Acta Palaeobot. 40(2): 113–129, 2000

Bennettitales from the Mecsek Mountains (Liassic), Hungary

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ABSTRACT. The Liassic sequences from the Mecsek Mountains in Hungary contain numerous examples of bennettitalean plant organs including leaf fragments, scales of female cones *Cycadolepis*, and small fragments of the bennettitalean stem *Bucklandia*. Of the 70 leaf specimens examined, two genera are recognized representing two species: *Pterophyllum subaequale* Hartz and *Anomozamites marginatus* (Unger) Nathorst. From the same deposits *Cycadolepis* is also represented by two species. Some of the scales were determined as *C. rugosa* Johansson, which is known to be related to *P. subaequale*, for the other kind of scales a new species, *C. johannae* is proposed. The stem, *Bucklandia* sp. shows bennettitalean cuticle, but its preservation makes it impossible to determine a precise identification.

KEY WORDS: Bennettitales, Liassic, Hungary

INTRODUCTION

Bennettites form a large group of extinct plants that are well known from the fossil record and range from the Triassic to Cretaceous. Numerous genera (and even more species) of bennettitalean leaves have been described as well as female and male reproductive organs, and trunks (mainly Harris 1932b, 1969, Sharma 1970, 1971, Watson & Sincock 1992). Mainly according to the specific form of their ovule-bearing structure and pollen organs, and also the presence of syndetocheilic stomata on their leaves they are considered as possibly related to the flowering plants and have previously been included in the antophytes (Doyle & Donoghue 1986).

From the two families (Cycadoideaceae and Williamsoniaceae) only the Williamsoniaceae are represented in the Mecsek Mountains by relatively few and fragmentary specimens. During ten years, only about 70 bennettitelean specimens have been found, with these collected mainly on dumps of the Zobák shaft near Komló (for locality data see Nagy 1961, Paál-Solt 1969, Lachkar et al. 1984). Although some fossil plant remains were published in 1961 (Nagy 1961), neither bennettitalean leaves nor scale leaves of the *Cycadolepis* – type were mentioned in this paper.

In the Liassic plant community in Hungary bennettites are considered to be rather rare plants. The low number of the specimens corresponds with low specific diversity: the Hungarian bennettites are represented by two species that belong to two distinct genera: *Pterophyllum subaequale* and *Anomozamites marginatus*. Scales from bennettitalean female fructifications, that are generally attributed to the genus *Cycadolepis* and are here represented by two species: *C. rugosa* and to a new species, *C. johannae*. Together with the leaves some fragments of the bennettitalean trunks have been collected, but their state of preservation is too poor for more precise determinations to be made. This type of bennettitalean or cycadalean trunks are usually classified as belonging to the genus *Bucklandia*.

The present paper gives a short taxonomical review of Hungarian bennettites, supported by cuticular examination.

MATERIAL

The material consists mainly of small leaf fragments (about 70 specimens), usually without base or apex, and separated scales that are typically incomplete (23 specimens, of which 9 are preserved completely). All samples are preserved with cuticles, but in several cases cuticles have been destroyed by pyrite. In addition three fragmentary bennettitalean stems have been identified. These sre strongly coalified, but often retain small pieces of cuticle at the leaf bases. All described specimens are stored in the Hungarian Natural History Museum, Budapest, in the palaeobotanical collection (BP) of the Botanical Department.

SYSTEMATICAL DESCRIPTION

BENNETTITALES

Pterophyllum Brongniart 1828

Pterophyllum subaequale Hartz 1896

Pl. 1 figs 1–2, Pl. 2 figs 1–4, Fig. 1

1896 *Pterophyllum subaequale* Hartz, p. 236, Pl. 15 fig. 1, 3.
1922 *Pterophyllum andraeanum* Johansson, p. 33, Pl. 5 fig. 15–17, Pl 8 fig. 22, 23.
1928 *Pterophyllum polonicum* Makarewiczówna, p. 20, Pl. 1(IX) figs. 3–5.
1932a *Pterophyllum subaequale* Hartz; Harris, p. 96, Text fig. 38 A-C.
1932b *Pterophyllum subaequale* Hartz; Harris, p. 74, Pl. 6 fig. 8–14, Figs. 39–42.
1963 *Pterophyllum subaequale* Hartz; Reymanówna, p. 22, Pl. 4 figs 1–3, Fig. 5A-G.

M a t e r i a l. BP 94.130.1.A, D, 94.179.1.B, 94.180.1.B, 94.182.1.A, 94.183.1.A, B, 96.180.1.A, 96.274.1, 96.276.1.C, 96.299.1.A, 96.300.1.A, 96.333.1, 96.337.1.B, 96.350.1.A, 96.394.1, 98.12.1, 98.997.1

D e s c r i p t i o n. Leaves with pinnules lateraly attached to the rachis, varied in size and shape (Fig. 1). At the base of leaf the pinnules are short and have broad bases, they are nearly triangular while towards the apex they become longer and narrower. Typical leaves have pinnules about 14–16 mm long and 3–4 mm wide (Figs 1.3, 1.8), unusual leaves (Figs 1.11, 1.17) have short and broad pinnules, 8 × 6 mm, 10 × 5 mm, or 9 × 5 mm. None of the specimens have leaf apices preserved. The venation is clearly visible, parallel, simple or once forked, reaching the end of the pinnule. The rachis is covered by transverse wrinkles (Pl. 1 figs 1, 2).

Leaves are hypostomatic. The cuticle is moderately thick, with the upper cuticle sometimes being as thick as the lower one although sometimes it may be slightly thicker. The upper cuticle shows uniform rectangular cells, often with oblique cell walls. The cell walls are sinuous (Pl. 2 fig. 1). On the lower cuticle (Pl. 2 figs 2–4) the cells are rounded to polygonal between the veins (among the stomata), the veins are marked by rectangular, slightly elongated or square cells. The cell walls are sinuous. Syndetocheilic stomata are situated in narrow (two-stomata wide) bands between the veins, excluding the area near the pinnule margins (29–30 μm wide) which are stomata free. The guard cells are oriented transversely to the veins. Hair bases are round or eliptical, surrounded by 6–7 unspecialised cells, distributed on the lower cuticle over the veins (Pl. 2 fig. 4).

