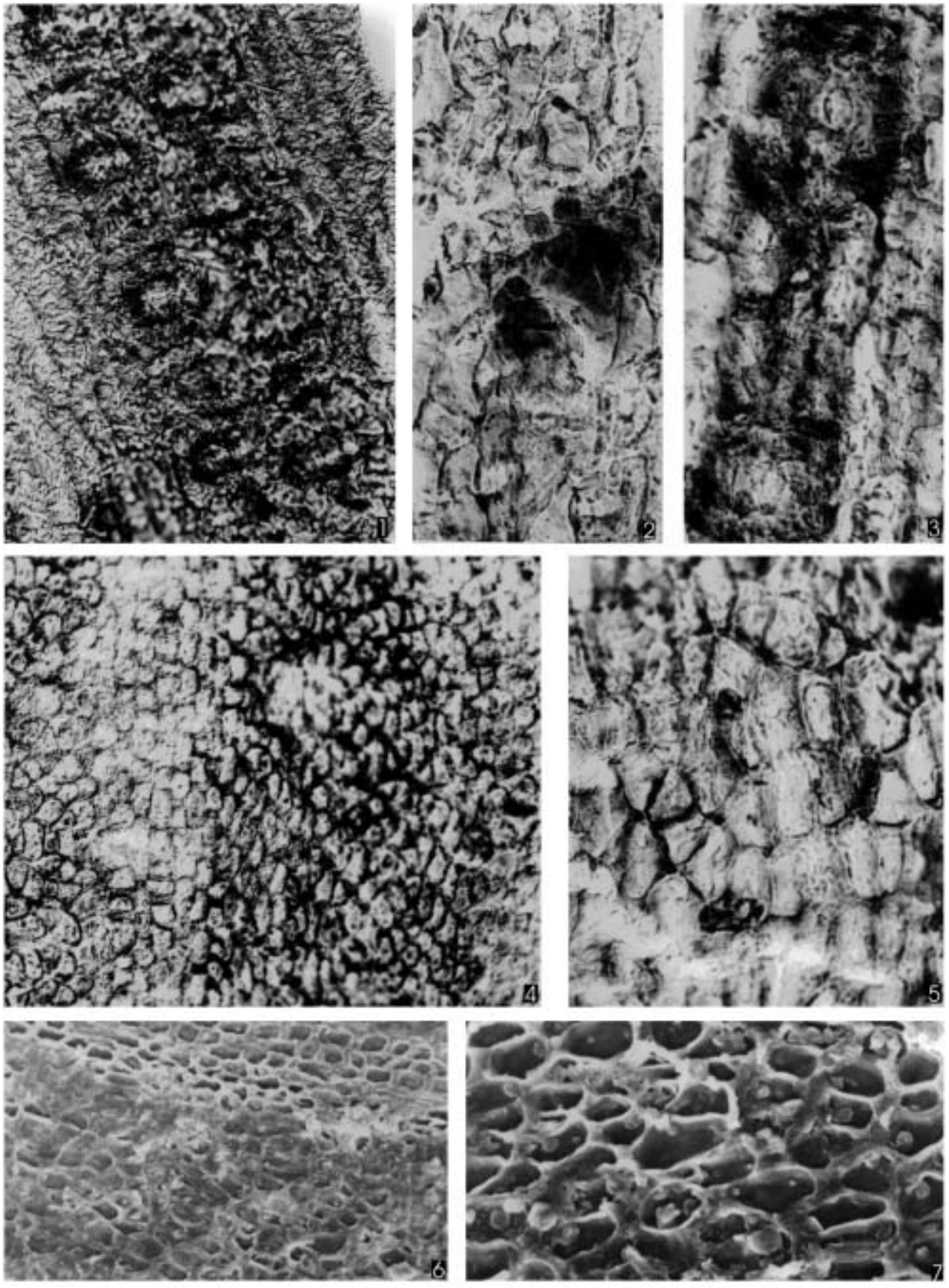
PLATE 32



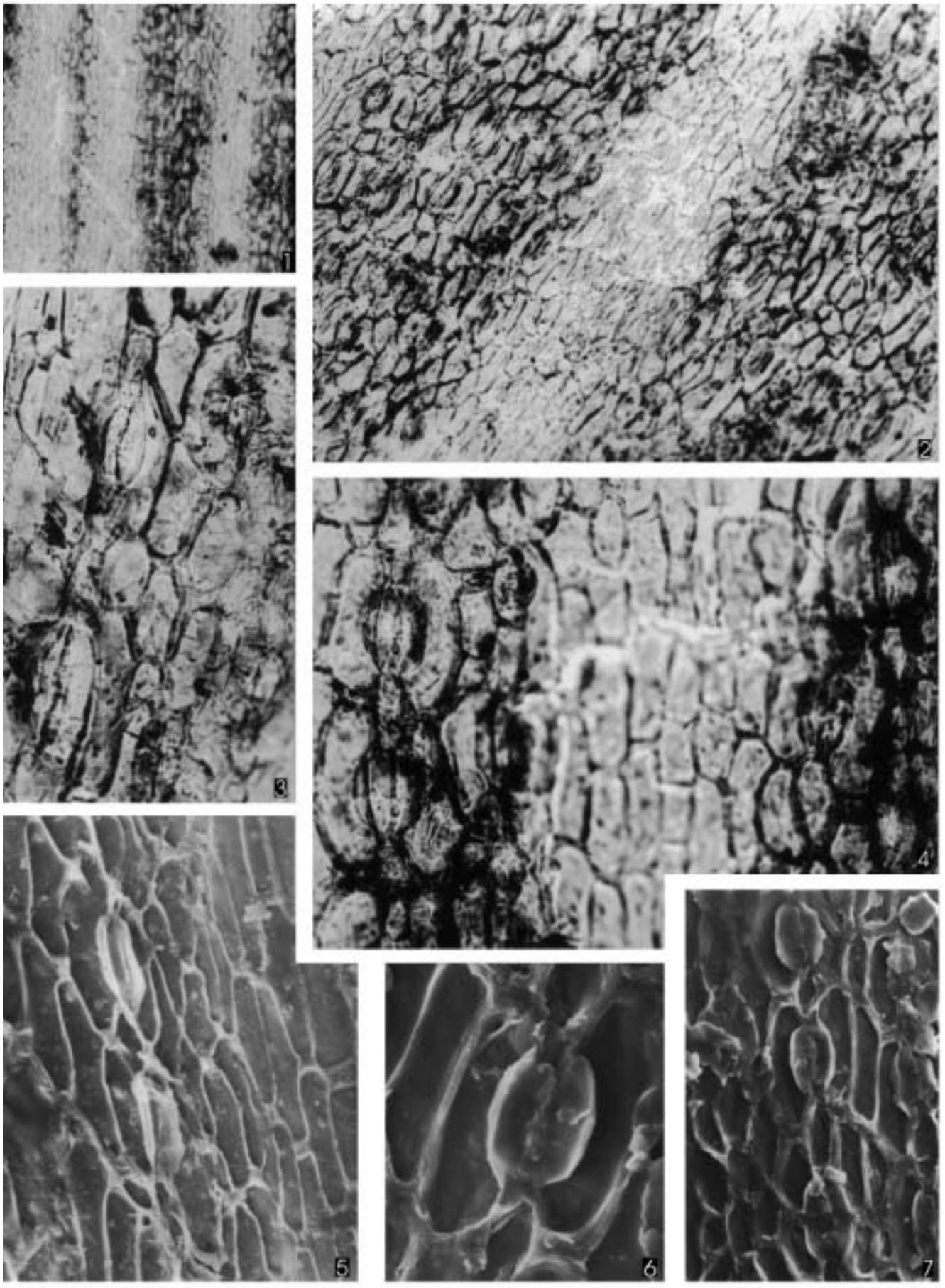

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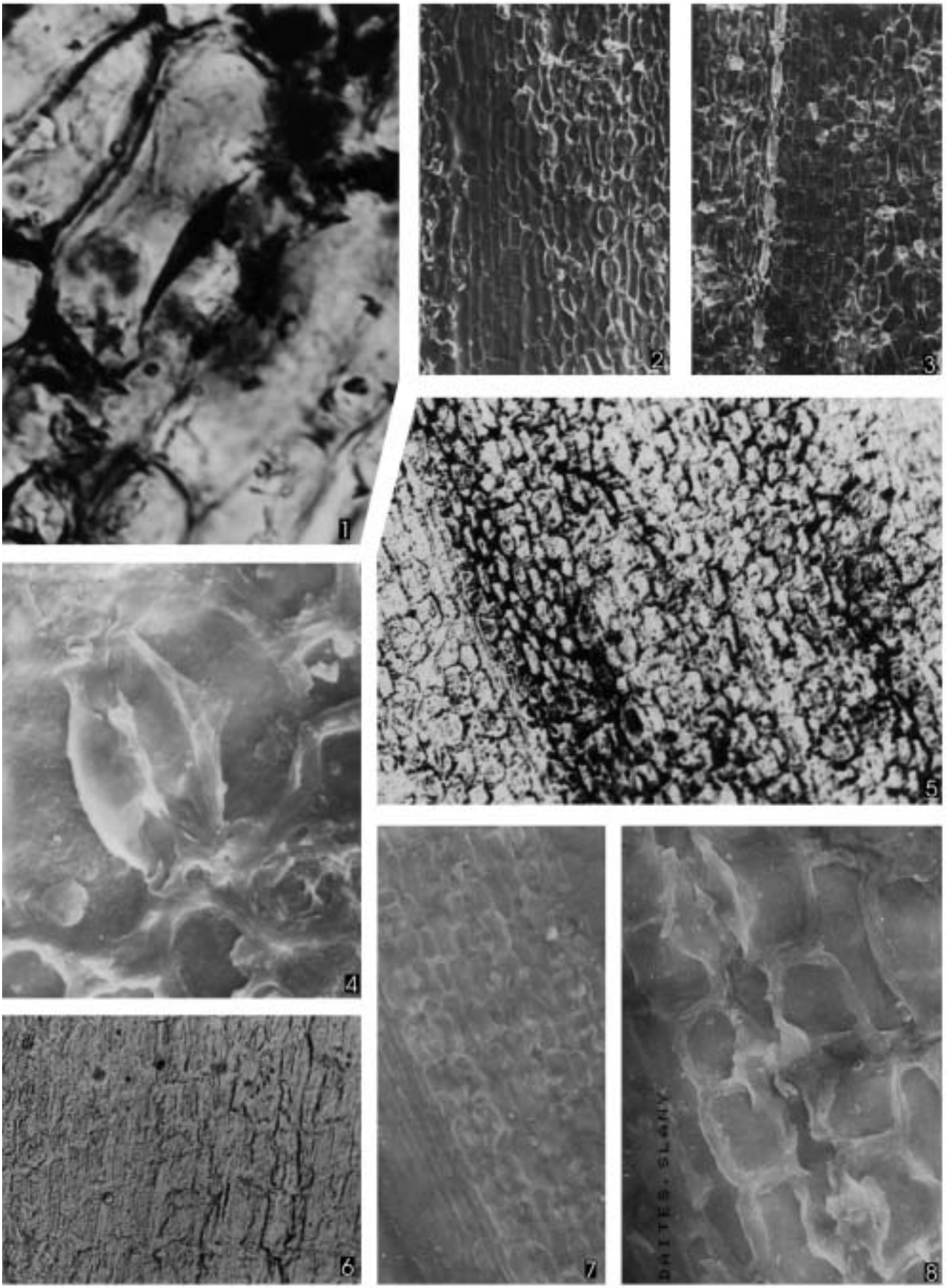
PLATE 34



