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Early Cretaceous flora of Hungary and its palaeoecological significance

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ABSTRACT. Several fossil plant fragments were collected in the Lábatlan Sandstone Formation, at Buza Hill near Lábatlan (Hungary). Although the preservation makes it impossible for some fossils to give a specific determination, these plant remains are of great interest. Early Cretaceous data about Hungarian flora are extremely scarce.

The collected flora consists of fragments belonging to two species of ferns *(Cladophlebis* sp. and *Sphenopteris* sp.), and three conifers (*Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey, *Sphenolepis kurriana* (Dunker). Schenk emend. Harris, and *Pseudofrenelopsis* sp.). The last has well preserved cuticle.

Besides leaf remains wood fragments were also collected in Lábatlan and examined. The species *Dadoxylon pannonicum* Greguss described earlier from this area, was revised and renamed as *Agathoxylon pannonicum* (Greguss) comb.nov. Two other species of wood were also recognised: *Podocarpoxylon* Gothan and dicotyledon wood.

KEY WORDS: leaf, wood, Filicales, Coniferales, dicotyledons, Early Cretaceous, Hungary

INTRODUCTION

Our knowledge on the macroflora of the Hungarian Early Cretaceous is very poor. There are localities rich in fossil plants of this age in Hungary. Some notes about few, poorly preserved plant remains were published (see the history of investigations), but Early Cretaceous plant remains have never been collected on a large scale. In 1996 a private collector Zoltan Sirányi discovered a small locality in Lábatlan with some fossil plants, where we could collect in 1998 and 1999. Unfortunately, the plant fossils are neither well preserved nor numerous. Many are unrecognisable because of fragmentation. Since this is the only locality with an Early Cretaceous macroflora in Hungary, we decided to describe it, despite of poor character of the flora.

GEOLOGICAL SETTING AND AGE OF THE FORMATION

The material has been collected in the Cretaceous strata of the Gerecse Mountains near Lábatlan (Buza Hill), approximately 70 km north-west from Budapest. Four lithostratigraphic units were recognised by Császár (1997, 1998) in the area.

1. The Bersek Marl Formation – mostly composed of grey and lilac-red marl, clayey marl and siltstone, interbedded with graded sandstone layers 3–10 cm thick occasionally with calcareous marl (Császár & Árgyelán 1994). The age of this formation, confirmed by the presence of the ammonite *Berriasella boissieri* (Fülöp 1958), according to the newest investigations, was determined as Middle Berriasian – Early Hauterivian (Császár 1997, 1998).

2. The Lábatlan Sandstone Formation – forms the upper part of the Cretaceous clastic sequence in the eastern part of the Gerecse Mountains. It consists of yellow – green, lilac – red, brownish – green, fine- to coarse- grained graded sandstones alternating with clayey marl, marl and sandy siltstone. The fossil plant remains are found in some more fine grained horizons (Császár & Árgyelán 1994). Based on the nannoplankton data (Sztanó & Báldi-Beke 1992), as well as on the orbitolinids (Schlagintweit 1990), the age of the formation is estimated between late Hauterivian – to early Albian (Császár 1998).

3. The Tata Limestone Formation consists of yellowish and brownish-grey to pinkish, echinoderm-bearing, crinoidal glauconitic limestone with frequent clasts from the underlying rocks (Császár & Árgyelán 1994). Its age, based on ammonites, was determined as late Aptian (Fülöp 1975), recently extended to early Albian (Császár 1998).

4. The Vértessomló Siltstone Formation is composed of arenaceous and glauconitic rocks. Fossil plant remains are frequent (Császár & Árgyelán 1994). Based on foraminiferal (Bodrogi in Fülöp 1975) and palynological data (Bóna & Juhász unpubl., cit. after Császár & Árgyelán 1994) the age of the formation was determined as early Albian.

HISTORY OF THE EARLY CRETACEOUS FLORAS INVESTIGATION IN HUNGARY

Greguss (1952) was the first, who discovered fossil plant remains in the Cretaceous of Lábatlan, i.e., an axis described as *Dadoxylon pannonicum* Greguss. Rásky (1954) noted the occurrence of the fern *Alsophilina cyatheoides* (Unger) Potonié in Lábatlan and a cone that was identified as *Striaestrobus* Velenovsky & Viniklár from Tata. Fülöp (1958) described a palynological assemblage from Lábatlan, thereby indicating the dominance of pteridophytes in this area. Notes about some fragments of fossil plants are also found in Császár and Árgyelán (1994), who mentioned unidentified fragments of plants in the Lábatlan Sandstone Formation and in the Neszmély Formation.

MATERIAL AND METHODS

Generally, the material is quite poor because of the low number of specimens as well as regarding the average preservation. Most remains present in the locality are small fragments of branches, fragments of coniferalean twigs, separated leaves, fragments of cones, small pieces of woods; only few collected specimens appeared to be identifiable.

The organic material is oxidized in such a high degree that the cuticle is usually not suitable for preparation or even lacking. Because of coarse grained matrix, the leaf fragments have usually unvisible venation or visible only in part. The sandstone usually falls apart very quickly after collecting, and it does not survive drying. Some specimens lacking cuticle were immediately covered by acrylan lacquer.

The only preserved cuticle of *Pseudofrenelopsis* sp. had to be taken from the compression after making a drawing because it broke into small pieces during drying. The cuticule was examined with a light microscope, fluorescence microscope, and the SEM.

