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THE JURASSIC FLORA FROM GROJEC NEAR CRACOW IN POLAND. PART I

Jurajska flora z Grojca koło Krakowa. Część I

INTRODUCTION

About 1890 M. Raciborski made a large collection of plants from the Lower Jurassic refractory clays in Grojec, Poręba and Mirów near Cracow. The clays had then been exploited and the pits themselves as well as the waste tips provided rich plant material. Raciborski published in 1889 two lists of plants, and in 1894 descriptions of 63 species and a few varietes and forms belonging to 14 families and 26 genera. Unfortunately he finished only the description of *Cryptogamae*; he classified as cryptogamic also the species of *Thinnfeldia* and *Ctenis*.

In 1956, following the suggestion of Professor W. Szafer, the Botanical Institute of the Polish Academy of Sciences in Cracow collected plants in Grojec in the last shaft which had just been abandoned, and also on waste tips. This material has very well preserved cuticles, while most of the Raciborski collection consists only of hollow casts of plants in the fine clay.

In this paper I give descriptions of 11 plants from the 1956 collection. When necessary, I have also used material from a small collection of plants with cuticles made by Raciborski and labelled „Grojec East"; I examined besides some of the material described by Raciborski. The collection of 1956 and the slides are deposited in the Botanical Institute of the Polish Academy of Sciences in Cracow. The collection of Raciborski mentioned here is in the Geological Museum of the Polish Academy of Sciences in Cracow.

I wish to express my sincere thanks to Professor T. M. Harris of the Botany Department of the Reading University for advice and help with the writing of this paper.

I am also grateful to the Department of Palaeontology of the British Museum (Natural History) in London where I examined the collection of Jurassic plants and slides; and also to the Geological Museum of the Polish Academy of Sciences in Cracow for lending me specimens from the Raciborski collection.

I wish to thank Mr L. C. Willis (Reading) for kindly taking the photographs: P. I, figs. 1, 4; Pl. V, figs. 1, 4, 5; Pl. VI, figs. 6; Pl. VII, figs. 3—5; Pl. IX, fig. 3 — and to Mgr S. Łuczko (Cracow) for the remaining photographs. And I wish to thank all those who took part in the making and preparation of the collection in 1956.

This work was carried out thanks to a grant from the Polish Academy of Sciences which enabled me to work for several months in the Botany Department of the Reading University. The collection of 1956 was made also thanks to a grant from the Polish Academy of Sciences.

SYSTEMATIC DESCRIPTION

Pteridophyta — Filicales
Leptosporangiatae
Matoniaceae

Phlebopteris angustiloba (Presl) Hirmer et Hoerhammer

Pl. I, figs. 1, 4, 5; Text-fig. 1A—E

1391 *Laccopteris angustiloba* (Presl) Raciborski, P. 15; Pl. II, figs. 6—9, Pl. III, figs. 1—3.
1892 *Laccopteris angustiloba* (Presl) Raciborski, Pl. II, fig. 22.
1919 *Gutbiera angustiloba* Presl, Antevs, P. 16; Pl. I, figs. 7—9.
1919 *Andriana baruthina* Braun. Antevs, P. 17; Pl. I, figs. 10—15.
1928 *Gutbiera angustiloba* Presl, Makarewiczówna, P. 4, no figures.
1931 *Laccopteris angustiloba* Raciborski, Harris, P. 74; Pl. XIV, figs. 6—16; Text-fig. 26.
1936 *Phlebopteris angustiloba* (Presl), Hirmer et Hoerhammer, P. 26; Pl. VI, figs. 1—4.
1946 *Phlebopteris angustiloba* Hirmer et Hoerhammer, Harris, P. 21; Text-fig. 8.
1950 *Phlebopteris angustiloba* Hirmer et Hoerhammer, Lundblad, P. 23; Pl. II, fig. 14, Pl. III, figs. 1—6, Pl. XIII, fig. 2; Text-fig. 4.

Material. The material consists of one small specimen which contains fragments of several pinnules. Some of them are sterile and have their lower sides exposed. They are preserved as casts in the fine clay and they show the venation.

Other pinnule fragments are fertile and show their upper side. In certain parts the leaf substance is still preserved in the form of black coaly matter showing plainly the division of the pinnae into quadrangles. The leaf substance is brittle and where it has fallen off there appears the

cast of its lower side. The cast shows a depression in the middle of each quadrangle which corresponds to the placenta and is surrounded by a strong bulge. Very rarely a sporangium is still present on the leaf; also a few dehisced sporangia were found in the matrix. One pinna fragment shows casts of complete sori.

Description. Size of the entire leaf unknown; the largest pinnule fragment 4 cm. long and 2 cm. wide. Rachis up to 1 mm. wide, showing longitudinal ridges. Pinnae of the fertile leaf, where complete, strongly falcate, arising at an angle of about 90° to the rachis and then bending upwards in about 1/3 of their length to form an angle of about 30° with the rachis. Bases of the pinnae 2—2·5 (3) mm. wide, their sides tapering gradually towards an obtusely pointed apex. Length of the pinnae up to 15 mm. Pinnae touching with their margins, sometimes overlapping, in a few places the web connecting their bases visible. Upper surface of pinnae convex, their margins recurved.

Pinna midrib strongly depressed on upper side, protruding on under side. Main lateral veins arising at intervals of 0·5 mm., opposite or nearly opposite, forming a right angle or nearly a right angle with the midrib, strongly depressed on upper side; near its beginning giving up a lateral branch running diagonally or at first diagonally and then parallel to the main branch.

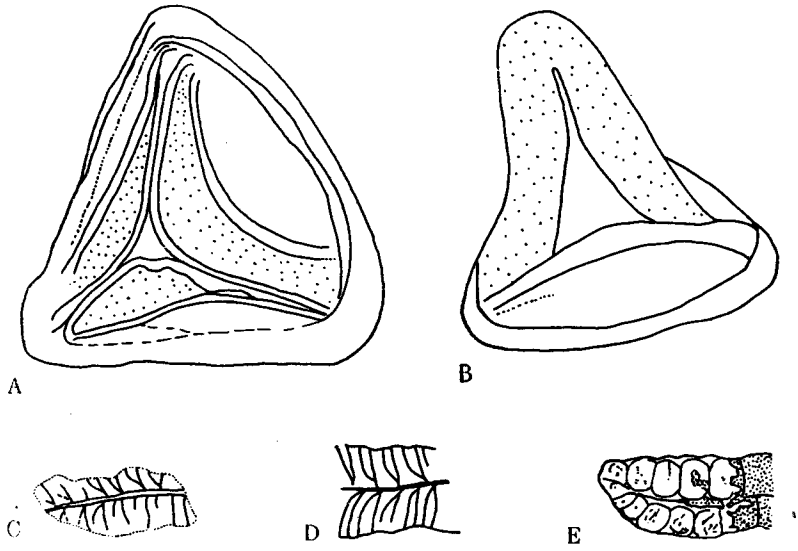
Sporangia bearing an annulus of large cells. Spores macerated from 5 different sporangia are all of the same type and of similar size; their shape rounded tetrahedral, their walls smooth; the average diameter of 10 spores measured is 55 μ, extremes 36 and 90 μ. The triradiate mark extending over more than 3/4 of the spore radius; margins of the mark bearing strongly cutinised bands. Spores usually compressed and showing their polar end with the triradiate mark; rarely preserved in lateral position.

Discussion and comparison. This plant was described by older authors under three different names: *Gutbiera angustiloba* Presl., *Andriana baruthina* Braun and *Laccopteris angustiloba* Raciborski. Raciborski (1891) was the first to include the plant into the *Matoniaceae* basing this conclusion on his study of fertile specimens from Gromadzice and Chmielów in Central Poland. Harris (1931) proved that *Andriana baruthina* and *Gutbiera angustiloba* were identical and transferred the species to the genus *Laccopteris*. Hirmer and Hoerhammer (1936) replaced the name *Laccopteris* by *Phlebopteris*.

P. angustiloba shares with *P. Muensteri* the feature distinguishing them from the remaining members of the genus: all the vein branches are free, not anastomosing.

It differs from *P. Muensteri* in that its lateral veins arise at a right angle to the pinna midrib, while in *P. Muensteri* the corresponding angle is 45°, although it may be up to 90° in fertile leaves. As the midrib and

the main lateral veins of *P. angustiloba* are deeply depressed, they divide the pinnae into quadrangular fields this being the most important feature distinguishing *P. angustiloba* from *P. Muensteri* where such fields may occur in fertile fronds, though they are never so conspicuous. The venation of a typical *P. angustiloba* as figured by Harris (1931) and Hirmer and Hoerhammer (1936) is very characteristic, as the main lateral vein gives off several branches running diagonally through the square field.



Text-fig. 1. *Phlebopteris angustiloba*, A, B, spores × about 800. C, D, venation of pinnae seen from the under side, × 5. E, upper side of a fertile pinna, × 6. C—E from No 101
Ryc. 1. *Phlebopteris angustiloba*. A, B, spory, × około 800. C, D, unerwienie odcinków liścia, × 5. E, zarodnionośny odcinek liścia widziany od góry, × 6. C—E, z okazu nr 101

In the specimen from Grojec the main lateral veins arise at a right or nearly right angle; the quadrangular fields are well marked by the depressed veins on the upper side of the leaf, or by the protruding veins where the under side is exposed. The venation is, however, much simpler than the typical one, as the main lateral veins arise at a distance of about 0·5 mm., compared with that of about 1 mm. in the specimen of Harris, and in consequence, they usually give off only one branch, often running parallel to it.

Spores macerated from sporangia found on the leaf are identical with those from detached sporangia. The spores agree in shape and their smooth surface with spores of *P. angustiloba* examined by Harris (1931) and Lundblad 1950). The spore in polar view (Text-fig. 1A) shows the same strongly cutinised bands along the triradiate mark that are seen on fig. 6,

Pl. III of Lundblad. The spore in lateral view (Text-fig. 1B) shows close similarity to that on fig. 6, Pl. XIV of Harris. The Polish spores, however, are larger; the average diameter of 10 spores is 55 μ compared with only 41 μ in the Swedish material and 40 μ in the material from Greenland. There occur also spores much smaller than the average, with thinner walls, often folded and with the Y mark not clearly visible (comp. Pl. I, fig. 5). These are evidently immature spores.

Age and distribution. Hirmer and Hoerhammer (1936) give an extensive list of localities where *P. angustiloba* occurs, their age ranging from Rhaetic to Upper Jurassic. In his paper on Greenland Harris (1937) expresses the opinion that the well characterised specimens derive only from the basal Lias.

P. angustiloba is known from two localities in East Greenland, from several localities in Scania (Sweden), from Bornholm, and from several localities in S. W. Germany. In Poland it was described from Gromadzice and Chmielów (Central Poland). The present specimen is the first one recorded in Grojec.

PHLEBOPTERIS MUENSTERI (SCHENK) HIRMER ET HOERHAMMER

Pl. II, fig. 1; Text-fig. 2A—D

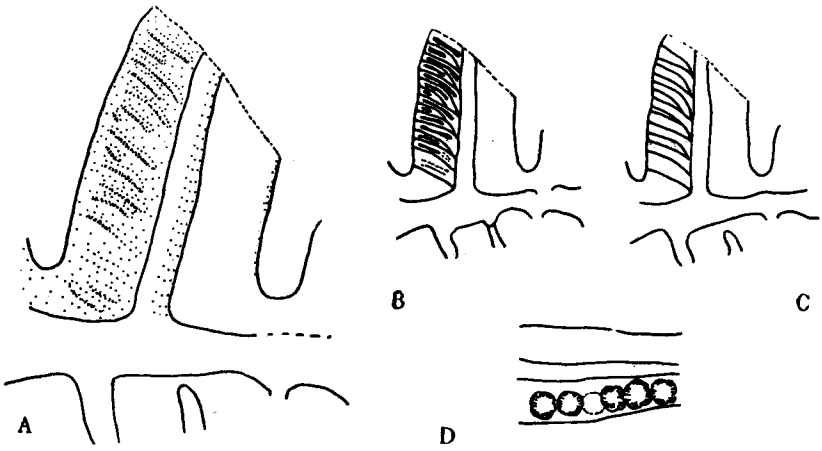
1894 *Laccopteris mirovensis* Raciborski, P. 40; Pl. XII, figs. 22, 23, Pl. XIII, figs. 1—2.
1926 *Laccopteris groenlandica* Harris, P. 62; Pl. III, fig. 5, Text-fig. 6A—E.
1928 *Laccopteris Muensteri* Schenk, Makarewiczówna, P. 4; Pl. I(X), figs. 2, 2a.
1931 *Laccopteris Brauni* Goeppert, Harris, P. 70; Pl. XIV, figs. 1, 2, Pl. XV, fig. 7, Text-figs. 24, 25.
1936 *Phlebopteris Muensteri* (Schenk), Hirmer et Hoerhammer, P. 17; Pl. III, Pl. IV, figs. 1—6, Text-figs. 5, 2A, 2B.
1937 *Phlebopteris Muensteri* Hirmer et Hoerhammer, Harris, P. 20; no figures.

Material. One specimen in the present collection shows its venation and possesses one fertile pinna and this specimen is described below. There are also two fertile fragments which may belong to the same species but since these do not show their veins they are left undetermined. The veins even on the first specimen are not shown directly but the lamina shows bulges which I interpret as protrusions between the veins and the reconstruction given in Text-fig. 2 is based on this.

The specimen of *P. Muensteri* is preserved as a hollow cast in fine clay which shows even the epidermal cells; the other specimens collected in 1956 show some of the plant substance as an organic or coaly matter.

Description. Full length of leaf and pinnae unknown. Largest leaf fragment 4 cm. long, pinnae visible only in their basal part up to 1 cm. long, their apex unknown.

Pinnae slightly falcate, arising at a right angle to the rachis, their margins touching or separated by a narrow gap, their bases connected by a web about 0·5 mm. wide. Pinnae 2—2·5 mm. wide at the base, then slightly tapering. Rachis about 1 mm. wide, depressed; pinna midrib about 0·5 mm. wide, depressed. Pinna surface flat or somewhat convex, margins slightly recurved, quadrangular fields absent.



Text-fig. 2. *Phlebopteris Muensteri*, A, basal part of a pinna showing parallel ridges which correspond to the protruding parts of the lamina between the veins, × 10. B, same pinna, hypothetical veins drawn between the ridges, × 5. C, same pinna, restoration of veins, × 5. D, pinna fragment showing distribution of sori, × 6. All figs. from specimen No 101 A

Ryc. 2. *Phlebopteris Muensteri*. A, nasadowa część odcinka liściowego z widocznymi równoległymi żeberkami, które odpowiadają wystającym partiom blaszki liściowej pomiędzy nerwami, × 10. B, ten sam odcinek liściowy, pomiędzy żeberka wrysowano hipotetyczne nerwy, × 5. C, ten sam odcinek liściowy z odtworzoną nerwacją, × 5. D, fragment odcinka liścia ukazujący rozmieszczenie kupek zarodni, × 6. Wszystkie rysunki z okazu nr 101 A

Veins as reconstructed forming an angle of 60—70° with the midrib; main lateral veins arising at intervals of $^1/_2$ mm. and usually giving off only one lateral branch (comp. Text-fig. 2).

Sori circular, about $^1/_2$ mm. in diameter, in contact, forming a file midway between the midrib and the pinna margin and leaving a narrow part of the lamina free on both sides. They consist of about 5 sporangia.

Discussion and comparison. Following the opinion of Harris (1931, 1937) I regard *Phlebopteris Muensteri* as the mature form of *P. Brauni* and include the latter into *P. Muensteri*.

There are differences in the size of the sori and the number of sporangia between the Grojec *P. Muensteri* and the material described by other authors. It differs from the Greenland and German specimens in the smaller diameter of the sori — 0·5 mm. compared with 1·1 mm. of Harris (1931) and 1—1·25 mm. of Hirmer and Hoerhammer (1936). There are also fewer sporangia in a sorus: 5 compared with the average 7—8 of these authors.

P. Muensteri from Grojec shows a close resemblance to *Laccopteris mirovensis* of Raciborski (1894) as figured in Pl. XIII, figs. 1, 2. The two species have crowded furcate veins arising at an angle between 60 and 70°, though in some specimens of *L. mirovensis* they form a right angle. Harris (1931) regarded *L. mirovensis* as different from *P. Muensteri,* but Hirmer and Hoerhammer included it into that species.

I have seen the specimens of *L. mirovensis* determined by Raciborski. There are specimens which show the crowded and furcate veins like in the figures mentioned above. But Raciborski gave the name *L. mirovensis* also to leaves with pinnae whose main lateral veins arise at a greater distance and produce up to 3 branches. This venation is very much like the venation in *Laccopteris Brauni* (= *Phlebopteris Muensteri*) of Harris 1931, P. 73, Text-fig. 25 b. There are also leaves with intermediate venation, therefore I consider *Laccopteris mirovensis* as identical with *P. Muensteri.*

L. Muensteri from Grojec shows a certain degree of similarity to *P. angustiloba* from the same locality. In particular the simple venation of *P. angustiloba* resembles that of *P. Muensteri* in their lateral veins consisting usually of two branches. But in *P. angustiloba* the lateral veins arise at an angle of 90° or near it, while in *P. Muensteri* it is most often between 60 and 70°; the two fossils differ also in that *P. angustiloba* has a distinctly convex leaf while it is flat or only slightly convex in *P. Muensteri.* The pinnae of *P. Muensteri* are not divided into quadrangular fields; such fields are, according to Hirmer and Hoerhammer, the distinguishing feature of *P. angustiloba.*

Age and distribution. Harris (1937) shows that when only the well-characterised material is considered, this species was not found outside the Lower Liassic or perhaps Rhaeto-Liassic strata.

