

***Polyphagichnium altenburgense* igen. & isp. nov.: A new trace fossil from the Egerian – Eggenburgian (late Oligocene to early Miocene), Central Paratethys, Lower Austria**

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Abstract

Silicified wood remains, especially redeposited driftwood, are relatively abundant in the Central Paratethys upper Oligocene (Egerian) to lower Miocene (Eggenburgian) fluviatile St. Marein-Freischling Formation (SMFF) in northwestern Lower Austria (Waldviertel), especially in the Horn Basin. The SMFF is superimposed on the crystalline units of the Bohemian Massif and in the Horn Basin overlain by marine formations of the lower Miocene (Eggenburgian). Several pieces of silicified wood show flight holes, tunnels (= domichnia) and feeding traces of the new ichnofossil *Polyphagichnium altenburgense* igen. & isp. nov. which is described in detail herein. The cross-sections of shafts ("flight holes") and tunnels, which are clearly visible on the surfaces of tangential sections and radial sections of several specimens, are compared with structures of different recent gnawing beetles (suborder Polyphaga). The silicified wood remains are mostly semi-ring-porous hardwoods of the fossil group around *Quercoxylon furwaldense* GROS 1983.

1. Introduction

Members of numerous groups of organisms, from bacteria to vertebrate, infest plant tissues for feeding, larval development and/or shelter. Such traces may occur in living or dead tissues. In rigid tissues such as bark or wood, the excavated shafts and tunnels are often filled with feces. The most frequent traces are produced by (gnawing-) beetles, wood wasps, ants, moths, mites, sawflies and bees (Rößler et al., 2023). In the fossil record the oldest traces are known from the Carboniferous onwards and become frequent towards the Quaternary. Questionable trace fossils of early Palaeozoic age are mentioned by McLoughlin and Mays (2022). Silicified woods are common in both palaeontological and mineralogical collections. However, most fossil woods are collected for systematic studies and specimens with traces are rarely

mentioned. The traces presented here are in silicified fossil wood from an upper Oligocene (Egerian) / lower Miocene (Eggenburgian) fluviatile formation (St. Marein-Freischling Formation, SMFF), deposited on top of the crystalline units of the Bohemian Massif and overlain by marine formations of the Eggenburgian in northern Lower Austria.

2. Geological setting

Silicified wood remains and the studied ichnofossils were found within the SMFF in several locations in the Horn Basin in Lower Austria (Fig. 1). This chapter describes the geology, sedimentology and lithostratigraphy of the fluvial sediments of the SMFF and the study sites of silicified wood remains.