The cuticles were prepared using Schulze's reagent: HNO_3 + $KClO_3$ during 4 hours. A weak solution of KOH was used for washing out the oxidized coal matter.

The wood material collected in Lábatlan, has been studied with the SEM JEOL 35CF, at the Centre de Microscopie of Claude Bernard University (CMEABG center, Lyon, France), using the conventional method (Philippe 1995). The preservation is poor but diagnostic features were clear enough for a justified generic identification.

Part of material belongs to the private collector Zoltán Sirányi and is stored in his own collection (Bz with, or without number), it partly belongs to the Hungarian Natural History Museum, Botanical Department (BP). The wood specimens are stored in the Palaeobotany Laboratory, Claude Bernard University, Lyon, France (MP).

SYSTEMATICAL DESCRIPTION

FILICALES

Cladophlebis Brongniart 1849

***Cladophlebis* sp.**

Pl. 1, fig. 1

M a t e r i a l. Bz 96/7

D e s c r i p t i o n. One fragment of a pinna was found, about 25 mm long, bearing 8 pinnules. The rachis is 0.8 mm wide. The pinnule is about 9 mm long, 4–5 mm wide at the base and entire-margined with rounded apex. Pinnules join the rachis at angle of 45°. Their basiscopic side is more developed than the acroscopic one. The venation, visible in one pinnule, is pinnate with a midrib reaching the top of pinnule and dichotomising secondary veins.

Discussion. *Cladophlebis* is the name applied to Mesozoic fern leaves of uncertain affinity which are sterile, bipinnate, and bear pinnules with a single midvein and diverging lateral veins. Harris (1937) has suggested to use *Todites* for fertile leaves and *Cladophlebis* for sterile leaves. The material of Lábatlan belongs to the genus *Cladophlebis* without specific determination. In gross features *Cladophlebis* sp. is near *Cladophlebis denticulata* (Brongniart) Fontaine described by many authors in European floras.

Sphenopteris Sternberg 1825

***Sphenopteris* sp.**

Pl. 1, figs 2, 3

Material. Bz, without number, BP 2000.1138.1, 2000.1144.1.

Description. One fragmentary preserved frond, 50 mm long, composed of alternate pinnae of 30–40 mm long. In addition, some small isolated pinnae were found. The length of the pinnae is about 20–25 mm, the length of the pinnules 6–7 mm and width is about 2 mm. Pinnules have lobed margins, lobes are more developed at the base of the leaf. Some pinnules are asymmetric in relation to their midrib; their margins are not lobed, but only slightly serrate. The venation of the pinnules is not visible.

Discussion. The form-genus *Sphenopteris* was established for pinnules which are constricted at the base, often attached by a short stalk, elliptical in outline, with a margin lobed or toothed, with lateral veins that diverge from the relatively straight or flexuous midvein at low angles singly or in groups.

The general form of the material is of *Sphenopteris* type. The sterile frond of *Coniopteris arctica* (Prynada) Samylina described by Samylina (1964) from the Mesozoic flora of Kolyma river has a strong resemblance to the material of Lábatlan, but without fertile frond.

CONIFERALES

Geinitzia Endlicher emend. Kunzmann 1999

Geinitzia reichenbachii (Geinitz) Hollick & Jeffrey 1909

Pl. 1, figs 4–7

Material. Bz 96/3, Bz 96/8, two pieces Bz without number, BP 98. 537.1, 98.538.1, 98.540.1, 98.543.1, 98.544.1, 98.548.1, 2000. 1140.1 – 2000 1142.1, 2000.98.1145.1

Description. Many small fragments of leaves or axes with coniferous affinities were found. The best preserved specimen consists of a main axis about 80 mm long and 3 mm wide, having three lateral shoots near the base. These shoots arise at an angle of about 45° from the main axis. The main axis shows leaf cushions about 3 mm long and 1.7 mm wide, rhomboidal in shape. Leaves are helically arranged showing 2+3 parastichies. The free part of leaves is between 5 and 10 mm long, slightly curved at the base. The leaves taper in upper third and finally strongly narrow to an obtusely pointed apex. Comparison of the two sides of leaves compressed in different directions proved that the free part of the leaves is square in cross section.

A fertile axis is about 65 mm long and bearing a cone 25 mm long and 15 mm wide. The cone consists of scales, 8 mm long, curved at the top. It is attached to the main axis that is 1.5 mm wide.

Discussion. *Geinitzia* Endlicher is a nomenclatural synonym of *Sedites* Geinitz (Index Nominorum Genericorum http://www.nmhn.si.edu/cgi-bin/wdb/ing). As the latter has not been used since more than 150 years, a conservation should be proposed. A nomenclatural study is needed. The case is particularly intricate, however, and we shall discuss in the future. For this paper we will use the generic name *Geinitzia*, as it is the most used name for the type of isolated leafy twigs we observed.

This genus was proposed by Endlicher (1847) for sterile shoots of the Early Cretaceous from Saxonia, first figured by Geinitz as *Araucarites reichenbachii* and *Sedites ? rabenhorstii* (Geinitz 1842). To this genus Endlicher (op. cit.) included also *Cryptomeria primaeva* Corda. All these species are recently referred to a new species *Geinitzia cretacea* Endlicher. In the description of *G. cretacea* Endlicher gave also some information on fertile shoots with cones. Kunzmann (1999) make an historical review about *Genitzia* Endlicher. The genus *Sedites* is not valid being in open nomenclatur. Kunzmann proposes an emended diagnosis of the genus *Genitzia*.