P. Muensteri is one of the most characteristic fossils of the *Thaumatopteris* zone in Greenland. It occurs also in the German and Roumanian Lower Lias and was described from the Lower Lias of Central Poland and from Grojec and its vicinity.

Prof. Harris suggested to me recently that *Phlebopteris angustiloba* and *P. Muensteri* are absent from the *Lepidopteris* zone (Rhaetic) but they are present and widespread in the *Thaumatopteris* zone (Lower Lias); however, we do not know how much younger they range, only that they are unknown in the Lower Oolite and younger floras.

SEED PLANTS

Cycadales

Nilssonia cracoviensis sp. n.

Pl. II, figs. 2—4; Text-fig. 3A—F

Type specimen: Instytut Botaniki PAN No 20, slide S 52.

Diagnosis. Leaf linear, full length unknown, width typically about 2 cm., occasionally 3 cm. Lamina flat, undivided, apex obtuse; margins straight or slightly undulate (leaf base unknown). Veins scarcely projecting on either side, arising at an angle of about 80° to the rachis, curving upwards near the margin. Their density from 24—31 per cm. Lamina thin; resin bodies rare [1].

Upper cuticle about 8 μ thick (measured in folds). Cells polygonal, uniform, their anticlinal walls straight, conspicuous, occasionally considerably thickened, periclinal walls flat, slightly granular. Veins not marked. Trichomes and stomata absent.

Lower cuticle fairly thin, consisting of elongated cells along the veins and shorter cells between them, their walls not always conspicuous. Cells in the strips between the veins often bulging to form a hollow papilla with a cutinised top; papillae occurring occasionally in vein strips. Trichome bases in the from of cells with a thickened ring mainly in the vein strips, abundant in some leaves, scarce in others.

Stomata scattered between the veins, forming irregular groups or short files. Their 4—7, typically 5 nearly equal subsidiary cells extending into heavily cutinised hollow papillae, concealing the guard cells.

Comparison. *Nilssonia cracoviensis* agrees in its outer appearance with most members of the *N. orientalis* Heer group. Having an undivided leaf 2—3 cm. wide and 24—31 veins per cm. it resembles macroscopically the following leaves:

N. orientalis Heer, Makarewiczówna, 1928, Pl. 1 (10), fig. 1. (Lias of Poland).

N. orientalis Heer, Frentzen, 1932, Pl. 2, fig. 4. (Rhaetic of Germany).

N. orientalis Heer, Oishi, 1940, Pl. 26, figs. 4, 5. (Upper Jurassic, Japan).

It differs in width of the lamina from:

N. orientalis Heer, Thomas, 1911, Pl. 7, fig. 1. (Jurassic of Russia).

N. orientalis Heer, Kimura, 1958, figs. 1—4, 7. (Upper Jurassic or Lower Cretaceous, Japan).

N. orientalis Heer, Semaka, 1962, Pl. XI, XII. (Lias of Roumania).

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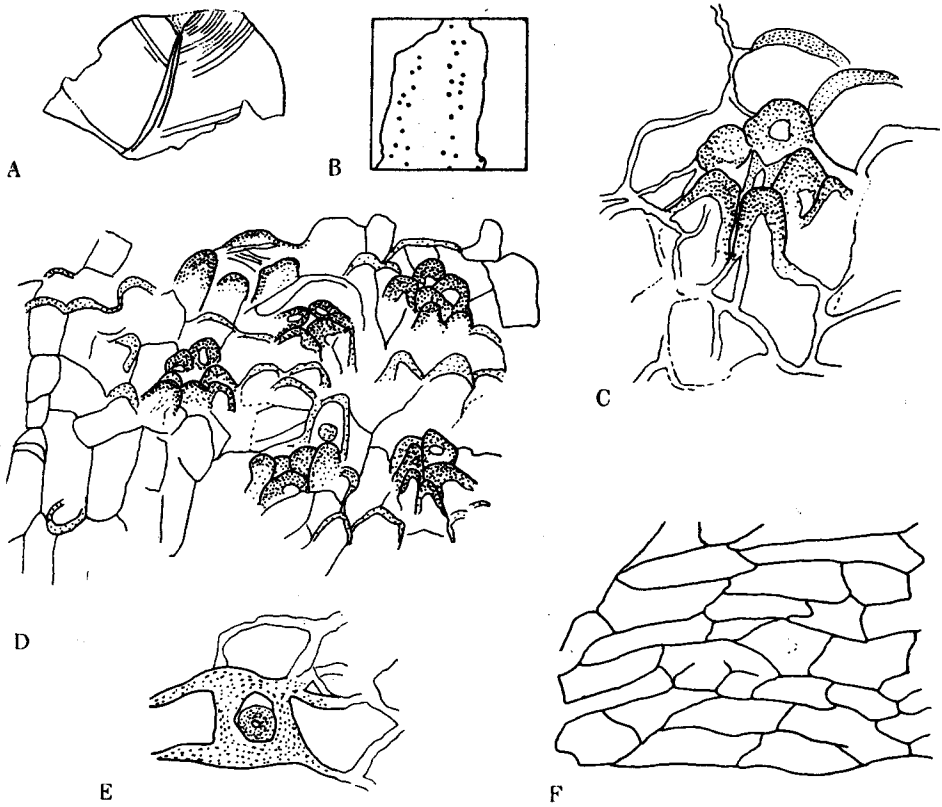
[1] In fact, only the maceration of the cuticle of one specimen, No 15, yielded 2 resin bodies 125 and 175 μ across, which are according to Prof. Harris very similar to those of *N. tenuinervis*.

Among the species of the *N. orientalis* group whose cuticle has already been described, there may be recognised groups agreeing in structure. For example *N. tenuinervis* Seward and *Nilssonia sp. A* Harris from Yorkshire (see Harris Yorkshire Catalogue II, in the press) and also *N. obtusa* (Nath.), Harris from the Lower Liassic of Greenland possess



Text-fig. 3. *Nilssonia cracoviensis*. A, leaf apex, No 41, × 2. B, distribution of stomata in 1 sq. mm., slide S 52. C, stoma overhung by cutinised papillae, slide S 52, × 400. D, lower cuticle, a vein lies on the left, slide S 52, × 200. E, trichome base, slide S 59, × 400. F, upper cuticle, slide S 52, × 200

Ryc. 3. *Nilssonia cracoviensis*. A, szczyt liścia, nr 41, × 2. B, rozmieszczenie szparek w 1 mm², preparat S 52. C, szparka otoczona i zasłonięta przez skutynizowane papille, preparat S 52, × 400. D, dolna kutykula, lewa strona leży ponad nerwem, preparat S 52, × 200. E, nasada włosa, preparat S 59, × 400. F, górna kutykula, preparat S 52, × 200

a thin cuticle with flat cells, with subsidiary cells unspecialised or only slightly specialised. They differ in all those features from *N. cracoviensis*. All those species posses resin bodies in their leaves, while in *N. cracoviensis* they are extremely rare.

Another group consists of *N. Thomasi* Harris and *N. revoluta* Harris (see Yorkshire Catalogue II). Here the cuticle is moderately thick and the subsidiary cells show heavily cutinised papillae, in which features these species agree with *N. cracoviensis*. But the leaf of *N. Thomasi* is much broader (up to 6·5 cm.) and that of *N. revoluta* much narrower (3—5 mm.) than in *N. cracoviensis*. *N. Thomasi and N. revoluta* show no resin bodies.

N. cracoviensis is characterised by having papillae on many of the under epidermal cells. Bulging cells are present also in *N. revoluta* and in the Yorkshire *Nilssonia sp. B* Harris (see Yorkshire Cat. II). In *N. sp. B* the stomata are placed in sunken grooves and the cuticle differs from that of *N. cracoviensis* by its inwards projecting walls, forming pegs or flanges. Bulging cells are also present in *N. undulata* (H a r r i s 1932) from Greenland, but its lamina is undulating, not flat as in *N. cracoviensis*. In *N. syllis* Harris (Yorkshire Cat. II) all the epidermal cells in the stomatal strips are bulging; this leaf, however, is pinnate.

As *Nilssonia cracoviensis* is different from all hitherto known species of the *N. orientalis* type with cuticles described, I consider it justifiable to make it into a new species.

Pteridospermae

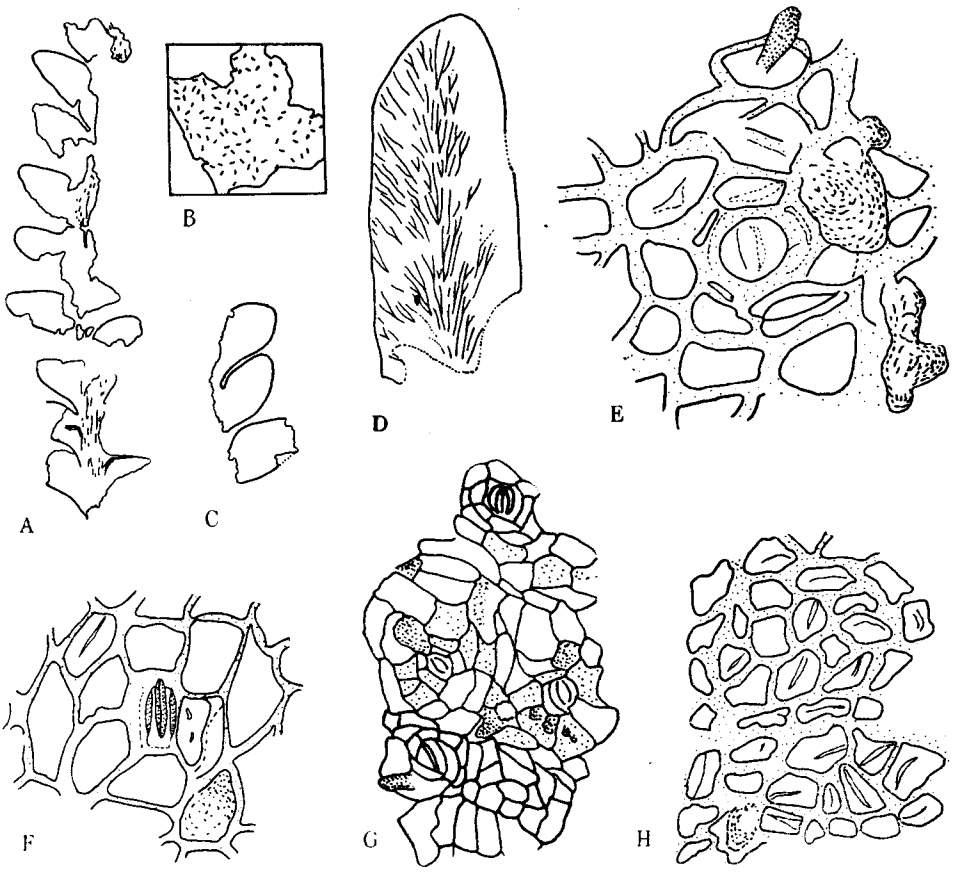
Pachypteris major (Raciborski) sp. n.

Pl. I, figs. 2, 3; Pl. III, figs. 1—5; Text-fig. 4A—H.

1894 *Thinnfeldia rhomboidalis* Ettingshausen, Raciborski, P. 206; Pl. XIX, figs. 9, ?10, 13, 14, 15 (but not 11a, 12b, and not Pl. XX, figs. 1, 2), Pl. XXI, figs. 3—5, 7.
1894 *Thinnfeldia (rhomboidalis forma) major*, Raciborski, P. 208; Pl. XIX, fig. 8, Pl. XXI, fig. 6.

T y p e s p e c i m e n: Instytut Botaniki PAN No 33, slides S 22, S 30.

D i a g n o s i s: Leaf (not known complete but assumed to be simply pinnate); width of largest specimens about 6 cm., but often as little as 1·5 cm., length unknown but in larger leaves estimated at about 20 cm. (on the basis of the taper of the rachis). Rachis up to 3 mm. (5 mm. near the base) wide, with longitudinal ridges. Segments of laminae arising at an angle of 45° in upper part of leaf but at a wider angle below, often crowded above but frequently separated below. Segments often oblong, obtuse but occasionally lanceolate, length of segment up to 3 times as broad but occasionally length equalling width. Apex of leaf often a large undivided segment tapering to an obtuse point, base of lamina also tapering, basal segments short and broad or irregular, individual segments usually obtuse or with a rounded apex, upper basal angle contracted, lower basal angle distinctly decurrent. Size of pinna segment typically 8×3 mm., large pinnae 32×15 mm., small pinnae 5×1·5 mm. Midrib not reaching the segment apex, conspicuous on both sides, lateral veins not



Text-fig. 4. *Pachypteris major*. A, type specimen, × 1. B, distribution and orientation of stomata in 1 sq. mm., slide S 22. C, specimen with cuticle collected by Raciborski, No R 4, × 1. D, venation of a large segment, No 128, × 2·5. E, stoma and papillae, slide S 22, × 400. F, stoma from under side, slide S 4, × 400. G, lower cuticle, slide S 22, × 200. H, upper cuticle, slide S 22, × 200

Ryc. 4. *Pachypteris major*. A, typ, × 1. B, rozmieszczenie i orientacja szparek na 1 mm², preparat S 22. C, zebrany przez Raciborskiego okaz z zachowaną kutykulą, nr R 4, × 1. D, unerwienie dużego odcinka liściowego, nr 128, × 2·5. E, szparka i papillae, preparat S 22, × 400. F, szparka od dołu, preparat S 4, × 400. G, dolna kutykula, preparat S 22, × 200. H, górna kutykula, preparat S 22, × 200

visible in smaller leaves but in large and thick leaves marked on upper side. They arise at an angle of about 45° to the midrib, dividing near the midrib; they occur at a density of 2 per 1 mm. Lowest veins on basal side arising directly from the rachis. Leaf coriaceous, its surface flat or wrinkled. Lamina margin entire, apparently slightly thickened and projecting a little downwards.

Upper cuticle typically 20 μ thick in folds, consisting of isodiametric polygonal cells tending to be square and to form longitudinal rows. Mid-

rib marked by rows of elongated cells. Anticlinal cell walls thick, uninterrupted by pits, deeply cutinised; periclinal walls flat, usually with a thin strip in the middle. Trichomes absent but often thickened cells occurring, and occasionally papillae similar to those on the under side occur near the midrib. No stomata were observed on the upper cuticle. Occasionally cells showing delicate striation.

Lower cuticle typically 10 μ thick in folds. The midrib is marked by a band of narrow elongated cells, course of lateral veins only rarely marked. Epidermal cells resembling those of the upper epidermis, cell walls straight, thick, unpitted. Stomata evenly scattered over the epidermis, variously orientated, numerous, about 200 per 1 sq. mm. Guard cells only slightly cutinised but their lateral walls more strongly cutinised. Guard cells sunken, surrounded by a group of 5—7 subsidiary cells of irregular size, smaller than the ordinary epidermal cells. Rim of stomatal pit raised, formed by cutinised upper parts of subsidiary cells but not overhanging the guard cells. Below the rim, subsidiary cells usually showing a thin strip, running parallel with the rim of the stomatal pit. Occasionally subsidiary cells showing a fine radial striation. Opening of stomatal pit oval, occasionally round, 22 μ across. An incomplete ring of unspecialised encircling cells often present. Rounded, solid cutinised papillae about 20 μ broad, sometimes irregular and broader, are scattered over the whole lower epidermis, occurring most often on one of the subsidiary cells, but also found on epidermal cells. Most epidermal cells and most subsidiary cells entirely without a papilla.

Description and discussion. The new material consists of three parts of the rachis about 5 cm. long bearing several leaf segments and of a number of smaller *Pachypteris* fragments. A few more leaf segments were found in maceration.

I thought at first that in Grojec there were two types of *Pachypteris* leaves. There are leaves with small, lanceolate, or linear segments, rather thin and showing a flat leathery surface. They could well belong to *P. lanceolata* as described by Harris (Yorkshire Cat. II, in the press). Then there are leaves with segments usually broader than 5 mm. which is the maximum width of the Yorkshire *P. lanceolata*. The broader segments from Grojec are oblong and have a broad rounded apex, their lamina being quite thick; their surface is wrinkled and shows the course of the midrib and of the lateral veins. The epidermis structure, however, is exactly the same in both types of pinnae and I regard them, therefore, as one species. I consider that the present fragments are specifically identical with the rather larger fragments figured by Raciborski (1894). These are the specimens called *Thinnfeldia rhomboidalis* p. 206, Pl. XIX, figs. 9, ?10, 13, 14, 15 (but not 11a, 12b, and not Pl. XX, figs. 1, 2), — Pl. XXI, figs. 3—5, 7; also *Thinnfeldia (rhomboidalis forma) major*, p. 208, Pl. XIX, fig. 8, Pl. XXI, fig. 6. One of the Raciborski speci-

mens was well preserved and gave an excellent and typical cuticle preparation.

Thinnfeldia rhomboidalis has been figured by Gothan (1914) and by Antevs (1914) and is clearly distinguished by its stomata which show a very regular ring of small subsidiary cells.

The epidermal structure of *Pachypteris major* is, indeed, very like that in *P. lanceolata* described by Vachrameev and Samylina (1958) from the Caucasus and by Harris from England. There is one differing feature present in the Grojec *Pachypteris:* there are cutinised papillae distributed irregularly over the lower epidermis. The papillae occur in both small and large leaves; their number is variable, there are leaves with scarcely any papillae at all and others with numerous papillae, intermediate forms occurring also. I have examined the large *P. lanceolata* material from Yorkshire and found that similar papillae are present there too but they are much scarcer and far less conspicuous.

As well in the collection of 1956 as in the large Raciborski collection none of the *Pachypteris* specimens shows twice pinnate leaves. It is therefore reasonable enough to presume that they were simply pinnate which is one more difference from *Pachypteris lanceolata.*

Pachypteris major is completely different from *P. papillosa (Pachydermophyllum papillosum* Thomas and Bose 1955), (comp. Harris Cat. II, in the press), where the subsidiary cells bear papillae, and also ordinary cells of the lower epidermis are papillose.