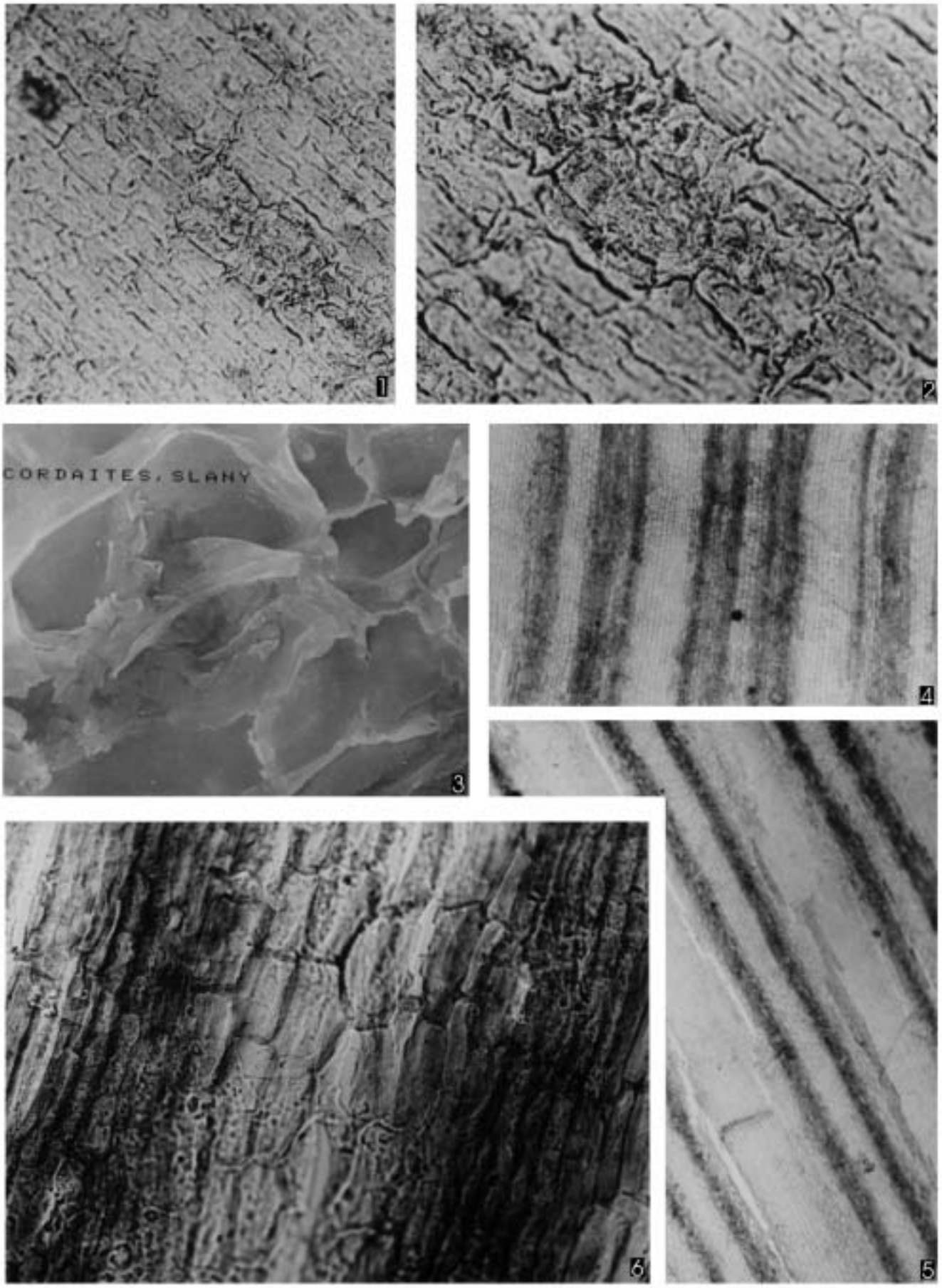

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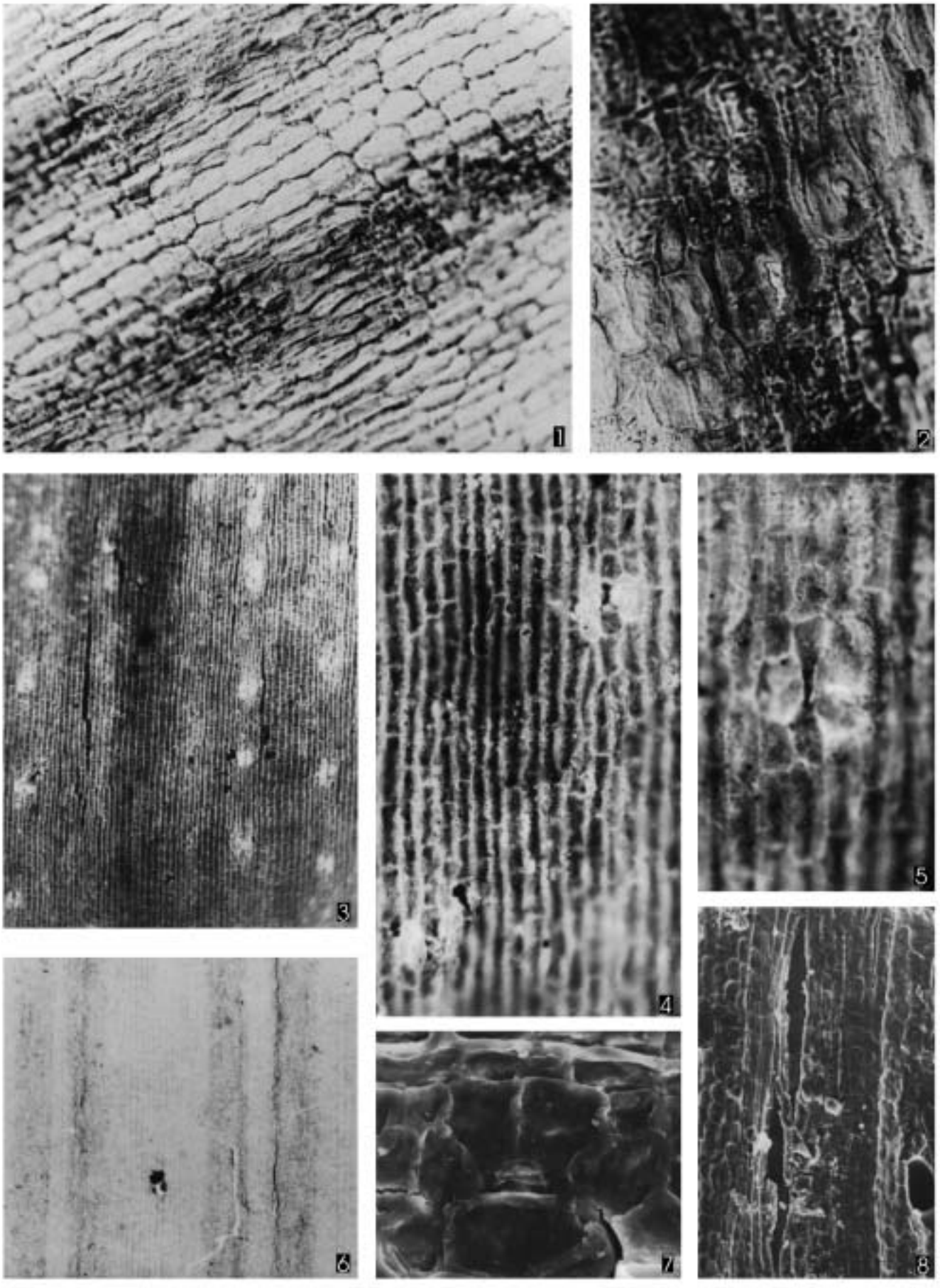
PLATE 36



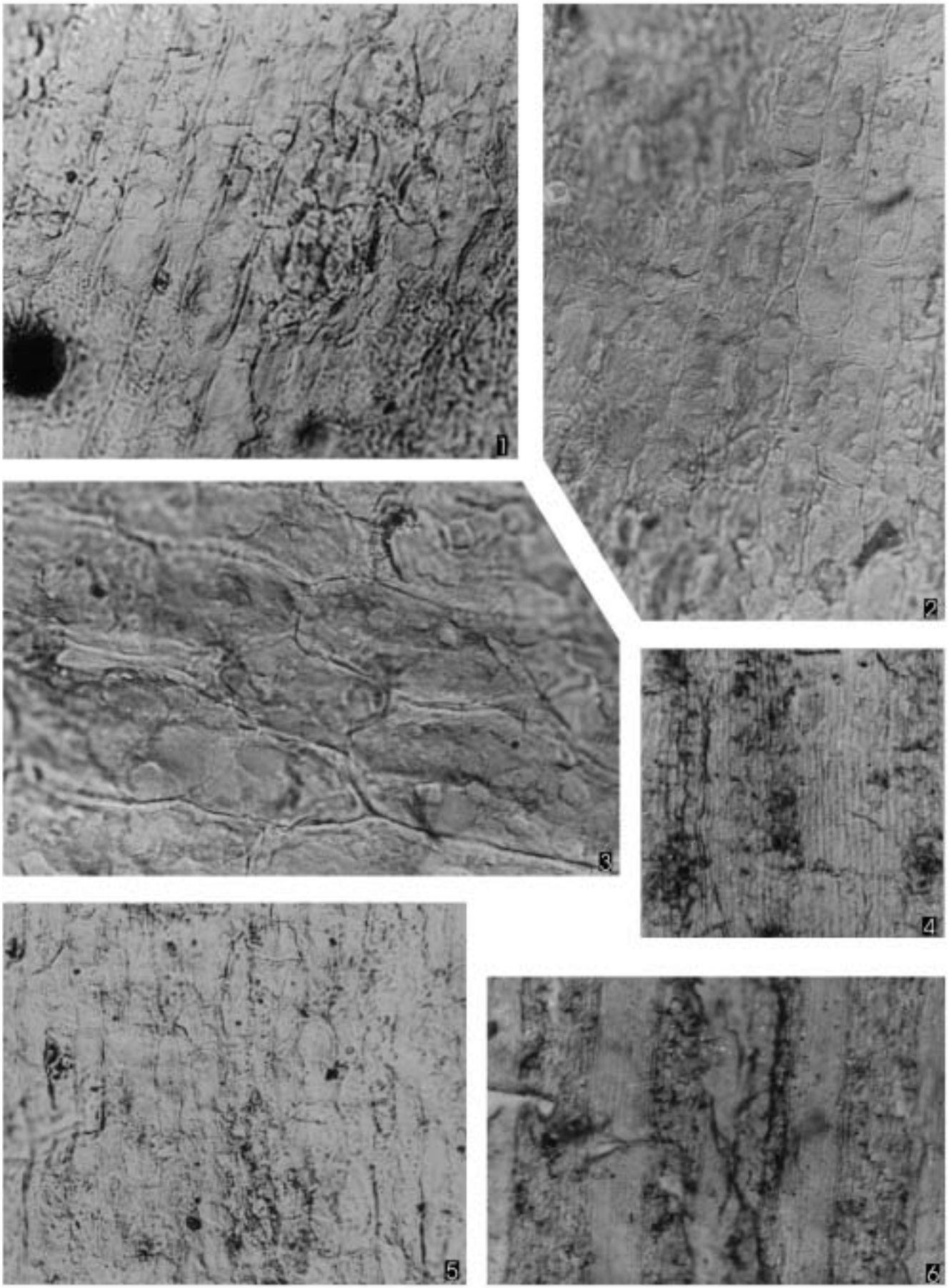

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