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FOSSIL MOSSES AND STONEWORTS AT IMBRAMOWICE NEAR WROCŁAW

Fosylne mchy i ramienice w Imbramowicach koło Wrocławia

ABSTRACT. Among abundant micro- and macrofossils in the Imbramowice profile, numerous leaves and leaved stems of leafy mosses as well as oogonia and oospores of stoneworts occurred. They were found in the Late Glacial of the Middle Polish Glaciation s. l., Eemian Interglacial and the first stadial of the Early Vistulian. The state of preservation of investigated groups, the frequency of species and data concerning the present-day conditions of their occurrence are presented.

INTRODUCTION

The flora of mosses and stoneworts from Imbramowice (about 40 km south--west of Wrocław), presented below, was distinguished and identified in the material derived from a profile drilled in 1960 (Szczepankiewicz 1961). A complex palaeobotanical study of this profile is presented in the same volume of the Acta Palaeobotanica (Mamakowa, this volume) and the distribution and abundance of the mosses and stoneworts identified can be traced in the macrofossil diagram included in it (Fig. 4). The profile covers the Late Glacial of the Middle Polish Glaciation, the Eemian Interglacial and the first stadial of the Early Vistulian. The synchronization of the samples with the local macrofossil zones (IM-1—IM-11) and their correlation with the stratigraphic division of the profile into regional pollen assemblage zones (R PAZ) are given after Mamakowa (l. c.) in Fig. 1.

BRYOPHYTA

An exceptionally rich and ecologically differentiated flora of leafy mosses (*Bryales*) and traces of the presence of a *Sphagnum* species, not closely identified, from the section *Acutifolia* have been found in the Imbramowice profile. The flora studied comprises 23 species, including two varieties and a form. The number of species in particular samples is variable, ranging from 1 to 5. The identifications of six species given by Hartmann (1907) from the old profile at Imbramowice have not been confirmed now, and so all the mosses identified at present are new to the flora of Imbramowice and five of them are new to the Pleistocene of Poland.

The moss flora from Imbramowice is characterized by a great generic, specific

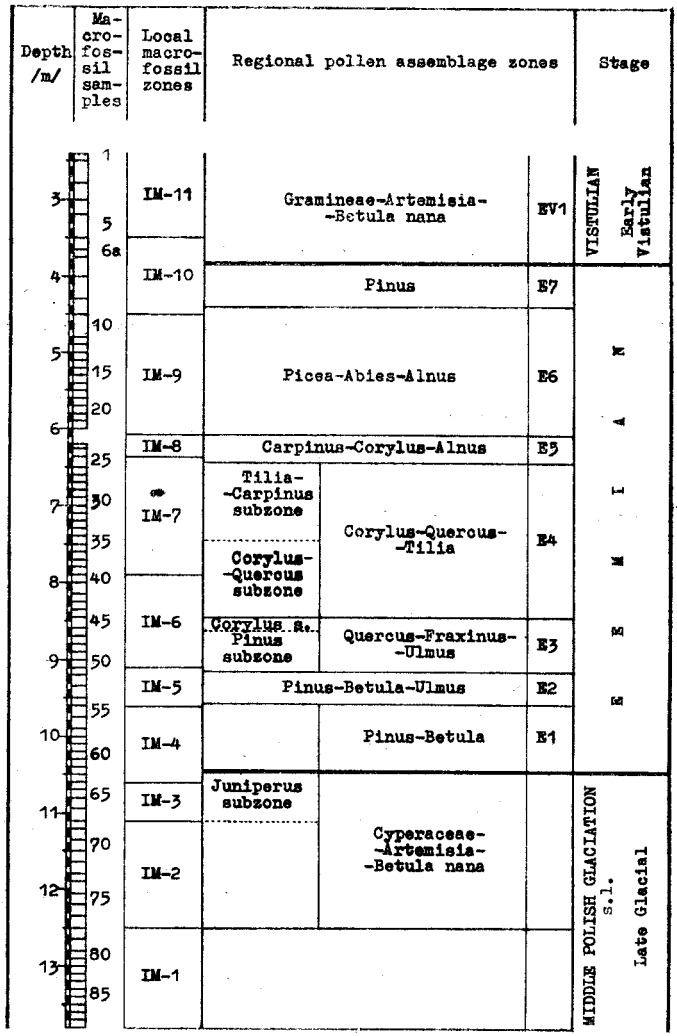

Fig. 1. Correlation of macrofossil samples and local macrofossil zones distinguished in the Imbramowice profile with the regional pollen assemblage zones (acc. to K. Mamakowa, this volume)