Comparison of the *Pachypteris* species

	P. lanceolata	*P. major*	*P. papillosa*
leaf	twice pinnate	simply pinnate (?)	simply pinnate
length and width of leaf segment	up to 15 mm. up to 5 mm.	up to 32 mm. up to 15 mm.	up to 45 mm. up to 10 mm.
lateral veins	not visible	distinct	distinct
thickness of cuticle	upper up to 10μ lower less	upper typically 20μ, lower typically 10μ	upper typically 6μ, lower typically 4μ
papillae on lower cuticle	unconspicuous	frequent	very frequent
cuticle structure	very similar		different

Age and distribution. *Pachypteris* is a Middle Jurassic genus, while the related genus *Thinnfeldia* is represented in the Lower Liassic floras of Greenland, Sweden and Germany.

Pachypteris lanceolata occurs in numerous localities in the Yorkshire Oolite and has also been found in the Middle Jurassic of the Caucasus. *P. papillosa* occurs also in the Yorkshire Oolite.

Bennettitales

Pterophyllum subaequale Hartz

Pl. IV, figs. 1—3; Text-fig. 5A—G

1896 *Pterophyllum subaequale* Hartz, P. 236; Pl. 15, figs. 1, 3.
1926 *Pterophyllum sp. C cf. P. intermedium* Harris, P. 95; Text-fig. 20A—E.
1928 ***Pterophyllum polonicum*** **Makarewiczówna, P. 20; Pl. 1(IX), figs. 3—5.**
1932 *Pterophyllum subaequale* Hartz, Harris, P. 96; Pl. 9, Text-fig. 38A—C.
1932 *Pterophyllum suabaequale* Hartz, Harris, P. 74; Pl. 6, figs. 8—14, Text-fig. 39—42.

Description of the specimen from Grojec. Length and shape of leaf unknown, width of specimen about 4 cm. Rachis about 1 mm. wide. Pinnae about 2 cm. long, 2 mm wide, arising at an angle of nearly 90° but bending forward to about 60° to the rachis. Pinnae alternating or opposite, beginning with an expanded base 3 mm. wide, constricted above, then almost parallel and tapering slightly towards the rounded apex. Shape of pinnae slightly falcate, distance 2—3 mm. Margin not specially developed.

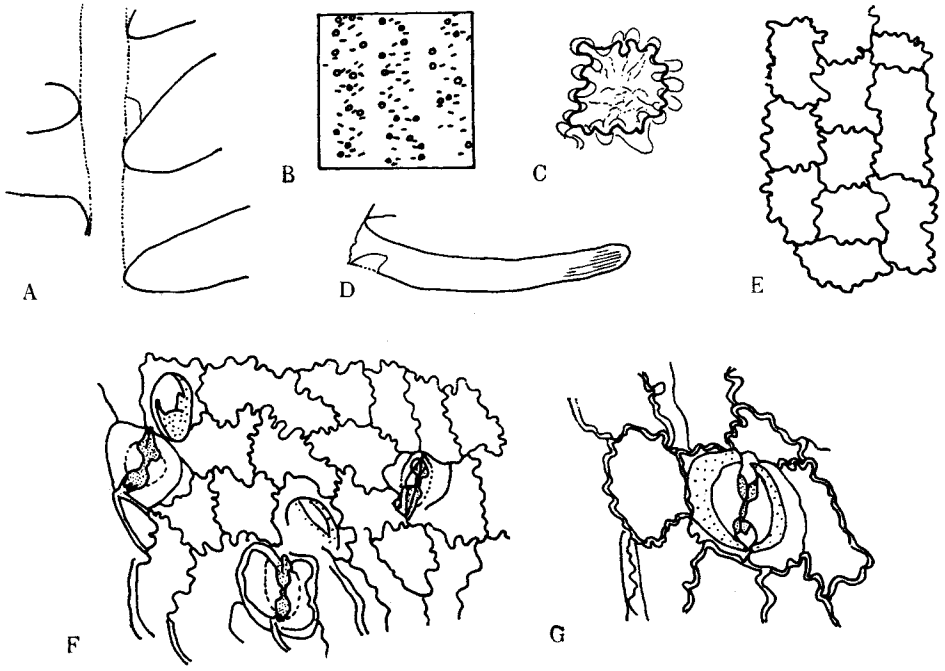
Veins unconspicuous, parallel in upper part, about 3 per 1 mm.

Upper cuticle consisting of longitudinal rows of regular oblong, sometimes square cells, their width diminishing towards the margins. Cell walls sinuous, with ridges extending inside the cell. No papillae nor trichomes present but upper cell walls uneven and showing obscure markings. Upper cuticle about 6 μ thick, lower one about 2·5 μ thick.

Lower cuticle showing stomata arranged in parallel bands running between the veins, stomatal bands about twice as wide as stoma-free spaces. Near pinna base five stomatal bands present, the two nearest to the margins wider than the rest. In each band from 1—4 rows of stomata, most of their apertures orientated transversely to the course of the veins. Certain epidermal cells in stomatal bands different from others, surface strongly cutinised and bulging outwards. Epidermal cells resembling in shape and dimensions those of upper epidermis, arranged in rows parallel to the veins. Their walls slightly undulating, their shape less regular between the veins than below them.

Stomata about 80 per 1 sq. mm. Subsidiary cells crescentic, smaller than epidermal cells, lying on a level with the epidermis surface, walls facing the stomatal aperture straight or bearing a more or less distinct papilla; when strongly developed, papillae meeting over the guard cells. External walls of subsidiary cells bearing strongly cutinised ridges. Guard cells sunken, 37 μ long.

Discussion and comparison. The material of *P. subaequale* consists of one single specimen No 91 representing the middle part of a leaf, 6 cm. long and 3 cm. wide. To the left side of the rachis only basal parts of 7 pinnae are seen, on the right side 10 fragmentary and 2 complete pinnae are present.



Text-fig. 5. *Pterophyllum subaequale*. A, part of the rachis and three pinna bases, No 91, × 5. B, distribution and orientation of stomata (black lines) and trichomes (rings) in 1 sq. mm. C, cell of upper cuticle, × 400. D, complete pinna, × 2. E, upper cuticle, × 200. F, lower cuticle, × 200. G, stoma, × 400. (B, C, E—G from slide S 114)

Ryc. 5. *Pterophyllum subaequale*. A, część ogonka liściowego i nasady trzech bocznych odcinków liścia, nr 91, × 5. B, rozmieszczenie i orientacja szparek (czarne kreski) i włosów (kółka) na 1 mm². C, komórka górnej kutykuli, × 400. D, kompletny odcinek liścia, × 2. E, górna kutykula, × 200. F, dolna kutykula, × 200. G, szparka, × 400. (B, C, E—G z preparatu S 114)

The cuticle is well preserved but it shows some transverse wrinkles on both sides which probably arose from compression. The above mentioned bulging cells between the veins are very conspicuous. It is difficult to say whether they are complete or just basal cells of trichomes.

The external features of the described *Pterophyllum* fit very well the description by Makarewiczówna (1928) of *P. polonicum* of the Lias from the environs of Ostrowiec in Central Poland. The specimen from Grojec shows 3 features in which, according to Makarewiczówna, *P. polonicum* differs from other members of this genus; i. e. the considerable length of the pinnae in comparison with their width, the notable

extension of the pinna base and the comparatively large distance between neighbouring pinnae. The size of the specimen from Grojec falls within the range of *P. polonicum* where the median pinnae of the leaf range up to 4 cm. in length and 3 mm. in width, but those near the apex are only 2—2·5 cm. long and 2 mm. wide, as they are in the specimen from Grojec. Also such features as the concentration of veins 3 per 1 mm. and the width of the rachis 1(—2) mm. agree in the two forms. Unfortunately, the cuticle of *P. polonicum* is not known.

Pterophyllum leaves of similar size and shape are figured by Harris (1932) p. 77, fig. 40, and p. 78, fig. 41. They are described under the name of *P. subaequale* Hartz and come from the *Thaumatopteris* zone in Greenland (Cap Stewart). Harris also includes in this species leaves of different appearance, some with pinnae up to 12 mm. wide, their margins nearly in contact and showing a truncate apex. Both types of leaves possess the cuticle figured by Harris 1926, p. 95, fig. 20 under the name *Pterophyllum sp. C cf. P. intermedium* Antevs, which name is regarded by Harris in his later paper (1932) as a synonym of *P. subaequale*. The same cuticle structure is found in Grojec.

The type of stomata is the same in the Grojec specimen as that described by Harris (1932) p. 96, Pl. 9, Text-fig. 38A—C in *Pterophyllum subaequale* from Greenland. But in the specimen from Grojec the walls of the subsidiary cells which face the stomatal aperture are more specialised. In a number of stomata they bear papillae while in *P. subaequale* from Greenland this wall is straight or only slightly bent inwards.

P. polonicum Makar. is most probably identical with the narrow pinnate form of *P. subaequale*; the fact that the specimen from Grojec possesses the *P. subaequale* type of cuticle makes it almost certain.

The specimens on which Hartz (1896) founded the species *P. subaequale* originate from Cap Stewart in Greenland; it is the same locality and Lower Liassic stratum (Lias α or perhaps β) that delivered the *P. subaequale* material described by Harris. The specimens figured by Hartz (Pl. XV, figs. 1—3) possess the characteristic shape shared by the Polish forms: pinnae wide apart, their bases expanded and their length many times exceeding their width. Makarewiczówna (1928) states that she did not see this form of leaf in any other *Pterophyllum;* but she omits the Hartz reference from her list. The width of the pinnae described by Hartz, 2—10 mm., is also similar to that of *P. polonicum* Makar. and the Grojec specimen which also speaks for the identity of those three forms.

Hartz states that this species is very variable. We do not know yet about the variability of the Polish *P. subaequale*. Makarewiczówna (1928) figures a *Pterophyllum sp.* with much wider pinnae which could perhaps represent the form of this species with much broader pinnae described by Harris (1932).

P. subaequale from Hör in Sweden (Lias) described by A n t e v s (1919) possesses pinnae of a shape different from the Grojec *Pterophyllum,* as they are only about 1 cm. long and their length is only twice their width. According to H a r r i s (1926) their cuticle is identical with that of *P. sp. C cf. P. intermedium* = *P. subaequale.*

Otozamites obtusus Lindley et Hutton

Pl. V, figs. 1—5; Pl. VI, fig. 3; Text-fig. 6A—I

M a t e r i a l. The material of *Otozamites obtusus* consists of 8 specimens. Two of them are single pinnae and the rest consist of leaf fragments bearing from 7—15 pinnae. No leaf apices nor bases were found. The specimen No 56 is preserved in a peculiar way, as it shows a leaf fragment in an oblique position to the bedding plane. The pinnae are compressed sideways and thus they appear to be considerably narrower than the rest. But only a few cm. apart on the same slab there is a single separated pinna preserved in the usual way. Specimen No 1 which is discussed below possesses exceptionally small pinnae.

The leaves show their upper side exposed; the lower side always needs cleaning with HF. The leaf substance is thick, it consists of a black coaly matter and yields, when macerated, a beautifully preserved cuticle. The margin is not specially developed. The leaves crack easily and fall off the matrix.

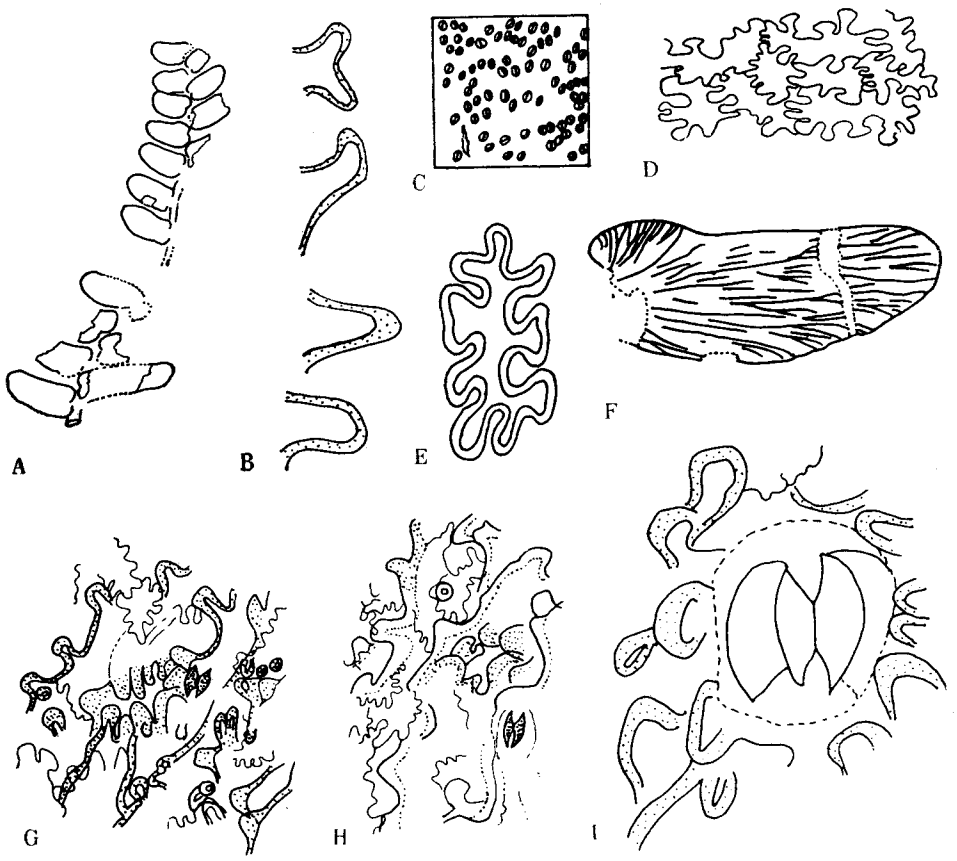
D e s c r i p t i o n. The shape and size of the leaf is unknown but it appears to be a comparatively small *Otozamites* leaf. The maximum width of the leaf is 2·5 cm., the length of the pinnae ranges from 5—20 mm., their width from 3—6 mm. The pinnae arise at an angle of 70° to the rachis; they do not overlap and are separated by a gap about 1 cm. wide.

The pinna base is expanded at its upper end into a distinct auricle; the pinna margins are parallel or slightly tapering towards the apex, the apex being rounded. The pinnae are straight or slightly bent upwards. The veins are conspicuous, and prominent above the upper surface, radiating, some of them bifurcating. Their frequency is about 4 per mm.

The upper cuticle is built of irregularly shaped elongated cells with deeply sinuous walls, tending to form longitudinal rows. Their outlines are thick and distinct. Stomata do not occur. Trichomes are not present except close to margin where scattered cells occur showing circular scars in the middle. These scars may be bases of trichomes shed earlier as the trichomes are not found in the rock on the counterpart. Similar cells occur on the lower cuticle along its marginal part that possesses upper cuticle structure.

The lower cuticle shows radiating bands of stomata, separated by bands formed entirely of epidermal cells that apparently mark the position of

the veins. The bands are not very strictly marked and they consist of 1—3 rows of stomata, placed in a rather irregular way. The stomatal apertures



Text-fig. 6. *Otozamites obtusus*. A, the most complete leaf, No 95, × 1. B, papillae, No 56, × 400. C, distribution of stomata in 1 sq. mm. of cuticle, No 56. D, cells of upper cuticle, slide S 119, × 200. E, single cell of upper cuticle, slide S 119, × 400. F, venation of a large pinna, No 56, × 3. G, lower cuticle from above showing stomatal aperture overhung by papillae and epidermis bearing numerous papillae; guard cells which are on the bottom of a pit are seen to the right of the stomatal aperture, No 56, × 200. H, the same stoma seen from below, × 200. I, single stoma with encircling papillae feebly developed, slide S 120, × 400

Ryc. 6. *Otozamites obtusus*. A, najbardziej kompletny liść, nr 95, × 1. B, papille, nr 56, ×400. C, rozmieszczenie szparek na 1 mm^2 kutykuli, nr 56. D, komórki górnej kutykuli, preparat S 119, × 200. E, pojedyncza komórka górnej kutykuli, preparat S 119, × 400. F, unerwienie dużego odcinka liściowego, nr 56, × 3. G, dolna kutykula widziana z góry, widoczna jama szparkowa otoczona i zasłonięta przez papille, oraz epiderma pokryta wielu papillami; komórki szparkowe znajdujące się na dnie jamy są widoczne na prawo, nr 56, × 200. H, ten sam aparat szparkowy widoczny od dołu, × 200. I, pojedynczy aparat szparkowy otoczony słabo rozwiniętymi papillami, preparat S 120, × 400

are orientated more or less transversely to the veins. There are about 70 stomata per 1 sq. mm.

The epidermal cells of the lower cuticle possess fairly strongly sinuous walls but it is not possible to establish their shape and arrangement because of the numerous papillae. The papillae are up to 20μ high, they arise from a relatively broad base and taper towards the apex. Their apex is rounded, hammer-shaped, or more or less bifurcating. They are hollow inside and possess a heavily cutinised wall about 3μ thick which is of about the same thickness, except for some papillae which have a solid cutinised top. The papillae often grow in rows on cutinised ridges or folds. The stomatal apparatus is sunken below the epidermis surface and lies at the bottom of a deep stomatal pit. The mouth of the pit is hidden under a dome formed by about 10 encircling papillae. The guard cells are usually seen beside and not below the stomatal opening. The lower cuticle is about 3 μ thick (bases of papillae), the upper thicker.

