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This paper is dedicated
to the Memory of Maria Reymanówna (1920–1997)

Hirmeriella muensteri (Schenk) Jung from Odrowąż (Poland), with female and male cones, and *in situ Classopollis* pollen grains

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ABSTRACT. *Hirmeriella muensteri* is one of the commonest species in the Hettangian locality at Odrowąż (Holy Cross Mts., Central Poland). The amount of collected samples reaches 37% of the whole material from this locality. The most numerous specimens are fragments of shoots, but female and male cones, attached to shoots or separate, are also quite common; the male cones often contain pollen grains. The present paper gives detailed description of this species from Poland, with some information on its palaeoecology.

KEY WORDS: *Hirmeriella muensteri*, reproductive organs, Jurassic, Liassic, Poland

INTRODUCTION

The Early Jurassic fossil flora from the Holy Cross Mountains has been studied for many years. First data regarding plant macrofossils from this area, but from different localities, were published by Raciborski (1891, 1892) and later by Makarewiczówna (1928). Then Reymanówna (1987, 1991a, b, 1992, 1993), Reymanówna et al. (1987) continued the study on the flora from a newly discovered locality in Odrowąż. The taxonomic list of macroflora was given by Wcisło-Luraniec (1987, 1991a, b, 1992, 1993), while the microflora was described by Ziaja (1989, 1991, 1992, 1993, 2006).

Geological investigations of the region proved the age of sediments as the Lower Hettangian (Karaszewski 1962, Pieńkowski 1983, Pieńkowski & Gierliński 1987, Pieńkowski 2004).

Hirmeriella muensteri is one of the most common elements among the plant fossils from Odrowąż. This species is well known from Great Britain (Harris 1957, Chaloner 1962), but mainly from several localities in Germany. First, Schenk (1867) described it from Bayreuth under the name *Brachyphyllum muensteri*. Schimper (1870) created the new generic name *Cheirolepis*, for the shoots associated with ovuliferous cone scales, and established the family name, Cheirolepidiaceae. However, the name *Cheirolepis*, already existing for the recent genus of Asteraceae, cannot be used. *Hirmeriella* was the genus established for fertile scales of a female cone by Hörhammer (1933). Jung (1967) realised association between both types of scales and reconstructed the female cone under the name *Hirmeriella*. A year later (Jung 1968) he attributed the shoots *Cheirolepis* to *Hirmeriella* and gave a first full taxonomic review. The name *Cheirolepis* was changed into *Hirmeriella* and has the same status. In the same year Weber described shoots using still the old name, *Cheirolepis muensteri* (Weber 1968) and discussed its ecology. The author mentioned a number of new localities; the species appeared to be one of the most common fossils in the Liassic of Germany.

Recently, the name *Hirmeriella* is used, after Jung (1968), for the entire plant, e.g. shoots and connected cones. In the case of separated cones, they also have the name *Hirmeriella*, while shoots without cones associated, usually are described as *Pagiophyllum* Heer or *Brachyphyllum* Brongniart.

Although this species was mentioned from Odrowąż, (Krassilov 1982, Reymanówna 1992) a proper description was not published. The present paper containing detailed descriptions of *Hirmmeriella muensteri* was prepared years ago, by M. Reymanówna. Unfortunately it had been not finished and now it is completed according to new data and interpretations.

MATERIAL AND METHODS

All material originates from the locality Odrowąż (known also as Sołtyków). It is a clay-pit, situated about 25 km north of Kielce in the Mesozoic margin of the Holy Cross Mountains in Central Poland (Fig. 1). Sediments from Odrowąż are of Lower Jurassic age. Pieńkowski (2004) assigned the whole Odrowąż section to the Zagaje Formation (Lower Hettangian). This formation consists mainly of mudstones, siltstones and sandstones. The composition of spores and pollen grains and the presence of the index species *Aratrisporites minimus* Schulz confirm the Lower Hettangian age of these sediments (Ziaja 2006). For more details of geological and palaeobiological investigations see also Karaszewski (1962), Pieńkowski (1983, 2004), Pieńkowski and Gierliński (1987), and Ziaja (2006).

The material consists mainly of leafy shoots in different sizes. Occasionally female and male cones were found attached at the end of shoots, or detached, as well as separated fragments of ovuliferous dwarf shoots from female cones. All fragments are preserved as compressions, having cuticles suitable for preparation.

The leaves and scales of female cones were first cleaned for several hours in hydrofluoric acid, then macerated in Schultze's reagent (HNO_3 + $KClO_3$) for an hour and washed in weak ammonia. The pollen cones were macerated also using Schulze reagent for 90 minutes, washed in 3% KOH.

After preparation, material was studied with light microscopy and SEM.

The cuticles of the leaves, but mainly those of reproductive organs, were also observed with fluorescence microscope. Leaves were studied in prepared-, and unprepared state, cones and their structures in unprepared state, on slab. In this way the material remained undamaged, on the other hand distribution of stomata or changes of cell pattern along the leaf were better observable.

All specimens are housed in the Palaeobotanical Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences, collection KRAM-P, PM.