The Hungarian material is preserved without cuticle but can be attributed to *G. reichenbachii* on the basis of its morphological features. This type of leafy shoots is quite common in the European province and are referred by different authors to *Araucarites, Cryptomeria, Sequoia, Elatides,* and also to some other genera.

Taxodiaceae

Sphenolepis Schenk 1871

Sphenolepis kurriana (Dunker) Schenk emend. Harris 1953

Pl. 1, figs 8, 9

Material. Bz 96/4, BP 98.536.1, 98.539.1, 2000.1136.2, 2000.1139.1, 2000.1143.1

Description. The species is represented by isolated sterile 1–2 mm wide branches bearing minute, scale like leaves. The leaves are always helically arranged with 2+3 contact parastichies. They are 2 mm long and 1 mm wide, their free part is short, up to 1 mm long. The apex varies from acute to rather obtuse. The free part is more of less closely appressed to the axis and curved in adaxial direction.

Remarks. The genus *Sphenolepis* is well known for its foliage, the structure of the wood, female cone and seeds (Harris 1953). They belong to the Taxodiaceae of which *Sphenolepis* is a typical member. Similar shoots are also found in *Athrotaxis cupressoides* Don and members of *Glyptostrobus* belonging to the same family.

The generic name *Sphenolepis* refers essentially to a type of female cone, but may be extended to include the whole plant if its attribution is clear (Harris 1953).

Sphenolepis kurriana is the type species designated by Harris (1953) and is based on the morphology and anatomy examination of sterile and fertile material.

Discussion. The material figured from Lábatlan is near to *Sphenolepis kurriana* (Dunker) Schenk figured by Carpentier (1927) from the Wealden Formation of Feron Glageon (France). It seems similar also to some twigs figured by Harris (1953) from the Wealden Formation of Belgium.

Pseudofrenelopsis Nathorst emend. Watson 1977

Pseudofrenelopsis **sp.**

Fig. 1, Pl. 2, figs 2–8

Material. BP 98.542.1

Description. The specimen is an unbranched axis of 55 mm long. The leaves are small, triangular to crescent shape with scarious margins. The interval between two adjacent leaves is approximately 5–6 mm (Fig. 1). The free part of leaf is about 1 mm long.

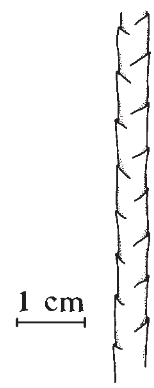

Fig. 1. *Pseudofrenelopsis* sp., the axis with leaves No. BP 98.542.1

The cuticle is thick. The leaves have a 300 μm wide stomata free zone at the margins. Both abaxial and adaxial cuticles are covered by crowded strongly cutinized hairs (Pl. 2, figs 4, 5). At the margins of leaves the hairs form distinct bands: the wider ones with erected hairs corresponding with stomatal bands, alternating with bands of flat lying hairs corresponding with the bands without stomata. The trichomes are oriented towards the apex of the leaf. They are scale-like, elongated and entirely cover the surface of the leaf, also the stomata.

The base of leaf is more cutinized than the leaf blade; also the trichomes are stronger cutinized at the basal margin in the stomata-free area. They are less cutinized, transparent, in the area with stomata, the stomata are weakly visible through them (Pl. 2, fig. 4, arrow). The small trichomes are about 20 μm long and 10 μm wide at the base, the large ones are about 45 μm long and 22 μm wide at the base. They are triangular in shape with a gradually narrowing, extended, almost subacute apex. Sometimes the apex is curved. The density of trichomes is so high that the ordinary epidermal cells are invisible from the outer side of the cuticle. In the stomata-free area near the margins of leaf the epidermal cells are about 50 µm long and 30 µm wide (Pl. 2, fig. 2). They are nearly rectangular with slightly rounded corners, arranged in longitudinal rows. Ordinary cells between the stomatal bands are 10–22 µm wide and 19–26 µm long. The stomata-free bands are about 2–3 cells wide. The anticlinal walls of the epidermal cells are thin (1–3 µm).

Stomata are arranged in single rows. They are crowded, separated from each other by 2–3 narrow ordinary epidermal cells (Pl. 2, fig. 3). Stomata are nearly circular, about 80 µm by 95 µm in diameter, with 4–7 subsidiary cells. They are triangular in shape. Periclinal wall of each subsidiary cell is extended into a small papilla that is directed towards the stomatal pit. The general form of the stomatal pit is oval. The inner surface of the subsidiary cells near the margin with ordinary cells form one or two bulgings which form together a broad thickened rim. The guard cells are not exposed. They are weakly cutinized, about 35 µm long and 15 µm wide. The apertures are orientated randomly (Pl. 2, figs 6, 7). The trichomes overhead stomata are more or less centripetal forming a protecting stomatal chamber. The density of stomata is 110/mm^2; 10 rows in 1 mm.

Discussion. The above described rounded axis with close-sheathed leaves can be attributed to the genus *Pseudofrenelopsis* Nathorst emend. Watson. The specimen from Lábatlan was compared to some other species described from different localities (Tab. 1).

As is clear from Table 1, the characteristics of our material do not show clear similarities to any other species. Our material mainly differs in the density of hairs, the organization, size and density of stomata. No other type of sterile shoot has such dense hairs on both surfaces of the cuticle. A similar density of hairs was observed only in fertile scales of male cones (*Classostrobus*). Therefore we cannot exclude that the axis fragment from Lábatlan might be a basal part of a fertile shoot just below the attachment of male cone.