Discussion and comparison. Specimen No 1 differs from the rest in having much shorter pinnae (2—5 mm. long compared with 5—20 mm. in other specimens, comp. Pl. VI, fig. 3). It differs also in its papillae which are small, undivided and less densely distributed than in the other leaves. There are, however, intermediate forms of cuticle on other specimens and a pinna of normal size found on the slab with specimen No 1 had no more than a few papillae with a slightly divided apex; therefore No 1 is included in *O. obtusus.*

Prof. Harris suggested to me that many *Bennettitales* produce a certain number of small leaves, and some at least of these are transitional from *Cycadolepis* to a foliage leaf.

Otozamites obtusus from Grojec is a rather small *Otozamites* leaf with a very characteristic cuticle. In such features of the pinnae as their small size, their broad obtuse apex, and their nearly parallel margin, *O. obtusus* from Grojec is similar to some Lower Liassic forms of *Otozamites.* It is thus similar to the figure of *Otopteris obtusa* Lindley et Hutton 1834, Pl. 128 and to *Otozamites obtusus* figured in Seward 1904, both from the Lower Lias of England, and to *O. hennoquei* from the Lower Lias of France figured by Saporta (1875). It resembles also *O. molinianus* and *O. reglei* from Bornholm, Möller 1903 (age presumably some stage in the Lias), but I believe it is nearest the Lower Liassic specimens of other floras determined as *O. obtusus.*

A description of *O. Bechei* regarded by the author as a synonym of *O. obtusus* is given by Harris (1961). The specimens derive from Ireland, Wales and England and extend from the Rhaetic into the Lower Lias. The cuticle figured in this paper is, however, different from that of the Grojec species, because there the guard cells are only slightly sunken and they are overhung by papillae much smaller than in *O. obtusus* from Grojec. The papillae on the epidermal cells of *O. Bechei*

are large but flat or only slightly protruding, but Harris mentions that this feature is variable and in a number of leaves the papillae protrude more than in others.

Otozamites obtusus from Grojec possesses a cuticle of a very characteristic structure. The stomata are deeply sunken in a pit which is overhung by papillae; also numerous papillae arise from the epidermal cells. The same type of cuticle occurs in leaves of *O. Beani* and *O. graphicus* from the Oolite of Yorkshire, only the papillae of these species are on the whole smaller and less densely distributed. I studied slides with cuticles of these two species in the British Museum and found that there is a range of intergrading cuticle structures, from that figured by Harris 1949, p. 569, fig. A, with low, small papillae, to cuticles with much stronger and denser papillae resembling those of *O. obtusus* from Grojec. In *O. Beani* I even saw bifurcating papillae but they are extremely rare.

However, both *O. graphicus* and *O. Beani* differ from *O. obtusus* in having much larger leaves with pinnae of a different shape and the *Otozamites* from Grojec cannot be assigned to any of them.

Otozamites Raciborskii sp. n.

Pl. VI, figs. 1, 2, 4—6; Text-fig. 7A—K

Type specimen: Instytut Botaniki PAN No 31a, b, slides S 134—136.

Diagnosis. Length of leaf unknown, width about 10 mm., full range of width from 2—12 mm. Rachis under 1 mm. wide, smooth and hairless. Pinnae from 2—5 mm. long and from 1—3 mm. wide, arising at an angle of about 70° to the rachis, separated by narrow gaps. Area of attachment of pinnae and rachis strongly depressed. Bases of the pinnae constricted to $^1/_3$ or $^1/_2$ of the total width; their sides almost parallel, apex obliquely truncate or rounded. Veins arising from the whole basis of the pinna, slightly radiating, very frequent, about 7 per mm., slightly sunken above, slightly prominent below. Cuticle well preserved.

Upper cuticle rather thin, about 10 μ at compressed pinna edge. Lower much thinner. Cells of the upper cuticle square, oblong, or somewhat irregular in outline, tending to form rows parallel to the veins. Cell walls strongly sinuous forming rounded loops almost reaching the middle of the cell. Cell outlines thick and distinct. No papillae nor trichomes present. Veins often recognisable by dark lines probably marking hypodermal fibres.

Lower cuticle showing marginal region 250 μ wide of cells resembling upper cuticle. Marginal region not or only weakly marked off by a fold from stoma-bearing part. Stomata numerous (about 100 per sq. mm.) forming rather ill defined bands between the veins. Stomata in bands

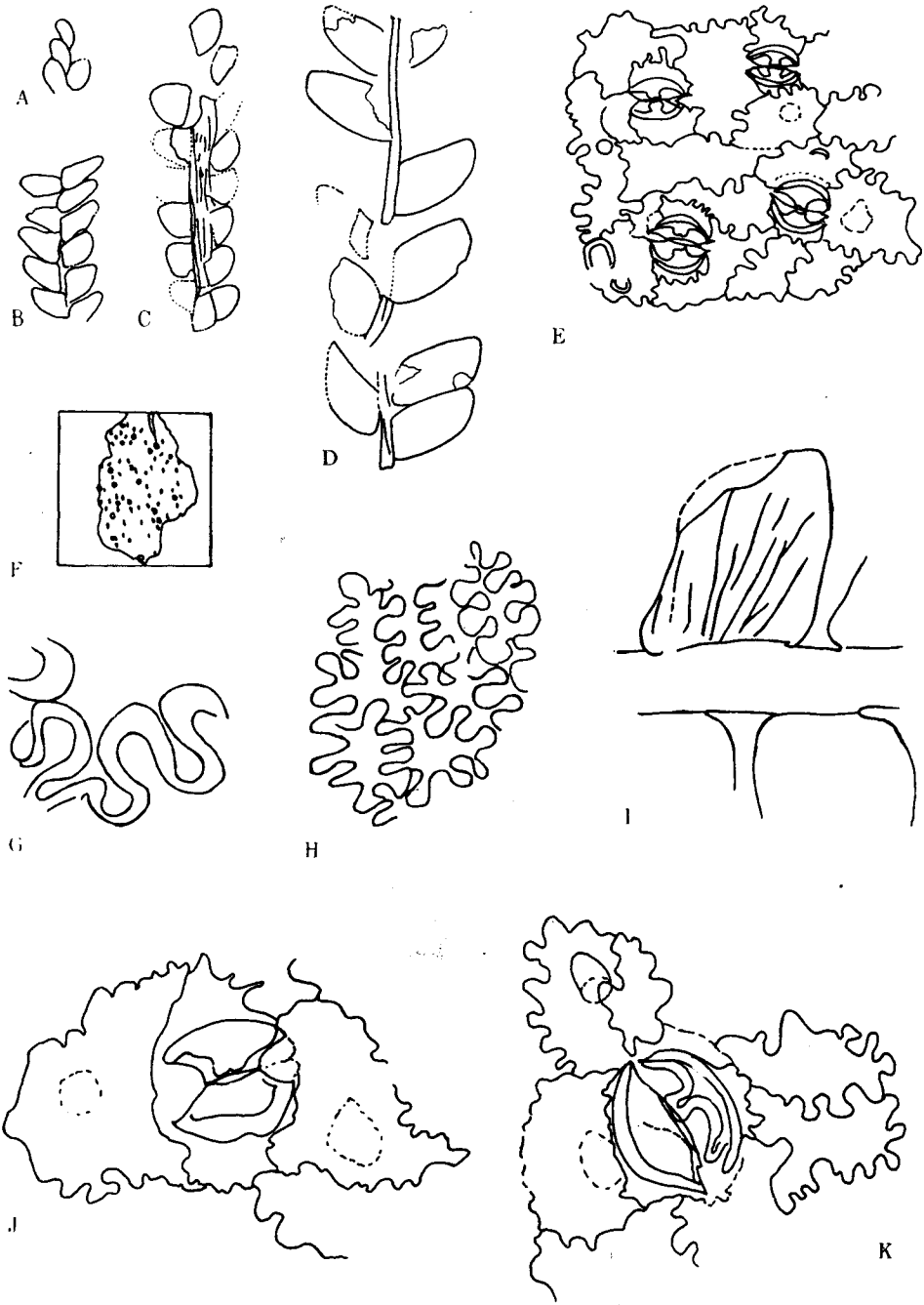
often forming longitudinal rows, but rows short and irregular. Number of rows 2—3. Orientation of stomatal apertures nearly always transverse to the veins. Subsidiary cells narrow, crescentic, their outer walls sinuous. Their inner walls extending into strongly cutinised ridges, each bearing one large papilla with a flattened apex, or apex slightly divided into two lobes. Papillae overhanging the stomatal pit, sometimes papillae of opposite sides meeting over aperture. Guard cells sunken, aperture 25 μ wide, crescent shaped, thickenings well developed. Epidermal cells rectangular between the stomatal bands, irregular in them, their walls thin and strongly sinuous, quite distinct. Some of the cells bearing a hollow papilla in the middle. Occasionally trichomes occur. Trichomes represented by basal cells consisting of single cells of nearly normal size, surface rather thicker than normal, bearing a thickened ring 27μ wide.

Description of material. *Otozamites Raciborskii* is represented by 30 fragments of leaves deriving from their middle part, one top and one fragment near the leaf base. The preservation is excellent but cleavage has occurred in the leaf mesophyll separating the two cuticles, so that in general only the one or the other cuticle is still present. Often the break has occurred near where the stomatal region meets the marginal region and this results in a margin which appears much more sharply marked than it was originally.

Generic position. *O. Raciborskii* is not a typical species of *Otozamites*. In placing it in a genus I have tried to follow Halle (1913). Halle gave as the distinguishing character of *Otozamites* the contraction of both sides of the pinna base, the upper being the more contracted so as to make the base asymmetrical, and the upper basal angle forming an auricle. In *Zamites* the two angles are symmetrically contracted and in *Ptilophyllum* the upper angle alone is contracted, the lower decurrent. In *Anomozamites* neither angle is much contracted. Halle did not use cuticle characters, but relied entirely on gross form; it is clear, however, that all the leaves in question have cuticles of the general Bennettitalean type.

O. Raciborskii has very small pinnae which are basally constricted at both sides; and the constriction is very slightly asymmetric; and this fits *Otozamites*. Although the veins of the upper angle are not seen in fig. 7, other pinnae show that they do radiate slightly, making an angle of about 45° with the rachis and ending near the rachis where an auricle might have been. The radiating venation fits *Otozamites*.

Another reason for placing it in *Otozamites* is that it is very close in form to certain other leaves such as *O. mimetes* Harris which has already been placed in that genus. It clearly would be rather awkwardly placed in either *Ptilophyllum* or *Anomozamites*. I originally thought it might be an *Anomozamites* like *A. marginatus,* but it proved that the *Anomozamites*-like form of the pinna base was merely due to the overlap of the



Text-fig. 7. *Otozamites Raciborskii.* A, top of a leaf, No 2, × 2. B, leaf fragment with small pinnae, No 103, × 2. C, basal part of a leaf, No 25, × 2. D, leaf fragment with especially large pinnae, No 34, × 2. E, lower cuticle, × 200. F, distribution and orientation of stomata (black lines) and trichomes (rings) in a fragment of lower cuticle. The square is 1 sq. mm., slide S 134. G, upper cuticle, detail of sinuation,

rachis, seen from below, and the slight margin was caused by a break in the cuticle.

The cuticle is unusual for an *Otozamites* but is remarkably like *Ptilophyllum pectinoides*, and the stomatal features are almost exactly similar to *P. pectinoides*. In the species of *Otozamites* described by Harris the whole stomatal apparatus is more or less sunken in a pit which may be constricted by several epidermal papillae while in *Ptilophyllum* the only papillae arise on the subsidiary cells.

Specific comparison. *O. Raciborskii* looks very much like *O. mimetes* Harris but the leaf in *O. Raciborskii* is barely 1 cm. instead of 2 cm. wide. It is in fact a remarkably small leaf for an *Otozamites*. It differs from *O. mimetes* in cuticle, for the stomata of *O. Raciborskii* have only two subsidiary papillae, while those of *O. mimetes* have a pit surrounded by a border of 4—6 papillae. No other species described by Harris is so close.

There are very few *Otozamites* species whose cuticle structure is known. None of the Yorkshire *Otozamites* possesses the type of stoma found in *O. Raciborskii*, but it was found by Florin in *O. bornholmiensis* Möller. The figure of the stoma (comp. Florin 1933, p. 20) shows that every subsidiary cell of *O. bornholmiensis* possesses a considerably thickened crescentic ridge and a broad papilla pointing towards the stomatal aperture which is exactly the same type as in *O. Raciborskii*. But judging from figures in Möller's paper the two species differ in the shape of leaves.

Ginkgoales

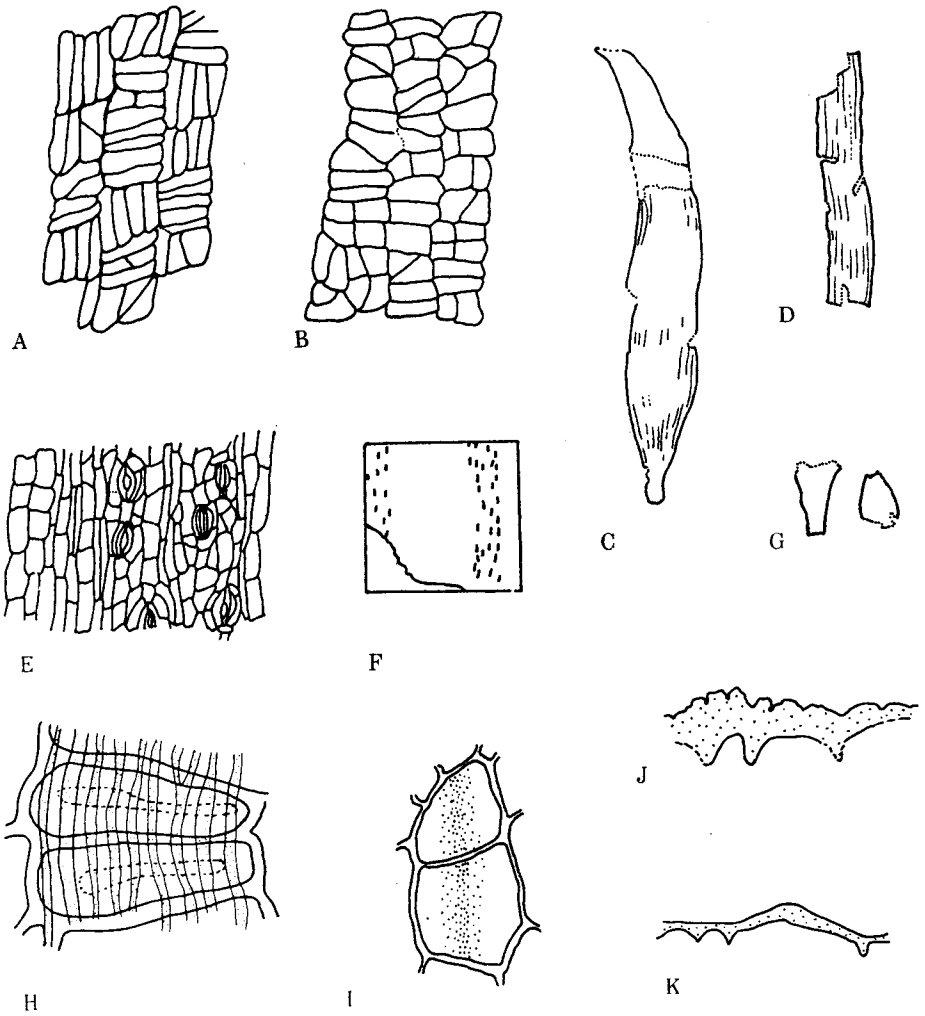
Ginkgo sp.

Pl. VII, fig. 2

There is only one specimen of a *Ginkgo* leaf in the collection and it cannot be assigned to a species because the cuticle is not preserved. Only in a few spots on the leaf can the density of the veins be made out; it is 2—3 per 1 mm.

× 500. H, upper cuticle, × 200. I, shape and venation of a pinna, No 32 a, × 10. J, K, stomata, × 500. (E, G, I—K from slide S 137)

Ryc. 7. *Otozamites Raciborskii*. A, szczyt liścia, nr 2, × 2. B, fragment liścia o małych odcinkach liściowych, nr 103, × 2. C, nasadowa część liścia, nr 25, × 2. D, fragment liścia o wyjątkowo dużych odcinkach liściowych, nr 34, × 2. E, dolna kutykula, × 200. F, rozmieszczenie i orientacja szparek (czarne kreski) i włosów (kółka) w fragmencie dolnej kutykuli. Kwadrat przedstawia 1 mm², preparat S 134. G, górna kutykula, fragment falistego brzegu komórki, × 500. H, górna kutykula, × 200. I, kształt i nerwacja odcinka liściowego, nr 32 a, × 10. J, K, aparaty szparkowe, × 500. (E, G, I—K, z preparatu S 137)



Text-fig. 8. *Pseudotorellia grojecensis.* A, upper cuticle, slide S 80, × 100. B, upper cuticle, slide S 79, × 100. C, leaf showing incomplete apex and a petiole at the leaf base, type specimen, × 1. D, middle part of a leaf showing parallel venation, No 85, × 1. E, lower cuticle, slide S 80, × 100. F, distribution and orientation of stomata in 1 sq. mm., slide S 67. G, leaf base with petiole, to the right incomplete apex, slide S 66, × 1. H, two cells of upper cuticle showing longitudinal striation and thin strips in the middle, slide S 79, × 400. I, two cells of lower cuticle showing a cutinised ridge in the middle, slide S 68, × 400. J. upper cuticle in section, slide S 65, ×400. K, lower cuticle in section, slide S 68, × 400

Ryc. 8. *Pseudotorellia grojecensis.* A, górna kutykula, preparat S 80, × 100. B, górna kutykula, preparat S 79, × 100. C, liść o niekompletnym szczycie posiadający u nasady ogonek liściowy, typ, × 1. D, środkowa część liścia z widoczną równoległą nerwacją, nr 85, × 1. E, dolna kutykula, preparat S 80, × 100. F, rozmieszczenie i orientacja szparek na 1 mm^2, preparat S 67. G, nasada liścia z ogonkiem liściowym, na prawo niekompletny szczyt liścia, preparat S 66, × 1. H, dwie komórki górnej kutykuli z widocznym podłużnym prążkowaniem i cieńszym pasem w środku, pre-

There are about 20 species of *Ginkgo*, ranging from the Jurassic to the Lower Cretaceous, which share this shape of leaf, e. g. such is the leaf of *G. Huttoni* from Yorkshire; also *G. ex gr. Huttoni* described by Vachrameev and Doludenko (1961) from the Lower Cretaceous of the Amurland. Similar forms were described by Heer from Siberia.