Anomozamites Schimper 1870

Anomozamites marginatus (Unger 1850) Nathorst 1878b

Pl. 1 fig. 3, Pl. 2 figs 5–6, Pl. 3 figs 1–2, Fig. 2

1850 *Pterophyllum marginatum*, Unger, p. 289.
1867 *Pterophyllum marginatum* Unger, Schenk, p. 166, Pl. 37 figs 2–4.
1876 *Anomozamites gracilis*, Nathorst, p. 43.
1876 *Anomozamites marginatus*, Nathorst, p. 45.
1878a *Anomozamites gracilis* Nathorst, p. 19, Pl. 2 figs 8–11.
1878b *Anomozamites gracilis* Nathorst, p. 21, Pl. 12 figs 4–12.
1878b *Anomozamites marginatus* Nathorst, p. 22, Pl. 12 figs 1–3.
1914 *Anomozamites gracilis* Nathorst; Gothan, p. 132, Pl. 23 figs 2–4, Pl. 24 fig. 3, Pl. 37 figs 1–4.
1919 *Anomozamites gracilis* Nathorst; Antevs, p. 34, Pl. 4 figs 27–29.
1924 *Anomozamites gracilis* Nathorst; Chow, p. 7, Pl. 1 figs 11–12, Pl. 2 fig. 12.
1932a *Anomozamites gracilis* Nathorst; Harris, p. 97, Text fig. 38 D-G.
1932b *Anomozamites marginatus* (Unger) Nathorst; Harris, p. 21, Pl. 6 figs 4–7; Text fig. 6.
1991 *Anomozamites minor* (Brongniart) Nathorst; Barbacka, p. 18, Pl. 1 figs 6–7; Pl. 2 figs 1–3, Text fig. 5.

M a t e r i a l. BP 94.129.1.A, 94.130.1.B, C, 94.131.1.A, C, 94.179.1.A, 94.182.1.B, C, 96.237.1, 96.267.1.D, E, 96.272.1.A, 96.273.1, 96.276.1.D, 96.300.1.B, C, 96.307.1.A, D, 96.308.1.D,

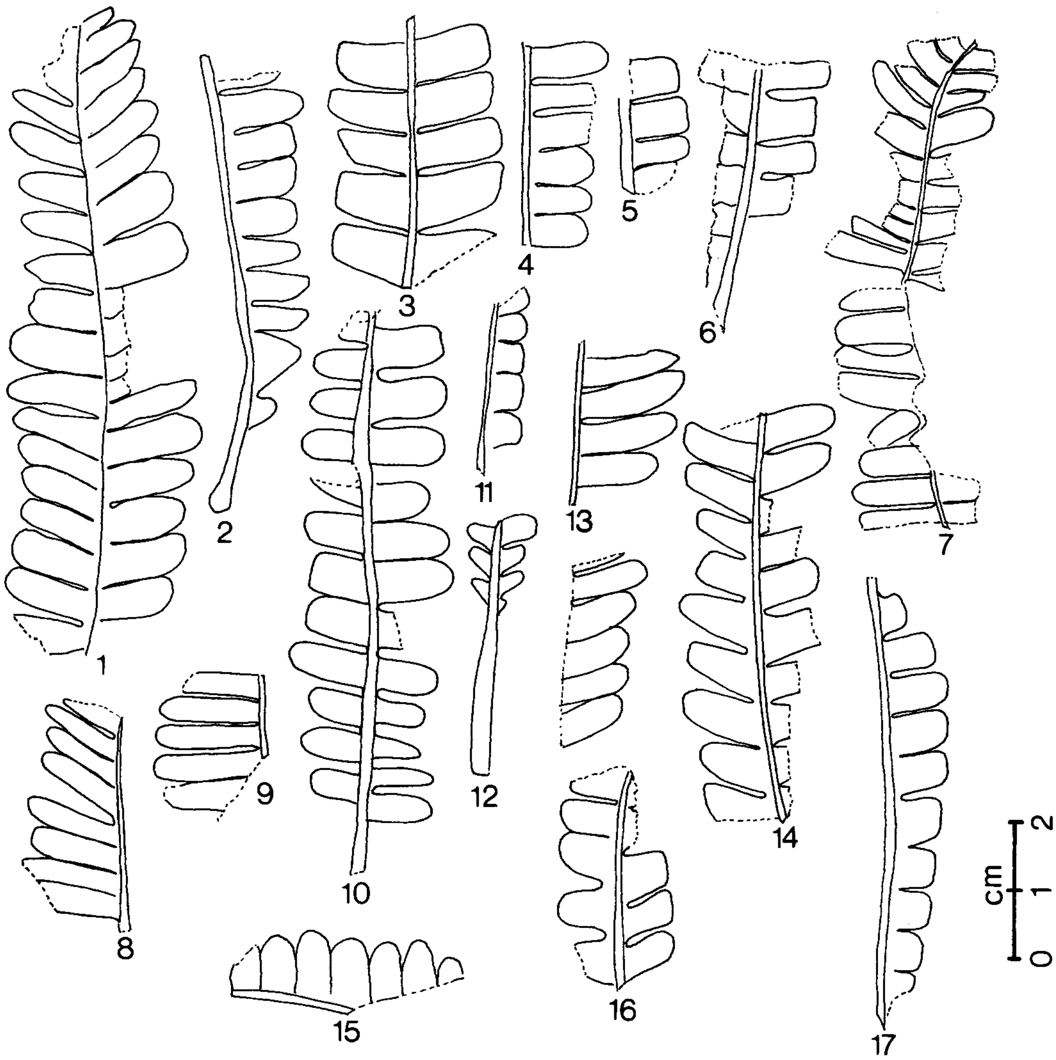

Fig. 1. *Pterophyllum subaequale* Hartz, variability of leaf form. **1** – BP 98.997.1; **2** – BP 96.300.1.A; **3** – BP 94.182.1.A; **4** – BP 94.183.1.B; **5** – BP 94.130.1.D; **6** – BP 94.180.1.B; **7** – BP 94.130.1.A; **8** – BP 96.274.1; **9** – BP 96.394.1; **10** – BP 94.180.1.A; **11** – BP 96.350.1.A; **12** – BP 98.12.1; **13** – BP 94.179.1.B; **14** – BP 96.276.1.C; **15** – BP 94.183.1.A; **16** – BP 96.299.1.A; **17** – BP 96.333.1