Table 1. Comparison of *Pseudofrenelopsis* sp. from Lábatlan with selected species

	P. parceramosa	*P. varians*	*P. intermedia*	*Pseudofrenelopsis* sp.
branching	sparse	sparse	–	–
internode, length (mm)	1–11	1.5–17	2–6	6
internode, width (mm)	1	3–7	2.5–8	4
presence of suture	in some “open” forms	no	occasionally	no
leaf number/node	1 (2/5 phyllotaxis)	1	1	1
max. length of free leaf (mm)	2	1.5	10	1
depth of sheathing base (mm)	0.8	0.8	–	–
leaf margin µm	hairs up to 80	hairs up to 60	entire, microscopically dentate	scarious
internode cuticle thickness (µm)	30	50–100	250	?
stomatal arrangement	well defined rows	scattered in “closed” forms	in files, sometimes scattered	well defined rows
density of stomatal rows / mm	6–10	8–10	10–12	10
diameter of stomatal apparatus (µm)	50–80	70–100	40–125	80–100
number of subsidiary cells	usually 5–6, rarely 4 or 7	usually 5–8, rarely 4 or 9	6–11 (in average 8)	4–7
orientation of stomatal aperture	random	random	random	random
papillae inside of stomatal pit	no	no	no	no
trichomes on epidermal cells µm	none to very long hairs	up to 80	no	up to 45, very dense, covering also stomata
rim of stomatal pit	round with- or without papillae	round with papillae	without papillae	with small papillae
strarigraphic range	Berriasian – Albian	Aptian – Albian	Cretaceous	Aptian – Albian

The specimen from Lábatlan was compared to the sterile shoot of *Pseudofrenelopsis parceramosa* (Fontaine) emend. Watson from France, the Aptian of Vocontien basin in southern France and to the scale of the male cone *Classostrobus* sp. from the same locality in France which may belong to the same species (the specimen from France is stored in the collection of the Palaeobotanical Laboratory, Claude Bernard University, Lyon, Gauthier unpubl.). The cuticle of the Hungarian specimen is more similar to the cuticle of the scale belonging to *Classostrobus* because of a similar density of hairs.

The difference is pronounced mainly in the distribution of stomata. They are more dense in *Pseudofrenelopsis* sp. than in *Classostrobus* sp. and bigger (80–100 µm in *Pseudofrenelopsis* sp. and about 60 µm in *Classostrobus* sp.). In *Classostrobus* the hairs around stomata do not arch over the stomatal chamber which is characteristic for the Hungarian specimen. The hairs tips in *Classostrobus* are wider and rounded instead of acute like the hair apices of *Pseudofrenelopsis* sp.

Undetermined specimen

Pl. 2, fig. 1

M a t e r i a l. 2000.1137.2, Bz without number

D e s c r i p t i o n. The leaf (scale?) is oval, 33 mm long and 12 mm wide at the widest point. It has 18 longitudinal veins converging to the apex. The base is incomplete, narrowing to 6 mm, the apex is obtuse.

R e m a r k s. Because of incomplete morphology and lack of cuticle it is impossible to attribute the specimen to any specific taxon. Such a type of structure may belong to Ginkgoales, Bennettitales or Coniferales.

XYLOTOMY

Agathoxylon Hartig 1848

Agathoxylon pannonicum (Greguss) **comb. nov.**

? 1952 *Podocarpoxylon* sp., Greguss, p. 177, Pl. 12, figs 28–30

1967 *Podocarpoxylon* sp. 7, Greguss, p. 42, Pl. 26–29

B a s i o n y m. *Dadoxylon pannonicum* Greguss 1952 , p. 174, Pl. 10, fig. 16–18, Pl. 11, figs 19–27. Vide quoque Greguss 1967, p. 19, Pl. 5, figs 1–9.

T y p e. Greguss (1952) described this species on the base of a sample set. He does not choose a holotype. The number of syntypes is unknown.

T y p e l o c a l i t y a n d s t r a t u m. Early Cretaceous of the Lábatlan Sharpening stone quarry (Greguss 1952: 174).

M a t e r i a l. MP 949

D e s c r i p t i o n. The specimen is a tracheidoxylous wood (Creber 1972), with distinct araucarian radial tracheid pitting and araucarian cross-fields. Its other ray-cell walls are thin and smooth. Because of the nature of the fossil material, which caused strong charging effect under scanning electronic microscop (SEM), we unfortunately did not managed to prepare acceptable views.

D i s c u s s i o n. The wood structure is that of *Agathoxylon* (Philippe 1993), and similar to that described by Greguss (1967) for his *Dadoxylon pannonicum*, also originating from Lábatlan. Despite extensive searches (Philippe & Barbacka 1997, Philippe et al. 1999) we did not manage to locate the holotype of *D. pannonicum* in Hungary. *Dadoxylon* is an illegitimate generic name (Philippe 1993, 1995), and considering the protologue we rename this wood *Agathoxylon pannonicum* (Greguss) comb. nov.

In the collections of the Geological Survey (Rákoczitelep), however, we have found the type material (Bx 57, 13 slides) for Greguss's *Podocarpoxylon* sp. ?, also described in 1952, and originating from the same locality and stratum in Lábatlan. Its preservation is really poor, and although the radial tracheid pitting is definitely araucarian we refer this wood to *Agathoxylon pannonicum*, because of the lack of preserved ray pit, with all proper reserves.