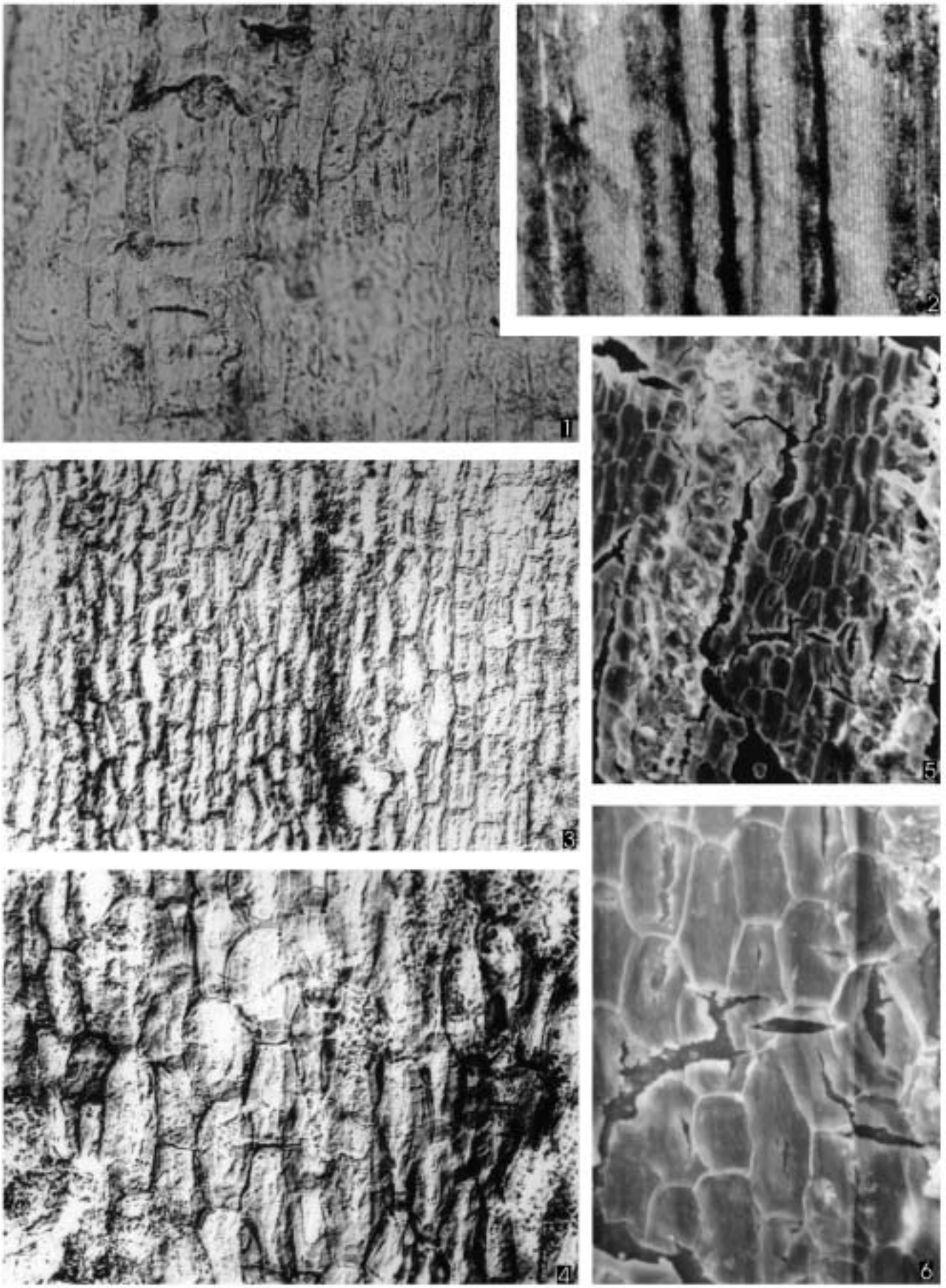
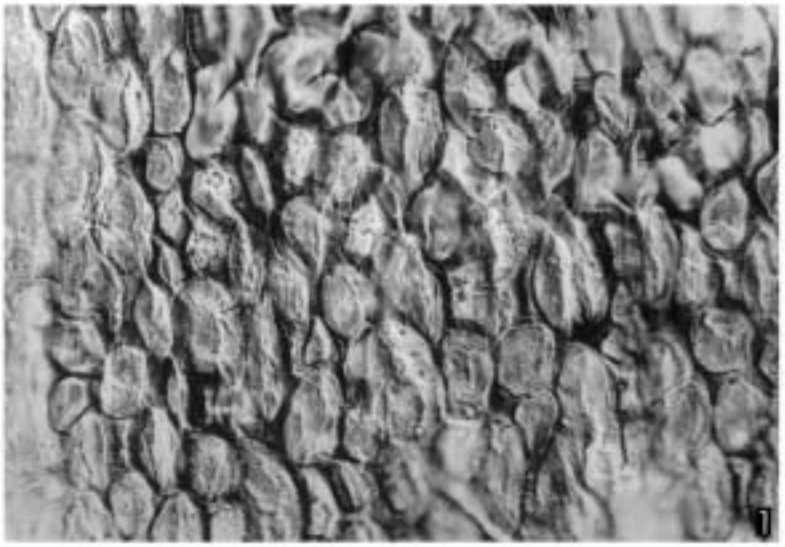
PLATE 38

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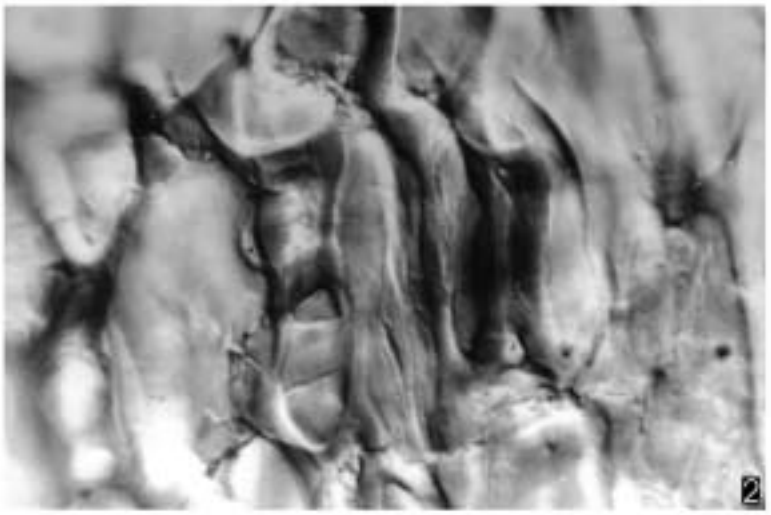
