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Contribution to the knowledge of the Middle Miocene flora from Konin Brown Coal Basin (Central Poland)

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ABSTRACT. Carpological remains from Miocene aged Lubstów open-pit mine in the Konin Brown Coal Basin are reported. Fossils were collected from rich fluvial deposits belonging to the uppermost part of the Adamów Formation. From this horizon 20 taxa have been identified and comprise mostly angiosperm plants. Four species (*Cupressoconus rhenanus* Kilpper, *Cupressospermum saxonicum* Mai, *Leucothoe lusatica* Mai, and *Cladium* cf. *europaeum* Dorofeev) represent first reports from the Tertiary of Poland. Determined macroremains evidence wetland domination and the collected carpological materials indicates warm temperate or subtropical climates.

KEY WORDS: fruits, seeds, cones, Middle Miocene, Lubstów, Konin Basin, Central Poland

INTRODUCTION

The Konin Brown Coal Basin is located in the western part of Central Polish Lowlands (Fig. 1). Lithology and stratigraphy of the Konin region are comparatively well known (Ciuk & Grabowska 1991, Biernacka et al. 1994, Widera 2000, Kasiński 2004) and active brown coal mining in the area enables collecting material for palaeobotanical studies. From this basin Raniecka-Bobrowska (1954, 1959) has previously documented leaf, fruit and seed remains, while fossil wood was described by Grabowska (1956) and Smólska (1959). Palynological studies of brown coals from localities within the Konin Basin including samples collected from Konin, Lubstów, Gosławice and Niesłusz were carried out by Kremp (1949), Mamczar (1960), and Ciuk & Grabowska (1991).

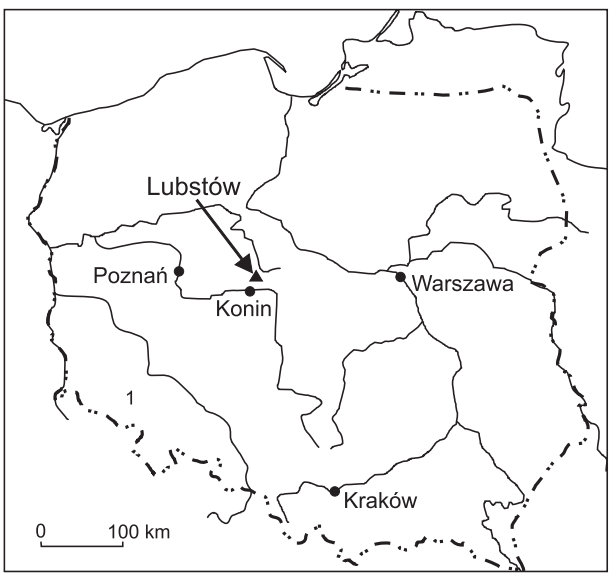

Fig. 1. Map showing the location of the Lubstów coal mine

GEOLOGY

Cenozoic sediments from the Lubstów locality are deposited within a tectonic graben extending NW-SE, or approximately N-S, and are of variable thickness ranging from several metres to over 200 m (Ciuk & Grabowska 1991). The most important factor controlling late Palaeogene and Neogene aged sedimentation was

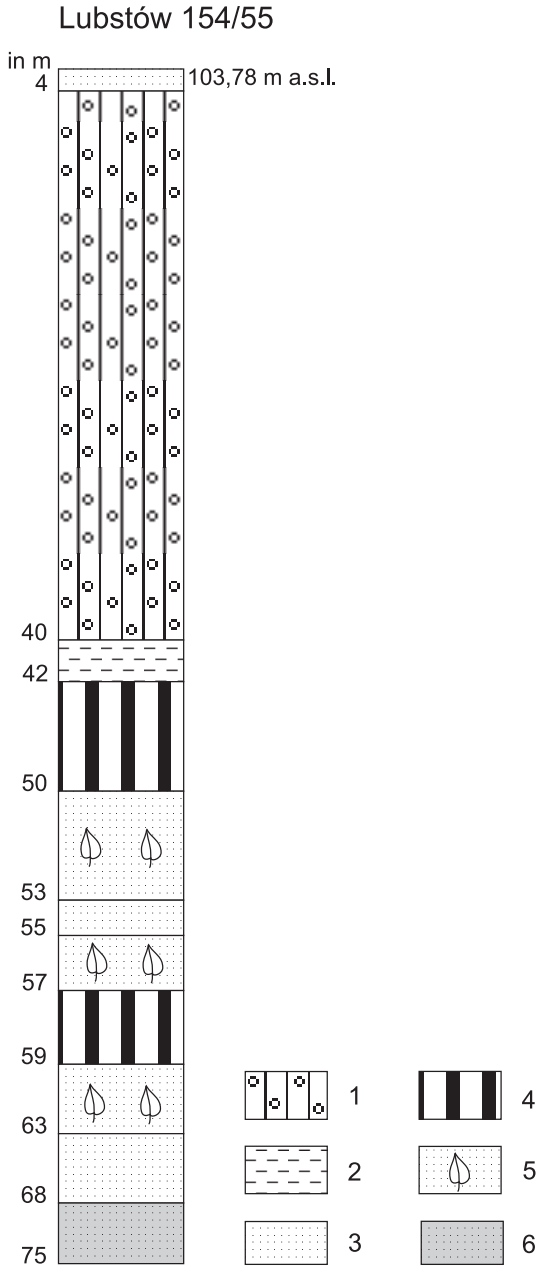

Fig. 2. Schematic geological profile of Lubstów, boring 154/55; **1** – till, **2** – dusty clay, **3** – sand, **4** – brown coal, 1st group of Middle Polish seams, **5** – sand with macrofossils, **6** – sand with glauconite

tectonic subsidence. The oldest Palaeogene deposits known from the Lubstów graben are Upper Eocene sediments that are underlain by Campanian-Maastrichtian aged deposits. Upper Eocene sediments are followed by Oligocene and Miocene sediments. The Miocene sequence is represented mostly by phytogenic deposits. There are two main brown coal seams in Lubstów and both are Middle Miocene in age (Biernacka et al. 1994, Kasiński 2004). The lower seam is over 90 m thick and belongs to the 2nd (Lusatian) group of coal seams in the area. The upper seam is up to 15 m thick and is placed in the 1st group of the Middle Polish seams (Ciuk & Grabowska 1991, Piwocki & Ziembińska-Tworzydło 1995). The lower and upper coal seams are separated by sandy deposits belonging to the Adamów Formation that is on average approximately 8 m thick.

MATERIAL AND METHODS

The plant materials studied were collected from the Lubstów exposure where they occur in sands underlying coals in the 1st group of the Middle Polish seams. The lithological profile presented in Fig. 2 comes from the core obtained from well No. 154/55 that is the nearest borehole to the sampling place for carpological studies. This locality was discovered in 2001 by Dr E. Durska (Faculty of Geology, Warsaw University). Most of the materials studied were collected by the present author in 2002. Samples were taken from gravel lenses revealed in the wall of the exposure. Some of the remains were extracted by sieving the material through 2.00 and 0.49 mm meshes. Carpological material was then identified, based on comparisons with extant and fossil fruits and seeds from the collection of the Museum of the Earth, Polish Academy of Sciences in Warsaw and the Natural History Museum in Berlin.

The collection of fruits and seeds from Lubstów described in the present paper were numbered UWPalaeo/mag.2004/1–26) and are housed at the Faculty of Geology, Warsaw University, Żwirki and Wigury Street, 93, Warsaw.

SYSTEMATIC PART

Cupressaceae

Chamaecyparis salinarum Zabłocki

Pl. 1, fig. 1

1930 *Chamaecyparis salinarum* Zabłocki, p. 140, pl. 10, figs 14–16.

1975 *Chamaecyparis obtusa* Sieb. & Zucc. *fossilis* Chochieva, p. 58, pl. 12, figs 1, 3.

1961 *Chamaecyparis pisifera* Sieb. & Zucc.; Szafer, p. 30, pl. 8, figs 8–10 .

2004 *Chamaecyparis salinarum* Zabłocki; Mai, p. 25, pl.5, figs 1–15.

Material. Seventeen cones, mostly well preserved (UWPalaeo/mag.2004/1).

Description. Cones 7–13 mm long, 6–12 mm wide and elliptical to spherical. Scales up to 8 mm in diameter, 7–11 (average 8) in number, of various shape mostly tetragonal

or hexagonal and peltate. Scales are sharp-edged. Usually a small nodule or short cone-shaped bract is weakly visible in the centre of the scale. Bract often merging with diagonal ridge.

Remarks. The main features for identification were diameters of the cones and their general similarity to the extant cones of *Chamaecyparis obtusa* Sieb. & Zucc., with which *Ch. salinarum* is compared (Zabłocki 1930, Mai 2004). Cones of the extant *Ch. obtusa* Seib. & Zucc. have, on average, 8–10 scales. Cones from Lubstów morphologically resemble *Ch. salinarum* Zabłocki from the Pliocene of Rüterberg and Lübtheen (Mai 2004), however, the number of scales is unknown in these specimens.

Chamaecyparis obtusa Sieb & Zucc. foss. cones described by Chochieva (1975) from the Lower Pleistocene of Georgia are smaller than Lubstów specimens and are only 4 mm long.