96.350.1.G, 96.377.1.A–C, 96.392.1.A, B, 96.403.1.C, D, G, J, 98.10.1,

Description. Fragmentary leaves with pinnules lateraly attached to the rachis, variable in shape (Fig. 2). Their size in the typical specimens is from 11 × 8 mm in large leaves to 6 × 4 mm in small ones. The extremely elongated pinnules (sometimes on the same rachis as typical pinnules) may be 13 × 6 mm, or even 14 × 4 mm (Figs 2.15, 2.18, 2.22). The rachis is transversely wrinkled, has conspicuous veins that may be simple or forked.

Leaves are hypostomatic. The cuticle is moderately thick, the upper cuticle is thicker than the lower one. On the upper cuticle cells are rectangular or square (Pl. 2 fig. 5), on the lower cuticle more polygonal (Pl. 2 fig. 6). Cell walls are sinusoid on the both surfaces. Syndetocheilic stomata (Pl. 3 fig. 1) are oriented randomly, sometimes in more or less regular strips between the veins, sometimes scattered on whole surface of the pinnule excluding area at the margins (12–27 μm wide). Round hair bases are occasionally present on the lower cuticle (Pl. 3 fig. 2).

Discussion. The genera *Pterophyllum* and *Anomozamites* are purely artificial since their reproductive organs are unknown. The differences between both genera refer to some macro- and micromorphological features. Harris (1932b, p. 20) gave a list of aspects on the grounds of which they may be distinguished, indicating also the exceptional cases. *P. subaequale* is an exception and its features are