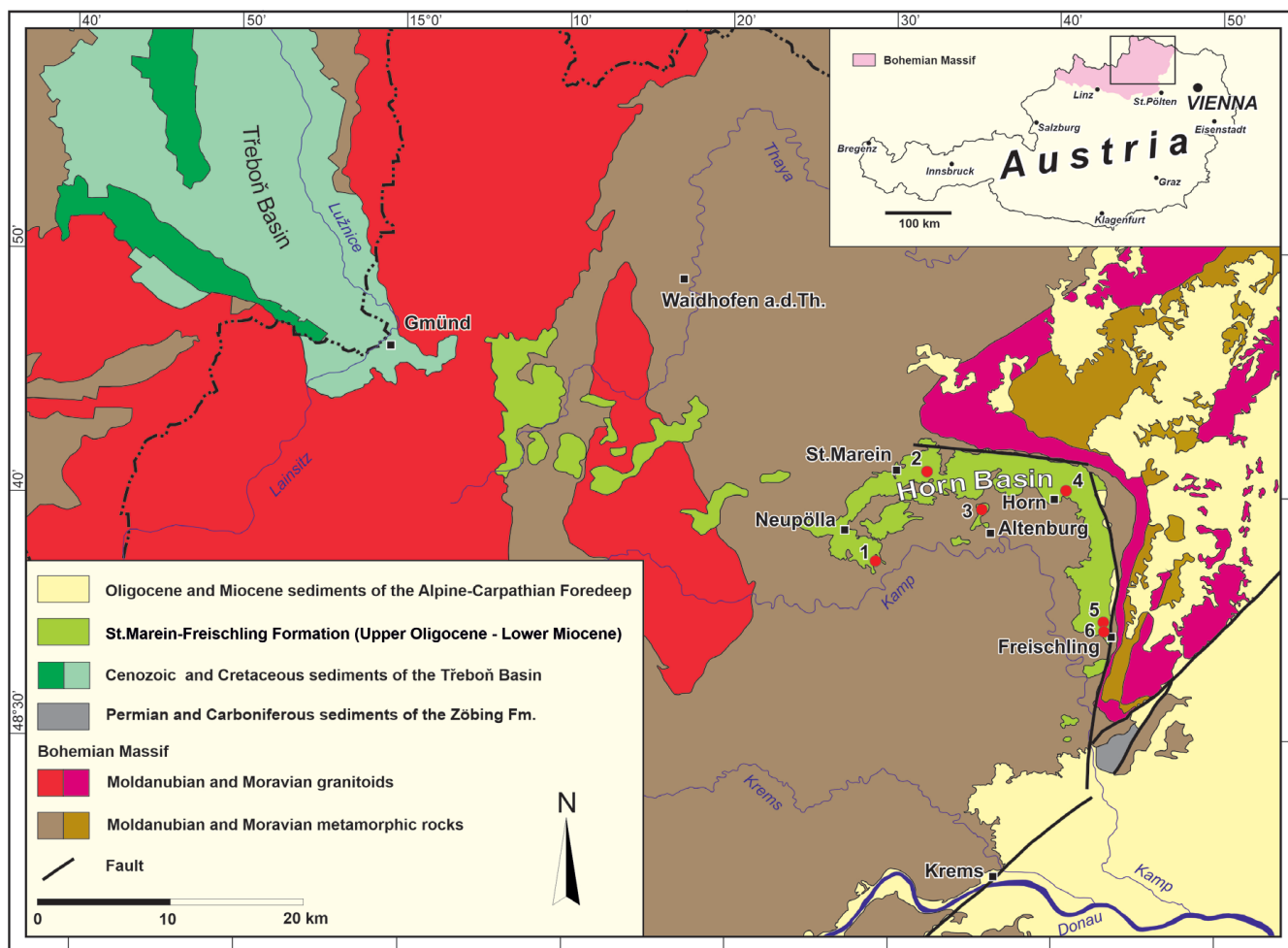


Figure 1: Simplified geological map of the Bohemian Massif in Lower Austria and adjacent Czech Republic and the extension of the St. Marein-Freischling Formation (SMFF). (after Nehyba and Roetzel, 2010, modified). Localities: 1: Altpölla; 2: Fürwald; 3: Altenburg; 4: Horn Thalhammer; 5: Maiersch Frings; 6: Freischling.

2.1. St. Marein-Freischling Formation

Roetzel (2022c, p. 122) characterises the SMFF as follows: “Sediments of the St. Marein-Freischling Formation are badly sorted arkosic and pelitic, coarse to fine sands and gravel with intercalations of kaolinitic silts and clays, showing typical sedimentary structures of a fluvial environment. In the southern part of the Horn Basin pelitic sediments are increasing towards the south and topwards in a progressively estuarine environment” (Nehyba and Roetzel, 2010, p. 64, Fig. 13). According to Nehyba and Roetzel (2010) the sediments of the SMFF characterise an ancient braided river system draining the Třeboň Basin in southern Bohemia and the southeastern Bohemian Massif from northwest to southeast from Gmünd via the Horn Basin to Krems in Lower Austria (Figs. 1, 2). Through detailed mapping of this formation, the latter authors reconstructed this braided river system, often referred to in popular literature as the “Horn-Palaeoriver” or “Palaeo-Kamp” (Roetzel and Steininger, 1991, 1999; Steininger and Roetzel, 1991; Fig. 2). Further recent results from mapping in the Horn Basin have been presented by Hofmayer (2024).

The sediments of the SMFF follow discordantly on top of the crystalline units of the Bohemian Massif (Schnabel et al., 2002) and are partly, mainly in the Horn Basin and south of it, overlain by marine formations of the Eggenburgian, e.g. Fels Formation (Roetzel, 2022d), Mold Formation (Roetzel, 2022e), and Loibersdorf Formation (Roetzel, 2022f), or directly by Pleistocene deposits.

2.2. Biostratigraphy

The SMFF can be correlated to the upper Oligocene (Egerian) / lower Miocene (Eggenburgian) by the pollen-zone Ng.Z. II (Hochuli, 1978, 1984). For further correlations of this pollen zonation with the standard nannoplankton and plankton zonation, as well as the Paratethys and the international standard chronostratigraphic stages, see Roetzel et al. (1999) and Rögl et al. (1979). Time-equivalent formations of the SMFF in Lower Austria are the Ravelsbach Formation (Roetzel, 2017, 2022b) and the Linz-Melk Formation (Krenmayr and Roetzel, 2000), with the latter extending to Upper Austria. Other time-equivalents in Upper Austria are the Frei-