Besides the species *Chamaecyparis salinarum* Zabłocki, two other species of this genus are known from the Tertiary floras of Europe, namely *Ch. europaea* (Saporta) Saporta from the Lower Miocene of Armissan (Saporta 1889) and the Lower Miocene of Spremberg, Staakow and Kringelsdorf (Mai 1999a), and *Ch. pisifera* Sieb. & Zucc. from the Lower Pliocene of Krościenko (Szafer 1947). Cones of *Ch. europaea* (Saporta) Saporta have fewer scales (6) in comparison with those from Lubstów. The cones and scales of *Ch. pisifera* Sieb. & Zucc. from Krościenko (Szafer 1947) are much smaller and are on average 6.7×6.2 mm long.

Extant *Chamaecyparis obtusa* Sieb, & Zucc. occurs in Japan (Krüssmann 1972), the variety *formosana* Hayata grows in Taiwan where it forms pure stands or co-occurs with other conifers (e.g. *Cunninghamia* R. Br., *Taiwania* Hayata) and evergreen trees of *Quercus* L. and *Castanopsis* (D. Don) Spach (Wang 1961).

Fossil occurrence in Poland. Wieliczka, Middle Miocene (Zabłocki 1930), Stare Gliwice, Middle Miocene (as *Chamaecyparis pisifera* Sieb & Zucc., Szafer 1961, Mai 2004).

Cupressoconus rhenanus Kilpper

Pl. 1, figs 3–6

1968b *Cupressoconus rhenanus* Kilpper, p. 102, pl. 34, figs 4–17.

1985 *Cupressoconus rhenanus* Kilpper; Mai & Walther, p. 30, pl. 5, figs 21, 22.

1987 *Cupressoconus rhenanus* Kilpper; van der Burgh, p. 304, pl. 1, figs 1, 5, 6, 8, 9.

Material. One incomplete and 2 almost complete cones (UWPalaeo/mag.2004/2a) and 8 isolated seeds (UWPalaeo/mag.2004/2b).

Description. Cones 16–21 mm long and 19–20 mm wide, subglobose or globose, comprising 11 more or less regularly shaped scales with rounded edges, tetragonal or hexagonal, with small button-like bracts or plain. Scales thick and massive. Seeds typically 3–4 mm long, 1.5–2.8 mm wide (extracted from one of the cones), and roughly oval, distorted by large papilla-like resinous inflations. The seed is conspicuously narrow with winglets to either side. Testa surface is striped longitudinally.

Remarks. Cones from Lubstów resemble *Cupressoconus rhenanus* Kilpper cones from the Miocene sands from the Zukunft-West (Eschweiler) open cast mine as described by Kilpper (1968b). Shape and size of both cones and scales, and the features of their surface are identical. Differences relate only to the smaller number of cone-scales (7–9) in the specimens from Zukunft-West. Cones of *C. rhenanus* Killper from Miocene of Eschweiler determined by van der Burgh (1987) have 8–12 scales and show high morphological similarity with those from Lubstów. The specimens reported by Mai and Walther (1985) from the Upper Eocene of Groitzsch are not so similar and have fewer scales (6), and specimens illustrated by Mai and Walther in their pl. 5, figs 21 and 22 differ slightly in shape of both cones and scales, which are more sharp-edged. Seeds of *C. rhenanus* Kilpper from Lubstów are very similar to those described by Mai & Walther (1985) and van der Burgh (1987). They bear distinctive resinous papillae, present also on specimens from Groitzsch and Eschweiler.

Among extant taxa, *Cupressus arizonica* Greene that grows in southern California, Texas and Mexico and occurs in dry habitats on permeable substratum, but it grows also in wet habitats (Krüssmann 1972) is most similar in its morphology to the fossil species (Mai & Walther 1985). It is a component of various types of communities, frequently of the mixed broad-leaved forest, the so-called "canyon riparian associations" with *Platanus wrightii* Watson, *Fraxinus pennsylvanica* Marshall, *Populus fremontii* Watson, *P. angustifolia* James, *Acer grandidentatum* Nutt,

A. negundo L., *Alnus oblongifolia* Torr., and *Juglans major* (Torr.) A. Heller. It is also found in higher parts of mountains in mixed coniferous forests with *Pinus ponderosa* Engelm. var. *arizonica*, *P. engelmannii* Carrière, and *P. leiophylla* Scheide & Dieppe var. *chihuahuana* (Engelm.) Shaw. (Sullivan 1993).

Fossil occurrence in Poland. Species hitherto not reported from Poland.

Geinitziaceae

Cupressospermum saxonicum Mai emend. Kunzmann

Pl. 1, figs 7, 8

1960 *Cupressospermum saxonicum* Mai, p. 74, pl. 3, figs 1–5.
1999 C*upressospermum saxonicum* Mai; Kunzmann, p. 91, pl. 21–23.
2004 C*upressospermum saxonicum* Mai; Mai, p. 26.

Material. 2 cones (UWPalaeo/mag.2004/3a; 33a) and 5 seeds (UWPalaeo/mag.2004/3b; 33b).

Description. Cones are elliptical and 15–16 mm long and 11–13 mm wide. The entire cone has 28 scales spirally arranged along the axis, the other cone has 19 scales preserved. Scales are 2–5 mm in diameter, peltate, uniformly arched, with rounded edges, and are tetragonal to pentagonal. Indistinct button-like bracts occur in the central part of some scales. Seeds 1.5–2.0 mm long and 1.25–1.50 mm wide, winged, roughly round and flat. Locule conspicuously amphitropous and the hilum and micropyle face each other.

Remarks. Structure and size of the cones, as well as shape, number and structure of the scales, as well as the small and rounded stipule, and especially the shape and structure of the extracted seeds with their distinctive amphitropous locule, indicate the specimen's affinity to *Cupressospermum saxonicum* Mai.

Initially *C. saxonicum* Mai was considered a representative of *Cupressaceae* (Mai 1960) or the family *Taxodiaceae* (Mai & Schneider 1988). However, according to Kunzmann (1999), the genus *Cupressospermum* Mai belongs to fossil family *Geinitziaceae* Kunzmann.

The fossil genus is represented by one fossil species *Cupressospermus saxonicum* Mai, known from the Upper Oligocene of Germany (including localities: Kleinsaubernitz, Horka-Kausche, Mai 1997), Lower Miocene of the Czech Republic, Kristina Mine (Holý 1975a), Most Basin (Teodoridis & Sakala in press), and Lower Miocene of Germany (e.g. Wernsdorf, Mai 2004).

The plant is supposed to have grown in wetland forest; it had ecological requirements similar to fossil *Glyptostrobus* Endl. or *Taxodium* Rich., as evidenced by the character of sediment in which it occurs, and remains of taxa typical for wetland forest co-occurring with *Cupressospermum saxonicum* (Kunzmann 1999, Mai 2004).

Fossil occurrence in Poland. Species hitherto not reported from Poland.

Pinaceae

Pinus urani (Unger) Schimper

Pl. 1, figs 10–11

1850 *Pinites urani* Unger, p. 363.
1870–1872. *Pinus urani* (Unger) Schimper, p. 262.
1968a *Pinus urani* (Unger) Schimper; Kilpper, p. 213, pl. 41, figs 12–14, pl. 42, figs 4, 5, pl. 44, figs 1–6.

Material. 20 mostly fragmentary cones (UWPalaeo/mag.2004/5–7) and 5 seeds (UWPalaeo/mag.2004/8).

Description. Cones 30–60 mm long and 30–60 mm wide, most frequently broadly ovoid and asymmetrical, with the shape depending on the degree to which the scales have opened. Apophyses broadly rhombic or pentagonal, on one side of the cone significantly elongated, up to 10 mm long and variable in shape (hook-like and curved). Umbo weakly preserved and with an inconspicuous morphology from which only the delicate radial ribs surrounding the umbo are visible in many cases. Seeds 12–14 mm long (with wing), ovate in shape, sometimes preserved inside cone.

Remarks. Cones of this fossil species are very distinctive, mainly because of their asymmetry and the hook-like curved apophyses on the seed scales. They are the most frequent finds in the Lubstów assemblage.

The extant species *Pinus uncinata* Miller ex Mirbel compares well with the fossil species *P. urani* (Unger) Schimper (Mai 1986, 1994). This extant pine species occurs in coniferous forests of the western part of the Alps and in the Pyrenees to an altitude of 2700 m above sea level.

Fossil occurrence in Poland. Lubstów, Middle Miocene (Zastawniak et al. 1996).

Magnoliaceae

Magnolia cf. ***burseracea*** (Menzel) Mai

Pl. 1, fig. 13

1913 *Carpolithus burseraceus* Menzel, p. 84, pl. 7, figs 10–12.
1975 *Magnolia burseracea* (Menzel) Mai, p. 567, pl. 35, figs 24–33.
2003 *Magnolia burseracea* (Menzel) Mai; Teodoridis, p. 13, pl. 1, figs 15, 18, 19, 22, pl. 2, figs 8, 9.

Material. One incomplete seed (UWPalaeo/mag.2004/10).

Description. Seed 6 mm long and 4 mm wide, broadly ovoid, flat, roughly symmetrical along the plane parallel to dorsal/ventral surface, slightly asymmetrical in perpendicular plane. Micropyle with a small inclined beak, chalazal end slightly concave, inside the seed, conspicuous broad heteropyle in the chalazal end. Sclerotesta very thin, ca. 0.1 mm at the chalaza, and with a smooth surface. Small longitudinal ridge on internal side of one half of the testa wall is visible.

