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Update and reassessment of the Miocene carpological flora from the Turów open pit mine of SW Poland and its palaeoenvironmental implications

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ABSTRACT. One of the largest and best known, but never completely investigated, fossil carpological floras of the Zittau Basin is revised. The list of revised taxa is supplemented with materials left by H. Czeczott and her team, and newly collected specimens. New combinations are proposed for four species. On the basis of taxa obtained and their location in the geological profile, Turów floras are assigned to two biostratigraphic stages of the Lower Miocene. The Integrated Plant Record vegetation analysis indicates domination of zonal broad-leaved evergreen forest in most studied fossil assemblages from Turów open pit mine (SW Poland). The palaeoclimate reconstruction using the Coexistence Approach method reveals MAT 17–22°C and MAP 1200–1600 mm for most floristic levels. The obtained palaeovegetation and palaeoclimate parameters correspond with those of other coeval floras of the Zittau Basin and Lusatia.

KEYWORDS: fruits, seeds, cones, palaeovegetation, palaeoclimate, Neogene, Zittau Basin

INTRODUCTION

The Turów open pit mine near Bogatynia (Fig. 1) was an area of intensive palaeobotanical exploration led by Hanna Czeczott from 1949 to 1975, supported by many of her collaborators from The Museum of the Earth of the Polish Academy of Sciences in Warsaw. Over all those years, a large amount of carpological material was collected including wood, leaves and disseminules. A significant portion of the material was published by H. Czeczott and her colleagues (Zalewska, 1953, 1955a, b, 1959, 1961; Greguss, 1955; Czeczott and Skirgiełło, 1959, 1961, 1967, 1975, 1980; Kostyniuk, 1967; Hummel, 1970, 1975; Juchniewicz, 1970, 1975; Czeczott and Juchniewicz, 1975, 1980; Baranowska-Zarzycka, 2001) thus the Turów flora is one of the best known Miocene floras in Central Europe. However, studies on the Turów flora have not been completed, which applies especially to a huge collection of unidentified disseminules. Recently, some studies returned to this material (e.g. Kowalski, 2010), but many questions about age, character of vegetation and (palaeo)climate remain.

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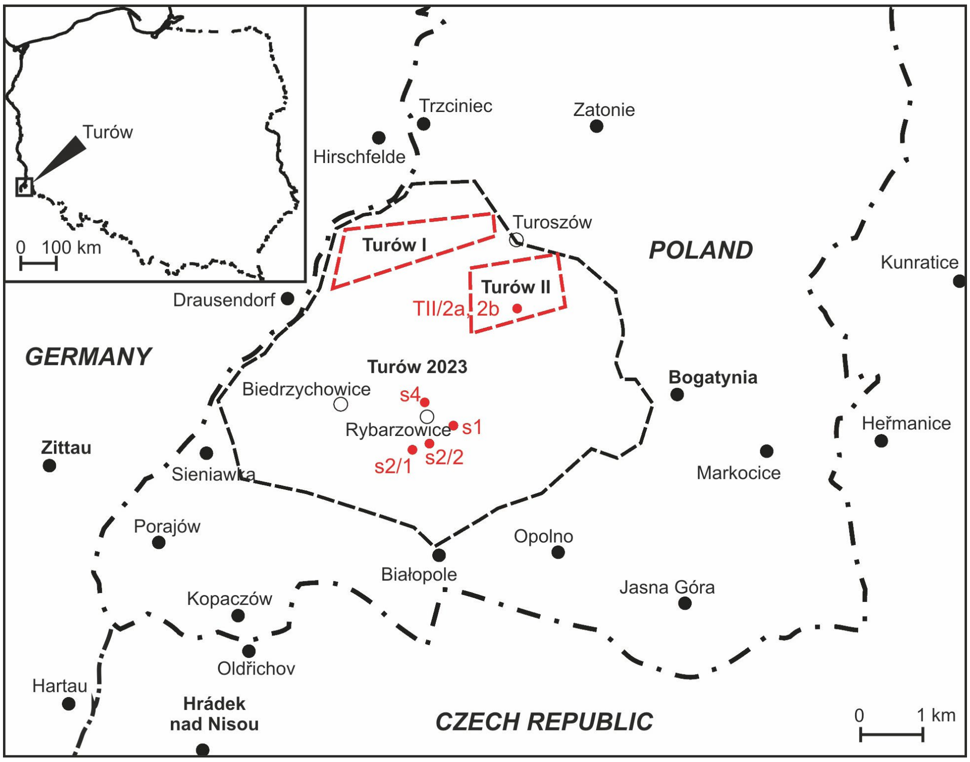

Figure 1. Geographical position of the Turów coal mine: dash-dotted line – national borders; dashed black line – actual excavation area; dashed red line – approximate areas where materials were collected by H. Czeczott and her team. Position of new (S1, S2/2, S2/2, S4) and historical (TII/2a, 2b) sites mentioned in the text

This study primarily aims to revise original fruit and seed material published by Czeczott, Skirgiełło, Zalewska and Baranowska-Zarzycka, but also includes many unidentified carpological fossils from the collection of the Museum of the Earth of the Polish Academy of Sciences in Warsaw and new finds collected by the first author. This revision provides new insight into the floristic diversity of the Turów flora and allows reconstructing palaeovegetation and palaeoclimatic characteristics, as well as age estimation and phytostratigraphic correlations.

GEOLOGY

The Zittau and Berzdorf-Radomierzyce basins of SW Poland represent the northern part of the Eger Rift, which stretches from Bayreuth in the south-west to Görlitz-Zgorzelec in the north-east (Kasiński, 2000). The crystalline basement of the Zittau Basin consists of Neoproterozoic (Cadomian) magmatic, Upper Paleozoic metamorphic, and pre-Cenozoic volcanic rocks. There are also several generations of Cenozoic volcanic rocks of various types (including pyroclastics) at the base and between the lower part of the sedimentary series; the youngest of them has been dated to ~19–20 million years based on radiometric dating (Kasiński, 2000).

According to Kasiński (2000, 2004), deposition in the Polish part of Zittau Basin started in the late Oligocene, however, the main preserved part represents the Early Miocene. The whole sedimentary series has been assigned to six lithostratigraphic units (Fig. 2F), consecutively from the oldest are the Turoszów (Upper Oligocene/Lower Miocene), Opolno, Porajów, Biedrzychowice and Rybarzowice Formation (Lower Miocene), which is covered unconformably by the Gozdnica Formation and the Quaternary (Fig. 2F). Outside the Zittau Basin, sediments of the Gozdnica Formation represent the interval between the Late Miocene and Pliocene, but in Turów its exact age has not been determined (Kasiński, 2000). There are two major coal seams, the so-called “lower” seam related to the Opolno Formation and the “upper” seam related to the Biedrzychowice Formation, which have been correlated by Kasiński (2000) and Kasiński et al. (2015) consecutively with the 3rd Ścinawa and the 2nd Lusatian group of seams (Fig. 2A–E – presents the first author’s proposed lithostratigraphic assignment of the “upper” seam, see also “Biostratigraphic and age estimation of Turów floras” chapter). Discontinuous and thin coal seams are reported

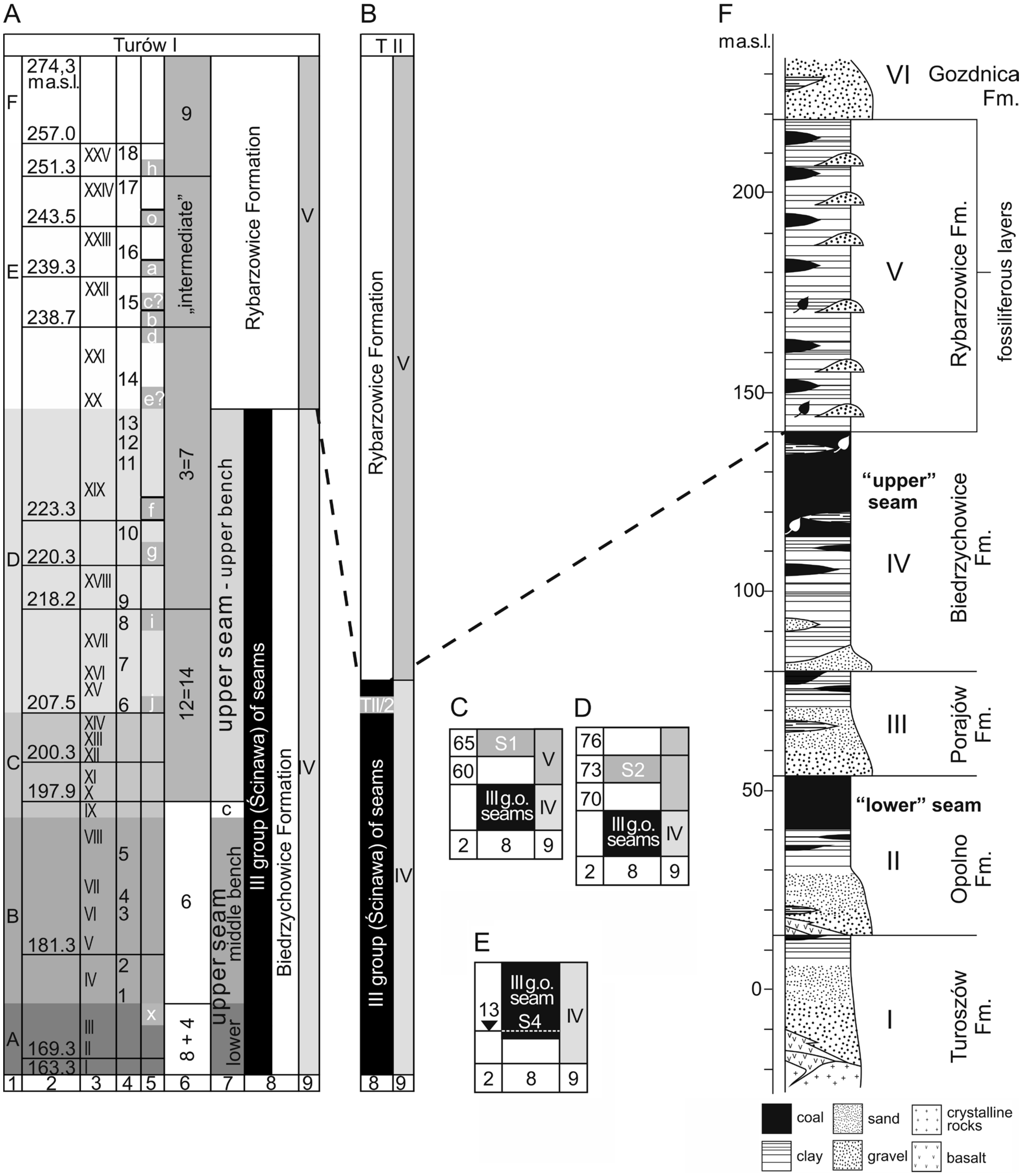

Figure 2. **A**. Schematic, tabular profile of Turów I including all division units used by Czeczott (1959) in the "Diagrammatic cross-section of the Turów brown-coal deposits". The lowermost row with column numbers: 1 – sedimentary divisions; 2 – elevation m a.s.l.; 3 – "forest beds", beds with fossil tree trunk in life position; 4 – clay layers with ironstone concretions; 5 – clay and sand layers where carpological remains were collected – fossiliferous "layers"; 6 – exploitation steps – "Levels"; 7 – terms/classification of coal used by miners; 8 – litostratigraphic division according to Kasiński, 2000 with new classification of the "upper" coal; 9 – sequences in sedimentary development scheme according to Kasiński, 2000; **B**. Schematic, tabular profile of Turów II with probable position of TII/2; the lowermost row with columns – see above; **C–E**. Schematic, tabular profile of Turów with probable position of new sites (S1, S2, S4); the lowermost row with columns – see above; **F**. Schematic lithological profile with lithostratigraphical units of the Turów Basin based on Kasiński et al. (2010) dashed line is a correlation line with profiles A–B. Roman numbers – sedimentary cycles by Kasiński (2000)

also among sediments of the Turoszów (=Basisflotz) and Porajów formations.

Macroscopic fossil plant remains described here from the "upper" seam, and overlying coal/clastic sediments, therefore can be clearly associated with the Biedrzychowice and Rybarzowice formations (classification by Kasiński et al., 2010).

A detailed overview of the geology of the Polish part of the Zittau Basin is beyond the scope of this paper. Besides, the issue of geology of the study area has been repeatedly and extensively studied and presented by Kasiński (2000) and Kasiński et al. (2010, 2015) (see also Bräutigam, 2021). What should be noted here is the fact that results obtained in the current studies are important for lithostratigraphic correlation of the Polish part of the Zittau Basin, and are planned to be presented in a separate paper.

MATERIAL AND METHODS

The exact location of each carpological site found by H. Czeczott and her team is unknown. However, exploration conducted by that team of researchers generally covered an area between 50°55′18.5″N, 14°52′31.7″E; 50°55′52.6″N, 14°53′04.8″E; 50°55′54.3″N, 14°54′55.1″E; 50°55′36.7″N, 14°54′56.9″E. Most materials probably come from the advancing wall of the mining operations which was generally oriented SW–NE. Until the beginning of the 1960s, exploitation was conducted in the NW part of the mining area (see Kasiński, 2000), ~3.5 km NW of Bogatynia. Today the Turów Mine covers 20.85 km^2, but in the late 1940s and 1950s it was smaller, and operated north-west from the present-time area. Over the time, exploitation generally progressed towards south within the Turoszów Hollow, and now operates within the Rybarzowice Depression (see Kasiński, 2000: plate 3).

The present study deals with the historical collection of disseminules collected by H. Czeczott and her team, which includes ~7000 identified specimens and a large number of unidentified specimens of which ~5000 are included here. In addition, ~3500 specimens collected by the first author (RK) from 2021 to 2023 are also studied here. The historical materials belong to two mining areas called Turów I (operated between 1949 and 1975) and Turów II (in operation since 1963) (Fig. 1). From the beginning, the fossil plant remains were collected in many layers located within different working levels and sites. The team of collectors provided only a vertical position in the profile without geographic coordinates. Therefore, for all Turów I and partially for Turów II materials we were able to identify only the approximate location of the collecting area which is shown in Figure 1. In the scheme provided by Czeczott (1959), 7 fossiliferous layers (h, o, a, b, d, g, x) within 7 working levels are mentioned (Fig. 2A). In the following years, more layers were added (i, j – Czeczott, 1961 + 5 more mentioned only in her notes, some without exact position in the profile – e, c, f) and some levels were renumbered (12 was changed to 14, 3 was changed to 7, 9 was changed to 11), but the general scheme remained unchanged.

In the light of the above, it is clear that the carpological fossil flora from Turów combines several taphocoenoses (at least 12) that occurred in a ~111 m thick profile. However, almost complete historical fossils belong to three exploitation levels, i.e. level “3” – containing 30% fossils, “intermediate level” – containing 52% fossils, and level “9” – containing 18% fossils. Therefore, most fossils were collected from the middle and upper part of the Turów I profile, at elevations between 218–251 m (layers “j” to “h”). The richest “intermediate level” comprises a ~12.5 m thick part of the profile. In this paper, each layer is considered a separate fossil assemblage, while the levels are regarded as a group of fossil assemblages. Layers from “e” to “h” are considered here belonging to the V sequence (Fig. 2F, see also Kasiński, 2000).

Information and labels left by Czeczott suggest that the fossil disseminules found in Turów II represent at least four samples that come from two localities, and encompass sections of the profile between 205 and 213 m. However, only two, of the most species-rich localities are included here. The sample from the first locality, marked here as TII/1, was collected at an altitude of 205–206 m, but its exact location could not be established. The second set of samples was collected from a layer (or layers) at an altitude of 207 m. It is separated here into two samples TII/2a, TII/2b, because disseminules of the sample TII/2a (Fig. 1 – geographical position based on map left by H. Czeczott) were extracted by the first author himself from a slab of grey clay (3 cm thick) collected by Juchniewicz and team (between 1963 and 1980), stored in the collection of MZ. While disseminules of the sample TII/2b were stored in a collection of MZ as already extracted materials. Despite the above, we consider these samples one fossil assemblage (taphocoenosis). According to Czeczott and Juchniewicz (1980), samples TII/2a and TII/2b were collected in the upper part of the “upper” coal. Considering the altitude and location noted by the collectors, these samples most likely belong to the IV sequence (Kasiński, 2000), while, because of the uncertain geographical position, TII/1 belonging to the IV sequence is less certain.

New material collected by the first author on 15/04/2021 is indicated here as sample S1 (50°54′2.3937456″N, 14°54′3.570948″E, altitude ~65 m – Fig. 1). This sample is represented by a rich assemblage of disseminules that were washed by rain and found at the base of the highwall. Therefore, sample S1 combines plant remains from more than one horizon. However, we believe that the fossils come from an about one metre thick series of alternating grey clayey silt, sand, and gravel occurring directly above the upper coal seam. Consequently, it is regarded similarly to the levels in Turów I, and considered a basal part of the V sequence (Kasiński, 2000). The low altitude of this sample in relation to fossiliferous levels of Turów I results from the fact that it comes from the Rybarzowice Depression where the bottom part of this sequence was noted even slightly below 60 m (Fig. 2C).

Another part of the new carpological material collected by the first author on 28/06/2022 (50°53′44.468484″N, 14°53′29.772924″E; altitude ~70 m – Fig. 1) is indicated here as sample S2/1. Fossils were washed by rain from a fossiliferous series of sediments occurring directly above the “upper” coal (Fig. 2D presented as S2). The fossil disseminules were collected directly from the ground along the ~200 m long base of the 10 m high wall therefore, they certainly come from several different layers but probably were deposited in a relatively narrow time range. On 29/09/2023 several portions of sediment indicated here as S2/2 (50°53′53.526″N, 14°53′44.156″E – Fig. 1) were collected by the first author in the same exploitation level and part of profile as S2/1 but in a different location. Samples were obtained from a 50 cm thick section of alternating sands and silts that occurred ~2 me above the upper coal. To extract fossils, sediment samples were processed and washed on sieves in the laboratory. Considering the way of obtaining, it is clear that sample S2/2 represents more than one taphocoenosis, but it was probably also deposited in a short interval of time. Similar to S1, samples S2/1 and S2/2 can be considered the lowermost part of the V sequence (Kasiński, 2000), within the Rybarzowice Depression. Samples S2/1 and 2/2 can be correlated with levels "intermediate" and "9" in Turów I. In some parts of this paper S2/1 and S2/2 are considered one level and presented collectively like in the Appendix 2.

Sample S4 was collected by the first author on 25/05/2023, from the bottom part of the "upper" coal seam (50°54′09.2″N, 14°53′43.8″E; altitude ~13 m; Figs 1, 2E). Therefore, it is considered a part of the IV sequence (in the sense of Kasiński, 2000) within the Rybarzowice Depression.

We applied three different quantitative methods to reconstruct the palaeoenvironmental character of the studied floras from the Turów Mine, i.e. Integrated Plant Record vegetation analysis, Drudge 1 and 2 (similarity approaches) and Coexistence Approach.

The Integrated Plant Record (IPR) vegetation analysis is a semi-quantitative method that assesses major zonal vegetation types in deep time based on the fossil plant record including leaves, carpological and pollen records (e.g. Kovar-Eder et al., 2008). This approach is based on leaf physiognomy and the autecology of most similar living relatives. The record of a given fossil assemblage is assigned to components. The proportions of major zonal angiosperm components are decisive for the assignment to a vegetation type. These major zonal angiosperm components are broad-leaved deciduous (BLD), broad-leaved evergreen (BLE), sclerophyllous (SCL), legume-like (LEG), dry herbs (DRY HERB), and mesophytic herbs (MESO HERB). The concept was evaluated by applying this approach to the modern vegetation in East Asia and was then adapted by Teodoridis et al. (2011). Since the plausibility of the results increases with the number of zonal taxa, the original minimum threshold of at least 10 zonal taxa was raised to 15 (Kovar-Eder and Teodoridis, 2018).

Drudge 1 and 2 tools (similarity approaches) serve to identify most similar modern vegetation proxies for Paleogene and Neogene plant assemblages out of a currently available set of 503 modern vegetation units from Asia and Europe (see Teodoridis et al., 2020: appendix 7). The similarity approaches are easily performed by the tools Drudge 1 and 2 (Teodoridis et al., 2020; Kovar-Eder et al., 2021; Teodoridis et al., 2021). Based on the IPR vegetation analysis, Drudges 1 and 2 calculate automatically the similarity of the proportions of major zonal angiosperm components (IPR similarity) and the taxonomic similarity (TS) on the genus level by cluster analysis (Ward's method, Euclidean distance) between a given fossil assemblage and the reference set of modern vegetation. Furthermore, the results mix is calculated in which the major zonal angiosperm components of the IPR similarity and the TS results are weighted equally. The results display the number of similarity hits for the fossil and modern plant assemblages. The five best fitted modern vegetation proxies for each of the IPR similarity, the TS and the results mix, are shown in Supplementary File 3. Drudge 1 extracts the highest level of correspondence of the proportions of woody angiosperms (BLD, BLE, and SCL + LEG) while Drudge 2 includes DRY and MESO HERBS (the zonal herb components) to better distinguish more open vegetation types from closed ones (Teodoridis et al., 2020; Kovar-Eder et al., 2021).

The Coexistence Approach (CA) uses climatic tolerances of all known nearest living relatives (NLRs) identified for a fossil flora (Mosbrugger and Utescher, 1997; Utescher et al., 2014). Climatic requirements of modern plants are obtained from the Palaeoflora Database (Utescher et al., 2024). For each climate variable considered, the range in which a maximum number of NLRs can coexist is identified as coexistence interval (CI). The CI is interpreted to represent the best approximation of the palaeoconditions. The accuracy of the method is likely to vary according to various factors such as regional and stratigraphical representativeness of the considered flora, diversity, taxonomic level of NLR identification, and quality of climate requirements of modern plants. A minimum of 10 taxa contributing with climate data is required. High diversity generally enhances the climatic resolution of CA reconstructions and, as a function of the grade of overlapping, accounts for a higher statistical significance of the results (Mosbrugger and Utescher, 1997). The CA includes a concept for non-overlapping taxa denoted "outliers", which contributes to the robustness of the method (Utescher et al., 2014). The CA is a widely used tool to quantitatively reconstruct palaeoclimate from fossil plant assemblages, applicable on all organ types, and has yielded robust results in numerous applications from the late Cretaceous to Pleistocene, that are largely consistent with data obtained from non-botanical proxies (e.g. Poole et al., 2005; Utescher et al., 2015; Altolaguirre et al., 2020). In this study, three temperature and four precipitation variables are reconstructed: mean annual temperature (MAT), warm and cold month means (WMMT, CMMT), mean annual precipitation (MAP), and mean monthly precipitation of the wettest, warmest, and driest month (MPwet, MPwarm, MPdry).

RESULTS OF TAXONOMICAL REVISION

The full list of previously described and here updated and reassessed taxa can be found in Appendix 1. The list of all (including published, unpublished and newly found materials) carpological taxa found in Turów ordered according to fossiliferous layers, levels and samples (sites – new materials) are presented in Appendix 2.

PINACEAE
Sprengel ex F. Rudolphi 1830

Only two representatives of Pinaceae can be confirmed among the carpological material gathered by Czeczott and team and described by Zalewska (1961). Other identifications made by Zalewska cannot be accepted. After careful examination six remains described as *Pinus* cones scales (Zalewska, 1961: p. 25, pl. 8, figs 10, 11) turned out to be miscellaneous plant parts including unidentified wood fragments, abraded cone scales of *Quasisequoia* and buds. Imprint preserved in ironstone identified as a cone of *Cedrus* was not verified in the course of these studies.

Cathaya bergeri
(Kirchheimer) Schneider 1981

Fig. 3A

1961 *Keteleeria bergeri* Kirchheimer; Zalewska, p. 96, pl. 10, fig. 8.
1961 *Pseudotsuga* cf. *glauca* Mayr; Zalewska, p. 25–28, text fig. 8a–b, pl. 10, fig. 1.

Material. Published: 1 cone, MZ VII/43b/46 (old number 229).

Description. For detailed description see Kunzmann and Mai (2005).

Remarks. We cannot confirm the generic affinity of the cone described by Zalewska (1961: pl. 10, fig 1) as *Pseudotsuga* Carrière 1867. This identification is based on misinterpretation of low diagnostic value features, including shape and size of poorly preserved cone, number of scales and angle they are attached to the axis. However, in respect of general shape, size, and the triangular shape of the only preserved bract, this cone (MZ VI/43b/46, old number 229) corresponds with *Cathaya bergeri* Kunzmann and Mai (2005). Based on the picture (Zalewska, 1961: pl. 10, fig. 8) cone described as *Keteleeria bergeri* Kirchheimer (1940) most likely also belongs to *Cathaya bergeri*, but we did not see specimen (in collection of the Museum of Wrocław University?). On the other hand, remains (MZ VII/43b/45, old number 154) described as cone scales of *Pseudotsuga* and most remains (MZ VII/43b/45, 47; old number 208) identified by Zalewska (1961) as cones scales of *Keteleeria bergeri* should be regarded as indeterminable plant debris.

cf. *Tsuga moenana*
Kirchheimer 1935

Fig. 3B

2005 *Tsuga moenana* Kirchheimer; Kunzmann and Mai, p. 99–106, pl. 11, figs 2–10.

Material. Unpublished: 1 cone, MZ VII/43b/65.

Description. For detailed description see Kunzmann and Mai (2005).

Remarks. Preservation does not allow for clear identification, however, considering general shape and size of cone, and shape of scales affinity with *Tsuga* (especially with *T. moenana*) seems probable.

CUPRESSACEAE
Gray 1821

Glyptostrobus europaea Heer 1850

Fig. 3F

1959 *Glyptostrobus europaeus* Heer; Zalewska, p. 120, pl. 1, figs 1–5.
1959 *Athrotaxis* cf. *laxifolia* Hooker; Zalewska, p. 120, pl. 14, figs 1, 3, 4, 6.