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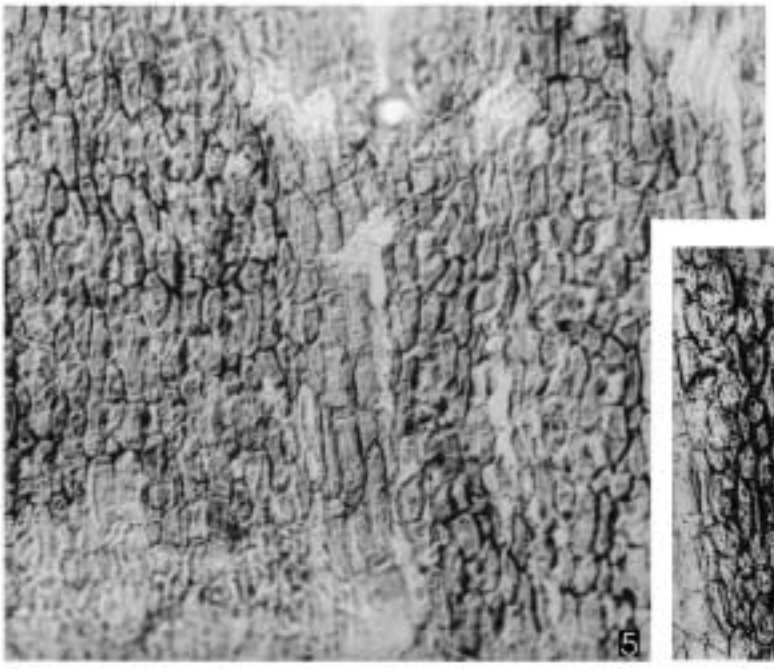
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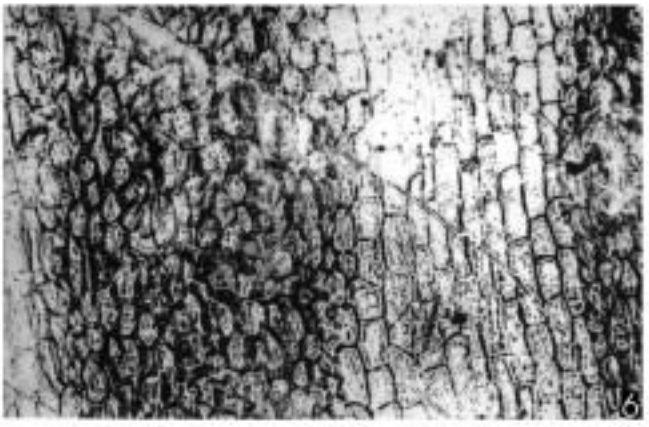
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