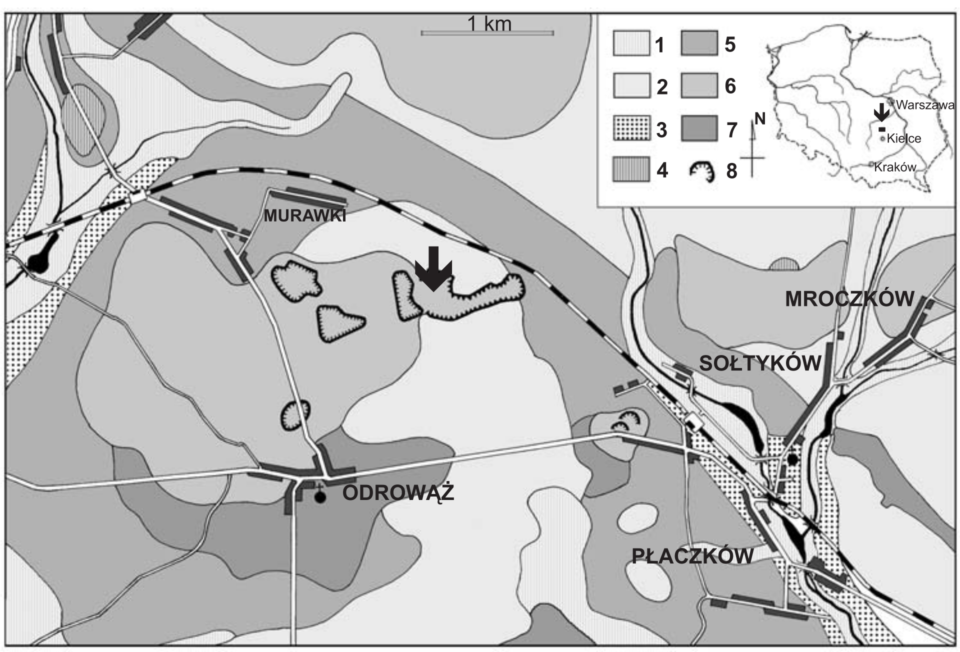

Fig. 1. Map of locality Odrowąż (Sołtyków). **1** – Holocene fluvial deposits, **2** – Quaternary sands, **3** – Pleistocene sands of the accumulation terraces, **4** – Pleistocene sands and gravels of a front moraine and eskers, **5** – Pleistocene postglacial sands with boulders, **6** – Jurassic sandstones, siltstones and mudstones, **7** – Triassic siltstones and silts, **8** – Old mine excavations. The Odrowąż outcrop with the Jurassic flora indicated by the arrow, after Krajewski (1955), modified (drawing by J.W. Wieser)

DESCRIPTIONS AND DISCUSSIONS

Coniferales

Cheirolepidiaceae Hirmer and Hörhammer 1934

Hirmeriella Hörhammer 1933

Hirmeriella muensteri (Schenk 1867) Jung 1968

Selected synonyms:

1867 *Brachyphyllum muensteri* Schenk, pp.187–190, pl. 43, figs 1–12.
1867 *Brachyphyllum affine* Schenk, pp. 190–191, pl. 43, figs 13–20.
1870 *Cheirolepis muensteri* (Schenk) Schimper, pp. 247–248, pl. 75, figs 8–10.
1914 *Cheirolepis muensteri* Schenk; Gothan, p. 64, pl. 30, figs 5–6; pl. 31/32, fig 5; pl. 39, fig. 3.
1933 *Hirmeriella rhaetoliassica* Hörhammer, pp. 29–32, pls. 5–7.
1933 *Cheirolepis muensteri* Schenk; Hörhammer, pp. 1–28, pls 1–4.
1957 *Cheirolepis muensteri* (Schenk) Schimper; Harris, pp. 293–304, pl. 8, text–figs 1–5.
1962 *Cheirolepis muensteri* (Schenk) Schimper; Chaloner, pp. 17–23, pl. 2.
1967 *Cheirolepis muensteri* (Schenk) Schimper; Jung, pp. 111–114.
1968 *Cheirolepis muensteri* (Schenk) Schimper; Weber, p. 64–65, pl. 15, figs 151–154; pl. 16, figs 172–175; text–fig. 13.
1968 *Hirmeriella muensteri* (Schenk) Jung, pp. 55–93, pls 15–19.
1982 *Hirmeriella muensteri* (Schenk) Jung; Alvin, p. 79, pl. 1, fig. 2, text–fig. 5.
1988 *Hirmeriella muensteri* (Schenk) Jung; Watson, p. 409, figs 9.1, 9.5A–G, 9.12A, 9.15, 9.16A–G.
1991 *Hirmeriella muensteri* (Schenk) Jung; Clement–Westerhof and van Konijnenburg-van Cittert, pp. 150–179, text-figs 1–3, pl. 1, figs 1, 2, pl. 2, figs 1a, b, pl. 3, figs 1–6, pl. 4, figs 1–3, pls 5–9, pl. 10, figs 3–4, pl. 11.
1992 *Hirmeriella muensteri* (Schenk) Jung and *Hirmeriella escheri* Heer; Kirchner, pp. 47–53, pls 13–15.
1998 *Hirmeriella muensteri* (Schenk) Jung; Guignard, Thévenard and van Konijnenburg-van Cittert, p. 119, pl. 1.

SHOOTS AND LEAVES

D e s c r i p t i o n. The shoot fragments (Pl. 2, figs 1, 2) are 1.5–5.0 mm wide and 3–6 cm long. Laterals, if found, arise at 30°–35°. Shoots are covered with scale-like leaves (Pl. 1, figs 1, 2), arranged spirally in a phyllotaxis 2+3 parastichies (reduced to 1+2 in the smallest shoots).

Leaves are thick, variable in shape, from small oval ones about as long as wide, to elongated ones up to 4 times as long as wide on larger shoots. The leaf base forms a decurrent cushion, 1–3 mm long and 0.8–2.0 mm wide. The free part of the leaf is about 0.5–1.0 mm long, tapering gradually towards a rounded or obtuse, triangular apex, or constricted at the base giving off a short triangular tip. The leaf tip is straight or bent towards the axis, on longer leaves it is occasionally spreading. The leaf margins are sometimes scarious. Abaxial leaf side frequently shows a protruding prominent midrib. On adaxial side leaves are thick at the margins and thinning out inwards.

C u t i c u l a r s t r u c t u r e. The cuticle is thick on both sides, showing longitudinal files of nearly rectangular cells with rounded corners. Their length is 0.5 to 2 times their width. Anticlinal walls are straight, periclinal walls generally bulging, towards the leaf apex bulges may turn into papillae, larger at the margins of leaf (Pl. 1, fig. 5). Cuticle on adaxial side shows less regular cell arrangement.

The leaves are amphistomatic. Stomata are usually arranged in approximately regular longitudinal, often incomplete files, in small leaves less regular. Stomatal files are usually separated by 2–7 rows of epidermal cells. Occasionally stomata in files have common or neighbouring subsidiary cells. Guard cells are slightly sunken, thinly cutinized, pores randomly oriented. Subsidiary cells, usually 4–6, form a raised ring around the stomatal pit, occasionally with papillae. Encircling cells, 6–9, often occur (Pl. 1, fig. 4).

D i s c u s s i o n. The fossil plant remains of *Hirmeriella muensteri* is known mostly from Germany. Several authors, beginning from the second half of 19th century, have described it. Schenk (1867) and Weber (1968) – from the region of Bayreuth; Gothan (1914) – the region of Nürnberg; Hörhammer (1933) and Kirchner (1992) – Bayreuth and Nürnberg; Clement-Westerhof and van Konijnenburg-van Cittert (1991) – two other localities in the region of Bayreuth. Single data come from France – Niort (Carpentier 1933) and Great Britain – Henfield and Yorkshire (Chaloner 1962, Harris 1957). It was also described from Poland (Makarewiczówna 1928), from the region of Ostrowiec.

