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Revision of a late Oligocene florule from the south-western edge of the Lower Rhine Basin (western Germany)

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ABSTRACT. The late Oligocene flora from the Nirmer Tunnel at the south-western edge of the Lower Rhine Basin was first described by Menzel (1913). A revision of Menzel's original material indicates that most taxa are from the vegetation of riparian forests (*Magnolia burseracea*, *Ocotea rhenana*, *Rhodoleia bifollicularis*, *Eotrigonobalanus furcinervis*, *Trigonobalanopsis rhamnoides*, *Sparganium* sp. vel *Typha* sp.) and mesophytic forests (*Carpolithes dactyliformis*, *Sapotacites minor*). Some specimens cannot be identified, so they are named *Dicotylophyllum* div. spp. here. The fossil species *Carpolithes dactyliformis* (sandstone imprints and endocasts) belongs to Cornaceae subfamily Mastixioideae and is lectotypified here. The floral assemblage is compared with some similar floras from the Oligocene of Central Europe.

KEYWORDS: macroflora, Late Oligocene, Köln Formation, Lower Rhine Basin

INTRODUCTION

Late Oligocene fossiliferous deposits bear the oldest evidence of vegetation from the Lower Rhine Basin and are restricted to the south-eastern edge of the basin and the Siebengebirge Volcanic Field (Winterscheid & Kvaček 2016a). The late Oligocene flora treated herein is from the Nirmer Tunnel near the town of Aachen – first described by Menzel (1913) – and is an exceptional case outside that region. The sandstone deposit at this locality is a late Oligocene residue directly within the sunken block east of the Feldbiss Fault at the south-western edge of the Lower Rhine Basin.

This paper is part of a ongoing systematic-taxonomic revision of the late Oligocene floras from different localities and stratigraphic levels of the Siebengebirge Volcanic Field and the southern part of the Lower Rhine Basin, with the aim of reconstructing the palaeofloristic, environmental and palaeogeographic settings.

GEOLOGICAL SETTING

The Cenozoic Lower Rhine Basin cuts into the north-western margin of the Rhenish Massif and consists of different tectonic blocks bordered by NNW–SSE-oriented fault systems. The Roer Valley Graben is one of the important tectonic structures in the south-western part of the Basin. The western main border fault in the southern part of the Roer Valley Graben is the Feldbiss Fault. At this fault, early Carboniferous sandstone and claystone and late Oligocene siliciclastic deposits are found next to each other between the towns of Aachen and Stolberg. On the sunken block east of the Feldbiss Fault, isolated relict siliciclastic deposits are preserved, containing fluviatile crossbedded sand and sandstone (Holzapfel 1910: 127–128, fig. 4) of the basin edge facies of the Köln Formation. These fluviatile deposits overlay marine sand of the Chattian Grafenberg Formation. Because of the isolation of these relict deposits, their exact position within the Köln Formation is not possible to determine.

LOCALITY AND MATERIAL

LOCALITY

Geographic position. Topographic map: TK25–5202 Aachen. Coordinates: N 50°47′14.9″ E 6°10′08.1″. Bundesrepublik Deutschland, Land Nordrhein Westfalen, Landkreis Aachen, Stadt Aachen, Ortsteil Eilendorf. The fossiliferous siliciclastic deposits were exposed during the construction of the railway tunnel (Nirmer Tunnel) near Eilendorf east of Aachen in 1847.

Literature. Holzapfel (1910: 128; text-fig. 4), Menzel (1913: 3, 78–86; pl. 7), Kirchheimer (1936b: 115; text-fig. 22), Mai (1975: 567–571).

MATERIAL

Conservation status. The plant remains are preserved as impressions (leaves) and endocasts (seeds) in light gray and light brown quartzitic sandstone, which show only the coarse structure of the plant morphology. All figured specimens from Menzel (1913: pl. 7) were re-investigated for the present study. Some characters of leaf venation illustrated by Menzel (1913: pl. 7) are no longer visible (cf. figs 2–4).

Repository. Museum für Naturkunde, Leibnitz Institute for Evolution and Biodiversity Science, Berlin [MfN]. Collection: Preußische Geologische Landesanstalt, Berlin [P.G.L.A. coll.]. Collectors: Geologist E. Holzapfel (afilliated with Preußische Geologische Landesanstalt) during geological mapping, and private collector Müller (afilliated to Königliche Polytechnische Schule zu Aachen) in the first decade of the 20th century.

SYSTEMATIC PALAEOBOTANY

MAGNOLIIDAE

Family **Magnoliaceae** Juss. 1789 nom. cons.

Genus ***Magnolia*** L. 1753

Magnolia burseracea (Menzel 1913) Mai 1975

Fig. 3A–E

1913 *Carpolithus burseraceus* Menzel: 84–86; pl. 7, figs 10–12 [Nirm].

1975 *Magnolia burseracea* (Menzel) Mai: 567–571; pl. 35, figs 24–33 [Nirm].

Specimens examined. MB.Pb.2005/0016 (orig. no. 221) [lectotype] = Menzel (1913: pl. 7, figs 12a, 12b) = Mai (1975: pl. 35, figs 24, 25), MB.Pb.2005/0014a–b (orig. no. 232) [syntype] = Menzel (1913: pl. 7, figs 11a, 11b), MB.Pb.2005/0023 (orig. no. 230) [syntype] = Menzel (1913: pl. 7, fig. 10) = Mai (1975: pl. 35, fig. 26).

Description. For detailed description, see Menzel (1913: 84–86) and Mai (1975: 567–571).