Remarks. Specimen from Lubstów corresponds to seeds *Magnolia burseracea* (Menzel) Mai with respect to features including their diameter, length/width ratio, general shape and the smooth-surfaced sclerotesta. They differ in features is of the thickness of sclerotesta that is approximately equal to 0.1 mm in the seed from Lubstów, and varies from 0.3–0.7 mm in specimens described by Mai (1975).

Chalaza features are indeterminable due to incomplete preservation of the heteropyle. Among the present-day species of *Magnolia* there is no close relative comparable in terms of seed structure (Mai 1975).

Fossil occurrence in Poland. Wieliczka, Middle Miocene (Łańcucka-Środoniowa & Zastawniak 1997).

Nymphaeaceae

Nuphar canaliculata C. & E.M. Reid

Pl. 1, figs 14, 15

1915 *Nuphar canaliculata* C. & E.M. Reid; Reid & Reid, p. 86, pl. 7, fig. 1–3.
1974 *Nuphar canaliculata* C. & E.M. Reid; Dorofeev, p. 79, pl. 86, fig. 19, pl. 110, figs 7, 8, pl. 112, figs 7–10.
2003 *Nuphar canaliculata* C. & E.M. Reid; Velichkevich & Zastawniak, p. 179, pl. 8, figs 17, 18.

Material. 21 seeds (UWPalaeo/mag. 2004/11).

Description. Seeds vary from 3.5–5.0 mm long and 2.5–3.0 mm wide and are ovoid or pear-shaped, symmetrical or slightly asymmetrical, and frequently deformed. The operculum is elliptical or ovoid and the micropyle round, turret-like and elevated. The hilum is elliptical and the micropyle and hilum contact one another or are slightly apart. Surface of the seed is mostly lustreless and brown, but some seeds are wholly or partly lustrous and black. The testa is ca. 0.25 mm thick and has small, roughly hexagonal cells visible on the surface. These cells are aligned in longitudinal rows closer to the operculum. In cross-section the seed wall is composed of two layers: a thin external layer comprising small cells, and thicker internal layer composed of large cells.

Remarks. Seeds from Lubstów are very similar to seeds from the Pliocene of Kholmech (Velichkevich & Zastawniak 2003), they also resemble *Nuphar canaliculata* C. & E. M. Reid from the Pliocene of Krivoborie (Dorofeev 1974). Similarities concern size of the seeds, operculum shape, and relative distribution of micropyle and hilum.

Nuphar Sm. is typical aquatic plant of temperate and warm temperate climate zones of the northern hemisphere (Engler 1964).

Fossil occurrence in Poland. The first reliable determination for Polish Tertiary. Seeds from the Pliocene of Krościenko, identified as *Nuphar canaliculata* (Szafer 1947) belong to *Mahonia staphylaeformis* Mai (Velichkevich & Zastawniak 2003).

Hamamelidaceae

Fothergilla aff. ***europaea*** Szafer

Pl. 1, figs 18–20

1947 *Fothergilla europaea* Szafer, pp. 247–251, pl. 7, figs 33–35.
1990 *Fothergilla europaea* Szafer; Geissert et al., p. 24, pl. 19, fig. 16.

Material. One endocarp with seed, 4 incomplete endocarps, and 4 seeds (UWPalaeo/mag.2004/12).

Description. The best preserved endocarp is 7 mm long and 6 mm wide, bell-shaped, and has loculicidal and septidal capsules and is thick-walled. The other fragmentary endocarps are 5.5–7.0 mm long and 4.5–6.0 mm wide, lyra-shaped, flat-convex and bilaterally symmetrical. Seeds vary from 4.0–4.3 mm long and 2.4–2.8 mm wide and are ovoid and slightly obliquely truncate at the base, gradually narrowing toward the apex, and lack a conspicuous sharp termination. The hilum is broad with a rugged edge, shallow and on both sides reaches ca. 1/3 length of the whole seed. This is similar in shape on both sides of the seed and roughly round (symmetrical). Surface of the testa is smooth, slightly lustrous and dark brown.

A single seed inhered in one of the endocarp locule preserves the hilum and shows the same features as the remaining seeds.

Remarks. The following features were considered for the determination of the generic affiliation of the seeds: their length, width, length:width ratio, shape, hilum diameter and shape, hilum position (i.e. whether it is symmetrically aligned on both sides of the seed), mode of base truncation, and the structure of the apical part of the seed (rounded or sharp at the top). The seeds described were compared with the following extant species of Hamamelidaceae: *Hamamelis mollis* Oliv., *Fortunearia sinensis* Rehd. & Wils., *Parrotiopsis jacquemontana* (Decne.) Rehd., *Loropetalum chinense* (R. Br.) Oliv., *Corylopsis spicata* Sieb. & Zucc., *Fothergilla gardenii* Murray, *F. major* Lodd., *Sycopsis sinensis* Oliv., and *Distylium racemosum* Sieb. & Zucc.

The specimens from Lubstów were also compared with the following fossil species; *Fothergilla europaea* Szafer from the Pliocene of Krościenko (Szafer 1947), *Fortunearia altenburgensis* Mai from the Middle Oligocene of Haselbach (Mai & Walther 1978), *Corylopsis urselensis* Mädler from the Pliocene of Frankfurt on the Main (Mädler 1939), the Upper Miocene of Meuro and Rauno in Lusatia (Mai 2001a), and from the Pliocene of „Fortuna-Garsdorf" (van der Burgh 1978).

Seeds of extant species *Distylium racemosum* Sieb. & Zucc., *Fortunearia sinensis* Rehd. & Wils., *Hamamelis mollis* Oliv., and *Parrotiopsis jacquemontana* (Decne.) Rehd. significantly differ in their diameters. With respect to the diameter (especially length:width ratio) Lubstów specimens resemble seeds of the extant species *Fothergilla gardenii* Murray, *Loropetalum chinense* (R.Br.) Oliv., and *Sycopsis sinensis* Oliv., as well as the fossil species *Corylopsis urselensis* Mädler and *Fothergilla europaea* Szafer. However, seeds of *Sycopsis sinensis*e Oliv. are of a different shape and seeds of *Loropetalum chinense* (R. Br.) Oliv. are different in the structure of the apical part of the seed and the hilum. Seeds from Lubstów have a symmetrical hilum, a feature absent among seeds of *Corylopsis* Sieb. & Zucc. (Mai 1999b). Furthermore, the base of the studied seeds of extant *C. spicata* Sieb. & Zucc. is truncated more or less perpendicular to the long axis of the seed, like in the fossil species *C. urselensis* Mädler. However, an obliquely truncate base as observed in the Lubstów seeds, is observed in seeds of *Fothergilla* L as reported by Szafer (1947).

The following features justify affiliation of the seeds from Lubstów to the genus *Fothergilla*: shape of the seeds, their diameter, symmetrical hilum, and obliquely truncate base. In comparison to seeds of *F. europaea* Szafer from the Pliocene of Krościenko (Szafer 1947), the seeds from Lubstów are smaller, hence they were identified as *Fothergilla* aff. *europaea* Szafer.

The extant species *Fothergilla gardenii* Murray from sout-eastern North America is compared with the *F. europaea* Szafer (Geissert et al. 1990). Extant species occurs in shrub bog assemblages named "pocosin", in warm temperate climate (Snyder 1993).

Fossil occurrence in Poland. Krościenko, Pliocene (Szafer 1947).

Fagaceae

Castanopsis aff. ***salinarum*** (Unger) Kirchheimer

Pl. 2, fig. 3

1850 *Castanea salinarum* Unger, p. 320, pl. 35, figs 11–13.
1941 *Castanopsis salinarum* Kirchheimer, p. 613, pl. 6.
1989 *Castanopsis salinarum* (Unger) Kirchheimer; Mai, p. 272, pl. 1, figs 5–10.

Material. One fruit (UWPalaeo/mag.2004/14).

Description. Fruit 11 mm long and 10 mm wide, broadly ovoid and with apical part rapidly narrowing and cone-shaped around the

swollen remains of a style. The termination is broken, triangular in cross-section. Nut scars measure ca. 9 mm in diameter. The pericarp wall is ca. 0.5 mm thick, thicker in the apical part where it is up to 1 mm thick, and in cross-section is composed of two layers, namely an external layer comprising densely packed cells aligned perpendicularly to wall surface (sclereids), and an internal layer composed of polygonal parenchyma cells. The surface of the pericarp is smooth, slightly lustrous, with delicate, weakly visible longitudinal stripes.

Remarks. The described specimen shows features typical for fruits of *Castanopsis* namely being triangular in shape, presence of a swelling in the apical part of the pericarp at the junction of modified stigmas, and a two-layered pericarp with an external layer comprising radially aligned sclereids and internal layer composed of parenchymal cells (Kirchheimer 1941, Szafer 1961, Mai 1989). According to Mai (1989) the species *C. salinarum* (Unger) Kirchheimer is characterized by its round-triangular shape, relatively large (9–13 mm in diameter) nut scar, and striped, satin lustrous pericarp surface. However, the specimen from Lubstów is smaller and has a thinner pericarp wall. Fruits of *C. salinarum* (Unger) Kirchheimer described by Mai (1989) are larger and have thicker pericarp wall (1.3–2 mm).