The species was not only described, but, because of its problematic nomenclature, widely discussed and revised (Hirmer & Hörhammer 1934, Clement-Westerhof & van Konijnenburg-van Cittert 1991, Kirchner 1992). Basing on descriptions and remarks in these papers, we agree that specimens from Odrowąż may be undoubtedly attributed to *Hrmeriella muensteri*.

It seems to correspond also with material described by Makarewiczówna (1928), although she gives little details, and the cuticle structure is unknown.

However, there are some minor differences between leaves from Odrowąż and those described from other localities. One of them is the size of shoots and leaves. The leaves from Odrowąż are half of the size of the leaves described by Hörhammer (1933) that are up to 6–10 mm long and 2.5–3.7 mm wide. The same differences are observable in the size of twigs, which in material from Odrowąż is much smaller. Nevertheless, such small leaves, even smaller (from 1 mm long onwards), were observed in some German localities (van Konijnenburg- van Cittert pers. comm.). These differences might be caused by local climatic conditions; also, the young leaves are usually smaller than old ones.

The other aspect regards distribution of stomata. Schenk (1867) defined his leaves as hypostomatic, but all later descriptions point out the amphistomatic type of *Hirmeriella* leaves. Makarewiczówna (1928) described shoots from Ostrowiec also as hypostomatic, referring to Schenk (op.cit.). Unfortunately, the collection of Makarewiczówna is not accessible for revision. The material from Odrowąż is evidently amphistomatic.

The other detail like dicyclic stomatal apparatus mentioned by Hörhammer (1933) was already discussed by Clement-Westerhof and van Konijnenburg-van Cittert (1991). Hörhammer also did not mention papillae (scarious margin?) at the leaf margins, which are common in material from Odrowąż and in German material in general.

FEMALE CONES

M a t e r i a l. Numerous separated, well-preserved fragments of ovuliferous dwarf shoots were found associated with vegetative shoots. There are also transverse fragments of cones, as well as a five complete cones, also in connection with shoots. They have well preserved cuticle.

The terminology applied in cone description is used according to Clement-Westerhof and van Konijnenburg-van Cittert (1991).

Description. Cone is nearly cylindrical, 18–50 mm long and 6–15 mm wide. Axis is covered by spirally arranged ovuliferous dwarf shoots and bracts. The leaves at the basis of cone show a transition into scales (Pl. 2, fig. 3).

BRACTS

D e s c r i p t i o n. Bracts (Pl. 3, fig. 6) are entire, 6–8 mm high, 5–11 mm wide, attached with a narrow basis, wide rhomboid in shape, with acute apex and a prominent keel running from one third of bract height.

C u t i c u l a r s t r u c t u r e. The thick cuticle shows square or rectangular cells with pillow-shaped periclinal surfaces. Stomata are not numerous, arranged in one-stoma wide rows, separated by wide nonstomatiferous bands (Pl. 3, fig. 7). Towards the basis, stomata are lacking.

OVULIFEROUS DWARF SHOOTS

D e s c r i p t i o n. Ovuliferous dwarf shoots (Pl. 1, figs 3, 7; Pl. 2, figs 5, 6; Pl. 3, figs 1, 2), often detached from cone at maturity, are 7–8 mm high and 8–12 mm wide. Since the fertile and sterile scales are basally adnate, the entire complex forms one large ovuliferous scale with sterile and fertile lobes.

The fertile lateral lobes are nearly ovate in shape, with triangular, emerging subacute to acute apex 3 mm wide and 2 mm long. The sterile abaxial lobe is simple, roundish with wide, obtuse or tapering apex, 5 mm wide and 3 mm long (Pl. 2, fig. 6). Among three adaxial lobes the median one is high-trapezoid in shape, 2 mm long and 1.5 mm wide (Pl. 2, fig. 5). Two lateral lobes are fan-shaped, almost as long as the median one, but half-size as wide. The flap covering ovules/seeds on the adaxial surface is rounded, weekly bordered.

C u t i c u l a r s t r u c t u r e. Two surfaces of dwarf shoot were investigated – abaxial surface and adaxial covering structure, according to Clement-Westerhof & van Konijnenburg-van Cittert (1991, see fig. 3) layers d1 and d4 respectively.

All terminal lobes (triangular lateral lobes of fertile and sterile scales) show similar cuticular structure. Their cuticle is much thicker than on the rest of dwarf shoot. Cells are small, square or slightly rectangular, with thick, pillow-shaped periclinal cell walls. Stomata are present only on their abaxial side (Pl. 2, figs 7–10). They are arranged in one-stoma wide rows, which are separated by wide nonstomatiferous bands. Stomata are oval or circular, about 60 µm in diameter. The 5–7 subsidiary cells often form a raised ring around the pit. Sometimes a ring of encircling cells is found.

At the bases of terminal lobes and towards the central part of dwarf shoot the cuticle becomes thinner with a quite sharp border (Pl. 1, figs 6a, b)

On the abaxial surface of the dwarf shoot (d1) in its central part, the cells are similar in shape to those of terminal lobes, but thinly cutinized. At the margins, fertile lobes have narrow, elongated cells.

The adaxial surface (d4), passing from the terminal lobes into the covering structure (flap), shows an area with small cells with papillae (Pl. 2, fig. 4) and towards the base the cells become longer and thinner, length of cells changes from 5–18 times its width (Pl. 3, figs 3, 4). At the basis, they may be more rectangular with undulated cell walls.

On the adaxial surface of the fertile lobes, cells are very variable as to their size, arrangement and shape. Large cells are neighbouring small ones, shape varies from polygonal to rectangular, square or very narrow elongated. They form irregular rows, often arch-curved (Pl. 3, fig. 5).

D i s c u s s i o n. The female cone of *Hirmeriella muensteri*, and both its macro- and micromorphological structure were already fully known since they were described several times before: Hörhammer (1933, dwarf shoots macro + cuticle), Hirmer and Hörhammer (1934, macro only), Florin (1944, macro), Harris (1957, macro + cuticle), Jung (1967, cone reconstruction), Alvin (1982, in general, after Jung 1967), Clement-Westerhof and van Konijnenburg-van Cittert (1991, macro + cuticle, new interpretation), and Kirchner (1992, macro, comparison with other species). Krassilov (1982) described some incomplete dwarf shoots (with cuticles) collected by M. Doludenko in Odrowąż. His interpretation of investigated details was discussed later by Clement-Westerhof and van Konijnenburg-van Cittert (1991). Krassilov, however, had not given the specific determination that is hereby confirmed as *H. muensteri*.