Pseudotorellia grojecensis sp. n.

Pl. VII, figs. 1, 3—5; Pl. VIII, figs. 2, 5; Text-fig. 8A—K; 9A—F.

Type specimen: Instytut Botaniki PAN, No 49b, slide S 79.

Diagnosis. Leaves with parallel margins in their middle part, tapering gradually towards the apex and more rapidly towards the base, up to 6 cm. long, 2—13 mm. wide, showing a recurved margin about 0·5 mm. wide in the middle region of the leaf but margin not developed near the base and apex. Leaf base ending with a wrinkled petiole about 1 mm. long and nearly 2 mm. wide.

Veins parallel, about 12 per cm., converging at the apex. Slender dark strands visible between pairs of veins. Trichomes absent on both sides. Cells along margins of leaf unspecialised.

Upper cuticle 10—16 μ thick, without stomata. Veins very obscurely marked. Upper cuticle consisting of elongated oblong cells arranged in a characteristic pattern due to packets of cells of the same length placed along or transversely to the leaf axis. Anticlinal walls clearly marked, straight, uninterrupted. Periclinal walls sometimes uniform and unsculptured, or showing fine longitudinal striations crossing from cell to cell. In some specimens periclinal walls with a thin strip in the middle. Occasionally cells visible beneath the upper epidermis, such cells being possibly of mesophyll nature.

Thickness of lower cuticle typically about 6 μ. Lower cuticle consists of alternate strips of epidermal cells with no stomata (presumably along the veins) and stomatal strips. Width of stomatal strip typically 270 μ, width of vein strip typically 570 μ. Epidermal cells of vein strip usually oblong, elongated, parallel with leaf axis. In some leaves they bear prominent cutinised ridges along their middle, in some leaves no such sculpture is present. Thin strips not observed. Epidermal cells of the stomatal strip on the whole narrower and shorter than those of the vein strip, in other features agreeing with them. Stomata scattered irregularly in the stomatal bands or in files, files short and stomata in a file separated by

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parat S 79, × 400. I, dwie komórki dolnej kutykuli z widocznym silniej skutynizowanym pasem biegnącym przez środek, preparat S 68, × 400. J, górna kutykula w przekroju, preparat S 65, × 400. K, dolna kutykula w przekroju, preparat S 68, × 400

a constant number of cells. Guard cells only slightly sunken, walls strongly cutinised along the aperture and also along the walls bordering the subsidiary cells. Subsidiary cells often consisting of two large lateral and two small terminal ones or lateral ones divided; lateral cells most commonly narrow, terminal ones usually small and short. Surface of lateral subsidiary cell thickened along its border with the guard cell and with a thin strip outside this thick strip. Lateral subsidiary cells often with a small and narrow encircling cell.

Cuticle of guard cells often forming a delicate diaphragm outside the aperture, diaphragm pierced by a large round or irregular hole; diaphragm often feebly developed and sometimes absent.

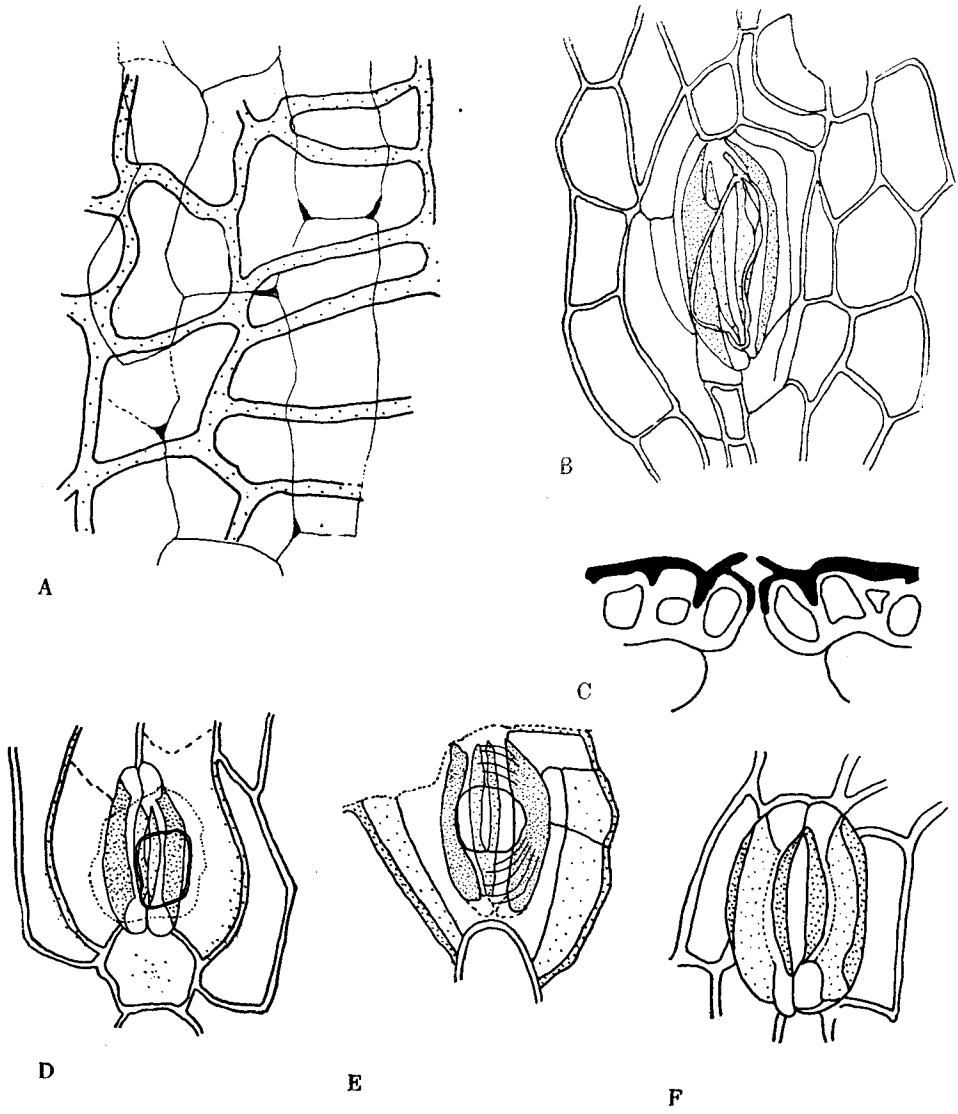
Description. *Pseudotorellia grojecensis* and *Otozamites Raciborskii* are the most frequent fossils in the 1956 collection from Grojec. There are 16 specimens identified by the aid of cuticle structure, one of them possibly a bunch of leaves on the top of a shoot (but if so, the base is missing), and the rest are separate leaves. Most of the remaining 16 specimens belong probably to the same species. The specimens are usually fragments of the medium part of the leaf, but one is preserved in its full length with only the very apex lacking.

The leaves on the rock tend to split in the mesophyll region, so that usually only one cuticle is present in those specimens. There are also a number of leaves macerated from the clay that have both cuticles preserved; among them are four basal and two apical parts of leaves. This material shows bands due to granular matter which is difficult to remove by maceration. This granular matter may represent the altered veins and in one such specimen slender continuous dark strands were seen between the thick granular ones. It was seen that stomata lie beneath the slender strands.

The most complete leaf is 6 cm. long and 8 mm. wide, this being the average width of the leaves; extremes are 2 and 13 mm.

As mentioned in the diagnosis, slender dark strands along the stomatal bands are occasionally to be seen in the lightly macerated leaf, and in fully macerated cuticles dark strands are occasionally seen also in this position. I imagine these are the same as one another and may be the same as what Harris called „interstitial ducts" though they could be slender bands of fibres and not ducts at all. Unfortunately no specimen shows the veins clearly enough at the apex for us to say whether they converge to one point or end separately. Similarly we do not know how the veins behave at the base.

Discussion and comparison. *Pseudotorellia grojecensis* agrees with *P. (Torellia) ephela* described by Harris (1935, 1937; compare also Orlovskaya 1962) which was the first member of the genus whose cuticle was described, in such essential features as the shape of the leaf, the cuticle consisting of elongated oblong cells, the presence of



Text-fig. 9. *Pseudotorellia grojecensis*. A, upper cuticle, epidermal cells, and beneath cells probably of hypodermal nature, slide S 79, × 400. B, D, stomata seen from above, slide S 80, × 400. C, stoma in section (restoration). E, stoma protected by a somewhat wrinkled diaphragm, slide S 68, × 400. F, stoma from below showing thickenings of the guard cell wall, × 400

Ryc. 9. *Pseudotorellia grojecensis*. A, górna kutykula, komórki epidermy, a poniżej komórki prawdopodobnie o charakterze hypodermalnym, preparat S 79, × 400. B, D, aparaty szparkowe widziane od góry, preparat S 80, × 400. C, aparat szparkowy w przekroju (rekonstrukcja). E, aparat szparkowy zasłonięty przez nieco zmarszczoną diafragmę, preparat S 68, × 400. F, aparat szparkowy od dołu z widocznymi zgrubieniami na ścianach komórek szparkowych, × 400

stomata only on the lower epidermis, their structure and irregular arrangement, and also in the presence of interstitial ducts and of cutinised ridges on the epidermal walls. Also the venation is similar, although in *P. grojecensis* the venation is not clear enough to show one of Harris's generic features, that is the forking of marginal veins.

The plant shows also the stomatal structure stressed by Florin (1936) in his definition of the genus *Pseudotorellia*. The guard cells have strongly cutinised inner and outer lateral walls and the cuticle of their periclinal walls forms a rim or diaphragm constricting the stomatal pit. The guard cells are surrounded by 4—6 subsidiary cells.

Following the key by Florin (1936 II, p. 44) the plant from Grojec is easily determined as *Pseudotorellia* and it is well differentiated from the remaining genera of *Ginkgophyta*. It is distinguished from *Ginkgo, Ginkgoites, Ginkgodium, Baiera, Sphenobaiera, Czekanowskia, Hartzia,* and *Arctobaiera* by its linear shape and undivided apex; it differs from *Culgoweria, Windwardia* and *Eretmophyllum whitbiense* by having stomata only on its lower epidermis; and from *Stephenophyllum,* the remaining *Eretmophyllum* species and from *Torellia* by having all stomatal apertures orientated longitudinally. It differs also from *Phoenicopsis speciosa* as described by Vachrameev and Doludenko (1961) where at least one part of the leaves shows stomata both on the upper and lower epidermis.

In having a fairly broad leaf of lanceolate shape *P. grojecensis* agrees with such species as *P. ephela* and *P. ensiformis* (Heer) Vachr. et Dol. (1961) and it is different from the species with narrow linear leaves, such as *P. angustifolia* Dol. (1961). *P. grojecensis* differs from all hitherto described species of this genus in having the cells of the upper epidermis arranged in a peculiar pattern formed by subdivision of the original cells. Its cuticle is thicker than in *P. ephela*. It is different from all but *P. Nordenskjöldi* in the cuticular diaphragm outside the stomatal apparatus (Pl. VII, figs. 4, 5). In some other species of this genus, such as *P. ephela, P. minuta* and *P. ensiformis* there are papillae around the stomatal aperture.

Cuticular extensions of the stomatal cells restricting the stomatal aperture occur in different gymnospermous groups. In *Ptilozamites Nilssoni Nath.* (Harris 1926, p. 69; 1932 b, p. 71) the stomatal pit is encircled by papillae of the subsidiary cells and the mouth of the pit overhung by a thin cutinised lamella with a pore in the middle. This lamella is an extension of the subsidiary cells. This structure is present also in *Ptilozamites Heeri* Nath. and is figured by Florin (1933), Pl. 11, fig. 3 and in text-fig. 16, p. 45. In *Ctenis* the subsidiary cells form a raised cutinised ring around the stoma (Florin 1933, p. 59). Cutinised ridges restricting the stomatal pit are also present on the guard cells of *Stangeria paradoxa* (Harris 1932 b, p. 81).

Taxales

Marskea laticosta sp. n.

Pl. VIII, figs. 1, 3, 4; Text-fig. 10A—G.

Type specimen. Instytut Botaniki PAN No 125, slides S 12, S 13.

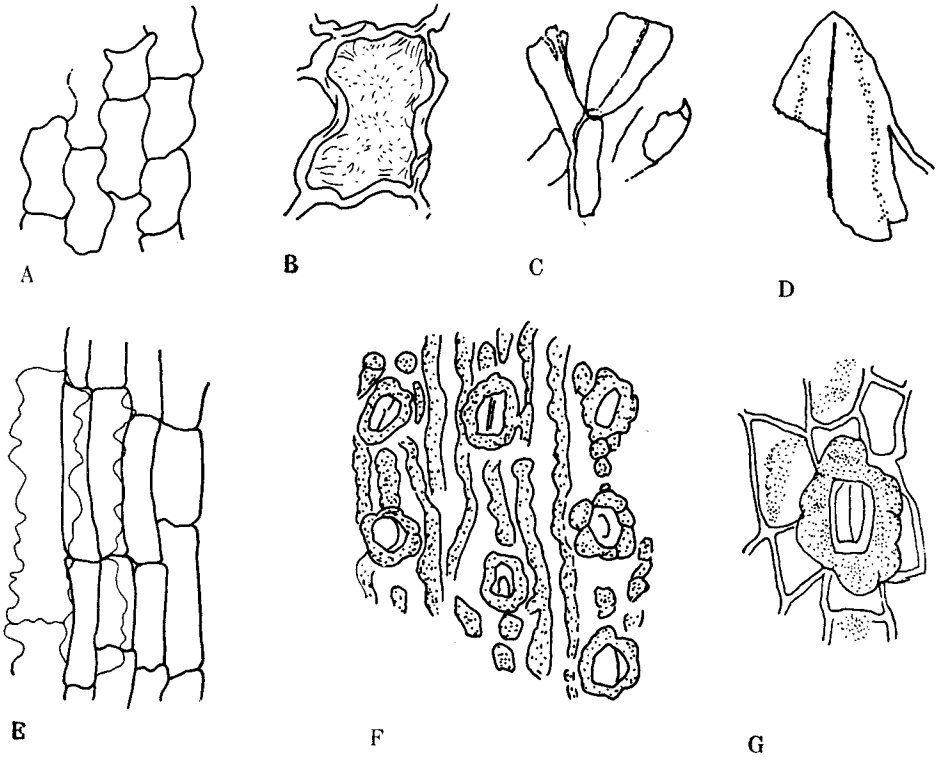
Diagnosis. Leaves linear lanceolate, single veined, arising at an angle of 30—40° to the shoot, basal cushion decurrent; leaf typically 3 mm. wide, their full length unknown, probably about 15 mm. Leaf base rather abruptly narrowed but without a distinct petiole, apex with an acute tip, leaf margin entire, microscopically uneven. Trichomes absent. Cuticle appears about 3 μ in folds.

Upper epidermis without stomata. Cells arranged in longitudinal rows, cells over the midrib oblong, sometimes square and with regularly sinuous walls; towards the margin irregular and deeply sinuous. Their periclinal walls showing faint median ridges or irregular thickenings, occasionally mottled.

Lower epidermis bearing two distinct, not depressed stomatal bands. Cells of the non stomatal bands oblong, usually narrow and elongated, their anticlinal walls straight in the median band and slightly sinuous in the marginal bands. Periclinal walls bearing a broad cutinised median ridge. Ridges continuous or consisting of concrescent papillae, especially strongly developed above the vein. Middle non stomatal band much wider than the lateral ones.

Stomata monocyclic or partially amphicyclic, arranged irregularly or forming short rows. Guard cells sunken, orientated longitudinally, surrounded by 5—7 subsidiary cells. Exceptionally two stomata sharing a subsidiary cell. Each subsidiary cell bearing a well developed papilla; papillae more or less connected and forming a ring enclosing the oval or oblong opening of the stomatal pit. Terminal encircling cells absent. Ordinary epidermal cells of the stomatal band shorter than those in non stomatal bands and bearing strong papillae, single or concrescent to form broad ridges.

Description and comparison. The material of *Marskea laticosta* consists of one specimen showing a short part of a shoot bearing fragments of leaves and three more specimens with separate leaves. In addition to this a few fragments were found in maceration. All the *Marskea* fragments from Grojec are similar in aspect as they are all brown and of leathery consistence. The internal substance has almost disappeared so that the two cuticles are in contact and they proved to adhere so strongly that it was rarely possible to separate them at all. However, they were



Text-fig. 10. *Marskea laticosta*. A, upper cuticle, slide S 11, × 200. B, cell of upper cuticle, slide S 11, × 400. C, type specimen consisting of a shoot and fragments of leaves, No 125, × 3. D, leaf apex showing distribution of stomata, slide S 7, × 10. E, cells of upper cuticle with short waves seen beneath the cells of the lower cuticle with straight walls, slide S 12, × 200. F, lower cuticle showing part of a stomatal band, slide S 12, × 200. G, stoma, slide S 12, × 400

Ryc. 10. *Marskea laticosta*. A, górna kutykula, preparat S 11, × 200. B, komórka górnej kutykuli, preparat S 11, × 400. C, typ, okaz złożony z kawałka pędu i fragmentów liści, nr 125, × 3. D, szczyt liścia ukazujący rozmieszczenie szparek, preparat S 7, × 10. E, komórki górnej kutykuli o słabo falistych ścianach są widoczne pod komórkami dolnej kutykuli o prostych ścianach, preparat S 12, × 200. F, dolna kutykula z fragmentem pasa szparkowego, preparat S 12, × 200. G, aparat szparkowy, preparat S 12, × 400

separated in a few minute areas. This made the observation of all details of the cells difficult, particularly the sculpture of the periclinal cell walls.