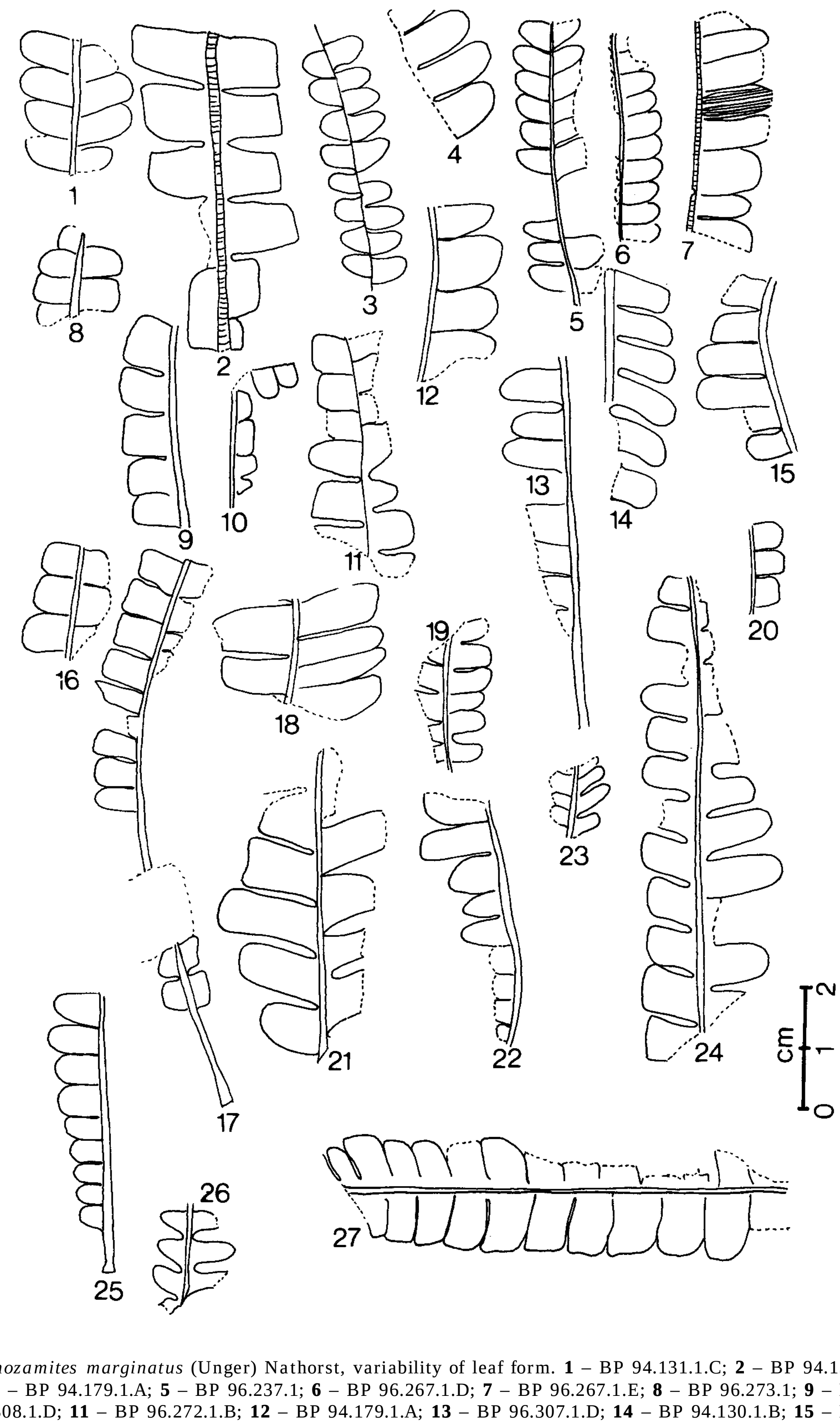

Fig. 2. *Anomozamites marginatus* (Unger) Nathorst, variability of leaf form. **1** – BP 94.131.1.C; **2** – BP 94.131.1.A; **3** – BP 94.182.1.B; **4** – BP 94.179.1.A; **5** – BP 96.237.1; **6** – BP 96.267.1.D; **7** – BP 96.267.1.E; **8** – BP 96.273.1; **9** – BP 96.403.1.C; **10** – BP 96.308.1.D; **11** – BP 96.272.1.B; **12** – BP 94.179.1.A; **13** – BP 96.307.1.D; **14** – BP 94.130.1.B; **15** – BP 94.130.1.C; **16** – BP 94.129.1.A; **17** – BP 96.276.1.D; **18** – BP 96.392.1.B; **19** – BP 98.10.1.; **20** – BP 96.377.1.B; **21** – BP 96.300.1.B; **22** – BP 96.403.1.J; **23** – BP 96.377.1.C; **24** – BP 96.392.1.A; **25** – BP 94.182.1.C; **26** – BP 96.300.1.C; **27** – BP 96.307.1.A

not fully representative for the genus (e.g. sinusoid cell walls and lack of papillae on epidermal cells, being characteristic for the genus *Anomozamites*). Moreover, the samples of both genera from the Mecsek Mts. have a very similar morphology (Figs 1, 2, Tab. 1).

Table 1. Comparison of Hungarian species *Pterophyllum subaequale* and *Anomozamites marginatus*

characteristics	*P. subaequale*	*A. marginatus*
length and breadth of typical segment (mm)	15 × 3	10 × 6
length and breadth of extremely elongated segment (mm)	–	14 × 4
length and breadth of extremely short segment (mm)	8 × 6	–
surface of midrib	wrinkled	wrinkled
veins	simple or forked	simple or forked
upper cuticle, cell wall	sinusous	sinusous
lower cuticle, cell wall	sinusous	sinusous
distribution of stomata	in narrow rows between the veins	more or less wide strips between the veins, or scattered
orientation of guard cells	transversal to the veins	random

Leaves of both species are uncommonly poorly developed. The specimens are often smaller and more slender than the typical forms of *P. subaequale* and *A. marginatus*. In each of the species there are besides typical morphological forms, forms of which the shape of leaves agrees with that of the other species. In *P. subaequale* leaves were found with unusualy short and broad pinnules, while in *A. marginatus* some pinnules are more elongated than usual. One specimen of *A. marginatus* among the typical segments shows some pinnules with a ratio length/width that usually characterize *Pterophyllum*. Both species are characterized by a noticably wrinkled rachis which, in addition to the atypical leaf forms makes it impossible to determine a leaf only on the basis of the morphological characteristics. In the present assemblage, determination was mainly based on the cuticular structure which shows clear features of both genera: they differ especially in orientation of stomata which is random in *Anomozamites* and transversal to the veins in *Pterophyllum* (Harris 1932b).

P. subaequale from Hungary is in comparison to the specimens described from Schonen by Johansson (1922) and from Greenland by Harris (1932b) rather small in size; they resemble mainly the specimen illustrated by Harris (1932b, Fig. 41 B). According to their size the Hungarian specimens are more similar to the Polish specimen described by Reymanówna (1963). The cuticular features are typical for the species (Harris 1926, 1932b, Johansson 1922, Reymanówna 1963).

Anomozamites marginatus (Unger) Nathorst is conspecific with *A. gracilis* Nathorst since the two species were united by Harris (1932b). Harris, following Gothan's opinion (Gothan 1914) proved, that the differences between two species do not justify their separation and conserved the name *gracilis* for the form of leaves that do not have the characteristic fold at the margins and have stomata confined to strips between the veins. *A. marginatus* from Hungary seems to belong to the form *gracilis* without a fold near the non-stomatal area at the margins of the pinnule. Its stomata are distributed in strips like in the form *gracilis*, or scattered, which is typical for the form *marginatus*. Perhaps both forms can not be clearly distinguished.

One specimen from the Mecsek Mts. mentioned by Barbacka (1991) under the name *A. minor* Nathorst was actually redetermined. Although the characteristics of *A. minor* are very close to those of *A. marginatus*, the rachis of *A. minor* is never wrinkled (Harris 1932b) and the occurence of *A. minor* is restricted to the Rhaetian *Lepidopteris* zone while *A. marginatus* belongs to the Liassic *Thaumatopteris* zone (Harris 1932b) which is represented in the Mecsek Mts.

Cycadolepis Saporta 1875

Cycadolepis rugosa Johansson 1922

Pl. 1 figs 4, 7, Pl. 3 figs 3–5, Fig. 3.

1922 *Cycadolepis rugosa* Johansson, p. 40, Pl. 5 figs 19–23

1932b *Cycadolepis rugosa* Johansson; Harris, p. 93, Pl. 11 figs 3, 8–11, Text fig. 47 A-G

Material. BP 96.302.1.B, 96.335.1, 96.350.1.D, 96.403.1.I, 96.496.1.C, 96.496.1.H, 96.510.1, 98.11.1, 98.996.1.