Podocarpoxylon Gothan 1905

Fig. 2: 1–3

M a t e r i a l. MP 948

D e s c r i p t i o n. The sample is another tracheidoxylous wood, however, with abietinean radial tracheid pitting (Fig. 2: 2). Its cross-fields show a single oculipore, which is taxodioid to podocarpoid (Fig. 2: 3). Other ray cell walls are thin and smooth.

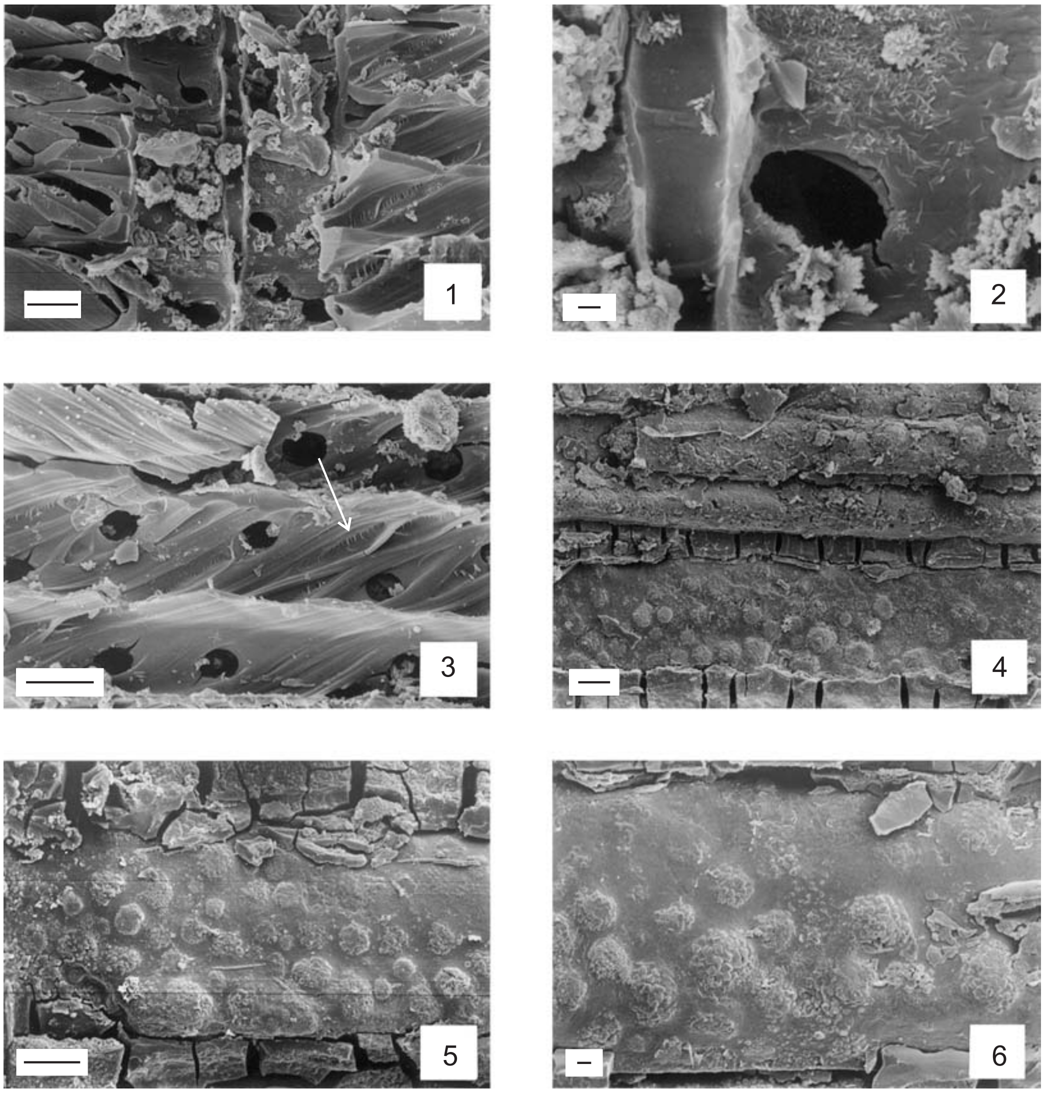

Fig. 2. 1–3. *Podocarpoxylon* sp., No. MP948, **1** – radial view, general view with uniseriate abietinean pitting on the radial walls of the tracheids and one-pitted crossfields with podocarpoid oculipores, SEM; **2** – radial view, detail of podocarpoid oculipores, SEM; **3** – radial view, detail of the uniseriate abietinean pitting on the radial walls of the tracheids, SEM. Arrow – the pseudo-spirals induced by wood decay; 4–6. *Dicotyledoxylon* sp., No. MP955, **4** – radial view, homoxylous wood with elements of variable radial diameter, covered by small simple pits, SEM; **5** – radial view, detail; cell walls are deeply altered and wood elements are preserved as internal casts, as well as the pits, SEM; **6** – radial view, detail of the pit with tunelling bacteria activity traces. Scale bar: figs 1, 3–5 = 10 μm; figs 2, 6 =1 μm

D i s c u s s i o n. Because of its xylological features we refer this sample to the morphogenus *Podocarpoxylon*, noting that its structure looks similar to that of *Podocarpoxylon ajkaense* Greguss. The latter species originates from the Upper Cretaceous (Turonian or early Senonian) of Ajka, Hungary (Borkent 1997).