However, it was possible to establish, using the phase contrast microscope, that the upper epidermal cells of *M. laticosta* bear a faint median ridge or, when of irregular shape, they have irregularly placed thickenings; there were also observed cells with a mottled surface; median ridges and mottled surface are also found in *M. thomasiana*.

Florin (1958) established the genera *Bartholinodendron, Marskea* and *Tomharrisia* to include plants with leaves agreeing in structure with

Taxus which differ, however, from that genus in having undulating cell walls. The species from Grojec belongs to the same group and it is very similar to *Marskea thomasiana* from Yorkshire.

The genus *Marskea* differs from *Bartholinodendron* in stomatal structure and from *Tomharrisia* in having narrower leaves with an even, non-serrate margin.

We do not know if the leaves of the plant from Grojec were more or less opposite as in *M. thomasiana* but I believe that it can be placed in the genus *Marskea* as it is very similar to *M. thomasiana* in other features. It differs, however, from *M. thomasiana* in having broader leaves (typically 3 mm. compared with 2—2·5 mm. of *M. thomasiana).* Also the median non stomatal strip in *M. laticosta* is twice as wide as a lateral one, while the opposite is the case in *M. thomasiana.* The two species show a difference in shape between the oblong or square epidermal cells of the median leaf-zone and the more irregular cells of the marginal zone. There is a difference in the two species between the cells of the median zone of the upper side. In *M. thomasiana* these show a few rather long waves but in *M. laticosta* they show more numerous and shorter waves. There is also a difference in the shape of the cells near the leaf margin in the lower epidermis. In *M. thomasiana* they are irregular and deeply sinuous, just like the corresponding cells of the upper cuticle, while in *M. laticosta* their walls are only slightly sinuous. I believe that these differences are a sufficient reason for separating the two species.

Marskea laticosta is very close in its cuticular structure to *Elatocladus tuberculatus* (Harris 1935) from the *Thaumatopteris* zone of East Greenland which also has leaves of similar width — about 3 mm. *M. laticosta* differs from *E. tuberculatus* in having only slightly sinuous cell walls in the lower epidermis while in *E. tuberculatus* they are as sinuous as that of the upper one. *E. tuberculatus* appears to be a species of *Marskea.*

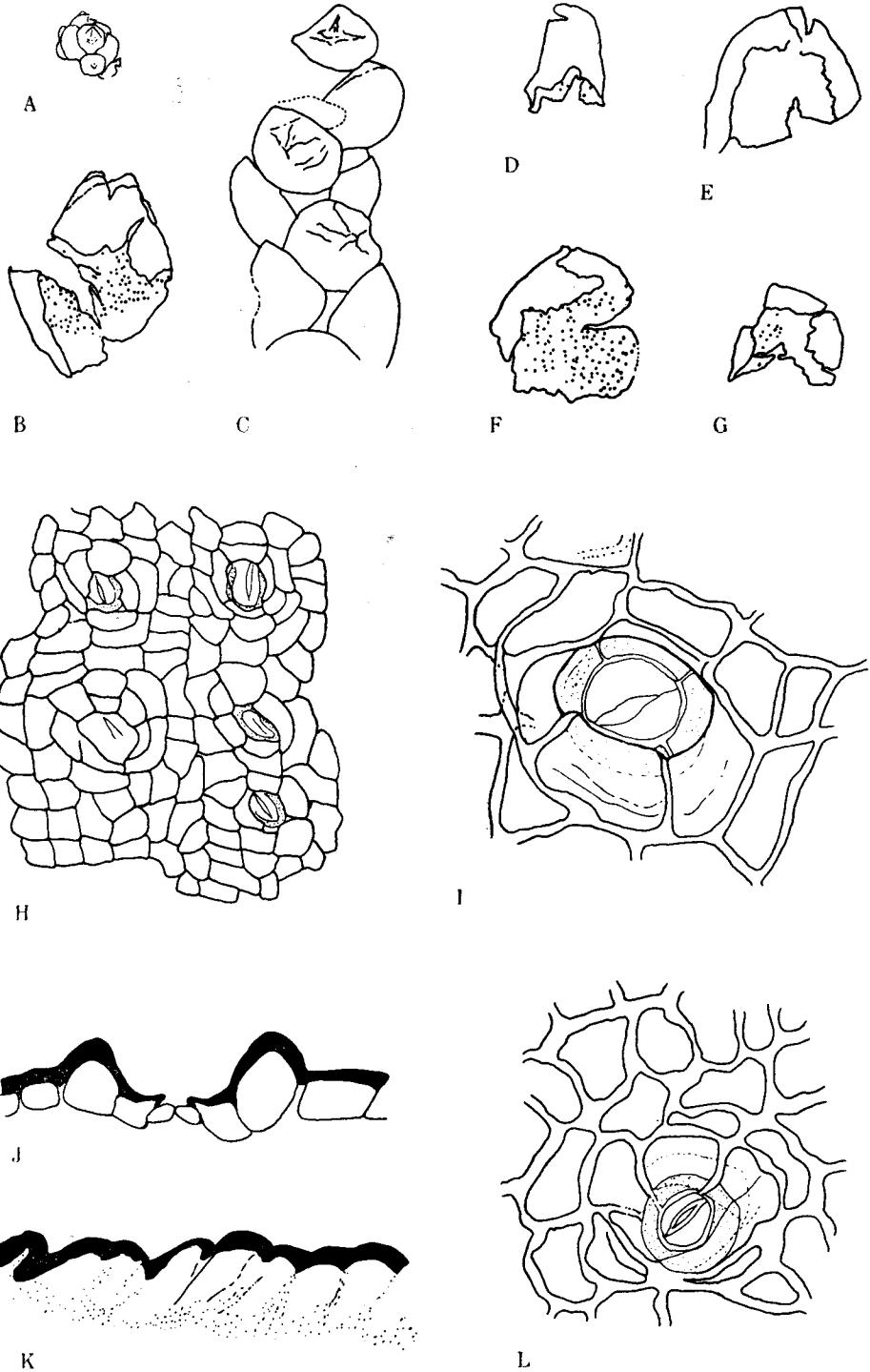
Coniferales

Brachyphyllum cyclophorum sp. n.

Pl. IX, figs. 1—5; Text-fig. 11A—L.

Type specimen: Instytut Botaniki PAN, slide S 14.

Diagnosis: The material consists of fragments of shoots showing spiral arrangement of leaves and also of isolated leaves. A typical leaf is a round or ovate scale, its length about equal or exceeding its width. The length of the leaves ranges from (1) 2—4·5 mm., their width from 1—2 mm. The leaf margins converge at an angle of 50—100°, to form a rounded, obtuse, or bluntly pointed apex. Near the apex the margin is specialised showing a serrate edge consisting of one layer of cutinised cells. In laterally compressed leaves the apex appears pointed and falcate.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Outer side of leaf convex, inner concave, adaxial cuticle much shorter than the abaxial one. Stomata present on both sides of the leaf, absent at the apex; stomata arranged in irregular files or scattered.

Guard cells and subsidiary cells considerably sunken. Guard cells about 25 μ long; subsidiary cells 4—6 in number, their inner side forming a thick raised ring around the guard cells. Both guard cells and subsidiary cells only slightly cutinised, differing in their whitish colour from the brown encircling and ordinary epidermal cells. The cutinised ring is yellow and usually shows a radiating stration. Margin of stomatal pit formed by 4—6 encircling cells, usually forming a prominent rim which never overhangs the pit.

Epidermal cells between files oblong or square, arranged in longitudinal rows. Epidermal cells in stomatal file showing less regular shape and arrangement. Anticlinal cell walls 5 μ thick, strongly cutinised, not interrupted by pits, occasionally showing protuberances. Periclinal walls each with a bulging area in its middle.

Description and discussion. *Brachyphyllum cyclophorum* is represented by one short apex and also numerous separate leaves found in macerations of the material collected in 1956. They are black and not much compressed, and their cuticle is very well preserved. In the material from Grojec collected by Raciborski are present many fragments of shoots; they are brown, compressed, and their cuticle is thin and fragile, but good enough to show structure.

Brachyphyllum cyclophorum does rather resemble *Brachyphyllum mamillare (Araucariaceae)* from Yorkshire, but the finer details of the stomata differ; in particular there is a thick ring of cutin immediately around the guard cells of *B. cyclophorum* that is only feebly developed or absent in *B. mamillare*. *B. mamillare* also has at least moderately developed longitudinal rows of stomata.

It is rather more similar to *B. crucis* (a plant of uncertain affinity from the Callovian and Bajocian of England (Kendall 1947, 1952). The leaves agree in the frill around the apical margin and the cuticles look alike in their scattered stomata. They can, however, be distinguished as *B. cyclo-*

Text-fig. 11. *Brachyphyllum cyclophorum*. A, apex of a small shoot, coll. 1956, × 5. B, D—G, leaf cuticles showing the shape of leaves and the arrangement of stomata (dots), × 10. C, fragment of a large shoot, No R 2, × 5. H, cuticle showing four stomata, slide S 14, × 200. I, L, stomata, slide S 14, × 400. J, restoration of a stoma in transverse section. K, specialised leaf margin, × 400

Ryc. 11. *Brachyphyllum cyclophorum*. A, szczyt małej gałązki z kolekcji 1956, × 5. B, D—G, kutykule liści ukazujące kształt liści i rozmieszczenie szparek (kropki), × 10. C, fragment dużego pędu, nr R 2, × 5. H, fragment kutykuli z czterema szparkami, preparat S 14, × 200. I, L, aparaty szparkowe, preparat S 14, × 400. J, odtworzenie aparatu szparkowego w przekroju poprzecznym. K, ząbkowany brzeg liścia, × 400

phorum has no papillae on the subsidiary cells such as are seen in *B. crucis*. In *B. cyclophorum* the whole of the subsidiary cells are distinctly sunken below the epidermal level while in *B. crucis* Kendall considers them to be superficial. In some of her preparations which I examined I would confirm this. In *B. cyclophorum* the encircling cells form nearly always a distinct and raised margin round the stomatal pit, while in *B. crucis* they are only sometimes slightly raised above the general level. The two species are also similar in having stomata scattered over the leaf surface, though in *B. cyclophorum* they occasionally form ill defined files.

Another plant very similar to *B. cyclophorum* is *Cheirolepis Muensteri* (Hoerhammer 1933, Harris 1957, Lewarne and Pallot 1957). *C. Muensteri* shows, as I was able to see in the material from the Liasso-Rhaetic of Wales, the same type of stomatal structure. Here too the subsidiary cells bear a cutinised ring running around the guard cells which is very similar to that in *B. crucis* and *B. cyclophorum*. Although previous accounts do not mention it, the encircling cells form a prominent rim at the edge of the stomatal pit, just as in *B. cyclophorum*.

The two plants differ in epidermal structure and perhaps also in leaf form. In *C. Muensteri* the more elongated leaves have stomata in stronger marked files. In the shorter leaves they are mostly in distinct files, but in a few leaves some or most of the stomata are scattered. In *B. cyclophorum*, of about 20 leaves examined not one has strongly marked files and in very few is there any suggestion of a file. However, the fact that in Grojec were found only leaves agreeing in size and shape with the rounded *C. Muensteri* leaves, but never with the longer lanceolate ones, speaks against the identity of those two species.

Prof. Harris suggested to me that the characteristic and similar structure of the stomata of *B. crucis*, *Cheirolepis Muensteri* and *B. cyclophorum* indicate that they are closely related.

AGE OF THE DESCRIBED FLORA

The plant bearing clays in the region of Grojec near Cracow lie on rocks belonging to several stages of the Carboniferous and Triassic and they are usually covered by Middle Jurassic strata. Since they are lacking in animals fossils their age can be determined only by studying the plant remains which are present in many places.

Raciborski made his collections in 11 localities, the collection of 1956 deriving only from the pit Stella in Grojec. Although none of these plant beds have been correlated, they are presumably of a similar age because, according to Raciborski and others (comp. Znosko 1955), the Grojec clays were deposited during a shot period of time.

Raciborski's first conclusion was that the Grojec flora was of Rhaetic age (1889). However, in his monograph of the flora published in 1894 he expressed the opinion that it was younger than the Lower Liassic stratum with *Ammonites angulatus* and only a little older than the Yorkshire Oolite flora from Scarborough.

Recently Znosko (1955) studied the megaspores of similar clays in the region of the Holy Cross Mts. in Central Poland and came to the conclusion that their age was Basal Liassic and corresponding to the zone with *Equisetites gracilis* of Troedsson and Harris. Znosko thought at the time that the clays from Grojec were most probably of the same age.

The few species described in the present paper give information about the age of the flora, when compared with the well known floras of the Basal Lias (*Thaumatopteris* zone) and of the Yorkshire Oolite (Bajocian, Bathonian).

Phlebopteris angustiloba and *Phlebopteris Muensteri* are widespread in the *Thaumatopteris* zone in Europe and Greenland and *Pterophyllum subaequale* is also known from the same zone. None of these species is represented in the Oolite, but it is not known how far they reach into the Lias.

Otozamites obtusus begins in the *Thaumatopteris* zone or perhaps even in the Rhaetic and it goes on through the *angulatus* zone.

Brachyphyllum cyclophorum is similar to both Lower Liassic and Oolithic species; shoots of this type are rare in the Rhaetic and very numerous in the Oolite.

The genus *Pachypteris* occurs in the Oolite and evidently earlier but it is not represented in the *Thaumatopteris* zone.

The genus *Marskea* had been found in the Oolite.

It appears therefore that the plants described here, collected in 1956 in Grojec, divide into two groups, one consisting of species found in the *Thaumatopteris* zone, the other of species suggesting the Oolite. The age of the Grojec flora can therefore be attributed to the middle region of Lias.

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STRESZCZENIE

JURAJSKA FLORA Z GROJCA KOŁO KRAKOWA. CZĘŚĆ I

Wstęp

Około roku 1890 M. Raciborski zebrał bogatą kolekcję roślin z dolnojurajskich glinek ogniotrwałych w miejscowościach Grojec, Poręba i Mirów, położonych na zachód od Krakowa. Glinki były w tym czasie eksploatowane, dzięki czemu bogaty materiał roślin kopalnych był dostępny zarówno w licznych szybach, jak i na hałdach. Raciborski opublikował w 1889 dwie listy roślin, a w 1894 ukazało się drukiem monograficzne opracowanie zawierające opisy 63 gatunków roślin należących do 14 rodzin i 26 rodzajów. Niestety Raciborski ukończył tylko opis *Cryptogamae*, do których zaliczył także rodzaje *Thinnfeldia* i *Ctenis*.

W 1956 roku z inicjatywy prof. W. Szafera i przy pomocy mgra M. Mazarakiego z Chrzanowa została zebrana w Grojcu nowa kolekcja roślin na terenie nieczynnej już w tym czasie kopalni „Stella". Wykonanie szybiku badawczego i zebranie materiału umożliwiła dotacja Polskiej Akademii Nauk.

Kolekcja z 1956 roku składa się z uwęglonych szczątków roślin, które po maceracji w stężonym kwasie azotowym, a następnie przemyciu wodą i potraktowaniu słabym roztworem amoniaku dają pięknie zachowane kutykule. W podobny sposób są zachowane rośliny w nie opracowanej dotąd kolekcji zebranej przez Raciborskiego, której etykiety są znaczone jego ręką „Grojec Wschód". Z tej kolekcji także korzystałam. Natomiast ogromna większość zbiorów Raciborskiego składa się z odcisków pozbawionych substancji roślinnej, ale ukazujących mimo to nerwację i inne drobne szczegóły budowy. Kolekcja z 1956 roku i preparaty anatomiczne wykonane w trakcie jej opracowania znajdują się w Instytucie Botaniki PAN w Krakowie, natomiast wymienione tu kolekcje Raciborskiego są przechowywane w Muzeum Geologicznym PAN w Krakowie.

Pracę niniejszą wykonałam w Botany Department Uniwersytetu w Reading w Anglii, w pracowni prof. T. M. Harrisa, któremu pragnę wyrazić swą wdzięczność za rady i pomoc przy pisaniu pracy. Pragnę także wyrazić podziękowanie dla działu Paleontologii British Museum (Natural History) w Londynie za udostępnienie mi zbiorów okazów i preparatów roślin jurajskich, a również dla Muzeum Geologicznego PAN w Krakowie za wypożyczenie okazów ze zbiorów Raciborskiego. Dziękuję Mr. L. C. Willisowi z Reading oraz mgrowi S. Łuczce z Krakowa za wykonanie fotografii. Wreszcie pragnę wyrazić wdzięczność dla tych wielu osób, które brały udział w zbieraniu i przygotowywaniu kolekcji z Grojca w 1956 r.

Praca niniejsza została wykonana dzięki stypendium Polskiej Akademii Nauk, które pozwoliło mi spędzić kilka miesięcy w pracowni paleobotanicznej w Reading.

Lista roślin

W pracy tej podaję opisy 2 gatunków paproci i 9 gatunków roślin nagonasiennych, w tym 5 gatunków nowych.