and ecological wealth. This may be referred to longlasting conditions favouring the development of the local aquatic mosses and the abundant accumulation of moss remains probably brought to the water reservoir by waters, particularly in the Late Glacial of the Middle Polish Glaciation and at the beginning of the interglacial. They were most likely carried chiefly from the uplift of the Ślęża massif or from the moraines left by the retreating ice sheet. The allochthonous mosses comprise mountain species growing on a rocky substratum (*Ditrichum flexicaule* and *Encalypta streptocarpa*), the common epilithic and epiphytic moss *Leucodon sciuroides* and the epilithic and epigean *Rhacomitrium canescens*. Now these species occur as the so-called mountain element of the Ślęża massif (Berdowski 1974). The steppe element is represented by *Pterygoneurum ovatum*, which grows in xero-

thermic slope grasslands and on shallow soils on a rocky substratum. The fact that this moss is present in the Imbramowice water body despite the fragility of its stems indicates its abundant occurrence in the close surroundings of the lake. At present the above-mentioned species are met with in very large numbers only in the area of uplands (Kuc 1964).

The presence of species typical of shady slopes and gorges (*Brachythecium rutabulum, Hypnum lindbergii, Oxyrrhynchium swartzii*) and the complete absence of the nemoral element are also characteristic features of the moss flora of Imbramowice. At that time *Leucodon sciuroides* or even *Amblystegium serpens* may have been epiphytic mosses of deciduous trees. The basic components of the moss layer of the water body were *Drepanocladus aduncus, Leptodictyum riparium* and *Cratoneuron commutatum*. On the other hand, the other two species of *Cratoneuron*, found in smaller numbers, may have been brought from nearby sources.

The survey of species gives the contemporary features of their distribution and ecological spectra. Ecological correlations with the species having similar demands and occurring in abundance in the same zone of the profile are roughly outlined for the typically calciphilous mosses. The species new to the Pleistocene of Poland are marked with an asterisk (*).

Amblystegiaceae

Amblystegium serpens (Hedw.) B. S. G. Fragments of leaved stems identified in several late-glacial samples from zones IM-1—IM-3. Species common on rocks, ground and tree bark; hydrophil-mesoxerophil, neutrophil.

Campylium chrysophyllum (Brid.) Bryhn. Species represented abundantly in many samples of zones IM-1 and IM-2. Nowadays it is common in lowlands and mountains. Frequent on exposed ground, on rocks and in xerothermic grasslands; xerophil-mesophil, relative calciphil.

Cratoneuron commutatum (Hedw.) Roth. Fragments of stems and leaves in many samples of zones IM-9—IM-11. The commonest *Cratoneuron* species throughout the profile. Common in mountains, uplands, rare in lowlands; hydrophil, calciphil.

Cratoneuron decipiens (De Not) Loeske. Fragments of leaved stems in samples 19 and 20 in zone IM-9. At present it is a rare spring species; hydrophil, calciphil.

Cratoneuron filicinum (Hedw.) Spruce. Fragments of leaved stems in sample 2 (zone IM-11). Frequent spring species, whose demands resemble those of the previous one.

Drepenocladus aduncus (Hedw.) Mnkm.:

— var. *aduncus* (fragments of leaved stems in sample 2).

— var. *kneiffii* (Brid. et Schimp.) Mnkm. It occurs in many samples throughout the profile except zone IM-8. Represented by single leaves and pieces of leaved stems, very numerous in IM-1 (sample 82).

— for. *capillifolia* (Warnst.) Mnkm. Abundant in samples belonging to Early Vistulian, especially 4—6 (IM-10, IM-11).

Commonest aquatic and marsh species, very variable. Both varieties and the form are described as hydrophil and neutrophil.

Leptodictyum riparium (Hedw.) Warnst. Fragments of leaved stems only in one sample in zone IM-11. Relatively rarely encountered in Quaternary floras. Known from Olszewice (Lilpop 1929), Ferdynandów (Janczyk-Kopikowa 1975), Walawa (Wilczek 1932) and Ludwinów (Żmuda 1914; Środoń 1960). Frequent aquatic moss of lowlands, less frequent in uplands and mountains; polyedaphic hygrophil.

Brachytheciaceae

Brachythecium rutabulum (Hedw.) B. S. G. Present in several samples in zones

IM-7—IM-9, generally as fragments of leaved stems. Exceedingly frequent species in lowlands and mountains; hygrophil-mesophil, neutrophil.

Oxyrrhynchium swartzii (Turn.) Warnst. Fragments of stems in zone IM-7 and in sample 13 of zone IM-9. It grows very commonly all over the country; hygrophil-mesohygrophil, basiphil.