Reymanówna (1991a, 1992) gave some remarks on the structure of the *Hirmeriella muensteri* cone from Odrowąż as an effect of environmental adaptation, but without description.

The macromorphology of cones and dwarf shoots from Odrowąż corresponds well with descriptions of *H. muensteri* mentioned above. Number and shape of fertile and sterile lobes and details of their cuticle observed directly in the fluorescent microscope on their whole surface confirm their identity with *H. munsteri* from other localities.

MALE CONES

M a t e r i a l. Numerous (43) complete male cones were found attached to-, or in close association with vegetative remains of *Hirmeriella muensteri* (Pl. 4, figs 1, 2). Their mass appearance is proved by slab stone with about 30 male cones preserved. The cones Nos 1, 22, 38, 42 and 43 contained *Classopollis* pollen grains that corresponded with dispersed *Classopollis* present in the sediment from Odrowąż (Ziaja 2006).

D e s c r i p t i o n. Cone is oval in shape, 3.8–6.8 mm long and 3.3–5.0 mm wide. Microsporophylls are widely rhomboid, spirally arranged, 14–20 per cone (Pl. 1, figs 8, 9). Their apex is rounded, scarious. Isolated axes have not been found.

C u t i c u l a r s t r u c t u r e. Cuticle of abaxial surface of the microsporophyll shows narrow, rectangular cells about 2–4 times as long as wide (Pl. 4, figs 3, 4). Towards the lateral margins cells become narrower, about 10 times as long as wide, forming longitudinal rows. Each cell has a spherical papilla on the surface, but not central, rather at the end, directed towards the top of the cone. Few, sparse stomata are distributed mainly in the central part of the microsporophyll. Small 6–8 subsidiary cells (papillate like the rest of cells) form a round or oval ring around stomatal pit.

The cuticle on the adaxial surface is thicker near the apex and along the central part than towards the lateral margins. On the thickly cutinized part periclinal cell walls are pillow-shaped. At the apex cells are rectangular and papillate like those on abaxial side (Pl. 1, fig. 10). Towards the scale base they become elongated, 2–5 times as long as wide. On lateral parts cells are thin, elongated, 3–8 times as long as wide, in more or less longitudinal rows. Neither papillae nor stomata are present.

The number of pollen sacs and their attachment is not visible. Only three groups, each consisting of six structures similar to pollen sacs, were observed after maceration of male cone no. 38 (for description of pollen see below).

Discussion. Male cones of *Hirmeriella muensteri* were first described and illustrated by Hörhammer (1933) under the name *Cheirolepis muensteri* Schenk from the Rhaeto-Liassic of Germany. He described the cone as consisted of the peltate microsporophylls and a ring of 10–12 pollen sacs per microsporophyll, situated around microsporophyll head. Harris (1957), who investigated charred fragments of *Ch. muensteri* (Schenk) Schimper (synonym of *Hirmeriella muensteri* (Schenk) Jung) from the Rhaeto-Liassic of Wales, observed, that pollen sacs "were only two, situated below the stalk and not a ring of twelve as in Hörhammer's restoration".

Jung (1968) described remains of *H. muensteri* from Rhaeto-Liassic sediments of Franconia (Germany) and confirmed Hörhammer's opinion about structure of its male cone.

Clement-Westerhof and van Konijnenburg-van Cittert (1991) described *H. muensteri* male cones from two localities in Germany of Early Liassic age. They observed about 6 pollen sacs and interpreted the microsporophylls as semi-peltate.

Kirchner (1992) investigated the fossil flora from Rhaeto-Liassic sediments of Franconia (Germany). In his description, the cone contained 10–18 microsporophylls, and the number of pollen sacs per microsporophyll depended on the position in the cone. It varied from 12 in the middle part of the cone to 6 at its ends. Kirchner suggested that ripe cones lost their microsporophyll heads and this way pollen dispersal was easier. Probably Hörhammer's reconstruction (Hörhammer 1933) was based on a ripe male cone without microsporophyll heads.

Morphologically the cones from Odrowąż correspond with cones of *H. muensteri* described by the authors mentioned above. Unfortunately, the most important diagnostic features, such as number and position of pollen sacs, are not observable because of the preservation or unripe state of cones. Considering that in Odrowąż *Hirmeriella* is represented by only one species that, the female cones belong to *H. muensteri* and that inside the cones the *Classopolis* pollen grains were found, it seems to be doubtless that the male cones belong to the same species.

IN SITU POLLEN GRAINS

Turma Kryptoaperturates Potonié 1960

Subturma Circumpolles Pflug 1953 emend. Klaus 1960

Genus ***Classopollis*** Pflug 1953 emend. Pocock & Jansonius 1961

Classopollis torosus (Reissinger 1950) Couper 1958

For synonyms see Ziaja (2006).

Material. *Classopollis* pollen grains were obtained from *Hirmeriella* pollen cones Nos 1 (Pl. 4, fig. 8), 5, 20, 22 (Pl. 4, figs 5–7), 38, 40, 41, 42 and 43.

Description. Pollen grains oval to circular in polar view, 30.4–36.8 µm × 24.8–30.4 µm in diameter. Circular cryptopore 4.8 µm in diameter on the distal side and triangular scar with concave sides on the proximal pole is visible on some specimens. Subeqatorially to the distal side there is circular groove or thinning, parallel to the equator of the pollen grain – the rimula about 1 µm wide. Equatorial region with internal thickening 4.0–4.8 µm wide. The surface of the exine visible in the SEM is granulate.