Castanopsis salinarum (Unger) Kirchheimer, hitherto known from the Middle Miocene of Central Europe, e.g. Kleinsaubernitz (Mai 1964), Slanic/Ploeşti (Givulescu 1964), belongs to palaeotropical, thermophilous floristic element (Mai 1967). The closest extant equivalent is *Castanopsis indica* (Roxb.) A. DC. from southern Asia (Mai 1989).

Fossil occurrence in Poland. Jerzmanki (Hermsdorf), Ujazd (Moys), Middle Miocene (Kräusel 1920), Wieliczka, Middle Miocene (Kirchheimer 1941).

Myricaceae

Myrica cf. ***suppanii*** Kirchheimer

Pl. 1, fig. 9

1938 *Myrica suppanii* Kirchheimer, p. 326, pl. 3, figs 13–15, 17.

1961 *Myrica suppanii* Kirchheimer; Szafer, p. 33, pl. 9, fig. 8.

1999b *Myrica suppanii* Kirchheimer; Mai, p. 42, pl. 15, figs 24–31.

Material. 9 endocarps (UWPalaeo/mag. 2004/15).

Description. Endocarps are 2–3 mm long and 2.5–3.5 mm wide, nearly globose and break into two or three parts. Internal locule is drop-shaped. The wall thickness is 0.5 mm on average. Endocarp has an uneven surface uneven and is lustreless.

Remarks. Endocarps found in the Lubstów flora are characterized by their globose shape that is typical of the genus according to Kirchheimer (1938). Their dimensions are the same as those of the endocarps of *Myrica suppanii* Kirchheimer from the Middle Miocene of Stare Gliwice (Szafer 1961). However, the determination is not quite certain because the exocarp is not preserved and this is important for providing an exact species determination.

Myrica suppanii Kirhcheimer is considered to have been associated with warmer climate episodes of the Miocene (Mai 1999b). The extant species *Morella cordifolia* (L.) Killick (= *Myrica cordifolia L.*) from South Africa is most similar to fossil species (Mai 1999b).

Fossil occurrence in Poland. Stare Gliwice, Middle Miocene (Szafer 1961); endocarps *Myrica suppani* Kirchheimer from Rypin (Łańcucka-Środoniowa 1957) belong to *M. ceriferiformis* Kownas (Mai 2004).

Theaceae

Ternstroemia sequoioides (Engelhardt) Bůžek & Holý

Pl. 2, fig. 2

1880 *Carpolithus sequoioides* Engelhardt, p.150, pl. 9, fig. 19.

1957 *Capparidispermum boveyanum* Chandler, p. 98, pl. 14, figs 92–96.

1971 *Ternstroemia boveyana* (Chandler) Mai, p. 333, pl. 35, fig. 42.

1996 *Ternstroemia sequoioides* Bůžek & Holý; Bůžek et al. p. 31, pl. 22, figs 11–14.

Material. Fragment of seed (UWPalaeo/mag.2004/17).

Description. The seed is 6 mm long and 5 mm wide, veniform, flat and of the campylotropous type. A small depression extends from the edge and disappears in the central part of the seed and is visible in the middle of its external side. The seed surface is uneven and rugged.

Remarks. The majority of features observed on the specimen correspond to *Ternstroemia sequoioides* Bůžek & Holý. Differences relate to the seed diameter in which the specimen from Lubstów is slightly longer, while seeds of *T. sequoioides* Bůžek & Holý. are in general 2.75–5.00 mm long (Mai 2000). Furthermore, the specimen from Lubstów does not show a tuberculed testa surface, nor any pattern of the surface. The lack of these distinctive features can be due to the preservation state of the seed from Lubstów.

Ternstroemia sequoioides Bůžek & Holý seeds are known from the Middle Oligocene up to the Upper Miocene of western and Central Europe (e.g. Chandler 1957, Zastawniak et al. 1996). The extant species *T. japonica* Thunbg. from East Asia is similar to the fossil species (Mai 2000). This thermophilous genus is a typical element in evergreen broad-leaved forest and mixed mesophytic forest assemblages (Wang 1961).

Fossil occurrence in Poland. Gozdnica, Upper Miocene (Zastawniak et al. 1996).

Cyrillaceae

Pirocarpella aquisgranensis Mai

Pl. 2, figs 8, 9, 12, 13, 15

1985 *Pirocarpella aquisgranensis* Mai; Mai & Walther, p. 88, pl. 23, figs 23–28.

Material. 7 seed capsules (UWPalaeo/mag.2004/18).

Description. Capsules vary from 2–3 mm long (without pedicel) and 2–3 mm wide and are pear-shaped or spherical, with 3–5 conspicuous longitudinal ribs on the surface. The style is of various lengths, frequently curved, and in some cases distinctly narrower in the middle part. The style terminates with a discoid inflation. Part or fragments of the pedicel frequently are preserved at the base of seed capsule. The capsule surface is uneven and lumpy. The capsule interior is divided into locules and is filled with seeds. A column of vascular bundles runs through the fruit centre. The locule surface is more or less smooth. Seeds are typically 1.3 mm long and 0.7 mm wide, roughly veniform, and have a scaled surface.

Remarks. Fossil remains from Lubstów flora are very similar to *Pirocarpella aquisgranensis* Mai from the Upper Eocene of Groitzsch (Mai & Walther 1985). The only difference is the structure of the fruit base; no distinctive disks with radiating sepals are observed in specimens from Lubstów. However, this can be due to preservational limitations.

At present, the range of the family Cyrillaceae encompasses areas of tropical and subtropical climate in south-eastern part of North America, Central America, and northern territories of South America (Takhtajan 1997). Supposedly, *Pirocarpella* Mai can have similar environmental preferences to *Cyrilla* Garden ex L., an extant representative of Cyrillaceae, forming scrubs in swamp banks, or growing in *Persea-Magnolia* swamp forests on acid peats (Mai 2004).

Fossil occurrence in Poland. Gozdnica-Stanisław, Upper Miocene (Dyjor et al. 1992).

Ericaceae

Comarostaphylis globula (Menzel) Mai

Pl. 2, fig. 6

1906 *Elaeocarpus globulus* Menzel, p. 141, pl. 7, figs 5–12.

1936 *Arctostaphyloides globula* (Menzel) Kirchheimer, p. 117, pl. 12, fig. 12a–g

1986 *Viticocarpum globulum* Mai; Knobloch & Mai, p. 91

1999c *Comarostaphylis globula* Mai, p. 56, pl. 5, figs 1–11

Material. 331 fruits (UWPalaeo/mag. 2004/19).

Description. Endocarps range from 3–10 mm in diameter and are globular. Some preserve a membranous exocarp that is loculicidally dehiscent and divides into 5–7 parts. Endocarp walls are lustrous and show granular structure. A conspicuous column of vascular bundles running through the endocarp interior. Seeds are 4 mm long and 2.5 mm wide, often approximately elliptical, flat, slightly arched, and are frequently encountered within the locules.

Remarks. The described fruits undoubtedly belong to *Comarostaphylis globula* (Menzel) Mai, as evidenced by their shape, diameter and internal structure features.

Formerly fruits of this type were associated with an extinct genus *Arctostaphyloides*

Kirchheimer from *Arbuteae* (Kirchheimer 1936, Knobloch & Mai 1986). Their affinity to the extant genus *Comarostaphylis* Zucc. was discovered by Mai (1999c). Fossil fruits of *C. globula* (Menzel) Mai are known from numerous Miocene localities in Europe (e.g. Kirchheimer 1936, Mai 1964). Fruits of the extant species *C. polifolia* (Kunth) Zucc. ex Klotzsch from Mexico are considered the most similar to the discussed fossil species (Mai 1999c, 2000).

The genus *Comarostaphylis* grows in mountain areas of the tropical to warm temperate regions and its geographical range includes California and Central America. *C. polifolia* (Kunth) Zucc. is endemic to Mexico where it occurs in mountains up to an altitude of 1500–2800 m above sea level, and occurs in various xeric communities i.e. in dry pine or oak-pine forests (Diggs 1995).

Fossil occurrence in Poland. Rypin, Middle Miocene (Łańcucka-Środoniowa 1957), Stare Gliwice, Middle Miocene (Szafer 1961), and Wieliczka, Middle Miocene (Łańcucka-Środoniowa & Zastawniak 1997).

Leucothoe lusatica Mai

Pl. 2, figs 13–17

2000 *Leucothoe lusatica* Mai, p. 65, pl. 18, figs 21–30, pl. 22, figs 7, 8, pl. 23, fig. 6.
2004 *Leucothoe lusatica* Mai, p. 60, pl. 15, figs 2, 3.

Material. 2 seed capsules almost complete, one fragment of another capsule (UWPalaeo/mag.2004/21a), and 3 seeds (UWPalaeo/mag.2004/21b).

Description. This species comprises closed fruit capsules 2.5–3.0 mm long and 3–5 mm wide that are broadly elliptical in outline. Capsules have 5 locules. A fragmentarily preserved calyx and pedicel is present at the base of one capsule. Seeds extracted from the largest capsule are 0.5–1.0 mm long, elliptical and flat. Cells of the testa are elongated, reticularly arranged and slightly lustrous.

Remarks. Fruit capsules from Lubstów are very similar to *Leucothoe lusatica* Mai from the Lower Miocene of Schlepzig and Middle Miocene of Puschwitz (Mai 2000, 2004) with respect to shape, diameter, and seed ornamentation. One of these capsules is larger, but the remaining features of its structure are in accordance with the species diagnosis.

