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ARE THE LOWER LIASSIC PLANTS OF ODROWĄŻ (POLAND) BURNT?

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ABSTRACT. An interesting type of preservation of fossil plants was observed during investigations on the Lower Liassic flora from Odrowąż, Poland. The flora was collected and determined by the late Professor Maria Reymanówna, Elżbieta Wcisło-Luraniec and Jadwiga Ziaja. Macro- and microfossils are partly preserved as fusain (fossil charcoal) and a large amount of black, opaque particles of different sizes and angular shapes was found after maceration of palynological samples. The cuticule of megafossils was macerated using conventional techniques and this proved to be very difficult, with leaves of the *Podozamites* type falling into small pieces during maceration. Three-dimensional structures, with open cell lumina in the cuticle of *Phlebopteris angustiloba* leaves have been observed in SEM. According to Reymanówna (1992, 1993) the Liassic vegetation in Odrowąż caught fire during the dry season, preasumbly initiated by lightning strikes. Furthermore it is considered that the now extinct trees *Hirmeriella muensteri* opened their cones after fire, to reproduce.

KEY WORDS: Liassic, Odrowąż, Holy Cross Mts., Poland, macrofossils, microfossils, fusain, charcoal

INTRODUCTION

The Liassic flora from the Holy Cross Mts. in Poland has been previously described a hundred years ago by the Polish palaeobotanists Raciborski (1891, 1892) and later by Makarewiczówna (1928). The macroflora from Odrowąż (near Końskie, Holy Cross Mts.) was recently investigated in Poland by Reymanówna (1991, 1992, 1993, Reymanówna *et al.* 1987) and by Wcisło-Luraniec (1991, 1992a, 1992b, 1993). The microflora (spores and pollen grains) was described by Ziaja (1989, 1992, 1993). The megaspores were investigated by Marcinkiewicz (1957, Marcinkiewicz *et al.* 1960). According to geological studies the sediments from Odrowąż belong to the Zagaje series (Lower Liassic, Lower Hettangian) that show a succession of continental environments (Karaszewski 1962, Pieńkowski 1983, Pieńkowski & Gierliński 1987). The flora from Odrowąż was preserved partly as compressions/impressions and partly as a fusain (fossil charcoal).

MACROFOSSILS

MATERIAL AND METHODS

In Odrowąż the plant fragments are preserved in grey shales. Leaves fragments were macerated in nitric acid followed by ammonia by Wcisło-Luraniec. Leaves, cones and ovuliferous scales of *Hirmeriella muensteri* were macerated by Reymanówna also in the usual way and with "Schulze Mixture" (equal quantities of nitric acid and distilled water to which a very small amount of $KClO_3$ has been added). The maceration is very difficult and the leaves, (e.g. of *Podozamites* type), fall into small pieces but remain black and do not show a cell structure (Pl. 2 fig. 2).

Fragments of *Podozamites* fossil leaves were transfered from the sediment to dentistic white plastic before the observations in the Scanning Electron Microscope (Pl. 1 figs 4–5). Then part of this material was cleaned in 10 % hydrochloric acid (1 hour), hydrofluoric acid with distilled water 1: 1 (1/2 hour), in nitric acid (1/2 hour) and in distilled water and coated with gold and photographed in a Tesla BS-301 Scanning Electron Microscope. Other fossil leaves were cleaned and transfered from the rock to the holder and photographed in SEM .

DESCRIPTION AND DISCUSSION

Partly charred specimens were observed in the macrofossils from Odrowąż. After maceration some cuticules show yellow brown cells and some fragments remain black, e.g. the cuticule from fragment of *Neocalamites* sp. stem (Pl. 2 fig. 1). Those black fragments of cuticule suggest the occurrence of fire. Fern leaves of *Phlebopteris angustiloba* from the family Matoniaceae (Pl. 1 fig. 1) also occur in this material. Three-dimensional fragments of midribs from a leaf (Pl. 1 fig. 2) and stomata (Pl. 1 fig. 3) were observed under SEM. This is evidence that those fragments are fossil charcoal. Similar preservation of leaves was observed by Harris (1958, 1961) in the Jurassic flora from Yorkshire, e.g. leaves of *Phlebopteris woodwardi*. Reymanówna (1965) described leaves of *Weichselia reticulata* preserved as a fossil charcoal from the Mesozoic (Lower Cretaceous in the Western Carpathians) of Poland. Leaves of *Podozamites* sp. (Coniferae) which were probably burnt, because they remain black after maceration (Pl. 2 fig. 2).