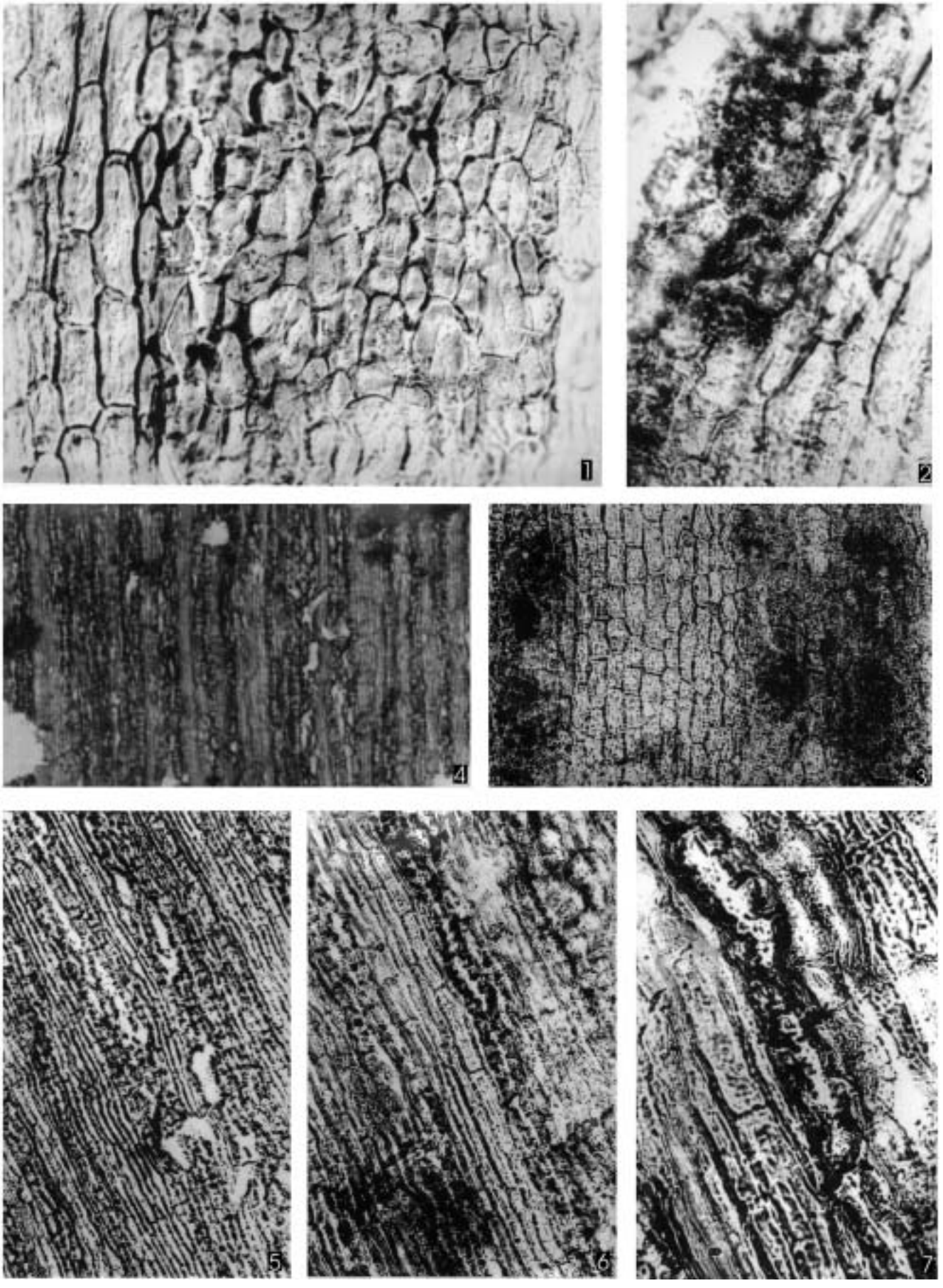
PLATE 40

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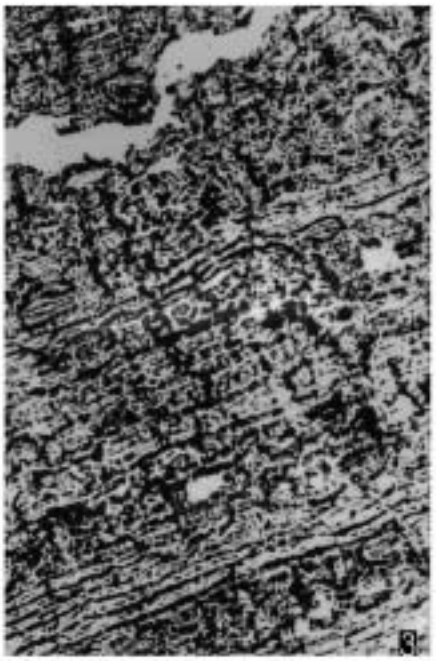
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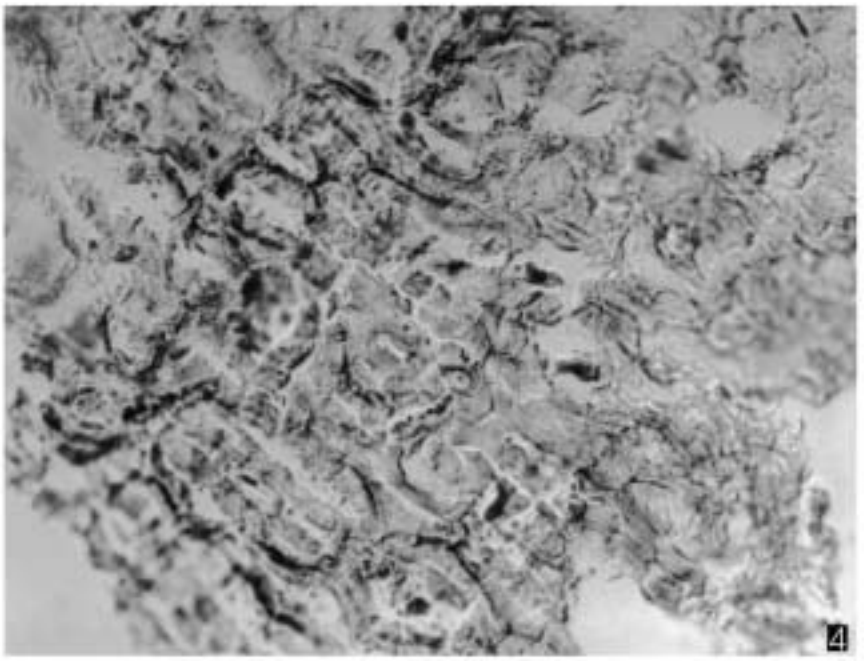