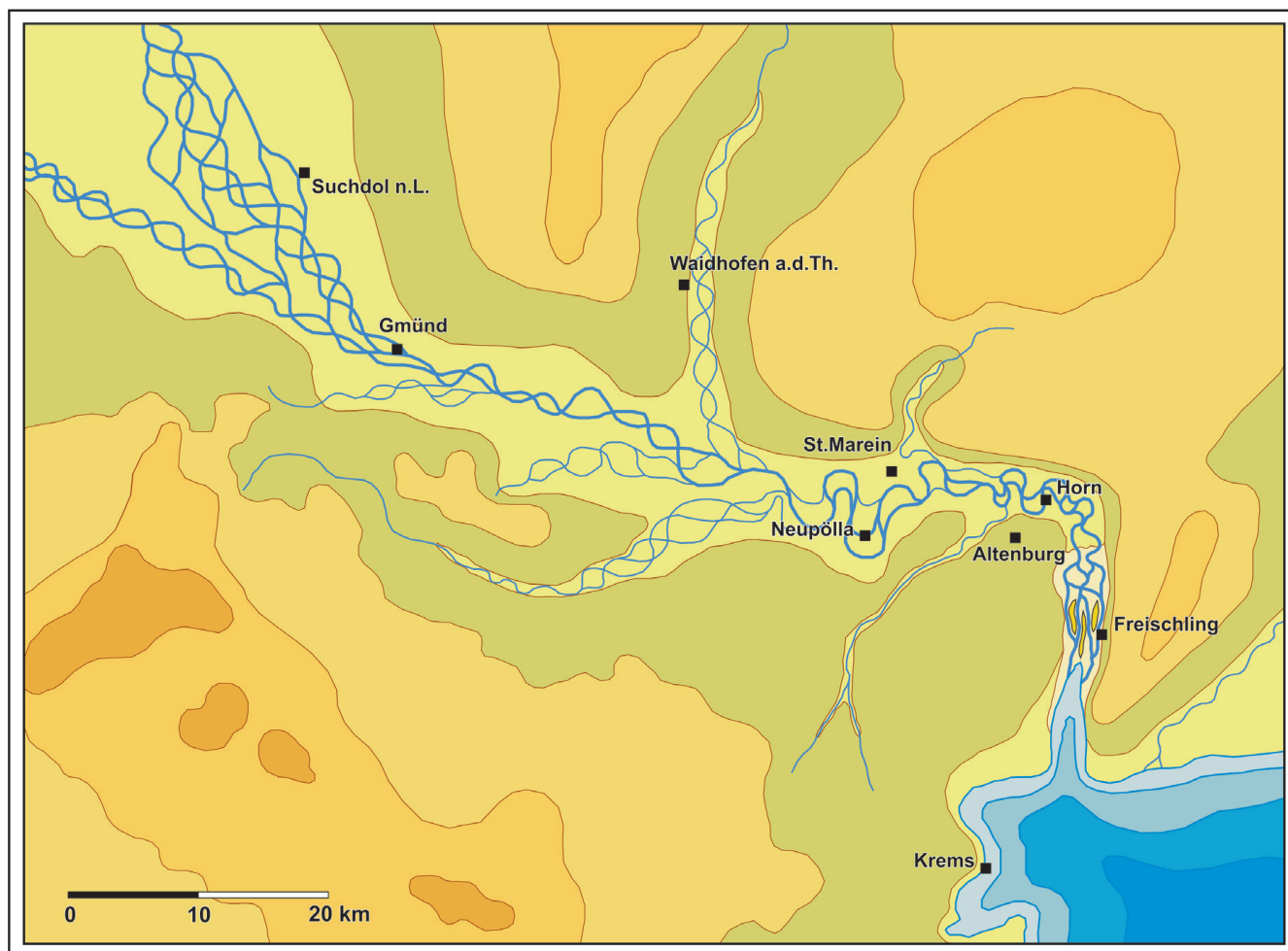


Figure 2: Hypothetical reconstruction of the braided river system ("Horn River") of the SMFF. In this sketch map the palaeogeographic situation in the final depositional stage in the early Miocene (late Egerian) is shown (after Nehyba and Roetzel, 2010, modified).

stadt-Kefermarkt Beds (Kohl, 1957) and the Eferding Formation ("Älterer Schlier" p.p.) (Piller et al., 2022). From the Ravensbach Formation, extending between Grubern and Obernholz, south of Eggenburg, rare silicified wood has been reported by Roetzel (2021). Silicified woods are also known from the upper Oligocene (Egerian) / lower Miocene (Eggenburgian) sandy to gravelly, fluvial sediments of the Freistadt-Kefermarkt Beds in the eastern part of the Mühlviertel district in Upper Austria (Kohl, 1957, 1983; Rockenschaub, 1998; Reiter, 1999; Chábera and Huber, 2000; Reiter and Kofler, 2011; Roetzel, 2022a). These beds can also be regarded as equivalents of the SMFF in time and facies. Examples of silicified wood in the collections of the Upper Austrian State Museum in Linz date back to 1835. So far, however, no traces have been reported from these woods. Siliceous woods are also frequently found in the upper Oligocene of the Eferding Formation ("Älterer Schlier" p.p.) of Peuerbach near Heiligenberg (Grieskirchen district) in Upper Austria (Reiter, 1999; Piller et al., 2022).

3. Silicified wood of the SMFF

Silicified wood from the SMFF deposited on the crystalline units of the Bohemian Massif in Lower Austria was collected from mostly recultivated sand and gravel pits (Figs. 1, 3a). Even today, surface finds of silicified wood are common in fields within the outcrop area of the SMFF. In general, most collections give only the name of the nearest village or town, but not the exact location of the site itself (Fig. 1). Silicified wood from the SMFF is common in the collections of the Horn Museum, the Krahuletz Museum, and in private and monastery collections from the following localities: Altenburg (Fig. 3a), Altpölla, Brunn an der Wild, Groß Burgstall "Schmiedbreiten", Frankenreith, Freischling, Fuglau, Fürwald, Horn, Kamegg, Mahersdorf, Neukirchen an der Wild, Poigen, and St. Marein in the western part of the Horn Basin. Without exaggerating, tons of silicified wood are deposited in these collections. In the oldest fossil collection from Lower Austria by Candid Ponz von Engelshofen (1803–1866), which covers a collection period from 1828 to 1865, nine pieces from the Horn area are preserved (Engelshofen Inv. No.: 0318, 0665, 0973, 0974, 1075, 2245, 2246, 2247, 2248; see Steininger,