Notes. The description of *Magnolia burseracea* refers to impressions and endocasts from late Oligocene sandstone. The species was well defined by Menzel (1913: 84–86) and particularly in the description and emended diagnosis by Mai (1975: 567–571).

Occurrence and habitat. In Central Europe in late Oligocene and Miocene browncoal and sand deposits of swamp and fluviatile

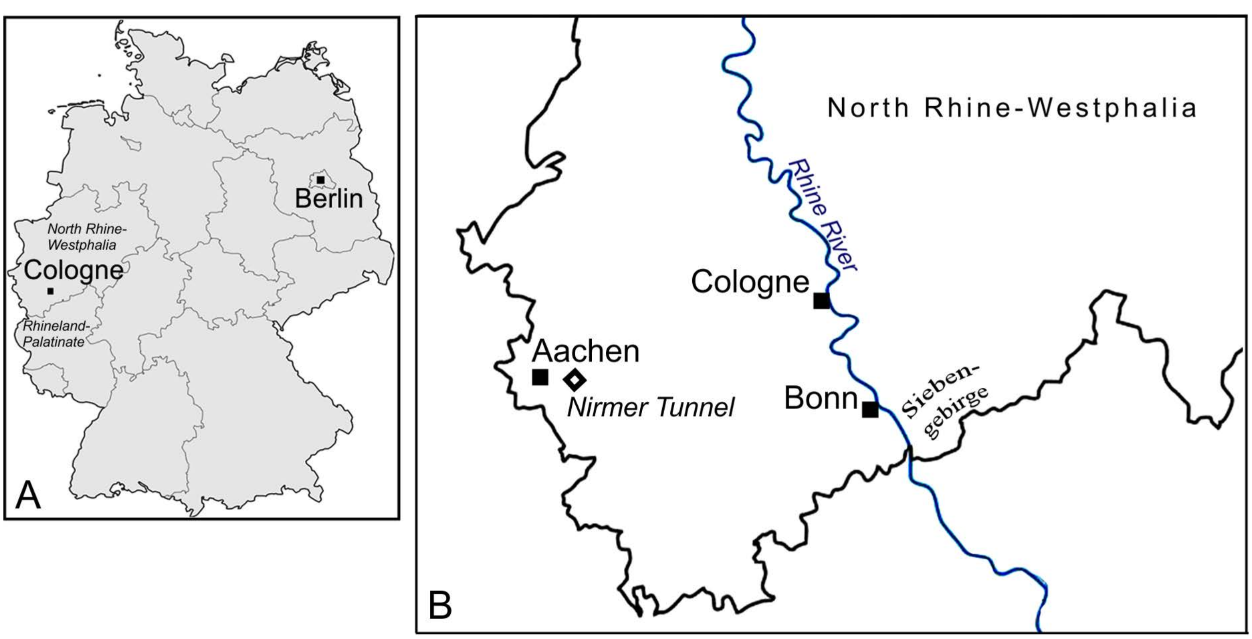

Fig. 1. Location of the investigated area in Germany (A), and in North Rhine-Westphalia (B)