Description. Among nine specimens of *Cycadolepis rugosa* (Fig. 3), five are completely

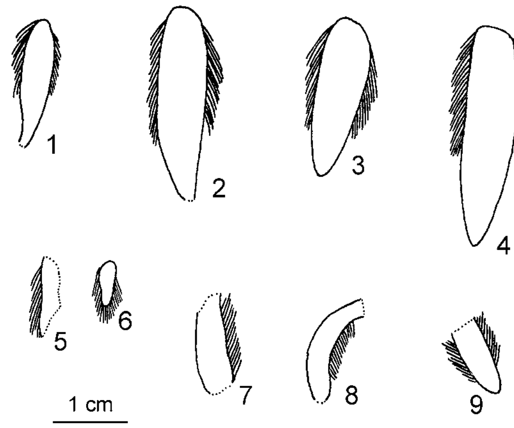

Fig. 3. *Cycadolepis rugosa* Johansson, different forms of scales. **1** – BP 96.335.1; **2** – BP 96.510.1; **3** – BP 96.350.1.D; **4** – BP 98.996.1; **5** – BP 96.302.1.B; **6** – BP 98.11.1; **7** – BP 96.496.1.C; **8** – BP 96.403.1.I; **9** – BP 96.496.1.H

preserved. The largest is 30 mm long and 7 mm wide in the widest point, the smallest one is 7 mm long and 2 mm wide. They are elongated in shape with a rounded base and gradually tapering, entire margins which form at the end of pinnule an acute or subacute apex. Usually the margins of the lower half bear dense, 3–4 mm long ramenta directed towards the apex (Pl. 1 figs 4, 7). Only one sample, the smallest, has ramenta on the whole length of margins and also covering the apex (Fig. 3.6). The surface of the scales is transversely wrinkled (Pl. 1 fig. 4).

The cuticle is rather thick, the adaxial thicker than the abaxial cuticle. The adaxial cuticle shows elongated, rectangular or rarely square cells with thick and straight cell walls. No stomata have been found on this cuticle (Pl. 3 fig. 3).

The abaxial cuticle has rather irregular cells (Pl. 3 figs 4, 5). Stomata are syndetocheilic, not dense, and are scattered on the whole surface except in a narrow area near the margins (about 16 μm). The guard cells are oriented longitudinally. Rare hair bases consist of the thickening surrounded by 4–7 concentrically arranged cells.

Cycadolepis johannae Barbacka, **sp. nov**.

Pl. 1 figs 5–6, Pl. 3 fig. 6, Pl. 4 figs 1–5, Fig. 4.

Holotype. 96.307.1.E, Pl. 1 fig. 5.

Repository. Botanical Department of the Hungarian Natural History Museum, Budapest.

Type locality. Komló, Zobák shaft, dump (Budafa), the Mecsek Mountains, Hungary.

Stratigraphic horizon. Lower Liassic (Hettangian), Karolinavölgy Formation

Derivatio nominis. Named in honour Dr. Johanna H.A. van Konijnenburg-van Cittert (Laboratory of Palaeobotany and Palynology, University of Utrecht, the Netherlands) in respect her scientific results.

Material. BP 98.11.1, 96.308.1.E, 96.308.1.H, 96.403.1.K, 96.305.1.D, 96.306.1.A, 96.403.1.K, 96. 308.1.A, 96.332.1.I, 96.307.1.B, 96.307.1.E, 96.307.1 F, 96.308.1.F, 96.403.1.B.

Diagnosis. Scales of varied shape, 15–30 mm long. From drop-shaped to rather narrow, elongated, sometimes curved. Margins entire, without ramenta. Surface wrinkled. Adaxial cuticle thicker with rectangular or elongated cells, abaxial cuticle thinner with square, sometimes rounded cells. Stomata, only on abaxial side, scattered, oriented longitudinally. Hair bases occasional.

Description. Several scales have been identified with varied shape and size. From fourteen specimens (Fig. 4) five are completely preserved. Two of them are drop-shaped with extended, rounded base and acute apex, one elongated and narrow, one crescent-shaped and one narrow with curved end that is probably the base. The fragmentary preserved scales belong to all mentioned forms, one small end (base? top?) that is hook-shaped. The average length of scales is about 25 mm, the small one measures 15 mm. The width of

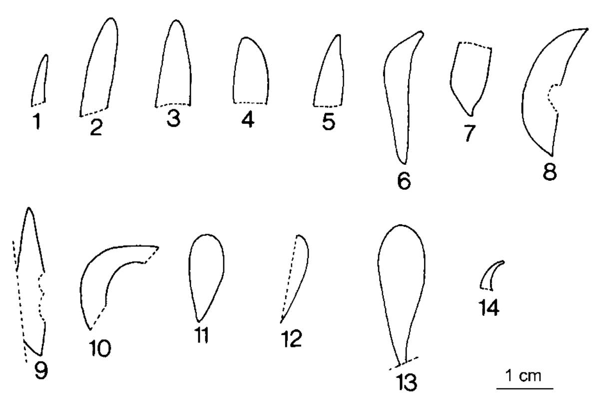

Fig. 4. *Cycadolepis johannae* sp. nov., different forms of scales. **1** – BP 98.11.1; **2** – BP 96.308.1.E; **3** – BP 96.308.1.H; **4** – BP 96.403.1.K; **5** – BP 96.305.1.D; **6** – BP 96.306.1.A; **7** – BP 96.403.1.K; **8** – BP 96. 308.1.A; **9** – BP 96.332.1.I; **10** – BP 96.307.1.B; **11** – BP 96.307.1.E (the holotype); **12** – BP 96.307.1 F; **13** – BP 96.308.1.F; **14** – BP 96.403.1.B

the drop-shaped scales is about 6–9 mm at the widest point, of the narrow type about 4 mm wide, the crescent-shaped one is 7 mm in the middle. The margins of these scales are entire, without ramenta (Pl. 1 figs 5, 6, Fig. 4).

The cuticle is moderately thick, the adaxial one is slightly thicker that the abaxial cuticle (Pl. 3 fig. 6). The adaxial cuticle shows rectangular cells with straight cell walls. Other characteristics are not observed (Pl. 4 fig. 1). Cells of the abaxial cuticle are square to rectangular or irregular with straight cell walls (Pl. 4 fig. 2). Stomata syndetocheilic, not very frequent, scattered (Pl. 4. figs 2, 3); the margins of the scales are free of stomata for a distance of about 20 µm. Guard cells are oriented longitudinaly. Occasionally simple hair bases are observed (Pl. 4 figs 4, 5).

