



Przed piętnastu laty zmarł prof. dr Władysław Szafer (1886—1970), znakomity uczony i niestrudzony organizator nauki w Polsce. W 1960 r. powołał do życia *Acta Palaeobotanica*, czasopismo służące rozwojowi dyscypliny, której Profesor zawdzięcza swe najpiękniejsze odkrycia naukowe

The prominent scientist and organizer of scientific activity in Poland Professor Władysław Szafer (1886—1970) died fifteen years ago. In 1960 he started *Acta Palaeobotanica*, a periodical conducive to the development of the branch of science in which the Professor made his most significant discoveries

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MIROVIA SZAFERI GEN. ET SP. NOV. (*GINKGOALES*)
FROM THE JURASSIC OF THE KRAKÓW REGION, POLAND

Mirovia szaferi gen. et sp. nov. (*Ginkgoales*) z jury okolic Krakowa

ABSTRACT. Among the small leaves occurring in the Middle Jurassic localities of the Kraków region particularly interesting is *Mirovia szaferi* gen. et sp. nov. Preserved as compressions, these leaves show certain characters occurring in the recent leaves of *Sciadopitys* Sieb. et Zucc. and *Acmopyle* Pilger (*Coniferae*). Nevertheless the analysis of 30 characters of *Mirovia* shows that most of them are common with the Mesozoic leaves *Pseudotorellia* Florin (*Ginkgoales*). It is therefore suggested that *Mirovia* is in fact a Ginkgoalean leaf.

INTRODUCTION

Looking at plants from the bore-hole Zabierzów (Jurkiewiczowa 1974) I found in macerated material from a thin coal layer numerous small leaves of an unusual type. They possessed one stomatal strip and their stomata, in particular the thickly cutinized outer walls of the guard cells were unlike any in the Kraków Jurassic flora, except perhaps those of the *Bennettitales* and also of certain species of *Pseudotorellia* Florin in which the flora abounds. The leaves had also other unusual characters which were particularly distinct in the material collected late at Mirów, one of the localities of Raciborski (1894).

On the whole, these leaves seem to possess characters occurring in different groups of gymnosperms. Nevertheless, they share so many characters with *Pseudotorellia* that I think they are leaves of a Ginkgoalean plant. Though, as yet, there is no evidence from fructifications.

MATERIAL AND METHODS

The material consists of leaves preserved as compressions from the localities Zabierzów and Mirów. At Zabierzów the leaves occur in a thin layer of coal in the Grojec clays and are associated with *Caytonia sewardi* Thomas, *Sagenopteris colpodes* Harris, *Pterophyllum cycadites* Harris et Rest, *Pseudotorellia grojecensis*

Reymanówna and *Allicospermum retemirum* Harris which plants indicate a Middle Jurassic age. According to Jurkiewiczowa (1974) this layer is probably Lower Bathonian. At Mirów the leaves were found in light grey Grojec clays from two waste tips. Here *Mirovia* is associated with *Brachyphyllum* leaves and occasionally with a megaspore which commonly occurs with the Kraków Middle Jurassic flora.

The coal was macerated for several months in nitric acid, then washed in water and weak ammonia, so that plant cuticles were obtained. The leaves from the clays were washed on sieves, when needed macerated in nitric acid and cleaned in hydrofluoric acid. Most were mounted in glycerine jelly, a few were coated with gold and studied in the SEM.

The leaves are quite thick and well preserved. Sectioning with a microtome and maceration of sections are planned in the future, as they may give suggestions about the venation pattern.

SYSTEMATIC DESCRIPTION

Order *Ginkgoales*

Gen. *Mirovia* nov.