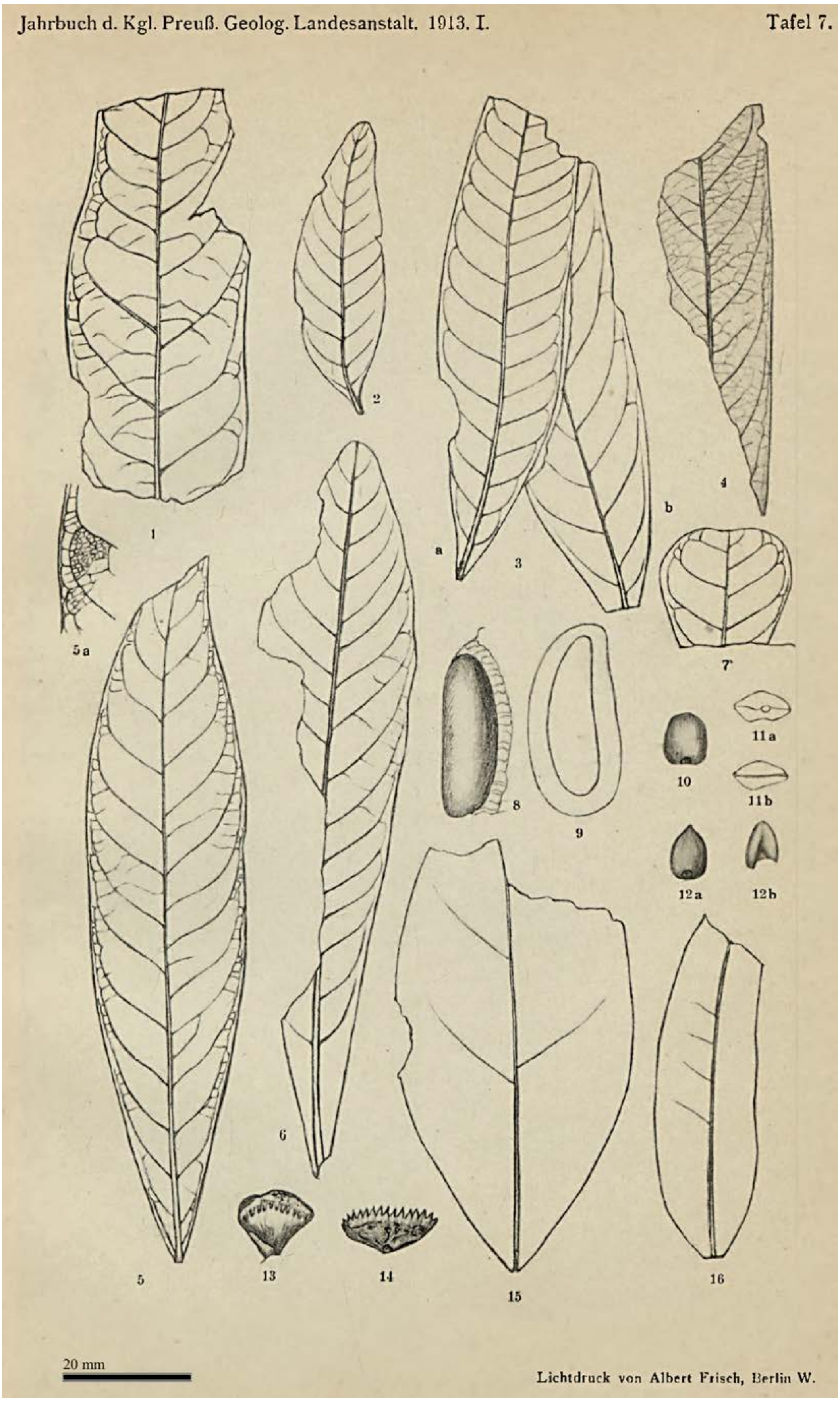

Fig. 2. Facsimile of Plate 7 from Menzel 1913: **1**. *Quercus lyelli* Heer; **2–3a**. *Quercus aizoon* Heer; **3b**, **4**, **5**. *Laurus tristaniaefolia* Weber; **5a**. (magnification 1.5 ×); **6**. *Myrsinophyllum doryphora* Unger; **7**. *Sapotacites minor* Unger; **8, 9**. *Carpolithes dactyliformis* Menzel; **10–12**. *Carpolithes burseraceus* Menzel; **13, 14**. "*Unbestimmbare Zapfenschuppen*"; **15, 16**. "*Unbestimmbare Blattreste*"

habitats (Mai 1975). In the Lower Rhine Basin this taxon occurs also in the late Oligocene sediments of the Siebengebirge Volcanic Field (Winterscheid & Kvaček 2014, 2016b), in the early Miocene fluviatile sand and clay deposits of Adendorf (Kempf 1968, as *M. sinuata* Kirchh.), Kreuzau (Pingen 1994), in the Fortuna-Garsdorf open-cast mine (Pingen 2001), and in middle to late Miocene fluviatile sand deposits of the Köln, Ville and Inden Formation in different open-cast mines (Kirchheimer 1936a, b, Thomson 1958, Van der Burgh 1987, 1988).

Family **Lauraceae** Juss. 1789, nom. cons.

Genus ***Ocotea*** Aubl. 1775

Ocotea rhenana Menzel 1913

Fig. 3G

1913 *Ocotea rhenana* Menzel: 30–31; pl. 4, figs 2–5 [Herzogenrath, middle Miocene].

1936b Mastixioideae gen. et sp. indet. – Kirchheimer: 115–116; text-figs 22a [Nirm].

1971 *Ocotea rhenana* Menzel – Mai: 321; pl. 33, figs 8–11 [Herzogenrath, middle Miocene].

Specimen examined. MB.Pb.2005/0024 = Kirchheimer (1936b: text-fig. 22a), Mai (1971: pl. 33, fig. 9).

Description. Inner cast of a round, bowl-shaped cupule 15 mm in diameter, with central round discus 5 mm in diameter, at the point of attachment of the fruit.

Notes. The nearest living relative of *Ocotea rhenana* Menzel is the modern species *Ocotea foetens* (Aiton) Baill. from the laurel forests of the Canary Islands.

Occurrence and habitat. Late Oligocene to late Miocene in Central Europe. In the Lower Rhine Basin also in early Miocene fluviatile sands from Adendorf (authors coll.).

Family **Typhaceae** Juss. 1789, nom. cons.

cf. Genus ***Sparganium*** L. 1753
vel Genus ***Typha*** L. 1753

cf. *Sparganium* sp. vel *Typha* sp.

Fig. 3F

Specimen examined. MB.Pb.2017/1477.

Description. Fragment 35 mm long, and 20 mm wide, of a linear-shaped oblong leaf with entire margin and prominent midrib accompanied by parallelodromous venation.

Notes. This leaf morphology is typical for leaves of the genus *Sparganium* L. and *Typha* L., which are elements of wetland environments. This leaf type is often described from Oligocene and Neogene floras and named *Typha latissima* A.Braun.

Family **Hamamelidaceae**
R.Br. in C.Abel 1818, nom. cons.

Genus ***Rhodoleia*** Champ. ex Hook.f. 1850

Rhodoleia Champ. ex Hook.f.
(Bot. Mag., 76 [3(6)]: pl. 4509. 1850).
Generic type: *R. championii* Hook.f. 1850.

New synonym: *Saxifragaceaecarpum* Menzel (Jahrb. Preuss. Geol. Landesanst., 34: p. 32. 1913), syn. nov. Generic type: *S. bifolliculare* Menzel 1913.

Rhodoleia bifollicularis
(Menzel 1913) Mai 2001

Fig. 3H–J

1913 *Saxifragaceaecarpum bifolliculare* Menzel: 32–34; pl. 4, figs 7–9 [Herzogenrath, middle Miocene].

1968 *Saxifragaceaecarpum bifolliculare* Menzel – Mai: 185–189; pl. 38, figs 1–8 [Herzogenrath, middle Miocene].

2001 *Saxifragaceaecarpum bifolliculare* Menzel – Pingen: 225; pl. 1, figs 4–5 [Fortuna-Garsdorf, early Miocene].