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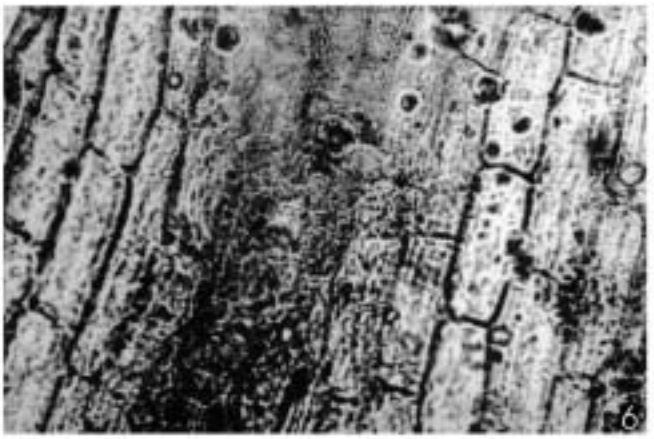
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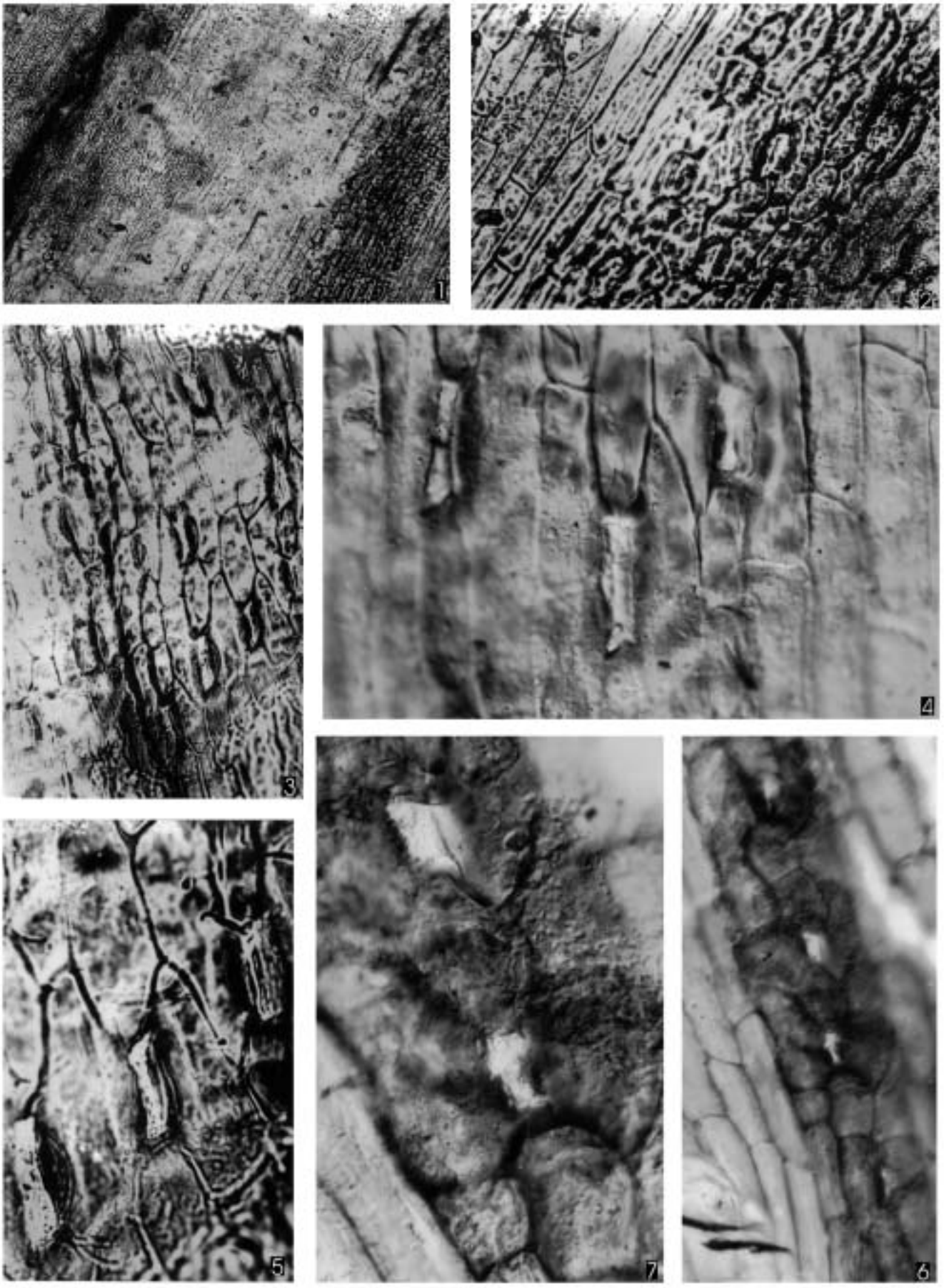
PLATE 42