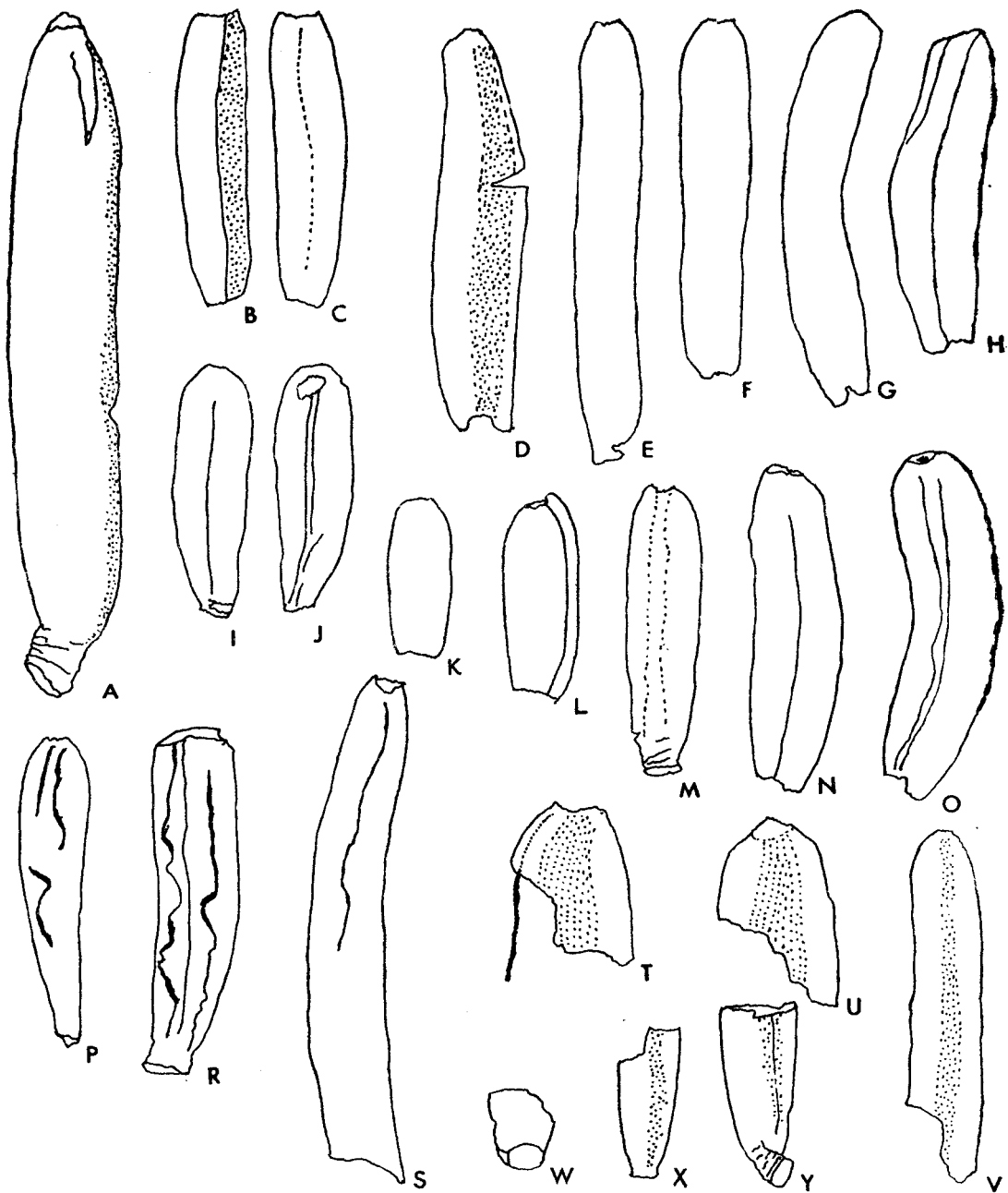
Diagnosis. Leaves small, approximately linear, apex broadly rounded; basis tapering towards very short petiole ending with an abscission scar, margin entire. Leaves polymorphic, consisting of dorsiventral, bilateral and intermediate forms. Filiform resin ducts, usually two, present.

Cuticle as a rule thick, composed of longitudinal rows of quadrangular cells with approximately straight walls. One stomatal strip with stomata arranged longitudinally. Stomata consisting of raised subsidiary cells and depressed guard cells showing strongly cutinized outer walls and walls abutting on subsidiary cells.