Pteridophyta — Filicales
Leptosporangiatae
Matoniaceae

1. *Phlebopteris angustiloba* (Presl) Hirmer et Hoerhammer
2. *Phlebopteris Muensteri* (Schenk) Hirmer et Hoerhammer

Rośliny nasienne

Cycadales

3. *Nilssonia cracoviensis sp. n.*

Pteridospermae

4. *Pachypteris major* (Raciborski) *sp. n.*

Bennettitales

5. *Pterophyllum subaequale* Hartz
6. *Otozamites obtusus* Lindley et Hutton
7. *Otozamites Raciborskii sp. n.*

Ginkgoales

8. *Ginkgo sp.*
9. *Pseudotorellia grojecensis sp. n.*

Taxales

10. *Marskea laticosta sp. n.*

Coniferales

11. *Brachyphyllum cyclophorum sp. n.*

Wiek flory

Glinki z okolicy Grojca na zachód od Krakowa, zawierające szczątki roślinne, zalegają na skałach pochodzących z różnych okresów karbonu i triasu, a przykryte są najczęściej utworami środkowej jury. Glinki te nie zawierają skamielin zwierzęcych i stąd ich wiek może być określony jedynie na podstawie szczątków roślinnych, które występują w nich w wielu miejscach.

Opisywana tu kolekcja pochodzi wprawdzie tylko z jednego miejsca, z kopalni „Stella" w Grojcu, ale bogate zbiory Raciborskiego po-

chodzą aż z 11 stanowisk. Nie jest wiadome, jaki jest wzajemny stosunek warstw ze szczątkami roślinnymi, które występują w glinkach grojeckich, można jednak przypuścić z dużym prawdopodobieństwem, że są one jednego wieku, ponieważ Raciborski, a także inni autorzy (por. Znosko 1955) uważają, iż glinki te osadziły się w przeciągu krótkiego okresu czasu.

Raciborski uważał początkowo (1889), że glinki grojeckie są osadem górnoretyckim. Później jednak w monografii flory z Grojca z 1894 roku wypowiedział pogląd, że flora ta jest młodsza niż dolnoliasowy poziom z *Ammonites angulatus,* a nieco starsza od flory angielskiego oolitu ze Scarborough (Yorkshire).

Znosko (1955), który opracował stratygrafię retyku i liasu między Krakowem a Wieluniem, uważa, że glinki podobne do grojeckich występujące w rejonie świętokrzyskim pochodzą z najniższego liasu, a wiek tych glinek, zdaniem Znoski, odpowiada poziomowi z *Equisetites gracilis* według podziału Troedssona i Harrisa. Znosko sądzi, że wiek glinek grojeckich jest najprawdopodobniej taki sam i zalicza zarówno glinki grojeckie, jak i glinki z rejonu świętokrzyskiego do warstw helenowskich dolnych.

Lista roślin opisanych w niniejszej pracy jest krótka, ale porównanie jej z bogatymi i dobrze poznanymi florami dolnoliasowymi poziomu z *Thaumatopteris Schenki* oraz z florą angielskiego oolitu z Yorkshire (bajos, baton) pozwala wysnuć wnioski co do wieku flory z Grojca.

Z opisanych tu gatunków *Phlebopteris angustiloba* i *P. Muensteri* są szeroko rozpowszechnione we florach poziomu z *Thaumatopteris* na obszarze Europy oraz w Grenlandii, a *Pterophyllum subaequale* występuje także w tym samym poziomie. Żaden z tych gatunków nie jest znany z oolitu, ale nie wiadomo na razie, jak wysoko sięgają one w obrębie liasu.

Otozamites obtusus zaczyna się pojawiać w poziomie z *Thaumatopteris,* a być może nawet w retyku i sięga poza poziom *angulatus.*

Brachyphyllum cyclophorum jest podobne zarówno do gatunków dolnoliasowych, jak i oolitowych. Szczątki tego typu są bardzo rzadkie w retyku, lecz częste w oolicie.

Rodzaj *Pachypteris* występuje w oolicie, natomiast nie jest on znany z poziomu z *Thaumatopteris.*

Jedyny poprzednio opisany gatunek *Marskea* był znaleziony w oolicie.

Jak wynika z powyższego przeglądu gatunków, można je podzielić na dwie grupy. Jedna z nich to gatunki występujące w innych florach w poziomie z *Thaumatopteris* z dolnego liasu, w skład drugiej zaś wchodzą gatunki wskazujące już na oolit. Sądzę wobec tego, że już w obecnym stadium opracowania flory z Grojca można wysnuć wniosek, że należy ona do środkowej strefy liasu.

EXPLANATION OF PLATES
OBJAŚNIENIA DO TABLIC

All the photographs are unretouched

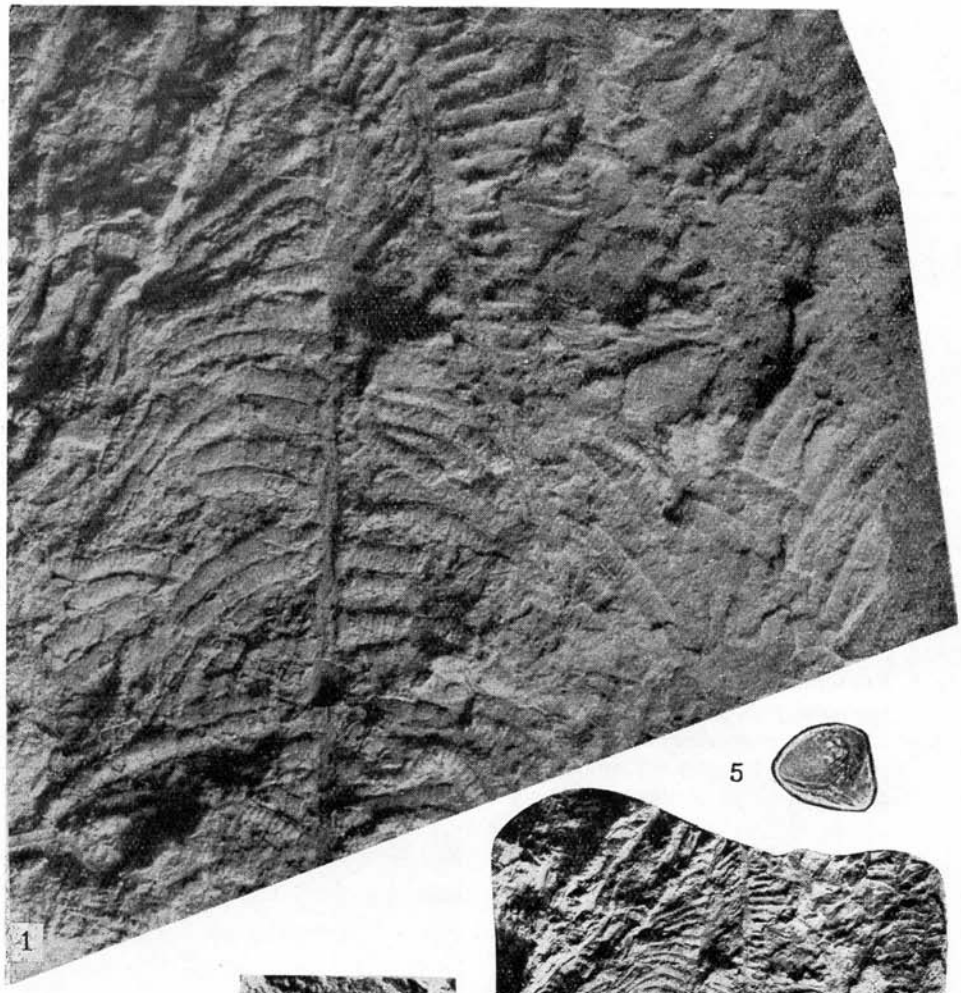
Wszystkie ryciny są nieretuszowanymi fotografiami

Plate I

Fig. 1. *Phlebopteris angustiloba,* central part of specimen No 101, showing the fertile pinnule, × 3.
Fig. 2. *Pachypteris major,* large pinna segment, × 2, No 102.
Fig. 3. *Pachypteris major,* cast on the clay of a large pinna segment, showing venation, × 2, No 128.
Fig. 4. *Phlebopteris angustiloba,* the specimen, × 1, No 101.
Fig. 5. *Phlebopteris angustiloba,* immature spore, × 400, slide S 47.

Tablica I

Fig. 1. *Phlebopteris angustiloba,* środkowa część okazu No 101, z widocznymi listkami zarodnionośnymi, × 3.
Fig. 2. *Pachypteris major,* duży odcinek liścia, × 2, No 102.
Fig. 3. *Pachypteris major,* odcisk w glince dużego odcinka liściowego z widoczną nerwacją, × 2, No 128.
Fig. 4. *Phlebopteris angustiloba,* cały okaz, × 1, No 101.
Fig. 5. *Phlebopteris angustiloba,* niedojrzała spora, × 400, preparat S 47.



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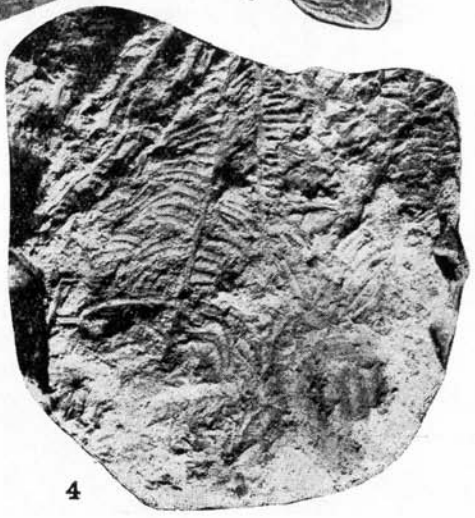

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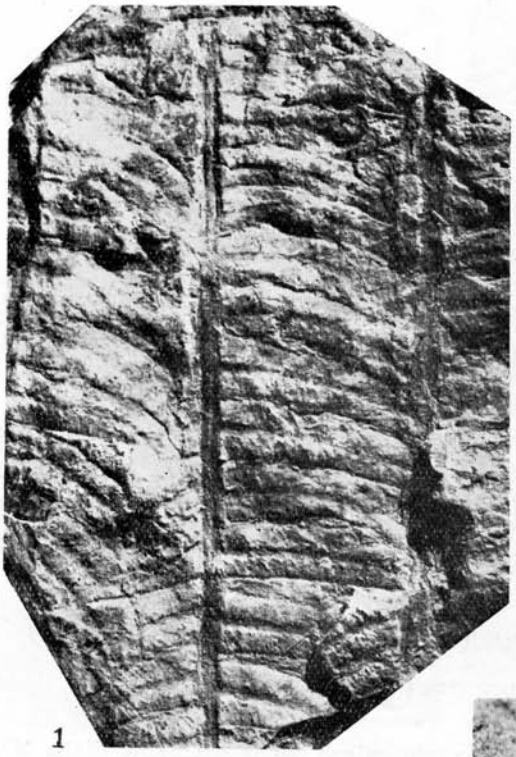
Plate II

Fig. 1. *Phlebopteris Muensteri*, two pinnules, × 3, No 101A.
Fig. 2. *Nilssonia cracoviensis*, type specimen, × 5/4, No 20.
Fig. 3. *Nilssonia cracoviensis*, lower cuticle showing the distribution of stomata, × 100, slide S 52.
Fig. 4. *Nilssonia cracoviensis*, lower cuticle showing bulging epidermal cells and stomata surrounded by papillae, × 250, slide S 52.

Tablica II

Fig. 1. *Phlebopteris Muensteri*, fragment okazu, × 3, No 101A.
Fig. 2. *Nilssonia cracoviensis*, typ, × 5/4, No 20.
Fig. 3. *Nilssonia cracoviensis*, dolna kutykula; widoczne rozmieszczenie aparatów szparkowych, × 100, preparat S 52.
Fig. 4. *Nilssonia cracoviensis*, dolna kutykula; widoczne brodawki występujące na niektórych komórkach epidermalnych oraz aparaty szparkowe otoczone przez papille, × 250, preparat S 52.



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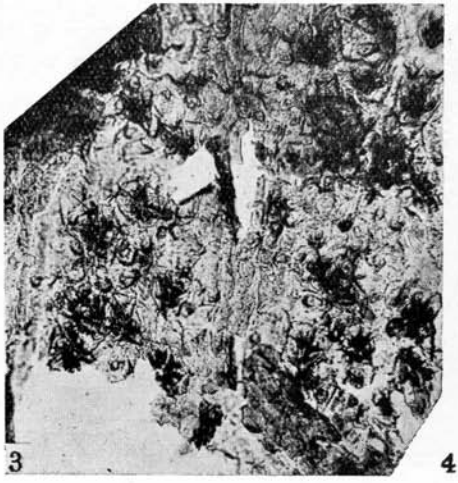

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Plate III

Pachypteris major

Fig. 1. Type specimen, × 1·5, No 33.
Fig. 2. Specimen showing the decurrent lower basal angle of leaf segments, × 2, No 14.
Fig. 3. Upper cuticle, × 100, slide S 22.
Fig. 4. Lower cuticle of a specimen with well developed papillae, × 100, slide S 3.
Fig. 5. Lower cuticle showing cutinised papillae often present on a subsidiary cell, × 250, slide S 22.

Tablica III

Pachypteris major

Fig. 1. Typ, × 1·5, No 33.
Fig. 2. Okaz, na którym są widoczne dolne, zbiegające partie odcinków liścia, × 2, No 14.
Fig. 3. Górna kutykula, × 100, preparat S 22.
Fig. 4. Dolna kutykula okazu z dobrze rozwiniętymi papillami, × 100, preparat S 3.
Fig. 5. Dolna kutykula z widocznymi papillami, które występują często na komórkach dodatkowych aparatów szparkowych, × 250, preparat S 22.


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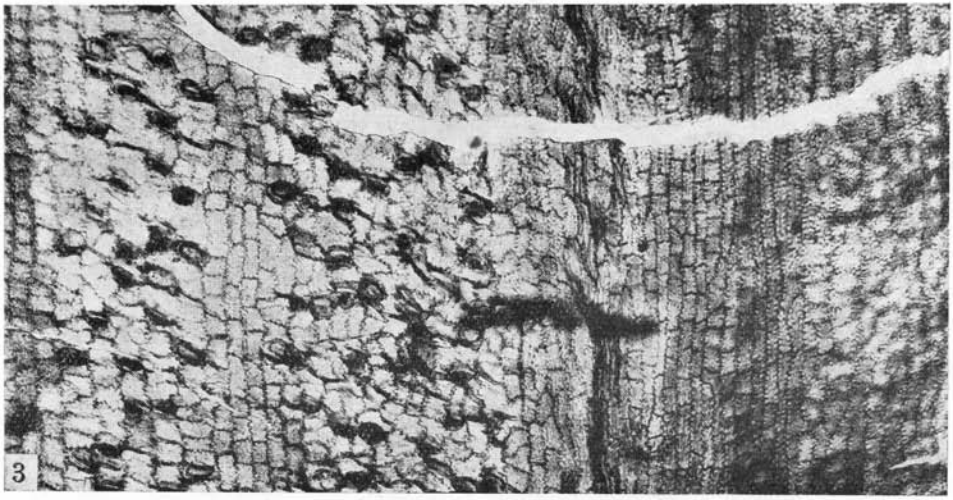
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Plate IV

Pterophyllum subaequale

Fig. 1. Leaf showing one complete pinna, third from the lower right angle, × 1·5, No 91.

Fig. 2. Lower cuticle, to the left cells of a non stomatal band, to the right stomatal band showing stomata and bulging cells, × 250, slide S 114.

Fig. 3. Cuticle, to the left lower side with two stomatal bands, then margin, to the right upper cuticle, × 100, slide S 114.

Tablica IV

Pterophyllum subaequale

Fig. 1. Fragment liścia posiadający jeden kompletny odcinek boczny (trzeci od dołu po prawej stronie), × 1·5, No 91.

Fig. 2. Dolna kutykula, po lewej komórki pasa bezszparkowego, po prawej pas szparkowy, w którym widoczne są aparaty szparkowe i komórki opatrzone brodawkami, × 250, preparat S 114.

Fig. 3. Kutykula, po lewej stronie dolna, ukazująca dwa pasy szparkowe, następnie brzeg liścia, potem na prawo górna kutykula, × 100, preparat S 114.


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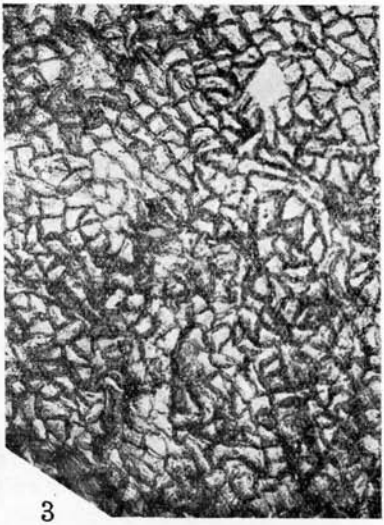
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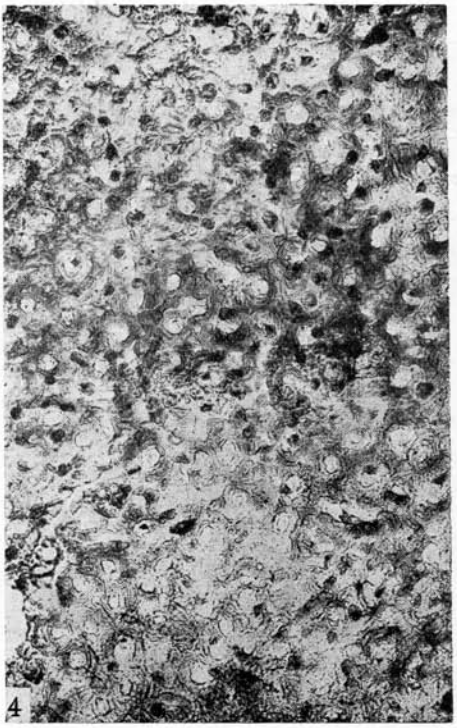
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Plate V

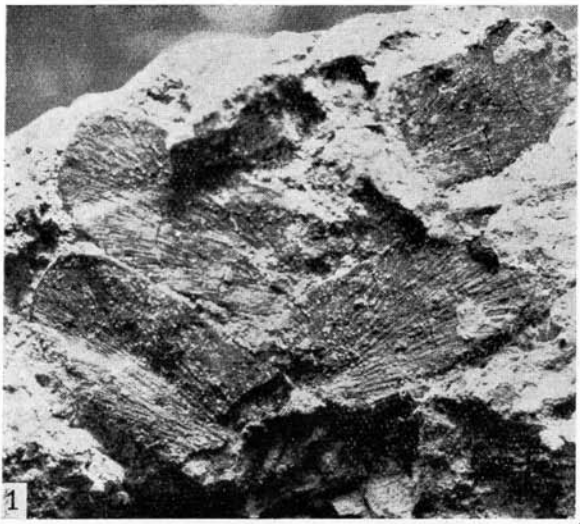
Otozamites obtusus

Fig. 1. Four pinnae coated with ammonium chloride to show the venation, × 4, No 81.
Fig. 2. Cuticle, upper side above, lower side below, × 100, slide S 122.
Fig. 3. Lower cuticle showing epidermal papillae and papillae encircling the stomata, × 250, slide S 122.
Fig. 4. Stoma at a high lewel showing upper part of the papillae encircling the stoma, oil immersion, × 700, slide S 125.
Fig. 5. Same stoma at a lower level, showing guard cells, oil immersion, × 700, slide S 125.