2001 *Rhodoleia bifollicularis* (Menzel 1913) Mai: 163–164; text-fig. 1B; pl. 1, figs 4–9; pl. 2, figs 11–15; pl. 3. figs 7–8; pl. 4. figs 6–7 [Herzogenrath, middle Miocene].

Specimens examined. MB.Pb.2017/1475, MB.Pb.2017/1478a–c.

Description. The endocasts show two elongated carpels, which are fused from base to apex, over their entire length. Carpels closed, ca 27 mm long (not fully preserved), 13–17 mm wide and 4–5 mm thick; seeds not visible.

Notes. *Rhodoleia bifollicularis* was first described as *Saxifragaceaecarpum bifolliculare* by Menzel (1913) and revised by Mai (1968) with a detailed description of this taxon on the basis of Menzel's original material.

Fig. 3. **A–E**. *Magnolia burseracea* (Menzel) Mai, seeds; **A**. MB.Pb.2005/0023 [syntype] = Menzel (1913: pl. 7, fig. 10) = Mai (1975: pl. 35, fig. 26), imprint, lateral side; **B–C**. MB.Pb.2005/0014a–b [syntype] = Menzel (1913: pl. 7, figs 11a–11b), imprint, basal (B) and apical view (C); **D–E**. MB.Pb.2005/0016 [lectotype] = Menzel (1913: pl. 7, figs 12a–12b) = Mai (1975: pl. 35, figs 24–25), imprint (D) and endocast (E) of seed; **F**. *Sparganium* sp. vel *Typha* sp., leaf fragment, MB.Pb.2017/1477; **G**. *Ocotea rhenana* Menzel, cupule, MB.Pb.2005/0024; **H–J**. *Rhodoleia bifollicularis* (Menzel) Mai, endocasts of carpels; **H**. MB.Pb.2017/1475; **I**. MB.Pb.2017/1478a; **J**. MB.Pb.2017/1478b; **K–M**. *Carpolithes dactyliformis* Menzel, endocasts; **K**. MB.Pb.2005/0027 [lectotype]; **L**. MB.Pb.2005/0022 [syntype], imprint of outer endocarp; **M**. MB.Pb.2005/0028. Scale bar: A–E = 5 mm; F–M = 10 mm

Occurrence and habitat. Besides the here-described fruits of *Rhodoleia bifollicularis* from fluviatile sands of the late Oligocene Köln Formation of Nirm, this taxon is also found in the Lower Rhine Basin in aeolian sands of the early Miocene (Burdigalian) Köln Formation (Morken Sand, Layer 5D) from the Garzweiler open-cast mine near Bergheim west of Cologne (Pingen 2001), and from fluvial sandy channel deposits in Frimmersdorf Seam (Layer 6D) of the middle Miocene (Serravallian) Ville Formation from Herzogenrath north of Aachen

(Menzel 1913). It is also found in the early Miocene of Osieczów in western Poland (Raniecka-Bobrowska 1962). The extant genus *Rhodoleia* is monotypic with the species *Rhodoleia championii* Hook.f., which is an element of laurel forests under subtropical humid climatic conditions in East and South-East Asia (Mai 2001).

Family **Fagaceae** Dumort. 1829, nom. cons.

Genus ***Eotrigonobalanus*** H.Walther & Kvaček in Kvaček & H.Walther 1989

Eotrigonobalanus furcinervis (Rossm. 1840) H.Walther & Kvaček in Kvaček & H.Walther 1989

Fig. 4A–G

1840 *Phyllites furcinervis* Rossmässler: 33–34; pl. 6, fig. 25; pl. 7, figs 26–31 (32–37) [Staré Sedlo (Altsattel), late Eocene].

1862 *Quercus lyellii* Heer: 1058–1060; pl. 63, figs 2–9; pl. 64, figs 1–4; pl. 65, fig. 12b; pl. 66, figs 1, 2; pl. 68, figs 4–5 [Bovey Tracey, Oligocene].

1913 *Quercus lyellii* Heer – Menzel: 78; pl. 7, fig. 1 [Nirm].

p.p. 1913 *Quercus aizoon* Heer – Menzel: 78–79; pl. 7, fig. 3a, non fig. 2 [Nirm].

1913 *Laurus tristaniaefolia* C.O.Weber – Menzel: 79–80; pl. 7, figs 3b, 4–5, 5a [Nirm].

1913 *Myrsinophyllum doryphora* (Unger 1866) Menzel 1913: 80–81; pl. 7, fig. 6 [Nirm].

1989 *Eotrigonobalanus furcinervis* (Rossm. 1840) Walther & Kvaček in Kvaček & Walther: 581–593; pl. 33–36; pl. 38, fig. 3; pl. 39–46; pl. 47, figs 1–3.

Specimens examined. MB.Pb.2005/0026 (orig. no. 227) = Menzel (1913: pl. 7, fig. 1, as *Quercus lyellii*). MB.Pb.2005/0012 (orig. no. 233) = Menzel (1913: pl. 7, fig. 3a, as *Quercus aizoon*). MB.Pb.2005/0013 (orig. no. 234) = Menzel (1913: pl. 7, fig. 3b, as *Laurus tristaniaefolia*), MB.Pb.2005/0017 (orig. no. 222) = Menzel (1913: pl. 7, fig. 4, as *Laurus tristaniaefolia*), B.Pb.2005/0019 (orig. no. 235) = Menzel (1913: pl. 7, fig. 5, 5a, as *Laurus tristaniaefolia*). MB.Pb.2005/0011 (orig. no. 224) = Menzel (1913: pl. 7, fig. 6, as *Myrsinophyllum doryphora*).