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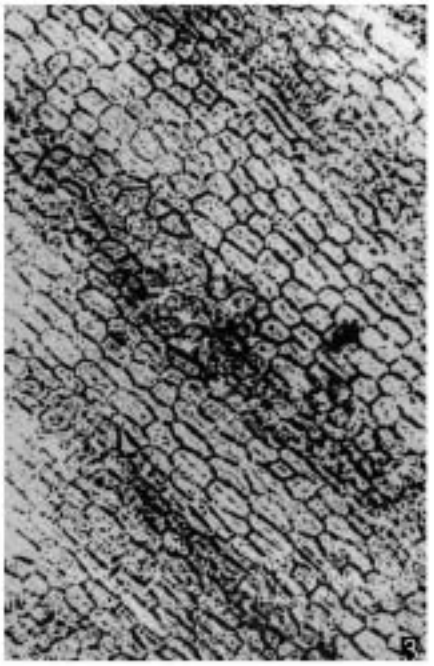
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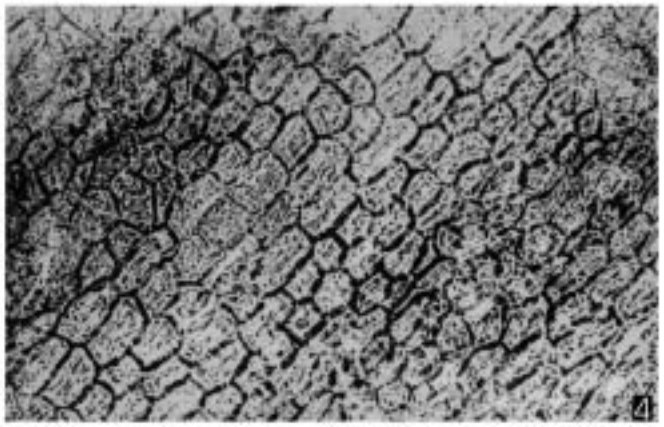