Discussion. Pollen grains found inside *Hirmeriella* male cones are similar to dispersed *Classopollis* Pflug (= *Corollina* Maljavkina) pollen grains. This kind of grains have been also found in the sediment from Odrowąż and determined as *Classopollis torosus* (Reissinger 1950) Couper 1958 (Ziaja 2006). *Classopollis* pollen grains are known from the Late Triassic – Cretaceous sediments and were found in male cones attached to or associated with the cheirolepidiaceous genera *Brachyphyllum* Lindley & Hutton ex Brongniart (pro parte), *Cupressinocladus* Seward (pro parte), *Frenelopsis* Schenk, *Hirmeriella* Hörhammer (= *Cheirolepidium* Takhtajan) *Pagiophyllum* Heer (pro parte), *Pseudofrenelopsis* Nathorst and *Tomaxellia* Archangelsky. Unattached male cones containing *Classopollis* pollen grains are known as *Classostrobus* Alvin, Spicer & Watson (Alvin 1982, van Konijnenburg-van Cittert 1971, 1987, Watson 1988). Hörhammer (1933) found *Classopollis* pollen grains in tetrads and groups from male cones of *Cheirolepis muensteri* Schenk – now *Hirmeriella muensteri* (Schenk) Jung – from Germany. Harris (1957) described pollen grains from charred fragments of male cones associated with *Cheirolepis muensteri* (Schenk) Schimper shoots from South Wales. Chaloner (1962) found *Classopollis torosus* (Reissinger) Balme pollen grains associated with fragments of *Cheirolepis muensteri* in southern England. Jung (1968) illustrated a tetrad of pollen grains from the male cone of *Hirmeriella muensteri* (Schenk) Jung from Rhaeto-Liassic of Germany.

Classopollis pollen grains have been also described and illustrated by Clement-Westerhof and van Konijnenburg-van Cittert (1991) from *Hirmeriella muensteri* (Schenk) Jung male cones from the Liassic sediments from Germany.

TAPHONOMICAL REMARKS

Wcisło-Luraniec (1991a–b, 1992) has already mentioned the dominant character of *Hirmeriella muensteri* in vegetation from Odrowąż. Its remains constitute 37% of all collected specimens from the locality, which means that it was the second important element besides *Pterophyllum* (Fig. 2). The material is preserved in fragments that were divided into 3 size categories: small (up to 20 mm long), middle (20–30 mm) and large (more than 30 mm).

Only in a few cases specimens are larger (44, 50, 60 mm) and branched. Most fragments belong to the small (65%) and mixed, small-middle category (13%). Middle and large categories are almost the same (8 and 9% respectively), other mixed categories are significantly rarer (about 1–2%, see also Fig. 3).

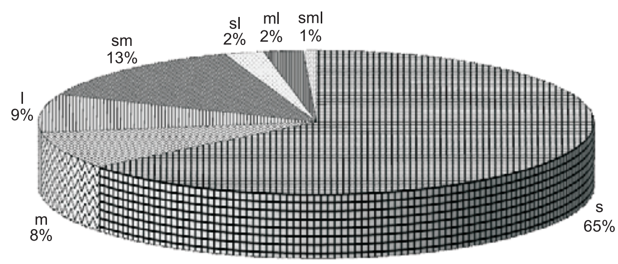

Fig. 3. Percentage of different-size shoot fragments in *Hirmeriella. muensteri.* Size categories: **s** = small – up to 20 mm long, **m** = middle – 20–30 mm long, **l** = large – more than 30 mm

The degree of fragmentation suggests that the shoots had been transported before they reached the sedimental basin. Remains are small but not extremely damaged: neither separated leaves, nor leafless branches/axes were observed. Therefore transport might have happened over a quite long distance, but with a slow speed of flow.

Co-ocurrence of *H. muensteri* with other taxa on the same specimens appears as follow: unaccompanied – 35%, with *Pterophyllum* sp. – 59%, with *Neocalamites* sp. 4%, with *Pachypteris lanceolata* 1%, and with fern remains 1% (see also Fig. 4). Among these taxa, *Pterophyllum* sp. and ferns are fragmented to

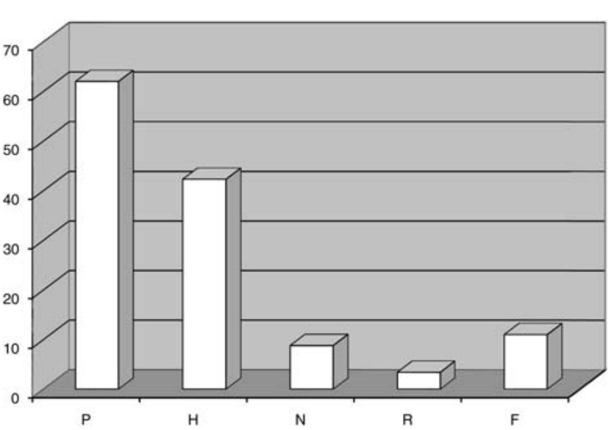

Fig. 2. Percentage of main elements of flora in Odrowąż; **P** – *Pterophyllum,* **H** – *Hirmeriella,* **N** – *Neocalamites,* **R** – *rhizomes,* **F** – *ferns*

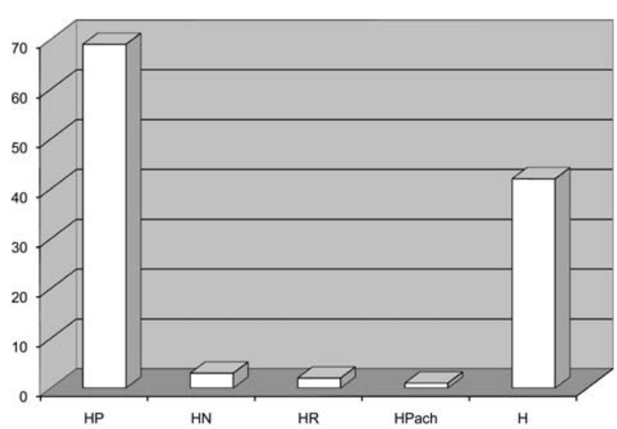

Fig. 4. Co-occurrence of *Hirmeriella muensteri* with other plants. **H** – *Hirmeriella*, **P** – *Pterophyllum*, **N** – *Neocalamites*, **R** – rhizomes, **Pach** – *Pachypteris*

a similar degree as *H. muensteri*; *Neocalamites* sp. occurs in large fragments (up to more than 150 mm), *Pachypteris lanceolata* (1 specimen) is almost complete (100 mm long).

The reconstruction of the environment was given by Pieńkowski (1998) because of a dinosaurus finding in the region of Odrowąż. According to the author the area was a meandering river plain with lateral channels. Trees of *Hirmeriella* was there the second most important component of the flora, besides *Pterophyllum* sp. Since both of them occur often together, they presumably grew in the same community forming a forest on the both sides of river – but not immediately on the banks and in certain distance from the other assemblage. *H. muensteri* was sometimes regarded as growing rather on dry territories. Its xeromorph structure was discussed (Reymanówna 1992, Ziaja & Wcisło-Luraniec 1998, 1999) with statement that *H. muensteri* might have been adapted to extreme conditions, like seasonal fire cases. On the other hand Weber (1968) on the grounds of associations with other species (in Germany the species co-occurs with e.g. *Nilssonia*, *Cycadites*, *Sagenopteris* etc.), revealed that in Germany a tree might have grown not directly on the river banks but a bit further away, although on not too dry territories.