Bryaceae

**Bryum caespiticium* Hedw. Single leaves in several samples of zones IM-1—IM-3 and fragments of leaved stems in samples 86 and 87 (IM-1) and in one sample of zone IM-9. Extremely common throughout the country; xerophil, neutrophil--basiphil.

Bryum pseudotriquetrum (Hedw.) Schwägr. Single leaves in sample 72 (IM-2). Very common polyedaphic hydrophil.

Climaciaceae

Climacium dendroides (Hedw.) Web. et Mohr. Fragments of leaved stems in sample 28 (IM-7). Common meadow-peatbog moss in lowlands up to mixed mountain forest zone; hydrophil-hygrophil, neutrophil.

Ditrichaceae

Ditrichum flexicaule (Schwägr.) Hampe. Species found only in the late glacial of the Middle-Polish Glaciation, in 15 samples of zones IM-1 and IM-2, mostly as fragments of leaved stems. Common mountain moss, frequent in uplands: on outcrops of rock and on thin soil layer on rocky substratum; xerophil, calciphil.

Ditrichum heteromallum (Hedw.) Britt. Fragments of leaved stems in sample 18 (IM-9). Frequent species of lowlands and mixed mountain forest zone; xerophil, neutrophil-basiphil.

Encalyptaceae

Encalypta streptocarpa Hedw. Single leaves in zones IM-2 and IM-3. Exceedingly calciphilous mountain-wide species; xerophil, calciphil.

Funariaceae

**Funaria hygrometrica* Hedw. Fragments of leaved stems in sample 24 (IM-8). Highly common polyedaphic species; xero-mesophil.

Grimmiaceae

**Rhacomitrium canescens* (Hedw.) Brid. Fragments of leaved stems in sample 23 (IM-8). Common on rocks and arid sands; xerophil, calcifug.

Hypnaceae

**Hypnum lindbergii* Mitt. Single leaves in zones IM-2 (sample 72), IM-3 (sample 67) and IM-7 as well as leaves and stems in some dozen samples of zones IM-4—IM-6. In the fossil state it may be readily confused with the related species *H. pratense* Koch. The tips of leaves are jagged, most probably, because of the long--distance transport of material. The species has hitherto be recorded only from sediments of the Mazovian Interglacial at Żydowszczyzna near Grodno as *H. lindbergii* for. *breidleri* (Kac & Kac 1960; Abramova & Abramov 1967). Now it is rather frequent in lowlands, uplands and mountains; hygrophil, neutrophil.

Leucodontaceae

Leucodon sciuroides (Hedw.) Schwägr. Fragments of leaved stems in sample 46 of zone IM-6. At the present time it is fairly common on sandstones, siliceous rocks and, as an epiphyte, on deciduous trees; xerophil.

Mniaceae

Plagiomnium affine (Funck) Kop. Single leaves in sample 19 (IM-9). Very common in lowlands, less in mountains; hygrophil, sciaphil, basiphil.

Pottiaceae

**Pterygoneurum ovatum* (Hedw.) Dix. Fragments of leaved stems in the late glacial of the Middle-Polish Glaciation (IM-2, sample 68). Species growing on

earth, more rarely on limestone, gypsum or sandstone rocks; xerophil, basiphil.

Tortula ruralis (Hedw.) Gaertn. Single leaves and a fragment of capsule of the Late Glacial, in zone IM-1 (sample 78). Polyedaphic species; xerophil, relative calciphil.

Rhytidiaceae

Rhytidiadelphus squarrosus (Hedw.) Mitt. Fragments of leaved stems in sample 22 (IM-9). Common lowland species of wet grasslands; hygrophil, neutrophil.

Sphagnaceae

Sphagnum sect. *Acutifolia*. Only two damaged branch leaves in sample 48 in zone IM-6.

CHAROPHYTA

Characeae

Chara hispida L. (Pl. I, Figs. 1—4). It appears in the Late Glacial of the Middle Polish Glaciation, in sample 68 (zone IM-2) and is abundant at the beginning of the climatic optimum of the Eemian Interglacial, at a depth of 8.25—8.80 m (IM-6), where also its occurrence comes to an end. Oospores are brown, brown-chestnut, oval, often strongly flattened and in consequence pyriform, with 12—13 thin ridges; 660—780 μm long, 420—640 μm broad; coronule preserved only in a small number of specimens; oospore membrane light brown, thin, translucent, granular on surface.