The fossil taxon *Leucothoe lusatica* Mai is known from Lower-Middle Miocene of Germany (Mai op. cit.). Similar extant taxa are *L. populifolia* (Lam.) Dippel and *L. acuminata* Dunal from south-eastern North America (Mai 2000).

Fossil occurrence in Poland. Species hitherto not reported from Poland.

Symplocaceae

Sphenotheca incurva Kirchheimer

Pl. 1, figs 16, 17

1935 *Sphenotheca incurva* Kirchheimer, p. 71, pl. 10, figs 27a–f.
1957 *Sphenotheca incurva* Kirchheimer, p. 600, pl. 52, fig. 195.
1967 *Sphenotheca incurva* Kirchheimer; Czeczott & Skirgiełło, pp. 131, 162, pl. 7, figs 7, 8.
2000 *Sphenotheca incurva* Kirchheimer; Mai, p. 48, pl. 14, figs 4, 5.

Material. 2 endocarps (UWPalaeo/ mag. 2004/22–23).

Description. Endocarps are elongate-ovoid and of a regular shape and have a truncate apex. One complete specimen is 22 × 17 mm in diameter and has a roughly flat apex. This lacks a ring-like swelling and irregular opening with vertical walls on top. The surface of the endocarp has longitudinal ripples and cracks. The broken endocarp measures 25 × 15 mm, has a concave apex and is surrounded by a ring-shaped swelling. In the apical depression there are four triangular in outline, aligned in a rosette openings, two fragmentarily preserved.

Remarks. Both specimens from Lubstów are similar in size to one another but differ in their state of preservation and also in the apical part structure. Large endocarps, with or without a weakly developed ring-shaped apical swelling, were identified as the fossil species *Sphenotheca gigantea* Kirchheimer (Kirchheimer 1935, Mai 1964). However, such abnormally developed endocarps represent, according to Mai (2000), the same fossil species, namely *Sphenotheca incurva* Kirchheimer.

Sphenotheca Kirchh., the fossil genus from Symplocaceae, is an important index taxon for Younger Mastixioid Floras of the European Neogene (Mai 1964).

Fossil occurrence in Poland. Turów, Lower Miocene (Czeczott & Skirgiełło 1967) and Gozdnica, Upper Miocene (Dyjor et al. 1992).

Symplocos casparyi Ludwig

Pl. 1, fig. 12

1857 *Symplocos casparyi* Ludwig, p. 99, pl. 20, figs 6a–f.
1920 *Symplocos jugata* E.M. Reid, p. 73, pl. 4, fig. 7.
1950 *Symplocos lignitarum* (Quenstedt) Kirchheimer, p. 14, pl. 1, fig. 4, pl. 2, fig. 15.
1957 *Symplocos gothanii* Kirchheimer; Łańcucka-Środoniowa, p. 33, pl. 5, figs 14–20.
1961 *Symplocos gothanii* Kirchheimer; Szafer, p. 79, pl. 21, figs 10, 11.
1967 *Symplocos gothanii* Kirchheimer; Czeczott & Skirgiełło, p. 159, pl. 7, figs 3, 11–13; pl. 10, fig. 5.
1967 *Symplocos lignitarum* (Quenstedt) Kirchheimer; Czeczott & Skirgiełło, p. 158, pl. 10, figs 1–2.
1992 *Symplocos lignitarum* (Quenstedt) Kirchheimer; Dyjor et al., p. 32.
1997 *Symplocos minutula* Kirchheimer; Łańcucka-Środoniowa & Zastawniak, pl. 2, figs 9, 10.
2004 *Symplocos casparyi* Ludwig; Gümbel & Mai, p. 201, pl. 8, fig. 3.
2006 *Symplocos casparyi* Ludwig; Mai & Martinetto, p. 5, pl. 1, figs 8–15, pl. 2, figs 1–8.

Material. One endocarp (UWPalaeo/mag. 2004/24).

Description. The endocarp is 6 mm long and 3 mm wide, spindle-shaped, symmetrical, and has a perpendicularly truncate apex. Three locules of irregular shape (one larger than the others) are visible in cross section of the endocarp. Surfaces of the endocarp are uneven, lustreless, and weakly visible delicate longitudinal stripes are visible at the base.

Remarks. The specimen from Lubstów is the most similar to the "lignitarum" morphotype of the species *Symplocos casparyi* Ludwig identified by Mai and Martinetto (2006). Similar are their shape and size, however, typical for this morphotype is a conspicuous, sharp longitudinal ribs that are absent in the specimen from Lubstów.

The fossil species *Symplocos casparyi* Ludwig is known in Europe from the Lower Oligocene to the Pliocene under a number of different names that include *S. lignitarum* (Quenstedt) Kirchheimer, *S. gothani* Kirchheimer and *S. jugata* E. M. Reid. Characterized by its high morphological variability, it is among the most frequently encountered species of *Symplocos* in fossil floras of the European Tertiary (Mai & Martinetto 2006).

Numerous extant species of this genus are compared with this fossil species, in particular *Symplocos sulcata* Kurz (= *S. yunnanensis* Brand.) from south-eastern and southern Asia (Czeczott & Skirgiełło 1967). The present-day species of *Symplocos* occurs in mixed mesophytic forests and evergreen broad-leaved forests, or tropical montane cloud forests of the south-eastern Asia and Central America (Mai & Martinetto 2006).

Fossil occurrence in Poland. *S. lignitarum* Kirchheimer: Turów, Lower Miocene (Czeczott & Skirgiełło 1967), Gozdnica-Stanisław, Upper Miocene (Dyjor et al 1992); *S. gothani* Kirchheimer: Turów, Lower Miocene (Czeczott & Skirgiełło 1967), Rypin, Middle Miocene (Łańcucka-Środoniowa 1957), Stare Gliwice, Middle Miocene (Szafer 1961); *S. minutula* Kirchhheimer: Wieliczka, Middle Miocene (Łańcucka-Środoniowa & Zastawniak 1997).

Mastixiaceae

Mastixia thomsonii Mai

Pl. 2, fig. 1

1935 *Mastixia pistacina* Kirchheimer, p. 50, pl. 3, fig. 10b, f.
1961 *Mastixia amygdalaeformis* (v. Schlotheim) Kirchheimer; Schürmann, p. 62, pl. 1, fig. 2, pl. 5, fig. 15.
1970 *Mastixia thomsonii* Mai, p. 465, pl. 63, figs 4–13.

Material. One endocarp (UWPalaeo/mag. 2004/25).

Description. The endocarp is 14 mm long and 10 mm wide, broadly spindle-shaped. Its base gradually narrows and the apex rapidly narrows to form a small beak. The endocarp is incomplete on its dorsal side and the germination valve is absent. A centrally aligned elongate septum is visible inside the locule. Delicate longitudinal ribs are present on the endocarp surface. Partially preserved remains of a thin exocarp is present on the ventral side.

Remarks. Shape and size of the endocarp and surface features suggest placement of the specimen within the species *Mastixia thomsonii* Mai. Especially broadly spindle-shaped specimens of this species from Konzendorf (Mai 1970) are highly similar.

The fossil specimens of *Mastixia* Blume are known in Europe from the Eocene to the Miocene, in relic stands also from the Pliocene (Mai 1997). The living plant is restricted to tropical zone of south-eastern Asia. It grows in evergreen rain forests, in moist mountain forests of monsoon climate areas, and at the northern border of its range in temperate semi-deciduous mountain forests (Holý 1975b). It is an important climatic indicator and indicates a mean annual temperature of 19–28 °C, and mean annual precipitation not less than 2000 mm (Mai op. cit.).

Fossil occurrence in Poland. Gozdnica, Upper Miocene (Dyjor et al.1992).

Cyperaceae

Cladium cf. ***europaeum*** Dorofeev

Pl. 1, fig. 21

1960 *Cladium europaeum* Dorofeev, p. 1428, pl. 3, figs 10–12.

1999a *Cladium europaeum* Dorofeev; Mai, p. 44.

Material. One incomplete endocarp (UWPalaeo/mag.2004/26).

Description. The endocarp is 1 mm long and 1.25 mm wide, approximately spherical, and has a slightly narrowed and cone-shaped in apical part and a neck-like narrowing at the base. The base of the endocarp has three distinct protrusions. Surface of the endocarp is smooth and lustreless.

Remarks. This specimen resembles the species *Cladium europaeum* Dorofeev described from the Middle Miocene of Krasnaya Sloboda in Belarus (Dorofeev 1960), recorded also in the Lower Miocene of Seese (Mai 1999a) in terms of its shape and diameter. However, the endocarp from Lubstów lacks a distinctive ring at the base which is an important diagnostic feature of the species noted from other locations. The Lubstów specimen has only three protrusions while the connecting ring is not preserved.

Endocarps of *Cladium mariscus* R. Br. foss. from Stare Gliwice (Szafer 1961) differ from the discussed specimen by having longitudinal ribs on the endocarp surface.

At present, the genus *Cladium* is widespread, occurring in temperate to tropical climates, in aquatic and marshy environments (Engler 1964).

Fossil occurrence in Poland. Species hitherto not reported from Poland.