It also deserves notice, that well developed papillae are present at the leaf margins, especially large near the leaf apex. Their tops are directed towards the apex. Papillae directed to the apex are also present on scales of the cones, particularly the male ones. According to Metcalfe and Chalk (1979) such type of papillae may have a rule in removing water from the surface of leaf (scale). It suggests high air humidity of the environment.

Hirmeriella muensteri was described from Poland from one locality near Ostrowiec (Makarewiczówna 1928), from sediments, according to Pieńkowski (2004), belonging to Ostrowiec Formation (Sinemurian) The distance between this locality and Odrowąż is about 60 km. The species was not mentioned from the other, Early Jurassic (according to Raciborski Rhaetic) locality laying more northern in the Holy Cross Mountains, described by Raciborski (1891, 1892).

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PLATES

Plate 1

Hirmeriella muensteri (Schenk) Jung, Odrowąż, all pictures are taken under the fluorescent microscope

1, 2. Leaves, KRAM-P, PM No. 68/54
3. Ovuliferous dwarf shoot, fragment, KRAM-P, PM No. 68/296/X
4. Stoma of leaf from fig. 1
5. Top of leaf from fig. 1 showing papillae
6. Ovuliferous dwarf shoot, intermediate part between terminal lobes and the central part
   a–b. Detail in different focus (indicated on fig. 6 by rectangular)
7. Ovuliferous dwarf shoot, fragment, KRAM-P, PM No. 68/1302
8. Male cone, adaxial surface KRAM-P, PM No. 68/1300
9. Male cone, abaxial surface KRAM-P, No. 68/1301
10. Male cone, detail of the scale from fig. 9

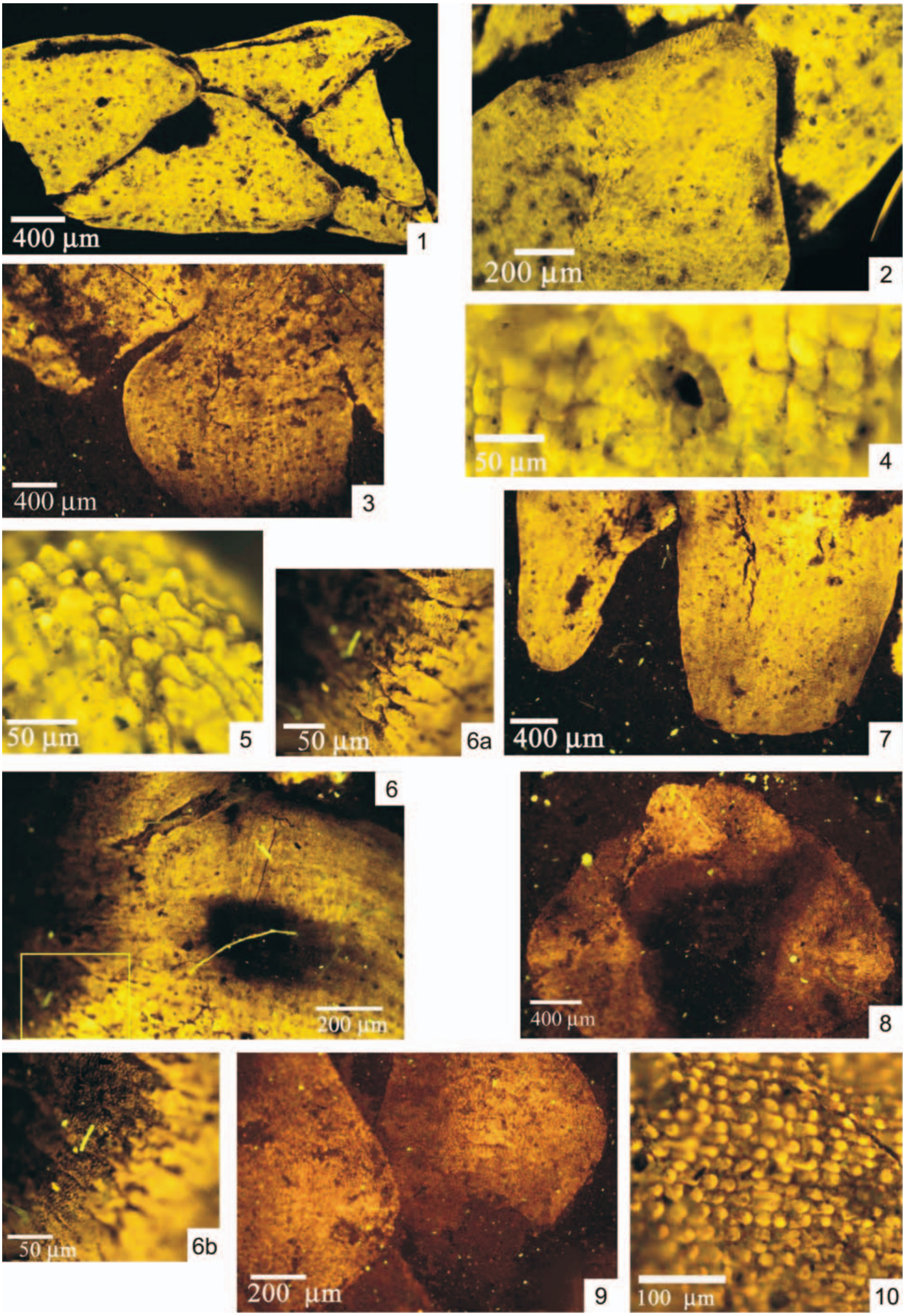
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Plate 2

Hirmeriella muensteri (Schenk) Jung, Odrowąż

1, 2. Shoot fragments, KRAM-P, PM No. 68/1303

3. Female cone, KRAM-P, PM No. 68/307

4. Ovuliferous dwarf shoot, adaxial surface, intermediate part between the terminal lobes into the covering structure (flap)

5. Ovuliferous dwarf shoot, adaxial lobes, KRAM-P, PM No. 68/305

6. Ovuliferous dwarf shoot, abaxial lobes, KRAM-P, PM No. 68/304

7. Ovuliferous dwarf shoot, abaxial side of the terminal lobe with stoma, from outside, SEM picture, KRAM-P, PM No. 68/280/7