Material. Published: 168 specimens (only reproductive organs), MZ VII/43b/2–5, 12 (old numbers: 153, 172, 187, 190, 201); unpublished: 48 specimens, MZ VII/43a/326, 468, 704, 715, 730, 913, 71 specimens, MZ VII/43b/6, 11, 14, 16, 58, 60; new: 229 specimens, MZ VII/158/15, 64, 122, 185, 250, 300, 312, 315, 338, 344, 353, 354.

Description. For detailed description see Mai (2004).

Remarks. Cones, scales, and seeds described by Zalewska (1959) as *Glyptostrobus europaea* undoubtedly are correctly identified. We agree with the opinion by Florin (1960) and Dorofeev and Sveshnikova (1963) that part of remains from Turów described as *Athrotaxis* cf. *laxifolia* represent young cones of *Glyptostrobus* (compare Averyanov et al., 2009).

Quasisequoia couttsiae
(Heer) Kunzmann 1999

Fig. 3C, E

1959 *Sequoia langsdorfii* (Brongn.) Heer; Zalewska, p. 117, 118, pl. 9, fig. 1.
1959 *Sequoia couttsiae* Heer; Zalewska, p. 117, 118, pl. 5, figs 1–4, pl. 6, fig. 5.
1959 *Taxodium distichum miocenicum* Heer; Zalewska, p. 119, 120, pl. 5, figs 1–4, pl. 6, fig. 5.
1961 *Chamaecyparis* sp.; Zalewska, p. 99, 100, pl. 15, figs 1–3.

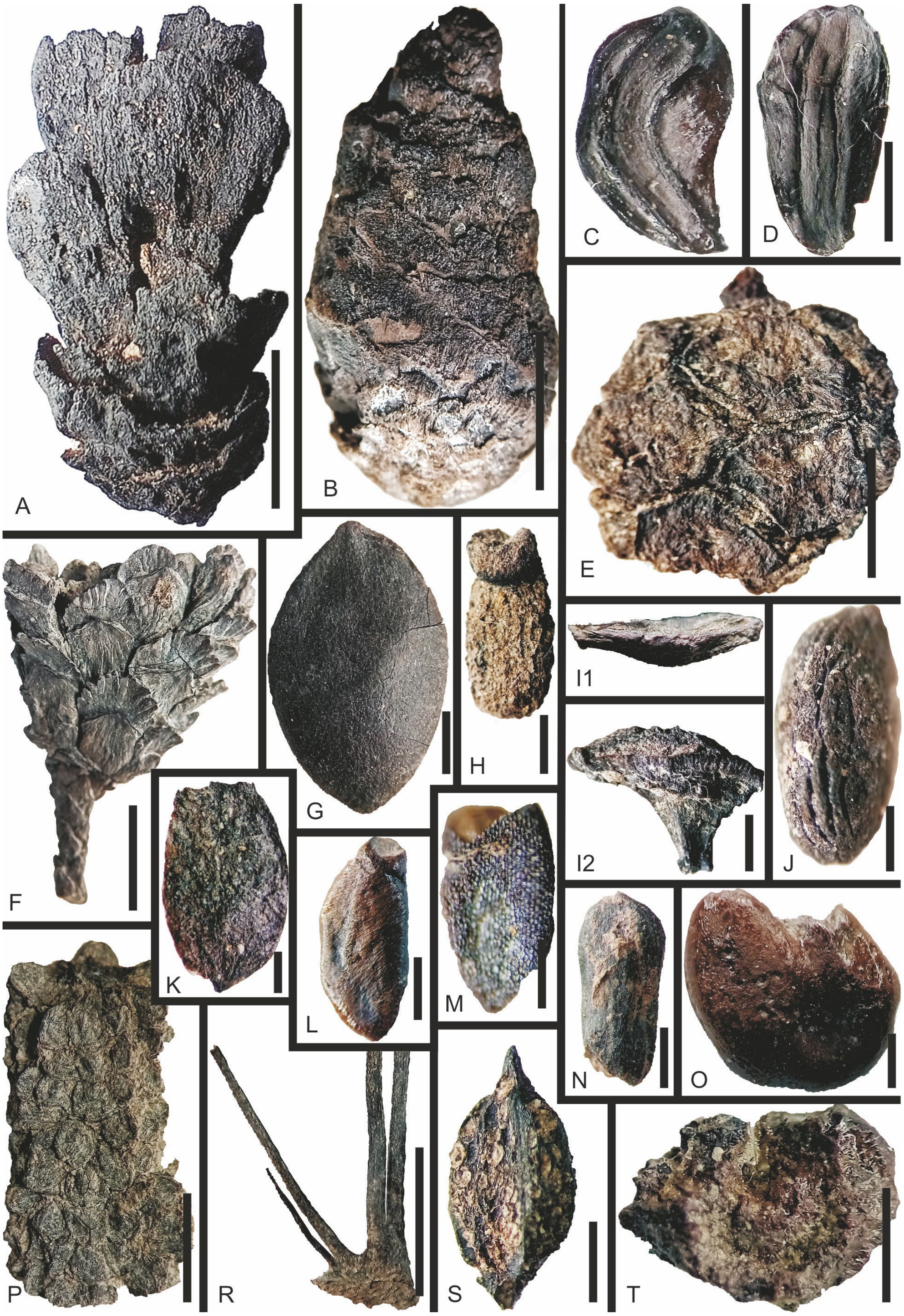

Figure 3. Carpological fossils from the Turów Mine. **A**. *Cathaya bergeri* (Kirchheimer) Schneider: seed cone, MZ VII/43b/46; **B**. cf. *Tsuga moenana* Kirchheimer: seed cone, MZ VII/43a/65; **C**, **E**. *Quasisequoia couttsiae* (Heer) Kunzmann: seed and seed cones, MZ VII/43b/30; **D**. *Sequoia abietina* (Brongniart) Knobloch: seed, MZ VII/43b/30; **F**. *Glyptostrobus europaea* Heer: incomplete seed cone, MZ VII/43b/14; **G**. *Cephalotaxus miocenica* (Krausel) Gregor: seed, MZ VII158/42; **H**. *Stratiotes kaltennordheimensis* (Zenker) Keilhack: seed, MZ VII/43a/790; **I1**, **I2**. *Sequoia abietina* (Brongniart) Knobloch: cone scale, apical surface (I1) and lateral view (I2), MZ VII/43b/40; **J**. *Lemnospermum pistiforme* Nikitin: seed, MZ VII/158/96; **K**. *Tetraclinis salicornioides* (Unger) Kvaček: branch segment, MZ VII158/134; **L**. *Spirematospermum wetzleri* (Heer) Chandler: seed, MZ VII/43a/307; **M**. *Carex plicata* Łancucka-Środoniowa: achene, MZ VII158/108; **N**. *Aracispermum canaliculatum* Nikitin: seed, MZ VII/43a/907; **O**. *Epipremnites reniculus* (Ludwig) Mai: seed, MZ VII/43a/594; P. *Spinopalmoxylon cicatricosum* Winterscheid: staminate flowers on rachilla, MZ VII/43a/916; **R**. *Spinopalmoxylon daemonorops* (Unger) Weyland, Kilpper et Berendt: spines, MZ VII/43a/915; **S**. *Sparganium haentzschelii* Kirchheimer: endocarp, MZ VII/43a/310; **T**. *Urospathites dalgasii* (Hartz) Gregor et Bogner: seed, MZ VII/43a/561. Scale bars: A, B, R = 10 mm; C, D, H, I, N, = 2 mm; F, G, L = 5 mm; J, M, O = 0.5 mm; K, S, T = 1 mm; P = 2.5 mm

Material. Published: MZ VII/43b/17–25, 27, 62 (old numbers: 155, 160, 166, 168, 170, 171, 174, 192, 204, 206, 222; missing: 163, 193, 199); unpublished: 106 specimens, MZ VII/43a/327, 591, 656, 663, 689, 720, 763, 914, 933, 946; MZ VII/158/2, 67, 1225 specimens, MZ VII/43b/59, 62–64, 66–76, 81, 84, 89, 90, 94, 95. See also Appendix 1.

Description. For detailed description see Kunzmann (1999).

Remarks. Apart from those correctly identified remains, many cones, cone scales and seeds were assigned to *Sequoia*, *Chamaecyparis* and *Taxodium*. In our opinion all these fossils should be transferred to *Quasisequoia couttsiae*. *Taxodium distichum miocenicum* originally was documented by Zalewska (1959) based on three cone scales (published number 198, later Czeczott transferred it to 200). Currently 15 specimens are stored under this number (actual number MZ VII/43b/43), but none of them could be identified as the published specimens of Zalewska (1959: pl. 14, fig. 8), and all of them clearly represent *Q. couttsiae* (see criteria below). Besides, in our opinion the cone scales presented in the published figures do not clearly show characteristics of *Taxodium* (i.e. lack of sulcate upper margins, characteristic medial ridge – see Kunzmann et al., 2009). The fact that it has not been found in newly collected carpological materials nor among standing stumps (*Taxodioxylon taxodii* Gothan, only a few drifted wood – Zalewska, 1959, 1961; Kostyniuk, 1967) suggests that this tree was rare or probably lacking in local flora at that time.

Remains of *Sequoia langsdorfii* (see also description by Zalewska, 1959) have all characteristics of *Q. couttsiae* including (see Kunzmann, 1999): 1) scales at an acute angle to cone axis, 2) scales wide, 4–6 sided, convex, without transverse groove, with clear mucro in the centre, 3) seeds with curved embryo locule.

Despite a relatively small number of cone scales (16), remaining features relate cones identified as *Chamaecyparis* sp. with *Q. couttsiae*. Verticillate arrangement of foliage preserved on one of the cone peduncles, which was argued by Zalewska (1961) to be typical *Chamaecyparis* feature, it is in fact spiral, therefore also corresponds with *Q. couttsiae*. Twigs described and included by Zalewska (1961) as *Chamaecyparis* sp. are not considered here.

Sequoia abietina
(Brongniart in Cuvier) Knobloch 1964

Figs 3D, I1, I2

1959 *Metasequoia europaea* Zalewska, p. 80–85, 118, 119, pl. 11, figs 1–7.

Material. Published: Two seed cones (one destroyed) MZ VII/43b/40 (old number: 207).

Description. For detailed description see Kunzmann and Mai (2005).

Remarks. In our opinion cones of *Metasequoia europaea* were wrongly transferred by Dorofeev and Sveshnikova (1963) to *Quasisequoia couttsiae* (see also Mai, 1994; Kunzmann and Mai, 2011). Considering straight embryos and shape of cone scales (narrow rhomboid, transversely concave, without mucro – see Kunzmann, 1999) these remains represent poorly preserved *Sequoia abietina*. Moreover, also many loose seeds with straight embryos (Fig. 3D) observed in the unpublished collection can be considered *Sequoia abietina* (see also Holý et al., 2012).

Tetraclinis salicornioides
(Unger) Kvaček 2000

Fig. 3K

Material. New: 2 specimens, MZ VII/158/134, 209.

Description. For detailed description see Kvaček et al. (2000) and Kunzmann and Mai (2005).

Remarks. Remains described by Zalewska (1961: p. 99, pl. 14, figs 14–16) as *Libocedrus salicornioides* Endlicher 1847, represent, in our opinion, indeterminable plant remains. However, presence of *Tetraclinis* in Turów can be confirmed based on isolated foliar segments (for detailed characteristics see Kvaček et al., 2000) found in new materials.

SCIADOPITYACEAE
Luerssen 1877

Imprints of *Sciadopitys* Siebold et Zuccarini 1842 were also documented among plant remains from Turów, however, verification of this type of fossils was not the subject of this paper.

TAXACEAE Gray 1822

Cephalotaxus miocenica (Krausel) Gregor 1979

Fig. 3G

Materials. New: 613 seeds, MZ VII/158/5, 42, 58, 144, 290, 301, 316, 336.

Description. For detailed description see Gregor (1979) and Kowalski et al. (2024).

MAGNOLIACEAE Jussieu 1789

Magnolia geinitzii (Engelhardt) Kowalski **comb. nov.**

Fig. 4B1, 4B2

Basionym.

1870 *Livistona geinitzii* Engelhardt, Fl. Braunkohlenfrom. Kgr. Sachsen, p. 35, pl. 10, figs 4, 5.

Synonyms.

1913 *Carpolithus fliegelii* Menzel, p. 16–18, pl. 1, figs 25–32.
1934 *Magnoliaespermum geinitzii* (Engelhardt) Kirchheimer, p. 772, 773, fig. 10.
1934 *Magnoliaespermum fliegeli* (Menzel) Kirchheimer, p. 772, 773, fig. 2.

Materials. Published: 1 specimen, MZ VII/43a/3 (old number: 149); unpublished: 1 specimen, MZ VII/43a/562; new: 1 specimen, MZ VII/158/73.

Description. For detailed description see Kirchheimer (1957), Czeczott and Skiergiełło (1975), Mai (1999b).

Remarks. Specimen published by Czeczott and Skirgiełło (1975) is missing, but other two were found among undetermined (MZ VII/43a/562) and new materials (MZ VII/158/73).

According to Kirchheimer (1957), large size (up to 3 cm wide), shape (bean-shaped), thick wall (1.5–4.0 mm), smooth surface, and pore type of chalaza justify considering these seeds separate magnoliaceous genus. Tiffney (1977) suggested that *Magnoliaespermum* may represent an extinct lineage of *Talauma* Juss., 1789 (currently as *Magnolia* sect. *Talauma* represented only by species in Central and South America – Wang et al., 2020). Considering current classification of Magnoliaceae (Figlar and Nooteboom, 2004; Wang et al., 2020) and diversity of seeds among modern magnolias (Xu, 2003), we see no reasons to separate *Magnoliaespermum* from *Magnolia*. Consequently, we propose a new combination for this fossil genus. Possible intrageneric relationships remain unresolved. However, this question may be unsolvable based on seeds only. It is also worth noting that similar (but smaller) seeds can be observed in some modern species of different sections (e.g. *Magnolia rabaniana* (Hook.f. et Thomson) D.C.S. Raju et M.P. Nayar, sect. *Gwillimia* DC.; *M. kwangsiensis* Figlar et Noot., sect. *Kmeria* (Pierre) Figlar et Noot.; *M. baillonii* Pierre, *M. balansae* Aug. DC. Sect. *Michelia*; *M. sinica* (Y.W. Law) Noot., sect. *Gynopodium* Dandy – first author observation).

Holotype was designated only by Mai (1964: pl. 11, fig. 2 – number not provided) among specimens from Kleinsaubernitz published by Engelhardt (1870: pl. 10, fig. 5), stored in the Museum für Mineralogie und Geologie, Dresden (Kirchheimer, 1957).

Magnolia burseracea (Menzel) Mai 1975

Fig. 4C

1961 *Juniperus* sp.; Zalewska, p. 100, 101, pl. 15, figs 12, 13.
1961 *Acer* cf. *hyrcanum* Fisch. et Mey.; Czeczott and Skirgiełło, p. 79, pl. 21, fig. 4a, 4b.

Materials. Published: 1 specimen, MZ VII/43a/55, 124 (old number 185, 103); unpublished: 23 specimens, MZ VII/43a/320, 335, 342, 364, 387, 520, 553, 617, 625, 632, 707, 752, 834, 891; new: 3 specimens, MZ VII/158/194, 308.

Description. For detailed description see Mai (1975) and Kowalski (2017).

Remarks. Fossil remains described as *A.* cf. *hyrcanum* (MZ VII/43a/124) and those described as cone scales of *Juniperus* sp. (MZ VII/43b/55) with no doubt represent the seed of *Magnolia* which is evidenced primarily by presence of characteristic heterophylar structure (moat and stalk type – see Tiffney, 1977). In respect of L/W ratio these seeds correspond to *M. burseracea* (see Kowalski, 2017).

Magnolia ludwigii Ettingshausen 1868

Fig. 4A

1980 *Illicium lusaticum* Czeczott et Skirgiełło; p. 5, pl. 1, figs 10, 11, pl. 2, figs 14, 15.

Materials. Published: 18 specimens, MZ VII/43a/4, 5, (old numbers: 412, 513); unpublished: 13 specimens, MZ VII/43a/347,350, 520, 649, 696, 834, 847, 849, 953; new: 23 specimens, MZ VII/158/14, 28, 52, 277, 293, 334.

Description. For detailed description see Mai (1975) and Kowalski (2017).

Remarks. Seeds identified by Czeczott and Skirgiełło as *Illicium lusaticum* belong to *Magnolia ludwigii* as evidenced by characteristic structures of the chalaza region. It should be added that the authors made a mistake when introducing the new *Illicium* species, because they used an epithet which already existed for fossil leaves *Illicium lusaticum* (Jähnichen), introduced by Kraüsel and Weyland (1959).

It is worth mentioning that some specimens of *Illicium germanicum* described from Wiesa by Mai (1970: pl. 59, fig. 22) also represent *Magnolia*, which, however, was already excluded from *Illicium* by Oh et al. (2003).

Seeds of the *Magnolia* are common in Turów, but in respect of L/W ratio most of them correspond to *M. burseracea* and only 25% represent *M. ludwigii*. We provisionally assumed the presence of these two species in Turów but the first author is skeptical about separating these two species (see Kowalski et al., 2024).

Mangolia germanica
(Mai) Kowalski in Kowalski et al. 2024

Fig. 4F

Materials. Unpublished: 20 seeds, MZ VII/43a/649, 681, 685, 739, 794, 814–817, 863, 923; new materials: 9 seeds, MZ VII/158/90, 198, 333, 350.

Description. For detailed description see Mai (1971a) and Kowalski et al. (2024).

Liriodendron geminata
Kirchheimer 1957

Fig. 4E

Materials. Unpublished: 11 seeds, MZ VII/43a/556, 809–811; new materials: 5 seeds, MZ VII/158/332.

Description. For detailed description see Mai (1999b) and Kowalski et al. (2024).

LAURACEAE Jussieu 1789

Laurocalyx rhenanum
Kirchheimer 1941

Fig. 4J1, 4J2

1961 *Acer* sp. 1; Czeczott and Skirgiełło, p. 116, pl. 21, fig. 3.

1980 *Ocotea rhenana* (Menzel) Kirchheimer; Czeczott and Skirgiełło, p. 12, pl. 1, figs 3–7, pl. 2, figs 1–7.

Materials. Published: 36 specimens, MZ VII/43a/6–14 (old numbers: 52, 77, 87, 228, 446, 551–554); unpublished: 38 specimens, MZ VII/43a/15, 125, 385, 447, 457, 477, 486, 490, 511, 512, 531, 565, 655, 660, 733, 765, 779, 843, 928.

Description. For detailed description see Mai (1964, 1971b).

Remarks. Cupuliferous fruits of this type were classified as *Ocotea* Aublet 1775 by Menzel (1913). Kirchheimer (1941) transferred these fossils to *Laurocalyx* and *Laurocarpum*, introduced by Reid and Chandler (1933) for Lauraceous cupules and fruits of unidentifiable generic affinity. Later, these fossils were restored to *Ocotea* by Mai (1964, 1971b) and their affinity was further supported by this author with Lauraceous flowers which he also assigned to *Ocotea rhenana*. It must be noted, however, that the relationship of these flowers with *Ocotea* is questionable, because characteristics they reveal can also be found among other modern lauraceous genera, e.g. *Cinnamomum* L. and *Phoebe* Nees (stated by Mai, 1964). Characteristics of cupule and fruits used by Mai (1971b) are of little diagnostic value even in view of variability observed among living *Ocotea* (see Van der Werff and Richter, 1996). For these reasons, the classification by Mai (1971b) was questioned several times (see e.g. Rohwer, 1993; Little et al., 2009). Criticism and current understanding of Lauraceae make classification of fossil fruits proposed by Mai (1971b) questionable. Consequently, we believe that the generic affinity of these fossils cannot be determined without doubt and the name *Laurocalyx rhenanum* is more appropriate for our materials.

***Laurocalyx* sp. 1**

Fig. 4K

Materials. Unpublished: 3 specimens, MZ VII/43a/830, 833, 938, new materials: 2 specimens, MZ VII/158/212.

Description. For details see description by Mai (1971b – of *Cinnamomum lusaticum* Mai).

Remarks. Short (up to ½ of fruit length) cupula with undulating margin (= remains of short tepals?) and abruptly tapered relatively

Figure 4. Carpological fossils from the Turów Mine. **A**. *Magnolia ludwigii* Ettingshausen: seed, MZ VII/43a/4; **B1**, **B2**. *Magnolia geinitzii* (Engelhardt) Kowalski: seed, MZ VII/43a/562; **C**. *Magnolia burseracea* (Menzel) Mai: seed, MZ VII/43a/342; **D1**, **D2**. *Parabaena europaea* Czeczott et Skirgiełło: endocarp, MZ VII/43a/17; **E**. *Liriodendron geminata* Kirchheimer: pair of seeds, MZ VII/43a/809; **F**. *Magnolia germanica* (Mai) Kowalski: seed, MZ VII/43a/685; **G**. *Sabia europaea* Czeczott et Skirgiełło: endocarp, MZ VII/43a/128; **H**. *Laurocalyx* sp. 3: cupule, MZ VII/43a/910; **I**. *Laurocalyx* sp. 2: fruit with cupule, MZ VII/43a/648; **J1**, **J2**. *Laurocalyx rhenanum* Kirchheimer: cupule, MZ VII/43a/14; **K**. *Laurocalyx* sp. 1: fruit with cupule, MZ VII/43a/830; **L**. *Passiflora kirchheimeri* Mai: seed, MZ VII/43a/98; **M**. *Sarcococca weylandii* Mai: seed, MZ VII/43a/22; **N**. *Sinomenium* aff. *cantalense* (E.M. Reid) Dorofeev: endocarp, MZ VII158/69; **O**. *Hypericum septestum* Nikitin ex Arbuzova: seed, MZ VII158/101; **P**. *Rubus laticostatus* Kirchheimer: endocarp, MZ VII/43a/100; **R**. *Acalypha fragilis* (Mai) Mai: seed, MZ VII158/12. Scale bars: A, C, D, F, H, M, N = 2 mm; B, I, K = 5 mm; R = 0.5 mm; E, G, L, P = 1 mm; J = 10 mm; O = 0.25 mm

short pedicel relate these fossils with *Cinnamomum lusaticum*. They are only slightly (~1 mm) broader than specimens described by Mai (1971b). However, generic affinity of these type of fossils is doubtful considering similarity between modern *Cinnamomum* and *Phoebe* (and others – see Little et al., 2009). Consequently, we believe this type of cupuliferous fruit should be transferred to *Laurocalyx*. This, however, must be preceded by more detailed studies which was too extensive task for this revision.

Laurocalyx sp. 2

Fig. 4I

Materials. Unpublished: 2 specimens, MZ VII/43a/421, 648; new materials: 3 specimens, MZ VII/158/213, 263.

Description. For detailed description see Mai (1971b – *Sassafras lusaticum* Mai).

Remarks. Cupula with undulated margin, gradually tapering into long pedicel, and size relate these fruits with *Sassafras lusaticum*. Considering, however, arguments mentioned above in remarks to *Laurocalyx rhenanum* and *Laurocalyx* sp. 1, generic affinity of this type of cupuliferous fruits should be reinvestigated. Until a new classification will be introduced using open nomenclature is more appropriate.

Laurocalyx sp. 3

Fig. 4H

Materials. Unpublished: 2 specimens, MZ VII/43a/910, 919.

Description. For detailed description see Mai (1971b – *Phoebe bohemica* Mai).

Remarks. Size of cupula (3.5 mm wide), as well as distinct five tepals relate these Lauraceous cupulas with *Phoebe bohemica*. However, considering that these characteristics can be observed among other genera, e.g. *Apollonias* Nees, *Cinnamomum* (Kostermans, 1957; Little et al., 2009) we doubt the generic affinity proposed by Mai (1971b).

It is worth mentioning that several unidentified lauraceous fruits described here as *Laurocarpum* sp. (see Appendix 2) were also found among unpublished materials. In respect of size they could be related with all three types of *Laurocalyx*.

ARACEAE Jussieu 1789

Aracispermum canaliculatum Nikitin 1955

Fig. 3N

Materials. Unpublished: 1 specimen, MZ VII/43a/907; new materials: 22 specimens, MZ VII/158/10.

Description. For detailed description see Mai (1999a)

Epipremnites reniculus (Ludwig) Mai 1989

Fig. 3O

Materials. Unpublished: 5 seeds, MZ VII/43a/594, 770.

Description. For detailed description see Mai (1999a).

Urospathites dalgasii (Hartz) Gregor et Bogner 1984

Fig. 3T

Materials. Unpublished: 2 seeds, MZ VII/43a/561; new materials: 19 seeds, MZ VII/158/7, 327.

Description. For detailed description see Mai (1999a) and Kowalski (2017).

Lemnospermum pistiforme Nikitin 1976

Fig. 3J

Material. New materials: 1 specimen, MZ VII/158/96.

Description. For detailed description see Mai (1999a).

HYDROCHARITACEAE Jussieu 1789

Stratiotes kaltennordheimensis (Zenker) Keilhack 1896

Fig. 3H

Material. Unpublished: 1 specimen, MZ VII/43a/790.

Description. For detailed description see Meller (1998).

ARECACEAE Bercht. et J. Presl 1820

Spinopalmoxylon daemonorops
(Unger) Weyland, Kilpper et Berendt 1966

Fig. 3P, 3R

1980 *Spinophyllum daemonorops* (Unger) Huard; Czeczott and Juchniewicz, p. 26–29, pls 4–8.

Materials. Published: 195 specimens, MZ VII/43a/795–804 (old numbers: 805–813 later changed to 554–563); Unpublished: 67 specimens, MZ VII/43a/860, 915, 916, 926; new materials: 17 specimens, MZ VII/158/152–168.

Description. For detailed description see Winterscheid (2019).

Remarks. In Turów this calamoid fossil palm is represented so far by spiny stems, spathaceous bracts, spines (single or in groups); staminate flowers (*Spinopalmoxylon cicatricosum* Winterscheid 2019 – Fig. 3P) and dispersed pollen of *Dicolpopollis kockelii* type (Ziembińska-Tworzydło, 1991; Ziembińska-Tworzydło and Konzalová, 2008).