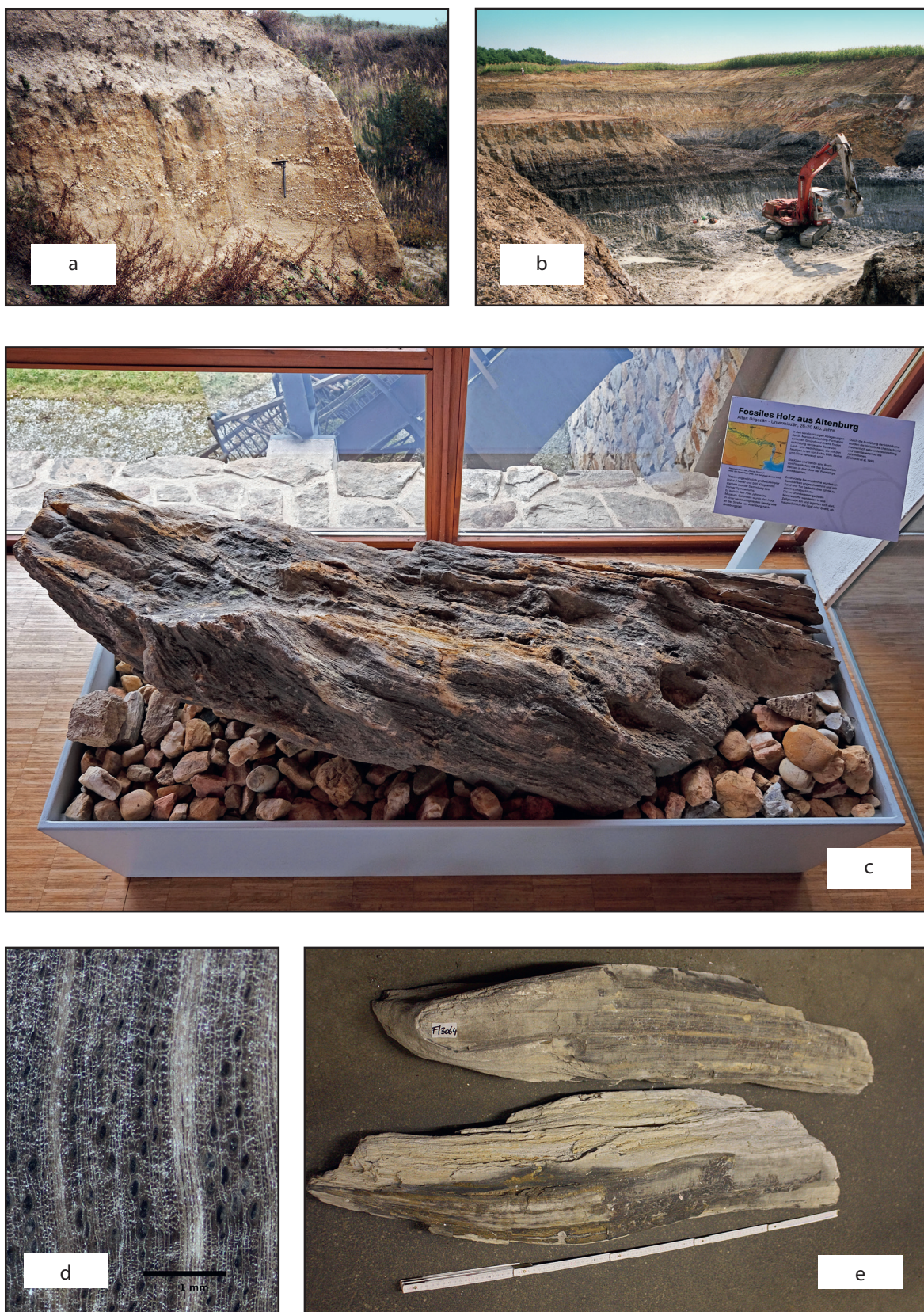


Figure 3: (a) Altenburg, historical section of the former sand and gravel pit northwest of Altenburg, west of “Hutbigl”, with alternation of coarse sands and gravel. Type location of the holotype (Coll. KraMu.: Inv. No. F/4352), shovel as scale in the centre of the photo. (b) Maieresch, former claypit Frings, east of the village, on the field parcel “Letten”: sequence with kaolinitic and lignitic layers (location of sample Ng.Z. II of Hochuli, 1978). Coordinates WGS 84: E: 15°42′32,3″, N: 48°34′51,3″; BMN M34: R: 704022, H: 382723. (c) *Quercoxylon furwaldense* Gros 1983, Altenburg (sand and gravel pit west “Hutbigl”). The log of this silicified wood is 2 m long and weighs 500 kg. The log is on display in the Horn Museum. (d) *Quercoxylon furwaldense* Gros 1983, thin section of Figure 3c with visible annual growth rings. (e) Larger, edge-rounded siliceous wood pieces (70 cm and 45 cm), Altenburg (sand and gravel pit west “Hutbigl”) (Coll. KraMu.: Inv. No. F/3064).

2024). Ellenberger (1948), Selmeier (1998), Havlíček (2017) and Vachek (2018) also mention silicified wood from this area. In a letter from Ludwig Margl of Gars/Kamp to D. Březinová (Prague) dated 28 February 1977, several localities are mentioned in detail (Margl, 1977).