8, 9. Cuticle from fig. 7, from inside, SEM picture

10. Detail from fig. 8, SEM picture

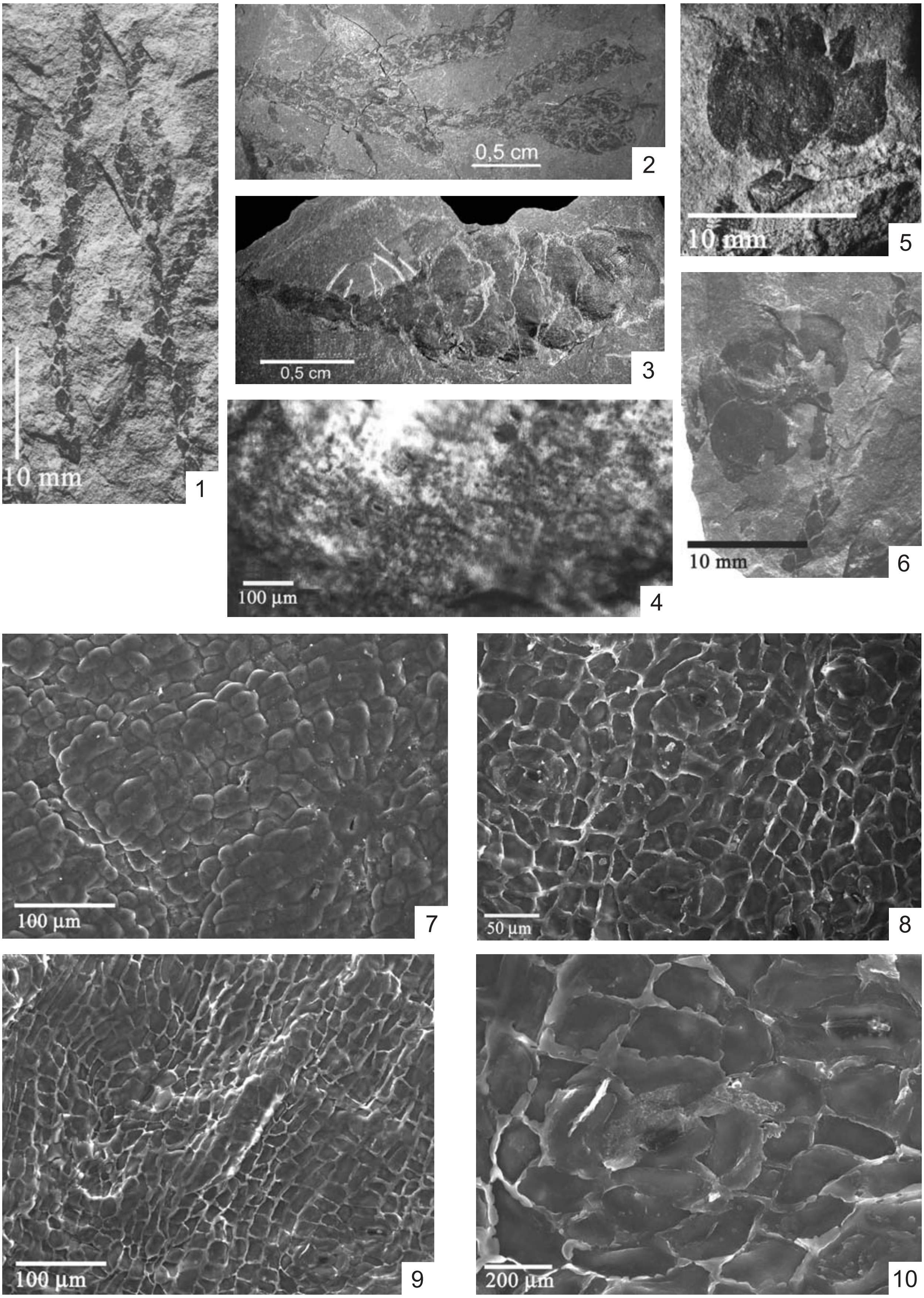
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Plate 3

Hirmeriella muensteri (Schenk) Jung, Odrowąż

1. Ovuliferous dwarf shoot, abaxial side, stoma, SEM picture, KRAM-P, PM No. 68/280/7
2. Ovuliferous dwarf shoot, fertile scale, SEM picture, KRAM-P, PM No. 68/280/7

3, 4. Ovuliferous dwarf shoot, adaxial surface, passing towards the covering structure (flap)

5. Adaxial surface of the fertile lobes, fluorescent microscope
6. Bract, KRAM-P, PM No. 68/280/7
7. Bract, stomata (detail from fig. 6)