TYPHACEAE Jussieu 1789

Sparganium haentzschelii
Kirchheimer 1941

Fig. 3S

1980 *Sparganium haentzschelii* Kirchheimer; Czeczott and Skirgiełło, p. 19, pl. 2, figs 27, 28.

Materials. Published: 2 specimens, MZ VII/43a/310 (old number: 499); unpublished: 3 specimens, MZ VII/43a/623, 637.

Description. For detailed description see Kirchheimer (1957).

Sparganium pusilloides
Mai in Mai and Walther 1978

Fig. 5P

Materials. Unpublished: 1 specimen, MZ VII/43a/882; new: 5 specimens, MZ VII/158/95.

Description. For detailed description see Mai (1997).

CYPERACEAE Jussieu 1789

Carex plicata
Łancucka-Środoniowa 1979

Fig. 3M

Material. New: 1 specimen, MZ VII/158/108.

Description. For detailed description see Łancucka-Środoniowa (1979).

Remarks. We relate our specimens to species described by Łancucka-Środoniowa (1979). However, we are also aware of problems related with *C. plicata* indicated by Jiménez-Mejías et al. (2016) therefore, for identification we also used specimens illustrated by the mentioned authors (pl. 5f) and specimens described by Kowalski et al. (2024).

ZINGIBERACEAE Martinov 1820

Spirematospermum wetzleri
(Heer) Chandler 1925

Fig. 3L

Materials. Published: 4 specimens, MZ VII/43a/307–308 (old numbers: 439, 517); unpublished: 1 specimen, MZ VII/43a/792.

Description. For detailed description see Fischer et al. (2009).

Remarks. For familial affinity see Smith et al. (2018).

MENISPERMACEAE Jussieu 1789

Parabaena europaea
Czeczott et Skirgiełło 1967

Fig. 4D1, 4D2

Materials. Published: 1 specimen, MZ VII/43a/17 (old number: 431); new: 1 specimen, MZ VII/158/211.

Description. For detailed description see Czeczott and Skirgiełło (1967).

Sinomenium* aff. *cantalense
(E.M. Reid) Dorofeev 1955

Fig. 4N

Material. New: 1 specimen, MZ VII/158/69.

Description. For detailed description see Mai (1997).

Remarks. Considering size (5.8 mm wide), shape (deformed but not oblique) and straight ventral margin, this endocarp corresponds with *S. cantalense*. However, the number of dorsal ridges (~30?) is greater than suggested for this species by Jacques et al. (2011). In this respect our specimen is closer to *Menispermum reidii* Geissert, Gregor and Mai, which, however, has a concave ventral margin. The same number of ridges was described for *S. militzeri* Kirchheimer (1957), yet it was synonymized with *S. cantalense* by Mai (1997). Considering the above differences and taxonomy of the fossil species of the *Menispermum-Sinomenium* complex proposed by Jacques et al. (2011), classification of this endocarp is uncertain.

PLATANACEAE
Lestiboudois 1826

Platanus neptuni
(Ett.) Bůžek, Kvaček et Holý 1967

Fig. 5B, 5C

Materials. Unpublished: 2 achenes and 1 receptacular core, MZ VII/43a/955.

Description. For detailed description see Kvaček and Manchester (2004).

SABIACEAE
Blume 1851

Sabia europaea
Czeczott et Skirgiełło 1959

Fig. 4G

Materials. Published: 6 specimens, MZ VII/43a/128 (old number 15, 15 bis); unpublished: 1 specimen, MZ VII/43a/680.

Description. For detailed description see Czeczott and Skirgiełło (1959).

Meliosma miessleri
Mai 1964

Fig. 5A1, 5A2

Materials. Unpublished: 2 specimens, MZ VII/43a/393, 653; new: 11 specimens, MZ VII/158/33, 77, 140, 260, 270, 296.

Description. For detailed description see Mai (1964).

Meliosma wetteraviensis
(Ludwig) Mai 1964

Fig. 5D

Materials. Unpublished: 2 specimens, MZ VII/43a/652; new: 3 specimens, MZ VII/158/82, 349.

Description. For detailed description see Mai (1973).

BUXACEAE Dumortier 1822

Sarcococca weylandii
Mai 1970

Fig. 4M

1980 *Sarcococca weylandii* Mai; Czeczott and Skirgiełło, p. 15, pl. 3, figs 4–6.

Materials. Published: 2 specimens, MZ VII/43a/22 (old number: 396); unpublished: 6 specimens, MZ VII/43a/551, 725.

Description. For detailed description see Mai (1970).

Remarks. Among six seeds (MZ VII/43a/22, old number 396) described by Czeczott and Skirgiełło (1980) only two were identified correctly (pl. 3, figs 4–6). The remaining four (two illustrated – pl. 3, figs 7–8) instead represent *Zanthoxylum tiffnei* Gregor (see also Gregor, 1978a), and are now stored under new number MZ VII/43a/906 (Fig. 9S1, 9S2).

ALTINGIACEAE Horaninov 1841

Liquidambar europaea
A. Braun in Unger 1847

Fig. 5E

1959 *Liquidambar magniloculata* Czeczott and Skirgiełło, p. 121, 122, pl. 15, figs 1–4.

Materials. Published: 23 specimens, MZ VII/43a/18–21 (old numbers 47, 47bis, 77, 83); unpublished: 2 specimens, MZ VII/43a/367, 371; new: 63 specimens, MZ VII/158/44, 59, 127, 149, 172, 191, 232, 286, 319.

Description. For detailed description see Mai (1997).

HAMAMELIDACEAE Brown 1818

Distylium protogaeum
Mai in Mai and Walther 1991

Fig. 5I

Materials. Unpublished: 1 specimen, MZ VII/43a/360; new: 59 specimens, MZ VII/158/16, 76, 143, 295, 309, 314, 347.

Description. For detailed description see Mai and Walther (1991).

Remarks. Among new materials we found seeds that morphologically correspond to *Distylium protogaeum*. In one of the layers Hamamelidaceae fruits and infructescences were discovered along with seeds of the

Figure 5. Carpological fossils from the Turów Mine. **A1**, **A2**. *Meliosma miessleri* Mai: endocarp, MZ VII/43a/393; **B**, **C**. *Platanus neptuni* (Ett.) Bůžek, Kvaček et Holý: achene and fragment of infruitescence (receptacular core), MZ VII/43a/955; **D**. *Meliosma wetteraviensis* (Ludwig) Mai: endocarp, MZ VII/43a/652; **E**. *Liquidambar europaea* A.Braun: infructescence, MZ VII/43a/18; **F**. Hamamelidoideae indet.: seed, MZ VII/43a/415; **G**. *"Fothergilla" europaea* Szafer: seed, MZ VII158/36; **H1**, **H2**. *Daphniphyllum cylindricum* (Ludwig) Mai: endocarp, * – micropyle, MZ VII/43a/699; **I**. *Distylium protogaeum* Mai: seed, MZ VII/43a/767; **J**. *Rhodoleia bifollicularis* (Menzel) Mai: fruit capsule, MZ VII158/40; **K**, **L**. *Itea europaea* Mai: fruit capsule, scale bar = 1 mm, seed, MZ VII/43a/829, MZ VII/158/105; **M**, **N**. *Paliurus favonii* Unger: endocarps, MZ VII/43a/555; **O**. *Cercidiphyllum helveticum* (Heer) Jähnichen, Mai et Walther: follicle, MZ VII/158/169; **P**. *Sparganium pusilloides* Mai: endocarp, MZ VI/43a/882; **R**. *Rubus semirotundatus* Łancucka-Środoniowa: endocarp, MZ VII/43a/911. Scale bars: E = 10 mm; A, D, F, G, I, J, M, N = 2 mm; O = 5 mm; B, C, K, R = 1 mm; H = 2.5 mm; L, P = 0.25 mm

D. protogaeum type. Infructenscences occur in the form of spikes, with up to 4 sessile fruits attached to a strong, short axis. Calyx remains observed on some specimens reached 2/3 the fruit length. Style remains were caducous, but fruits on which styles were observed were probably immature. Considering these characteristics our fossil fruits do not seem to belong to *Distylium* Siebold et Zuccarini 1841 (compare Endress, 1970), but since all seeds were found detached, this relationship is still possible.

"Fothergilla" europaea Szafer 1947

Fig. 5G

Materials. New: 2 specimens, MZ VII/158/36, 336.

Description. For detailed description see Kowalski (2017).

Remarks. Seeds in type of *F. europaea*, but their real generic affinity is problematic (see also Kowalski, 2017).

Rhodoleia bifollicularis (Menzel) Mai 2001

Fig. 5J

Material. New: 1 fruit capsule, MZ VII/158/40.

Description. For detailed description see Mai (2001).

CERCIDIPHYLLACEAE Engler 1907

Cercidiphyllum helveticum (Heer) Jähnichen, Mai et Walther 1980

Fig. 5O

Materials. New: 23 fruit pod, MZ VII/158/79, 169, 337.

Description. For detailed description see Jähnichen et al. (1980).

DAPHNIPHYLLACEAE Müll. Arg. 1869

Daphniphyllum cylindricum (Ludwig) Mai 1973

Fig. 5H1, 5H2

Material. Unpublished: 1 specimen, MZ VII/43a/699.

Description. For detailed description see Mai (1973).

Remarks. In respect of size (8.5 × 3.2 mm), narrow elliptic shape, thin endocarp wall (0.3–0.7 mm thick), external swollen suture and internal vascular bundle canal, this endocarp resembles the most *Daphniphyllum cylindricum* from the Lower Pliocene of Wetterau (Mai, 1973). We consider this identification reliable; however, it should be noted that our endocarp is not complete, lacking basal (hilar-end) part and has thinner walls than Wetterau specimens, yet this results from poorer preservation.

ITEACEAE J. Agardh 1858

Itea europaea Mai 1985

Fig. 5K, 5L

Materials. Unpublished: 1 specimen, MZ VII/43a/829; new: 18 specimens, MZ VII/158/105, 193, 346.

Description. For detailed description see Mai (1985).

Remarks. Both fruits (Fig. 5K) and seeds (Fig. 5L) are represented in Turów.

VITACEAE Jussieu 1789

Ampelopsis malvaeformis (Schlotheim) Mai in Mai et Gregor 1982

Fig. 6A1, 6A2

1959 *Vitis ludwigi* A. Braun; Czeczott and Skirgiełło, p. 124, pl. 17, fig. 2.

Materials. Published: 2 specimens, MZ VII/43a/145, 149 (old numbers 112, 248 later changed to 250); new materials: 2 specimens (MZ VII/158/92).

Description. For detailed description see Mai (1999b).

Remarks. Our revision is based on the new combination for *Vitis ludwigi* proposed by Mai and Gregor (1982). Only one of the three specimens assigned by Czeczott and Skirgiełło to *Vitis ludwigi* represents *A. malvaeformis*. This is evidenced by long and narrow triangular shape of seeds, shape of chalaza, radial wrinkles around lanceolate chalaza, widely diverged short and narrow ventral infolds (see Mai and Gregor, 1982). Remaining seeds represent *Vitis* (see *V. lusatica*).

Ampelocissus lobatum (Chandler) Chen et Manchester 2007

Fig. 6G1, 6G2

1959 *Tetrastigma chandleri* Kirchheimer; Czeczott and Skirgiełło, p. 104, 105, pl. 18, figs 2, 3.

2007 *Ampelocissus lobatum* (Chandler) Chen et Manchester; p. 1546.

Materials. Published: 6 specimens, MZ VII/43a/143, 144 (old numbers 249, 251); unpublished: 21 specimens, MZ VII/43a/414, 500, 588, 604, 691, 718, 775, 879, 909, 918.

Description. For detailed description see Chandler (1925) and Chen and Manchester (2007).

Ampelocissus chandleri
(Kirchheimer) Chen et Manchester 2007

Fig. 6D1, 6D2

1959 *Tetrastigma chandleri* Kirchheimer; Czeczott and Skirgiełło, p. 104, 105, pl. 18, fig. 4.

Materials. Published: 10 specimens, MZ VII/43a/143 (old number: 249); unpublished: 5 specimens, MZ VII/43a/337.

Description. For detailed description see Kirchheimer (1957) and Chen and Manchester (2007).

Ampelopsis rotundata Chandler 1925

Fig. 7A1, 7A2

1959 *Vitis teutonica* A. Braun; Czeczott and Skirgiełło, p. 102, pl. 16, figs 4, 5.

1959 *Ampelopsis* sp.; Czeczott and Skirgiełło, p. 125, pl. 19, figs 1–3.

Materials. Published: 5 specimens, MZ VII/43a/142, 148 (old number 23, 263); unpublished: 9 specimens, MZ VII/43a/612, 619, 622, 673, 894, 917; new: 4 specimens, MZ VII/158/66, 253, 326.

Description. For detailed description see Mai and Walther (1978) and Kowalski et al. (2024).

Remarks. According to Holý et al. (2012), some seeds from Turów assigned to *Vitis teutonica* A. Braun represent *Ampelopsis rotundata*, which is true for two specimens (key features: chalaza pyriform and close to the apex of seed) illustrated by Czeczott and Skirgiełło (1959: pl. 16, figs 4, 5). Remaining seeds represent *Vitis*, including *V. teutonica* (MZ VII/43a/148) and *V. lusatica*. For diagnostic criteria see remarks to *Vitis lusatica*.

Vitis lusatica
Czeczott et Skirgiełło 1959

Fig. 6E1, 6E2

1959 *Vitis lusatica* Czeczott and Skirgiełło, p. 124, pl. 17, figs 4–12.

1959 *Vitis ludwigi* A. Braun; Czeczott and Skirgiełło, p. 124, pl. 17, figs 1, 3.

Materials. Published: 11 specimens, MZ VII/43a/146, 147, (old number 70); unpublished: 3 specimens, MZ VII/43a/336, 356; new: 8 specimens, MZ VII/158/136, 203, 254.

Description. For detailed description see Czeczott and Skirgiełło (1959) and remarks to *Vitis* aff. *parasilvestris* in Kowalski et al. (2024).

Remarks. As key for this species we considered the following features: seeds relatively small, radial folds around chalaza; chalaza small centrally located (see also Kowalski et al., 2024).

Vitis aff. ***parasilvestris***
Kirchheimer 1940

Fig. 6F1, 6F2

1959 *Vitis teutonica* A. Braun; Czeczott and Skirgiełło, p. 123, specimens not illustrated.

1959 *Vitis* cf. *sylvestris* C.C. Gmel.; Czeczott and Skirgiełło, p. 102, 123, pl. 16, figs 1, 2.

2024 *Vitis parasilvestris* Kirchheimer; Kowalski, p. 9, fig. 10K, 10N.

Materials. Published: 3 specimens, MZ VII/43a/148, 150 (old number 263, 247); unpublished: 6 specimens, MZ VII/43a/605, 613, 982; new: 33 specimens, MZ VII/158/20, 46, 61, 179, 255, 310, 324.

Description. For detailed description see Kowalski et al. (2024).

Remarks. According to Kowalski et al. (2024), features diagnostic for this species are: relatively large size and robustness; smooth surface or with slight radial striation around chalaza; chalaza large, elliptic; beak articulated, long and thick. We believe that despite atypical shape and size, our seeds represent *V. parasilvestris*. As conclusive features we considered: smooth surface and articulated beak.

Vitis teutonica
A. Braun 1854

Fig. 6B1, 6B2

1959 *Vitis teutonica* A. Braun; Czeczott and Skirgiełło, p. 102, pl. 16, figs 3, 7.

Materials. Published: 6 specimens, MZ VII/43a/148; new: 12 specimens, MZ VII/158,35, 54, 93, 205, 241.

Description. For detailed description see Mai (1997) and Kowalski et al. (2024).

Remarks. Only two specimens (Czeczott and Skirgiełło 1959: pl. 16, figs 3, 7) can be assigned to *V. teutonica* among materials published. We based this identification on the following features: small size of seeds, triangular in shape; smooth surface; small chalaza, beak long but not narrowed (inarticulate) at the junction with the main body of the seed.

Vitis globosa Mai 1964

Fig. 6H1, 6H2

1959 *Vitis* cf. *thunbergii* Sieb. et Zucc.; Czeczott and Skirgiełło, p. 124, pl. 16, fig. 8.

Materials. Published: 1 specimen, MZ VII/43a/149; Unpublished: 8 specimens, MZ VII/43a/338, 501, 602, 611.

Description. For detailed description see Mai (2000a).

Remarks. Considering the small size and shape of seeds, shape, size and position of chalaza, smooth surface around chalaza, and short beak, these seeds can be assigned to *Vitis globosa*. Out of two seeds described as *Vitis* cf. *thunbergii*, one is regarded here as an indeterminable plant remain.

Vitis palaeomuscadinia Mai 2000a

Fig. 6C1, 6C2

Materials. Unpublished: 2 specimens, MZ VII/43a/893, 954; new: 7 specimens, MZ VII/158/204, 240, 311, 325.

Description. For detailed description see Mai (2000a).

Remarks. Based on large size, close to rectangular shape, radial striation or folds around large chalaza, beak articulated but short and thin, we relate these seeds with *V. palaeomuscadina*.

Parthenocissus britannica (Heer) Chandler 1957

Fig. 7B1, 7B2

Materials. Unpublished: 1 specimen, MZ VII/43a/831; new: 1 specimen, MZ VII/158/269.

Description. For detailed description see Chandler (1957).

HYPERICACEAE Jussieu 1789

Hypericum septestum Nikitin ex Arbuzova 2005

Fig. 4O

Materials. New: 6 specimens, MZ VII/158/101.

Description. For detailed description see Mai (1997) and Arbuzova (2005).

PASSIFLORACEAE Jussieu ex Roussel 1806

Passiflora kirchheimeri Mai 1960

Fig. 4L

Materials. Published: 1 specimen, MZ VII/43a/98 (old number 281).

Description. For detailed description see Mai (2000a) and Czeczott and Skirgiełło (1967).

EUPHORBIACEAE Jussieu 1789

Acalypha fragilis (Mai) Mai 1987

Fig. 4R

Materials. New: 3 specimens, MZ VII/158/12, 210.

Description. For detailed description see Mai (2000a).

ROSACEAE Jussieu 1789

Prunus leporimontana Mai 1984a

Fig. 7G1, 7G2

Materials. Unpublished: 1 specimen, MZ VII/43a/524.

Description. For detailed description see Mai (2000a).

Remarks. This drupe clearly represents *Prunus* considering its general shape and presence of partially exposed vascular bundle canal. In respect of shape, size (7.5 × 6.5 mm), morphology (including smooth surface and lack of clear ventral swollen suture) and thickness of the wall (0.8–1.2 mm), the closest is *P. leporimontana* from the Miocene of Germany and Poland (Mai, 2000a).

Prunus langsdorfii Kirchheimer 1936

Fig. 7J1, 7J2

Materials. Unpublished: 2 specimens, MZ VII/43a/458, 835.

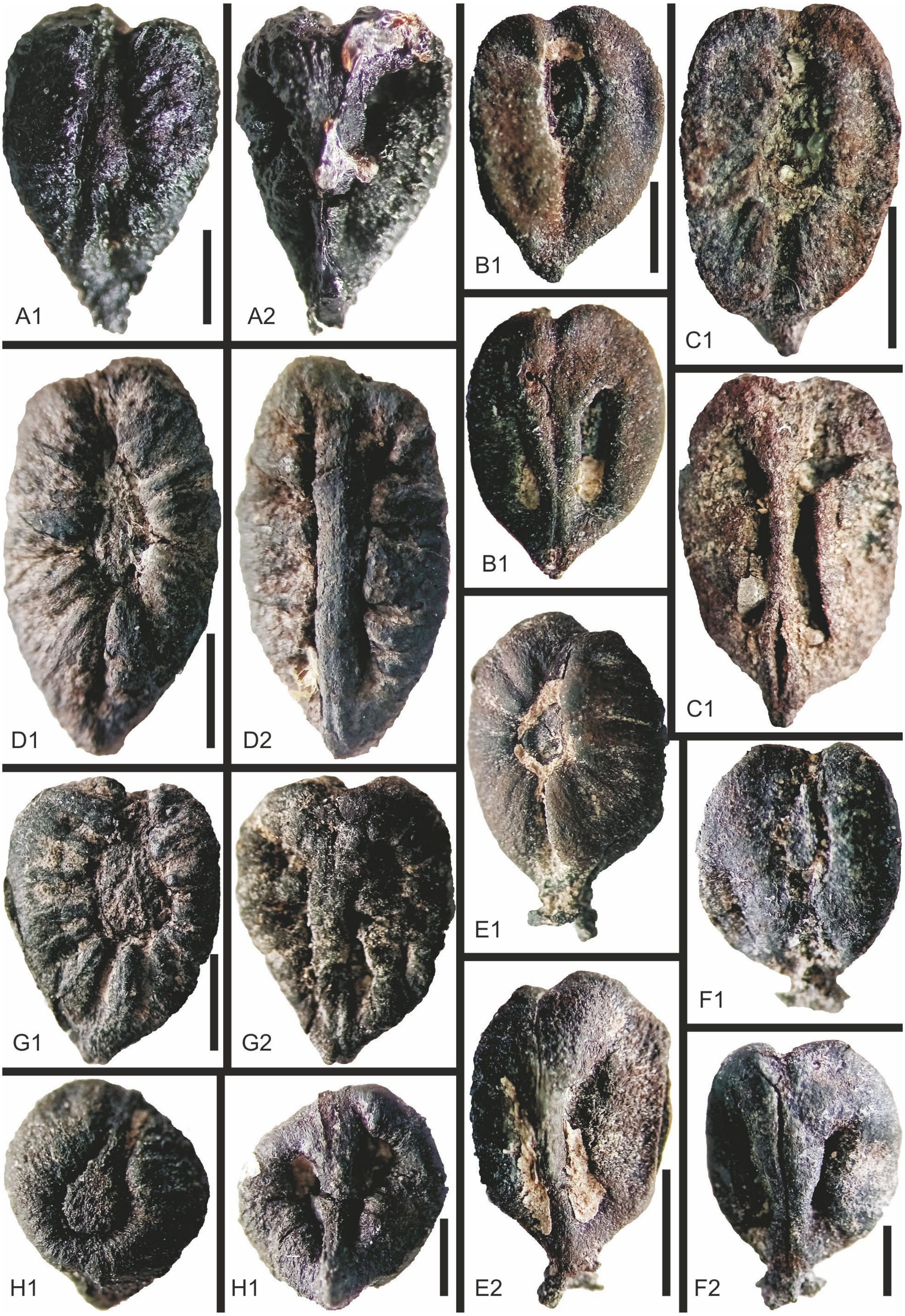

Figure 6. Carpological fossils from the Turów Mine. **A1**, **A2**. *Ampelopsis malvaeformis* (Schlotheim) Mai: seed, MZ VII/43a/145; **B1**, **B2**. *Vitis teutonica* A. Braun: seed, MZ VII/43a/148; **C1**, **C2**. *Vitis palaeomuscadinia* Mai: seed, MZ VII/43a/893; **D1**, **D2**. *Ampelocissus chandleri* (Kirchheimer) Chen et Manchester: seed, MZ VII/43a/143; **E1**, **E2**. *Vitis lusatica* Czeczott et Skirgiełło: seed, MZ VII/43a/147; **F1**, **F2**. *Vitis* aff. *parasilvestris* Kirchheimer: seed, MZ VII/43a/150; **G1**, **G2**. *Ampelocissus lobatum* (Chandler) Chen et Manchester: seed, MZ VII/43a/143; **H1**, **H2**. *Vitis globosa* Mai: seed, MZ VII/43a/149. Scale bars: A, B, F, H = 1 mm; C–E, G = 2 mm

Description. For detailed description see Kirchheimer (1957) and Mai (1984a).

Remarks. Shape, size (13–15 mm long), smooth surface and lack of clear ventral swollen suture, thick wall (up to 2 mm) relate these endocarps with *Prunus langsdorfii* (see Mai, 1984a).

Rubus laticostatus
Kirchheimer 1942

Fig. 4P

1980 *Rubus* cf. *laticostatus* C. et E.M. Reid; Czeczott and Skirgiełło, p. 14, pl. 2, figs 18–20.

Materials. Published: 4 specimens, MZ VII/43a/100 (old number 516); unpublished: 6 specimens, MZ VII/43a/599, 783; new: 15 specimens, MZ VII/158/104, 231.

Description. For detailed description see Mai (1997).

Rubus semirotundatus
Łańcucka-Środoniowa 1979

Fig. 5R

Materials. Unpublished: 3 specimens, MZ VII/43a/911; new: 13 specimens, MZ VII/158/331.

Description. For detailed description see Łańcucka-Środoniowa (1979) and Mai (1997).

RHAMNACEAE
Jussieu 1789

Zizyphus striatus
(Ludwig) Mai et Gregor 1982

Fig. 7C, 7D

Materials. Unpublished: 32 endocarps, MZ VII/43a/382, 454, 570, 579, 587, 601, 629, 676, 683, 687, 694, 729, 832, 868, 878.

Description. For detailed description see Mai (1997).

Paliurus favonii Unger 1847

Fig. 5M, 5N

Materials. Unpublished: 14 endocarps, MZ VII/43a/555.

Description. For detailed description see Mai (2000a).

Frangula solitaria Gregor 1977

Fig. 7H

Materials. New: 15 drupes, MZ VII/158/72, 192, 351.

Description. For detailed description see Gregor (1977) and Mai (2000a).

CANNABACEAE Martinov 1820

Gironniera carinata Mai 1970

Fig. 7K

Materials. New: 3 endocarps, MZ VII/158/119, 223.

Description. For detailed description see Mai (1970).

Gironniera neglecta
Mai (nomen invalidum)
sensu Knobloch et Mai 1986

Fig. 7F

Materials. Unpublished: 95 endocarps, MZ VII/43a/322, 333, 352, 361, 419, 460, 497, 499, 504, 508, 510, 515, 530, 578, 585, 618, 635, 644, 657, 679, 701, 709, 712, 736, 757, 774, 866, 875, 877, 887, 890, 904, 927, 945; new: 6 endocarps, MZ VII/158/85, 200, 274.