Type species. *Mirovia szaferi*

Derivatio nominis. From the locality Mirów

Fig. 1. *Mirovia szaferi* gen. et sp. nov. A — cotype, bilateral macerated leaf with wrinkled petiole and stomatal strip along one margin, Zabierzów × about 7.5, IB PAN PM 880; B, C — leaf without apex and petiole, Mirów, B — from below with stomatal strip to the right, C — from above showing groove in middle, × 4; IB PAN PM 881; D — wide leaf from below with stomatal strip on the right side, Zabierzów, × 4, IB PAN PM 882; E, F, G, K — leaves from Zabierzów, × 4, IB PAN PM 883, PM 884, PM 885, PM 888; H — leaf from below with stomatal strip in part hidden, Mirów, × 4; IB PAN PM 886; I, J — holotype, I — from above showing shallow groove, J — from below with stomatal strip hidden, Mirów, × 4, IB PAN PM 887; L — small leaf from below, stomatal strip hidden to the right, Mirów, × 4, IB PAN PM 889; M — small almost complete leaf, Mirów, × 4, IB PAN PM 890; N — leaf showing groove on upper side, Mirów, × 4, specimen lost; O — leaf from below showing scar at apex and ridges hiding stomatal strip, Mirów, × about 6, IB PAN PM 891; P, R, S — macerated leaf fragments showing resin ducts inside, Zabierzów, × 4, IB PAN PM 892, PM 893, PM 894; T — leaf apex with protruding resin duct, stomatal strip in the middle, Mirów, × about 6, specimen lost; U — complete leaf apex, stomatal strip in the middle, Mirów, × about 6, IB PAN PM 895; V — upper part of narrow, long leaf with stomatal strip in the middle, Mirów, × 4, IB PAN PM 896; W, X, Y — leaf bases with petiole, Mirów, × 4, IB PAN PM 887, PM 888, PM 889. Stomatal strip marked by stippling



Mirovia szaferi sp. nov.

Pls. I — III; Fig. 1

Diagnosis. Leaves thick, coriaceous, straight to falcate, (5)10—14 mm long but judging from fragments occasionally about 20 mm long, typically about 2 mm wide, extremes 1.6—3.5 mm, with a tapering occasionally twisted basis and a distinct transversely wrinkled petiole about 1 mm long, 1—1.5 mm wide, ending in crescent-shaped abscission scar 0.8—1 mm long, about 0.5 mm high. Leaf apex as a rule incomplete, with thick dark substance protruding between cuticles; when complete showing rounded end with small pointed tip, distinct from lustrous cuticle of remaining part of leaf, apparently covered with much thinner cuticle. Leaves polymorphic, dorsiventral with stomatal strip along middle of lower side, or bilateral with stomatal strip along leaf margin or intermediate. Frequently along each side of stomatal strip a cutinized ridge, protruding in most leaves so as to meet and hide the stomatal strip, at least in lower part of leaf. Approximately opposite the stomatal strip on the other side of the leaf a narrow longitudinal groove. Resistant to maceration filiform resin ducts about 0.1 mm wide consisting of a red-brown substance, usually two, occasionally three, straight or irregularly undulating but not dichotomising, running along leaf till apex.

Upper cuticle about 20 μm thick, consisting of longitudinal rows of quadrangular cells with almost straight walls and rounded corners, cells about 25 μm wide, their length 1—3 times their width. Periclinal walls mottled or with delicate punctuation, peripherally with delicate wrinkles running in different directions. Lower cuticle outside stomatal strip consisting of longitudinal rows of cells about 20 μm wide, their length up to 7 times their width, their periclinal walls smooth or with delicate longitudinal striation, occasionally 1—2 files of much narrower cells, otherwise like cells of upper cuticle.

One stomatal strip about 1 mm wide of much thinner cuticle, ordinary epidermal cells shorter and less regular than outside strip. Stomata crowded, arranged in 6 to 10 longitudinal files consisting of rows of up to 9 stomata; stomata in rows abutting with their guard cells or polar subsidiary cells, rows in a file separated by 1—4 ordinary epidermal cells. Occasionally additional short row of stomata inserted between stomatal files. Files of stomata abutting or separated by 1—4, occasionally more epidermal cells. Stomata arranged longitudinally, rarely (1 to 4) arranged transversely. Stomata 50—70 \times 45—55 μm approximately circular occasionally elliptical typically with a ring of 4(—6) subsidiary cells, usually lateral cells longer than polar ones. Walls of subsidiary cells facing entrance of stomatal pit raised, forming a strongly cutinized ring, as a rule without papillae, entrance to stomatal pit quadrangular about 22 μm long 12 μm wide. Guard cells depressed, with thick cutin lamellae on outer walls and walls abutting on subsidiary cells.