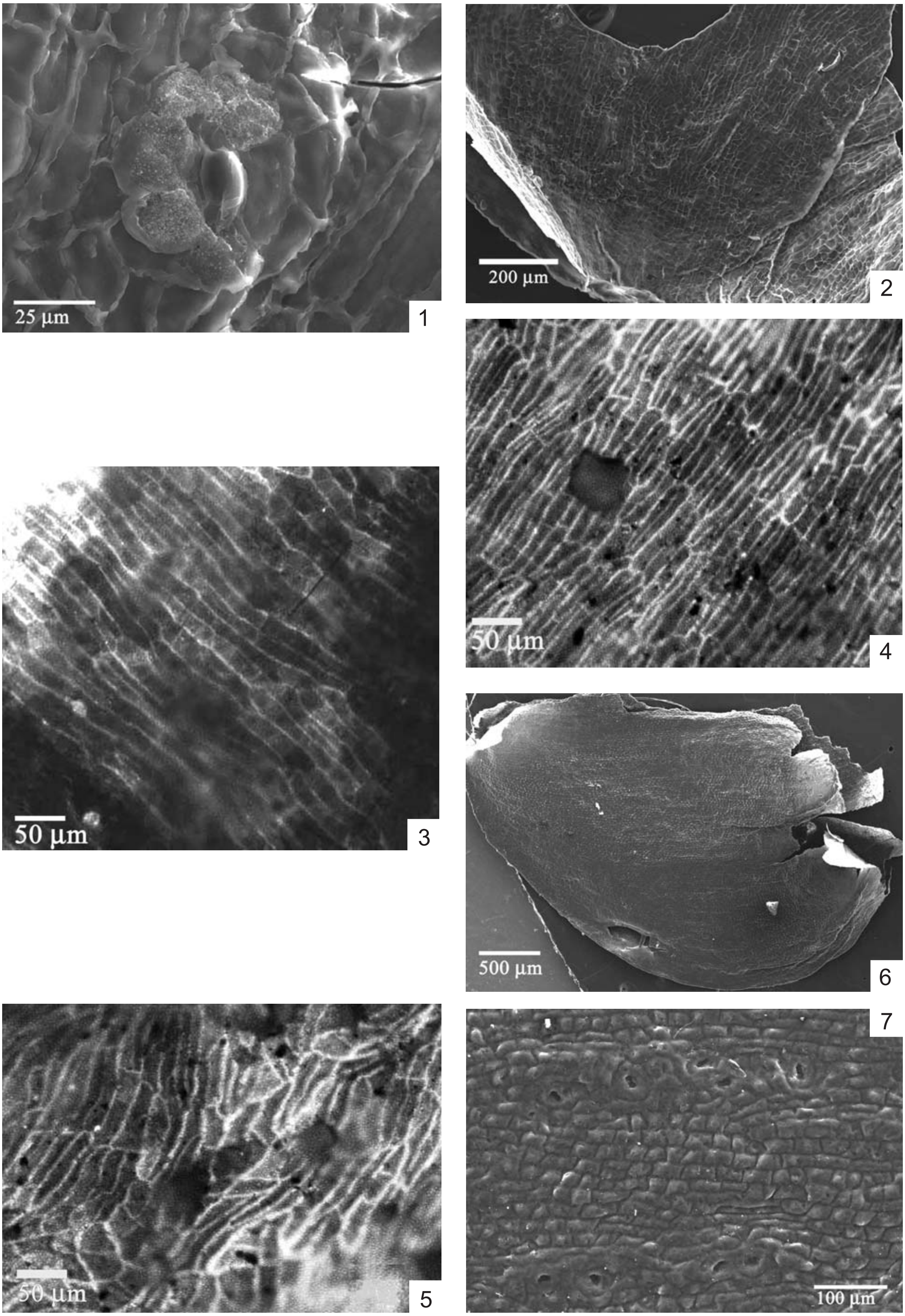
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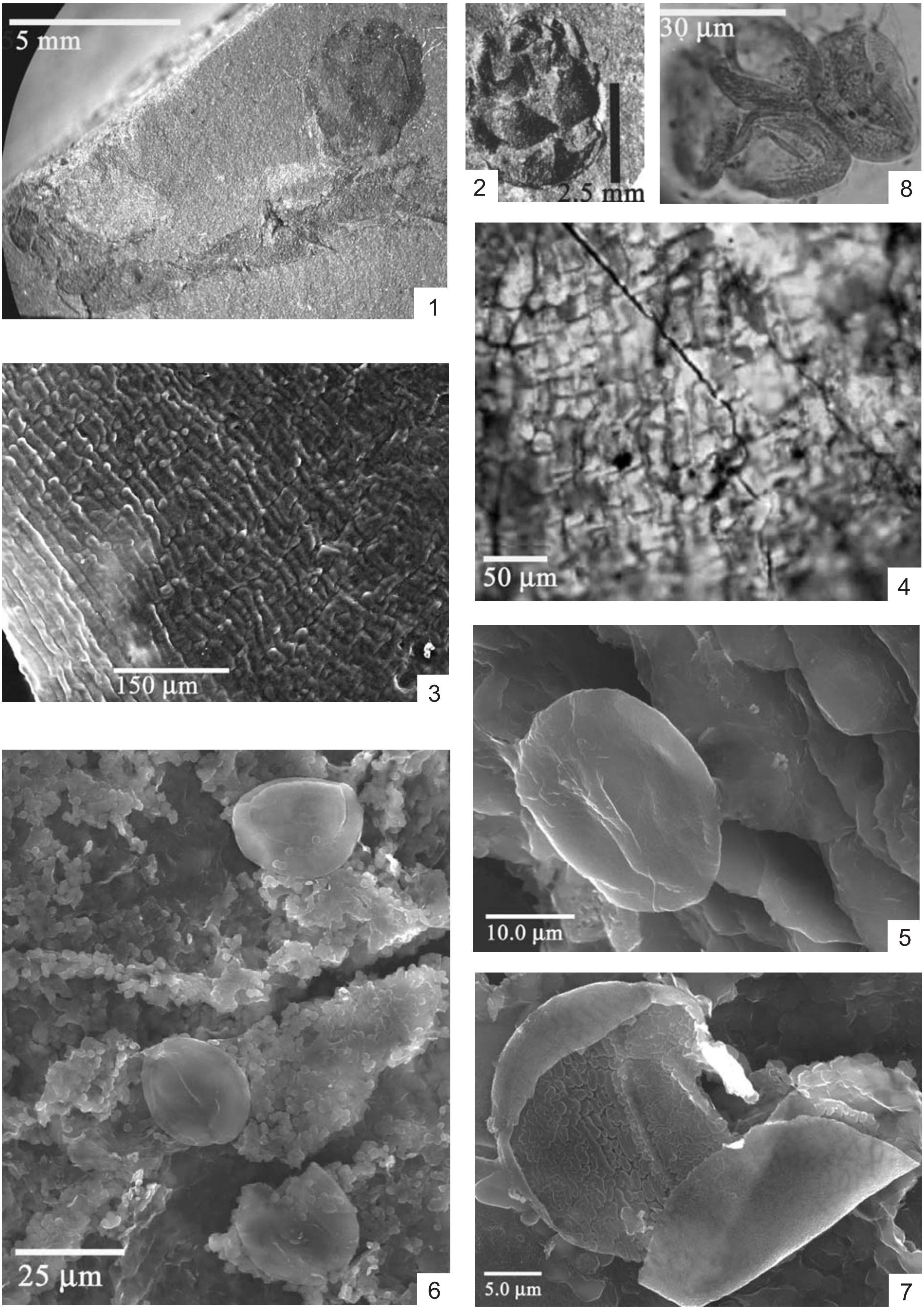
Plate 4

Hirmeriella muensteri (Schenk) Jung, Odrowąż

1. Male cone, KRAM-P, PM No. 68/1304
2. Male cone No 1 on the rock before maceration
3. Male cone No 22, scale margin, abaxial surface, SEM picture
4. Male cone KRAM-P, PM No. 68/1300, scale, adaxial surface, fluorescent microscope

5, 6. Male cone No 22, pollen grains on the scale

7. Male cone No 22, damaged pollen grain showing sculptured layer of exine from inside, SEM picture
8. *Classopollis* in situ pollen grains isolated from pollen cone No. 1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