Description. Leaves as impressions in sandstone. Leaves simple, leaf attachment marginal. Lamina attachment petiolate, laminar size microphyll to notophyll, laminar shape elliptic, oblong and obovate, lamina symmetrical, up to 110 mm long, 19–29 mm wide. Margin only entire in the present population, base angle acute and base shape cuneate, apex angle acute, apex shape straight. Primary venation pinnate, secondary venation craspedodromous, secondary vein spacing and vein angles uniform, veins sub-parallel and branching near margin, intersecondaries present (typical for entire-margined forms).

Notes. The extinct *Eotrigonobalanus furcinervis* shows wide morphological variability in laminar shape, leaf margin, and venation patterns (Kvaček & Walther 1989, Winterscheid & Kvaček 2016a). *Eotrigonobalanus* is an extinct genus and is strongly isolated within the Fagaceae (Grímsson et al. 2016).

Occurrence and habitat. This taxon occurred in Europe from the Eocene to the early Miocene (Denk et al. 2012). In the Lower Rhine Basin it is very frequent in the late Oligocene pre-volcanic fluviatile siliciclastic deposits of the Siebengebirge Volcanic Field (Weyland 1940) and from Altenrath and Stallberg at the south-eastern rim of the basin (Winterscheid & Kvaček 2016a). The specimens from Kreuzau (Weyland 1934, Ferguson 1971) are from early Miocene sand and clay deposits. In the Lower Rhine Basin, *Eotrigonobalanus furcinervis* grew in late Oligocene and early Miocene riparian forests in fluviatile environments.

Genus ***Trigonobalanopsis*** Kvaček & H.Walther 1988

Trigonobalanopsis rhamnoides (Rossm. 1840) Kvaček & H.Walther 1988

Fig. 4H

1840 *Phyllites rhamnoides* Rossmässler: 35–36; pl. 8, figs 30–31 [Staré Sedlo (Altsattel), late Eocene].

p.p. 1913 *Quercus aizoon* Heer – Menzel: 78–79; pl. 7, fig. 2, non fig. 3a [Nirm].

1988 *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & Walther: 405–413; pl. 49, figs 1–8; pl. 50–54; pl. 55, figs 2–7; pl. 56, figs 1–4; pl. 57, figs 2–4.

Specimen examined. MB.Pb.2005/0021 (orig. no. 218) = Menzel (1913: pl. 7, fig. 2, as *Quercus aizoon*).

Description. Leaf as impression in sandstone. Leaf simple, leaf attachment marginal. Lamina attachment petiolate, laminar size microphyll, laminar shape ovate to oblong, 45 mm long, 15 mm wide. Margin entire, base angle acute, base shape cuneate, slightly asymmetrical, apex angle acute, apex shape