This species is very variable, closely related to *Ch. rudis*, from which it differs in having its oospore membranes covered with fine granularities. In Poland it has hitherto been known in the fossil state only from Imbramowice (Hartmann 1907) and Roztoki near Jasło (Wołoszyńska 1938). Two new species of the genus *Chara*, namely, *Ch. pygmaea* and *Ch. quinqueradiata*, described by Hartmann (l. c.), as may be judged from his very short diagnoses, belong to a series of very variable developmental forms of oospores of *Ch. hispida*. This opinion is supported by such characters as smoothness of the membrane and the variable number of ridges in the oospores examined (Karczmarz in print).

Nitellaceae

Nitella gracilis (Sm.) Ag. (Pl. I, Figs. 15—16). Oospores, 113 in number, found in sample 7 (IM-10), at the decline of the interglacial, and one in sample 5 (IM-11), at the beginning of the Early Vistulian. Oospores sub-round, dark brown, with 6—7 protruding ridges, 360—380 μm long and 320—340 μm broad; oospore membrane more or less dark brown or yellow-brown, with irregularly elongated, granulate processes.

This species has not as yet been recorded from the Pleistocene of Poland. Today it grows rather rarely, mainly in the north-western part of Poland and in the Lublin Province (Dąmbska 1964).

Nitella mucronata (A. Br.) Miquel (Pl. I, Figs. 11—14). The species was found only at the beginning of the Early Vistulian, in sample 6a in zone IM-10, together with three oospores of *Nitellopsis obtusa*. There were 80 oogonia in a poor state of preservation and well-preserved oospores with remains of the coronule cells. Oospores oval, dark brown, with 5—6 ridges, small, 250—295 μm in length and 220—250 μm in breadth; oospore membrane light yellow-brown; seen in a magnification of 800 diameters, it is irregularly reticular, with dark lines; meshes 4—5 μm across, in 8 (9—11) rows.

This species is new to the Pleistocene of Poland. Owing to the stable structural

characteristics of oospores (Wood 1959) it is easily distinguished from other species of *Nitella*. In the present flora it is the commonest species of the genus *Nitella* (Dąmbska 1964).

Nitellopsidaceae

Nitellopsis obtusa (Desv.) Grov. (Pl. I, Figs. 5—10). Single specimens appear in the Late Glacial of the Middle Polish Glaciation, from the bottom of zones IM-1. At the top of zone IM-2 (sample 68) it is very abundant for the first time. It keeps being numerous to the end of zone IM-7, with two peaks, in IM-6 and IM-7. It is missing from zones IM-8 and IM-9 and reappears, not numerous, in zone IM-10, at the decline of the interglacial and the very beginning of the Early Vistulian.

It is the commonest stonewort species in the profile of Imbramowice, preserved in the form of black-brown or brown oospores (Pl. I, Figs. 5—9) and white-grey oogonia (gyrogonites) with a thick calcareous envelope (Pl. I, Fig. 10). Oospores oval, more rarely broadly pyriform, with 7—8 ridges; 650—720 μm long and 470—510 μm broad; oospore membrane brown, partly transparent, with unequal processes, weakly granulated (in a magnification of 1000 times). Oogonia, ± 830—1110 μm long and 650—1120 μm broad; thickness of pedicel: 50—65 μm, angle of inclination of ridges: 15—20°, apical rosette diameter (Pl. I, Fig. 10b) 375—570 μm, pore diameter: 75—85 μm (Pl. I, Fig. 10c).

The identifications of this species in Hartmann's (1907) study need a revaluation, Hartmann identified the oospores of *Nitellopsis obtusa* as *Chara meriani* A. Br. and included the biggest gyrogonites in the species, newly described by him, *Ch. truncata*. Later, Mädler (1955) described the gyrogonites of *N. obtusa* as belonging to *Tectochara meriani diluviana* Mädler. On the basis of rich fossil and stratigraphic materials from the Tertiary and Quaternary of Germany (Nötzold 1962a, 1966, 1975; Krause 1986) and the USSR (Krasavina 1971, 1975; Gollerbakh & Krasavina 1975) it has been established that the gyrogonites, oogonia and oospores of *Tectochara meriani* and *T. meriani diluviana* are identical with these organs of the present species *Nitellopsis obtusa*, which is also known from the Upper Tertiary. On the grounds of both exceedingly distinct and very stable taxonomic characters and the occurrence of *N. obtusa* as early as the Upper Tertiary the distinctness of the family *Nitellopsidaceae* with the monotypic genus *Nitellopsis* has recently been generally accepted (Gollerbakh & Krasavina 1975).