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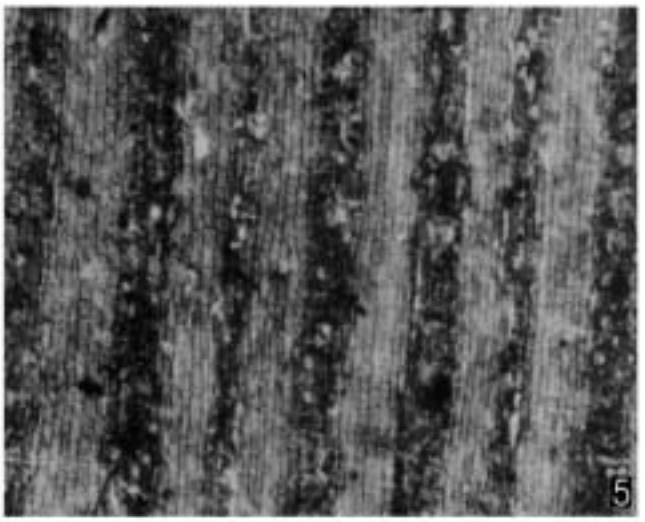
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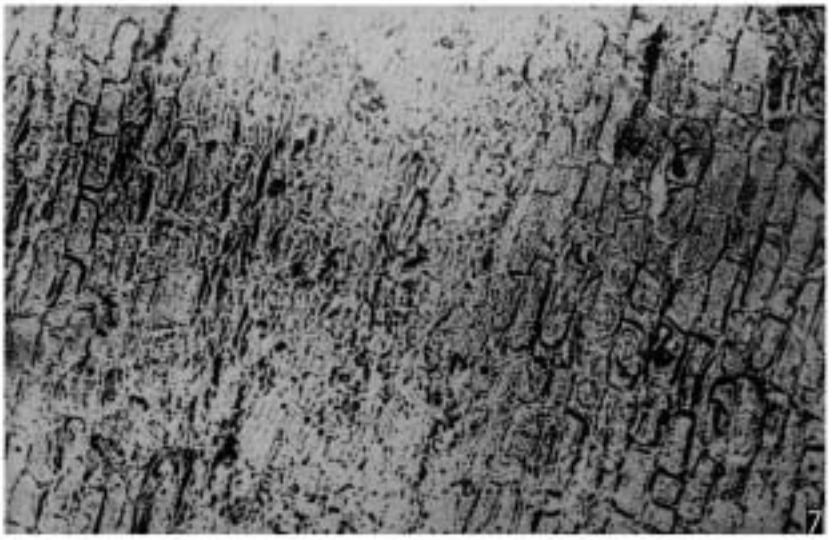
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PLATE 44