Dicotyledon wood

Fig. 2: 4–6

M a t e r i a l. MP 955

D e s c r i p t i o n. It is a homoxylous wood, with low and homogeneous rays. Cross-section, observed under binocular, displays faintly marked growth-rings, although inside the early wood the radial diameter of axial elements vary from (45) 50 μm to 110 (120 μm) (Fig. 2: 4), with narrow and large elements evenly distributed. In radial view these axial cells (tracheids ?) are long and covered with minute pits, like these covering the vessel elements (Fig 2: 4–5). The tips of these cells are tapering, but the preservation is too poor to determine whether these longitudinal cells are true vessel elements or an unknown type of tracheid. Rays are uniseriate to locally biseriate over 2 or 3 levels. Each cross-field has 1 to 4 pores, but again the preservation is too poor to safely relate them to a type and to see if other ray-cell walls have pits or not.

Remarks. This third sample from Lábatlan is much more remarkable. Its shape is rounded and it is deeply altered by tunnelling bacteria (Fig. 2: 6), which suggests that it floated a long time in the water before to be buried in the sediment. Unfortunately, this long taphonomical process led up to a poor preservation. This wood looks similar to *Tetracentronites hungaricum* Greguss, a wood from the Miocene of Tokaj, Hungary (Greguss 1964). The latter wood is remarkable. Its taxonomic position is still a matter of debate (Suzuki et al. 1991). Its holotype is housed in the Josef Attila University in Szeged (S 14, 3 slides), and after examining it we can fully confirm the correctness of Greguss's observations. Whatever the systematical position of *Tetracentronites hungaricum* is, the Lábatlan sample has most affinities with the homoxylous dicots and we will thus refer it to *Dicotyledoxylon*.

Discussion. Previous study (Greguss 1952) and our new data assert the occurrence of several wood types in Lábatlan : *Agathoxylon pannonicum* (Greguss) comb. nov., *Podocarpoxylon* cf. *ajkaense* (new data), *Dicotyledoxylon* sp. (new data). This wood assemblage is quite unexpected. The occurrence of *Agathoxylon* and *Podocarpoxylon* is classical in other European Mid-Cretaceous localities (e.g. Stopes 1915, Alvarez-Ramis et al. 1981, Pons et al. 1993). However, the lack of any wood with a structure of Pinaceae is curious, as this type is frequent in Europe at this time (e.g. Pons 1973). Moreover, the occurrence of a homoxylous wood with dicotyledonous affinities is astonishing. Most of recent studies on early dicotyledonous woods underline that, despite its primitive-looking structure, homoxylous wood seems to be absent in Mid-Cretaceous assemblages (Suzuki et al. 1996, Herendeen 1991, Wheeler & Baas 1991). The tectonical framework of Hungary at this time, in an intricate microplate context (Vörös & Galácz 1998), may account for this peculiar distribution.

GENERAL REMARKS

The plant remains from Lábatlan are preserved in such a low amount that a comparison with other floras would be missleading. Table 2 shows some selected European localities. One of them is of the same age as the Lábatlan flora, the Vocontian basin in south-eastern France (Barale & Bréhéret 1995), the age of the other localities is from Hauterivian to Turonian.

The Cenomanian flora of the Bohemian Massif is not presented in the table. It is composed of ferns, Bennettitales, Coniferales and angiosperms (Knobloch & Kvaček 1997) as well as Caytoniales and Cycadales (Kvaček 1999). One genus of Coniferales, *Geinitzia*, is common with the flora from Lábatlan. The rich Bohemian flora provides a long list of species in contrast to the Lábatlan flora, so a comparison of the two floras is questionable.

The similar case is with the flora of the English Wealden, given by Watson and Alvin (1996). It is composed of Bryophyta, Pteridophyta, Prespermatophyta, Spermatophyta except for angiosperms. Cycadales, Bennettitales and Coniferales are well represented. Two conifers are common with the Lábatlan flora: *Pseudofrenelopsis* and *Sphenolepis*.

PALAEOECOLOGICAL REMARKS

The mid-Cretaceous is remarkable because of the very high sea level causing the flooding of the continents. Some were converted into systems of large islands separated by intercontinental seaways occupying vast areas (Dercourt et al. 1986). Alternating polar nights and days inevitable in the Cretaceous polar regions had to result in distinct seasonal variations of climate. The middle latitudes (30–60°) were characterized by humid warm belts. On the basis of palaeobotanical and lithological indications the climatic belt under consideration was termed as tropical to subtropical (Vakhrameev 1978, 1991).

The Early Cretaceous Hungarian plates were probably at the boundary between the northern hot and humid latitudinal belt and the hot and dry tropical belt. Analysis of the composition of the Lábatlan flora shows that conifers and ferns are predominant. Conifers have small leaves, especially Cheirolepidiaceae. The xeromorphous characters of this family have often be discussed by previous authors, particularly Watson (1988). The thickness of the cuticle of *Pseudofrenelopsis* sp.