RESULTS

Plant remains were sampled from sands associated with the fluvial episode preceding deposition of the upper coal seam belonging to the 1st group of Middle Polish coal seams. A total of 435 seeds, fruits and cones were studied; they were identified as belonging to 19 plant taxa from 14 families (Tab. 1). They were accompanied by fragments of undetermined coniferous plant shoots and drift wood trunks (personal observation). Four taxa were described for the first time from the Tertiary of Poland, i.e. *Cupressoconus rhenanus* Kilpper, *Cupressospermum saxonicum* Mai emend. Kunzmann, *Leucothoe lusatica* Mai, and *Cladium* cf. *europaeum* Dorofeev.

The most abundant remains of the Lubstów taphocenosis belong to *Comarostaphylis globula* (Menzel) Mai, which is represented by 331 fruits. Cones of *Pinus urani* (20) are numerous, as are seeds of *Nuphar canaliculata* C. & E.M. Reid (21), cones of *Chamaecyparis salinarum* Zabłocki (17), endocarps and seeds of *Fothergilla* aff. *europaea* Szafer (9), endocarps of *Myrica* cf. *suppanii* (9), seed capsules of *Pirocarpella aquisgranensis* (7) and *Leucothoe lusatica* (3). Each of the remaining taxa are represented by single specimens (Tab.1).

PRELIMINARY ECOLOGICAL INTERPRETATION

During the Miocene the present-day Konin region was covered by a dense network of river valleys, with very numerous wetlands (Biernacka et al. 1994, Kasiński 2004). Specific sedimentary conditions caused by fault trough subsidence took place in one of these valleys and in the vicinity of Lubstów. Active substratum favoured the accumulation of large quantities of phytogenic material, periodically interrupted by fluvial sandy sediment deposition (Kasiński 2004). Presumably, a dynamic balance between subsidence and accumulation existed over a relatively long period in this wetland valley, which enabled the formation of the lower coal seam, up to 90 m thick, belonging to the 2nd (Lusatian) group of seams.

Table 1. Taxonomic list of the Lubstów flora; A – arctotertiary, P – palaeotropic (after Mai 1967, 1995, van der Burgh 1987)

Taxa	Number of specimens	Element
Cupressaceae *Chamaecyparis salinarum* Zabłocki	17	A
Cupressaceae *Cupressoconus rhenanus* Kilpper	3	A
Geinitziaceae *Cupressospermum saxonicum* Kunzmann	2	
Pinaceae *Pinus urani* (Unger) Schimper	20	A
Magnoliaceae *Magnolia* cf. *burseraceae* (Menzel) Mai	1	P
Nupharaceae *Nuphar canaliculata* C. & E.M. Reid	21	A
Hamamelidaceae *Fothergilla* aff. *europaea* Szafer	9	A
Fagaceae *Castanopsis* aff. *salinarum* (Unger) Kirchheimer	1	P
Myricaceae *Myrica* cf. *suppanii* Kirchheimer	9	P
Myrica sp.	2	
Theaceae *Ternstroemia sequoioides* (Engelhardt) Bůžek & Holý	1	P
Cyrillaceae *Pirocarpella aquisgranensis* Mai	7	P
Ericaceae *Comarostaphylis globula* (Menzel) Mai	331	P
Leucothoe lusatica Mai	3	A
Ericaceae indet.	3	
Symplocaceae *Sphenotheca incurve* Kirchheimer	2	P
Symplocaceae *Symplocos casparyi* Ludwig	1	P
Mastixiaceae *Mastixia thomsonii* Mai	1	P
Cyperaceae *Cladium* cf. *europaeum* Dorofeev	1	A
∑ specimens	435	
		P=63%

Subsidence rate increased in the next stage of trough development. This is evidenced by thick (up to 26 m) fluvial sandy deposits. The valley was gradually filled with sediments, which in turn slowed down the river, flooding the valley and subsequently turning it to a wetland. The occurrence of swamps increased simultaneously in many river palaeovalleys in the Konin region, resulting in the formation of numerous deposits that have subsequently been uncovered in the brown coal mines (Konin, Adamów, Pątnów). They belong to the 1st group of Middle Polish coal seams (Matl & Wagner 1986, Kasiński 2004). Subsidence during this stage was not as stable and balanced as during the deposition of the lower seam. This is evidenced by lower thickness of the 1st seam and sandy intercalations within it (Biernacka et al. 1994, Kasiński 2004).

Known ecological preferences of extant plants, which were compared with fossil taxa from Lubstów flora (Tab. 2), allow conclusions concerning the composition and type of plant communities occurring in the studied palaeovalley during the Middle Miocene. High numbers of remains of conifers (cones of Pinaceae and Cupressaceae) and of the taxa of Ericaceae, Myricaceae, and Cyrillaceae families indicate local domination of mixed coniferous –evergreen – broad-leaved forests growing in wetland environments, with respect to fertility and hydrology related to fens with nearly neutral pH and various nutrient content. Also assemblages similar to raised bogs developing on acid, oligotrophic soils, could occur locally. This is indicated by the presence of the following taxa: *Pinus urani* (Unger) Schimper, *Chamaecyparis salinarum* Zabłocki, *Cupressoconus rhenanus* Kilpper, and *Cupressospermum saxonicum* Mai emend. Kunzmann. Abundant remains of evergreen taxa of the families Ericaceae (*Comarostaphylis globula* (Menzel) Mai, *Leucothoe lusatica* Mai, Ericaceae indet.), Myricaceae (*Myrica* cf. *suppanii* Kirchheimer), and Cyrillaceae (*Pirocarpella aquisgranensis* Mai) indicate the presence of numerous shrubs that could have formed scrubs or thick brushwood in forests of low density.

The dominant plant remains occurring in Lubstów flora allow it to be included in the communities described by Mai (2001b, 2004) as laurel-conifer forest („Lorbeer-Koniferen-Wälder") and shrub bogs („Moor-Lorbeer-Gebüsche"). Similar communities are treated by van der Burgh (1983) as "coniferous forest" and „peat bogs" (see Fig. 3).

Among the extant plant communities, the "Atlantic white cedar swamp" with

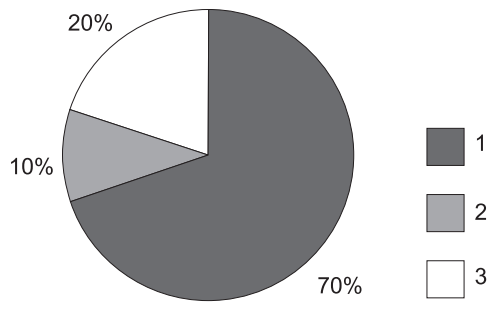

Fig. 3. Percentage number of taxa characteristic for plant communities in the Lubstów fossil flora; **1** – laurel–conifer forest, **2** – aquatic and streamside vegetation, **3** – laurel forest

Table 2. Nearest living representatives of fossil taxa with their geographic distribution and ecological preference

Taxon	Extant taxa	Geographic distribution and ecology
Chamaecyparis salinarum Zabłocki	*Chamaecyparis obtusa* Sieb. & Zucc.	southern Japan, Taiwan; humid mountain forests; climate warm temperate to subtropical
Cupressoconus rhenanus Kilpper	*Cupressus arizonica* Greene	California, Texas, Mexico; coniferous and riparian forests, xeric habitats (south-facing slopes), chaparal; climate warm temperate to subtropical
Cupressospermum saxonicum Kunzmann	?	?
Pinus urani (Unger) Schimper	*Pinus uncinata* Miller ex Mirbel	Alps and Pyrenees; coniferous forests; humid, mild climate
Magnolia cf. *burseracea* (Menzel) Mai	Evergreen magnolias	southern Asia
Nuphar canaliculata C. & E.M. Reid	*Nuphar* Sm.	northern hemisphere; climate temperate to tropical
Fothergilla aff. *europaea* Szafer	*Fothergilla gardenii* Murray.	North America; pocosin communities, xeric pine woods; climate warm temperate
Castanopsis aff. *salinarum* (Unger) Kirchheimer	*Castanopsis indica* (Roxb.) A. DC.	southern Asia; mixed and evergreen broad-leaved forests; climate warm temperate to subtropical
Myrica cf. *suppanii* Kirchheimer	*Morella cordifolia* (L.) Killick	southern Africa; low nutrient content sandy hills; climate subtropical
Ternstroemia sequoioides (Engelhardt) Bůžek & Holý	*Ternstroemia japonica* Thunbg.	western and south-western Asia; mixed mesophytic and evergreen broad-leaved forests; climate warm temperate to subtropical
Pirocarpella aquisgranensis Mai	family Cyrillaceae	south-western North America, Central America and northern South America, climate subtropical and tropical
Comarostaphylis globula (Menzel) Mai	*Comarostaphylis polifolia* (Kunth) Zuccarini ex Klotzsch	California and Central America; arid scrub communities, dry pine and oak-pine forests, climate warm temperate to subtropical
Leucothoe lusatica Mai	*Leucothoe populifolia* (Lam.) Dippel, *L. acuminata* Dunal	southern Carolina and Florida; almost always in wetland; climate warm temperate
Sphenotheca incurva Kirchheimer	?	?
Symplocos casparyi Ludwig	*Symplocos sulcata* Kurz	south-eastern Asia; mixed mesophytic and evergreen broad-leaved forests; climate warm temperate to tropical
Mastixia thomsonii Mai	*Mastixia* Blume	south-eastern Asia, evergreen rain and semi-deciduous mountain forests; climate warm tropical to subtropical
Cladium cf. *europaeum* Dorofeev	*Cladium* R. Browne	world-wide distribution, wetland plant communities; climate temperate to tropical

Chamaecyparis thyoides (L.) Britton, Sterns, & Poggenburg, *Pinus*, *Magnolia*, *Myrica*, *Cyrilla* etc. from the Atlantic coast of North America (Nelson 1986), particularly resembles the fossil assemblages from Lubstów. Also communities of oligotrophic shrub bogs from south-eastern part of North America, termed "pocosin", show some similarities. They are characterized by rich participation of evergreen shrubs, e.g. from the family of Ericaceae and the genera of *Cyrilla*, *Clethra*, and *Myrica*. In the poorly developed tree layer pines are dominant (Nelson 1986, Snyder 1993).