The first fossil locality of *Nitellopsis obtusa* in Poland was discovered in the profile at Imbramowice. Rich materials containing this species were determined from the Mazovian Interglacial at Boczów near Rzepin in western Poland, unfortunately after the publication of a paper by Janczyk-Kopikowa & Skompski (1977) concerning that locality. Samostrzelniki near Grodno (Krasavina 1975) is the nearest Eemian locality where this species was found. It is also known from the Pliocene and Pleistocene of both the European and Asiatic parts of the USSR (Krasavina 1971, 1975). It is reported under the name of *Tectochara meriani* from the Pleistocene of England (Groves & Bullock-Webster 1924), from the profile of Okrilla and Tüllinger in the GDR (Nötzold 1961, 1962b, 1975) and Elce in the FGR (Mädler 1955). At the present time this species is rather rare throughout its range; it grows in eutrophic water bodies, such as deep ponds and lakes (Willen 1957; Dąmbska 1964; Karczmarz & Malicki 1971).

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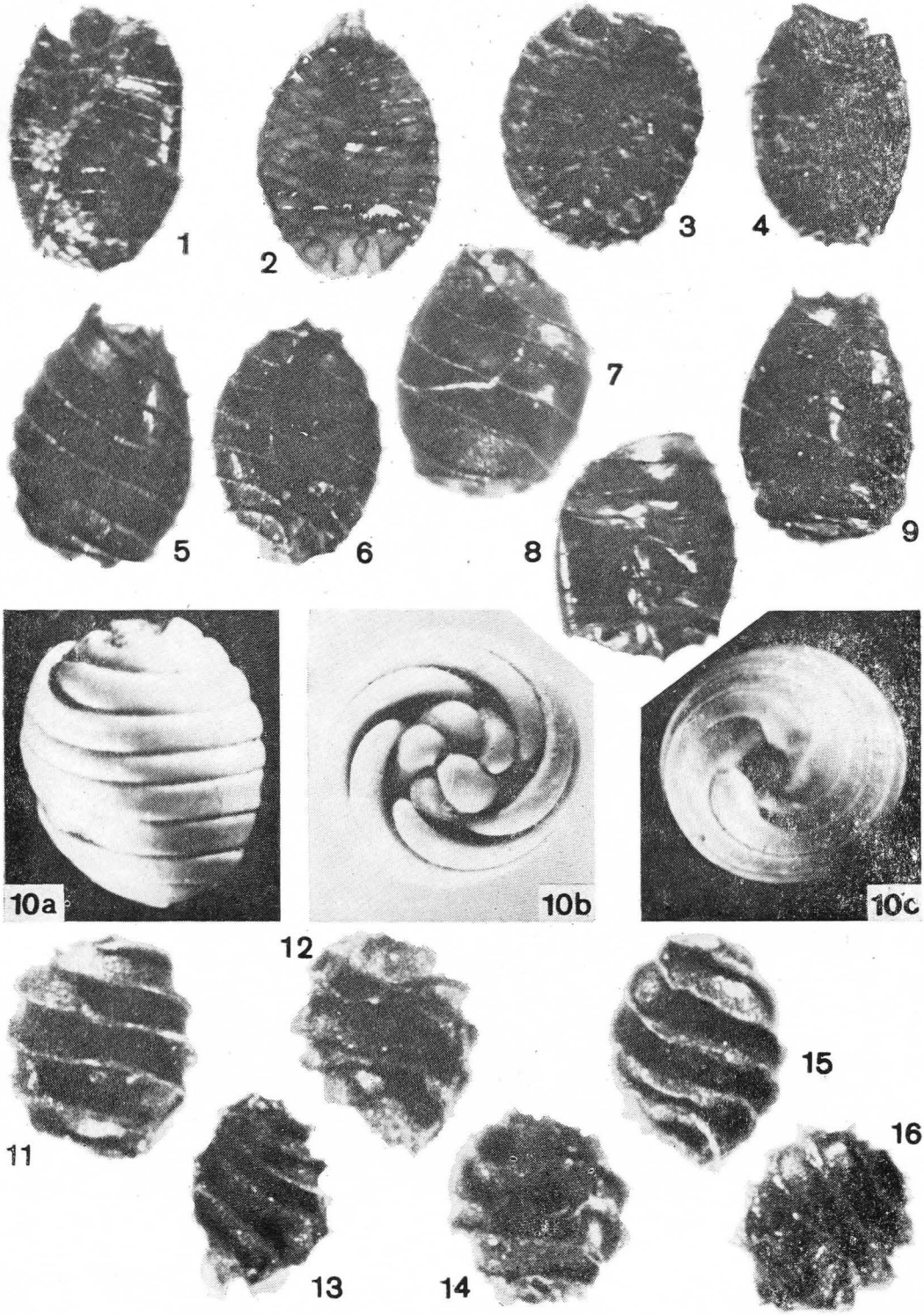
PLATE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