Holotype. IB PAN PM 887

Locus typicus. Zabierzów borehole

Stratum typicum. Grojec clays (glinki grojeckie), Middle Jurassic
 Derivatio nominis. In memory of the late Professor Władysław Szafer of
 Kraków

DISCUSSION

Venation and resin ducts. The venation in *Mirovia szaferi* is not known. The shallow groove on the upper surface need not correspond to a vein, as e.g. in *Sciadopitys* Sieb. et Zucc. such a groove runs between the two veins of the leaf. In *Sciadopitys* the two veins protrude on the lower side along the raised margins of the stomatal groove. In *Mirovia* there can frequently be seen a protruding strand along each side of the stomatal groove, but I think they are not vascular strands but resin ducts. They are only about 0.1 mm thick, they consist of a red brown substance resistant to maceration and do not show any tracheid-like cells. They are usually two, occasionally three in a leaf, they run from the leaf basis to its apex under which they might be slightly swollen, and they tend to protrude from broken leaves. They are straight or irregularly sinuous and they do not dichotomise. I think that their narrow diameter and the occasional sinuous course as well as the apparent lack of tracheids indicate that these strands are not vascular strands.

Leaf apex. Leaves of *Mirovia*, even not macerated look usually notched, but in fact they have a damaged apex showing some thick black substance between the cuticles. Occasionally there are leaves with only a small scar on the apex representing a break in the cuticle. Rarely in an unmacerated leaf there is preserved the complete apex which is broadly rounded with a slightly pointed tip. The tip is not lustrous and appears to be covered with a much thinner cuticle than the remaining part of the leaf. Maceration shows that near apex the cuticle is very thin and farther on no cuticle at all is found after maceration.

The unusual leaf apex in *Mirovia* is similar to that described in leaves of *Bilsdalea dura* (Harris 1979; Weisło-Luraniec 1985). Harris suggested two possible explanations, either that the damaged apex represented a hydathode, or that it produced food bodies eaten by insects. In *Mirovia* all the leaves have this type of apex but no veins with widened ends similar to those present in *Bilsdalea* were observed. It is interesting to note that the two resin ducts reaching the apex may be somewhat swollen at their ends. Perhaps the resin ducts produced some substance secreted through the leaf apex.

THE AFFINITIES OF *MIROVIA*

Comparison with *Sciadopitys* and *Acmopyle*. *Mirovia* possesses certain rare characters which at first seem to suggest the affinity with certain groups of conifers. Very rare is the single stomatal strip which in living gymnosperms is found in *Sciadopitys* Sieb. et Zucc. Mesozoic leaves with a single stomatal strip are usually placed

in *Sciadopityes* Goepfert and regarded as coniferous. Another character shared by *Mirovia* and *Sciadopitys* leaves is that the stomatal strip may form a more or less protected groove. The cuticle, however of the stomatal strip is different, as in *Sciadopitys* each epidermal cell including the subsidiary cells shows an elongated papilla, while there are no papillae in *Mirovia*. The stomata in *Sciadopitys* differ from those of *Mirovia* in having 8—12 subsidiary cells (Florin 1931) as compared with 4—6 in *Mirovia*. The walls of the guard cells appear thinly cutinized and lacking the thick cutin plates of *Mirovia*. The leaves of *Sciadopitys* differ from *Mirovia* in being dorsiventral, much longer and in lacking a specialized apex and a petiole.

The second unusual character of *Mirovia* are the frequently bilateral i. e. sideways (radially) and not dorsiventrally flattened leaves. Such leaves occur recently in a few conifers mainly podocarps and particularly well known are those of *Acmopyle* Pilger (Sahni 1920). *Acmopyle*, however, is different from *Mirovia* in having linear as well as scale-like leaves of which only the linear ones are bilateral, while scale-like leaves are dorsiventral or intermediate (Sahni 1920). *Mirovia* is different, as scale-like leaves are not known and her linear leaves may be dorsiventral, bilateral or intermediate. *Acmopyle* is also different in having two stomatal strips (Florin 1931).

These comparisons appear to suggest that although leaves of *Mirovia* share certain important characters with leaves of *Sciadopitys* and *Acmopyle*, there are several characters in which *Mirovia* is different from each of them. As a result, there is no convincing evidence of the affinity of *Mirovia* with either of these conifers.