Description. For detailed description see Knobloch and Mai (1986), Meller et al. (1999) and Czaja (2003).

Gironniera verrucata
Mai in Mai et Gregor 1982

Fig. 7O

Materials. New: 8 endocarps, MZ VII/158/17, 222.

Description. For detailed description see Mai and Gregor (1982) and Meller et al. (1999).

Trema lusatica Mai 1964

Fig. 7I

Materials. Unpublished: 14 endocarps, MZ VII/43a/614, 650, 769, 786, 871, 884, 939; new: 149 endocarps, MZ VII/158/3, 221, 275.

Description. For detailed description see Mai (1964).

MORACEAE
Gaudichaud 1835

Ficus lucida Chandler 1962

Fig. 7L

Materials. New: 6 specimens, MZ VII/158/22.

Description. For detailed description see Chandler (1962).

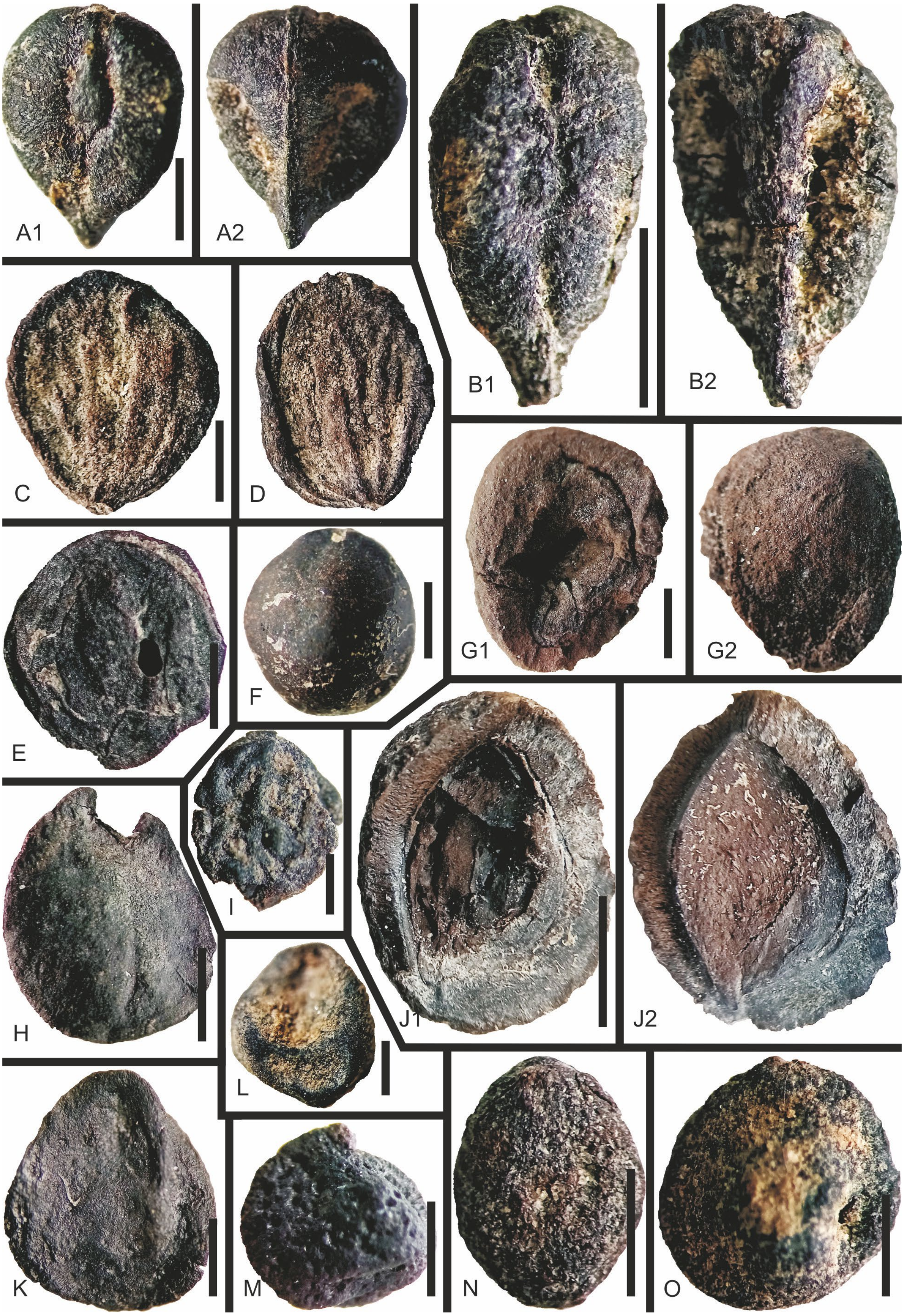

Figure 7. Carpological fossils from the Turów Mine. **A1**, **A2**. *Ampelopsis rotundata* Chandler: seed, MZ VII/43a/894; **B1**, **B2**. *Parthenocissus britannica* (Heer) Chandler: seed, MZ VII/43a/831; **C**, **D**. *Zizyphus striatus* (Ludwig) Mai: endocarps, MZ VII/43a/832; **E**. *Rhamnospermum bilobatum* Chandler: seed, MZ VII/43a/909; **F**. *Gironniera neglecta* Mai: endocarp, MZ VII/43a/497; **G1**, **G2**. *Prunus leporimontana* Mai: endocarp, MZ VII/43a/524; **H**. *Frangula solitaria* Gregor: drupe, MZ VII158/72; **I**. *Trema lusatica* Mai: endocarp, MZ VII/43a/650; **J1**, **J2**. *Prunus langsdorfii* Kirchheimer: endocarp, MZ VII/43a/458; **K**. *Gironniera carinata* Mai: endocarp, MZ VII/158/119; **L**. *Ficus lucida* Chandler: achene, MZ VII158/22; **M**. *Broussonetia* aff. *rugosa* Chandler: achene, MZ VII158/115; **N**. *Myrica* aff. *ceriferiformis* Kownas: endocarp, MZ VII/43a/950; **O**. *Gironniera verrucata* Mai: endocarp, MZ VII158/17. Scale bars: B, C, D, F, G, H = 2 mm; J = 5 mm; I, L = 0.5 mm; A, E, K, M, N, O = 1 mm

Remarks. Considering relatively large size (1.2–1.8 mm diameter), small apical projection and very thin achene wall, these fossils seem to be the closest to *Ficus lucida*. Presence of this species in Turów is surprising, because so far it has been reported in older floras (see Mai and Walther, 1991).

Broussonetia aff. ***rugosa***
Chandler 1925

Fig. 7M

Materials. Unpublished: 6 specimens, MZ VII/158/115.

Description. Achenes are broadly ovoid, flattened, 1.8 mm in length, with small funicular plug on a side of short apical projection. Surface covered with small pits, but without tubercles.

Remarks. Most observed features relate these achenes with *Broussonetia*, and among fossil representatives of this genus *B. rugosa* seems to be the closest (see Chandler, 1925; Mai and Walther, 1985). However, our specimens are problematic, because unlike *B. rugosa* they have only pits without tubercles on the surface. It is likely that tubercles as a part of thin outer layer may be abraded, but it may be as well a new taxon.

FAGACEAE
Dumortier 1829

Quercus sapperi
(Menzel) Mai ex Gregor 1982

Fig. 8A, 8D

Materials. Unpublished: 20 specimens, MZ VII/43a/425, 543, 764, 864.

Description. For detailed description see Gregor (1982) and Hummel (1983).

Remarks. Fruits and characteristic cupules of this species are quite common among materials collected by Czeczott and her team, but most cupules found in Turów are preserved as imprints in a white clay. In many sites of Central Europe fruits of *Q. sapperi* are accompanied by leaves of *Quercus rhenana* which according to Holý et al. (2012) suggest these organs represent one species (*Q. rhenana* plexus species). Cuticules of the *Quercus rhenana* (Kräusel et Weyland) E. Knobloch et Kvaček 1976 (= "*Quercus*" *lusatica* Jähnichen 1966) were also documented in Turów (Juchniewicz, 1975). Merging these species was previously suggested by Jähnichen (1966), however, according to Mai (1999a), this view is incorrect. Certainly, the opinion of Jähnichen (1966) and Holý et al. (2012) is premature, as they point out fruits and leaves have never been found in physical connection. It is also worth mentioning that in some sites (Ruszów – Hummel, 1983) *Q. rhenana* is missing, while *Q. sapperi* cupules occur in massive quantities along with leaves of *Q. gigas* Göppert emend. Walther et Zastawniak 1991 (=*Q. czeczottiae* Hummel 1983, *Q. pontica miocenica* Kubát 1955). Both are considered representatives of the *Cerris* group (Hummel, 1983; Barrón et al., 2017), however, *Q. rhenana* was probably related to evergreen oaks of the section *Lobatae* (Kvaček and Walther, 1989). In view of the above, we consider *Q. sapperi* and *Q. rhenana* separate species. *Quercus sapperi* has been reported from Zittau Basin (Hatrau-Tongrube – Mai, 1999a).

Trigonobalanopsis exacantha
(Mai) Kvaček et Walther 1988

Fig. 8B

Materials. Published: 121 cupules, MZ VII/43a/23–25, 126; Unpublished: 432 cupules, MZ VII/43a/324, 343, 357, 363, 372, 390, 395, 406, 416, 463, 466, 467, 492, 507, 509, 525, 526, 545, 552, 563, 567, 596, 616, 631, 646, 654, 682, 697, 706, 731, 749, 756, 836, 881; new: 610 cupules and nuts, MZ VII/158/37, 55, 141, 180, 182, 187, 227, 233, 249, 284, 292, 304, 317.

Description. For detailed description see Kvaček and Walther (1988, 1989).

Remarks. Inventory numbers published by Baranowska-Zarzycka (2001) are wrong (MZ VII/43a/261–263.

MYRICACEAE Richard ex Kunth 1817

Morella stoppii
(Kirchheimer) Kowalski 2024

Fig. 8C1, 8C2

Materials. Unpublished: 1 specimen, MZ VII/43a/808. new: 1 specimen, MZ VII/158/259.

Description. For detailed description see Kirchheimer (1957) and Mai (1999b).

Figure 8. Carpological fossils from the Turów Mine. **A**, **D**. *Quercus sapperi* (Menzel) Mai: cupule and nut, MZ VII/43a/764; **B**. *Trigonobalanopsis exacantha* (Mai) Kvaček et Walther: cupule, MZ VII/43a/25; **C1**, **C2**. *Morella stoppii* (Kirchheimer) Kowalski: endocarp, MZ VII/43a/808; **E**, **F**. *Carya ventricosa* (Sternb.) Unger: nuts, MZ VII/43a/50; **G**, **H**. *Myrica boveyana* Chandler: endocarps, MZ VII/43a/873; **I1**, **I2**, **M**. *Carya globosa* (Ludwig) Mädler: nuts, MZ VII/43a/39, 68; **J1**, **J2**. *Juglans bergomensis* (Balsamo Crivelli) Massalongo: nut, MZ VII/43a/63; **K**, **L**. *Pterocarya limburgensis* C. et E.M. Reid: nuts, MZ VII/43a/76, 869; **N**. *Carya globosa* (Ludwig) Mädler: nut, MZ VII/43a/41; **O**. *Palaeocarya macroptera* (Brongniart) Jähnichen, Friedrich et Takáč: nut, MZ VII/158/117; **P1–P3**. *Cyclocarya cyclocarpa* (Schlechtendal) Iljinskaja: nut, MZ VII/43a/71. Scale bars: D, E, F, I, M, J, N = 10 mm; A, B, C = 5 mm; G, H, K, L, O, P = 1 mm

Myrica boveyana Chandler 1957

Fig. 8G, 8H

Materials. Unpublished: 20 specimens, MZ VII/43a/726, 873, 912.

Description. For detailed description see Chandler (1957) and Mai (1999b).

Remarks. These are typical *Myrica* endocarps, which in respect of size (3–4 mm long), morphology (uneven surface, irregular shape) and lack of remains of exocarp correspond the most with *M. boveyana*.

Myrica aff. ***ceriferiformis*** Kownas 1955

Fig. 7N

Materials. Unpublished: 26 specimens, MZ VII/43a/558, 559, 948, 950.

Description. For detailed description see Mai (1999b).

Remarks. These endocarps in respect of symmetric shape, even surface, relatively thin walls and remains of sparsely spaced remains of verrucae match *M. ceriferiformis*, except for general shape, which is elliptic, while in type materials (Kownas, 1956) it is circular in outline.

JUGLANDACEAE DC. ex Perleb 1818

Juglans aff. ***bergomensis*** (Balsamo Crivelli) Massalongo 1852

Fig. 8J1, 8J2

1961 *Juglans berckhemeri* Kirchheimer; Czeczott and Skirgiełło, p. 106–107, pl. 18, figs 1–4

Materials. Published: 1 specimen, MZ VII/43a/62 (old number 41); unpublished: 1 specimen, MZ VII/43a/63.

Description. For detailed description see van der Ham (2015).

Remarks. Specimen (MZ VII/43a/63, Fig. 8J) is unusual, because unlike in typical *J. bergomensis* there are no clear longitudinal ridges, instead structures on the surface seem to be connected resembling honeycombs. There is also no clear pointed apex. The locule is clenched.

Carya globosa (Ludwig) Mädler 1939

Fig. 8I1, 8I2, 8M, 8N

1961 *Carya hauffei* Kirchheimer; Czeczott and Skirgiełło, p. 109, 110, pl. 19, figs 8–12.

1961 *Juglans globosa* Ludwig; Czeczott and Skirgiełło, p. 107, 108, pl. 16, figs 19, 20, pl. 17, figs 1–11.

1961 *Carya* sp. 1; Czeczott and Skirgiełło, p. 112, pl. 20, figs 4–7.

1961 *Carya* sp. 2; Czeczott and Skirgiełło, p. 113, pl. 20, fig. 1.

1961 *Carya turovensis* Czeczott and Skirgiełło, p. 111, pl. 20, figs 8–11.

1961 *Carya bohemica* Brabenec; Czeczott and Skirgiełło, p. 60–62, pl. 18, figs 7–11.

1961 *Carya lusatica* Czeczott and Skirgiełło, p. 110, pl. 19, figs 1–7.

Materials. Published: 93 specimens, MZ VII/43a/64, 65, 26–29, 35–37, 41, 42, 46, 47, 53, 58, 59 (old numbers: 66, 137, 40, 25, 63, 267, 191, 252, 260, 265, 266, 2, 88, 268, 36, 366); unpublished: 55 specimens, MZ VII/43a/30–34, 38–40, 43–45, 48, 54–57, 60, 61, 66–69.

Description. Nuts in outline circular to elliptical; 17–33 mm long and 9–27 mm wide; nutshell exterior surface variable, delicately longitudinally wrinkled, folded to ribbed (the highest 4 ribs corresponds with lines of husk dehiscence), also all these morphological structures may occur together; nutshell 1–2.5 mm thick; 4 broad and shallow to prominent internal longitudinal ribs; lacunae present; secondary septum present.

Remarks. According to Czaja (2003) *Carya bohemica* described by Brabenec (1904) from the Lower Miocene of Holedeč is probably a synonym of *C. ventricosa* (Sternberg) Unger 1861 (Fig. 8E, 8F), and also nuts from Lusatia assigned to *C. bohemica* (Czeczott and Skirgiełło, 1961; Mai, 1964, 1999b) should be included to *Carya hauffei*. Previously these species were separated by Mai (1981) based on apex shape and nut wall thickness (apiculate apex and thin wall – *C. bohemica*; blunt apex and thicker wall – *C. hauffei*). However, wide variability of external morphology and apex shape observed among nuts of these types from Turów seems to confirm opinion by Czaja (2003). Moreover, in the opinion of Manchester (1987), *C. hauffei* should be synonymized with *C. globosa*. These species were separated by Mai (1981) mainly based on presence (*C. globosa*) or absence (*C. hauffei*) of lacunae, which, however, appear to be an ineffective diagnostic feature, because apparently they can occur in both species (Czeczott and Skirgiełło, 1961; Mai, 1981). We agree with the opinion by Mai (1999b) and Czaja (2003) about similarity in external morphology between *C. turovensis* (see Fig. 8N; Czeczott and Skirgiełło, 1961:

pl. 19, figs 4, 5) and *C. lusatica* (see Czeczott and Skirgiełło, 1961: pl. 20, fig. 8), and what is more we believe that in this respect the first mentioned species certainly corresponds with nuts assigned by Czeczott and Skirgiełło to *C. hauffei* (Fig. 8I1, 8I2, 8M), while the second to those assigned by these authors to *C. globosa* and *C. bohemica*. As a consequence, all four mentioned species from Turów most likely represent one, morphologically diverse (including also abrasion and preservation states) *C. globosa* (see also Manchester, 1987).

Carya ventricosa
(Sternberg) Unger 1861

Fig. 8E, 8F

1961 *Carya ventricosa* (Sternberg) Unger; Czeczott and Skirgiełło, p. 111, 112, pl. 20, figs 12–14.

1961 *Carya bohemica* Brabenec; Czeczott and Skirgiełło, p. 108, 109, pl. 18, figs 5, 6, 12.

Materials. Published: 19 specimens, MZ VII/43a/49–51 (old numbers: 4, 37, 365); unpublished: 2 specimens, MZ VII/43a/52, 947; new materials: 249 specimens, MZ VII/158/4, 47, 62, 146, 219

Description. For detailed description of this species based on the type material see Deng et al. (2024).

Remarks. Among the *Carya* nuts collected by Czezott, this species is present but less common than *C. globosa*. In more recent collecting, only *C. ventrocosa* was found.

Cyclocarya cyclocarpa
(Schltdl.) Iljinskaja 1953

Fig. 8P1–8P3

1961 *Pterocarya cyclocarpa* Schlecht.; Czeczott and Skirgiełło, p. 103, 104, pl. 16, fig. 7.

Materials. Published: 1 specimen, MZ VII/43a/71 (old number 230); unpublished: 10 specimens, MZ VII/43a/584, 674, 778, 785, 813, 842, 844, 905; new materials: 9 specimens, MZ VII/158/206, 251.

Description. For detailed description of this nut see Mai (1999b).

Pterocarya limburgensis
C. Reid et E. Reid 1915

Fig. 8K, 8L

1961 *Pterocarya* cf. *stenoptera* DC.; Czeczott and Skirgiełło, p. 54–56, pl. 16, figs 1–6.

1961 *Pterocarya* cf. *rhoifolia* Sieb. et Zucc.; Czeczott and Skirgiełło, p. 53, 54, pl. 16, figs 9, 10, 12–18.

1961 *Pterocarya* cf. *insignis* Rehd. et Wils.; Czeczott and Skirgiełło, p. 56, 57, pl. 16, fig. 11.

Materials. Published: 136 specimens, MZ VII/43a/72–76; unpublished: 159 specimens, MZ VII/43a/323, 328, 332, 344, 348, 358, 420, 451, 482, 483, 491, 541, 542, 566, 580–583, 624, 627, 675, 686, 688, 693, 698, 710, 716, 744, 750, 755, 777, 848, 867, 869, 880, 886, 895; new materials: 1208 specimens, MZ VII/158/21, 26, 60, 183, 192, 237, 247, 282, 297, 303, 321, 330, 339.

Description. For detailed description see Mai (1999b, c).

Remarks. According to Mai (1999c), all specimens from Turów described as *P.* cf. *rhoifolia* represents *P. miolusatica* Mai 1999c, however, his statement was not supported by evidence. Mai seems to rely only on identification given by Czeczott and Skirgiełło (1961). All these authors discuss external morphology (shape of nut and sculpture), but never refer to the structure of secondary septa in the fossil nuts, which is crucial for identification of living *P. rhoifolia* Siebold et Zuccarini 1845 and fossil *P. miolusatica* (see also Mai, 1999c). In our opinion, the shape of the nut is highly variable and the sculpture difficult to objectively assess.

Among all examined nuts from Turów (including identified and found among unpublished materials) there were only a few specimens that enable observation of the internal structures, however, none of them (even among *P.* cf. *rhoifolia*) possesses horns on secondary septa which is typical for the *Platyptera* section and fossil *P. miolusatica* (see Mai, 1999c). Moreover, among specimens indicated by Czeczott and Skirgiełło (1961) as *Pterocarya* cf. *rhoifolia* many were considered morphologically typical for *P. limburgensis* (short style base, ribs in upper part of the nut exceeding style base – Mai, 1999c). In our opinion, all these indicate that without knowing the structure of secondary septa, distinguishing between *P. miolusatica* and *P. limburgensis* is problematic, which agrees with the view of Gregor (1978b). Therefore, we consider the presence of *P. miolusatica* in the Turów flora doubtful and we provisionally include all *Pterocarya* nuts (including *P.* cf. *insignis* Rehder et Wilson 1916 and *P.* cf. *stenoptera* DC. 1862) in *P. limburgensis*.

Palaeocarya macroptera (Brongniart) Jähnichen, Friedrich et Takáč 1984

Fig. 8O

Materials. New: 3 specimens, MZ VII/158/117, 207.

Description. For detailed description see Jähnichen et al. (1977, 1984).

Remarks. Despite poor preservation these nutlets can be safely assigned to Engelhardieae. This is evidenced by an outline of hook-like secondary septa marked on the surface of a thin wall and remains of a basal scar. There seems to be no consensus about classification of this fossil type among European palaeobotanists. *Engelhardia macroptera* (Brongniart) Unger reflects the traditional concept of the genus (e.g. Mai, 1999b; Czaja, 2003; Macaluso et al., 2018). We, however, followed argumentation by Manchester (1987).

BETULACEAE Gray 1821

Alnus sp.

Fig. 9R

Materials. New: 48 specimens, MZ VII/158/39, 56, 141, 190, 226, 238, 280, 320, 343.

Remarks. These fossil remains clearly represent infruitescence axes of *Alnus*, however, species cannot be determined due to preservation state.

Carpinus sp.

Fig. 9A

Materials. New: 61 specimens, MZ VII/158/71, 129, 196, 239, 323, 341.

Remarks. There is no doubt about generic affinity of these fossils, however, identification of species is problematic due to preservation state.

Ostrya scholtzii Gregor 1982

Fig. 9B

Materials. Unpublished: 2 specimens, MZ VII/43a/.

Description. For detailed description see Gregor (1982).

LYTHRACEAE J. Saint-Hilaire 1805

Microdiptera uralensis (Dorofeev) Mai 1987

Fig. 9I

Materials. Unpublished: 1 specimen, MZ VII/43a/772.

Description. For detailed description see Mai (1987).

Remarks. Considering small size (1.2 mm long), narrow trapezoid shape and germination valve that reaches ½ the length of the seed we believe this fossil best match *Microdiptera uralensis.*

STAPHYLEACEAE Martinov 1820

Turpinia ettingshausenii (Engelhardt) Mai 1964

Fig. 9C1, 9C2, 9G

Materials. Published: 1093 specimens, MZ VII/43a/104–123 (old numbers: 71, 293, 276, 246, 320, 321, 323, 345, 361, 371, 379, 402, 408, 426, 442, 504, 506, 508, 510, 815); Unpublished: 189 specimens, MZ VII/43a/331, 351, 380, 388, 459, 461, 462, 474, 479, 480, 488, 506, 516–519, 537, 549, 554, 576, 626, 641, 666, 700, 708, 711, 740, 753, 759, 776, 903, 924, 935, 951; new: 163 specimens, MZ VII/158/9, 24, 50, 148, 197, 236, 262, 278, 287, 305, 318.

Description. For detailed description see Mai (1964).

ANACARDIACEAE R.Br. 1818

Choerospondias turovensis Kowalski 2010

Fig. 9P

Materials. Published: 8 specimens, MZ VII/43a/311–318.

Description. For detailed description see Kowalski (2010).

SAPINDACEAE Jussieu 1789

Acer sp. 1

Fig. 9N

Materials. New: 2 specimens, MZ VII/158/75.