DISCUSSION

In general, the scales of both described species are very similar to each other (Fig. 4). The variability of their shape and size suggests that they might occupate different positions on the axis of the fructification. The main difference between the two types of scales is the presence of ramenta in *Cycadolepis rugosa* and the absence of ramenta in *C. johannae*. For hitherto described species this feature was considered a specific one (Harris 1969, Watson & Sincock 1992).

Although a similar cuticular structure in both species may suggest that all scales represent one taxon only, their morphology rather contradicts it. In both species there are scales of similar categories of size and shape. If we assume that they belong to one species, the different position on the stalk of the same organ would cause a stronger differentiation of shape and size between scales with ramenta and without them.

Generally the bennettitalean leaf-scales of a particular species do not differ in a high degree from each other; usually their shape and size are slightly different and also the absence or presence of hairs (each of these features may depend also on the scale position along the stalk). The Hungarian species are not similar to any species from the Cretaceous of English Wealden (Watson & Sincock 1992), nor from the French Kimmeridgian (Barale 1981), but *C. johannae* is morphologically rather similar to *C. spheniscus* Harris, *C. nitens* Harris, and some specimens of *C. hypene* Harris from the Jurassic of Yorkshire (Harris 1969). The difference, observed in the cuticular structure regards details like the structure of the hairs. The most important is their attribution which directly determines their taxonomy. *C. spheniscus* probably belongs to *Otozamites gramineus* Phillips, *C. nitens* to *Ptilophyllym pecten* Phillips and *C. hypene* is related probably to *Ptilophyllum pectinoides* Phillips (Harris 1969).

Since the bennettitalean leaves are represented in Hungary by two taxa only, the scales may be also attributed to two different species. *C. rugosa* is known to be related to *Pterophyllum subaequale* (Johansson 1922, Harris 1932b).

It seems to be obvious that *Cycadolepis johannae* might belong to *Anomozamites marginatus*, even although its relationship with any reproductive organ has not been established as yet.

Bucklandia Presl 1825

Bucklandia sp.

Pl. 1 fig. 8, Pl. 4 fig. 6.

M a t e r i a l. BP 96.209.1–211.1

D e s c r i p t i o n. Three specimens that probably represent three pieces of the same trunk (they were found in the same time and in the same place) are all fragments of the outer surface of a bennettitalean trunk. They are strongly coalified. The leaf cushions are rhomboid and the leaf bases are visible as drop-shaped scars with small fragments of cuticles at their edges. The rhomboid cushions reach 44 mm in height and 20–22 mm in width. The smaller, drop-shaped scars are about 22 mm high and about 10 mm wide in the widest point (Pl. 1 fig. 8).

The cuticle shows polygonal cells with sinusoid cell walls, unfortunately very fragmentary, without stomata (Pl. 4 fig. 6).

R e m a r k s. The preservation of trunk fragments is too poor for exact determination to be permitted. The cuticle remains found at the leaf bases show clear affinity to the bennettitalean leaves described from the same locality since both species have sinusoid cell walls. The size of the trunk fragments and size of the leaf bases on their surface suggest that the trunk was rather large in size.

ACKNOWLEDGEMENTS

I wish to thank Dr. Johanna H.A. van Konijnenburg-van Cittert (Laboratory of Palaeobotany and Palynology, University of Utrecht, the Netherlands) for her advice during my work. The drawings were done by Éva Budai (Hungarian Natural History Museum, Budapest). This study was supported by a grant from the Hungarian National Science Found (OTKA T 025665).

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PLATES

Plate 1

1. *Pterophyllum subaequale* Hartz, bar = 10 mm, No BP 98.997.1
2. *Pterophyllum subaequale* Hartz, bar = 20 mm, No BP 96.274.1
3. *Anomozamites marginatus* (Unger) Nathorst, bar = 10 mm, No BP 96.307.1.A
4. *Cycadolepis rugosa* Johansson, bar = 30 mm, No BP 96.350.1.D
5. *Cycadolepis johannae* sp. nov., holotype, bar = 26 mm, No BP 96.307.1.E
6. *Cycadolepis johannae* sp. nov., bar = 22 mm, No BP 96.308.1.A
7. *Cycadolepis rugosa* Johansson, bar = 27 mm, No BP 96.510.1
8. *Bucklandia* sp., bar = 13 mm, No BP 96.210.1