It is interesting to note that most of the fossil logs were recovered in the SMFF from the western Horn Basin. According to Nehyba and Roetzel (2010, Fig. 13) and Roetzel (2022c), this area features a change from a more gravelly lithofacies in the northwest into a sandy-gravelly to fine-grained lithofacies towards the east. This change in lithology may have resulted in more frequent deposition of fossil logs in form of driftwood assemblages (Trümper et al., 2020, 2022). These pieces are all edge-rounded or rolled. Large tree trunks and pieces between 40 and 70 cm are rare (Fig. 3e), but pieces between 5 and 15 cm are common (Figs. 4a to c), as well as broken pieces of 1–2 cm. The Horn Museum displays a 2 m long and about 500 kg heavy tree trunk from the recultivated sand and gravel pit west of the “Hutbigl”, northwest of Altenburg (Fig. 3c). A thin section of this trunk shows, according to O. Cichocki (personal communication), the typical anatomy of *Quercoxylon furwaldense* GROS 1983, with annual rings. It could be a semi-annular porous hardwood (oak-wood?) of the Mediterranean type (Fig. 3d). Most pieces are compact or completely silicified. Some show a white weathering crust in cross section. Smaller, edge-rounded or rolled pieces are often completely covered with such a crust (Figs. 4a–c).

The following fossil wood taxa are described from the SMFF by Hofmann (1933), Gros (1983, 1984, 1988), Cichocki (1988, 1991, 1992), and Cichocki et al. (1991): *Metacacioxylon marglii* GROS 1984, *Metacacioxylon lemoinnei* GROS 1984, *Fraxinoxylon* sp., *Ulmoxylon* sp., *Quercoxylon furwaldense* GROS 1983, and *Taxodioxylon sequoianum* (SCHMALHANS) GOTHAN. Further taxa include those by Prakash et al. (1974): *Canarioxylon cescobudejovicense*, *Manilcaroxylon bohemicum*, *Sapotoxylon paltovae* and *Laurinoxylon oligocenicum*. The pollenflora was described by Hochuli (1978) and Draxler (1991). Knobloch (1977, 1981a, b) described megaspores, seeds, leaves and fruits from this formation. Floral elements were described by Kovar (1982).

4. Description of the trace fossil

A number of siliceous wood pieces from the SMFF show bioerosion marks on the exposed surfaces of the fossil wood. These traces are cylindrical perforations with numerous rounded openings perpendicular to the surface and tunnels parallel to the surface of the slabs. In recent wood, they are interpreted as flight holes of gnawing beetles.

***Polyphagichnium* igen. nov.**

Type ichnospecies: *Polyphagichnium altenburgense* isp. nov. (in this study, by monotypy).

Diagnosis: Shafts in wood logs, perpendicular to surface, in longitudinal rows following growth direction of the wood fibres. Tunnels horizontal, millimeters to centimeters long. Shafts and tunnels penetrate growth and cell structures.

Etymology: The new genus name *Polyphag* is derived from the suborder Polyphaga of the order Coleoptera, *ichnium* derived from latinized Greek *ikhnos* - trace.

Remarks: *Polyphagichnium* igen. nov. is similar to recent traces of Polyphaga families by its shafts and tunnels. However, there is not sufficient information on the shafts and tunnels of either recent or fossil taxa and therefore it is not possible to give a precise systematic position for the new taxon *Polyphagichnium* igen. nov. However, traces of recent wood borers such as beetles, mites, bees, wood wasps, sawflies and even termites, if known, differ mainly, in the arrangement, size and structure of shafts, tunnels and nests. Unfortunately, no fossil remains of the organism itself, either adults or larvae, were observed in our material, which then would help to compare them with recent organisms. In any case the tracefossil described here seems to be close to recent representatives of the suborder Polyphaga. Therefore, it is reasonable to name this trace fossil genus *Polyphagichnium* igen. nov. to indicate the systematic proximity to this recent suborder. The validity of *Polyphagichnium* igen. nov. was checked by consulting Bertling et al. (2006), Häntzschel (1975) and Simpson (1975).

***Polyphagichnium altenburgense* isp. nov.**

(Figs. 4–6)

Figures 5a–c: Holotype of *Polyphagichnium altenburgense* Steininger, Roetzel, Capellmann isp. nov.

Figures: 6a–b, 6c/1, 6c/2: Paratype of *Polyphagichnium altenburgense* Steininger, Roetzel, Capellmann isp. nov.

Material figured, including type species:

Altenburg (sand and gravel pit west “Hutbigl”); holotype, Figures 5a–c (Coll. KraMu.: Inv. No. F/4352).

Altenburg (sand and gravel pit west “Hutbigl”); paratype, Figures 6a–b, 6c/1, 6c/2 (Coll. KraMu.: Inv. No. F/4353).

Altenburg (sand and gravel pit west “Hutbigl”); two typical logs of driftwood, Figure 3e (Coll. KraMu.: Inv. No. F/3064).

Altenburg (sand and gravel pit west “Hutbigl”); one larger log, Figures. 3c, d (Coll. Horn Museum).

Frankenreith, (sand pit southeast of the village on the road to Wutzendorf), two examples, Figs. 4a, b, c (Coll. KraMu.).

Horn, former Thalhammer brickworks, today waste collection point, two examples, Figures 4 d, e, e/2 (Coll. KraMu.).

Diagnosis: As for the ichnogenus.