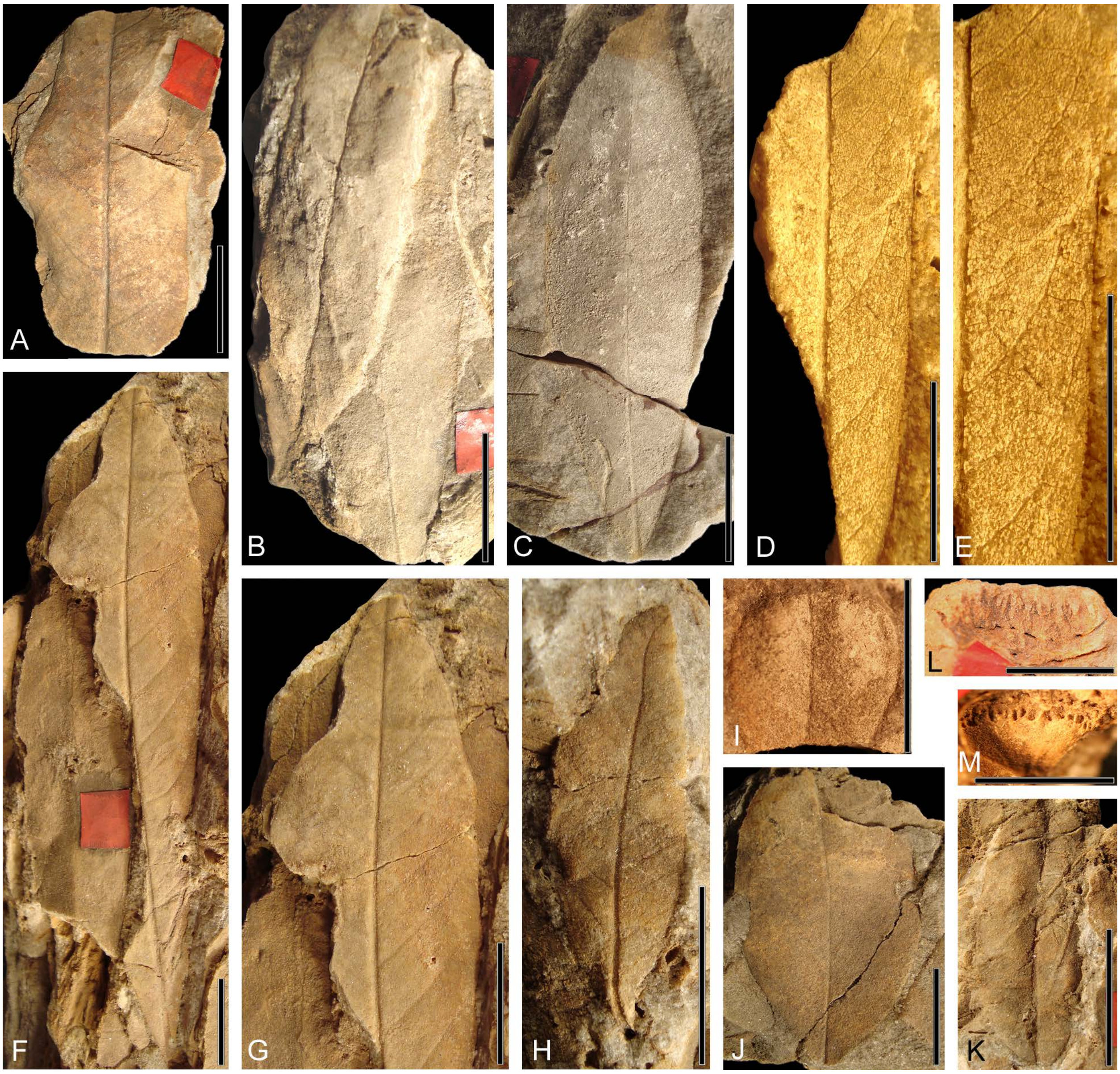

Fig. 4. **A–G**. *Eotrigonobalanus furcinervis* (Rossm.) H.Walther & Kvaček in Kvaček & H.Walther, leaves; **A**. MB.Pb.2005/0026 = Menzel (1913: pl. 7, fig. 1, as *Quercus lyellii*); **B**. MB.Pb.2005/0012 = Menzel (1913: pl. 7, fig. 3a, as *Quercus aizoon*), MB.Pb.2005/0013 = Menzel (1913: pl. 7, fig. 3b, as *Laurus tristaniaefolia*); **C**. MB.Pb.2005/0019 = Menzel (1913: pl. 7, fig. 5, 5a, as *Laurus tristaniaefolia*); **D–E**. MB.Pb.2005/0017 = Menzel (1913: pl. 7, fig. 4, as *Laurus tristaniaefolia*); **F–G**. MB.Pb.2005/0011 = Menzel (1913: pl. 7, fig. 6, as *Myrsinophyllum doryphora*); **H**. *Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & H.Walther, leaf, MB.Pb.2005/0021 = Menzel (1913: pl. 7, fig. 2, as *Quercus aizoon*); **I**. *Sapotacites minor* (Unger) Menzel, leaf fragment, MB.Pb.2005/0018 = Menzel (1913: pl. 7, fig. 7); **J–K**. *Dicotylophyllum* sp., leaf fragments; **J**. MB.Pb.2005/0015 = Menzel (1913: pl. 7, fig. 15); **K**. MB.Pb.2005/0020 = Menzel (1913: pl. 7, fig. 16, as indet. leaf remain); **L–M**. Magnoliidae, gen. indet., cone scales, MB.Pb.2005/0025a+b = Menzel (1913: pl. 7, figs 13–14). Scale bar: A–K = 20 mm; L–M = 10 mm

straight, slightly rounded. Primary venation pinnate, secondary venation eucamptodromous, higher-order venation not preserved.

N o t e s. This leaf, identified as *Trigonobalanopsis rhamnoides*, fits well with the descriptions of this taxon by Mai & Walther (1985, 1991) and Kvaček & Walther (1988). The extinct genus *Trigonobalanopsis* shares an affinity with the isolated trigonobalanoid complex with three monotypic genera: *Colombobalanus* Nixon & Crepet, *Formanodendron* Nixon & Crepet, and *Trigonobalanus* Forman (Grímsson et al. 2016).

O c c u r r e n c e a n d h a b i t a t. In Europe from the late Eocene to late Miocene (Denk et al. 2012). In the Lower Rhine Basin it is very common in the late Oligocene pre-volcanic fluviatile siliciclastic deposits of the Siebengebirge Volcanic Field (Weber 1851–1852), within the same habitat as *Eotrigonobalanus furcinervis*. It is not known from Altenrath and Stallberg (Winterscheid & Kvaček 2016a) but has been found in the early Miocene fluviatile sand and clay deposits of Adendorf (Kvaček & Walther 1988, Mai & Walther 1991).

Family **Cornaceae** Bercht. & J.Presl 1825, nom. cons.

Subfamily **Mastixioideae** Harms 1897

cf. fossil-genus ***Eomastixia*** M.Chandler 1926

cf. *Eomastixia* sp. [*Carpolithes dactyliformis* Menzel 1913]

Fig. 3K–M

1913 *Carpolithes dactyliformis* Menzel: 83–84; pl. 7, figs 8–9 [Nirm].

1936b Mastixioideae gen. et sp. indet. – Kirchheimer: 115–116; text-figs 22b–c [Nirm].

Taxonomic treatment. *Carpolithes dactyliformis* has not yet been typified.

Lectotype (designated here). [MB.Pb.2005/0027 (orig. no. 219)!], illustrated in: Menzel (1913: pl. 7, fig. 8), Kirchheimer (1936b: text-fig. 22c, as Mastixioideae gen. indet.).

Syntype (designated here). [MB.Pb.2005/0022 (orig. no. 229)!], illustrated in: Kirchheimer (1936b: text-fig. 22b, as Mastixioideae gen. indet.)].

Repository. Museum für Naturkunde, Leibnitz Institute for Evolution and Biodiversity Science, Berlin, former Preußische Geologische Landesanstalt, Berlin (leg. E. Holzapfel).

Type locality. Germany, North Rhine-Westphalia: railway tunnel (Nirmer Tunnel) near Eilendorf east of Aachen [N 50°47′14.9″E 6°10′08.1″].

Stratigraphy. Late Oligocene (Chattian) sandstone of the Köln Formation.

Additional specimen examined. MB.Pb.2005/0028 (orig. no. 219) = Menzel (1913: pl. 7, fig. 9).