According to Reymanówna (1991, 1992, 1993) *Hirmeriella muensteri* trees (Pl. 3 figs 1–2) have small xeromorphic leaves covered by a thick cuticule. Cuticules from *Hirmeriella* leaves (Pl. 2 fig. 7) need a very long time for maceration. The seminiferous scales from this plant founded in Odrowąż, yielded no cuticule. It is possible to obtain *Classopollis* pollen grains from male cones from *Hirmeriella* (Pl. 2 fig. 8) but only after using heavy agents, e.g. bleach (Reymanówna personal communication). The long time and difficulties of maceration prove that *Hirmeriella muensteri* from Odrowąż may have been partly charred. Harris (1957) suggests that delicate things, e.g. male cones, were probably charred and not burnt to ash because they were laying on the soil. They were partly protected when the fire passed over them. He wrote that this would explain why some fragments resist maceration longer than others. A Liasso-Rhaetic flora in South Wales (Harris 1957) contains mainly *Cheirolepis (Hirmeriella) muensteri* with seminiferous scales, seeds, fragments of male cones, leaves, wood and C*lassopollis* pollen grains. The flora from Odrowąż is richer than that from South Wales and charred to a lesser degree.

MICROFOSSILS

MATERIAL AND METHODS

Palynological samples were taken from 8 types of plant bearing sediments from the outcrop in Odrowąż. They were macerated in hydrochloric acid, hydrofluoric acid, "Schulze Mixture" or in HNO_3, HF, NH_4OH and cleaned in KOH and distilled water. Then samples were embedded in glycerine solution. Microfossils were observed and photographed in glycerine jelly.

DESCRIPTION

A great amount of black, opaque particles of different sizes and angular shape was found in palynological slides (Pl. 2 figs 3–6). Similar types of particles were also observed in the Quaternary sediments (e.g. Patterson III *et al*. 1987) and in Cretaceous and Jurassic sediments (e.g. Van der Zwan 1990) and are considered to be fossil charcoal. Fern and another spores and bisaccate pollen grains are thin and light brown or yellow after maceration. *Classopollis torosus* pollen grains have a thicker exine and a darker colour, rather more brown than yellow.

GENERAL DISCUSSION

Numerous papers on charcoal of different geological ages and localities have now been published. Most of the authors agree that fusain is the result of wildfire, e.g. Harris (1958), Cope & Chaloner (1985), Scott (1989), Sander & Gee (1990), Jones (1997). The fossil material from Odrowąż was investigated on the basis of macroscopic and microscopic features. Harris (1981) indicates differences between leaves preserved as charcoal and ones preserved as compression. Some fossil leaves from Odrowąż, e.g. fern leaves of *Phlebopteris angustiloba*, posses the same macroscopic and microscopic features as charcoal, but they were not experimentally investigated. The sediment contains numerous fragments of charcoal, and we may see many fragments of dark tracheids (Pl. 2 fig. 5) and other black, opaque fragments (Pl. 2 figs 3–4 and 6) in the palynological slides. Some authors counted charred particles and made charred particle analysis in the Quaternary sediments (Tolonen 1986). The charred particle analysis is not possible in the investigated Liassic sediments from Odrowąż, because the samples were not taken from a long core, but from the outcrop. Reymanówna (1992, 1993) assumed that the Liassic vegetation in Odrowąż, probably in greater part a conifer forest with dominant *Hirmeriella muensteri* trees, must have grown in a climate with a rainy and dry season. During the dry season it is belived that the plant material caught fire from lightning strikes. Some recent North American pines, e.g. *Pinus contorta* and *Pinus rigida*, open their cones and shed their seeds only after fire. Reymanówna (1993) wrote: " The strange seminiferous scales of *Hirmeriella* with the seed covered by a flap of tissue was perhaps also adapted to a similar type of dissemination. The cones shed those scales together with seeds, but also many separate seeds are found. Both complete scales and separate seeds are extremly difficult to macerate which indicates that they were under the influence of fire. It seems possible that the fire caused the opening of the covering flap of tissue and shedding of the seeds."

An answer to the question from the title of this paper is: Yes, but not completely. Some plants or parts of plants are charred in different grades and some of them are not charred but preserved as compression.

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REFERENCES

COPE M.J. & CHALONER W.G. 1985. Wildfire: An Interaction of Biological and Physical Processes. In: Tiffney B.H. (ed.) Geological Factors and the Evolution of Plants. Yale University Press, New Haven and London: 257–277.

HARRIS T.M. 1957. A Liasso-Rhaetic flora in South Wales. Proceedings of the Royal Society, London, Ser. B, 147: 289–308.