Numerous seeds of *Nuphar canaliculata* C. & E.M. Reid indicate also the presence of aquatic vegetation and *Cladium* cf. *europaeum* Dorofeev is typical of reed-swamp vegetation („streamside vegetation" sensu van der Burgh 1983).

Numerous taxa of palaeotropical element (Tab. 1) including *Castanopsis* aff. *salinarum* (Unger) Kirchheimer, *Magnolia* cf. *burseracea* (Menzel) Mai, *Mastixia thomsonii* Mai, *Ternstroemia sequoioides* (Engelhardt) Bůžek & Holý, *Sphenotheca incurva* Kirchheimer, and *Symplocos casparyi* Ludwig, are probably associated with small and diminishing patches of laurel forest („Lorbeer Wälder" assemblages sensu Mai 2001b). Extant plants from the families Symplocaceae, Mastixiaceae, Theaceae, and Magnoliaceae occur primarily in evergreen broad-leaved forests and in mixed mesophytic forests of south-eastern Asia (Wang 1961).

AGE AND COMPARISON OF THE STUDIED FLORA

The flora from Lubstów is characterized by a significant percentage of palaeotropical elements, accounting for 63% of the taxa present (Tab. 1). This is represented by the species *Castanopsis* aff. *salinarum* (Unger) Kirchheimer, *Comarostaphylis globula* (Menzel) Mai, *Leucothoe lusatica* Mai, *Magnolia* cf. *burseracea* (Menzel) Mai, *Mastixia thomsonii* Mai, *Myrica* cf. *suppanii* Kirchheimer, *Pirocarpella aquisgranensis* Mai, *Sphenotheca incurva* Kirchheimer, *Symplocos casparyi* Ludwig and *Ternstroemia sequoioides* (Engelhardt) Bůžek & Holý. The following taxa belong to arctotertiary element, namely *Chamaecyparis salinarum* Zabłocki, *Cladium* cf. *europaeum* Dorofeev, *Cupressoconus rhenanus* Kilpper, *Fothergilla* aff. *europaea* Szafer, *Nuphar canaliculata* C. & E.M. Reid and *Pinus urani* (Unger) Schimper.

The flora from Wieliczka (Łańcucka-Środoniowa 1984) is the most similar among Polish localities with respect to taxonomic constitution and age (Tab. 3). This flora has 5 species in common with Lubstów, namely *Castanopsis* aff. *salinarum* (Unger) Kirchheimer, *Chamaecyparis salinarum* Zabłocki, *Comarostaphylis globula* (Menzel) Mai, *Magnolia* cf. *burseracea* (Menzel) Mai and *Myrica* cf. *suppanii* Kirchheimer.

The Middle Miocene flora from Stare Gliwice (Szafer 1961) has 3 species in common, namely *Chamaecyparis salinarum* Zabłocki, *Comarostaphylis globula* (Menzel) Mai, and *Myrica* cf. *suppanii* Kirchheimer. This flora is dominated by deciduous broadleaved forest, with a minor percentage of evergreen elements (Mai 1995).

However, the younger, Upper Miocene flora from Gozdnica has 5 species in common with the Lubstów flora. These are *Mastixia thomsonii* Mai, *Pirocarpella aquisgranensis* Mai, *Sphenotheca incurve* Kirchheimer, *Symplocos casparyi* Ludwig and *Ternstroemia sequoioides* (Engelhardt) Bůžek & Holý. The dominant type of environment in Gozdnica is a mixed coniferous forest or deciduous broad-leaved forest (Dyjor et al. 1992).

Table 3. Occurrence of fossil species described from the Lubstów flora in the other comparable fossil floras: Wieliczka (Zabłocki 1930, Kirchheimer 1941, Łańcucka-Środoniowa & Zastawniak 1997), Stare Gliwice (Szafer 1961), Kleinleipisch, Römerkeller (Mai 2001b), Klettwitz–Tagebau Fdp.8 (Mai op. cit.), Rypin ((Łańcucka–Środoniowa 1957), Zukunft West, sample 14401 (van der Burgh 1987) and Gozdnica (Dyjor et al.1992)

Age	Middle Miocene				Upper Miocene		Mio/ Pliocene
Locality / Taxon	Wieliczka	Stare Gliwice	Kleinleipisch, Römerkeller	Klettwitz (Tagebau) Fdp. 8	Rypin	Zukunft West, sample 14401	Gozdnica
Chamaecyparis salinarum Zabłocki	×	×	×				
Cupressoconus rhenanus Kilpper						×	
Cupressospermum saxonicum Kunzmann							
Pinus urani (Unger) Schimper						×	
Magnolia cf. *burseracea* (Menzel) Mai	×			×			
Nuphar canaliculata C. & E.M. Reid							
Fothergilla aff. *europaea* Szafer							
Castanopsis aff. *salinarum* (Unger) Kirchheimer	×			×			
Myrica cf. *suppanii* Kirchheimer	×	×		×		×	
Ternstroemia sequoioides (Engelhardt) Bůžek & Holý			×				×
Pirocarpella aquisgranensis Mai							×
Comarostaphylis globula (Menzel) Mai	×	×		×	×	×	
Leucothoe lusatica Mai							
Sphenotheca incurva Kirchheimer			×				×
Symplocos casparyi Ludwig			×	×			×
Mastixia thomsonii Mai							×
Cladium cf. *europaeum* Dorofeev							
Σ	5	3	4	5	1	4	5

Table 4. Occurrence of fossil species from the Lubstów flora in the zones of Mai (Mai 1967, 2000, 2001a)

Taxon	Zone of Mai												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Chamaecyparis salinarum Zabłocki			×	×								×	×
Cupressospermum saxonicum Kunzmann	×	×	×	×		×						×	
Magnolia cf. *burseracea* (Menzel) Mai						×	×	×	×	×		×	×
Castanopsis aff. *salinarum* (Unger) Kirchheimer						×		×				×	
Myrica cf. *suppanii* Kirchheimer				×		×		×	×	×		×	
Ternstroemia sequoioides (Engelhardt) Bůžek & Holý	×			×		×				×		×	
Pirocarpella aquisgranensis Mai						×						×	
Comarostaphylis globula (Menzel) Mai				×		×		×	×	×		×	
Sphenotheca incurva Kirchheimer						×		×		×	×	×	×
Symplocos casparyi Ludwig	×		×	×		×	×	×	×	×		×	×
Number of species in particular zones	3	1	3	6	0	9	2	6	4	6	1	10	4

Fossil flora from Lubstów has the greatest number of species characteristic for the XII zone of Mai (Tab. 4), represented in the Klettwitz floristic complex for the Lusatia region (Mai 1967, 1995). The most similar locality with respect to floristic composition is Klettwitz Fdp. 8. (Mai 2001b), in which *Comarostaphylis globula* (Menzel) Mai plays a significant role, as it does in the Lubstów flora. Additional taxa are include *Symplocos casparyi* Ludwig, *Magnolia burseracea* (Menzel) Mai, *Castanopsis salinarum* Zabłocki and *Myrica suppanii* Kirchheimer.

According to Mai (2001b), the plants belonging to Klettwitz floristic complex indicate warm temperate or subtropical climate, with mean annual temperature 13–17ºC and mean annual precipitation equal to 500–1500 m.

Similar taxonomic composition to the Lustów flora has the Upper Miocene flora from Zukunft West, especially from the sample no. 14401 (van der Burgh 1987).