Description. The lectotype specimen (MB.Pb.2005/0027) shows an elongate-ovate, spindle-shaped, smooth endocast (steinkern) of a single C- or horseshoe-shaped locule within the endocarp. Specimen MB.Pb.2005/0022 (syntype) is an imprint of the outer endocarp with conspicuous longitudinal segments of irregular ridges and ledges. The morphology of specimen MB.Pb.2005/0028 is not quite clear. It shows a slightly curved imprint of a fruit with a smooth inner part (endocast of the locule) surrounded by a rugose deepening.

Notes. The stone fruit endocast and imprints resemble *Eomastixia* M.Chandler, with 1–4-loculed endocarps, which are more or less conspicuously ribbed with a rugose surface (Holý 1975: 138); cf. *Eomastixia saxonica* (Menzel in Gothan & Sapper 1933) Holý 1975, *Eomastixia holzapfeli* (Menzel 1913) Kirchh. 1935, *Eomastixia persicoides* (Unger 1850a) Gregor.

Occurrence and habitat. Fruits of *Eomastixia* species are known from the late Cretaceous Maastrichtian to the late Miocene. Some plant remains from the late Oligocene fluviatile deposits of the Siebengebirge Volcanic Field obviously belong to *Eomastixia* (author's coll.). In the Lower Rhine Basin the genus occurs in the middle to late Miocene fluviatile sands of the Ville and Inden Formation.

Magnoliidae inc. sed.

Sapotacites Ettingsh. 1853

Sapotacites cf. ***minor*** (Unger 1850) Heer 1859

Fig. 4I

1850a *Pyrus minor* Unger: 481 [Parschlug and Radoboj, early Miocene; Sotzka, early Oligocene].

1850b *Pyrus minor* Unger 1850 – Unger: 183; pl. 59, figs 16–24 [Sotzka, early Oligocene].

1859 *Sapotacites minor* (Unger 1850) comb. nov. Heer: 14; pl. 103, fig. 9 [Hoher Rhonen, early Miocene].

1866 *Bumelia minor* (Unger 1850) Unger: 25; Taf. 6, Fig. 11–19 [Parschlug and Radoboj, early Miocene; Sotzka, early Oligocene].

1913 *Sapotacites minor* (Unger 1850) Heer 1859 – Menzel: 82–83; pl. 7, fig. 7 [Nirm].

Specimen examined. MB.Pb.2005/0018 (orig. no. 223) = Menzel (1913: pl. 7, fig. 7).

Description. Leaf fragment only apically preserved. Laminar size microphyll, laminar shape obovate. Margin entire, base not preserved; apex angle obtuse, apex shape rounded. Primary venation pinnate.

Notes. Such Oligocene and Miocene leaf morphotypes, given as *Pyrus minor*, *Sapotacites minor* and *Bumelia minor*, are of unknown systematic affiliation.

Genus ***Dicotylophyllum*** Saporta 1892

Dicotylophyllum div. spp.

Fig. 4J–K

1913 "*Unbestimmbare Blattreste*" [indet. leaf remain] – Menzel: 86; pl. 7, figs 15, 16 [Nirm].

Specimens examined. MB.Pb.2005/0015 (orig. no. 228) = Menzel (1913: pl. 7, fig. 15), MB.Pb.2005/0020 (orig. no. 225) = Menzel (1913: pl. 7, fig. 16).

Description. Leaf fragments as impressions in sandstone. Leaves simple, leaf attachment marginal. Lamina attachment petiolate, laminar size microphyll, laminar shape elliptic. Margin entire, base angle acute, base shape cuneate, apex not preserved. Primary venation pinnate, three secondary veins visible.

Notes. The morphological features do not allow the leaf to be assigned to a specific taxon. Some other leaf remains in drawer P0148/10r in the P.G.L.A. collection of the Museum für Naturkunde Berlin cannot be assigned to a specific taxon due to their fragmentary and poor preservation.

Pinidae vel **Magnoliidae** inc. sed.

Gen. et sp. indet. (cone or fruit scales)

Fig. 4L–M

1913 "*Unbestimmbare Zapfenschuppen*" [indet. imprints of cone scales] – Menzel: 86; pl. 7, figs 13, 14 [Nirm].

Specimens examined. MB.Pb.2005/0025a+b (orig. no. 226) = Menzel (1913: pl. 7, figs 13, 14).

Description. Imprints of arc-shaped scales, with basal stalk and densely arranged spine-shaped imprints at periphery (in fig. 4M) or with dentate periphery (in fig. 4L).

Notes. The systematic affinity of these scales remains unclear.

RESULTS

The results of this systematic-taxonomic revision are shown in Table 1.

The assemblage from the Nirmer Tunnel is similar to those from the late Oligocene (Chattian) siliciclastic deposits directly underlying the pyroclastic rock (tephra) of the Siebengebirge Volcanic Field near Bonn, and is considered to be of the same age (Weber 1851–1852, Holzapfel 1910: 127–128, footnote 1, Winterscheid & Kvaček 2016a). This flora also consists of *Magnolia burseracea*, *Ocotea rhenana*, *Sparganium* sp. vel *Typha* sp., *Eotrigonobalanus furcinervis*, *Trigonobalanopsis rhamnoides* and *Eomastixia* sp. (*Carpolithes dactyliformis*). These taxa are elements of a riparian forest found in a depositional environment comparable to that of the late Oligocene part of the Köln Formation at the southern edge of the Lower Rhine Basin. The beginning of enhanced taphrogenesis of the basin in the late Oligocene produced a braided river system with a high stream gradient and increased sediment load. The rivers coming from the south and east deposited siliciclastic sediments at the north-western margin of the Rhenish Massif. Lithostratigraphically, the deposits can be placed in the Köln Formation (Unterflöz-Serie IV, Ton 06, according to the stratigraphic sequence of Schneider & Thiele 1965) of the late Oligocene (Winterscheid & Kvaček 2016a).