HARRIS T.M. 1958. Forest fire in the Mesozoic. The Journal of Ecology, 46: 447–453.

HARRIS T.M. 1961. The Yorkshire Jurassic Flora. I. Thallophyta – Pteridophyta. British Museum (Natural History), London.

HARRIS T.M. 1981. Burnt ferns from the English Wealden. Proceedings of the Geologists' Association, London, 92(1): 47–58.

JONES T.P. 1997. Fusain in Late Jurassic sediments from the Witch Ground Graben, North Sea, U.K. In: Herngreen G.F.W. (ed.) Proceedings of the 4th European Palaeobotanical and Palynological Conference, Heerlen/ Kerkrade, 19–23 September 1994: 93–103.

KARASZEWSKI W. 1962. Stratygrafia liasu w północnym obrzeżeniu Gór Świętokrzyskich (summary: The stratigraphy of the Lias in the northern Mesozoic zone sourrounding the Święty Krzyż Mountains (Central Poland)). Prace Instytutu Geologicznego, 30(3): 333–416.

MARCINKIEWICZ T. 1957. Liasowe megaspory z Praszki, Zawiercia i Gór Świętokrzyskich (summary: Megaspores of the Lias from Praszka, Zawiercie and the Święty Krzyż Mountains). Kwartalnik Geologiczny, 1(2): 299–302.

MARCINKIEWICZ T., ORŁOWSKA-ZWOLIŃSKA T. & ROGALSKA M. 1960. Wiek warstw helenowskich górnych (lias) w przekroju geologicznym Gorzów Śląski-Praszka w świetle badań mega- i mikrosporowych (summary: Age of upper Helenów beds (Lias) in view of mega- and microspore investigations (geological section Gorzów Śląski-Praszka)). Kwartalnik Geologiczny, 4(2): 386–398.

MAKAREWICZÓWNA A. 1928. Flora dolno-liasowa okolic Ostrowca. Prace Towarzystwa Przyjaciół Nauk w Wilnie, 4(3): 1–49.

PATTERSON III W.A., EDWARDS K.J. & MAGUIRE D.J. 1987. Microscopic charcoal as a fossil indicator of fire. Quaternary Science Reviews, 6: 3–23.

PIEŃKOWSKI G. 1983. Środowiska sedymentacyjne dolnego liasu obrzeżenia Gór Świętokrzyskich (summary: Early Lias sedimentary environments at northern margin of the Holy Cross Mts). Przegląd Geologiczny, 31(4): 223–230.

PIEŃKOWSKI G. & GIERLIŃSKI G. 1987. New finds of Dinosaur footprints in Liassic of the Holy Cross Mountains and its Palaeoenvoronmental background. Przegląd Geologiczny, 35(4): 199–203.

RACIBORSKI M. 1891. Flora retycka północnego stoku Gór Świętokrzyskich. Rozprawy Wydziału matematyczno-przyrodniczego Akademii Umiejętności w Krakowie, 23: 292–326.

RACIBORSKI M. 1892. Przyczynek do flory retyckiej Polski. Rozprawy Wydziału matematyczno-przyrodniczego Akademii Umiejętności w Krakowie, 22: 345–360.

REYMANÓWNA M. 1965. On *Weichselia reticulata* and *Frenelopsis Hoheneggeri* from the Western Carpathians. Acta Palaeobotanica, 6(2): 15–26.

REYMANÓWNA M. 1991. Are developing ovules and seeds of Mesozoic gymnosperms protected against the environment? Fifth Symposium on Mesozoic Terrestrial Ecosystems and Biota. Extended Abstracts. Contributions from the Paleontological Museum University of Oslo, 364: 53–54.

REYMANÓWNA M. 1992. Two conifers from the Liassic flora of Odrowąż in Poland. In: Kovar-Eder J. (ed.) Palaeovegetational development in Europe and regions relevant to its palaeofloristic evolution. Proceedings Pan-European Palaeobotanical Conference, Museum of Natural History, Vienna: 307–311.

REYMANÓWNA M. 1993. Forest fire in the Lower Liassic of Odrowąż, Poland. Plants and their environment. Resumes des communications. Premier Congres Europeen de Paleontologie „Organismes – Paleoenvironnement Interactions", Lyon: 111.

REYMANÓWNA M., WCISŁO-LURANIEC E. & ICHAS-ZIAJA J. 1987. The Liassic flora of the Holy Cross Mts.; 14 Intern. Botan. Congress Berlin, Guide to excursion No. 24, From the Jurassic to the Holocene... 46–54.