Table 2. Comparison of the Hauterivian to Turonian floras of Europe. The floristic list contains the original specific names

Age	Locality	Floristic list	References
Turonian	Romania (near Dobrogea)	*Sequoia reichenbachii* *Comptonites antiquum*	Givulescu 1966
Cenomanian	Bulgaria (Belno vrak- Gipfel)	*Gleichenia zippei* *Elatocladus elegans* cf. *Aralia coriacea*	Tenchov & Chernyavska 1965
Cenomanian/ Albian limit	Crimea (near Bakchisaray)	*Hepaticites* sp. *Ruffordia goeppertii* *Anemia dicksoniana* *Gleichenites zippei* *Sagenopteris variabilis* *Lindleycladus lanceolatus* *Geinitzia cretacea* Angiospermae	Krassilov 1984
Albian	Ukraine (Kanev)	*Frenelopsis kanevensis* *Brachyphyllum squamosum* *Kanevia pimenovae* *Kanevia teslenkoi* *Sequoia* sp. *Sagenopteris* sp. *Dnepria schmalhausenii*	Doludenko 1994
	Crimea	*Phlebopteris dunkeri* *Sphenopteris* cf. *delicatissima* *Pterophyllum* sp. *Sphenolepis kurriana* *Elatides curvifolia* *Elatides* sp.	Stanislavsky & Kiselevich 1986
Late Hauterivian – Early Albian	Hungary (Lábatlan)	*Cladophlebis* sp. *Sphenopteris* sp. *Geinitzia reinchenbachii* *Sphenolepis kurriana* *Pseudofrenelopsis* sp.	the present paper
	France (South East)	*Weichselia reticulata* *Frenelopsis alata* *Pseudofrenelopsis parceramosa*	Barale & Bréheret 1995
Barremian	Poland (Przenosza)	*Cycadeoidea* sp.	Reymanówna 1960
Hauterivian	Boundary Poland/ Czech Republic (near Bielsko)	*Weichselia reticulata* *Frenelopsis hoheneggeri*	Reymanówna 1965

can explain its presence in the fossiliferous beds while the cuticle of the others fossils is not preserved. The presence of hairs on the leaves which serve to capture condensing atmospheric moisture during the night is an interesting character already indicated by many authors. The ferns are characterized by small pinnules more in relation with conditions of a hot and relatively dry climate.

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PLATES

Plate 1

1. *Cladophlebis* sp., Bz 96/7
2. *Sphenopteris* sp., Bz
3. *Sphenopteris* sp., detail from fig. 2
4. *Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey, Bz 96/8
5. *Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey, Bz 96/3
6. *Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey, female cone, Bz
7. *Geinitzia reichenbachii* (Geinitz) Hollick & Jeffrey, Bz
8. *Sphenolepis kurriana* (Dunker) Schenk emend. Harris, Bz 96/4
9. *Sphenolepis kurriana* (Dunker) Schenk emend. Harris, SEM material MP No. 91098-4