The subtropical evergreen Fagaceae *Eotrigonobalanus furcinervis* and *Trigonobalanopsis rhamnoides* are typical elements of late Eocene and Oligocene riparian and mixed mesophytic forests, for example in the Czech Republic, in the late Eocene of the Sokolov Basin and the Česke Středohoři Mountains, and in the early Oligocene Staré Sedlo Formation in the Cheb Basin in western Bohemia, with predominance of *Eotrigonobalanus furcinervis* (Kvaček & Teodoridis 2007). The two species were also found in late Eocene and Oligocene fluviatile floras (Tieflandsfloren) in eastern Germany (Mai & Walther 1978, 1985, 1991) and in early Oligocene fluviatile deposits of Hochstetten-Dhaun in the Nahe area (Uhl et al. 2002). *Eotrigonobalanus furcinervis* and *Trigonobalanopsis rhamnoides* seem to become scarcer after the Oligocene and remain only accessory elements of early Miocene floras, such as those of the Cypris Shale (Bůžek et al. 1996) and the Most Basin (Teodoridis & Kvaček 2006) in Bohemia (Czech Republic).

In the Lower Rhine Basin, *Eotrigonobalanus furcinervis* occurs predominantly in the late Oligocene floras of the Siebengebirge area and Altenrath. *Trigonobalanopsis rhamnoides* existed from the late Oligocene in the Siebengebirge area (Winterscheid & Kvaček

Table 1. Revision of taxonomic identifications by Menzel (1913) and on labels in the collection of Nirm

Determinations by Menzel (1913) and on labels in collections	New systematic determinations
Magnoliidae Novák ex Takht. 1967	
Magnoliaceae Juss. 1789, nom. cons.	
Lectotype of *Carpolithus burseraceus* Menzel 1913 – MB.Pb.2005/0016 = Menzel (1913: pl. 7, figs 12a, 12b) = Mai (1975: pl. 35, figs 24, 25). Syntypes – MB.Pb.2005/0014a–b = Menzel (1913: pl. 7, figs 11a, 11b), MB.Pb.2005/0023 = Menzel (1913: pl. 7, fig. 10) = Mai (1975: pl. 35, fig. 26)	*Magnolia burseracea* (Menzel) Mai
Lauraceae Juss. 1789, nom. cons.	
MB.Pb.2005/0024 = Kirchheimer (1936b: text-fig. 22a, as Mastixioideae gen. indet.), Mai (1971: pl. 33, fig. 9)	*Ocotea rhenana* Menzel
Typhaceae Juss. 1789, nom. cons.	
MB.Pb.2017/1477	*Sparganium* sp. vel *Typha* sp. (leaf fragment)
Hamamelidaceae R.Br. in C.Abel 1818, nom. cons.	
MB.Pb.2017/1475, MB.Pb.2017/1478a–c	*Rhodoleia bifollicularis* (Menzel) Mai
Fagaceae Dumort. 1829, nom. cons.	
MB.Pb.2005/0026 = Menzel (1913: pl. 7, fig. 1, as *Quercus lyellii*). MB.Pb.2005/0012 = Menzel (1913: pl. 7, fig. 3a, as *Quercus aizoon*). MB.Pb.2005/0011 = Menzel (1913: pl. 7, fig. 6, as *Myrsinophyllum dory-phora*). MB.Pb.2005/0013 = Menzel (1913: pl. 7, fig. 3b), MB.Pb.2005/0017 = Menzel (1913: pl. 7, fig. 4), MB.Pb.2005/0019 = Menzel (1913: pl. 7, fig. 5, as *Laurus tristaniaefolia*)	*Eotrigonobalanus furcinervis* (Rossm.) H.Walther & Kvaček in Kvaček & H.Walther
MB.Pb.2005/0021 = Menzel (1913: pl. 7, fig. 2, as *Quercus aizoon*)	*Trigonobalanopsis rhamnoides* (Rossm.) Kvaček & H.Walther
Cornaceae Bercht. & J.Presl 1825, nom. cons.	
Lectotype of *Carpolithes dactyliformis* Menzel 1913 – MB.Pb.2005/0027 = Menzel (1913: pl. 7, fig. 8) = Kirchheimer (1936a: text-fig. 22c – Mastixioideae gen. et sp. indet.). Syntypes – MB.Pb.2005/0028 = Menzel (1913: pl. 7, fig. 9), MB.Pb.2005/0022 = Kirchheimer (1936b: text-fig. 22b – Mastixioideae gen. et sp. indet.)	cf. *Eomastixia* sp. [*Carpolithes dactyliformis* Menzel]
Magnoliidae inc. sed.	
MB.Pb.2005/0018 = Menzel (1913: pl. 7, fig. 7 – *Sapotacites minor*)	*Sapotacites minor* (Unger) Menzel
MB.Pb.2005/0015 = Menzel (1913: pl. 7, fig. 15), MB.Pb.2005/0020 = Menzel (1913: pl. 7, fig. 16)	*Dicotylophyllum* sp. (leaf fragments)
Pinidae vel **Magnoliidae** inc. sed.	
MB.Pb.2005/0025 = Menzel (1913: pl. 7, figs 13, 14)	Pinidae vel Magnoliidae, gen. indet. (cone scales)

2016a, Weber 1851–1852, and unpublished data) to the early Miocene of Adendorf (Kilpper 1968, Kvaček & Walther 1988) and Kreuzau (Ferguson 1971, Ferguson et al. 1998).

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