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PLATES

Plate 1

1a, b, 2. *Chamaecyparis salinarum* Zabłocki, cones, 1 – × 4; 2 – × 3; UWPalaeo/mag. 2004/1

3–6. *Cupressoconus rhenanus* Kilpper, seeds, 3 – × 8; 4, 5 – × 7.5; UWPalaeo/mag. 2004/2b; 6 – cone, × 1.5; UWPalaeo/mag. 2004/2a

7, 8. *Cupressospermum saxonicum* Mai emend. Kunzmann, 7 – seed, × 15; UWPalaeo/mag. 2004/3a; 8 – cone, × 3; UWPalaeo/mag. 2004/3b

9. *Myrica* cf. *suppanii* Kirchheimer, endocarp, × 8.5;(UWPalaeo/mag. 2004/15

10, 11. *Pinus urani* (Unger) Schimper, 10 – cone, × 1; UWPalaeo/mag. 2004/5; 11 – seed, × 3; UWPalaeo/mag. 2004/8

12 a, b. *Symplocos casparyi* Ludwig, endocarp, a – × 8; b – × 7; UWPalaeo/mag. 2004/24

13 a, b. *Magnolia* cf. *burseracea* (Menzel) Mai, seed, × 6.5; UWPalaeo/mag. 2004/10

14, 15. *Nuphar canaliculata* C. & E.M. Reid, seed, 14 – × 5.5; 15 – × 6; UWPalaeo/mag. 2004/11

16, 17. *Sphenotheca incurva* Kirchheimer, endocarps, × 3; UWPalaeo/mag. 2004/22, 23

18–20 *Fothergilla* aff. *europaea* Szafer, 18 – seed, × 7.5; 19a, b – endocarp, × 6; 20 – endocarp, × 5; UWPalaeo/mag. 2004/12

21a, b. *Cladium* cf. *europaeum* Dorofeev, endocarp, a – × 59; b – × 41; UWPalaeo/mag. 2004/26

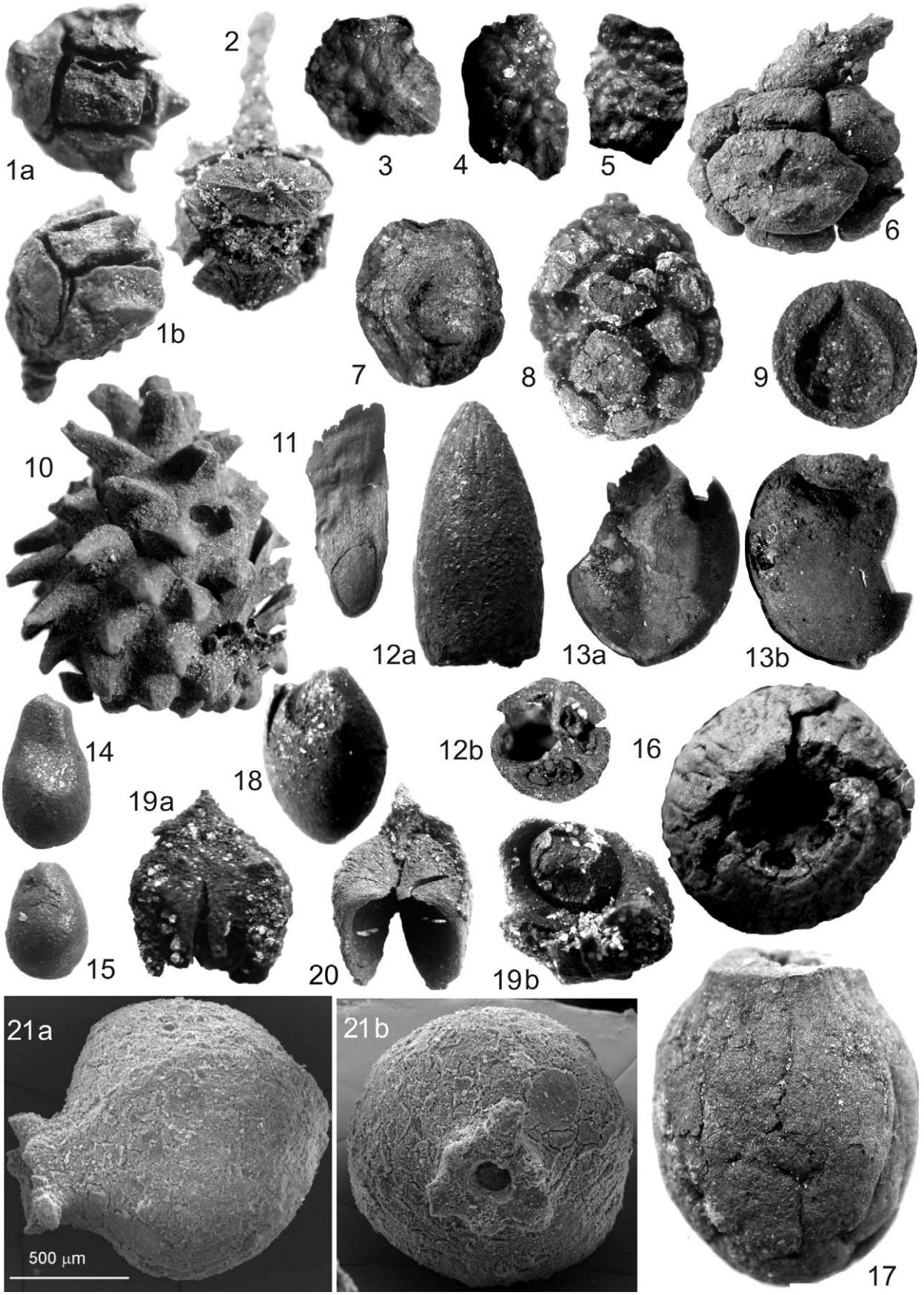
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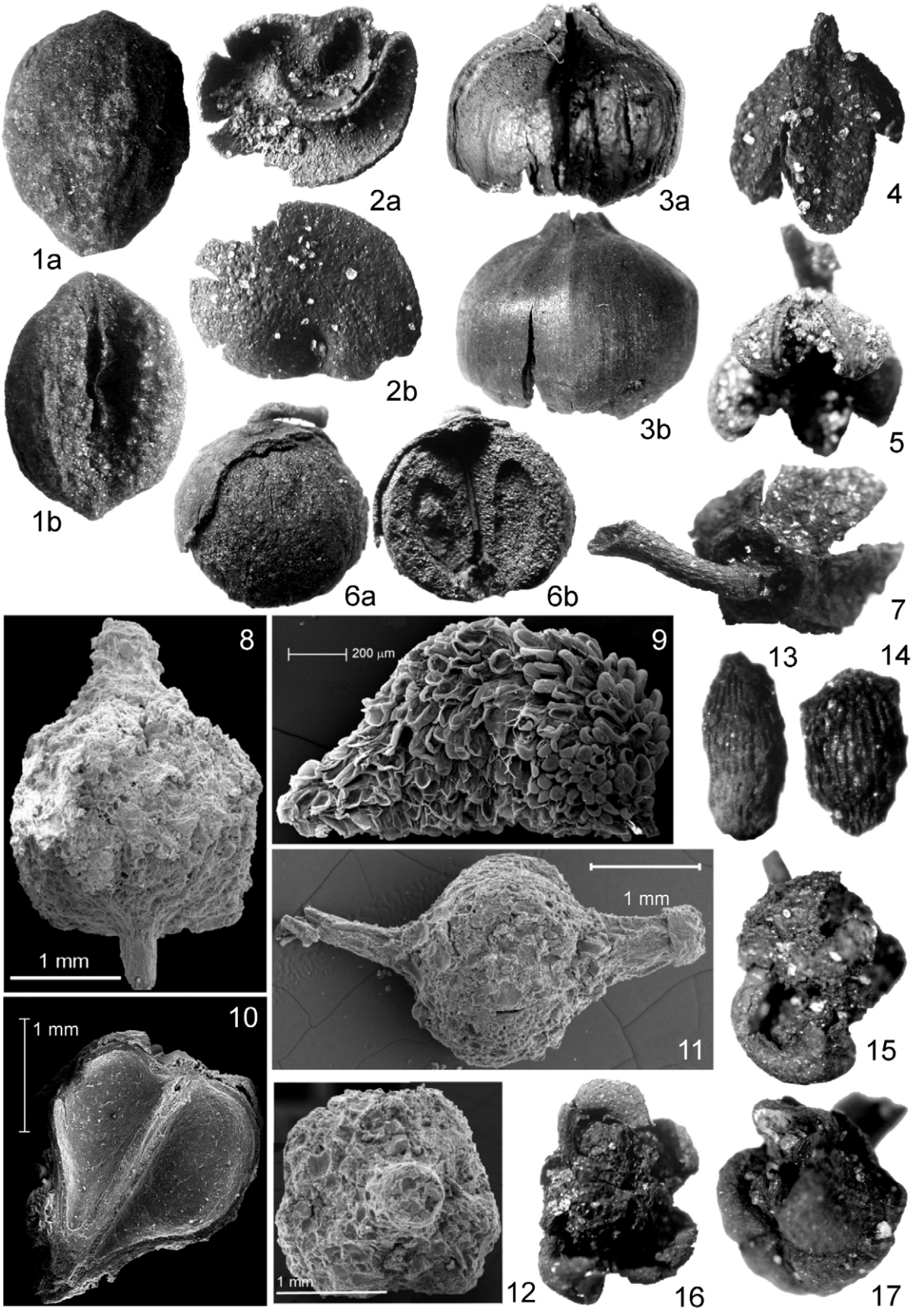
Plate 2

1a, b. *Mastixia thomsonii* Mai, endocarp, × 3; UWPalaeo/mag. 2004/25
2a, b. *Ternstroemia sequoioides* (Engelh.) Bůžek & Holý, seed, × 7; UWPalaeo/mag. 2004/17
3a, b. *Castanopsis* aff. *salinarum* (Unger) Kirchheimer, fruit, × 3.5; UWPalaeo/mag. 2004/14
4, 5 ,7. Ericaceae gen., fruits, 4 – × 7; 5, 7 – × 6; UWPalaeo/mag. 2004/20
6a, b. *Comarostaphylis globula* (Menzel) Mai, fruit, × 3.5; UWPalaeo/mag. 2004/19
8–12. *Pirocarpella aquisgranensis* Mai, fruits, 9 – seed; UWPalaeo/mag. 2004/18
13, 14. *Leucothoe lusatica* Mai, seeds, 13 – × 35; 14 – × 43; UWPalaeo/mag. 2004/21b
15–17. *Leucothoe lusatica* Mai, fruits, 15 – × 13; 16 – × 8; 17– × 13; UWPalaeo/mag. 2004/21a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