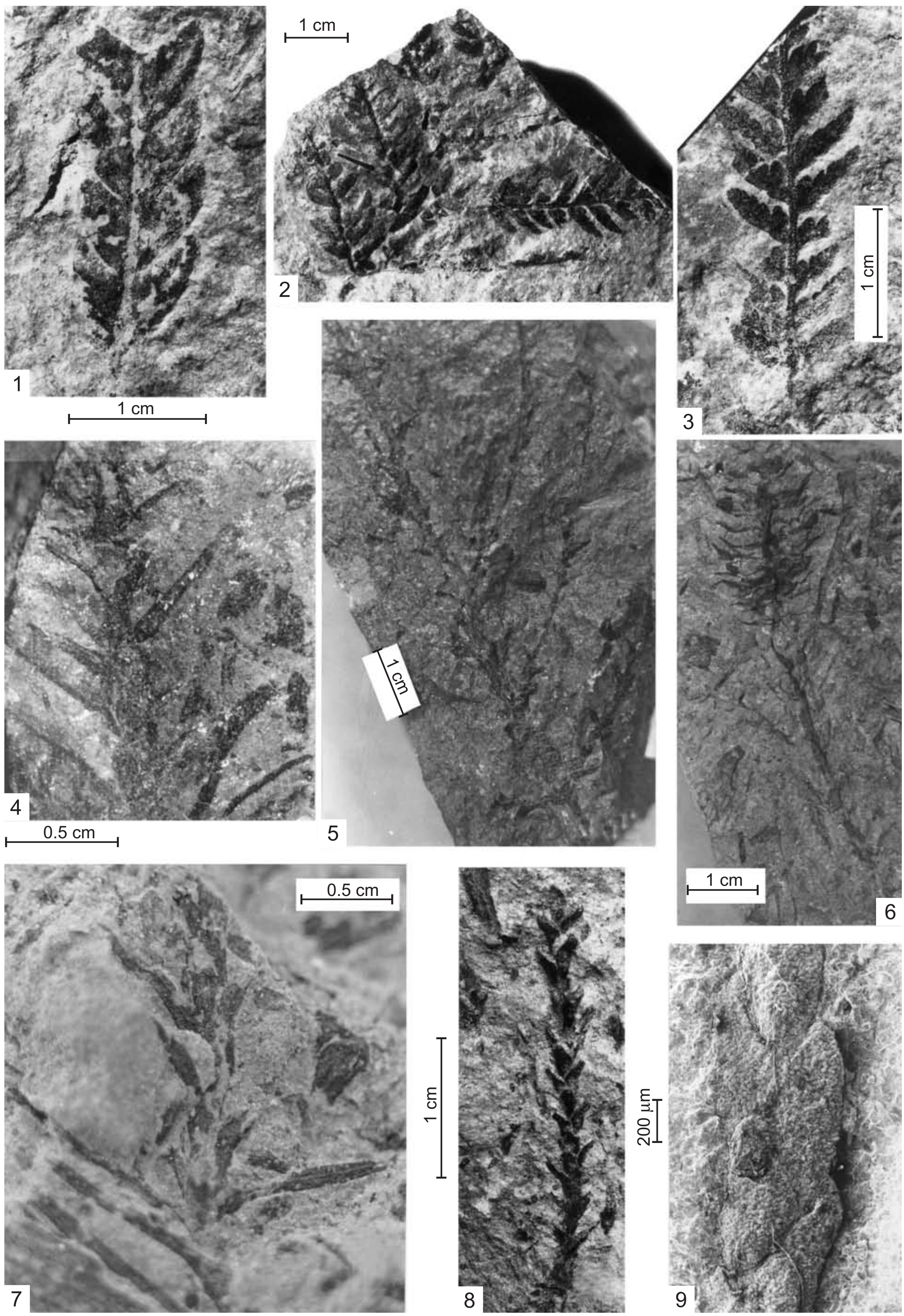
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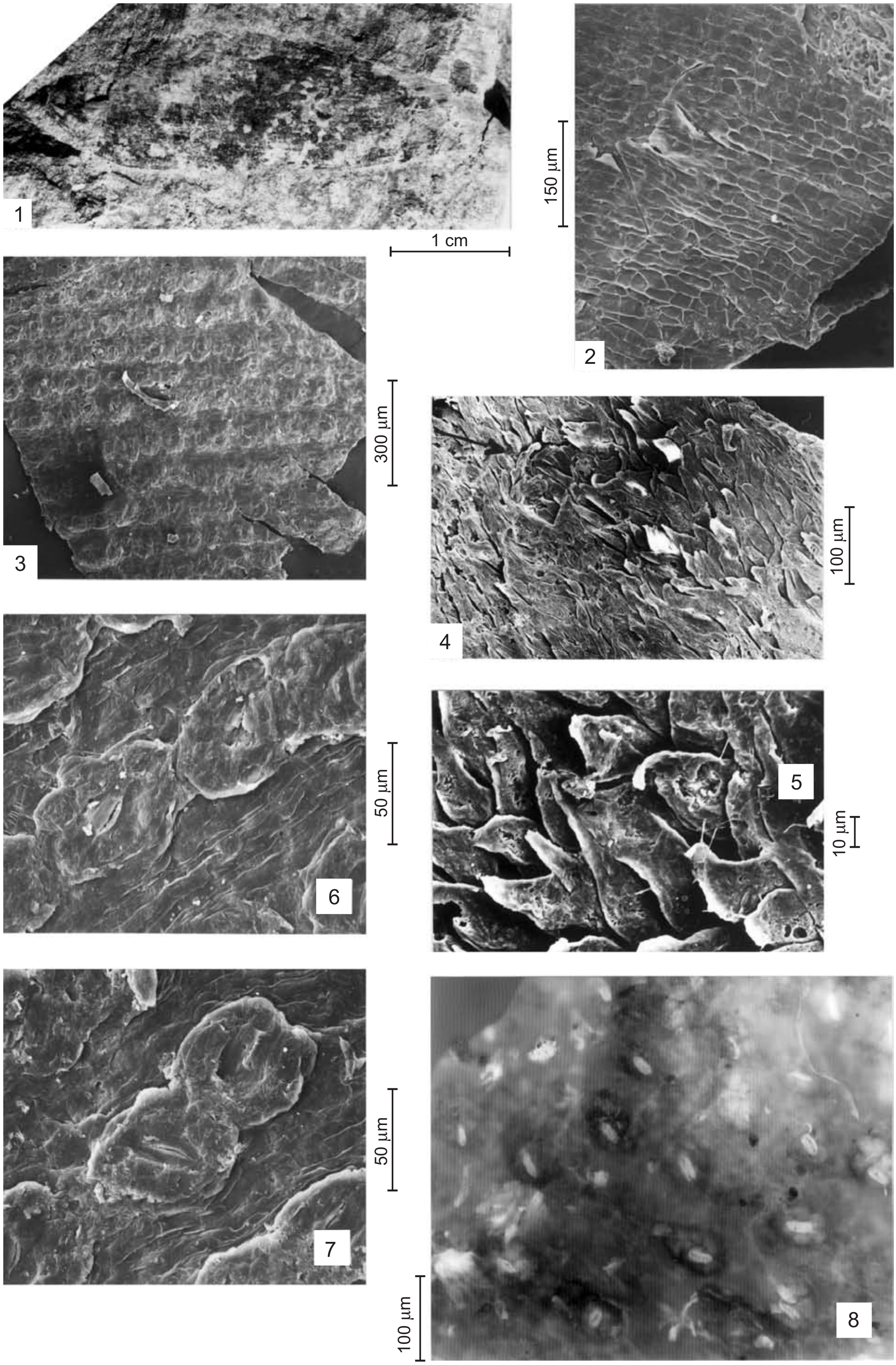
Plate 2

1. Undetermined specimen, the scale (?), No. BP 2000.1137.2
2–8. *Pseudofrenelopsis* sp., No. BP 98.542.1
2. Inner side of the upper cuticle, SEM
3. Inner side of the lower cuticle, SEM
4. Outer side of the lower cuticle with stoma, SEM (the stoma indicated by arrow)
5. Outer side of the lower cuticle, detail with trichomes, SEM
6–7. Inner side of the lower cuticle with stomata, SEM
8. Outer side of the lower cuticle with destroyed trichomes, stomatal pits, fluorescence microscope, slide No. BP 1256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