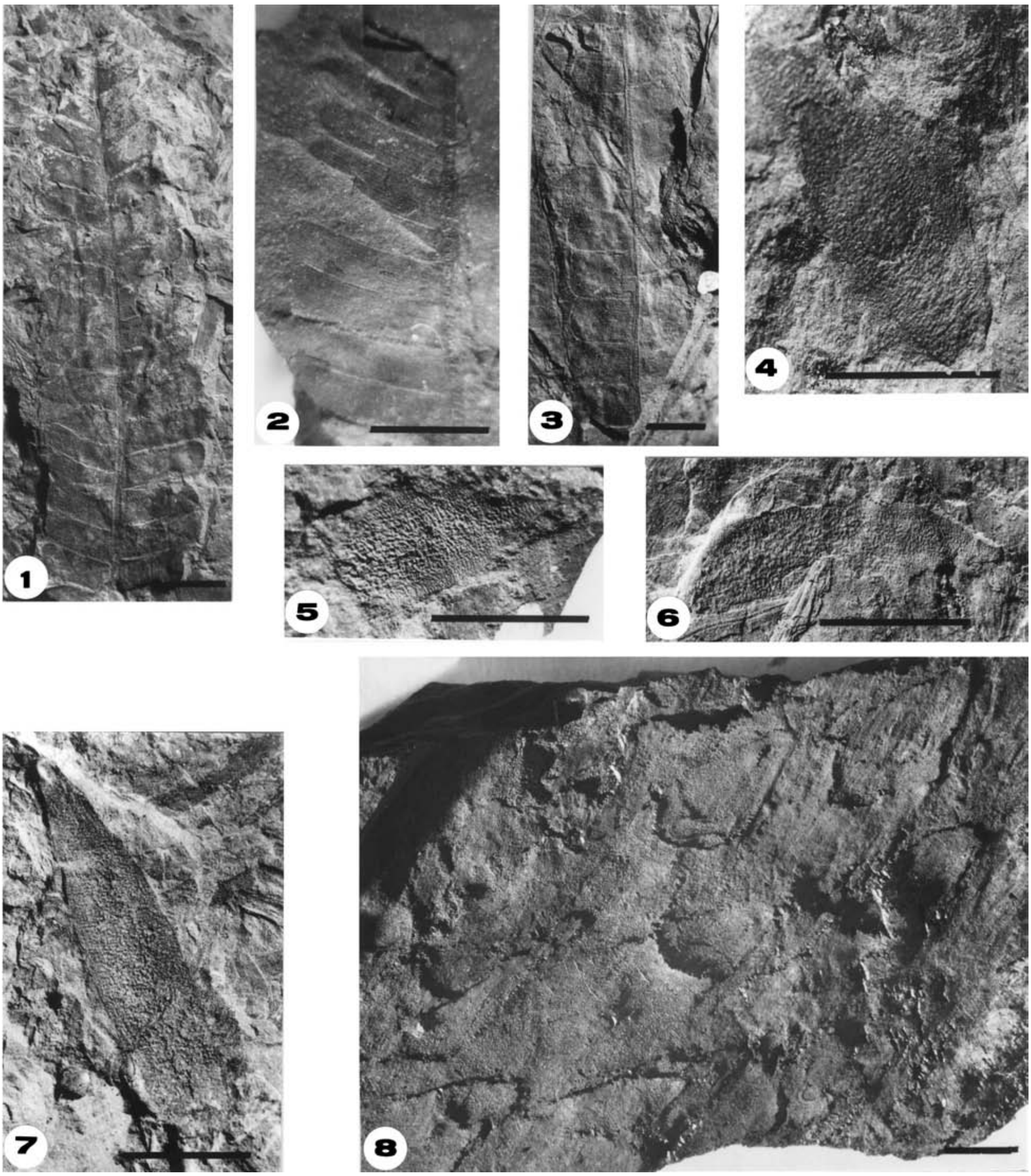
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Plate 2

1–4. *Pterophyllum subaequale* Hartz

1. upper cuticle, bar = 100 μm, No BP 96.276.1.C, slide No 938
2. lower cuticle, bar = 200 μm, slide as in fig. 1
3. lower cuticle, stoma, bar = 50 μm, No BP 96.350.1.A, slide No 986
4. lower cuticle, hair base, bar = 50 μm, slide as in fig. 3

5–6. *Anomozamites marginatus* (Unger) Nathorst

5. upper cuticle, bar = 200 μm, No BP 96.272.1.A, slide No 936
6. lower cuticle, bar = 200 μm, No BP 96.350.1.G, slide No 987

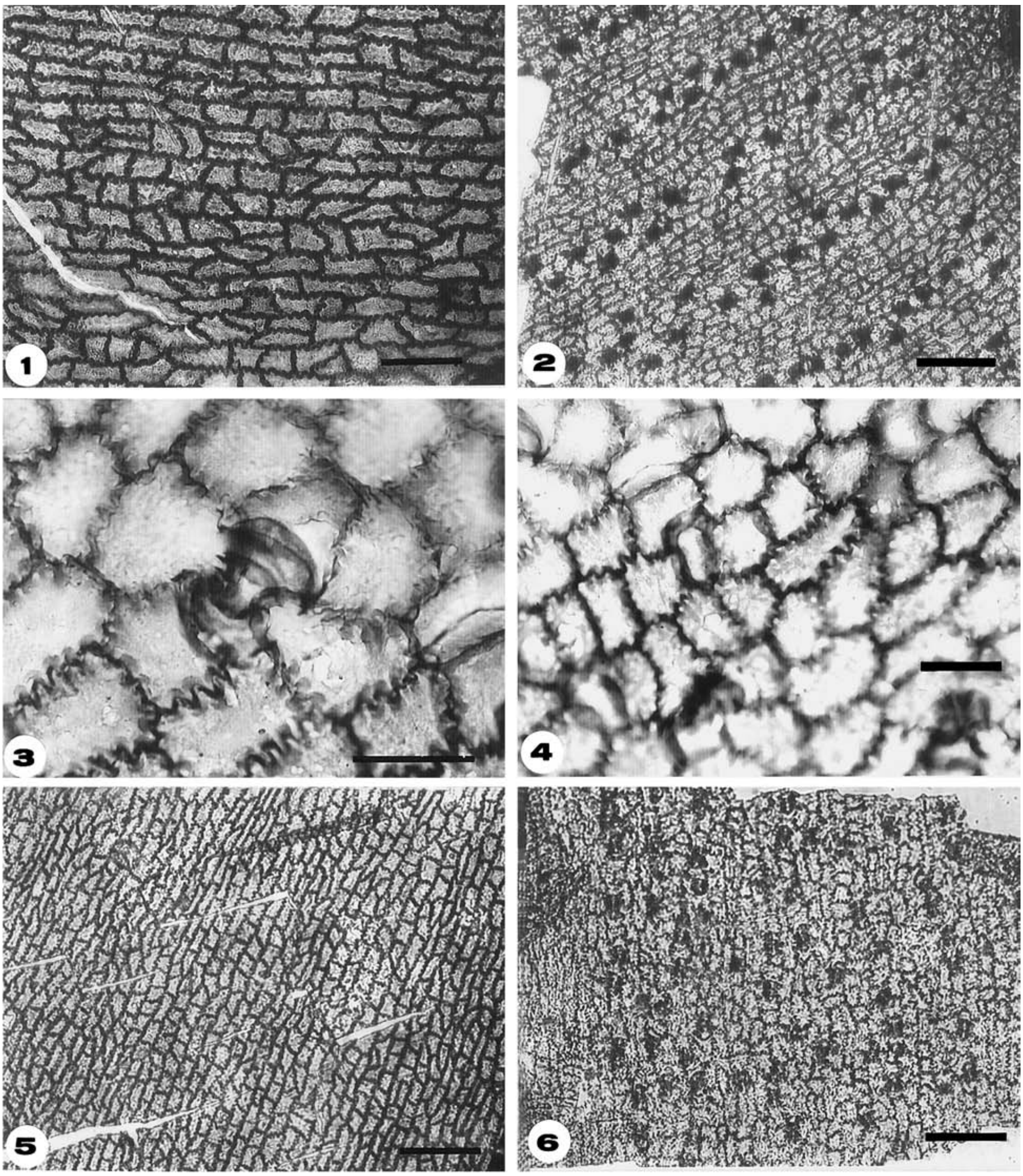
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Plate 3