Figure 4: (a) Edge-rounded silicified wood with characteristic white weathering surface and typical shafts of *Polyphagichnium altenburgense* igen. & isp. nov. Coll. KraMu.: Inv. No. F/4353. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* GROS 1983; Frankenreith, (sand pit southeast of the village on the road to Wutzendorf). (b) Polished section of the silicified wood as in Figure 4a with characteristic white weathering structures and typical shafts of *Polyphagichnium altenburgense* igen. & isp. nov. (Coll. KraMu.: Inv. No. F/4353). Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* GROS 1983; Frankenreith, (sand pit southeast of the village on the road to Wutzendorf). (c) Silicified wood showing characteristic white weathering structures and typical shafts of *Polyphagichnium altenburgense* igen. & isp. nov. as in Figure 4a from the side (Coll. KraMu.: Inv. No. F/4353). Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* GROS 1983; Frankenreith, (sand pit southeast of the village on the road to Wutzendorf). (d) Limonitised wood piece with wood structure and steinkern-casts of different traces, Horn former Thalhammer brickworks, today waste collection point. (Coll. KraMu.: Inv. No. 3303). (e) Limonitised wood piece with wood structure and tunnels and preserved burrow fills as a network of thin, thread-like fillings branching into each other (see Fig. 4e and inset). Horn, former Thalhammer brickworks, today waste collection point. (Coll. KraMu.: Inv. No. 2550). Inset: Detail of tunnel fill as a network of thin, thread-like fillings branching into each other. Horn, former Thalhammer brickworks, today waste collection point. (Coll. KraMu.: Inv. No. 2550).

Etymology: The new species name is a toponym derived from the name of the municipality Altenburg near Horn, Lower Austria.

Type horizon and locality: St. Marein-Freischling Formation, upper Oligocene (Egerian) / lower Miocene (Eggenburgian) in a recultivated sand and gravel pit west of the topographic point “Hutbigl” (altitude 411 m), north-west of the municipality of Altenburg, Lower Austria; coordinates: WGS 84: E: 15°35′12,8″, N: 48°39′28,2″; BMN M34: R: 695100, H: 391358 (Figs. 1, 2, 3a).

Type material:

Holotype KraMu.F/4352 (Figs. 5a–c): *Polyphagichnium altenburgense* Steininger, Roetzel, Capellmann isp. nov. is described from a silicified wood piece from the municipality of Altenburg, Lower Austria (recultivated sand and gravel pit west of “Hutbigl”), St. Marein-Freischling Formation, upper Oligocene (Egerian) / lower Miocene (Eggenburgian). Collected by F. Steininger and deposited in the Krahuletz Museum Eggenburg; collection inventory number: Coll. KraMu.: Inv. No. F/4352 (Figs. 5a–c).

Paratype KraMu.F/4353 (Figs. 6a–b, 6c/1, 6c/2): originating from the same locality as the holotype, collected by F. Steininger and deposited in the Krahuletz Museum Eggenburg; collection inventory number: Coll. KraMu.: Inv. No. F/4353 (Figs. 6a–b, 6c/1, 6c/2).

Description: Shafts are perpendicular to the log surface, arranged in longitudinal rows clearly following the growth direction of the fibers (parenchyma rays) of the fossil wood (Figs. 5a, b). More or less horizontal tunnels several millimeters to centimeters long below the surface of the fossil log. Shafts and tunnels penetrate growth and cell structures, as evident in the CTs in Figures 5c, d. Shafts and tunnels are open and not filled with faeces or sediment. All shafts and tunnels of the type species and other logs are preserved unaltered. Shafts and tunnels triggered obviously no wound reaction of the plant (callus tissue), so we assume that traces were produced in dead wood.

Description of the holotype: diameter of shafts: about 1 mm; length of visible tunnels: about 3 to 4 cm; diameter of tunnels: about 1.2 mm; found in semi-ring-porous hardwood, obviously *Quercoxylon furwaldense* GROS 1983; measurement of the log: length: 23 cm, width: 11 cm, thickness: 4.5 cm. Log with rounded edges, probably redeposited.

Description of the paratype: diameter of shafts and length of visible tunnels similar to holotype, occurs in semi-ring-porous hardwood, obviously *Quercoxylon furwaldense* GROS 1983; measurement of the log: length: 20 cm; width: 1.5 cm (one half of the log polished); thickness: 3.5 cm. Log with rounded edges, probably redeposited.

Additional material mentioned, but not figured:

However, other specimens from the collection of the Krahuletz Museum in Eggenburg from the following localities have been included in this study: Altpölla, Frauenhofen, Freischling, Fürwald, Groß Burgstall, Mahrsdorf, Neukirchen an der Wild, St. Bernhard, Strögen, and Wegscheid. Material from the following localities is deposited in the Horn Museum (Horn): Altenburg, Feinfeld, Neukirchen an der Wild, Poigen, Rodingersdorf, Röhrenbach, Schirmannsreith, and Wanzenau. Numerous specimens are kept in several private collections.

Remarks: In two pieces (Inv. No. 2550, 3303) of a limonitised wood steinkern-features were found that look like larval cradles (Fig. 4d) and in another piece, burrow fillings, a network of thin, thread-like fillings that branch out (Figs. 4e and inset). Both pieces are from Horn, Lower Austria, from the former Thalhammer brickworks, today a waste collection point.