Bilateral leaves occur also in the Lower Cretaceous leaf *Paracmopyle florinii* (Krassilov 1967). *Paracmopyle* is different from *Mirovia* in having leaves more than 3 cm long and in showing one stomatal strip running between the median part of the leaf and its margin, in cells of the stomatal strip possessing papillae and in the loose arrangement of stomata which do not form files.

Comparison with *Bennettitales*. The stomata of *Mirovia* are unusual in having thick cutin lamellae on the outer and dorsal walls of the guard cells. Thick cutin lamellae on the outer walls of the guard cells are regarded as characteristic of the *Bennettitales* and as a rule do not occur in other groups of gymnospermae (Harris 1932, 1969). In addition many stomata of *Mirovia* resemble at first sight those of the *Bennettitales* in showing a pair of subsidiary cells opposite the guard cells looking as if they all originated through division of one cell. There occur, however, also other stomata which have a distinct ring of 4—6 subsidiary cells and this shows that *Mirovia* is not a Bennettitalean plant. Also the shape of the leaf and the wrinkled petiole do not occur, as far as I know, in any Bennettitalean leaf.

Comparison with *Pseudotorellia* Florin. While working on species of *Pseudotorellia* from the Kraków Jurassic I found that *Mirovia* shared many characters with leaves of this genus which is attributed to the *Ginkgoales*. In Table 1 are listed the characters of *Mirovia* and the characters of *Pseudotorellia* according to Florin (1936) and Harris et al. (1974), as well as a few additional characters common to *Pseudotorellia* species from the Kraków region. In Table 2 these characters are compared.

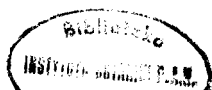
Mirovia and *Pseudotorellia* share 18 characters out of 30. Five further characters

Table 1

Comparison of *Mirovia* and *Pseudotorellia*

| No | Characters (+ present, - absent) | <i>Mirovia</i> | <i>Pseudotorellia</i> |
|-----|----------------------------------------------------|----------------|-----------------------|
| 1. | Leaf: approximately linear | + | + |
| 2. | entire | + | + |
| 3. | occasionally falcate | + | + |
| 4. | apex broadly rounded | + | + |
| 5. | apex specialized | + | usually |
| 6. | tapering towards basis | + | + |
| 7. | petiole short, transversely wrinkled | + | +, (-) |
| 8. | not swollen at basis | + | + |
| 9. | abscission scar | + | + |
| 10. | veins dichotomising in lower part | ? | + |
| 11. | filiform resin ducts | + | frequently |
| 12. | resin bodies | - | - |
| 13. | polymorphic (dorsiventral, bilateral intermediate) | + | - |
| 14. | one shallow groove on upper side | + | - |
| 15. | one stomatal strip | + | occasionally |
| 16. | stomatal strip forming groove | + | - |
| 17. | Epidermis: cells \pm elongated | + | + |
| 18. | cell walls straight or slightly sinuous | + | + |
| 19. | transverse walls very thick | on petiole | frequently |
| 20. | hypostomatic | + | + |
| 21. | poor definition of stomatal strips | - | usually |
| 22. | stomata arranged in short longitudinal rows | + | + |
| 23. | stomata longitudinally orientated | + | + |
| 24. | stomata distributed sparsely | - | + |
| 25. | Stomata: haplocheilic | + | + |
| 26. | monocyclic or partly dicyclic | + | + |
| 27. | subsidiary cells 4-6 | + | + |
| 28. | Guard cells: with cutinized strip along slit | + | + |
| 29. | strongly cutinized wall along subsidiary cells | + | + |
| 30. | strongly cutinized outer wall | + | frequently |

found in *Mirovia* occur usually in *Pseudotorellia* but not in all species. One character of *Mirovia*, the single stomatal strip may exceptionally be found also in *Pseudotorellia*, as in *P. heterophylla* Watson (1969) the stomata are distributed over the lower cuticle and may be regarded as one stomatal strip. Then there are two characters in which *Mirovia* differs from a typical *Pseudotorellia* which is as a rule characterized by indistinctly defined stomatal strip and sparse arrangement of stomata, while in *Mirovia szaferi* there is one very distinct stomatal strip in which the stomata are