Remarks. These large (8 mm high and 6 mm long), flat, thin walled, wingless fruits clearly represent *Acer*, however, their specific

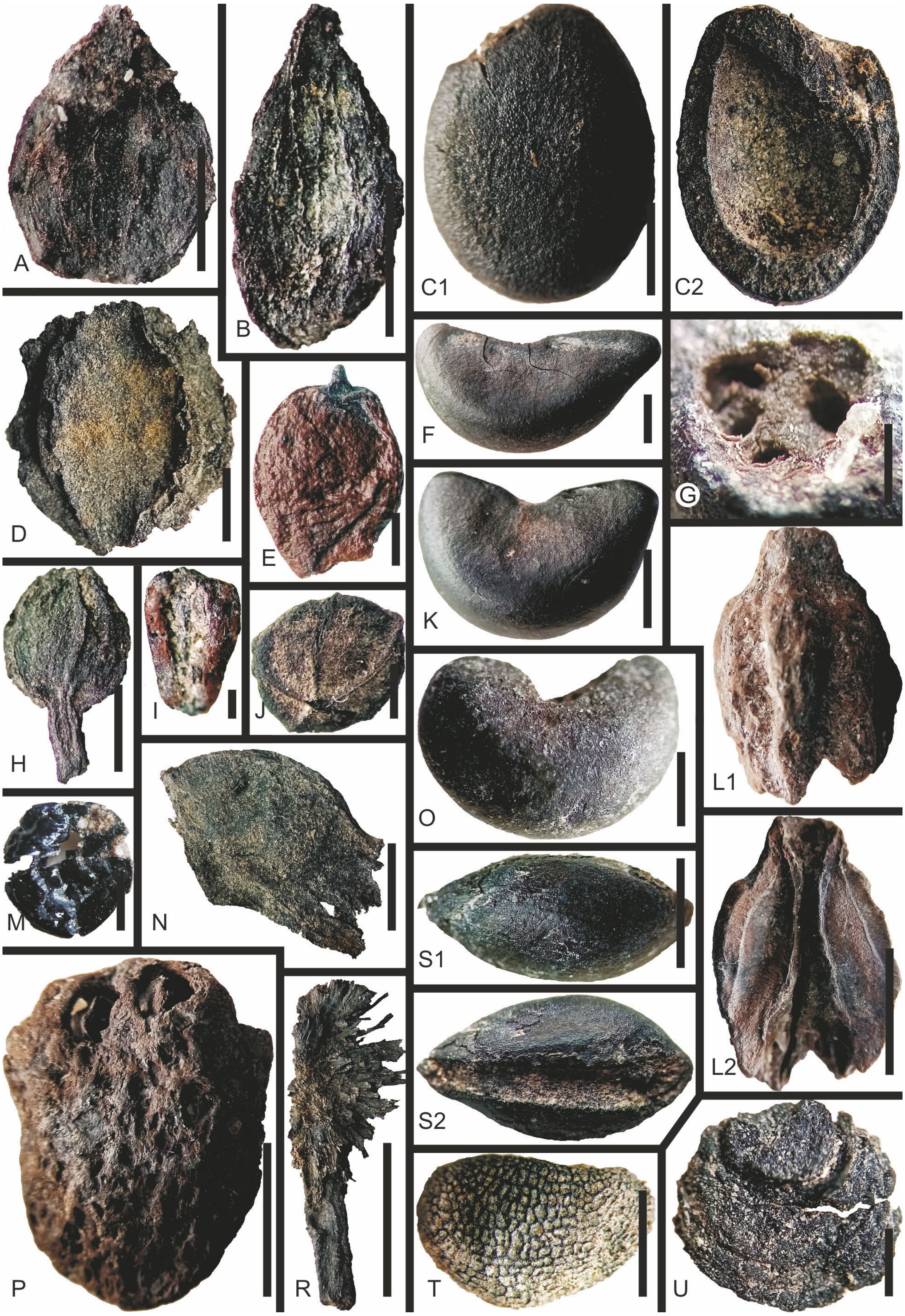

Figure 9. Carpological fossils from the Turów Mine. **A**. *Carpinus* sp.: fruit, MZ VII158/71; **B**. *Ostrya scholtzii* Gregor: fruit, MZ VII158/81; **C1**, **C2**. *Turpinia ettinghausenii* (Engelh.) Mai: seed, MZ VII/43a/109; **D**. *Craigia bronnii* (Unger) Kvaček, Bůžek et Manchester: fruit, MZ VII/158/125; **E**. *Viscum morlotii* (Unger) E. Knobloch et Kvaček: fruit, MZ VII/43a/633; **F**. *Zanthoxylum turovense* (Czeczott et Skirgiełło) Kowalski: seed, MZ VII/43a/132; **G**. *Turpinia ettinghausenii* (Engelh.) Mai: seed, MZ VII/43a/109; **H**, **J**. *Craigia bronnii* (Unger) Kvaček, Bůžek et Manchester: flower buds, MZ VII/43a/823; **I**. *Microdiptera uralensis* (Dorofeev) Mai: seed, MZ VII/43a/772; **K**. *Zanthoxylum naviculaeformis* (E.M. Reid) Kowalski: seed, MZ VII/43a/138; **L1**, **L2**. *Melia czeczottii* Gregor: endocarp, MZ VII/43a/140; **M**. *Moehringia miocaenica* Mai: seed, MZ VII158/78; **N**. *Acer* sp. 1: nutlet, MZ VII/158/75; **O**. *Zanthoxylum maii* (Gregor) Kowalski: seed, MZ VII/43a/130; **P**. *Choerospondias turovensis* Kowalski: endocarp, MZ VII/43a/315; **R**. *Alnus* sp.: infruitescence, MZ VII/158/141; **S1**, **S2**. *Zanthoxylum tiffnei* Gregor: seed, MZ VII/43a/906; **T**. *Phellodendron lusaticum* Kirchheimer: seed, MZ VII158/6; **U**. *Cleome probstii* Gregor: seed, MZ VII158/130. Scale bars: A – D, F, H, K, S, T = 2 mm; L, P = 5 mm; E, G, J, O, U = 1 mm; N = 4 mm; I, M = 0.25 mm; R = 10 mm

affinity is difficult to determine. Despite the significant contribution made by Mai (1983, 1984b, 1999c) to the understanding of living and fossil maple fruits, identifying species is still problematic in many cases and many authors indicate this problem (see Walther and Kvaček, 2007).

Acer sp. 2

Fig. 10P

Materials. Unpublished: 2 specimens, MZ VII/158/132.

Remarks. These endocarps are relatively poorly preserved. In respect of size (3.2 × 2.5 mm), thin walls and longitudinal ribs on sides, these endocarps resemble, to some degree, *A. hercynicum*, however, differ from the mentioned species in that they are distorted half-elliptic instead of distorted oval in shape and have straight ventral side instead of s-shaped.

Acer aff. ***hercynicum***
Mai in Mai et Walther 1978

Fig. 10W

Materials. Unpublished: 1 specimen, MZ VII/158/120.

Description. For detailed description see Mai and Walther (1978).

Remarks. In respect of size (4 mm high and 2 mm long), shape (distorted oval in outline, elliptic in cross-section) and longitudinal ribs on sides, this endocarp resembles *Acer hercynicum*, differs, however, in that it has convex instead of s-shaped ventral side. Considering some differences and problems mentioned above (see remarks to *Acer* sp. 1), specific identification of this fossil is uncertain.

MELIACEAE Jussieu 1789

Melia czeczottii Gregor 1978b

Fig. 9L1, 9L2

Materials. Published: 20 specimens, MZ VII/43a/139–141; unpublished: 1 specimen, MZ VII/43a/791; new: 6 specimens, MZ VII/158/29, 53, 178, 242, 279.

Description. For detailed description see Czeczott and Skirgiełło (1967) and Gregor (1978b).

RUTACEAE Jussieu 1789

Phellodendron lusaticum
Kirchheimer 1940

Fig. 9T

Materials. New: 6 specimens, MZ VII/158/6, 135, 252.

Description. For detailed description see Kirchheimer (1957).

Remarks. These seeds are relatively large (4.5–4.8 mm long) for *P. lusaticum* (Kirchheimer, 1957, but see Mai, 2000a), but have strong ornamentation and thick seed coat (~0.2 mm) which undoubtedly match this species.

Zanthoxylum maii
(Gregor) Kowalski **comb. nov.**

Fig. 9O

Basionym.

1975 *Toddalia maii* Gregor, Cour. Forsch. – Inst. Senckenberg, p. 125, text-fig. 5.

Synonyms.

1980 *Toddalia maii* Gregor; Czeczott and Skirgiełło, p. 14, Pl. 2, figs 21–26.

Materials. Published: 6 specimens, MZ VII/43a/129–131 (old numbers: 498, 500, 503); unpublished: 2 specimens, MZ VII/43a/341.

Description. For detailed description see Gregor (1978a).

Remarks. Justification for new combination see remarks for *Zanthoxylum turovensis.*

Zanthoxylum naviculaeforme
(E.M. Reid) Kowalski **comb. nov.**

Fig. 9K

Basionym.

1923 *Martya naviculaeformis* E.M. Reid; Bull. Soci. Géol. de France, p. 327–331, fig. 5a.

Synonyms.

1978a *Toddalia naviculaeformis* (E.M. Reid) Gregor; p. 27–29, pl. 5, figs 5–7, pl. 6, fig. 1.

Materials. Published: 3 specimens, MZ VII/43a/138 (old number 496).

Description. For detailed description see Gregor (1978a).

Remarks. For justification for the new combination see remarks for *Zanthoxylum turovensis.*

Zanthoxylum turovense (Czeczott et Skirgiełło) Kowalski **comb. nov.**

Fig. 9F

Basionym.

1975 *Sapoticarpum turovense* Czeczott et Skirgiełło; Prace Muz. Ziemi, p. 44, 45, pl. 11, figs 1–14.

Synonyms.

1978a *Toddalia turovensis* (Czeczott et Skirgiełło) Gregor; p. 29, 30, pl. 6, figs 2–4.

Holotype. Czeczott and Skirgiełło (1975: pl. 11, figs 1–3; old number 68) designated three syntypes instead of holotype. Among them we selected one as lectotype (Fig. 9F; Czeczott and Skirgiełło, 1975: pl. 11, fig. 2), MZ VII/43a/132, remaining two specimens are designated here as isotypes.

Materials. Published: 11 specimens, MZ VII/43a/132–137 (old numbers: 22, 68, 104, 105, 348, 360, 385); unpublished: 7 specimens, MZ VII/43a/340, 465.

Description. For detailed description see Czeczott and Skirgiełło (1975) and Gregor (1978a).

Remarks. According to the new classification proposed by Appelhans et al. (2018) *Toddalia* Juss. is included in *Zanthoxylum*. Therefore, we introduce a new combination for all species found in Turów.

Zanthoxylum tiffnei Gregor 1978a

Fig. 9S1, 9S2

1980 *Sarcococca weylandii* Mai; Czeczott and Skirgiełło, p. 15, pl. 3, figs 7, 8.

Materials. Published: 4 specimens, MZ VII/43a/906 (old number: 396).

Description. For detailed description see Gregor (1978a).

Remarks. See also remarks on *Sarcococca*.

MALVACEAE Jussieu 1789

Craigia bronnii (Unger) Z. Kvaček, Bůžek et Manchester 1991

Fig. 9D, 9H, 9J

?1967 *Quisqualis pentaptera* Mai; Czeczott and Skirgiełło, p. 156, 157, pl. 8, figs 6, 7.

Materials. Published: 1 fruit, MZ VII/43a/102 (old number: 430); unpublished: 2 fruits, MZ VII/43a/630, 742, MZ VII/40/1271, 11 flower buds, MZ VII/43a/780, 823–826, 885; new: 2 fruits, MZ VII/158/125, 12 flower buds, MZ VII/158/83, 86, 131, 216.

Description. For detailed description see Kvaček et al. (2002).

Remarks. Based on an extracted capsule (Pl. 9D) and imprint of a capsule with partially preserved wings found in a collection of imprints from Turów (MZ VII/40/1271) presence of *Craigia bronnii* in Turów is certain. We allow the possibility that remains of *Quisqualis pentaptera* Mai described by Czeczott and Skirgiełło (1967) represent young fruit of *Craigia*. This seems probable considering similarity between these taxa and the fact they occur in the same locality. We must note, however, that according to Kvaček et al. (2002) the relationship between these fruits suggested above is equivocal.

Flower buds found among old and new materials in respect of general shape and size correspond with *Burretia* Mai (Mai, 1961, 2000a). According to Kvaček et al. (2002) flower buds of this type may come from *C. bronnii* and we followed this suggestion here. There are two types of flower buds among our materials, larger more elongated (in type of *B. instructa* (R. Potonie) Mai 1961) and smaller circular in outline (in type of *B. insculpta* Mai et Walther 1991). However, according to Kvaček et al. (2002), criteria used by Mai (1961) to separate these two species are doubtful.

CLEOMACEAE Horaninow 1834

Cleome probstii Gregor 1982

Fig. 9U

Materials. New: 2 specimens, MZ VII/158/130, 228.

Description. For detailed description see Gregor (1982).

SANTALACEAE R. Br. 1810

Viscum morlotii (Unger) E. Knobloch et Kvaček 1976

Fig. 9E

1961 *Viscum lusaticum* Czeczott, p. 113–116, pl. 22, figs 3–7, pl. 23, figs 1–5, text-figs 12g-h.

Materials. Published: 8 specimens, MZ VII/44/225, 234, 429–433 (old numbers: 153, 172, 442–446); unpublished: 1 specimen, MZ VII/43a/633.

Description. For detailed description see Mai (1997).

Remarks. *V. lusaticum* was introduced by Czeczott (1961) for leaves and loose fruits based on materials from Turów. Mai (1997) used the name *V. miquelii* (Geyler and Kinkelin) Czeczott for fruits based on close resemblance in epidermis structure between leaves and fruits, considering *V. lusaticum* as a synonym. However, Knobloch and Kvaček (1976) and Holý et al. (2012) recognized *V. lusaticum* as a synonym of *Viscum morlotii*. Moreover, these authors suggest two species, narrow leaved *V. morlotii* related mostly with Miocene floras, and broad-leaved *V. miquelii* (Geyler and Kinkelin) Czeczott which prevail in the Pliocene (Holý et al., 2012). It remains unresolved whether there is any difference in fruit morphology between the two mentioned species.

CARYOPHYLLACEAE Jussieu 1789

Moehringia miocaenica
Mai in Mai et Walther 1991

Fig. 9M

Materials. New: 1 specimen, MZ VII/158/78.

Description. For detailed description see Mai and Walther (1991).

NYSSACEAE Jussieu ex Dumortier 1829

Mastixia lusatica Mai 1970

Fig. 10H, 10I, 10N

1975 *Mastixia amygdalaeformis* (Schlotheim) Kirchheimer; Czeczott and Skirgiełło, p. 49, 50, pl. 9, figs 2, 3.

Materials. Published: 920 specimens, MZ VII/43a/238–256 (old numbers: 26, 38, 39, 64, 94, 99, 245, 382, 405, 483–486, 904); unpublished: 69 specimens, MZ VII/43a/346, 366, 368, 379, 391, 396, 407, 410, 412, 436–439, 445, 456, 473, 487, 539, 548, 665, 746, 748, 758, 920; new: 267 specimens, MZ VII/158/1, 41, 57, 142, 145, 170, 189, 234, 285, 291, 306.

Description. For detailed description see Mai (1970).

Remarks. Based on criteria established by Mai (1970), endocarps from Turów longer than 21 mm should be identified as *M. lusatica*, while shorter than 15 mm as *M. amygdalaeformis* (Schlotheim) Kirchheimer 1957. Among 278 measured (published) materials, 87% endocarps represent *M. lusatica* and 13% are between *M. lusatica* and *M. amygdalaeformis* (length between 15 and 21 mm). We also examined the thickness of the endocarp's wall, which according to Mai (1970), is between 2 and 3.5 mm in *M. lusatica*, and between 1 and 1.8 mm in *M. amygdalaeformis*. Because of the destructiveness of measurements, we randomly selected and examined only 5 specimens. In four endocarps of the *M. lusatica* type, the wall was between 1.5 and 2 mm thick. Only one specimen was very small (16 mm long), close to *M. amygdalaeformis* type, but had a wall 2.2 mm thick. Despite the small sample, measurements suggest that thickness of the endocarp's wall may not be diagnostically useful. We suspect that it may depend on the preservation, the size of the endocarp and the degree of development of the locule.

Consequently, we assume that the whole Turów population represents *Mastixia lusatica*, but this assumption is based solely on the endocarp's length.

Diplopanax limnophilus
(Unger) Czaja 2003

Fig. 10E

1975 *Mastixicarpum lusaticum* (Kirchheimer) Mai; Czeczott and Skirgiełło, p. 51, 52, pl. 9, figs 6–18, pl. 10, fig. 3.

Materials. Published: 309 specimens, MZ VII/43a/257–284 (old numbers: 21, 43, 67, 97, 102, 138, 257, 259, 261, 298, 325, 341, 350, 381, 384, 387, 399, 406, 417, 465, 476, 482, 488, 489); unpublished: 118 specimens, MZ VII/43a/374, 377, 392, 397, 401, 402, 411, 413, 424, 426, 427, 429, 431, 432, 434, 435, 444, 470, 471, 475, 478, 481, 485, 489, 536, 540, 761, 762, 840; new: 1 specimen, MZ VII/158/27.

Description. For detailed description see Czaja (2003).

Eomastixia saxonica
(Menzel) Holý 1975

Fig. 10A–10D

1975 *Ganitrocera persicoides* (Unger) Kirchheimer; Czeczott and Skirgiełło, p. 52, 53, pl. 10, figs 4–15, pl. 11, figs 15–20.

Figure 10. Carpological fossils from the Turów Mine. **A–D**. *Eomastixia saxonica* (Menzel) Holy: endocarps, MZ VII/43a/259; **E**. *Diplopanax limnophilus* (Unger) Czaja: fruit, MZ VII/43a/158; **F**. *Nyssa ornithobroma* Unger: endocarp, MZ VII/43a/151; **G**, **R**. *Tectocarya elliptica* (Unger) Holy: endocarps, MZ VII/43a/303; **H**, **I**, **N**. *Mastixia lusatica* Mai: endocarps, MZ VII/43a/239, 246; **J**. *Nyssa disseminata* (Ludwig) Kirchheimer: endocarp, MZ VII/43a/529; **K**, **L**. *Retinomastixia oertelii* Gregor: endocarps, MZ VII/43a/287; **M**. *Symplocos casparyi* Ludwig: endocarp, MZ VII/43a/87; **O**, **U**. *Cornus gorbunovii* (Dorofeev) Negru: endocarps, MZ VII/43a/821, 889; **P**. *Acer* sp. 2: nutlet, MZ VII/158/132; **S**. *Cephalanthus pusillus* Friis: mericarp, MZ VII/43a/651; **T**. *Physalis pliocaenica* Szafer: seed, MZ VII158/107; **V**. *Eurya stigmosa* (Ludwig) Mai: seed, MZ VII/43a/850; **W**. *Acer* sp. 3: nutlet, MZ VII/158/120; **X**. *Ternstroemia sequoioides* (Engelhardt) Bůžek et Holý: seed, MZ VII/43a/728; **Y**. *Symplocos schereri* Kirchheimer: endocarp, MZ VII/43a/94. Scale bars: A–E, G, R = 10 mm; J, H, W, X = 2 mm; F, H, I, L, K, N, Y = 5 mm; T = 0.25 mm; O, U, P, V = 1 mm

Materials. Published: 1638 specimens, MZ VII/43a/153–237 (old numbers: 1, 7, 24, 29, 34, 35, 44, 45, 48, 65, 72, 84–86, 89, 90, 92, 96, 98, 120, 140, 186, 235, 244, 253, 254, 256, 258, 262, 277, 278, 285, 287, 294, 295, 315–317, 326, 335, 349, 353, 359, 368, 369, 372, 373, 378, 380, 385, 386, 391, 394, 397, 398, 410, 416, 420, 425, 440, 441, 445, 447, 454, 457–459, 469, 471, 474, 479, 492, 494, 495, 502, 504, 801, 803, 808, 812); unpublished: 154 specimens, MZ VII/43a/ 319, 373, 376, 386, 400, 409, 422, 423, 428, 430, 433, 472, 944; new: 6 specimens, MZ VII/158/175.

Description. For detailed description see Holý (1975).

Retinomastixia oertelii Gregor 1978b

Fig. 10K, 10L

1975 *Retinomastixia schultei* Kirchheimer; Czeczott and Skirgiełło, p. 53, 54, pl. 10, fig. 1.

Materials. Published: 106 specimens MZ VII/43a/285–299 (old numbers: 3, 11, 32, 58, 100, 238, 255, 284, 292, 324, 330, 357, 400, 428); unpublished: 90 specimens, MZ VII/43a/ 300, 375, 381, 408, 440–443, 452, 495, 929, 941.

Description. For detailed description see Gregor (1978b).

Remarks. Length between 14 and 24 mm (mode value is 20 mm), and up to 10 longitudinal ribs on the surface relate these endocarps more with *R. oertelii* than with *R. schultei* (see Gregor, 1978b).

Tectocarya elliptica (Unger) Holý 1975

Fig. 10G, 10R

1975 *Tectocarya lusatica* Kirchheimer; Czeczott and Skirgiełło, p. 54, pl. 10, fig. 2.

Materials. Published: 40 specimens, MZ VII/43a/301–306 (old numbers: 79, 136, 243, 490, 491); unpublished: 8 specimens, MZ VII/43a/ 394, 399, 403, 404, 484, 538, 659; new: 15 specimens, MZ VII/158/51, 126, 298.

Description. For detailed description see Holý (1975).

Nyssa disseminata (Ludwig) Kirchheimer 1937

Fig. 10J

Materials. Unpublished: 3 specimens, MZ VII/43a/529, 645.

Description. For detailed description see Mai (2004).

Nyssa ornithobroma Unger 1861

Fig. 10F

1959 *Nyssa disseminata* (Ludwig) Kirchheimer; Czeczott and Skirgiełło, p. 127, 128, pl. 20, figs 1–4.

Materials. Published: 32 specimens, MZ VII/43a/151, 152 (old number 121); unpublished: 80 specimens, MZ VII/43a/321, 369, 405, 528, 529, 564, 595, 645, 837; new: 47 specimens, MZ VII/158/11, 34, 186, 246, 352.

Description. For detailed description see Mai (1973).

Remarks. Several features, including size (10–19 × 4–9 mm), the broadest part in the upper part of the endocarp, ribs on the surface, thin walls, triangular germination valve, undoubtedly indicate that these endocarps represent *Nyssa ornithobroma.*

CORNACEAE Bercht. et J. Presl 1825

Cornus gorbunovii Dorofeev 1955

Fig. 10O, 10U

Materials. Unpublished: 29 specimens, MZ VII/43a/590, 672, 677, 684, 819–822, 870, 872, 897, 957.

Description. For detailed description see Mai (2000a).

Remarks. Considering shape, size and morphology, endocarps from Turów match those of *Cornus gorbunovii*, however, some specimens have distinctively long-acuminate bases which make them comparable to *C. maii* Martinetto (2015).

PENTAPHYLACACEAE Engler 1897

Eurya stigmosa (Ludwig) Mai 1960

Fig. 10V

Materials. Unpublished: 116 specimens, MZ VII/43a/557, 560, 768, 812, 850, 883, 922; new: 41 specimens, MZ VII/158/8, 224, 273.

Description. For detailed description see Mai (1997).

Ternstroemia sequoioides (Engelhardt) Bůžek et Holý in Bůžek et al. 1996

Fig. 10X

Materials. Unpublished: 2 specimens, MZ VII/43a/728, 771; new: 1 specimen, MZ VII/158/19.

Description. For detailed description see Mai (2000a).

SYMPLOCACEAE Desfontaines 1820

Symplocos germanica Mai 1970

Fig. 11B

Materials. Unpublished: 1 specimen, MZ VII/43a/956.

Description. For detailed description see Mai and Martinetto (2006).

Remarks. Elliptic outline, size (5.5 × 3 mm), wrinkled-granular surface and 2 locules are characteristic of *S. germanica*. What is surprising is the fact that there is only one specimen of this species in all of the material. However, unlike most of the Turów disseminules, this specimen comes from a small assemblage collected in the lowest level (205–206 m a.s.l.) of Turów II.

Symplocos casparyi Ludwig 1857

Fig. 10M

1967 *Symplocos gothani* Kirchheimer; Czeczott and Skirgiełło, p. 159, pl. 7, figs 3, 11–13, pl. 10, fig. 5.

1967 *Symplocos lignitarum* (Quenstedt) Kirchheimer; Czeczott and Skirgiełło, p. 158, 159, pl. 10, figs 1, 2.

1967 *Symplocos lusatica* Mai; Czeczott and Skirgiełło, p. 160, pl. 9, figs 2–6.

Materials. Published: 621 specimens, MZ VII/43a/ 80–92 (old numbers: 30, 56, 69, 93, 240, 329, 344, 432–436); unpublished: 387 specimens, MZ VII/43a/325, 330, 339, 345, 349, 353, 362, 370, 378, 383, 389, 418, 446, 569, 571–575, 577, 615, 634, 671, 678, 703, 705, 722, 743, 745, 754, 766, 773, 874, 876, 888, 901, 921, 937; new: 952 specimens, MZ VII/158/18, 23, 49, 110, 128, 147, 174, 184, 235, 248, 281, 288, 289, 302, 322.

Description. For detailed description see Mai and Martinetto (2006).

Symplocos incurva
(Kirchheimer) Manchester et Fritsch 2014

Fig. 11A

Materials. Published: 5 specimens, MZ VII/43a/78, 79 (old numbers: 437, 438); new: 2 specimens, MZ VII/158/176.

Description. For detailed description see Czeczott and Skirgiełło (1967), Mai (2000a) and Manchester and Fritsch (2014).

Symplocos schereri
Kirchheimer 1935

Fig. 10Y

1967 *Symplocos wiesaensis* Kirchheimer; Czeczott and Skirgiełło, p. 160, 161, pl. 7, fig. 9.

Materials. Published: 2 specimens, MZ VII/43a/94 (old number: 18); unpublished: 1 specimen, MZ VII/43a/502; new: 6 specimens, MZ VII/158/43, 177, 208, 257.

Description. For detailed description see Mai and Martinetto (2006).

STYRACACEAE
Candolle et Sprengel 1821

Rehderodendron ehrenbergii
(Kirchheimer) Mai 1970

Fig. 11C–11E

1967 *Durania ehrenbergii* Kirchheimer; Czeczott and Skirgiełło, p. 161, 162, pl. 8, figs 1–3.

Materials. Published: 3 specimens, MZ VII/43a/77 (old number: 42); unpublished: 2 specimens, MZ VII/43a/77; new: 7 specimens, MZ VII/158/30, 123, 171, 188, 283.

Description. For detailed description see Mai (1970).

Styrax maxima
(Weber) Kirchheimer 1949

Fig. 11K

Materials. Published: 32 specimens, MZ VII/43a/95–97 (old numbers: 12, 61, 423); unpublished: 51 specimens, MZ VII/43a/365, 384, 469, 494, 503, 513, 514, 550, 586, 600, 721, 751, 839, 865; new: 1 specimen, MZ VII/158/25.

Description. For detailed description see Czeczott and Skirgiełło (1967) and Mai (1997).

ERICACEAE Jussieu 1789

cf. **Pieris quinquealata**
(Menzel) Mai 2000a

Fig. 11T1, 11T2

Materials. Unpublished: 10 specimens, MZ VII/43a/496, 523, 598, 690, 841.

Description. For detailed description see Mai (2000a).

Remarks. These capsules most closely resemble *Pieris quinquealata*, however, since seeds were missing, which would be conclusive evidence, identification cannot be certain.

RUBIACEAE Jussieu 1789

Cephalanthus pusillus Friis 1985

Fig. 10S

Materials. Unpublished: 1 specimen, MZ VII/43a/651.