All siliceous wood pieces recovered from the SMFF belong to semi-ring-porous hardwoods, apparently to *Quercoxylon furwaldense* GROS 1983 (personal communication by O. Cichocki) and are redeposited.

In this paper we are only concerned with wood-boring traces, and as mentioned above, shafts and tunnels can be compared with borings of several wood-boring Polyphaga groups and their superfamilies such as *Elat-eriformia* (*Buprestoidea*, *Elateroidea*); *Bostrichiformia* (*Bostrichoidea*); *Cucujiformia* (*Lymexyloidea*, *Cucuj-joidea*, *Curculionoidea*), further to wood wasps, sawflies and eventual to bees and termites. However, shafts and tunnels from these recent groups are usually only mentioned, but not described in detail or figured.

Most similar traces are *Ctenopholeus* described by Seilacher and Hemleben (1966) from the Devonian “Huns-rückschiefer” with long horizontal straight tunnels and shafts rising at equal intervals but seem much too small (see also Häntzschel, 1975; Scott, 1992). Also, the shafts in equal intervals cannot be compared to our traces. *Pectichnus multicylindrus* is more or less worldwide known trace from Carboniferous to Permian, however, has a completely other arrangement of shafts and tunnels and seems to be specialised on fossil conifer wood. (Rößler et al., 2023). In the same publication Rößler et al. (2023) describe and figure an unnamed trace in a Permian silicified wood from Appenrode near Ilfeld, Germany with holes (shafts) in a row. Linck (1949) describes a trace *Anobich-nium simile* from the Triassic (Keuper) of Germany with shafts and tunnels similar to our trace but with much larger diameters and random distributed shafts on the surface. A re-evaluation of this trace rather compares it with a trace of the ship borer *Teredo*.

Biostratigraphy and chronostratigraphy of the SMFF

The SMFF can be correlated to the Central Paratethys pollen-zone Ng.Z. II of Hochuli (1978, 1984). This pollen-zone Ng.Z. II was recovered from locality No. 49



Figure 5: (a) *Polyphagichnium altenburgense* igen. & isp. nov. Holotype: surface with characteristic shaft openings. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* Gros 1983. Altenburg (sand and gravel pit west "Hutbigl") (Coll. KraMu.: Inv. No. F/4352). (b) *Polyphagichnium altenburgense* igen. & isp. nov. Holotype: enlarged surface of Figure 5a with shafts in fibre direction of the wood. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* Gros 1983. Altenburg (sand and gravel pit west "Hutbigl") (Coll. KraMu.: Inv. No. F/4352). (c) *Polyphagichnium altenburgense* igen. & isp. nov. Holotype: CT image, about one cm below the surface of the specimen shown in Figure 5a with characteristic shafts and tunnels. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* Gros 1983. Altenburg (sand and gravel pit west "Hutbigl") (Coll. KraMu.: Inv. No. F/4352). (d) *Polyphagichnium altenburgense* igen. & isp. nov. Holotype: CT image, about two cm below the surface of the specimen shown in Figure 5a with characteristic shafts and tunnels. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* Gros 1983. Altenburg (sand and gravel pit west "Hutbigl") (Coll. KraMu.: Inv. No. F/4352).



Figure 6: (a) Polished tangential section of an elongated piece of wood with characteristic white weathering structures, shafts and tunnels of *Polyphagichnium altenburgense* igen. & isp. nov. paratype. Semi-annular-porous hardwood, probably *Quercoxylon furwaldense* GROS 1983. Altenburg (sand and gravel pit west "Hutbigl") (Coll. KraMu.: Inv. No. F/4353). (b) Enlarged tangential section of Figure 6a, paratype (Coll. KraMu.: Inv. No. F/4353). 6c/1: CT image of Figure 6a near surface, paratype (Coll. KraMu.: Inv. No. F/4353). 6c/2: CT image of Figure 6a, deeper part of the log, paratype (Coll. KraMu.: Inv. No. F/4353).

(Eggenburg “Liegendtegel”) and locality No. 50 (Maiersch Frings claypit, Fig. 3), see table 3, p. 38 in Hochuli (1978). The Neogene pollen-zone Ng.Z. II is characterised by thermophilic elements such as *Momipites punctatus*, *Caryapollenites simplex* and others.

Based on cross correlations, the SMFF is dated to the late Oligocene / early Miocene (Aquitania to early Burdigalian) or, in terms of the Central Paratethys stage concept, into the Egerian – Eggenburgian time span (Rögl et al., 1979; Roetzel et al., 1999).

5. Discussion

Animal-plant interactions and the geologic distribution in space and time

Petrified wood is relatively common throughout the world, especially in continental deposits on all continents. The weathering of petrified wood from sediments has often led to the accumulation of such deposits, giving rise to the establishment of protected areas such as (geo)parks or natural/national monuments. Increasing attention is being paid to the topic of traces of life in relatively resistant fossil woods, which have good preservation potential and reveal animal-plant interactions from different periods of the Earth’s history, and are therefore always of great interest to palaeontologists, ecologists and zoologists.

A search in the relevant literature and on the Internet for texts and illustrations on wood-boring insects (gnawing beetles) in petrified woods helped to assess the significance of the new finds described here. Some few examples of these reports are given below.