Analysis of characters

| | | |
|---------------------|----------------------------------------------------------------------------------------|----|
| 1. | Characters shared by <i>Mirovia</i> and <i>Pseudotorellia</i> | 18 |
| 2. | Characters of <i>Mirovia</i> shared by most species of <i>Pseudotorellia</i> | 5 |
| 3. | Character of <i>Mirovia</i> shared by one species of <i>Pseudotorellia</i> | 1 |
| 4. | Characters of <i>Mirovia</i> absent from <i>Pseudotorellia</i> | 3 |
| 5. | Characters of <i>Pseudotorellia</i> as a rule absent from <i>Mirovia</i> | 2 |
| 6. | Character of <i>Pseudotorellia</i> not possible to observe in <i>Mirovia</i> | 1 |
| Together characters | | 30 |

crowded. These characters may, however, be found exceptionally also in *Pseudotorellia*. Distinct stomatal strips occur in *P. heeri* Manum (1968) and in *P. grojecensis* Reymanówna (1963) and the stomata are quite densely arranged in these two species. Particularly interesting to note is that the widest leaves of *Mirovia* show stomata distributed sparsely and of elliptical outline and thus resembling a typical *Pseudotorellia*. But in all leaves *Mirovia* shows the characteristic arrangement of stomata in short longitudinal rows which is found in the *Ginkgoales*. One important character, the venation, could not be observed in *Mirovia*.

This comparison seems to me convincing evidence of the affinity of *Mirovia* and *Pseudotorellia*. Particularly important seems to me the presence in both genera of the filiform resin ducts, the short transversely wrinkled petiole and the stomata arranged in short longitudinal rows. *Pseudotorellia* is attributed to the *Ginkgoales* and I am convinced that *Mirovia* belongs to the same group, although the typical dichotomous venation of the *Ginkgoales* was not observed in *Mirovia*. Additional evidence of affinity are the widest leaves of *Mirovia* where the stomatal strips and stomata are like those of *Pseudotorellia*.

Apart from the more or less important similarities there are three differences which to my mind justify the separation of *Mirovia* from *Pseudotorellia*. They have already been discussed in detail and will be mentioned briefly. One such difference is the polymorphism of the leaves of *Mirovia* which are dorsiventral or bilateral or intermediate. The second difference is the deep groove frequently closing over the stomatal strip. The third important difference of *Mirovia* from *Pseudotorellia* is the shallow narrow groove on the other side of the leaf opposite the stomatal strip. No such characters occur in any *Pseudotorellia* I know.

Ecology. It appears that *Mirovia* may have originated from *Pseudotorellia* by extreme specialization. Its leaves are much smaller than those of any *Pseudotorellia*, they have a very thick cuticle, the stomata are concentrated in a single strip and in addition protected in a groove which may close over them. Most of the leaves are either bilaterally flattened or intermediate to dorsiventral ones. The recent conifer *Acropyle* which also possesses bilateral leaves grows according to Sahni (1920) on a xerophytic habitat. The guard cells show thickly cutinized outer walls and are sunken below a ring of protruding subsidiary cells. On the whole, *Mirovia* is a very

xeromorphic leaf. Particularly interesting is the specialized apex, appearing to suggest secretion. It is interesting to note that also several species of *Pseudotorellia* from the Kraków area and also *Bilsdalea dura* (*Coniferae*) show this type of apex which may be connected with one particular habitat for all these plants.