Description. For detailed description see Friis (1985).

SOLANACEAE Jussieu 1789

Physalis pliocaenica Szafer 1947

Fig. 10T

Materials. New: 1 specimen, MZ VII/158/107.

Description. For detailed description see Mai (1997).

Solanispermum reniforme Chandler 1957

Fig. 11V

Materials. New: 1 specimen, MZ VII/158/13.

Description. For detailed description see Chandler (1957).

Remarks. Mai (1971b) transferred these seeds to *Ternstroemia* (Pentaphylacaceae), however, Särkinen et al. (2018) confirmed the original familial identification by Chandler (1957).

EHRETIACEAE Martius 1827

Ehretia europea Reid 1923

Fig. 11F, 11H

Materials. Unpublished: 12 specimens, MZ VII/43a/788, 789.

Description. For detailed description see Reid (1923).

Remarks. Considering size (2–2.5 × 1.4–1.8 mm), elliptic shape, emarginations on both poles, median groove, uneven and stripped surface, and 2 locules, these pyrenes (also called endocarpids – see Gottschling et al., 2002) most closely resemble those of *Ehretia europea* from the lower Pliocene of Pont-de-Gail (Cantal, France) described by Reid (1923).

OLEACEAE
Hoffmannsegg and Link 1809

Chionanthus kornii Gregor 1978c

Fig. 11J

Materials. Unpublished: 1 specimen, MZ VII/43a/793.

Description. For detailed description see Gregor (1978c).

Remarks. Although compressed, this endocarp in respect of size (9.5 × 5.5 mm), cordiform shape, pointed apex, subbasal cavity (funicular canal entrance) most closely resembles *Chionanthus kornii*.

PAULOWNIACEAE Nakai 1949

Paulownia cantalensis
(E.M. Reid) Mai in Martinetto 1995

Fig. 11G

Materials. New: 5 specimens, MZ VII/158/68.

Description. For detailed description see Mai (2000a).

AQUIFOLIACEAE Berchtold et Presl 1825

Ilex delicata
Mai in Mai and Walther 1991

Fig. 11N1, 11N2

Materials. Unpublished: 1 specimen, MZ VII/43a/589.

Description. For detailed description see Mai (1970).

Remarks. Based on following features: size (3.5 × 2.5 mm), shape (regular elliptic), divergence of ventral walls (at a right angle), surface morphology (ventrally nearly smooth, dorsally with 3 small ribs), this pyrene most closely resembles *Ilex delicata*. This species is very close to *I. ahrensii* Mai 1970, but it was separated by Mai and Walther (1991) based mainly on smaller size.

Ilex cf. ***ahrensii*** Mai 1970

Fig. 11M1, 11M2

Material. Unpublished: 1 specimen, MZ VII/43a/737.

Description. For detailed description see Mai (1970).

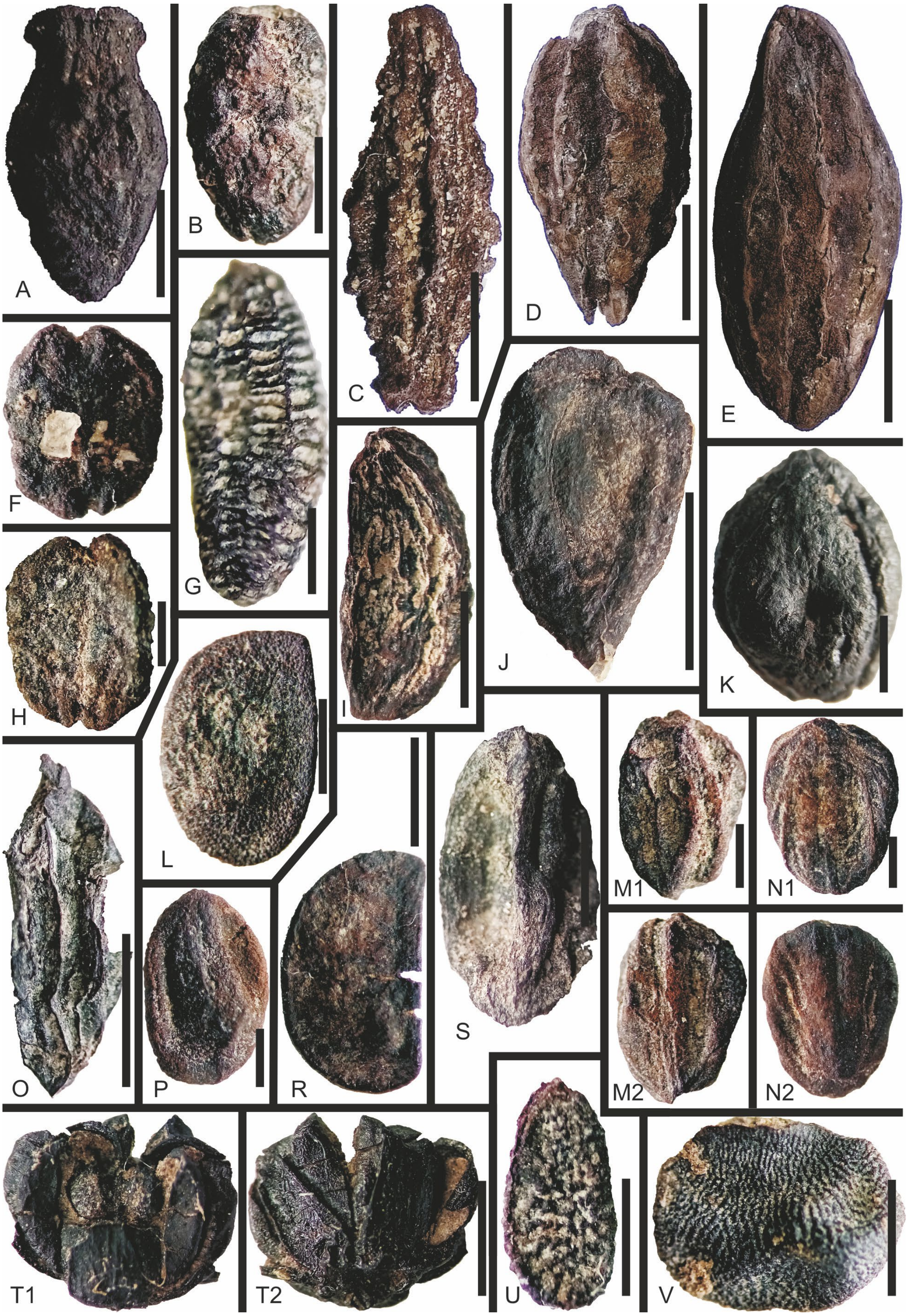

Figure 11. Carpological fossils from the Turów Mine. **A**. *Symplocos incurva* (Kirchh.) Manchester et Fritsch: fruit, MZ VII/43a/79; **B**. *Symplocos germanica* Mai: fruit, MZ VII/43a/956; **C–E**. *Rehderodendron ehrenbergii* (Kirchheimer) Mai: endocarps, MZ VII/43a/77; **F**, **H**. *Ehretia europea* Reid: endocarpids, MZ VII/43a/788; **G**. *Paulownia cantalensis* (E.M. Reid) Mai: seed, MZ VII158/68; **I**, **S**. *Ilex lotschii* Mai: endocarps, MZ VII/43a/597, MZ VII158/70; **J**. *Chionanthus kornii* Gregor: endocarp, MZ VII/43a/793; **K**. *Styrax maxima* (Weber) Kirchheimer: endocarp, MZ VII/43a/96; **L**. *Eleutherococcus uralensis* Dorofeev: endocarp, MZ VII/43a/862; **M1**, **M2**. *Ilex* cf. *ahrensii* Mai: endocarp, MZ VII/43a/737; **N1**, **N2**. *Ilex delicata* Mai in Mai and Walther: endocarp, MZ VII/43a/589; **O**. *Ilex* cf. *saxonica* Mai: endocarp, VII/43a/908; **P**. *Viburnum* cf. *hercynicum* Mai et Walther: endocarp, MZ VII/43a/738; **R**. *Pentapanax tertiarius* Mai: endocarp, MZ VII/43a/667; **T1**, **T2**. cf. *Pieris quinquealata* (Menzel) Mai: fruit capsule, MZ VII/43a/523; **U**. *Sambucus lucida* Dorofeev: seed, MZ VII/43a/607; **V**. *Solanispermum reniforme* Chandler: seed, MZ VII158/13. Scale bars: B, I, K, L, O, R–V = 2 mm; C–E = 10 mm; A, J = 5 mm; G = 0.25 mm; F, H, M, N, P, U = 1 mm

Remarks. This pyrene resembles *Ilex ahrensii* in respect of size (3 × 2 mm), divergence of lateral walls at a right angle, except that surface ornamentation is not that strong as documented in type materials (Mai, 1970), which may be the result of abrasion. Therefore, our identification is uncertain.

Ilex lotschii Mai 1970

Fig. 11I, 11S

Materials. Unpublished: 1 specimen, MZ VII/43a/597; new: 1 specimen, MZ VII/158/70.

Description. For detailed description see Mai (1970).

Remarks. These pyrenes can be safely assigned to *Ilex lotschii* considering their size (4.9 × 2 mm), shape (narrow, half elliptic), divergence of lateral walls at an acute angle, wrinkled and knobbed surface with unclear ribs.

Ilex cf. ***saxonica*** Mai 1964

Fig. 11O

Material. Unpublished: 1 specimen, MZ VII/43a/908.

Description. For detailed description see Mai (1964).

Remarks. Size (5 mm long), shape, divergence of lateral walls (acute angle) and ornamentation (highly elevated ribs on dorsal side) suggest that this incomplete pyrene may represent *Ilex saxonica*.

ARALIACEAE Jussieu 1789

Eleutherococcus uralensis Dorofeev 1977

Fig. 11L

Material. Unpublished: 1 specimen, MZ VII/43a/862.

Description. For detailed description see Mai and Walther (1988).

Remarks. Considering size (5 × 3 mm), knobbed surface, and thickened dorsal margin, this endocarp can be safely assigned to *Eleutherococcus uralensis*.

Pentapanax tertiarius
Mai 1973

Fig. 11R

Materials. Unpublished: 2 specimens, MZ VII/43a/667, 818.

Description. For detailed description see Mai and Walther (1985).

Remarks. Our assignment to *Pentapanax tertiarius* seems safe considering the large size, semicircular shape, and thin walls of these endocarps (see also Kowalski et al., 2024).

VIBURNACEAE
Rafinesque 1820

Sambucus lucida
Dorofeev 1963

Fig. 11U

Materials. Unpublished: 2 specimens, MZ VII/43a/607.

Description. For detailed description see Mai (1997).

Remarks. Black, lustrous surface covered with transverse, connected lumps observed in our endocarps are diagnostic features of *Sambucus lucida* (Mai and Walther, 1991).

Viburnum cf. ***hercynicum***
Mai et Walther 1988

Fig. 11P

Materials. Unpublished: 1 specimen, MZ VII/43a/738.

Description. For detailed description see Mai and Walther (1988) and Kowalski (2017).

Remarks. General shape and size (3.5 × 2.2 mm), grooves on ventral and dorsal side resemble endocarps of *Viburnum hercynicum*, except missing tubercles on the surface, which, however, may result from abrasion.

Incertae sedis

Rhamnospermum bilobatum
Chandler 1925

Fig. 7E

Materials. Unpublished: 6 specimens, MZ VII/43a/909.

Description. For detailed description see Chandler (1925, 1962).

Remarks. Despite the generic name, the familial affinity of this taxon has not been resolved (Chandler, 1962).

FABACEAE?

1961 *Acer* sp. 3; Czeczott and Skirgiełło, p. 117, pl. 21, figs 5, 6.
1967 *Trapa* sp.; Czeczott and Skirgiełło, p. 157, 158, pl. 7, figs 1, 2.

Materials. Published: 3 specimens, MZ VII/43a/103, 127, (old number: 453, 122).

Remarks. Both specimens described as *Acer* sp. 3 (MZ VII/43a/127) are flat or flattened by compaction. They have robust structure, are more or less fusiform in shape, and wrinkled on the surface. Both also have a round or elliptic depression on one, narrowed end (attachment scar?), while the opposite end in both specimens is broken. The wall is thick, up to 1.5 mm. In our view, the general structure and morphology are unlike those in *Acer* fruits, which is especially evidenced by shape and location of the attachment scar. We were unable to determine the affinity of these fruits. We also believe that specimen described as *Trapa* sp. (MZ VII/43a/103) may represent the same taxon. If that is correct these fruits occur as a pair or consist of more segments, which suggests Fabaceae.

The specimen described as *Trapa* sp. (MZ VII/43a/103) is missing, however, considering description and photographs, the relationship with *Trapa* L. 1753 is highly doubtful. We see, however, resemblance between this specimen and those described as *Acer* sp. 3.

Excluded taxa

Among 12 taxa of Cupressaceae (including former Taxodiaceae) recognized and documented by Zalewska only *Glyptostrobus europaeus* (Brongniart) Unger 1833 (Fig. 3F) and *Quasisequoia couttsiae* (Heer) Kunzmann 1999 (consecutively Zalewska, 1959: p. 115, pl. 1–3, p. 116, pl. 5, figs 1–4) can be confirmed without any doubt (see above). Remaining taxa including *Cupressus* sp., *Juniperus* sp., *Thuja* cf. *occidentalis* L. 1753 are all rejected here. After careful examination it is clear that remains attributed to these taxa were misinterpreted by Zalewska (1961). Some of them were already questioned before (see Kvaček, 1986, 1999). It is clear that some of these remains can be regarded as unidentified plant debris, fragmented or poorly preserved seeds or fruits of other taxa reported from Turów (see above) and unidentified disseminules.

Rubus* cf. *tomskiana
Dorofeev 1963

Materials. Published: 3 specimens, MZ VII/43a/101 (old number: 515).

Remarks. Only three out of four specimens of *R.* cf. *tomskiana* are still present in the collection of the Museum of the Earth. However, those which remained are not coalified, and have perfectly preserved sculpture, which suggests that they are modern contaminant endocarps. In the light of that, we remove this species from the floristic list (full list see Appendix 1), although the genus is still represented by the other species mentioned above.

Sterculia polonica
Czeczott et Skirgiełło 1975

Materials. Published: 1 specimen, MZ VII/43a/99 (old number: 1).

Remarks. After careful examination we are certain that *Sterculia polonica* is just a deformed Juglandaceae fruit, which is evidenced by the pyriform shape, comparable size, smooth exterior surface, well-defined corners on the nutshell, thick nutshell, and characteristic juglandaceous shape of locule. The long protruding apex suggests that it could be *Carya rostrata* (Schloth.) Schimper. For many years, some authors believed that this specimen was found in Turów (i.e. Mai, 1995), but Czeczott and Skirgiełło (1975) clearly stated that it came from Babina open pit coal mine, near Mużaków.

DISCUSSION

TAPHONOMICAL REMARKS

Depositional environment and taphonomy cannot be fully characterized for historical materials, because nothing has been known on deposits from which carpological fossils were extracted. Considering the taxonomic composition of this part of the collection, the most abundant disseminules according to their size are: *Eurya* Thunberg 1783 (small <2 mm in diameter), *Turpinia* Ventenat 1807 (medium 2–5 mm long), and *Eomastixia* Chandler 1925 (large >5 mm long). The most common taxa observed in all studied samples are *Diplopanax* Handel-Mazzetti 1933 and *Mastixia* Blume 1825. However, it seems most likely that the predominance of large specimens observed in the collection results mostly from selective collecting.

New materials come from several different types of sediments of both high and low energy environments. The high energy environment is represented by medium to coarse sands which provide mostly large and medium, robust, mostly well-preserved disseminules (S1, S2/1). Fossil assemblages extracted from this type of sediments are allochthonous, but the preservation state of the disseminules and characteristics of sand grains (small grade of rounding) suggest mostly short transportation. This type of sediments is the main source of large disseminules in Turów. However, one exception is *Mastixia* which was also observed in some (silt) sediments of low energy sedimentary environments, suggesting that it could be an intrabasinal vegetation element as well.

The low energy sedimentary environment is represented by a wide range of deposits including clay/silts (TII/2), silts (S2/2) and coal (S4).

VEGETATION RECONSTRUCTION

Disseminules of woody angiosperms dominate in all studied old samples. The overwhelming majority are taxa (except samples from Turów II) that can be related with riparian (i.e. *Liquidambar* L. 1753, *Carya* Nuttall 1818, *Cercidiphyllum* Siebold et Zuccarini 1846, *Platanus* L. 1753, *Pterocarya* Kunth 1824) and/or mesophytic (see below) environments (77–92%), including evergreen genera (understood here as exclusively evergreen today) with up to 45% share, deciduous genera with a share between 32% and 36%, evergreen or deciduous genera between 19% and 26%. It is worth noting the high diversity of lianas (*Parabaena* Miers 1851, *Sinomenium* Diels 1910, *Sabia* Colebrooke 1819, *Passiflora* L. 1753, *Ampelocissus* Planchon 1884, *Ampelopsis* Michaux 1803, *Vitis* L. 1753, *Parthenocissus* Planchon 1887, *Rubus* L. 1753, *Spinopalmoxylon* Weyland, Kilpper et Berendt 1966) which make up 23% of all taxa in some samples. Lianas and herbaceous plants (*Cleome*, *Moehringia*) may suggest the presence of open (frequently disturbed?) habitats. Conifers are very common, but have little diversity, mostly represented by *Glyptostrobus*, *Quasisequoia*, and *Cephalotaxus* Siebold et Zuccarini ex Endlicher 1842, the latter only in new materials, while *Sequoia* Endlicher 1847, *Tetraclinis* Masters 1892, *Cathaya*, cf. *Tsuga* are rare or only individuals. The high proportion of exclusively evergreen genera suggests that Broad-leaved Evergreen Forests (BLEF) or ecotone between BLEF and Mixed Mesophytic forests (MMF) may have been the dominating vegetation type in the Turów vicinity at the time (see IPR vegetation analysis below) when the studied part of the profile was deposited. This vegetation is evidenced by: *Choerospondias*, *Ilex*, Araliaceae (*Eleutherococcus*, *Pentapanax*), Betulaceae (*Carpinus*, *Ostrya*), *Sarcococca*, Cannabaceae (*Gironniera*, *Trema*), *Daphniphyllum*, *Ehretia*, *Acalypha*, Ericaceae (cf. *Pieris*), Fagaceae (*Trigonobalanopsis*, *Quercus*), Hamamelidaceae (*"Fothergilla"*, *Distylium*, *Rhodoleia*), *Itea* , Juglandaceae (*Carya*, *Cyclocarya*, *Palaeocarya*, *Juglans*, *Pterocarya*), Lauraceae (four taxa), Magnoliaceae (*Magnolia*, *Liriodendron*), Malvaceae (*Craigia*), Nyssaceae (*Cornus*, *Diplopanax*, *Eomastixia*, *Mastixia*, *Retinomastixia*, *Tectocarya*), *Melia*, Menispermaceae (*Parabaena*, *Sinomenium*), Moraceae (*Broussonetia*, *Ficus*), *Morella*, *Chionanthus*, *Passiflora*, *Paulownia*, Pentaphylacaceae (*Eurya*, *Ternstroemia*), Rhamnaceae (*Frangula*, *Paliurus*, *Zizyphus*), *Prunus*, Rutaceae (*Phellodendron*, *Zanthoxylum*), Sabiaceae (*Sabia*, *Meliosma*), *Acer*, Solanaceae (*Physalis*, *Solanispermum*), *Turpinia*, Styracaceae (*Rehderodendron*, *Styrax*), Symplocaceae (four taxa), Viburnaceae (*Sambucus*, *Viburnum*).

The presence of parasitic plants is also marked by *Viscum*.

Obligate aquatics, including floating hydrophytes (*Lemnospermum*) and submerged plants are nearly absent. There is only a single seed of *Stratiotes* in Turów II/2 and imprints of *Salvinia* preserved in ironstones from "intermediate" and "3" levels. Amphibious hydrophytes are represented, but in a small number of specimens (*Carex*, *Epipremnites*, *Microdiptera*, *Sparganium*, *Spirematospermum*, *Urospathites*, also possibly *Hypericum*).

Woody elements of swamp forest are common (both in Czeczott and new collection), represented mostly by trees *Glyptostrobus*, *Nyssa*, *Myrica* and less often by *Alnus*. Herbaceous elements that can be connected with swamp forest, like *Cephalanthus*, *Microdiptera*, *Sparganium*, *Spirematospermum* are scarce. Sample Turów II/2 deserves special attention among the materials collected by

Czeczott and team, because the whole fossil assemblage was extracted from one layer, therefore can be considered more or less isochronous. It is characterized by low number of species, with dominating *Glyptostrobus* and *Spinopalmoxylon daemonorops*/*S. cicatricosum* and marginal share of *Rubus*, *Quasisequoia*, *Aracispermum*. The sediment characteristics (silty-clay) and the fact that different parts of *Glyptostrobus* (leaves, twigs, seeds, cones) and *Spinopalmoxylon* (spines, inflorescences, shoot axis fragments) occur together suggest a para- or autochthonous character of this taphocoenosis. A similar habitat is represented by S4 sample, which, however, provided only one species. Because fossils occur in coal, S4 is considered autochthonous. The coexistence of *Glyptostrobus* and climbing palm *Spinopalmoxylon* resembles the modern *Glyptostrobus pensilis* swamp forest from Vietnam, where *Calamus palustris* can be seen as modern ecological equivalent to *Spinopalmoxylon* (Averyanov et al., 2009). It must be noted that the *Glyptostrobus* swamp forest taphocoenosis that occurs above “upper” coal does not provide *Spinopalmoxylon.*

The sample 2/2 assemblage is dominated by trees and shrubs, vines are relatively diverse (6 taxa), but herbs are marginal (2 taxa). Riparian/mesophytic elements dominate and are mostly represented by zoochorous taxa. Considering the number of disseminules, the most abundant in this sample is *Pterocarya*. Swamp plants are rare (6 out of 46 taxa), while aquatic plants were not found. Palaeotropical elements prevail over Arctotertiary ones, reaching 56%.

BIOSTRATIGRAPHY AND AGE ESTIMATION OF TURÓW FLORAS

Despite the long multidisciplinary exploration of the Turów brown coal pit mine, no geological or animal evidence was found to independently estimate the time frame for the part of the sequence studied here. For this reason, the authors use the lithostratigraphic and palynostratigraphic classification established for the Polish Lowlands and Turów (Piwocki and Ziembińska-Tworzydło, 1997; Kasiński et al., 2010). The floristic complexes concept, a method of biostratigraphic classification introduced by Mai and Walther (Mai and Walther, 1978; Mai, 1995) is also used here for reference, but we are cautious about its stratigraphic significance.

Turów I

The lowermost section from Turów I studied here is represented by layer “x” (level “4” – Fig. 2A, see also Czeczott, 1959). Fossil material found here (one *Magnolia geinitzii* seed) is insufficient for biostratigraphic conclusions, however, it should be emphasized that layer “x” occurred within the lower part of the “upper” seam”.

Fossil material found in level “6” (Fig. 2A) is also insufficient (one *Carya* nut) for biostratigraphic conclusions. While presence of *Trigonobalanopsis exacantha* and *Mastixia lusatica* in level “12” (layers “i”, “j” – Fig. 2A) makes this florula resembling those of the Wiesa-Eichelskopf floristic complex.

The taxonomic composition of fossil assemblages from the lower part of level “3” (layers “g” and “f” – Fig. 2A) is generally comparable to above lying layers, except the presence of Arecaceae [*Sabalites* sp. leaf (=*Trachycarpus rhapifolia* (Sternberg) Takhtajan), see Appendix 2, fibers – Czeczott and Juchniweicz, 1975]. This is the only part of the Turów I profile where palm remains were found. The reason for the lack of palms above layer “f” is unknown, it may result from climatic or sedimentary environment change. The biostratigraphic position of this part of the sequence is equivocal. However, the taxonomic composition of layers “e” and “d” suggests that the biostratigraphic position of the floras from the upper part of level “3” is similar to the “intermediate” and “9” levels (see below).

The “intermediate” and “9” levels represent the upper part of the Turów I profile. The first mentioned is the most species-rich level documented in Turów. Despite the division introduced by Czeczott (1959), the taxonomic composition of the carpological assemblages found in these levels (Fig. 2A) suggests that they represent one biostratigraphic zone and can be safely compared with floras of the Wiesa-Eichelskopf floristic complex. This is evidenced by the presence of: 1) index fossils like *Mastixia lusatica* and *Retinomastixia*; 2) other mastixioids *Eomastixia*, *Tectocarya*, *Diplopanax*; 3) evergreen Lauraceae and Fagaceae; 4) various Pentaphylacaceae (*Eurya*, *Ternstroemia*), Rutaceae (*Zanthoxylum*, *Phellodendron*), Symplocaceae, Sabiaceae (*Sabia*, *Meliosma*), Magnoliaceae (*Magnolia*, *Liriodendron*) (compare

Mai, 2000b; Czaja, 2003). A typical feature of the Wiesa-Eichelskopf floristic complex is also a very high (much above 50%) participation of palaeotropical elements in all fossil assemblages of this part of the profile.

Turów II

Materials of this exploitation field are represented here only by two samples (TII/1, TII/2) from two different locations (Fig. 2B – only TII/2 is marked). Species observed in sample TII/1 make this fossil assemblage similar to floras of the Wiesa-Eichelskopf floristic complex, while the presence of *Spinopalmoxylon* and accompanying *Aracispermum canaliculatum*, *Glyptostrobus*, *Quasisequoia*, *Stratiotes kaltennordheimensis* relate the flora of the samples TII/2 with floras of the Bílina-Brandis floristic complex (Mai, 2000b; Czaja, 2003). The presence of *Platanus neptuni* (Ett.) Bůžek, Kvaček et Holý in sample TII/2 further supports the suggested biostratigraphic classification, as this species is relatively more common in floras of the Bílina-Brandis floristic complex in Czech Republic and Germany (Mai, 2000b; Kvaček and Manchester, 2004).