SANDER P.M. & GEE C.T. 1990. Fossil charcoal: techniques and applications. Review of Palaeobotany and Palynology, 63(3,4): 269–279.

SCOTT A.C. 1989. Observations on the nature and origin of fusain. International Journal of Coal Geology, 12: 443–475.

TOLONEN K. 1986. Charred particle analysis. In: Berglund B.E. (ed.) Handbook of Holocene Palaeoecology and Palaeohydrology. Wiley, New York: 485–496.

VAN DER ZWAN C.J. 1990. Palynostratigraphy and Palynofacies Reconstruction of the Upper Jurassic to Lowermost Cretaceous of the Draugen Field, Offshore Mid Norway. Review of Palaeobotany and Palynology, 62(1,2): 157–186.

WCISŁO-LURANIEC E. 1991. The Lower Liassic flora from Odrowąż in Poland and its ecosystem. Fifth Symposium on Mesozoic Terrestrial Ecosystems and Biota. Extended Abstracts. Contributions from the Paleontological Museum University of Oslo, 364: 69–70.

WCISŁO-LURANIEC E. 1992a. Flora from Odrowąż in Poland – a typical Lower Liassic European flora. In: Kovar-Eder J. (ed.) Palaeovegetational development in Europe and regions relevant to its palaeofloristic evolution. Proceedings Pan – European Palaeobotanical Conference, Museum of Natural History, Vienna: 331–335.

WCISŁO-LURANIEC E. 1992b. A Fructification of *Stachyopitys preslii* SCHENK from the Lower Jurassic of Poland. Courier Forschungsinstitut Senckenberg, 147: 247–253.

WCISŁO-LURANIEC E. 1993. Forest fire in the Lower Liassic of Odrowąż, Poland. Plant megafossils. Resumes des communications. Premier Congres Europeen de Paleontologie „Organismes – Paleoenvironnement Interactions", Lyon: 135.

ZIAJA J. 1989. The Lower Liassic flora from Odrowąż in Poland: Preliminary comparision of microflora with megaflora. 2nd European Palaeobotanical Conference, Madrid, Abstracts of contributed papers and poster sessions: 12.

ZIAJA J. 1992. The Lower Liassic microflora from Odrowąż in Poland. In: Kovar-Eder J. (ed.) Palaeovegetational development in Europe and regions relevant to its palaeofloristic evolution. Proceedings Pan – European Palaeobotanical Conference, Museum of Natural History, Vienna: 337–340.

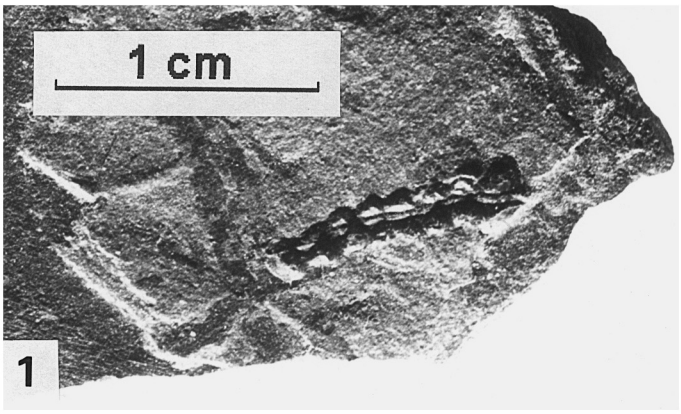
ZIAJA J. 1993. Forest fire in the Lower Liassic of Odrowąż, Poland. Plant microfossils. Resumes des communications. Premier Congres Europeen de Paleontologie „Organismes – Paleoenvironnement Interactions", Lyon: 139.

ZIAJA J. & WCISŁO-LURANIEC E. 1998. Are the Lower Liassic plants of Odrowąż (Poland) burned? Abstracts of the Fifth Palaeobotanical–Palynological Conference in Cracow, 26–30.06.1998: 207.