Tablica V

Otozamites obtusus

Fig. 1. Cztery odcinki liściowe pokryte chlorkiem amonu dla ukazania nerwacji, × 4, No 81.
Fig. 2. Kutykula liścia, od góry górna strona, od dołu dolna strona, × 100, preparat S 122.
Fig. 3. Dolna kutykula; widoczne papille na komórkach epidermalnych i papille otaczające aparaty szparkowe, × 250, preparat S 122.
Fig. 4. Aparat szparkowy od góry, widoczna górna część papilli otaczających szparkę, imersja, × 700, preparat S 125.
Fig. 5. Ten sam aparat szparkowy przy niżej opuszczonym obiektywie; widoczne komórki szparkowe, imersja, × 700, preparat S 125.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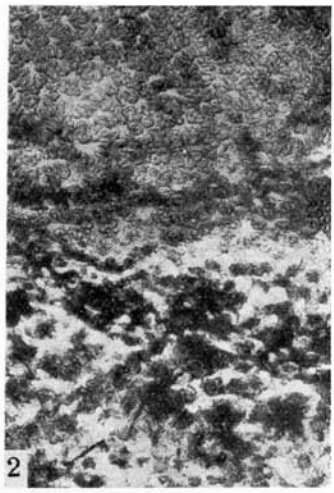
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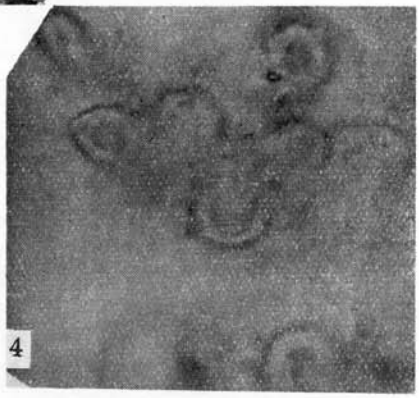
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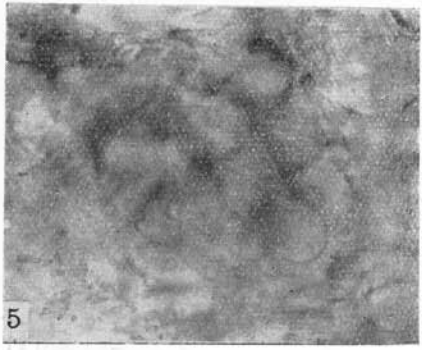
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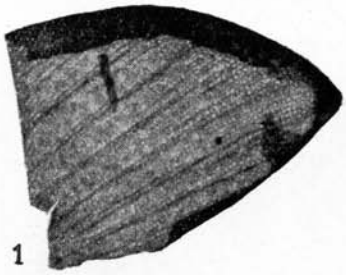
Plate VI

Fig. 1. *Otozamites Raciborskii,* macerated pinna showing dark lines, probably hypodermal fibres, on the upper cuticle, × 20, slide S 131.
Fig. 2. *Otozamites Raciborskii,* two pinnae attached to the rachis, showing veins, × 10, slide S 159.
Fig. 3. *Otozamites obtusus,* specimen with small leaves, × 1·5, No 1.
Fig. 4. *Otozamites Raciborskii,* type specimen showing two pinnae from the upper side, × 1·5, No 31 a, b.
Fig. 5. *Otozamites Raciborskii,* upper cuticle, × 100, slide S 131.
Fig. 6. *Otozamites Raciborskii,* lower cuticle showing stomata and hollow papillae, × 350, slide S 137.

Tablica VI

Fig. 1. *Otozamites Raciborskii,* wymacerowany odcinek liścia; na górnej kutykuli liścia widoczne ciemne linie odpowiadające prawdopodobnie włóknom hypodermalnym, × 20, preparat S 131.
Fig. 2. *Otozamites Raciborskii,* dwa odcinki liściowe z widocznymi nerwami, wyrastające z ogonka liściowego, × 10, preparat S 159.
Fig. 3. *Otozamites obtusus,* okaz o małych listkach, × 1·5, No 1.
Fig. 4. *Otozamites Raciborskii,* typ, × 1·5, No 31 a, b.
Fig. 5. *Otozamites Raciborskii,* górna kutykula, × 100, preparat S 131.
Fig. 6. *Otozamites Raciborskii,* dolna kutykula. Widoczne aparaty szparkowe i puste wewnątrz papille, × 350, preparat S 137.



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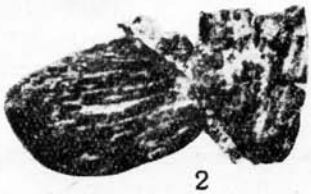

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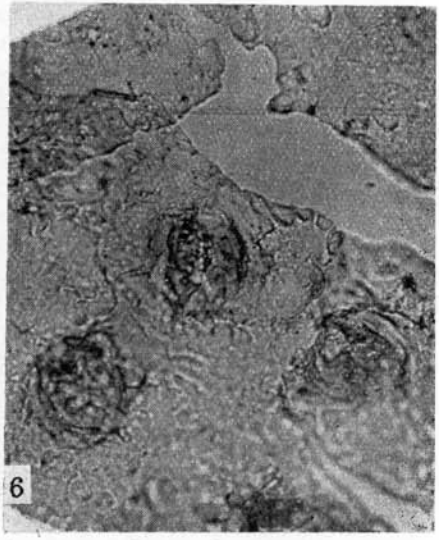

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Plate VII

Fig. 1. *Pseudotorellia grojecensis,* lower cuticle showing epidermal cells bearing cutinised ridges; to the right part of a stomatal strip, × 100, slide S 68.

Fig. 2. *Ginkgo sp.,* leaf, × 1, No 42.

Fig. 3. *Pseudotorellia grojecensis,* cells of upper cuticle showing fine longitudinal striation, × 350, slide S 79.

Fig. 4. *Pseudotorellia grojecensis,* stoma from below showing guard cells strongly cutinised along the aperture and along the walls bordering the subsidiary cells. Polar parts of guard cells thinly cutinised; oil immersion, × 700, slide S 80.

Fig. 5. *Pseudotorellia grojecensis,* same stoma seen at a higher level and showing the diaphragm outside the stomatal aperture; oil immersion, × 700, slide S 80.

Tablica VII

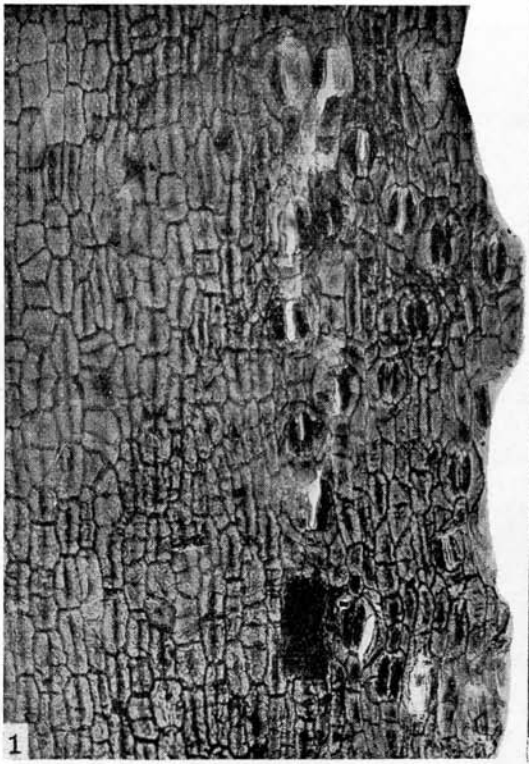
Fig. 1. *Pseudotorellia grojecensis,* dolna kutykula ukazująca komórki epidermy opatrzone skutynizowanymi listwami; po prawej stronie część pasa szparkowego, × 100, preparat S 68.

Fig. 2. *Ginkgo sp.,* × 1, No 42.

Fig. 3. *Pseudotorellia grojecensis,* komórki górnej kutykuli opatrzone delikatnymi prążkami, × 350, preparat S 79.

Fig. 4. *Pseudotorellia grojecensis,* aparat szparkowy od dołu. Widoczne komórki szparkowe silnie skutynizowane wzdłuż szparki i wzdłuż ścian graniczących z komórkami dodatkowymi. Biegunowe partie komórek szparkowych słabo skutynizowane; imersja, × 700, preparat S 80.

Fig. 5. *Pseudotorellia grojecensis,* ten sam aparat szparkowy widziany przy nieco podniesionym obiektywie; widoczna diafragma na zewnątrz otworu szparkowego, imersja, × 700, preparat S 80.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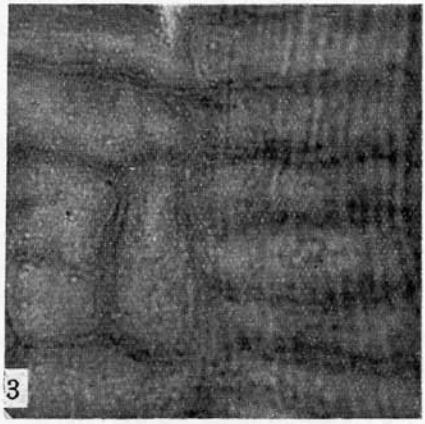
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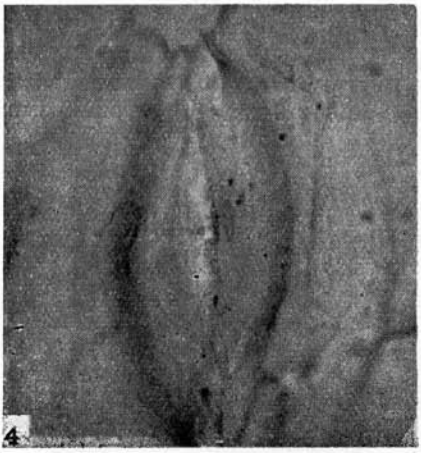
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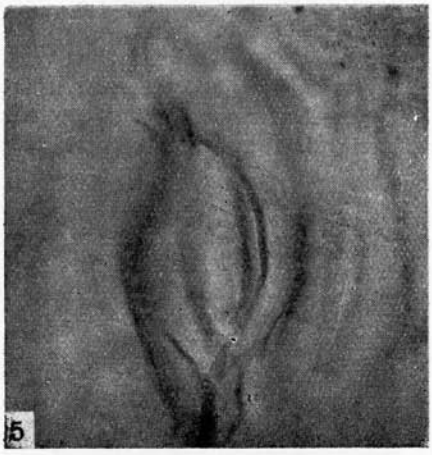
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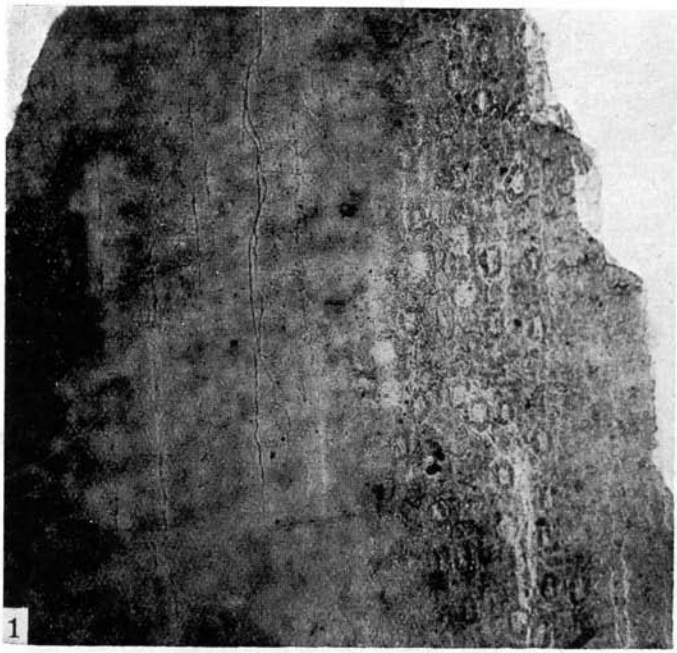
Plate VIII

Fig. 1. *Marskea laticosta.* under side of a leaf fragment showing the stomatal band and the middle non stomatal band. Along the edges fragments of the upper cuticle are visible, × 100, slide S 10.
Fig. 2. *Pseudotorellia grojecensis,* type specimen, × 1·5, No 49 b.
Fig. 3. *Marskea laticosta,* type specimen. × 2, No 125.
Fig. 4. *Marskea laticosta,* fragment of the lower cuticle showing two stomata, × 250, slide S 10.
Fig. 5. *Pseudotorellia grojecensis,* slightly macerated leaf by transmitted light showing a slender dark strand to the left and bands of granular matter, × 20, slide S 70.

Tablica VIII

Fig. 1. *Marskea laticosta,* dolna strona fragmentu liścia, ukazująca pas szparkowy i środkowy pas bezszparkowy; wzdłuż brzegów widoczne fragmenty górnej kutykuli, × 100, preparat S 10.
Fig. 2. *Pseudotorellia grojecensis,* typ, × 1·5, No 49 b.
Fig. 3. *Marskea laticosta,* typ, × 2, No 125.
Fig. 4. *Marskea laticosta,* fragment dolnej kutykuli z dwoma aparatami szparkowymi, × 250, preparat S 10.
Fig. 5. *Pseudotorellia grojecensis,* słabo wymacerowany liść widziany w świetle przechodzącym, ukazujący cienkie ciemne pasmo po lewej stronie oraz pasma ziarnistej substancji, × 20, preparat S 70.



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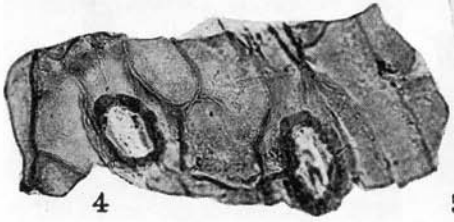

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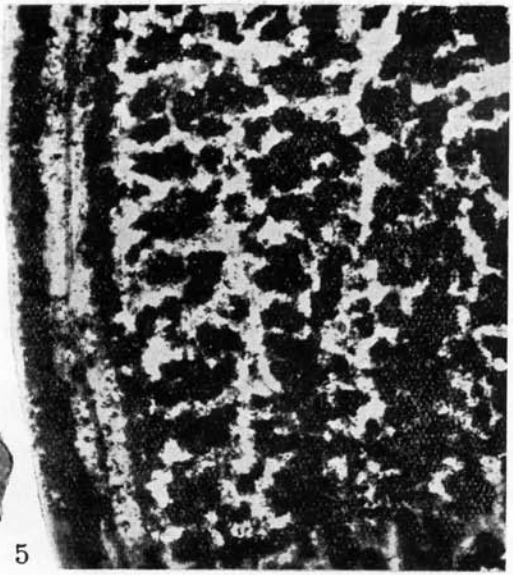

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Plate IX

Brachyphyllum cyclophorum

Fig. 1. Shoots from the material collected by R a c i b o r s k i, × 3, No R 2.
Fig. 2. and 4. Cuticle showing stomata with the cutinised ring around the guard cells, × 250, slide S 14.
Fig. 3. Fragments of shoots and leaves from the 1956 collection, × 6.
Fig. 5. Cuticle showing arrangement of stomata, × 100, slide S 14.

Tablica IX

Brachyphyllum cyclophorum

Fig. 1. Pędy na okazie ze zbiorów R a c i b o r s k i e g o, × 3, No R 2.
Fig. 2 i 4. Kutykula, widoczne aparaty szparkowe; naokoło komórek szparkowych skutynizowany pierścień, × 250, preparat S 14.
Fig. 3. Fragmenty pędów i liście wypłukane z materiału zbieranego w 1956, × 6.
Fig. 5. Kutykula; widoczne rozmieszczenie szparek, × 100, preparat S 14.


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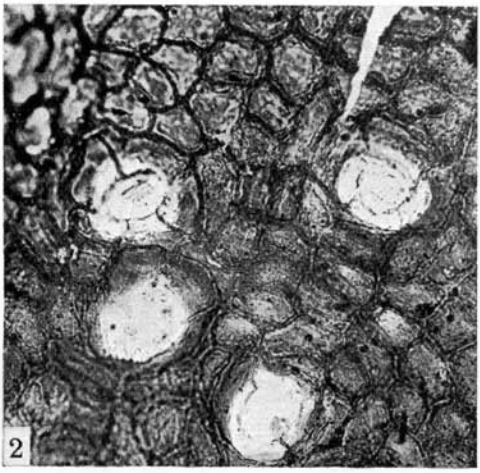
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