Turów, S1 (new materials – Fig. 2C)

Considering its position in the geological profile, sample S1 most likely corresponds with those of the historical materials from Turów I (compare layers "e" to "h"). However, it is less than half as rich in species as the "intermediate" level, and it shares only ~50% of taxa. Particularly striking is the poverty among mastixioids (only genus *Mastixia* is represented) and lack of Lauraceae and Fagaceae. The differences observed between these samples could result from climatic changes or different dynamics of the sedimentary environment. However, since the S1 fossil assemblage represents fossils washed by rain, it is more likely that the taxonomic composition is skewed mostly by transportation during surface runoff after washing out from sediments. Therefore, any taphonomical or sedimentary environment discussion is unjustified. Despite that, the combined fossil assemblage of S1 provides information on floristic diversity and is useful for biostratigraphic conclusions. The presence of old, Lower Miocene taxa like *Distylium protogaeum*, *Sparganium pusilloides*, *Solanispermum reniforme* and several typical "mastixioid floras elements" like *Acalypha fragilis*, *Gironniera* sp. div., *Magnolia germanica*, *Trema lusatica*, *Turpinia ettingshausenii* suggest the Wiesa-Eichelskopf floristic complex as the most probable biostratigraphic zone.

Turów, S2 (new materials – Fig. 2D)

Unlike sample S1, in S2 four mastixioid genera (including *M. lusatica*), and other typical "mastixioid flora elements" like *Gironniera*, *Magnolia geinitzii*, *Melia*, *Rehderodendron ehrenbergii*, *Meliosma*, *Trigonobalanopsis exacantha* are documented, indicating that this fossil assemblage can be safely assigned to the Wiesa-Eichelskopf floristic complex.

Turów, S4 sample (new materials – Fig. 2E) represents the same biostratigraphic position as was suggested for Turów II/2, which is evidenced by the mass occurrence of *Spinopalmoxylon* within the coal.

We consider *Spinopalmoxylon* to be crucial for the biostratigraphic classification in Turów Mine, and probably for Lusatia but this should be verified by future studies. Micropalaeobotanical studies on the stratigraphic range of *Dicolpopollis kockelii* Pflanzl 1956 which has been linked to *S. daemonorops* (Winterscheid, 2019) suggest that this calamoid palm declined in Central Europe before the end of the Early Miocene (Von der Brelie et al., 1981; Planderova, 1990; Piwocki and Ziembińska-Tworzydło, 1997). In western Poland (also in Turów, see Ziembińska-Tworzydło 1991) this corresponds with the III – *Arecipites parareolatus* zone and coincides with the 3rd Ścinawa group of seams (= 3 MFK) (Piwocki and Ziembińska-Tworzydło, 1997; Kasiński and Słodkowska, 2016). Consequently, we propose latest Early Miocene age for all macroscopic floras documented above (contrary to the Middle Miocene – see Kowalski, 2010). By similarity with other Lusatian floras assigned to the Bílina-Brandis floristic complex (i.e. comprising *Spinopalmoxylon*) we think that middle/late (or late) Burdigalian is the most probable age for floras found within the "upper" seam in Turów while fossil floras collected in the lower part of clastic deposits above the "upper" seam by resemblance with the Wiesa-Eichelskopf floristic complex floras probably should be considered latest Burdigalian (or even latest Burdigalian/Langhian). Thus, the probable time range for the Turów plant assemblages is 18–16 Ma. Considering our observation and pieces of evidence available in literature (Von der Brelie et al., 1981; Planderova, 1990; Piwocki and Ziembińska-Tworzydło, 1997; Winterscheid, 2019), we propose including the “upper” seam in Turów – instead of the 2nd Lusatian – to the 3rd Ścinawa group of seams (=3rd MFK).

Consequently, we also believe that floras of Turów II/2 (including S4) most likely correspond with those of the “middle coal seam”, while the remaining floras from Turów correspond with those of the “upper coal seam” from Hrádek, Czech part of the Zittau Basin (Teodoridis, 2003). However, in our view floras of the layers A, C, B (probably also D, E, F) described from Hrádek by Holý et al. (2012) – instead to the Wiesa-Eichelskopf floristic complex – should be assigned to the Bílina-Brandis floristic complex. Correspondingly, floras of Turów II/2 correlate with floras E–F, while the remaining floras described from Turów correlate with A–D floras from Hartau 1/69, German part of the Zittau Basin (Mai, 2000b). Considering Berzdorf-Radomierzyce Basin, there is a clear similarity between floras of Turów II/2 and those from Berzdorf-seam 2 and sand-silt layer below (sites 51 and 51a), while the remaining floras from Turów correspond with those of Berzdorf-“Schluffmulde” (sites 1, 8, 31–39, 42, 54, 55, 58, 74 – Czaja, 2003).

PALAEOENVIRONMENTAL ANALYSIS – IPR VEGETATION ANALYSIS AND AFFINITIES WITH EXTANT PLANT ASSEMBLAGES

The IPR vegetation analysis predicts a zonal broad-leaved evergreen forest (BLEF) for Turów-intermediate level (Appendix 3a, 3b), where the specific pattern of the key components is as follows: BLD (46.8%), BLE (50.1%), SCL + LEG (3.11%) and DRY + MESO HERBS (2.4%), number of zonal taxa (63), number of zonal woody elements (59). Stratigraphically comparable levels of Turów-S1 and Turów-S2 show (Supplementary File 1[1]) a very similar composition of BLD (38.3%, 54.25%), BLE (57%, 43%), SCL + LEG (4.7%, 2.8%) and DRY + MESO HERBS (8.7%, 5%) corresponding to BLEF. Unfortunately, the oldest vegetation assemblage of Turów TII/2a contains only 4 zonal woody angiosperms within 10 woody elements (Supplementary File 2[2]), which does not allow using the IPR vegetation analysis (Kovar-Eder and Teodoridis, 2018). The underrepresentation of zonal herbaceous elements in the studied plant assemblages of Turów (2, 3 and 0 elements) is accounted for in the application of Drudge 1 to determine the closest modern analogue plant assemblage at genus level from a calibration dataset containing 505 living plant assemblages from Europe, Caucasus, China, Mongolia and Japan (Teodoridis et al., 2020). The closest modern analogue plant assemblage for Turów “intermediate” level indicated by Drudge 1 is a plant community of *Castanopsis fargesii* of broad-leaved evergreen forest growing at an altitude of 650–700 m in Mt. Longqi (Fujian, China) sensu Li (1994). For details see Supplementary File 3[3]. The gridded climate proxies for this modern analogous vegetation at 580 m altitude are predicted as follows: MAT 17.8°C, WMMT 26.5°C, CMMT 8°C and MAP 1596 mm (Teodoridis et al., 2011: table 5). These values are compatible with our CA estimates for the cumulative flora of the Turow Mine (see below).

PALAEOCLIMATE

Climate data were calculated for a total of six sampled levels of Turów Mine using the coexistance approach (Table 1). Our concept employs NLR identification at the genus/family levels, with 10 to 86 different NLR taxa (mean 41.8) in each case contributing to the analysis (Supplementary File 4[4]). Detailed climatic range charts for the richest assemblage (intermediate) are provided in Figs 12 and 13 (MAT, MAP), charts for the other levels and the complete set of climate variables are made available in Supplementary File 4.

For all studied levels, the CA analysis reveals a high degree of overlapping (>95%) of the climatic ranges of NLR taxa. This points to a high statistical significance of the results (Mosbrugger and Utescher, 1997). The results obtained for the single levels largely resemble

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[1] Supplementary File 1. Assignment of the individual taxa to the different components for Turów S1 and S2, and (below) characteristics of the zonal vegetation units (redrawn from Kovar-Eder et al., 2008)

[2] Supplementary File 2. Assignment of the individual taxa to the different components for Turów II/2a and (below) characteristics of the zonal vegetation units (redrawn from Kovar-Eder et al., 2008)

[3] Supplementary File 3. Summary of the IPR results and dataset

[4] Supplementary File 4. Summary of the Coexistence Approach (CA) results and dataset

Table 1. Climate data obtained for the different sampling levels using the Coexistence Approach (CA). MAT: mean annual temperature (°C); CTM, WMT: mean temperatures of the coldest, warmest month (°C); MAP: mean annual precipitation (mm); MPWET, MPDRY, MPWARM: mean precipitation of the wettest, driest, warmest month (mm). Min/max in each case refers to the lower and upper ends of the resulting coexistence intervals (CIs)

Samples	No. of taxa	MATmin	MATmax	CMTmin	CMTmax	WMTmin	WMTmax	MAPmin	MAPmax	MPWETmin	MPWETmax	MPDRYmin	MPDRYmax	MPWARMmin	MPWARMmax
intermediate	86	17.2	18.2	9.6	13.6	24.7	27.8	1219	1531	254	295	21	38	149	177
3	48	17.2	21.3	9.6	13.6	24	28.1	1219	1531	254	295	25	43	149	187
9	22	17.2	22.2	9.6	13.6	24	28.1	1217	1597	254	295	7	64	149	177
TII/2a	10	13.3	21.7	–0.1	15.2	22.8	29.4	850	1900	92	295	9	295	73	221
s1	40	16.7	21.3	9.6	15	23.8	28.5	1096	1724	182	295	25	51	149	177
s2	45	17.2	17.8	9.6	13.6	24.7	26.4	1217	1531	254	295	21	38	149	177

each other, except for Turów II/2a where the low diversity (10 taxa) leads to broad, unspecific Cis that are not further interpreted here. MATs range from 17 to 22°C and 17 to 18°C (intermediate, S2), respectively. For CMMT, 10–14°C (S1: 15°C) are obtained, while WMMT values are within the range of 24 to 28°C (Table 1). The reconstruction yields high MAP rates within the range of 1200–1600 mm for most levels, for the diverse sample S1 a somewhat broader range of 1096–1724 mm is obtained. MPWET ranges of 254–295 mm are typical while S1 may have been somewhat drier (182–295 mm). With MPDRY of ~20–50 mm (level 9: 7–64 mm) a distinct seasonality of rainfall results. MPWARM rates of ~150–190 mm exclude the existence of a summer-dry climate and rather point to humid conditions during the warm season.

In the reconstruction of temperature variables *Sequoia* forms a permanent cool outlier regarding MAT and WMMT, *Cercidiphyllum* (fossil: *C. helveticum* 1980) occurring in sample S2 is too temperate to overlap with the other of taxa in the CMMT reconstruction. Regarding precipitation, MPDRY and MPWARM of modern *Sequoia*, distributed on the Pacific coast of North America in a Mediterranean type of climate, are incompatible with the values suggested by the rest of the taxa. The outlier status of *Sequoia* refers to most climate reconstructions from Paleogene to earlier Neogene palaeofloras of the mid-latitudes of Europe (Utescher et al., 2014). *Cercidiphyllum* had a considerably wider distribution in the northern hemisphere since the early Cenozoic compared to today. Thus, it can be assumed that its modern distribution does not cover the entire ecological range of the genus.

With MAT being ~17–22°C, CMMT at 10–14°C, and WMMT at 24–28°C reconstructed with the CA, the studied assemblages reveal values that are close to other Central European floras dating to the later part of the Burdigalian. The overall high temperature level probably relates to the Miocene Climatic Optimum (MCO), the globally warmest phase of the Neogene, which began ~17 Ma and extended over ~3 Myr under moderately raised atmospheric CO_2 at 400–600 ppmv (Zachos et al., 2008; Kürschner et al., 2008). For the late Burdigalian of the Lusatian Basin, the carpoflora of the lowermost Wiesa level (floral zone 6) yielded MAT of 17.5–18°C, CMMT of 10°C and WMMT of 26.5°C (Mosbrugger et al., 2005). Coeval microfloras from the Lower Rhine Basin (late Burdigalian Morken Seam) and sothern North Sea Basin (Vium core, Arnum Fm.) indicate CMMT of 12°C, MAT of 18°C and WMMT of 26°C for the warm phases along the profile (Larsson et al., 2011; Utescher et al., 2012), all being in the same magnitude of the actual reconstruction for the Turów levels. For the Central Paratethys, a similarly high continental temperature level is reported from CA analysis of Karpatian microfloras (Doláková et al., 2020; Hevlín, Slup, Medlov sections, ~16.3–17.2 Ma; CMMT of ~12°C, MAT of ~17–19°C, WMMT of). The comparatively moderate temperature seasonality (>10°C), a characteristic climatic feature of the earlier part of the MCO in Central Europe (Bruch et al., 2011; Utescher et al., 2015; Doláková et al., 2020) has been related to the transient existence of an effective Palaeo-Gulf Stream, as early as the late Early to Middle Miocene (Utescher et al., 2015).

As evident from other reconstructions, the warmth of the MCO in Central Europe was

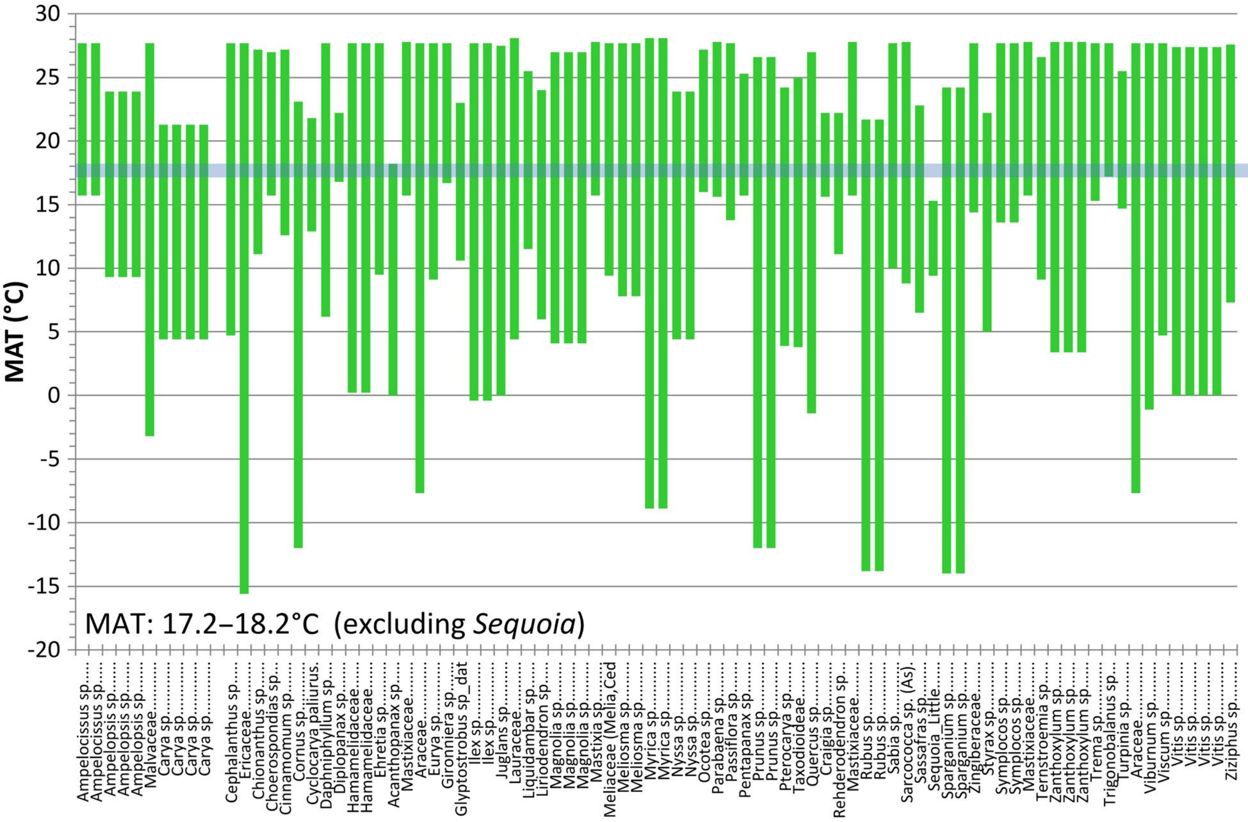

Figure 12. Application of the Coexistence Approach (CA) on the flora of the "intermediate" sampling level. Range chart for mean annual temperature (MAT). Coexistence interval (CI), defined by maximum overlapping, is indicated by shaded area. Fossil taxa and their nearest living relatives (NLRs) with corresponding MAT ranges are bolded

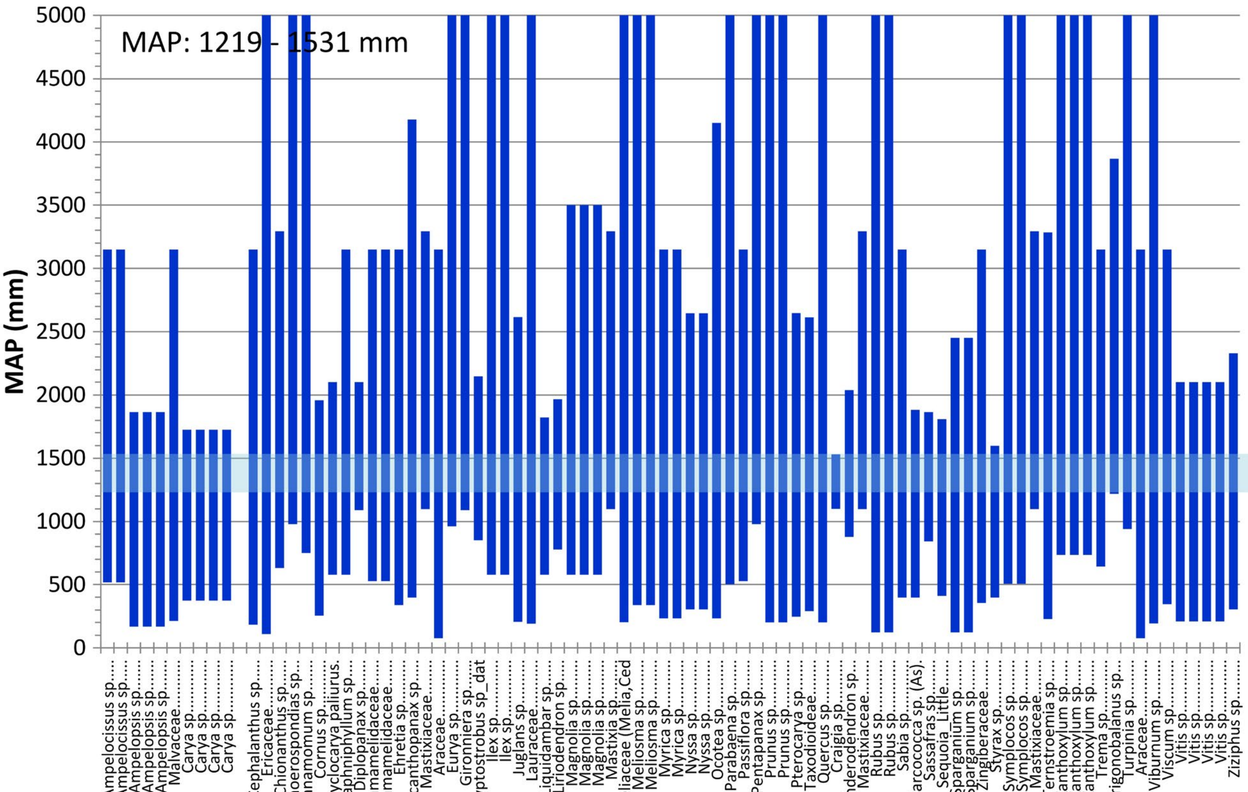

Figure 13. Application of the Coexistence Approach (CA) on the flora of the "intermediate" sampling level. Range chart for mean annual precipitation (MAP; range of values >5000 mm is not shown). Coexistence interval (CI), defined by maximum overlapping, is indicated by shaded area. Fossil taxa and their nearest living relatives (NLRs) with corresponding MAP ranges are bolded

connected to very humid conditions. MAP rates in the range of 1200–1600 mm, as reconstructed for most of the Turów levels, tend to be higher compared to the Wiesa flora (Mosbrugger et al., 2005: 1146–1355 mm), but are in line with MAP mean values obtained for coeval microfloras of the Lower Rhine Basin mostly varying from 1250 to 1600 mm (Utescher et al., 2012). MAP rates reconstructed by Doláková et al. (2020) from Karpatian microfloras of the Central Paratethys (means ranging between 1300 and 1400 mm) are in the same order. Since vegetation strongly responds to the seasonal distribution of rainfall, it is important to consider monthly precipitation rates. As stated above, the reconstructed MPWARM rates of ~150–190 mm points to humid conditions during the warm season. Comparable conditions have also been reported from the above referenced regions for the later Burdigalian and the later Early Miocene in general for most of Europe (Bruch et al., 2011). Nevertheless, our results reveal a distinctly seasonal precipitation pattern with about tenfold higher values in the wettest month compared to the driest. A permanently high Mean Annual Range of Precipitation (MARP) in the order of 250 mm possibly was a characteristic feature of the later Burdigalian of the Central Paratethys (Doláková et al., 2020, and this pattern obviously related to larger scale atmospheric circulation, persisted throughout the Langhian (Kovar-Eder and Teodoridis, 2018).

Although being the warmest time-span of the Neogene (Zachos et al., 2008), the Central European continental temperature records reveal short-term climate variability with intermittent cooler and drier climate phases, probably in the order of 5°C MAT and several hundreds of mm of MAP (Utescher et al., 2012). These phases have been related to global glacial events recorded in the marine realm (Miller et al., 1991, 1998; Westerhold et al., 2005). Although the studied part of the Turów profile is supposed to cover a time-span of ~2 Myr, our results do not show such a variability. Either, the climatic resolution of the CA is not sufficient to record this variability, or the levels yielding rich flora in each case were deposited during the warmest phases.

Considering the reconstructed values for all climate variables analyzed, a Cfa Köppen type climate (CMMT −3–18°C; WMMT >10°C; MPDRY >30 mm) is suggested for the Turow palaeofloras. With an inferred MPDRY range of 20–50 mm and with the driest month probably being in the cold season, also the winter-dry Cw climate type cannot be excluded (Kottek et al., 2006). Thus, the Turów palaeofloras existed under considerably warmer and more humid conditions compared to today, under moderately raised atmospheric CO_2 (climate data Bogatynia MAT ~8°C, MAP ~700 mm). The favourable Early Miocene palaeoclimate, as presently observed e.g. in the southern part of East Asia, a region today known to represent biodiversity hotspots, such as that of Yunnan in SW China existing under Cfa/Cwa climate conditions (Su et al., 2022) supported the considerable plant diversity at the Turów Mine. Actually, atmospheric CO_2 has probably almost reached the MCO level in the course of anthropogenic impact, and mid-latitude temperatures are steadily increasing. As regards the high humidity reconstructed for the Early Miocene, the differing palaeogeography with larger water bodies at the expense of continental area in Central Europe likely was an important factor.

CONCLUSIONS

Our revision revealed 102 taxa among the historical carpological collection and 28 more taxa in new materials. The number of 74 carpological taxa originally described from Turów was reduced to 51, but 52 more taxa from the unpublished old collection turned out to be new to the opencast mine. Fossil carpological floras from Turów now include 130 taxa in total. Discovered so far, fossil assemblages represent two biostratigraphic stages that can be related with the Bílina-Brandis and Wiesa-Eichelskopf floristic complexes. Characteristics of the floras, palynostratigraphic evidence and lithostratigraphic position suggest that the most likely age of these floras is between the late Early Miocene (late Burdigalian) and Early/Middle Miocene (latest Burdigalian/Langhian). IPR vegetation analysis and CA palaeoclimate analysis have not detected any change between the suggested biostratigraphic stages, which results from low taxonomic diversity in the older samples. IPR vegetation analysis revealed zonal broad-leaved evergreen forest (BLEF) as the main type of vegetation in the younger interval. *Castanopsis fargesii* of broad-leaved evergreen forest growing at altitudes from 650 to 700 m a.s.l. in Mt. Longqi (China) is suggested as a modern analogue. The CA palaeoclimate analysis indicates MAT of 17–22°C, CMMT of 10–14°C, WMMT of 24–28°C, MAP of 1200–1600 mm (1700 mm) which coincides with most climate proxies obtained with IPR vegetation analysis (MAT of 17.8°C, WMMT of 26.5°C, CMMT of 8°C and MAP of 1596 mm). Cfa Köppen type climate is suggested for the younger levels of Turow, with the driest month probably in the cold season (winter-dry Cw?). The climate parameters obtained for Turów correspond well with those suggested for fossil macro and microfloras of comparable age like Wiesa (except MAP), Berzdorf, the Lower Rhine Basin, and Karpatian microfloras of the Central Paratethys.