PLATES

Plate 1

1. *Phlebopteris angustiloba* (Matoniaceae) on the rock – fragment of fern leaf – 3.5 ×
2. *Phlebopteris angustiloba* – fragment of midrib from leaf after burning on the longitudinal view – 2000 × (SEM)
3. *Phlebopteris angustiloba* – two stomata – 3000 × (SEM)
4. *Podozamites* sp. – fragments of leaves after burning, on white plastic – 1.5 ×
5. *Podozamites* sp. – the small fragment of leaf, on white plastic – about 60 × (SEM)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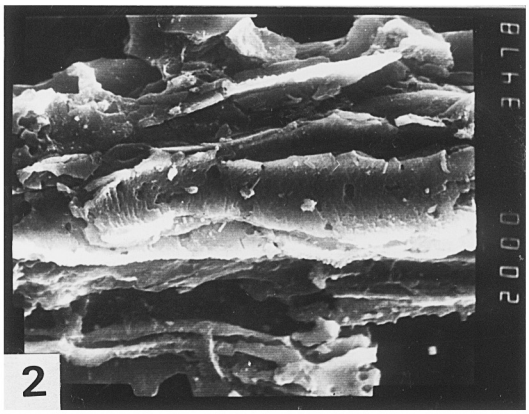
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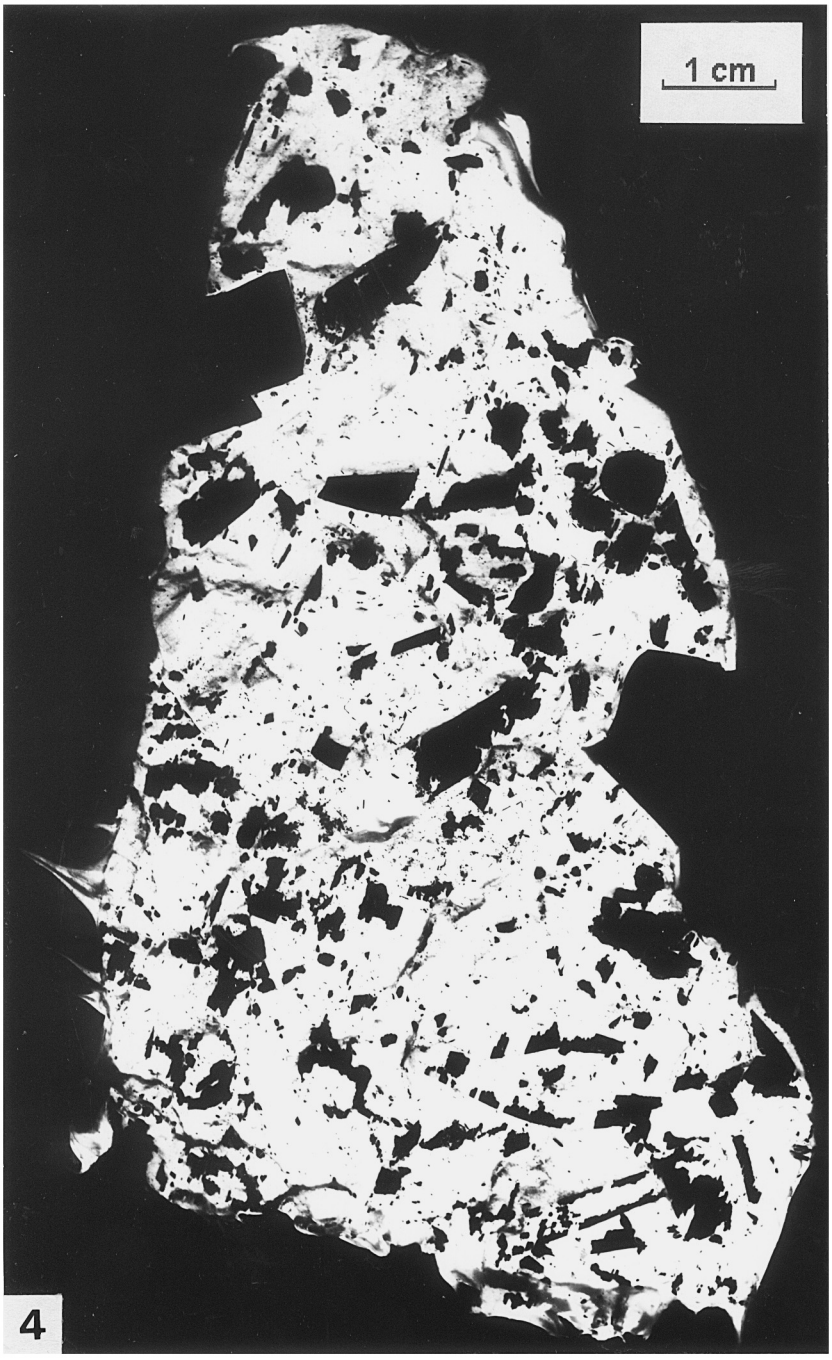
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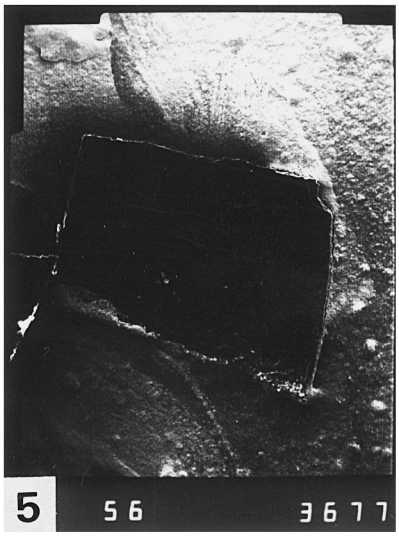
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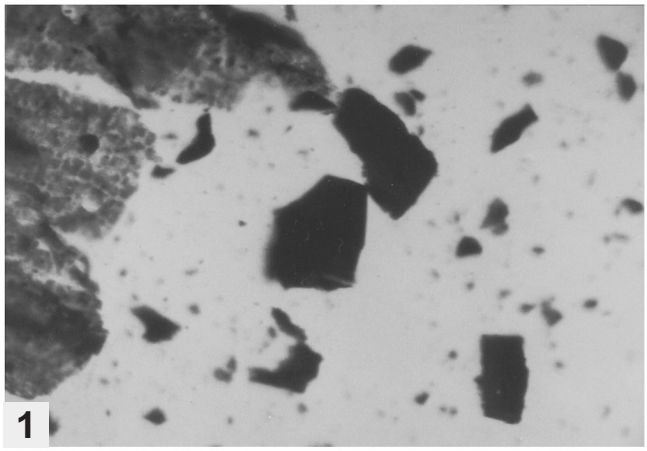
Plate 2