1–2. *Anomozamites marginatus* (Unger) Nathorst
1. lower cuticle, stomata, bar = 50 μm, No BP 96.350.1.G, slide No 987
2. lower cuticle, hair base, bar = 50 μm, No BP 96.299.1.A, slide No 924

3–5. *Cycadolepis rugosa* Johansson
3. adaxial cuticle, bar = 100 μm, No BP 96.496.1.H, slide No 969
4. abaxial cuticle, bar = 100 μm, slide as in fig. 3
5. abaxial cuticle, bar =50 μm, slide as in fig. 3

6. *Cycadolepis johannae* sp. nov., both abaxial and adaxial cuticles, bar = 200 μm, No BP 96.302.A, slide No 947

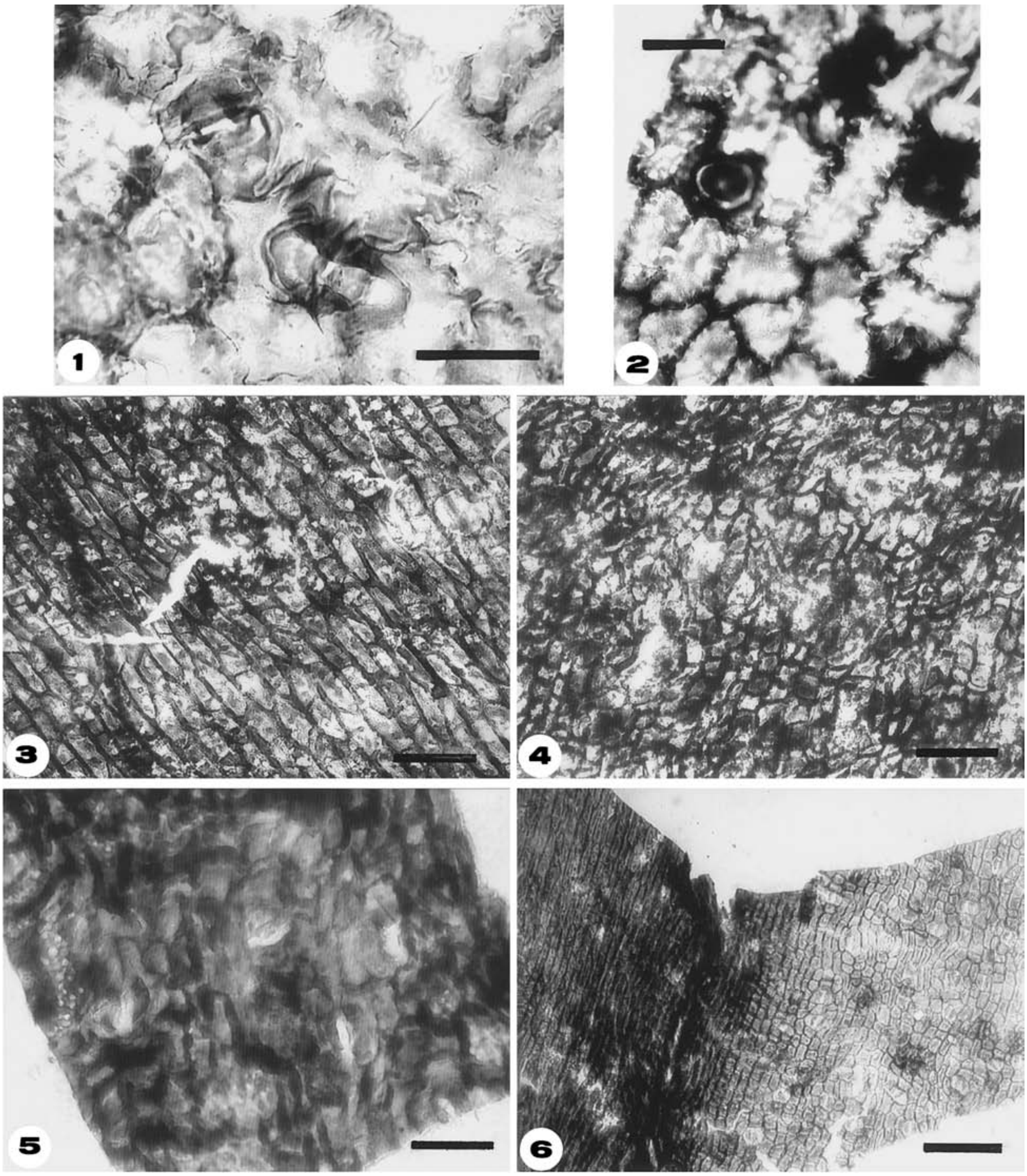
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Plate 4

1–5. *Cycadolepis johannae* sp. nov.

1. adaxial cuticle, bar = 100 μm, No BP 96.283.1.I, slide No 919
2. abaxial cuticle, bar = 50 μm, No BP 96.302.1, slide No 947
3. abaxial cuticle, stoma, bar = 50 μm, No BP 96.308.1.A, slide No 1085
4. abaxial cuticle, hair base, bar = 50 μm, slide as in fig. 3
5. abaxial cuticle, hair base, bar = 50 μm, No BP 96.302.1.A, slide No 947
6. *Bucklandia* sp., cuticle fragment from the base of leaf, bar = 50 μm, No BP 96.307.1, slide No 941