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REFERENCES

- Florin R. 1931. Untersuchungen zur Stammesgeschichte der Coniferales und Cordaitales. Kungl. Svenska Vetenskapsakademiens Handl., 3 ser., 10 (1):1—588.
- 1936. Die fossilen Ginkgophyten von Franz-Joseph-Land nebst Erörterungen über vermeintliche Cordaitales Mesozoischen Alters I. Spezieller Teil. Palaeontographica, 81 B (3—6):71—173.
- Harris T. M. 1932. The fossil Flora of Scoresby Sound, East Greenland. Part 3. Medd. om Greenland., 85 (3):1—112.
- Harris T. M., Millington W. & Miller J. 1974. The Yorkshire Jurassic Flora. IV. *Ginkgoales*, *Czekanowskiales*. Brit. Mus. (Nat. Hist.), London.
- Jurkiewiczowa I. 1974. Rozwój jury środkowej we wschodniej części obszaru krakowskiego (summary: Development of the Middle Jurassic in the Eastern part of the Kraków region), Inst. Geol. Bull., 278:201—239.
- Krassilov V. A. 1967. Ranniemiłowaja flora Jużnogo Primorja. Nauka, Moskwa.
- Manum S. 1968. A new species of *Pseudotorellia* Florin from the Jurassic of Andöya, Northern Norway. J. Linn. Soc. (Bot.), 61 (384):197—200.
- Raciborski M. 1894. Flora kopalna ogniotrwałych glinek krakowskich. I. Pamiętnik Akad. Umiej., 18:43—101.
- Reymanówna M. 1963. The Jurassic flora from Grojec near Kraków in Poland. I. Acta Palaeobot., 4(2): 9—48.
- Sahn B. 1920. On the structure and affinities of *Acropyle pancheri* Pilger. Phil. Trans. Roy. Soc. London, B 210:253—310.
- Watson J. 1969. A revision of the English Wealden Flora. I. *Charales-Ginkgoales*. Bull. Br. Mus. Nat. Hist. (Geol.), London, 17 (5):209—254.
- Wcisło-Luraniec E. 1985. New details of leaf structure in *Bilsdalea dura* Harris (*Coniferae*) from the Jurassic of Kraków, Poland. Acta Palaeobot., 25 (1, 2): 13—20.

Plate I

Mirovia szaferi gen. et sp. nov.

Non macerated specimens from Mirów, all \times about 10

1. Long leaf without apex and basis from below, stomatal strip covering right part of leaf; IB PAN PM 881
2. Leaf basis from below with twisted wrinkled petiole showing abscission scar. Stomatal strip in middle; IB PAN PM 899
3. Leaf basis from above showing groove in middle and short wrinkled petiole; IB PAN PM 898
4. Leaf basis with abscission scar facing upwards; IB PAN PM 897
5. Holotype. Dorsiventral leaf from above, in lower half visible groove in middle; IB PAN PM 887
6. Holotype from below, stomatal strip in middle almost hidden
7. Complete leaf apex from below, stomatal strip along middle; IB PAN PM 900
8. Leaf apex from below with stomatal strip on left side; IB PAN PM 901
9. Upper part of leaf showing stomatal strip along right margin reaching over on other side; specimen lost
10. Same leaf from other side, part of stomatal strip along left margin (horizontal markings on right side represent an epiphyte)
11. Leaf apex from above with small scar on tip; specimen lost
12. Upper part of leaf from below, stomatal strip in middle, in part hidden; IB PAN PM 902