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ADDITIONAL INFORMATION

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Appendix 1. The list of revised taxa originally described by Czeczott and Skirgiełło (1959, 1961, 1967, 1975, 1980), Czeczott and Juchniewicz (1975, 1980), Zalewska (1959, 1961) and Baranowska-Zarzycka (2001). PMZ – Prace Muzeum Ziemi

Determination by Czeczott and others	New determination	Current Inv. No. MZ VII/43a/	Numbers published in Prace Muzeum Ziemi (PMZ), 3, 4, 10, 24, 33	References
Acer cf. *hyrcanum* Frisch. et Mey.	*Magnolia burseraceae* (Menzel) Mai	124	103	PMZ 4: 116
Acer sp. 1	*Laurocalyx rhenanum* Kirchheimer	125	103	PMZ 4: 116
Acer sp. 2	*Trigonobalanopsis exacantha* (Mai) Kvacek et Walther; *Ocotea rhenana* (Menzel) Kirchheimer	126	122	PMZ 4: 117
Acer sp. 3	Fabaceae?	127	122	PMZ 4: 117
Ampelopsis sp.	*Ampelopsis rotundata* Chandler	142	23	PMZ 3: 104
Carya bohemica Brabenec	*Carya globosa* (Ludwig) Mädler	26–34	40, 25, 63, 267, 530, 390, 427, 475, 480	PMZ 4: 108
Carya hauffei Kirchheimer	*Carya globosa* (Ludwig) Mädler	35–40	191, 252, 260, 412, 473, 463	PMZ 4: 109
Carya lusatica Czeczott et Skirgiełło	*Carya globosa* (Ludwig) Mädler	41–45	265, 266, 401, 404, 522	PMZ 4: 110
Carya sp. 1	*Carya globosa* (Ludwig) Mädler	53–56	268, 527, 532	PMZ 4: 112
Carya sp. 1	*Carya globosa* (Ludwig) Mädler	57	537	PMZ 4: 112
Carya sp. 2	*Carya globosa* (Ludwig) Mädler	58	36	PMZ 4: 113
Carya sp. 2	*Carya globosa* (Ludwig) Mädler	59	366	PMZ 4: 113
Carya sp. 2	*Carya globosa* (Ludwig) Mädler	60	524	PMZ 4: 113
Carya sp. 2	*Carya globosa* (Ludwig) Mädler	61	521	PMZ 4: 113
Carya turovensis Czeczott et Skirgiełło	*Carya globosa* (Ludwig) Mädler	46–48	2, 88, 367	PMZ 4: 111
Carya ventricosa (Sternberg) Unger	*Carya ventricosa* (Sternberg) Unger	49–51	4, 37, 365	PMZ 4: 111
Durania ehrenbergii Kirchheimer	*Rehderodendron ehrenbergii* (Kirchheimer) Mai	77	42	PMZ 10: 160
Ganitrocera persicoides (Unger) Kirchheimer	*Eomastixia saxonica* (Menzel) Holý	153–237	1, 7, 24, 29, 34, 35, 44, 45, 48, 65, 72, 84–86, 89, 90, 92, 96, 98, 120, 140, 186, 235, 244, 253, 254, 256, 258, 262, 277, 278, 285, 287, 294, 295, 315–317, 326, 335, 349, 353, 359, 368, 369, 372, 373, 378, 380, 385, 386, 391, 394, 397, 398, 410, 416, 420, 425, 440, 441, 445, 447, 454, 457–459, 469, 471, 474, 479, 492, 494, 495, 502, 504, 801, 803, 808, 812	PMZ 24: 52–53
Illicium lusaticum Czeczott et Skirgiełło	*Magnolia ludwigii* Ettingshausen	4–5	412, 513	PMZ 33: 5
Juglans berckheimeri Kirchh.	*Juglans bergomensis* (Balsamo Crivelli) Massalongo	62	41	PMZ 4: 106
Juglans globosa Ludwig	*Carya globosa* (Ludwig) Mädler	64–65	66, 137	PMZ 4: 107
Liquidambar magniloculata Czeczott et Skirgiełło	*Liquidambar europaea* A.Braun	18–21	47, 47bis, 77, 83	PMZ 3: 121
Magnoliaespermum geinitzii (Engelhardt) Kirchheimer	*Magnolia geinitzii* (Engelhardt) Kowalski	3	149	PMZ 24: 47–48
Mastixia amygdalaeformis (Schloth.) Kirchheimer	*Mastixia lusatica* Mai	238–256	26, 38, 39, 64, 94, 99, 245, 382, 405, 483–486, 904	PMZ 24: 49–50
Mastixicarpum limnophilum (Kirchh.) Mai	*Diplopanax limnophilus* (Unger) Czaja	257–284	21, 43, 67, 97, 102, 138, 257, 259, 261, 298, 325, 341, 350, 381, 384, 387, 399, 406, 417, 465, 476, 482, 488, 489	PMZ 24: 51–52
Melia cf. *azedarach* L.	*Melia czeczottii* Gregor	139–141	19, 46, 422	PMZ 10: 110
Nyssa disseminata (Ludwig) Kirchheimer	*Nyssa ornithobroma* Unger	151	121	PMZ 3: 109
Nyssa sp.	*Nyssa ornithobroma* Unger	152	242	PMZ 3: 128

Appendix 1. Continued

Determination by Czeczott and others	New determination	Current Inv. No. MZ VII/43a/	Numbers published in Prace Muzeum Ziemi (PMZ), 3, 4, 10, 24, 33	References
Ocotea rhenana (Menzel) Kirchheimer	*Laurocalyx rhenanum* Kirchheimer	6–14	52, 77, 87, 228, 446, 551–554	PMZ 33: 12
Parabaena europaea Czeczott et Skirgiełło	*Parabaena europaea* Czeczott et Skirgiełło	17	431	PMZ 10: 109
Passiflora kirchheimeri Mai	*Passiflora kirchheimeri*	98	281	PMZ 10: 156
Pterocarya cf. *insignis* Rehd. et Wils., *P.* cf. *rhoifolia* Sieb. et Zucc., *P.* cf. *stenoptera* DC.	*Pterocarya limburgensis* C et E M Reid	72–76	233, 141 bis, 144, 231, 232	PMZ 4: 104
Pterocarya cyclocarpa Schlecht.	*Cyclocarya cyclocarpa* (Schltdl) Iljinskaja	71	230	PMZ 4: 103
Quisqualis pentaptera Mai	?*Craigia bronnii* (Unger) Z. Kvacek, Buzek et Manchester	102	430	PMZ 10: 123
Retinomastixia schultei Kirchheimer	*Retinomastixia oertelii* Gregor	285–299	3, 11, 32, 58, 100, 238, 255, 284, 292, 324, 330, 355, 357, 400, 428	PMZ 24: 53–54
Rubus cf. *laticostatus* C. et E.M. Reid	*Rubus laticostatus*	100	516	PMZ 33: 14
Rubus cf. *tomskiana* Dorofeev	excluded	101	515	PMZ 33: 14
Sabia europaea Czeczott et Skirgiełło	*Sabia europaea* Czeczott et Skirgiełło	128	15, 15 bis	PMZ 3: 99
Sapoticarpum turovensis Czeczott et Skirgiełło	*Zanthoxylum turovense* (Czeczott et Skirgiełło) Gregor	132–137	22, 68, 104, 105, 348, 360, 385	PMZ 24: 44
Sarcococca weylandii Mai	*Sarcococca weylandii*, and *Zanthoxylum tiffnei* Gregor	22	396	PMZ 33: 15
Sparganium haentzschelii Kirchh.	*Sparganium haentzschelii*	310	499	PMZ 33: 19
Sphenotheca incurva Kirchheimer	*Symplocos incurva* (Kirchh.) Manchester et Fritsch	78–79	437, 438	PMZ 10: 162
Spinophyllum daemonorops (Unger) Huard	*Spinopalmoxylon daemonorops* (Unger) Weyland, Kilpper et Berendt emend. Winterscheid	795–804	805–813 (later changed to 554–563)	PMZ 33: 26–28
Spirematospermum wetzleri (Heer) Chandler	*Spirematospermum wetzleri*	307–308	439, 517	PMZ 33: 19
Styrax maxima (Weber) Kirchheimer	*Styrax maxima*	95–97	12, 61, 423	PMZ 10: 164
Symplocos gothani Kirchheimer, *S. lignitarum* (Quenstedt) Kirchheimer, *S. lusatica* Mai	*Symplocos casparyi* Ludwig	80–92	329, 432, 434, 30, 56, 69, 93, 240, 344, 433, 533, 435, 436	PMZ 10: 158–160
Symplocos wiesaensis Kirchheimer	*Symplocos schereri Kirchheimer*	94	18	PMZ 10: 160
Tectocarya lusatica Kirchheimer	*Tectocarya elliptica* (Unger) Holý	301–305	79, 136, 243, 490, 491	PMZ 24: 54
Tetrastigma chandleri Kirchheimer	*Ampelocissus chandleri* (Kirchheimer) Chen et Manchester	143	249, 251	PMZ 3: 104
Trapa sp.	Fabaceae?	103	453	PMZ 10: 157
Tetrastigma chandleri Kirchheimer	*Ampelocissus lobatum* (Chandler) Chen et Manchester	143, 144	249, 251	PMZ 3: 104
Toddalia maii Gregor	*Zanthoxylum maii* (Gregor) Kowalski	129–131	498, 500, 503	PMZ 33: 9
Toddalia naviculaeformis (E.M. Reid) Gregor	*Zanthoxylum naviculaeformis* (E.M. Reid) Kowalski	138	496	PMZ 33: 9
Trigonobalanus exacantha Mai	*Trigonobalanopsis exacantha* (Mai) Kvacek et Walther	23–25, 126	261–263	PMZ 46: 145
Turpinia ettingshausenii (Engel.) Mai	*Turpinia ettingshausenii*	104–123	71, 293, 276, 246, 320, 321, 323, 345, 361, 371, 379, 402, 408, 426, 442, 504, 506, 508, 510, 815	PMZ 33: 15
Vitis cf. *silvestris* Gmel.	*Vitis* cf. *parasilvestris* Kirchheimer	150	247	PMZ 3: 123
Vitis ludwigi A. Braun	*Ampelopsis malvaeformis* (Schlotheim) Mai	145	112, 248	PMZ 3: 102
Vitis lusatica Czeczott et Skirgiełło	*Vitis lusatica* Czeczott et Skirgiełło	147	70	PMZ 3: 124
Vitis teutonica A.Braun	*Vitis teutonica* + *Ampelopsis rotundata* + *Vitis* cf. *parasilvestris*	148	263	PMZ 3:102
Vitis thunbergii Sieb. et Zucc.	*Vitis globosa* Mai	149	250	PMZ 3: 124
Viscum lusaticum Czeczott	*Viscum morlotii* (Unger) E. Knobloch et Kvaček	MZ VII/44/225, 234, 429–433	153, 172, 442–446	PMZ 4: 113

Appendix 1. Continued

Determination by Czeczott and others	New determination	Inv. No. MZ VII/43b/	Numbers published in Prace Muzeum Ziemi (PMZ), 3, 4, 10, 24, 33	References
Chamaecyparis sp.	*Quasisequoia couttsiae* (Heer) Kunzmann and gall	53	197	PMZ 4: 99
Cupressus sp.	Indeterminate plant remain	49	162	PMZ 4: 98
Glyptostrobus europaeus Heer	*Glyptostrobus europaeus* (Brongniart) Unger	2–5, 12	172, 187, 190, 201, 153	PMZ 3: 115
Juniperus sp.	*Magnolia burseraceae* (Menzel) Mai, gall and indeterminate plant remain	55	185	PMZ 4: 100
Keteleeria bergeri Kirchh.	*Cathaya bergeri* (Kirchheimer) Schneider and Indeterminate plant remain	47	208	PMZ 4: 96
Libocedrus salicornioides Endl.	Bud and indeterminate plant remain	51	158	PMZ 4: 99
Metasequoia europaea Zalewska	*Sequoia abietina* (Brongniart in Cuvier) Knobloch	40	207	PMZ 3: 118
Pinus sp.	Indeterminate plant remain	57	311	PMZ 4: 95
Pseudotsuga cf. *glauca* Mayr.	*Cathaya bergeri* (Kirchheimer) Schneider	45	154	PMZ 4: 95
Pseudotsuga cf. *glauca* Mayr.	Indeterminate plant remain	46	229	PMZ 4: 95
Sequoia couttsiae Heer	*Quasisequoia couttsiae* (Heer) Kunzmann	17–25, 27, 62	160, 166, 168, 170, 171, 174, 204, 206, 222, 155	PMZ 3: 116
Sequoia langsdorfii (Brongn.) Heer	*Quasisequoia couttsiae* (Heer) Kunzmann	26, 39	210, 217	PMZ 3: 117
Taxodium distichum miocenicum Heer	*Quasisequoia couttsiae* (Heer) Kunzmann	43	198 (transferred to 200)	PMZ 3: 119
Thuja cf. *occidentalis* L.	Unidentified seed and fruit	56	301	PMZ 4: 101

Appendix 2. The list of all (including published, unpublished and newly found materials) carpological taxa found in Turów according to fossiliferous layers, levels and samples (sites – new materials) where they were found

No.	Taxa	Historical collection and materials																			New materials	
		L9		Level intermediate					Level 3					L12		L6	L4		TII/1	TII/2	s1	s2/1
		h		o	a	c	b		d	e	f	g		i	j		x					s2/2
1	*Acalypha fragilis*																				1	1
2	*Acer* sp. 1																					1
3	*Acer* sp. 2																					1
4	*Acer* aff. *hercynicum*																					1
5	*Alnus* sp.																					1
6	*Ampelocissus chandleri*	1		1	1		1	1	1			1										
7	*Ampelocissus lobatum*	1	1	1	1		1	1	1			1										
8	*Ampelopsis malvaeformis*	1																			1	
9	*Ampelopsis rotundata*		1	1				1											1			1
10	*Aracispermum canaliculatum*																		1		1	
11	*Broussonetia* aff. *rugosa*																				1	
12	*Carex plicata*																				1	
13	*Carpinus* sp.																					1
14	*Carya globosa*			1	1	1	1	1	1	1		1		1	1							1
15	*Carya ventricosa*			1			1	1	1						1						1	1
16	*Cathaya bergeri*				?		?	1														
17	*Cephalanthus pusillus*			1																		
18	*Cephalotaxus miocenica*																				1	1
19	*Cercidiphyllum helveticum*																					1
20	*Chionanthus kornii*							1														
21	*Choerospondias turovensis*			1	1		1	1					1									
22	*Laurocalyx* sp. 1			1				1				?		?								
23	*Cleome probstii*																					1
24	*Cornus gorbunovii*			1	1		1	1					1									
25	*Craigia bronnii*			1			1	1														1
26	*Cyclocarya cyclocarpa*			1	1		1	1	1			1										
27	*Daphniphyllum cylindricum*	1						1														

Appendix 2. Continued

No.	Taxa	Historical collection and materials																			New materials	
		L9		Level intermediate					Level 3					L12		L6	L4		TII/1	TII/2	s1	s2/1
		h		o	a	c	b		d	e	f	g		i	j		x					s2/2
28	*Diplopanax limnophilus*	1	1	1	1	1	1	1	1	1	1	1	1	1	1							1
29	*Distylium protogaeum*							1													1	1
30	Hamamelidoideae							1						1								
31	*“Fothergilla” europaea*																					1
32	*Ehretia europea*			1			1	1														
33	*Eleutherococcus uralensis*				1			1														
34	*Palaeocarya macroptera*																				1	1
35	*Eomastixia saxonica*	1		1	1	1	1	1	1	1	1	1	1	1	1				1	1		
36	*Epipremnites reniculus*						1	1														
37	*Eurya stigmosa*		1	1				1					1								1	
38	*Ficus lucida*																				1	
39	*Frangula solitaria*																					1
40	*Gironniera carinata*																				1	
41	*Gironniera neglecta*			1	1		1	1				1	1						1			1
42	*Gironniera verrucata*																				1	
43	*Glyptostrobus europaea*		1					1					1							1	1	1
44	*Hypericum septestum*																				1	
45	*Ilex* cf. *ahrensii*							1														
46	*Ilex lotschii*										1?											1
47	*Ilex delicata*						1															
48	*Ilex* cf. *saxonica*																			1		1
49	*Itea europaea*											1									1	
50	*Juglans bergomensis*							1														
51	*Laurocarpum* sp.			1			1	1														
52	*Liquidambar europaea*		1	1	1		1	1						1					1			1
53	*Liriodendron geminata*						1	1														
54	*Lemnospermum pistiforme*																				1	
55	*Magnolia burseraceae*			1	1		1	1	1			1		1					1			
56	*Magnoliaespermum geinitzii*												1				1					1
57	*Magnolia germanica*		1	1	1		1	1				1	1								1	
58	*Magnolia ludwigii*			1	1		1	1					1								1	1
59	*Mastixia lusatica*	1		1	1	1	1	1	1	1	1	1	1	1	1						1	1
60	*Melia czeczottii*	1		1			1	1			1	1	1									1
61	*Meliosma miessleri*			1	1		1	1														1
62	*Meliosma wetteraviensis*			1	1		1	1														1
63	*Microdiptera uralensis*											1										
64	*Moehringia miocaenica*																					1
65	*Morella stoppii*							1														
66	*Myrica boveyana*		1					1												1		
67	*Myrica ceriferiformis*												1									
68	*Nyssa disseminata*						1													1		
69	*Nyssa ornithobroma*			1			1	1	1		?										1	1
70	*Laurocalyx rhenanum*			1	1		1	1	1			1	1	1	1				1	1		
71	*Ostrya scholtzii*																					1
72	*Paliurus favonii*																			1		
73	*Parabaena europaea*			1																		
74	*Parthenocissus britannica*												1									
75	*Passiflora kirchheimeri*						1															
76	*Paulownia cantalensis*																				1	
77	*Pentapanax tertiarius*		1					1														
78	*Phellodendron lusaticum*																				1	
79	*Laurocalyx* sp. 3																			1		
80	*Physalis pliocaenica*																				1	
81	cf. *Pieris quinquealata*		1	1	?																	
82	*Platanus neptuni*																			1		
83	*Prunus leporimontana*							1														
84	*Prunus langsdorfii*							1	?	?												

Appendix 2. Continued

No.	Taxa	Historical collection and materials																			New materials	
		L9		Level intermediate					Level 3					L12		L6	L4		TII/1	TII/2	s1	s2/1
		h		o	a	c	b		d	e	f	g		i	j		x					s2/2
85	*Pterocarya limburgensis*	1		1	1		1	1	1			1	1						1		1	1
86	*Quasisequoia couttsiae*		1					1					1							1		
87	*Quercus sapperi*			1				1														
88	*Rehderodendron ehrenbergii*							1														1
89	*Retinomastixia oertelii*			1	1	1	1		1			1										
90	*Rhamnospermum bilobatum*																			1		
91	*Rhodoleia bifollicularis*																					1
92	*Rubus laticostatus*						1														1	
93	*Rubus semirotundatus*												1							1		
94	*Sabalites* sp.										1											
95	*Sabia europaea*			1	1			1	1													1
96	*Sambucus lucida*												1									
97	*Sarcococca weylandii*							1	1													
98	*Laurocalyx* sp. 2							1														
99	*Sequoia abietina*		1					1					1								1	1
100	*Sinomenium* aff. *cantalense*																					1
101	*Solanispermum reniforme*																				1	
102	*Sparganium haentzschelii*			1	1			1														
103	*Sparganium pusilloides*			1																	1	
104	*Spinopalmoxylon daemonorops*																			1		
105	*Spirematospermum wetzleri*						1	1														
106	*Stratiotes kaltennordheimensis*																			1		
107	*Styrax maxima*	1		1	1	1	1	1	1	1	1			1	1				1			1
108	*Symplocos casparyi*	1		1	1	1	1	1	1	1		1	1	1	1				1	1	1	1
109	*Symplocos incurva*			1					1	1		1										
110	*Symplocos germanica*																		1			
111	*Symplocos schereri*								1													1
112	*Tectocarya elliptica*			1	?	1	1				1	1										1
113	*Ternstroemia sequoioides*			1	1		1														1	
114	*Tetraclinis salicornioides*																					1
115	*Trema lusatica*			1	1		1														1	
116	*Trigonobalanopsis exacantha*		1	1	1		1	1	1			1		1					1			1
117	cf. *Tsuga moenana*														?							
118	*Turpinia ettingshausenii*	1	1	1	1	1	1	1	1			1	1	1	?				1		1	1
119	*Urospathites dalgasii*						1														1	
120	*Viburnum* cf. *hercynicum*			1																		
121	*Viscum morlotti*			1																		
122	*Vitis palaeomuscadinia*						1	1													1	
123	*Vitis* aff. *parasilvestris*						1	1					1								1	1
124	*Vitis globosa*			1	1		1		1										1			
125	*Vitis lusatica*																		1			
126	*Vitis teutonica*			1																	1	1
127	*Zanthoxylum maii*			1	1		1												1			
128	*Zanthoxylum naviculaeformis*				1		1															
129	*Zanthoxylum tiffnei*								1													
130	*Zanthoxylum turovense*			1	1		1		1						1				1			
131	*Zizyphus striatus*			1	1		1	1							?							

Appendix 3a. Assignment of the individual taxa to the different components for Turów – intermediate level

Site: Turów (intermediate level)	ZONAL									AZONAL			PROBLEMATIC taxa	
Taxa	CONIF	BLD	BLE	SCL	LEG	ZONPALM	ARBFERN	DRY HERB	MESO HERB	AZONAL WOODY	AZNW	AQUATIC		
Ampelocissus chandleri		0.50								0.50				1.00
Ampelocissus lobatum		0.50								0.50				1.00
Ampelopsis rotundata		0.50								0.50				1.00
Burretia sp.		1.00												1.00
Carya globosa		1.00												1.00
Carya ventricosa		1.00												1.00
Cathaya bergeri	1.00													1.00
Cephalanthus pusillus	1.00													1.00
Laurocalyx sp. 1 (=*Cinnamomum lusaticum*)			1.00											1.00
Cornus gorbunovii		1.00												1.00
Craigia bronnii		0.50								0.50				1.00
Cyclocarya cyclocarpa		1.00												1.00
Daphniphyllum cylindricum			1.00											1.00
Diplopanax limnophilus			1.00											1.00
Distylium protogaeum			1.00											1.00
Ehretia europea			1.00											1.00
Eleutherococcus uralensis		1.00												1.00
Eomastixia saxonica			1.00											1.00
Epipremnites reniculus									1.00					1.00
Eurya stigmosa			1.00											1.00
Gironniera neglecta			1.00											1.00
Glyptostrobus europaea										1.00				1.00
Chionanthus kornii		1.00												1.00
Choerospondias turovensis		1.00												1.00
Ilex cf. *ahrensii*		0.50	0.50											1.00
Ilex delicata		0.33	0.33	0.34										1.00
Juglans bergomensis		1.00												1.00
Laurocarpum sp.			1.00											1.00
Liquidambar europaea		0.50								0.50				1.00
Liriodendron geminata		1.00												1.00
Magnolia burseraceae										1.00				1.00
Magnolia germanica		0.50								0.50				1.00
Magnolia ludwigii		0.33	0.33							0.34				1.00
Mastixia lusatica			1.00											1.00
Melia czeczottii		0.80	0.20											1.00
Meliosma miessleri		0.50	0.50											1.00
Meliosma wetteraviensis		0.20	0.80											1.00
Morella stoppii			1.00											1.00
Myrica boveyana			0.50	0.50										1.00
Nyssa disseminata		0.50								0.50				1.00
Nyssa ornithobroma		0.50								0.50				1.00
Laurocalyx rhenanum			1.00											1.00
Parabaena europaea			1.00											1.00
Passiflora kirchheimeri									0.50		0.50			1.00
Pentapanax tertiarius		0.50	0.50											1.00
Pieris quinquealata cf.		0.50								0.50				1.00
Prunus leporimontana		0.50	0.50											1.00
Prunus langsdorfii		1.00												1.00
Pterocarya limburgensis		0.50								0.50				1.00
Quasisequoia couttsiae										1.00				1.00
Quercus sapperi		1.00												1.00
Rehderodendron ehrenbergii		1.00												1.00
Retinomastixia oertelii			1.00											1.00
Rubus laticostatus		0.50								0.50				1.00

Appendix 3a. Continued

Site: Turów (intermediate level)	ZONAL									AZONAL			PROBLEMATIC taxa	
Taxa	CONIF	BLD	BLE	SCL	LEG	ZONPALM	ARBFERN	DRY HERB	MESO HERB	AZONAL WOODY	AZNW	AQUATIC		
Sabia europaea		0.50	0.50											1.00
Sarcococca weylandii			1.00											1.00
Laurocalyx sp. 2 (=*Sassafras lusaticum*)		1.00												1.00
Sequoia abietina	0.50									0.50				1.00
Sparganium haentzschelii											1.00			1.00
Sparganium pusilloides											1.00			1.00
Spirematospermum wetzleri											1.00			1.00
Styrax maxima		1.00												1.00
Symplocos casparyi			1.00											1.00
Symplocos incurva			1.00											1.00
Tectocarya elliptica			1.00											1.00
Ternstroemia sequoioides			1.00											1.00
Zanthoxylum maii			1.00											1.00
Zanthoxylum naviculaeformis			1.00											1.00
Zanthoxylum turovensis			1.00											1.00
Trema lusatica			1.00											1.00
Trigonobalanopsis exacantha			1.00											1.00
Turpinia ettingshausenii			1.00											1.00
Urospathites dalgasii											1.00			1.00
Viburnum cf. *hercynicum*		1.00												1.00
Viscum morlotti													1.00	1.00
Vitis globosa		0.50								0.50				1.00
Vitis palaeomuscadinia		0.50								0.50				1.00
Vitis cf. *parasilvestris*		0.50								0.50				1.00
Vitis teutonica		0.50								0.50				1.00
Zizyphus striatus				1.00										1.00
														80.00
Sum of taxa	2.50	27.66	29.66	1.84	0.00	0.00	0.00	0.00	1.50	11.34	4.50	0.00	1.00	80.00
Sum zonal taxa														63.16
Percentage of zonal taxa	3.96	43.79	46.96	2.91	0.00	0.00	0.00	0.00	2.37					100.00
Sum zonal woody angiosperms														59.16
Percentage of zonal woody angiosperms		46.75	50.14	3.11	0.00	0.00								100.00
Sum of % SCL + LEG	3.11													
Sum of % DRY HERB + MESO HERB (ZONAL HERB)	2.37													

Appendix 3b. Characteristics of the zonal vegetation units (redrawn from Kovar-Eder et al., 2008)

Vegetation type	Zonal woody components			Zonal herbaceous components (fossil record)	Zonal herbaceous components (modern record)
	BLD	BLE	SCL + LEG	MESO + DRY HERB	MESO + DRY HERB
Broad-leaved deciduous forests	>80%			≤ 30%	40–70%
Ecotone	75–80%	<30%	<20%	<30%	40–55%
Mixed mesophytic forests	<75%				
Ecotone		30–40%			
Broad-leaved evergreen forests		>40%	(SCL + LEG) < BLE	<25%	10–45%
Subhumid scleropyllous forests			≥ 20%	<30%	40–55%
Xeric open woodland		<30%	≥ 20%	30–40%; MESO HERB > DRY HERB up to 10% of all zonal herbs	n.a.
Xeric grassland or steppe		<30%		≥ 40%	n.a.