1. *Neocalamites* sp. (stem) – macerated cuticule and charcoal pieces – about 200 × (LM)
2. *Podozamites* sp. – leaf fragment after burning – about 200 × (LM)
3. *Classopollis torosus* pollen grain from the Liassic sediment and black, opaque material, probably charcoal, Odrowąż 11/1/5; 101/9 – about 400 × (LM)
4. Fragment from the palynological slide – macerated tissue and charcoal piece, Odrowąż 6/2/1; 107/10 – about 200 × (LM)
5. Tracheid fragment from the Liassic sediment, Odrowąż 6/1/2; 102/11 – about 1600 × (LM)
6. Fragment of the palynological slide – black, opaque particles of charcoal, Odrowąż 8/21; 106/13 – about 400 × (LM)
7. *Hirmeriella muensteri* – cuticule fragment of a leaf after maceration – about 200 × (LM)
8. *Hirmeriella muensteri* – pollen grains (*Classopollis*) after maceration of male cone – about 200 × (LM)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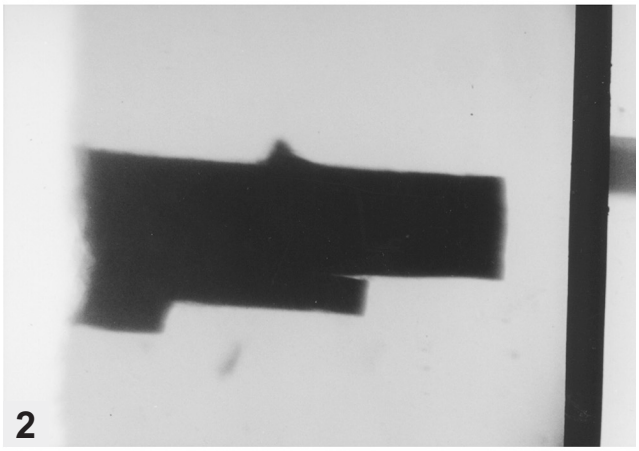
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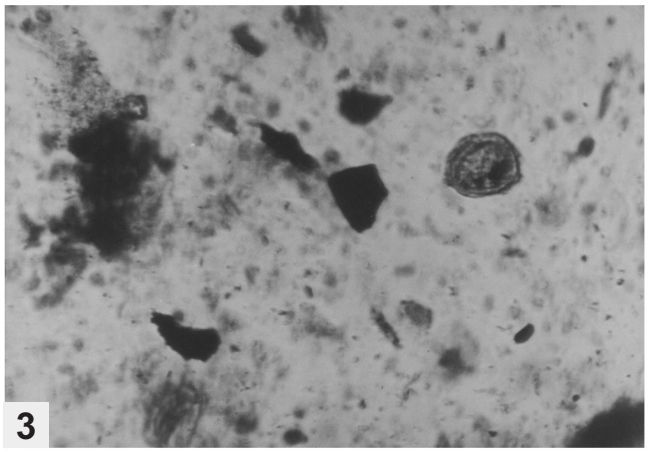
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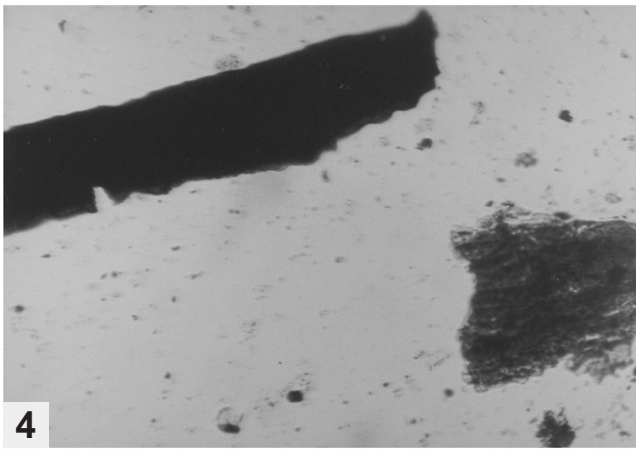
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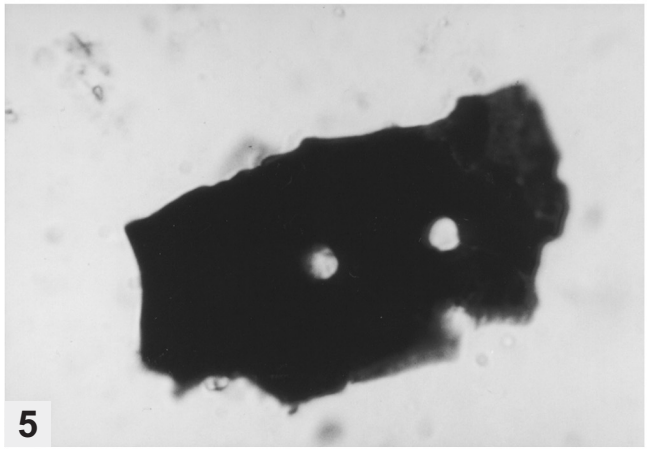