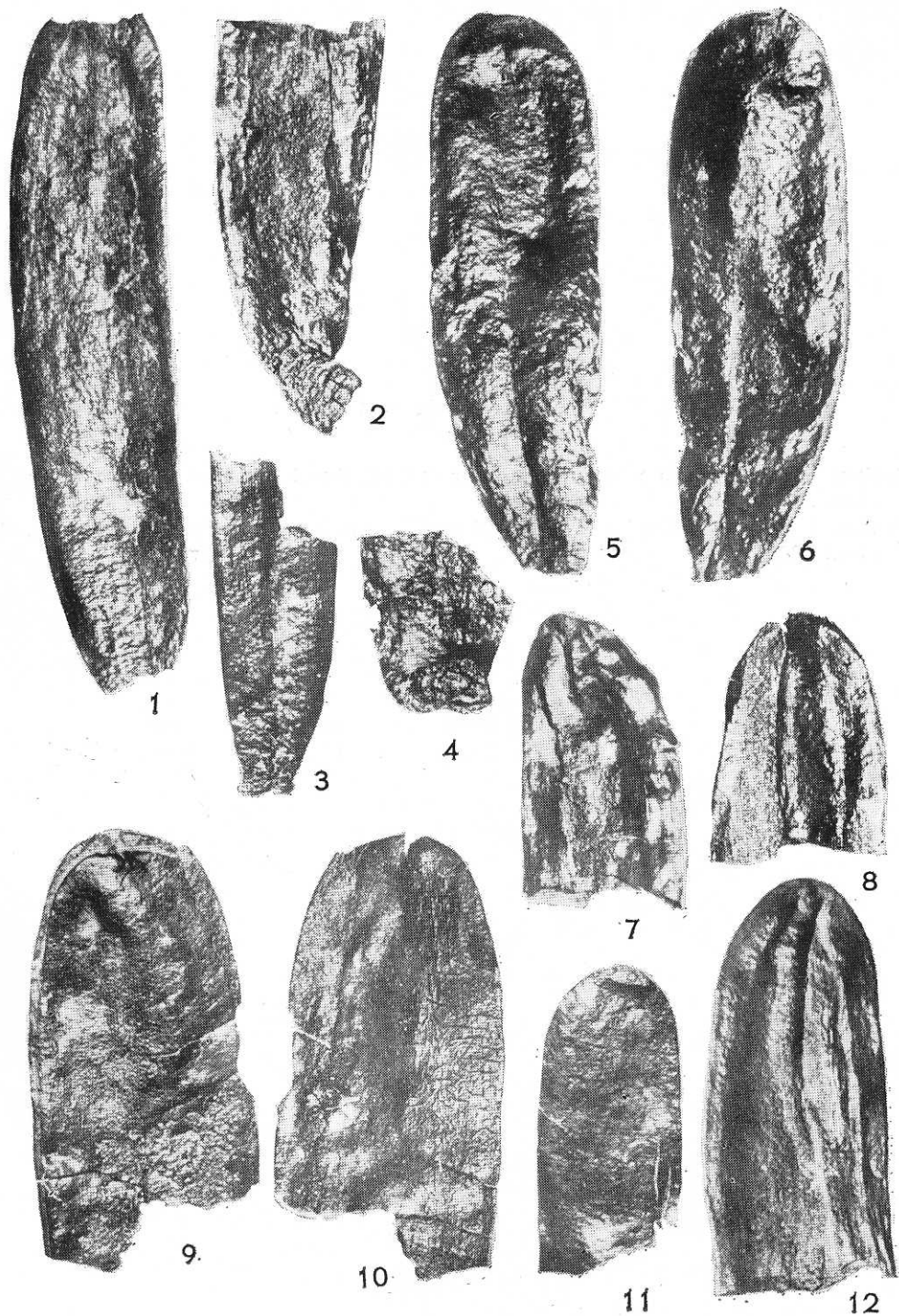


Plate II

Mirovia szaferi gen. et sp. nov.

1. Stomatal strip from above showing stomata arranged into short longitudinal rows forming files, SEM × about 50
2. Stomata from above showing raised ring of subsidiary cells and entrance to stomatal pit, SEM × about 250

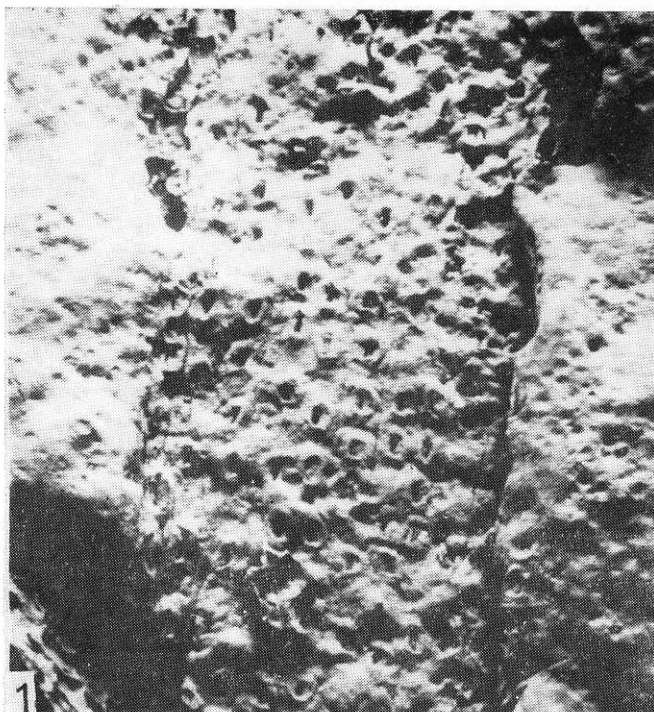


Plate III

Mirovia szaferi gen. et sp. nov.

1. Typical stoma from below, visible subsidiary cells and thick cutin lamellae of outer walls of guard cells?
SEM \times about 1000
2. Stoma of elliptical outline showing subsidiary cells and thick cutin lamellae of outer and dorsal walls of guard cells, SEM \times about 1000