Rößler et al. (2023) described feeding traces of *Pectichnus multicylindricus* from upper Palaeozoic conifer woods (Upper Carboniferous; “Stephanian”) from localities such as Tilleda at Kyffhäuser in the Saale depression, Crock in southern Thuringia, Pilsen (Pilsen Basin) in the Czech Republic, from the Triassic of Germany (Kelber, 2007 and *pro parte* in Linck, 1949; Rößler et al., 2023), Ukraine and China (see Lorenz, 2024). Walker (1938) and others described Triassic insect traces from the Petrified Forest National Monument in Arizona. The “beetle track” *Dekosichnus meniscatus* has been described from an *Araucaria* wood from the Jurassic of Argentina (Genise et al., 1995) and from the Upper Cretaceous of southeast Africa (Philippe et al., 2022). Fossil wood from the lower Eocene (53–49 Ma) Green-River Formation of the “Blue Forest” in the USA (Utah, Colorado, Wyoming) shows calcareous algae growth and various insect, worm and woodpecker holes (Viney, 2020). Haug et al. (2021, 2023) describe various larvae of solid-wood-borers and tunnels preserved in amber. Prakash et al. (1974) and Trunco (1976) mention such trace fossils from the Cenozoic and the Oligocene of Germany, respectively.

Occurrences of silicified woods in Austria are reported by several case studies from the Permian to the Pleistocene:

The oldest examples of petrified wood in Austria were found in the lower Permian (Cisuralian) of Zöbing, Lower Austria in the form of steinkerns of *Calamites* (Berkholz, 2015; Vasicek, 1991; Steininger and Vasicek, 1983); further from the lower Permian near Laas in Carinthia (Kothe, 2012). In both localities the *Calamites* steinkerns do not show trace fossils as described by Laab et al. (2020).

Examples in younger deposits from the Oligocene to the Pleistocene are:

From the Oligocene in the Linz-Melk Formation (Kiscellian to Egerian) from the former sand pits near Hermannsschacht, Winzing and in the Melk area (Roetzel, 2022g) and from the SMFF in the Horn area, as described above. Further from sands of the Retz Formation (Ottnangian) near Retz (Hofmann, 1936a, b) and from the Freistadt-Kerfermarkt Beds (Egerian to Eggenburgian) in the vicinity of Freistadt and Gallneukirchen (see above). In Ottnangian deposits of the former Trimmelkam coal mining area (Trimmelkam Beds, Braunau Formation (Rupp and Piller, 2022a) and at Gallspach, Upper Austria. (Atzbach Formation, Ottnangian; Selmeier, 1970, 1989). Silicified wood is also reported from gravelly sands between Limberg and Maissau (Laa Formation, Karpatian; Roetzel, 1996). From the Pannonian, fossilized wood comes from outcrops near Haag am Hausruck in the Hausruck Formation (Rupp and Piller, 2022b) and from the Csatherberg (Csaterberg) near Kohfidisch with fungal filaments and wood of *Lillia*, *Ulmium* and *Qercinium* from the uppermost Pannonian (Kümel, 1956; Mörtl, 2000). In addition to other silicified woods in the Pleistocene March gravels in the district of Gänserndorf, ring-porous hardwoods with frass veins, palm woods and root soils have been recorded in these gravels (personal communication O. Schmitsberger).

Literature and Internet research shows the abundance of petrified fossil wood in Austria, but traces comparable to those found in the wood of the SMFF are only known from a single additional site in the Marchschotter (personal communication O. Schmitsberger). This study aims to draw more attention to such traces in the future.

6. Conclusions

In this paper the new ichnotaxon *Polyphagichnium altenburgense* igen. & isp. nov. from a silicified driftwood with frequent traces is described in detail. It originates from the St. Marein-Freischling Formation, which is distributed from the Gmünd area via Horn and Krems in Lower Austria and especially in the Horn Basin. The infested silicified wood remains were redeposited in the SMFF and belong to the semi-ring-porous hardwoods of the fossil group around *Quercoxylon furwaldense* GROS 1983.

The small, rounded cross-sections of the boreholes - the shafts - of *Polyphagichnium altenburgense* igen. & isp. nov. measure about 0.9 to 1.5 mm in diameter and are arranged in lines that follow the direction of growth (fibres) of the wood on the tangential plane of the pieces. The

shafts penetrate and cross the wood anatomy to a depth of several millimeters to centimeters, as can be seen in thin sections and CT images. In radial sections, the shafts merge into straight to slightly winding vertical tunnels, which also cross the wood anatomy. Accordingly, these bioerosion structures can be interpreted as endichnia/fodinichnia. These structures are best compared to those of the recent gnawing beetles of the suborder Polyphaga (see above).

The poorly sorted, coarse-grained, arkosic sands, gravels and pelites of the fluviatile SMFF date to the upper Oligocene (Egerian) to lower Miocene (Eggenburgian) according to the pollen flora and are overlain by marine fossil-bearing sediments of the Eggenburgian. Based on geological mapping, these sediments can be traced from the Třeboň Basin in South Bohemia via Gmünd and Horn to Krems, forming a braided palaeofluvial river system.

As shown, fossil wood is very common, but traces of boring insects have rarely been described. Increasing attention should be paid to the topic of traces of life in relatively resistant fossil woods, which have a good preservation potential and reveal animal-plant interactions from different periods of the Earth's history, and are therefore of great interest to palaeontologists, ecologists and zoologists. We hope that this study will stimulate the further search for such traces.

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