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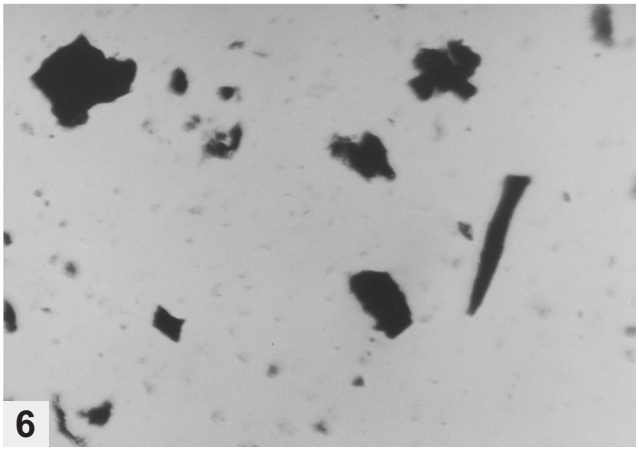
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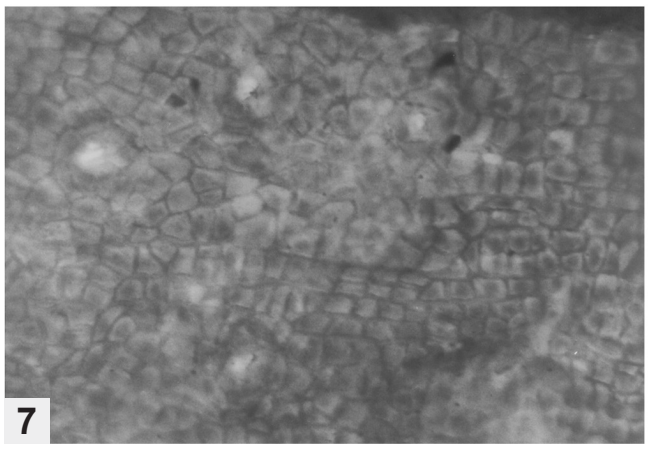
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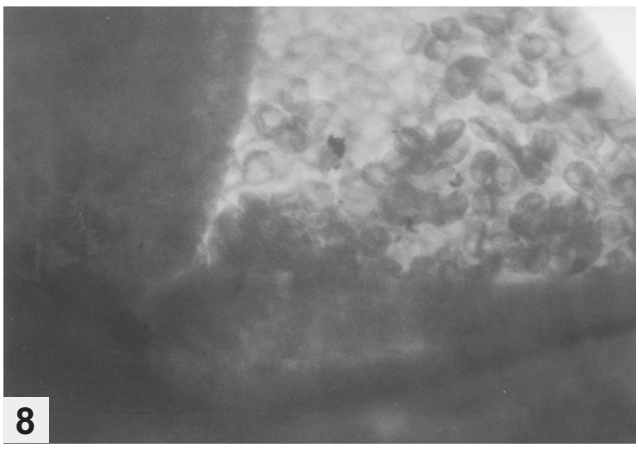
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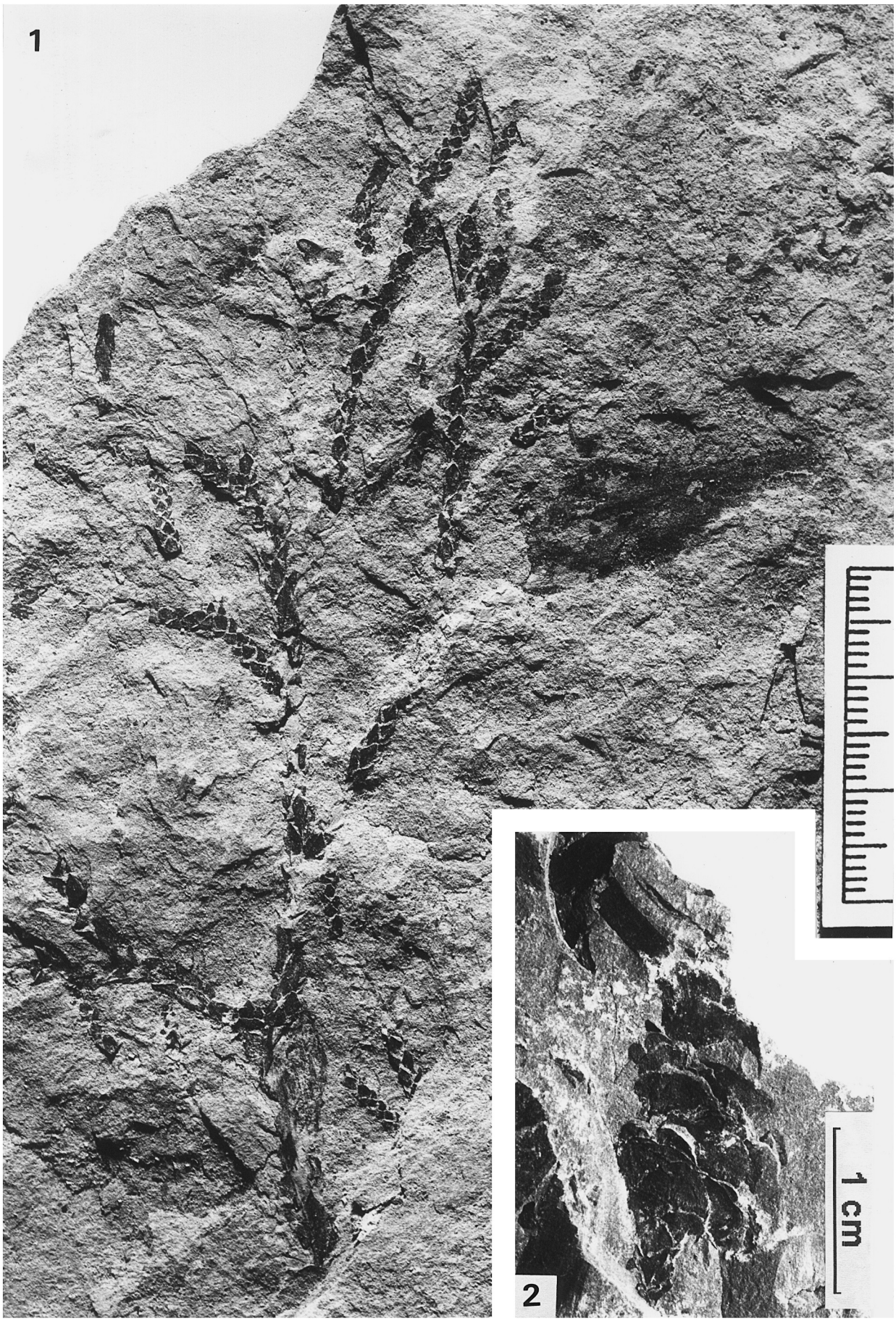
Plate 3

1. *Hirmeriella muensteri* – shoot on the rock – 2 ×
2. *Hirmeriella muensteri* – ovuliferous cone on the rock – 3 ×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